Malone

Annual TECHNICAL REPORT: 1999

Name of Contractor:	**University of Washington**
Principal Investigators:	**S. D. Malone, R.S. Crosson, and A.I. Qamar** **Geophysics Program** **Box 351650** **University of Washington** **Seattle, WA 98195-1650**
Government Technical Officer:	**Dr. John Unger** **MS 905** **U.S. Geological Survey** **12201 Sunrise Valley Drive** **Reston, VA 20192**
Short Title:	**Cooperative Operation of the Pacific Northwest Seismograph Networ**
Program objective number:	**I-1**
Effective Date of J.O.A.:	**Dec. 1, 1997**
Amount of J.O.A., 1999:	**$490,554.**
Time Period Covered in Report:	**1/1/99 - 12/31/99**
Date Report Submitted:	**January 31, 1999**

Research supported by the
U.S. Geological Survey, Department of the Interior
under USGS award number 1434-HQ-98-AG-01937

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1999 Annual Technical Report
PACIFIC NORTHWEST SEISMOGRAPH NETWORK OPERATIONS

USGS-1434-HQ-98-AG-01937

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Jan. 1, 1999 - Dec. 31, 1999

ABSTRACT and NONTECHNICAL SUMMARY

This is the 1999 annual technical report for USGS Joint Operating Agreement 1434-HQ-98-AG-01937 *"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 1999, an overview of our public information program, and a summary of 1999 seismicity. During 1999, 30 earthquakes within our network area were reported felt.

The largest earthquake in Washington this year was a coda magnitude 5.1 (body wave magnitude 5.5) earthquake on July 3 UTC (July 2 6:43 PM PDT). It occurred at a depth of about 41 km, about 8 km north of Satsop, WA. The July 3 UTC earthquake was felt throughout most of western Washington and northwest Oregon, and in parts of southwest British Columbia, Canada. The maximum acceleration recorded during the July 3 UTC earthquake was 8%g at Wynoochee dam. The estimated acceleration at the epicenter is 17%g. The strongest shaking corresponded to a level of about VI on the Modified Mercalli Intensity scale. Structural damage included cracked chimneys and broken windows. The three-story Grays Harbor County Courthouse, built in 1910 and located in Montesano, suffered extensive structural damage to its cupola. Interior walls were also cracked. The Montesano fire station, built around 1979, also suffered structural damage. In Aberdeen, some structural cracks of walls and beams were reported. In addition, power outages and water main breaks occurred. The wood-framed roof of a furniture store collapsed.

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"PACIFIC NORTHWEST SEISMOGRAPH NETWORK (PNSN) OPERATIONS"

SUMMARY

This is the 1999 annual technical report for USGS Joint Operating Agreement 1434-HQ-98-AG-01937 *"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 1999, an overview of our public information program, and a summary of 1999 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 1999.

CURRENT INITIATIVES

Introduction

The PNSN is currently in the process of upgrading operations, including extensive changes to data recording, exchange, and processing systems. 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 compatibility

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. In 1998 the PNSN installed three CREST-compatible (but not CREST equipment) stations (real-time, broad-band, and strong-motion; ERW, ELW, and SP2) installed. Two stations, RWW and GNW, with full CREST equipment were installed in Washington during 1999. An EARTHWORM node was configured, tested, and shipped to Eugene, Oregon, and installation of two CREST stations in Oregon is expected in early 2000.

PNSN Strong Motion Program and RACE (Rapid Alerts for Cascadia Earthquakes) System

Since May of 1996 the the Pacific Northwest Seismograph Network (PNSN) has been upgrading strong-motion instrumentation in urban areas. The strong-motion update began in the Seattle area, and in 1999 was extended into Portland, Oregon. A total of twenty stations, most of them real-time, are currently operating in Washington and Oregon. Table 1C gives locations, instrumentation, and telemetry methods. Several of the strong-motion sites also have broad-band three-component sensors.

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 prototype mode at five emergency management agencies in Washington and Oregon.

In order to continue development of both the strong-motion network and the RACE system, the PNSN is creating a "research associates" plan which will make it easier to form partnerships with public or private groups that need immediate strong motion information from critical facilities. In addition, the PNSN is seeking additional funding from the state of Washington to support ongoing and enhanced operations.

EARTHWORM Progress Report

Work on EARTHWORM and PNSN Y2K compatibility was ongoing throughout 1999. Over the year, extensive work was done on basic EARTHWORM software and PNSN analysis and distribution software to make them Y2K compliant. The millennial rollover was completed without significant problems.

OPERATIONS

Seismometer Locations and Network Maintenance

By the end of 1999, the PNSN EARTHWORM SYSTEM was digitally recording 246 channels of real-time or near-real-time seismic data Stations available include a total of 141 short-period analog stations (7 of them received from other networks via EARTHWORM), 11 broad-band and 17 strong-motion stations.

The majority of sites have a single short-period vertical, component which is telemetered continuously in analog form to the UW. This contract (JOA 1434-HQ-98-AG-01937) supports 92 short-period sites (some with multiple components) and operation of 17 strong motion and 8 broad-band stations, plus horizontal seismometers with Wood-Anderson-response at station SEA on the campus of the University of Washington. The supported stations cover much of western Washington and Oregon, including the volcanos of the central Cascades.

Additional stations funded by other contracts are also used in event locations. The locations of all stations operating at the end of 1999 are given in Tables 1A (short-period), 1B (broad-band), and 1C (strong motion) and shown in Fig. 1. Quarterly reports provide additional details of station operation. Quarterly reports from January 1, 1999 through December, 1999 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 stations with continuous telemetry to the PNSN lab which were operated by the PNSN at the end of the reporting period. Table 1B lists broad-band stations in the Pacific Northwest, and Table 1C lists strong-motion, three component stations. The first column in Tables 1A and 1B gives the 3-letter station designator. Column 2 designates the funding agency; operations of stations marked by a % symbol were fully supported by USGS joint operating agreement 1434-HQ-98-AG-01937 Stations designated # were installed or are maintained by the USGS, but are telemetered to the PNSN lab. Stations from the Northern California network, received over internet, are marked "C". Data from some of the broad-band stations operated under other support are archived at the PNSN. Remaining 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 1A - Short-period Stations operating during the fourth quarter 1999

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 39.6	119 52 59.4	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
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
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
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

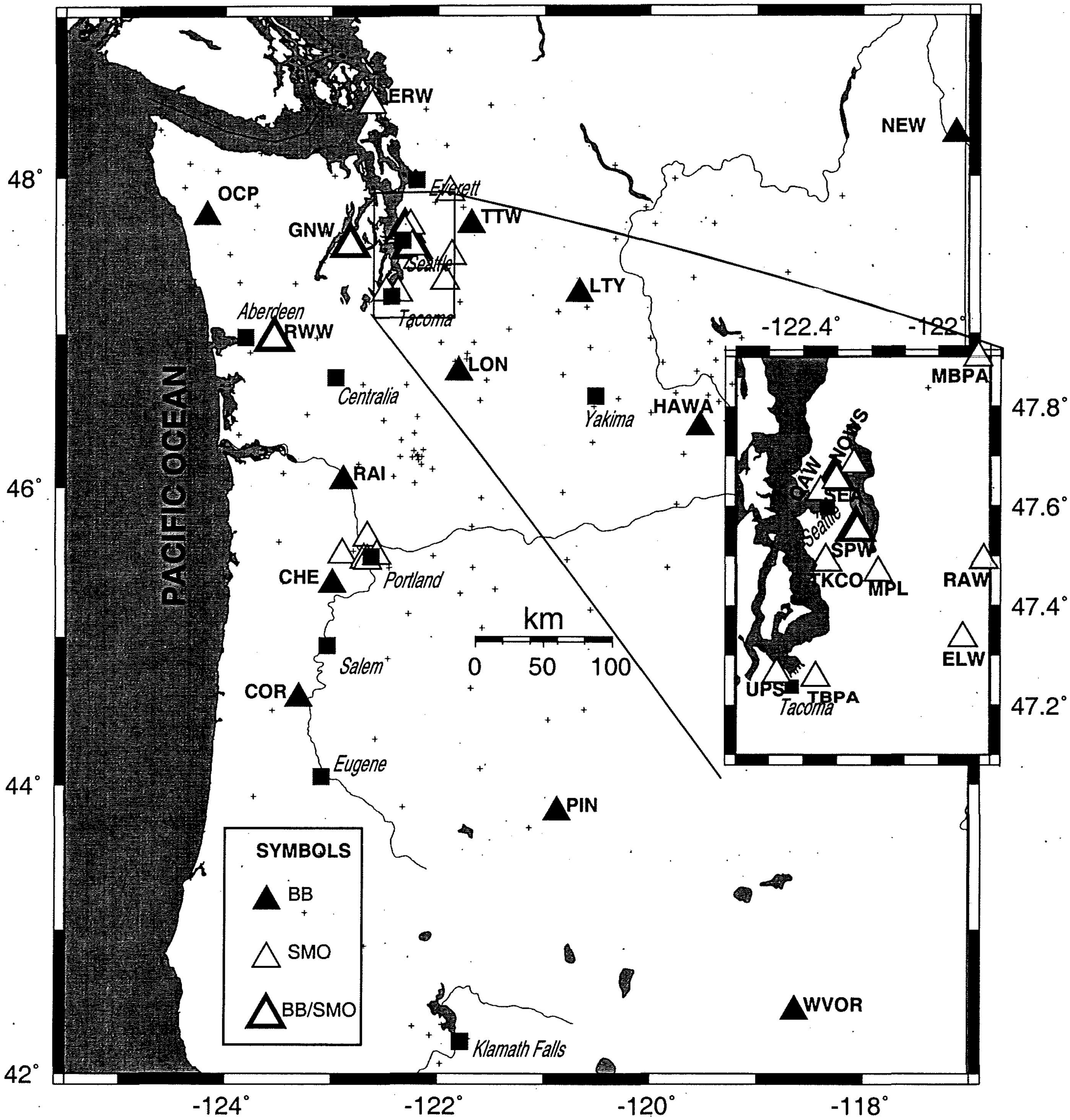

Figure 1: Stations operating at the end of the fourth quarter, 1999. Small + signs represent short period stations. Cities are shown as squares. Filled triangles represent broad-band stations. Strong motion stations are shown as unfilled triangles. Stations which have both broad-band and strong-motion components are shown as an unfilled triangle with a heavy border.

TABLE 1A continued

STA	F	LAT	LONG	EL	NAME
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
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
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
KEB	C	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	C	41 49 51.0	123 52 33.0		CAL-NET
KTR	C	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	C	41 36 35.2	122 37 32.1	1.769	CAL-NET
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
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (BB,LONLZ)
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 Center
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	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
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
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
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek

TABLE 1A continued

STA	F	LAT	LONG	EL	NAME
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
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens Dome
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.
SND	%	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectified
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 1B

Broad-band three-component stations operating at the end of the fourth quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
CHE		45 21 16.0	122 59 19.0	0.436	Chehalem, Oregon (Operated by UO)
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
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)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire, WA (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 (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)
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.

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 an Internet earthworm system

TABLE 1C

Strong-motion three-component stations operating at the end of the fourth quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALST	%	46 6 31.2	123 01 47.4	0.000	Alston, Oregon BPA	A20	E
CSO	#	45 31 01.0	122 41 22.5	0.036	Canyon Substation, Oregon	FBA23	D
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	L
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	L
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
KEEL	%	45 33 0.0	122 53 44.40	0.000	Keeler, Oregon BPA	A20	E
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	0.00	NOAA, Bldg 3	A20	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
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte, Oregon	FBA23	D
ROSS	%	45 39 46.2	122 39 37.0	0.100	Ross BPA	A20	L,E
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
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
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 56.1	122 28 58.4	0.113	U. Puget Sound	A	D,I

Data Processing

The seismograph network operated by the University of Washington consists of small numbers of broad-band and strong-motion sensors, plus over 130 short-period, vertical component, real-time-telemetered seismographic stations. Using real-time-telemetry data, the PNSN seismic recording system operates in an 'event triggered' mode, recording data at 100 samples per sec. per channel. Data from stations with other telemetry systems are retrieved and integrated with the event-triggered data. 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 teleseisms, regional events, and all locatable local events. Each trace data file has an associated 'pickfile' which includes arrival times, polarities, coda lengths, and other data.

In 1998, EARTHWORM replaced the SUNWORM system as the main PNSN data-acquisition system. The SUNWORM system continues to operate as a backup system. We continue to use our UW2 format data and the same analysis tools in place for the past several years.

Most PNSN broad-band stations record continuously, as well as having the ability to trigger and record on-site. Stations LTY, and LON record digitally on-site, and data are retrieved via dial-up modem. Stations RWW and GNW used to be similar, but have been upgraded to CREST equipment, and no longer record on-site. We also receive data for selected events via Auto-DRM from U.S. National Seismograph Network (USNSN) stations NEW; in north-eastern Washington, and WVOR; in south-eastern Oregon. Data for specific events are provided to the PNSN from broad-band stations PIN, DBO, COR, and RAI (operated by Oregon State University and the University of Oregon).

Broad-band data in "raw" formats are stored on ongoing "network-archive" backups along with all unedited network-trigger trace data. Broadband data are also archived in merged and edited UW2 format on our "Master Event" tapes along with data from the PNSN short-period network, Our "Master Event" files are also translated to IRIS-SEED format and submitted to the IRIS Data Management Center for archive and distribution. All of our "Master Event" tapes of seismic trace data from 1980-1998 have now been reformatted to the IRIS-SEED format and submitted to the IRIS Data Management Center, where they are made available through the standard request mechanisms of the IRIS data-base system.

Oregon State University (OSU) provides broad-band data for some events from stations COR and RAI. The University of Oregon (UO) provides broad-band data for some events (from stations PIN and DBO. Phase data for earthquakes in northern Washington and southern British Columbia are exchanged with the Canadian Pacific Geoscience Centre promptly for significant events. We also exchange data occasionally with the Montana Bureau of Mines, Boise State University, and CALNET. 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.

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 1999 which were reported felt. For comparison purposes, Table 3 gives information on seismic activity recorded at the PNSN annually since 1980. During this reporting period there were 20 earthquakes reported felt west of the Cascades in Washington, ranging in magnitude from 1.8 to 5.1 (body wave magnitude 5.5). No earthquakes were felt in Washington east of the Cascades. In Oregon, 10 earthquakes were reported felt.

The largest earthquake in Washington this year was a coda magnitude 5.1 (body wave magnitude 5.5) earthquake on July 3 UTC (July 2 6:43 PM PDT). It occurred at a depth of about 41 km, about 8 km north of Satsop, WA. The July 3 UTC earthquake was felt throughout most of western Washington and northwest Oregon, and in parts of southwest British Columbia, Canada.

The maximum acceleration recorded during the July 3 UTC earthquake was 8%g at Wynoochee dam. The estimated acceleration at the epicenter is 17%g. The strongest shaking corresponded to a level of about VI on the Modified Mercalli Intensity scale. Structural damage included cracked chimneys and broken windows. The three-story Grays Harbor County Courthouse, built in 1910 and located in Montesano, suffered extensive structural damage to its cupola. Interior walls were also cracked. The Montesano fire station, built around 1979, also suffered structural damage. In Aberdeen, some structural cracks of walls and beams were reported. In addition, power outages and water main breaks occurred. The wood-framed roof of a furniture store collapsed.

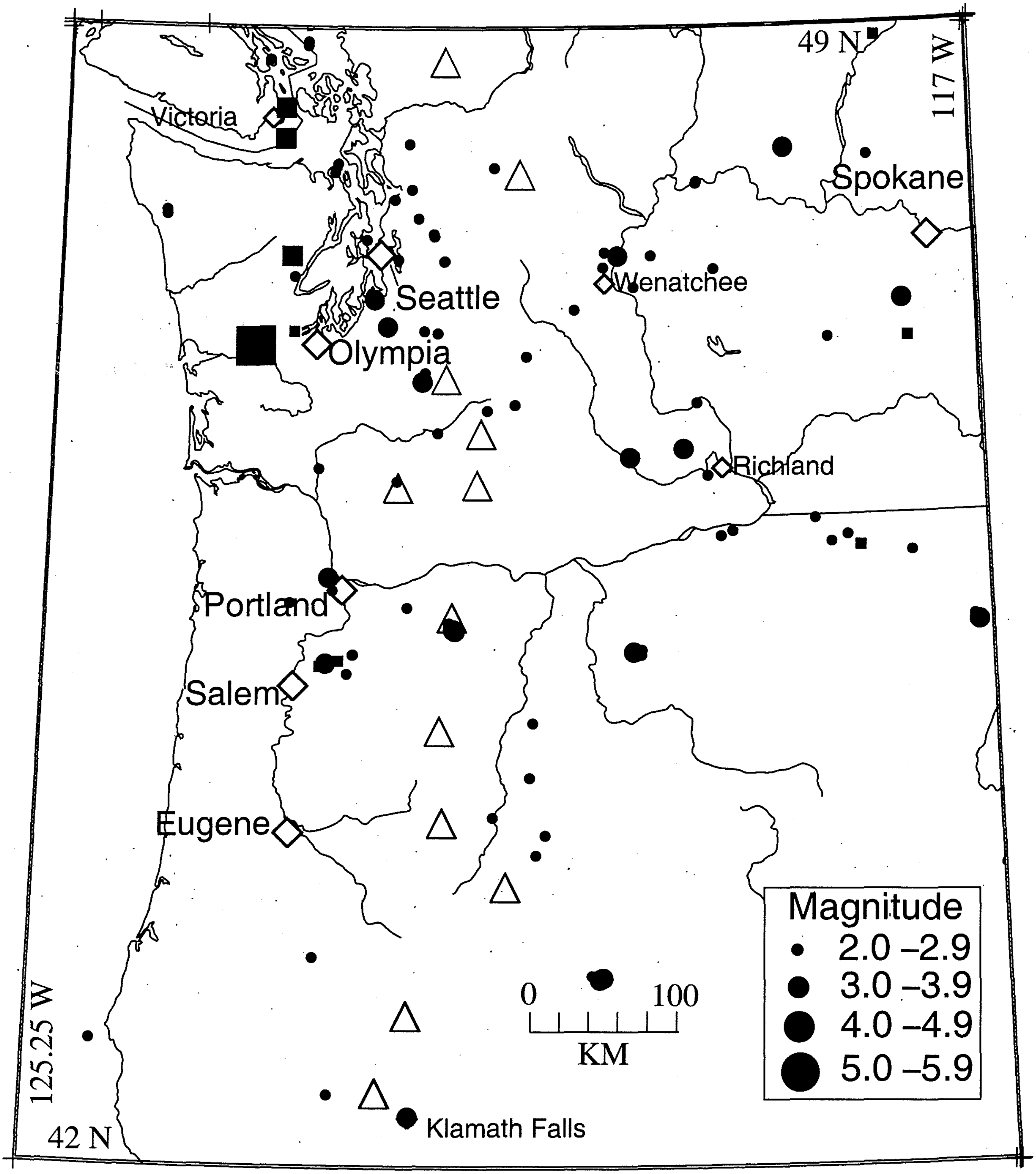

Figure 2. Earthquakes larger than magnitude 2.0 during calandar year 1999. Locations of a few cities are shown as white–filled diamonds. Earthquakes are indicated by circles or squares; circles represent earthquakes at depths shallower than 30 km, and squares represent earthquakes at 30 km or deeper. Cascade volcanic centers are represented by triangles.

TABLE 2

Felt Earthquakes during 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
99/01/04 15:10:37	47.20N	122.27W	22.2	3.2	12.5 km ESE of Tacoma, WA
99/01/11 13:48:46	45.32N	121.65W	7.5	2.5	6.5 km SSE of Mount Hood, OR
99/01/11 16:54:11	45.32N	121.65W	7.0	3.0	6.6 km SSE of Mount Hood, OR
99/01/11 22:04:14	45.31N	121.65W	6.9	3.2	7.0 km SSE of Mount Hood, OR
99/01/14 11:56:47	45.33N	121.66W	7.6	3.2	5.4 km SSE of Mount Hood, OR
99/01/14 16:13:42	45.32N	121.66W	5.9	3.0	6.2 km SSE of Mount Hood, OR
99/01/31 11:33:32	42.77N	124.68W	25.0	2.6	76.4 km SSW of Coos Bay, OR
99/02/24 16:45:17	45.13N	122.66W	35.7	2.7	14.6 km S of Canby, OR
99/03/16 13:39:49	48.48N	121.80W	0.0	1.8	7.3 km SW of Concrete, WA
99/04/03 17:29:22	48.35N	123.24W	46.3	3.1	11.4 km SE of Victoria, BC
99/04/11 00:05:37	48.19N	122.75W	20.3	2.6	39.5 km SW of Mount Vernon, WA
99/04/17 07:31:09	46.86N	121.95W	9.8	3.6	15.2 km W of Mount Rainier
99/06/29 04:51:43	48.94N	123.05W	19.6	2.7	20.6 km S of Vancouver,BC
99/06/29 13:31:46	48.91N	123.05W	20.1	2.2	23.4 km S of Vancouver,BC
99/07/02 05:22:19	47.36N	122.39W	27.1	3.1	14.9 km N of Tacoma, WA
99/07/03 01:43:54	47.07N	123.46W	40.7	5.1	8.0 km N of Satsop, WA
99/07/09 07:45:42	47.06N	123.46W	39.8	2.1	6.8 km N of Satsop, WA
99/07/16 05:58:24	45.65N	122.77W	19.7	2.3	17.7 km NW of Portland, OR
99/07/16 05:59:59	45.65N	122.77W	18.9	2.3	17.7 km NW of Portland, OR
99/07/16 21:34:03	45.64N	122.76W	18.1	3.1	17.2 km NW of Portland, OR
99/08/25 17:48:43	47.75N	121.86W	7.4	2.0	9.5 km ENE of Duvall, WA
99/09/03 07:16:18	47.50N	123.12W	0.0	2.9	38.2 km W of Bremerton, WA
99/09/05 18:01:36	47.16N	123.12W	46.5	2.8	22.3 km NW of Olympia, WA
99/09/20 11:16:54	47.60N	121.76W	16.9	2.8	10.4 km ENE of Fall City, WA
99/10/03 10:50:29	46.54N	121.81W	3.7	2.5	28.2 km W of Goat Rocks
99/11/16 20:51:16	47.86N	122.00W	19.7	2.5	2.7 km WNW of Monroe, WA
99/11/21 11:33:45	45.46N	122.07W	13.6	2.6	31.3 km WNW of Mount Hood, OR
99/11/25 14:46:15	45.11N	122.78W	28.3	3.4	6.5 km ESE of Woodburn, OR
99/11/29 04:04:15	42.31N	122.01W	7.0	3.4	22.2 km WNW of Klamath Falls, OR
99/12/11 12:53:40	48.53N	123.24W	49.2	3.7	14.4 km NNE of Victoria, BC
99/12/25 06:49:58	48.70N	125.91W	10.0	4.0	49.0 km S of Tofino, BC
99/12/25 07:01:49	48.62N	125.93W	10.0	3.2	58.3 km S of Tofino, BC

Emergency Notification

The RACE system, discussed earlier, is a pager-based alarm system that updates earthquake locations mapped on a PC screen. When a "significant" event (magnitude 2.9 or larger) is located by the PNSN automatic systems, 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.

TABLE 3
Annual counts of events recorded by the PNSN, 1980-1999

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

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 most frequently requested information is our "recent earthquakes" list of Pacific Northwest earthquakes magnitude 2.0 or larger. It can be accessed in several ways; Table 4 shows the quarterly usage of our "recent earthquakes" list. Our list is also picked up, reformatted and offered on a wide variety of other web sites, so the number of people who access this information is much larger.

TABLE 4
Accesses of PNSN "Most recent earthquakes M>=2.0" list
Quarterly Comparison

Access Method	98-A	98-B	98-C	98-D	99-A	99-B	99-C	99-D
Finger Quake	124,000	113,367	122,429	113,430	105,557	99,451	87,981	111,000
World-Wide-Web	50,000	55,600	49,000	47,400	41,700	34,000	64,000	42,000

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, including a frequently updated "recent earthquakes" message. 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 very busy one for the PNSN. We organized or participated in several very special events:

- The PNSN, along with UW Geological Sciences and the USGS co-sponsored an Urban Hazards Workshop to review the current status of a variety of geologic mapping and geophysical exploration projects which are providing detailed geologic-hazards information that can be used for land-use and code planning. The invitation-only meeting was attended by about 200 people from the scientific, government and business communities.
- The PNSN hosted the 94th Annual Meeting of the Seismological Society of America, held May 3-5 at the Seattle Center. More than 375 seismologists attended. The meeting had a special focus on current and ongoing work on the Pacific Northwest, including results from the 1998 SHIPS experiment. A special Public Forum on PNW Earthquake Hazards was attended by more than 250 scientists and members of the public.
- The PNSN organized natural hazards information fairs for two "Disaster Saturday" presentations (Sponsored by Seattle Project Impact). USGS and UW scientists working in the Puget Sound region presented their work on earthquake hazards to the public.
- The second phase of the U.S. Geological Survey's (USGS) SHIPS (Seismic Hazards in Puget Sound) active seismic experiment took place from September 20-22. This phase consisted of about 40 explosions at 33 shot-points along a 100 km long east-west line running from the Cascade foothills to the Olympic Peninsula. Seismic waves were generated by explosions in boreholes. Waves reflected from underground layers were recorded by about 1,000 seismic recorders spaced at 100 meter intervals along the same line, and also by the permanent stations of the PNSN.
- PNSN representatives continued their involvement with **CREW** (the **Cascadia Regional Earthquake Workgroup**) and **Project Impact**. Both these projects are aimed at mitigation of earthquake damage, and the PNSN role in providing information on geologic hazards is crucial to the education and mitigation effort.

Our World-Wide-Web site is an important element of our outreach, handling around 600,000 public contacts/quarter. An additional 800,000 Web-contacts/quarter are made through other earthquake-related pages hosted on the PNSN web-server; including the "CREW" Web-site, the very popular "Tsunami!" site, the "seismosurfing" page, and the "Council for the National Seismic System (CNSS)" Web-site

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 Sandra Corso handled routine data analysis and archiving of digital trace data in UW2 format. Dr. Peter Lombard worked on EARTHWORM and PNSN Y2K compliance. George Thomas worked on various projects related to strong motion instrumentation and software. Ruth Ludwin wrote reports, maintained the PNSN web-pages, and handled administrative tasks. Peter Burkholder modified SEED routines and archived data in SEED format. Oregon State University (OSU) provided broad-band data from stations COR and RAI, which is archived with PNSN trace-data files. The University of Oregon (UO) provided broad-band data from stations PIN and DBO.

QUARTERLY NETWORK REPORT 99-A
on
Seismicity of Washington and Oregon

January 1 through March 31, 1999

Pacific Northwest Seismograph Network
Geophysics Program
Box 351650
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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 1434-HQ-98-AG-01937

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 1999 from the University of Washington Geophysics Program *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon. These comprehensive quarterlies have been produced 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.

ATTENTION!! ATTENTION!! ATTENTION!!

Beginning in 1999, we have changed our quarterly listing. Earthquakes smaller than magnitude 2.0 are not listed in the printed catalog. 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.

Comments or objections should be directed to Ruth Ludwin:
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ruth@geophys.washington.edu, (206)543-4292, FAX (206)543-0489

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. Some earthquake locations may be revised if new data become available, such as P and S readings from Canadian or USGS CALNET seismograph stations. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

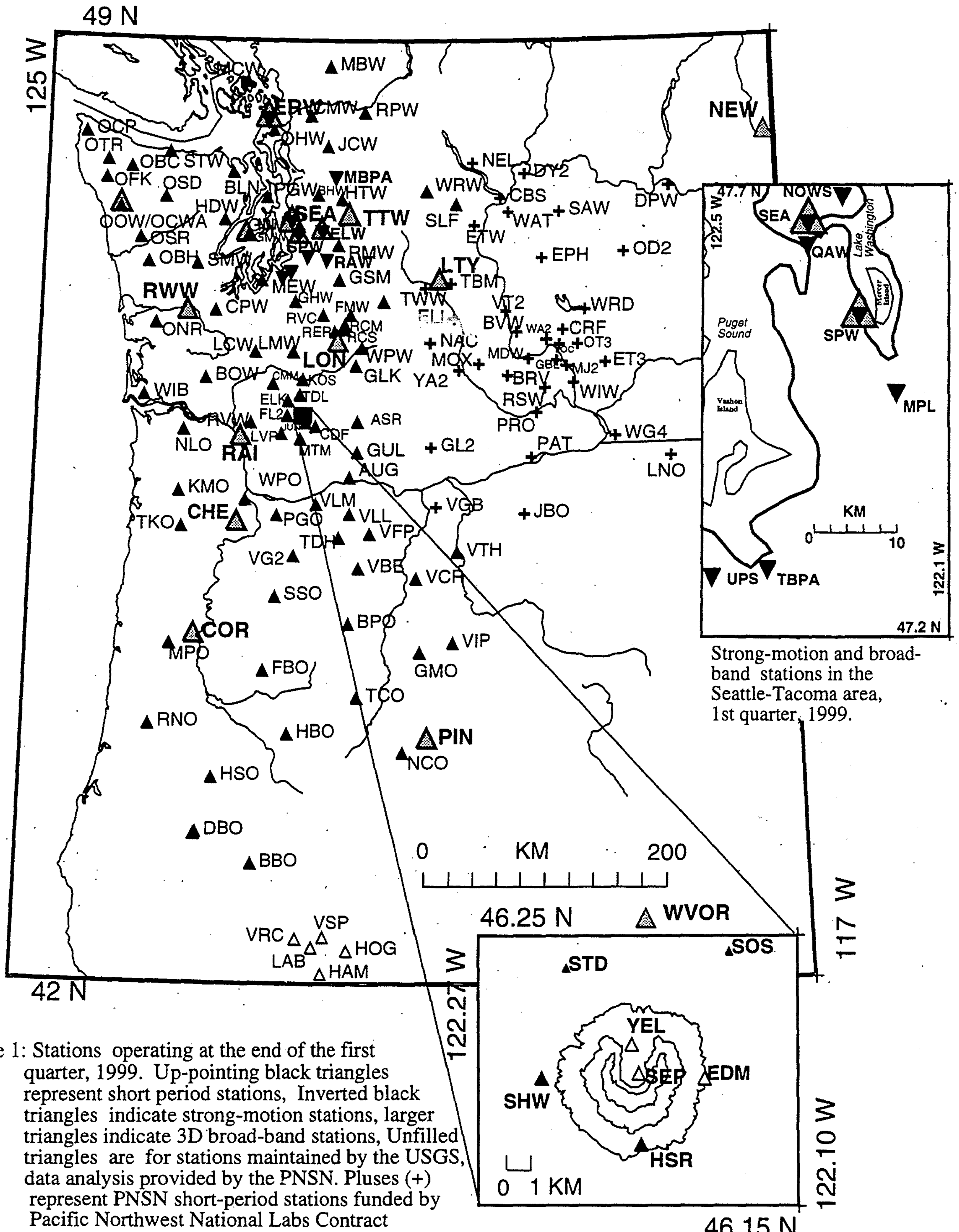
Figure 1 shows a map view of stations operating during the quarter, and Table 1 gives approximate periods of time when individual stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals and automated digital signal checks, plus records of maintenance and repair visits. During the first quarter, it is very common for stations to malfunction temporarily due to low batteries and snow-covered solar panels and antennas. Many stations are typically inaccessible due to winter conditions. This year, there is an unusually heavy snowpack, twice the normal snowpack and even more in some areas. A lot of stations were inoperative and inaccessible at the end of the first quarter. Others were out intermittently after heavy snowfalls.

Station CMM was temporarily disconnected last August so that its telemetry path could be used for a crater microphone, SND. Activity at Mt. St. Helens has been very low, and the telemetry path for SND (through YEL) failed in February. SND will be discontinued and CMM restored when access permits.

This quarter, we had several unusual operational problems:

At about 06:00 Jan. 31 (UTC), a power outage on the UW campus caused the data acquisition computers to switch over to UPS power. Our alarm setup failed, and no power-outage pager alarm was sent. The good news was that data acquisition continued uninterrupted, and power was restored about 1 hour later. Unfortunately, when power was restored, not all computers essential for completion of preliminary data processing rebooted properly, and our pager system was disabled until about 18:00 Jan. 31. When the failed computers were rebooted, the pages did go out. An earthquake (M 3.1) which would normally have triggered pages, did not page in a timely way, although the pages did, eventually go out. In addition, continuously telemetered data from one of our broadband stations, TTW, was not recorded until about 00:00 Feb. 1, due to the off-line status of the computer that records it. We are reviewing and modifying our power-failure procedures to make them more robust.

On March 10, UTC the computer that records continuous data from station TTW was inadvertently unplugged by a custodian and was off-line from 1:33 UTC to 18:18 UTC.



Strong-motion and broad-band stations in the Seattle-Tacoma area, 1st quarter, 1999.

Figure 1: Stations operating at the end of the first quarter, 1999. Up-pointing black triangles represent short period stations, Inverted black triangles indicate strong-motion stations, larger triangles indicate 3D broad-band stations, Unfilled triangles are for stations maintained by the USGS, data analysis provided by the PNSN. Pluses (+) represent PNSN short-period stations funded by Pacific Northwest National Labs Contract 259116-A-B3

The earthworm system was disfunctional from March 18 at 19:00 UTC to March 19 17:00 UTC - three events were retrieved from the SUNWORM system.

On March 19, our main source of incoming data, carrying data from around 100 stations, failed. This is a T1 data line which links the UW with the Bonneville Power Administration (BPA) microwave facility on Queen Anne Hill in Seattle. The T1 line was inoperable from 3/20 15:16 UTC to 3/22 ~21:00 UTC. The failure was caused by a scheduled power outage at the Queen Anne microwave facility. (Unfortunately, the PNSN was not on the list of folks to be informed of scheduled outages.) When the power came back on, our equipment failed due to a blown power supply on the channel router. The power supply had to be shipped, and was installed on Monday, 3/22 around 21:00 UTC. During the outage, the data recording system continued to function with the limited station array available. However, without the T1 line, the PNSN received no data from eastern Washington. The Hanford Network, operated by Battelle, provided trace data for three events that they recorded while our network was disabled.

TABLE 1
Station Outages, Repairs, and Installations 1st quarter 1999

Station	Outage Dates	Comments
BPO	3/26-End	Dead - Winter conditions
CDF	12/22-End	Dead - Winter conditions
CMM	8/11/98-end	TEMPORARILY OFF-LINE, telemetry used for SND
EDM	2/23-End	Intermittent - Winter conditions
KOS	11/3-1/4	Repaired - Replaced batteries
GHW	12/23-1/8	Repaired - Replaced receiver
GSM	11/2-End	Dead - Damaged cable
HBO	2/23-End	Intermittent - Winter conditions
HDW	1/8-End	Intermittent - Winter conditions
JUN	1/2-End	Intermittent - Winter conditions
LNO*	12/16-12/28	Back on line - improved weather conditions
LTY	12/23-2/4	Repaired - Restored reftek data recording function
OBH	3/8-3/19	Repaired - Replaced batteries
OOW	1/11-End	Dead - Winter conditions
OSD	1/19-End	Dead - Winter conditions
RCM	11/3-End	Intermittent - Low batteries
RCS	1/8-End	Dead - Winter conditions
SEP	12/22-End	Intermittent - Winter conditions
SND	2/23-End	Dead - Winter conditions
TKO	1/4-End	Dead - Winter conditions
YEL	2/23-End	Dead - Winter conditions

* Note: LNO was out last quarter, 12/16-12/28, but was not noted in the last quarterly

Strong-motion Instrumentation Update

In May of 1996 the US Geological Survey (USGS) funded the Pacific Northwest Seismograph Network (PNSN) to begin installation of some modern strong-motion instrumentation in the Puget Sound urban area. Table 2C gives locations, instrumentation, and telemetry methods used for each of the strong-motion stations currently installed. Several of the strong-motion sites also have broad-band three-component sensors.

Discussions between PNSN and BPA representatives have led to an agreement with BPA to provide space and Internet connections for a central receiving computer node in the *Ross* installation in Vancouver, WA. BPA will also provide telemetry from several sites in the Portland area to this node via their microwave system. The PNSN will provide and install the central computer equipment which will run the EARTHWORM seismic system, to collect data from up to possibly 8 strong-motion instruments and relay those data on to the PNSN site in Seattle in real-time via the Internet. Our understanding at this time is that PNSN/USGS will provide three strong-motion instruments, DOGAMI will provide two instruments and Portland Water will provide one instrument (already installed at Bull Run). Telemetry of all instruments to Ross will be by BPA micro-wave (or leased telephone from Bull Run). The EARTHWORM computer and associated electronics has been obtained and configured. The software has been installed and tested. Installation of the hub computer and a strong-motion instrument at Ross is planned for early in the next quarter.

No earthquakes this quarter were large enough near strong motion instruments to produce useful data.

EARTHWORM Installation Progress Report

EARTHWORM development this quarter included ongoing bug finding and fixing. For example, a significant bug in the trigger routine called *carl_sta_trig* was diagnosed and fixed early in the quarter and returned to the EARTHWORM team for general distribution. This bug only generated problems when there were mismatches of data time tags, but could cause serious problems under those conditions. Most other bugs were minor and of little consequence.

In cooperation with the USGS EARTHWORM team, work is progressing on Y2K compliance. A new Sun workstation was acquired early in the quarter to be used for developing and to fully test all aspects of EARTHWORM Y2K performance in the SUN SPARC station environment. All of the main EARTHWORM modules have been now upgraded to be Y2K compliant and preliminary testing (using only current time) has been done. Work is well underway to convert PNSN specific programs and routines to be Y2K compliant. These programs and routines are being installed on the new testing computer to be run completely independently of the production systems. We plan to run the full system under full stress real conditions in June and will be modifying the incoming time tags of data to simulate times after Dec 31, 1999 for full compliance testing. The University of Washington has provided extra support to fund the development and complete testing of the PNSN system for Y2K compliance.

Early in this quarter we completed our testing of the Antelope seismic monitoring system developed by Boulder Real Time Technologies, Inc. as requested by the CNSS. We got the system going on our network data using the Earthworm2orb utility and ran it for several short periods of time. The effort to get it all going was more than anticipated and the results of the tests were somewhat disappointing. For the periods that we ran it, Antelope did not perform nearly as well as earthworm and used considerable computer resources. In some respects this was not a totally fair test since there are probably tuning parameters which we did not have properly set. Without investing quite a bit more time (which we don't have) learning the system much better and how to tune it, we probably have not given it as complete a test as could be done. Thus our comparisons with EARTHWORM are not completely valid.

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 1434-HQ-98-AG-01937. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. "C" indicates USGS Cal-net stations received via EARTHWORM. 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 operating during the first quarter 1999

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 39.6	119 52 59.4	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

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
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
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
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
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
KEB	C	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	C	41 49 51.0	123 52 33.0		CAL-NET
KTR	C	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	C	41 36 35.2	122 37 32.1	1.769	CAL-NET
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
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (BB,LONLZ)
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 Center
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	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
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
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
RC1	+	46 56 42.6	119 26 39.6	0.485	Royal City
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
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
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
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens Dome
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.
SND	%	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectified
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 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
CHE		45 21 16.0	122 59 19.0	0.436	Chehalem, Oregon (Operated by UO)
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
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 (operated by UW)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire, WA (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 (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 (operated by UW)
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle (operated by UW)
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, BB = Guralp CMG-40T 3-D broadband velocity sensor. The "TELEMETRY" field indicates the type of telemetry used to recover the data. C = continuously telemetered via dedicated telephone lines, D = dial-up, I = Internet.

TABLE 2C

Strong-motion three-component stations operating at the end of the first quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	C
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	C
MBPA	%	47 53 56.6	121 53 20.2	0.186	Monroe BPA	A20	C,D
MPL	%	47 28 08.2	122 11 06.2	0.122	Maple Valley	A	C,D
NOWS	%	47 41 12.0	122 15 21.2	0.00	NOAA, Bldg 3	A20	I
QAW	%	47 37 53.2	122 21 15.0	0.140	Queen Anne	A	C
RAW	%	47 20 14.0	121 55 57.6	0.208	Raver BPA	A	C,D
SEA	%	47 39 18.0	122 18 30.0	0.030	Seattle	A,BB	C,D
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle	A,BB	C
TBPA	%	47 15 28.1	122 22 05.9	0.002	Tacoma WA BPA	A	C,D
UPS	%	47 15 56.1	122 28 58.4	0.113	U. Puget Sound	A	D,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.geophys.washington.edu/SEIS

Special Events

- PNSN Lab Coordinator Bill Steele spoke at the Kitsap County Mitigation Conference. Later in the quarter, Mr. Steele and Craig Weaver of the USGS were invited to follow-up meetings with the Kitsap County Commissioners and the Kitsap County Policy Board to discuss current research activities related to Puget Sound earthquake hazards. Kitsap County officials are very interested in projects that provide them needed hazards information.
- PNSN faculty and staff have continued to support the activities of CREW and Project Impact, and have hosted and/or participated in numerous meetings. Bill Steele led a break-out session at the CREW Annual Meeting in February and assisted Rob Johnson, the new Executive Director of CREW.
- The PNSN, along with UW Geological Sciences and the USGS co-sponsored an Urban Hazards Workshop to review the current status of a variety of geologic mapping and geophysical exploration projects which are providing detailed geologic-hazards information that can be used for land-use and code planning. The invitation-only meeting was attended by about 200 people from the scientific, government and business communities. The proceedings are being organized and edited by the Seismology Lab for publication in 2000.
- The PNSN is hosting the 94th Annual Meeting of the Seismological Society of America, scheduled for May 3-5 at the Seattle Center. Preparations began some time ago, but required more involvement during this quarter.

Press Interviews, Lab Tours, and Workshops

PNSN staff provided several television, radio, or press interviews this quarter. During the first quarter, 17 K-12 school groups and 3 post-secondary education groups toured the Seismology Lab. Presentations were made to 5 outside groups.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 800 calls this quarter. 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. This quarter we responded in person to: Emergency Management and ~ 30 calls from emergency management and government, ~ 40 calls from the media, ~ 40 calls from educators, ~ 40 calls from scientists involved in the Urban Hazards Workshop (Feb.), ~50 calls from the business community, and about 75 calls from the general public.

The list of recent Pacific Northwest earthquakes can be accessed by a variety of methods beyond the audio library described above: via our World-Wide-Web site, through the Internet with the UNIX "finger" utility, or by e-mail or modem. The computer methods have an advantage over the audio library. Not only are more earthquakes listed, but update is automated, and the location and magnitude information is available more rapidly. Table 3 shows the number of times the computerized PNSN list of recent earthquakes magnitude 2.0 or larger was accessed. The Internet UNIX utility "finger quake@geophys.washington.edu" was most popular, followed by access over the WWW. For computer users without direct access to Internet, this information can be accessed via e-mail (by sending e-mail to "quake@geophys.washington.edu").

The PNSN recent earthquake list, and much more, is also available through the World-Wide-Web (WWW) at:

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

TABLE 3
Accesses of PNSN "Most recent earthquakes M>=2.0" list
Quarterly Comparison

Access Method	97-A	97-B	97-C	97-D	98-A	98-B	98-C	98-D	99-A
Finger Quake	66,800	95,000	97,000	118,000	124,000	113,367	122,429	113,430	105,557
World-Wide-Web	15,700	27,700	37,100	34,700	50,000	55,600	49,000	47,400	41,700

Web usage of the entire suite of PNSN web pages ranged from 194,000 visits in January to 111,000 visits during March.

The PNSN web-site offers web pages for Mt. St. Helens, Mt. Hood, and Mt. Rainierthat include a map and list of the most recent PNW earthquakes, plus general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Quarterly summaries of seismicity extracted from these reports are also included.

"Webicorder" pages that allow Web visitors to view continuous data from six PNSN seismographic stations were implemented at the end of last quarter:

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

The Webicorders are real-time continuous displays, similar to our in-lab helicorder records. Each Webicorder can display (in highly compact gif format) 24 hours of continuous data from a station. New files are initiated each day at 0:00 UTC, and updated every 10 minutes throughout the day. Files from the preceding seven days are also available for viewing.

For larger earthquakes, the PNSN has a standard set of web pages that are generated automatically using preliminary information, at the same time that the initial page is sent to seismologists. Features offered include a "felt form" that readers can fill out, several maps of the regional area and immediate vicinity of the earthquake, a list of other sizable earthquakes known historically, a list of the nearest strong-motion sites, focal mechanisms, and strong motion trace-data.

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

- **Seismosurfing** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. About 14,000 visits were made to this page each month. This page is mirrored at two sites in Europe.

  http://www.geophys.washington.edu/seismosurfing.html

- The **Council of National Seismic Systems** (CNSS) site features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system. The CNSS site was visited about 39,000 times per month this quarter.

  http://www.cnss.org

- The **"Tsunami!"** web site offers many pages of information, including an excellent discussion on the physics of tsunamis, and short movie clips. **"Tsunami!"** was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering). It is very popular, with about 170,000 visits a month.

  http://www.geophys.washington.edu/tsunami

- The UW Geophysics Program **Global Positioning System (GPS)** web site provides information on geodetic studies of crustal deformation in Washington and Oregon. The GPS site received about 1,800 visits per month this quarter.

  http://www.geophys.washington.edu/GPS/gps.html

EARTHQUAKE DATA - 1999-A

There were 757 events digitally recorded and processed at the University of Washington between January 1 and March 31, 1999. Locations in Washington, Oregon, or southernmost British Columbia were determined for 474 of these events; 449 were classified as earthquakes and 25 as known or suspected blasts. The remaining 283 processed events include teleseisms (104 events), regional events outside the PNSN (61), 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 and retrieve broad-band data for some of them.

Table 4 is a listing of all earthquakes reported to have been felt during the this quarter. Table 5, located at the end of this report, is this quarter's catalog of earthquakes and blasts, 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 ($M_c \geq 0$).

TABLE 4 - Felt Earthquakes during the 1st Quarter of 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
99/01/04 15:10:37	47.20N	122.26W	22.2	3.2	12.5 km ESE of Tacoma, WA
99/01/11 13:48:46	45.31N	121.65W	7.5	2.5	6.5 km SSE of Mount Hood, OR
99/01/11 16:54:11	45.31N	121.65W	7.0	3.0	6.6 km SSE of Mount Hood, OR
99/01/11 22:04:14	45.31N	121.65W	6.9	3.2	7.0 km SSE of Mount Hood, OR
99/01/14 11:56:47	45.31N	121.66W	7.6	3.2	5.4 km SSE of Mount Hood, OR
99/01/14 16:13:42	45.31N	121.65W	5.9	3.0	6.2 km SSE of Mount Hood, OR
99/01/31 11:33:32	42.76N	124.68W	25.0	2.6	76.4 km SSW of Coos Bay, OR
99/02/24 16:45:17	45.11N	122.66W	35.7	2.7	14.6 km S of Canby, OR
99/03/16 13:39:49	48.48N	121.80W	0.0	1.8	7.3 km SW of Concrete, WA

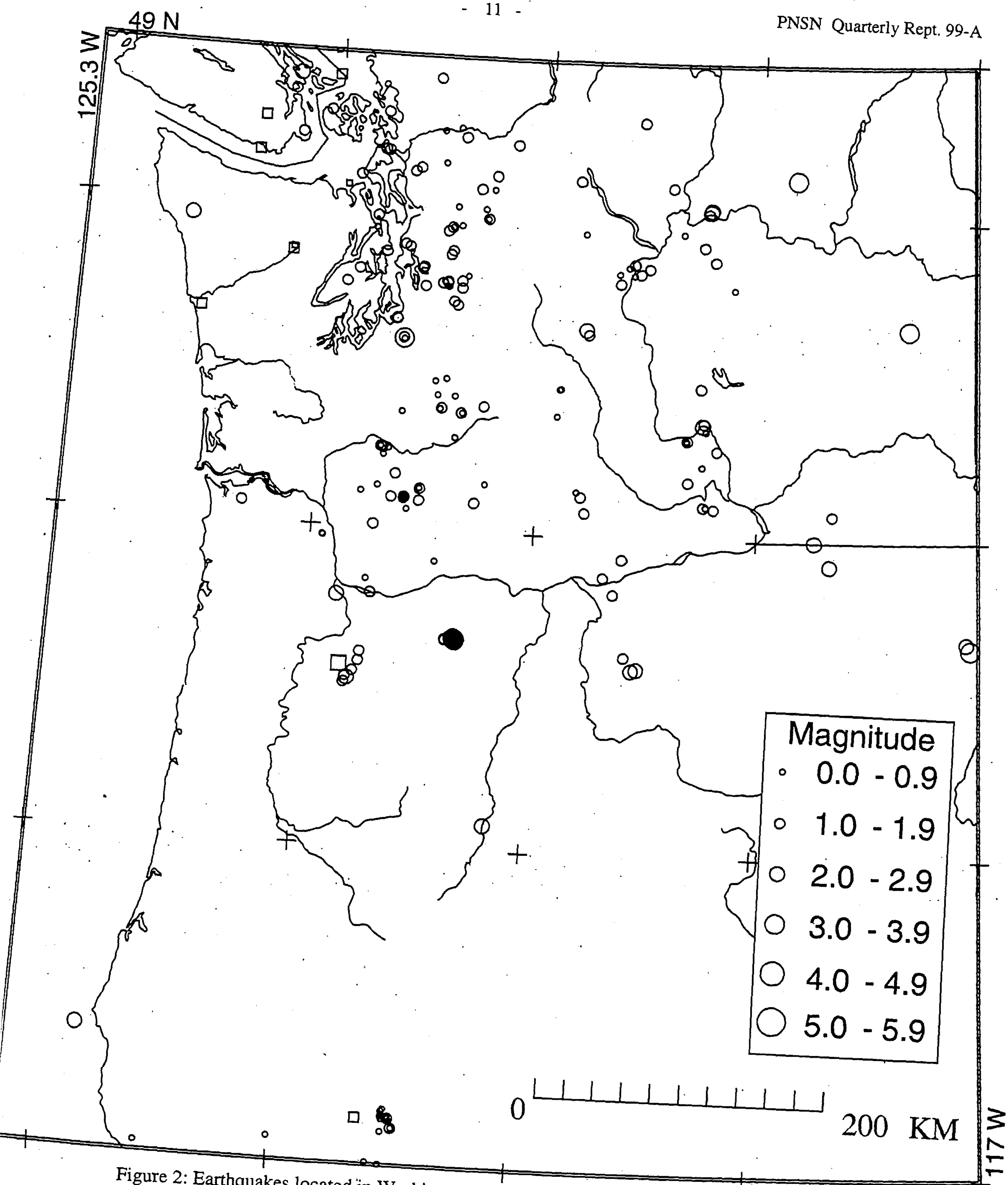


Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than or equal to 0.0 during the first quarter of 1999. Square symbols indicate events located at depths of 30 km or more.

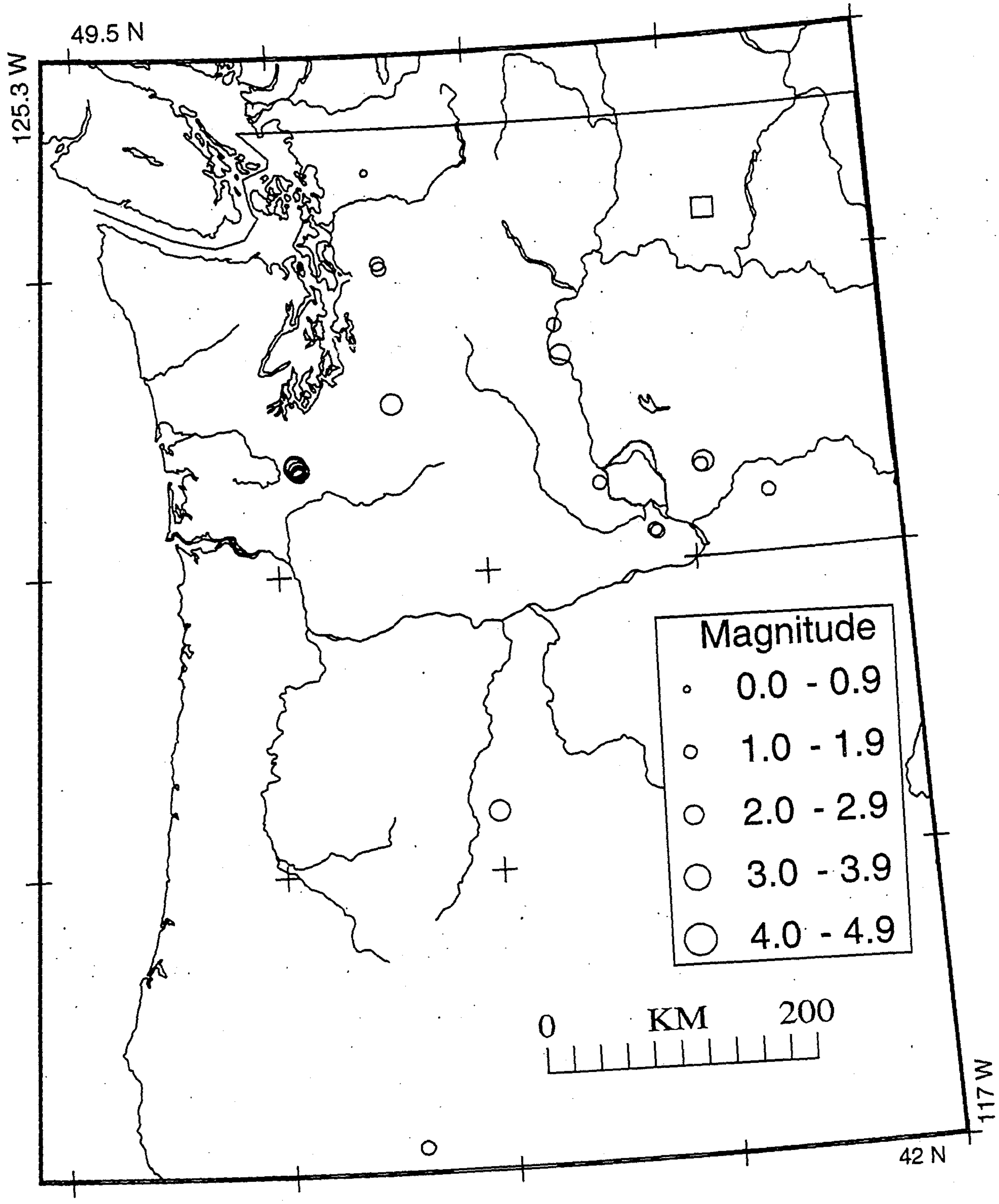


Figure 3: Blasts and probable blasts, first quarter, 1999.

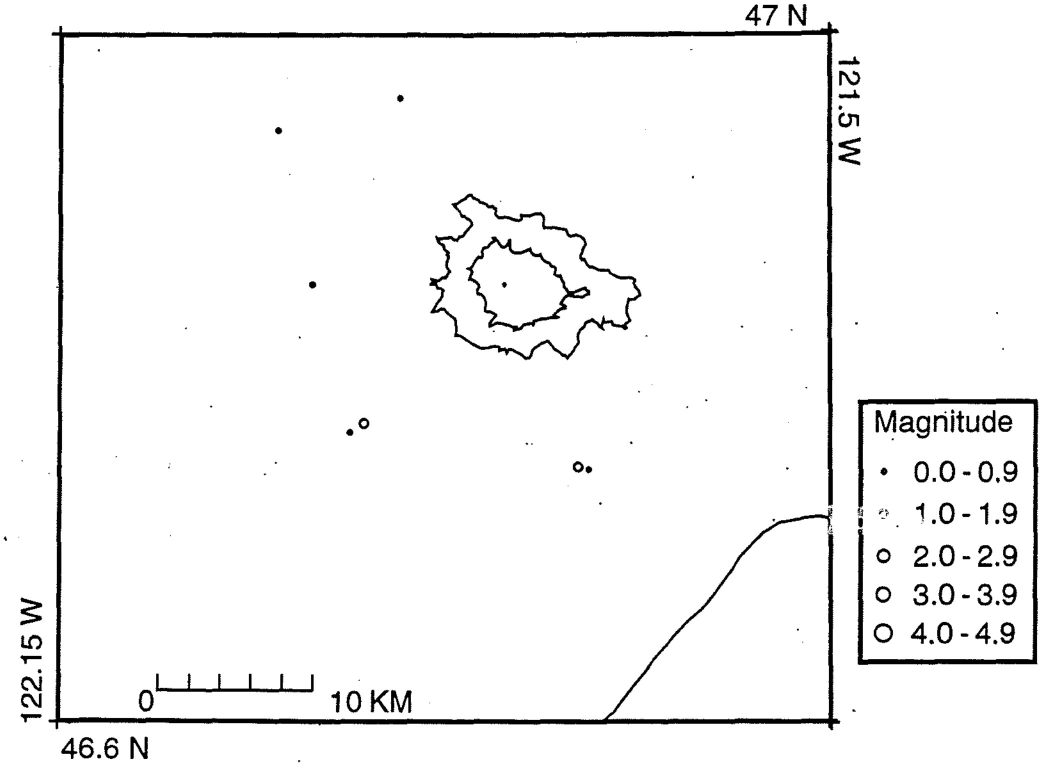


Figure 4: Earthquakes located in the Mt. Rainier area first quarter, 1999. All events shown are greater than magnitude 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper.

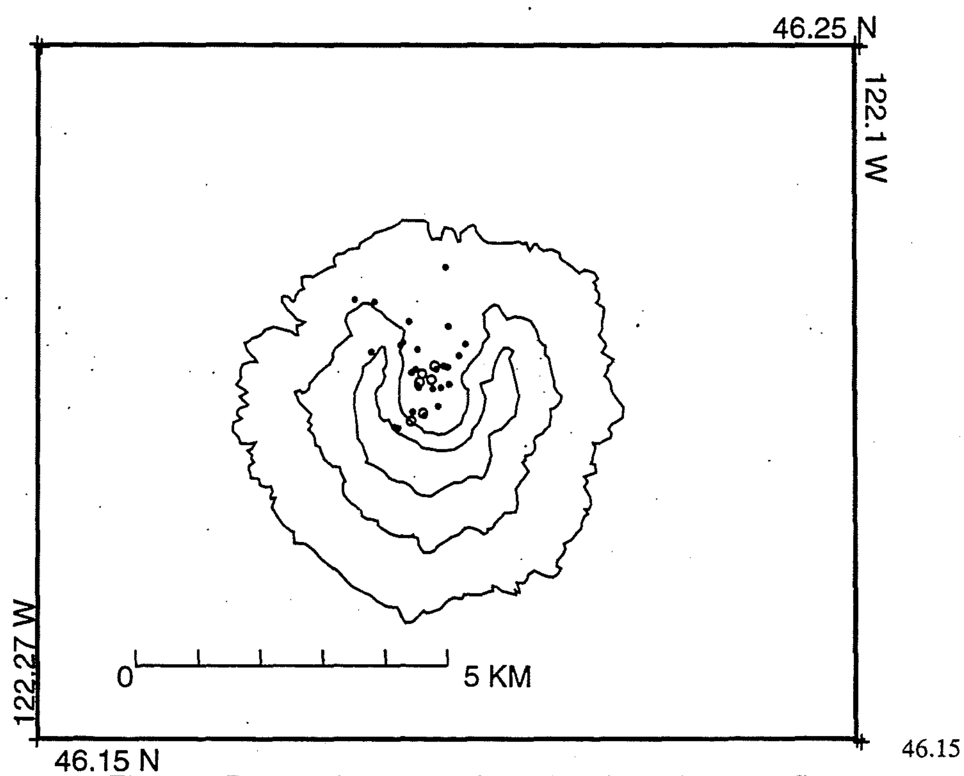


Figure 5: Earthquakes located in the Mt. St. Helens area first quarter, 1999. All events shown are greater than magnitude 0.0. Contours shown are at 5,000, 6,400 and 7,500 feet elevation. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper. Symbol scaling as in Fig. 4.

TABLE 4A Comparison of quarterly 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" and "Blasts". The remaining numbers are counts of earthquakes only 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 at Mt. St. Helens (MSH) are between 46.15-46.25 degrees north latitude and 122.10-122.27 degrees west longitude, and earthquakes near Mt. Rainier are between 46.6-47.0 degrees north latitude and 121.5-122.15 degrees west longitude. "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.

TABLE 4A Comparison of quarterly earthquake counts over several years

Year	Q	Total	Quakes	Blasts	western WA	MSH	Rainier	eastern WA	OR
1993	A	**457**	380	77	**267**	34	77	**32**	**72**
	B	**450**	384	66	**284**	63	62	**57**	**33**
	C	**727**	579	148	**368**	82	75	**65**	**141**
	D	**2616**	2556	60	**355**	82	92	**39**	**2157**
1994	A	**1585**	1501	84	**232**	43	73	**44**	**1222**
	B	**873**	775	98	**350**	60	130	**56**	**364**
	C	**822**	656	166	**379**	67	81	**62**	**208**
	D	**555**	506	49	**236**	52	44	**55**	**211**
1995	A	**488**	426	62	**273**	18	38	**47**	**101**
	B	**726**	636	90	**438**	104	91	**58**	**134**
	C	**1072**	924	148	**693**	318	84	**75**	**138**
	D	**687**	610	77	**484**	264	41	**41**	**70**
1996	A	**504**	434	70	**303**	82	56	**53**	**75**
	B	**967**	864	103	**752**	68	57	**39**	**72**
	C	**696**	544	152	**426**	83	75	**45**	**67**
	D	**476**	387	89	**312**	65	59	**45**	**29**
1997	A	**417**	353	64	**270**	49	47	**45**	**34**
	B	**525**	473	52	**386**	70	31	**65**	**21**
	C	**633**	568	65	**473**	183	45	**66**	**28**
	D	**680**	614	66	**505**	292	47	**56**	**45**
1998	A	**692**	639	53	**478**	293	35	**57**	**106**
	B	**1248**	1183	65	**1048**	776	47	**74**	**58**
	C	**1727**	1635	92	**1464**	1107	76	**84**	**86**
	D	**1373**	729	43	**620**	349	69	**60**	**49**
1999	A	**474**	449	25	**248**	122	16	**49**	**148**

OREGON SEISMICITY

During the first quarter of 1999 a total of 148 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude.

Mt. Hood Earthquake Swarm

A earthquake swarm occurred near Mt. Hood this quarter. Beginning on Jan. 11, the swarm continued vigorously through Jan. 15, including a total of 81 located events, 7 larger than magnitude 2.0. The largest event was magnitude 3.2. Most events were at depths of 4-7 km. The first-arrival focal mechanism for the largest earthquake indicates normal motion on a NW striking fault. Five of the largest events were reported felt at Timberline, Brightwood, Parkdale, and Mount Hood Meadows. Location details are given in Table 4. The Seattle USGS Office installed several portable digital seismic recording instruments during the weekend of Jan. 16-17, just after the end of the vigorous activity, and removed them about two weeks later without recording much useful data. Activity continued at a lower level through the end of the quarter - 34 additional earthquakes were located in the same area, including one larger than magnitude 2.0; a M 2.6 on Feb. 15 at 15:37 UTC.

Since 1990, Mount Hood has produced about 15 earthquake swarms similar to this quarter's. These swarms have lasted from a few hours to several days, have produced from several to tens of well-located earthquakes, have been clustered between 4 and 7 km (2.5-5 miles) south of the volcano's summit, and have generally produced maximum magnitudes between 1.6 and 3.5. Seismic data of lower quality indicate that swarms also occurred in the 1970s and 1980s. The largest recorded earthquake at Mount Hood was a magnitude 4.0 in December 1974.

All of the earthquakes in the Mount Hood swarms have characteristics similar to tectonic earthquakes rather than volcanic earthquakes (indicative of magma movement). The recent Mount Hood earthquakes most likely result from regional tectonic stresses, although they may also be caused by deep seated changes in the volcano's plumbing system.

Maps and and general information about Mount Hood may be found on the WORLD WIDE WEB at URL:

http://vulcan.wr.usgs.gov/Volcanoes/Hood/framework.html

Information about seismic activity near Mount Hood may be found at:

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

A magnitude 2.7 earthquake on Feb. 24, 1999 was rather widely felt in northern Oregon, with reports from Salem, Portland, Oregon City, Washougal and Vancouver WA. The unusual depth of this earthquake (35 km) may account for the large felt area. Although this event was located in the general vicinity of the 1993 Magnitude 5.6 Scott's Mills earthquake, the much greater depth of the Feb. 24 event suggests that it is unrelated to the Scott's Mills activity. Details on the earthquake location are included in Table 4.

In the Klamath Falls area, 21 earthquakes were located this quarter. Most earthquakes northwest of Klamath Falls are aftershocks of a pair of damaging earthquakes in September of *1993* (Sept. 21, 03:29 and 05:45 UTC; M_c 5.9 and 6.0 respectively). These earthquakes were followed by a vigorous aftershock sequence which has decreased over time.

WESTERN WASHINGTON SEISMICITY

During the first quarter of 1999, 248 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude.

This quarter, the deepest events recorded by the PNSN were not in Washington, but north of the border in British Columbia beneath Vancouver Island. A magnitude 1.7 earthquake occurred at a depth of about 53 km on March 5 at 02:36 UTC, and a magnitude 1.9 quake at a depth of about 54 km on March 21 at 19:29 UTC.

The largest earthquake in Washington this quarter was the magnitude 3.2 earthquake on Jan. 4 (see Table 4). One other earthquake was reported felt in western Washington this quarter. Details are provided in Table 4.

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). "L" and "S" type events are listed in the catalog, but not shown in Figure 4. Although no events flagged "L" or "S" events were located at Rainier this quarter, 7 "L" or "S" events there were too small to locate.

A total of 16 events (7 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, 12 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). The largest tectonic earthquake this quarter was magnitude 1.8.

This quarter, there was only one higher-frequency, tectonic-style earthquake 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 122 earthquakes were located at Mt. St. Helens in the area shown in Fig. 5. Of these 32 were magnitude 0.0 or larger and 82 were deeper than 4 km, including 21 larger than magnitude 0.0. The largest tectonic earthquake at Mount St. Helens this quarter was magnitude 1.9.

Although no type "S" or "L" events were located at Mount St. Helens, 26 "S" events too small to locate were recorded.

Mt. St. Helens activity, 1998-1999					
	98-A	98-B	98-C	98-D	99-A
Located earthquakes	**293**	**776**	**1107**	**349**	**122**
Magnitude 0 or larger	**73**	**205**	**302**	**65**	**32**
Deeper than 4 km and M>0.0	**57**	**141**	**232**	**52**	**21**
Unlocated Crater Rockfalls	**21**	**120**	**565**	**115**	**26**

EASTERN WASHINGTON SEISMICITY

During the first quarter of 1999, 49 earthquakes were located in eastern Washington in the area described in Table 4A. The largest two earthquakes recorded this quarter in eastern Washington were magnitude 3.1, and both had somewhat unusual locations. The first, on Jan. 31 at 11:05 UTC was located at 10 km depth about 44 km NNE of Grand Coulee. The second, on March 12 at 13:05 UTC was located at 6 km depth about 42 km SSW of Spokane. No foreshocks or aftershocks were recorded, and neither earthquake was reported felt to the PNSN.

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

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail or FAX 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 is 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: Northwest Interpretive

Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephone: (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** ≤ 90° and **DMIN** ≤ (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 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

Earthquakes and Blasts, Magnitude 2.0 or larger, First Quarter, 1999.

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

Jan 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
4	15:10:37.50	47 12.13	122 16.62	22.17	3.2	65/72	33	0.32	CA	P3	F
4	23:16:01.72	46 44.84	122 48.34	1.40	2.3	16/16	116	0.08	AC	P3	P
7	09:35:25.03	46 43.47	119 30.19	2.06	2.1	13/17	56	0.11	AB	E3	
7	12:25:18.74	48 04.99	119 28.65	0.47$	2.9	22/27	108	0.41	CC	N3	
7	12:26:56.76	48 04.45	119 29.01	3.28	2.7	19/25	177	0.43	CC	N3	
11	13:25:55.75	45 19.38	121 39.68	5.24	2.1	20/22	67	0.25	BC	O0	
11	13:48:46.29	45 19.47	121 39.33	7.54	2.5	36/45	66	0.42	CB	O0	F
11	16:54:11.96	45 19.39	121 39.26	7.02*	3.0	33/35	37	0.21	BB	O0	F
11	22:04:14.59	45 19.17	121 39.27	6.92	3.2	37/39	67	0.24	BB	O0	F
11	22:11:09.82	45 19.11	121 39.40	6.65	2.0	26/28	67	0.24	BB	O0	
14	11:56:47.02	45 19.82	121 40.19	7.56	3.2	32/37	63	0.33	CB	O0	F
14	16:13:42.32	45 19.45	121 39.83	5.92*	3.0	20/20	80	0.23	BB	O0	F
15	14:33:52.17	45 19.67	121 40.37	5.72	2.2	17/20	78	0.38	CB	O0	
15	23:14:40.63	46 44.22	122 49.26	6.16$	2.3	11/11	90	0.17	CB	P3	P
19	20:56:31.81	46 44.97	122 48.98	0.02*	2.2	6/06	147	0.09	AC	P3	P
21	23:50:56.01	49 14.85	123 37.01	16.71	2.6	19/28	257	0.27	BD	P3	
25	09:27:57.58	48 50.00	123 24.06	9.76$	2.6	25/33	216	0.34	CD	P3	
30	15:42:16.35	45 03.03	122 35.60	24.46	2.1	27/35	119	0.47	CB	O0	
31	11:05:57.68	48 16.72	118 40.92	10.53	3.1	17/25	242	0.61	DD	N3	
31	11:33:32.49	42 46.40	124 41.19	25.01	2.6	13/17	238	0.35	CD	O0	F

Feb 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
10	01:54:13.27	45 34.10	122 43.82	18.84	2.1	19/26	81	0.13	AA	C3	
15	15:37:07.61	45 19.17	121 39.38	7.24	2.6	26/32	71	0.38	CB	O0	
15	22:14:03.58	46 38.04	118 52.21	1.35	2.4	14/14	281	0.08	BD	E3	P
16	23:17:41.37	46 42.81	122 46.64	0.56	2.4	10/10	139	0.13	AC	P3	P
18	20:23:30.05	44 23.82	121 00.98	5.13	2.9	5/05	241	0.17	CD	O0	P
24	16:45:17.33	45 07.98	122 40.10	35.66	2.7	27/34	99	0.30	BB	O0	F
28	14:10:27.01	47 54.28	124 18.69	0.02*	2.1	12/16	147	0.54	DC	P3	

Mar 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
3	08:25:04.98	45 19.86	117 04.94	18.90	3.0	12/16	320	0.45	DD	O0	
3	08:27:14.12	45 22.13	117 07.12	18.25	2.2	4/07	331	0.23	CD	O0	
8	22:18:48.34	46 44.09	122 49.17	1.99	2.3	5/05	175	0.15	BD	P3	P
10	16:55:34.25	45 59.95	118 28.83	5.08	2.6	19/28	139	0.33	CC	E3	
11	00:13:58.58	47 08.46	121 51.27	2.51*	2.4	10/10	155	0.13	AC	C3	P
12	03:46:11.69	47 18.35	120 35.94	6.93	2.5	35/41	54	0.28	BB	N3	
12	13:05:11.46	47 20.04	117 38.45	5.68	3.1	21/34	208	0.41	CD	N3	
13	05:27:40.90	48 19.67	118 40.73	31.82$	2.0	8/09	300	0.60	DD	N3	P
15	23:21:41.36	44 09.81	121 19.03	27.67$	2.0	5/06	145	0.77	DD	O0	
16	19:59:01.11	46 42.64	122 47.06	0.02*	2.0	5/05	174	0.04	AD	P3	P
17	22:03:36.14	45 51.07	118 20.58	2.60	2.3	13/19	279	0.35	CD	E3	
21	19:43:32.10	45 10.82	120 01.94	22.54	2.9	29/41	249	0.45	CD	O0	
24	22:58:07.40	47 24.79	120 10.51	0.77	2.4	8/08	86	0.23	BC	N3	P
27	07:55:15.90	45 10.26	120 04.74	0.04*	2.0	9/09	149	0.16	BC	O0	

QUARTERLY NETWORK REPORT 99-B
on
Seismicity of Washington and Oregon

April 1 through June 30, 1999

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.

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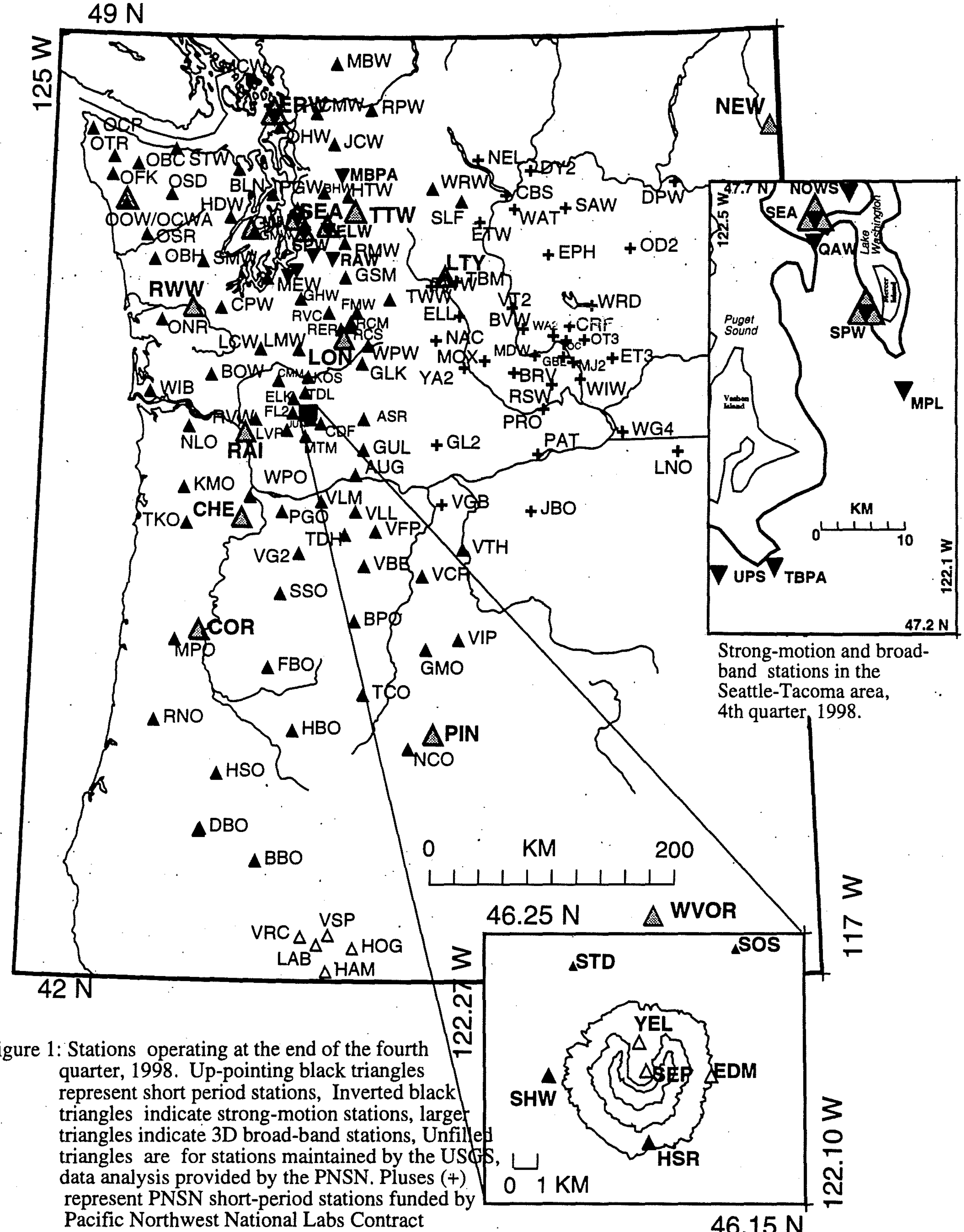

Figure 1: Stations operating at the end of the fourth quarter, 1998. Up-pointing black triangles represent short period stations, Inverted black triangles indicate strong-motion stations, larger triangles indicate 3D broad-band stations, Unfilled triangles are for stations maintained by the USGS, data analysis provided by the PNSN. Pluses (+) represent PNSN short-period stations funded by Pacific Northwest National Labs Contract 259116-A-B3

The EARTHWORM computer restarted all right, but the event triggering algorithm (carlstatrig) quit a few minutes later for unknown reasons. Because the waveserver continued to work, data loss was minimal.

TABLE 1
Station Outages, Repairs, and Installations 2nd quarter 1999

Station	Outage Dates	Comments
BPO	1/15-End	Dead - Winter conditions
CDF	12/22-4/30	Came back to life when weather improved
CMM	8/11/98-end	TEMPORARILY OFF-LINE, telemetry used for SND
CMW	1/13-end	Dead
DBO	2/1-end	Intermittent
ETW	4/2-end	Dead
EDM	2/23-4/30	Came back to life when weather improved
FL2	Feb.-end	Intermittent
GMW	9/1/98-end	Intermittent
GNW	5/21	Switched to CREST compatible equipment
GSM	11/2-5/27	Repaired Damaged cable
HAWA	6/10	NEW USNSN BB station
HBO	2/23-End	Dead - Winter conditions
HDW	1/8-End	Dead - Winter conditions
HSR	2/5-6/6	Came back to life when weather improved
JCW	5/5-End	Dead - VCO failure
JUN	1/2-5/11	Came back to life when weather improved
LCW	4/27-End	Dead
LVP	3/1-End	Dead
MBW	1/29-End	Dead
MEW	11/16/98-End	Dead - Bad Seismomter?
NLO	8/97-End	Intermittent
OCP	6/15-End	Dead
OOW	1/11-4/30	Came back to life when weather improved
OSD	7/98-End	Dead
RCM	11/3-5/28	Intermittent - Low batteries
RCM	5/28-End	Dead, bad VCO
RCS	1/8-4/29	Came back to life when weather improved
RER	1/30-End	Dead
RWW	04/18-end	Dead
SEP	12/22-4/10	Came back to life when weather improved
SPW	6/3-6/18	Cable cut by backhoe
TKO	1/4-End	Dead - Winter conditions - Then vandalized.
VLM	2/1-5/31	Came back to life when weather improved
YEL	2/23-End	Dead - Winter conditions

Emergency Preparedness

The PNSN continues to improve its ability to function following a strong earthquake in the Puget Sound Region. This quarter emergency lighting was installed in critical areas occupied by PNSN operations staff. The low wattage lamps are activated by toggling lighted switches located near entry ways and run on our uninterruptible power supply backed up by our generator. These improvements were funded by the UW College of Arts and Sciences and the Union Pacific Foundation.

Strong-motion Instrumentation Update

Last quarter, discussions between PNSN and BPA representatives led to an agreement. BPA agreed to provide space and Internet connections for a central receiving computer node in the **Dittmer** installation in Vancouver WA, and telemetry from several sites in the Portland area to the Dittmer node via the BPA microwave system. The PNSN agreed to provide and install the local computer equipment that will run the Dittmer EARTHWORM seismic system which will collect and relay data to the PNSN in real-time via the Internet.

This quarter, the PNSN acquired, configured, and tested a SUN SPARC computer for the Dittmer BPA site, and began selecting sites for the new instruments. Our understanding is that PNSN/USGS will provide three strong-motion instruments, DOGAMI will provide two instruments and Portland Water will provide one instrument (already installed at Bull Run). Telemetry of all instruments to Dittmer will be by BPA micro-wave (or leased telephone from Bull Run). The PNSN will supply strong motion information to the BPA. Installation of the hub computer and a strong-motion instrument at Dittmer is planned for early in the next quarter.

No earthquakes this quarter near strong motion instruments were large enough to produce useful data.

EARTHWORM Y2K Progress Report

In cooperation with the USGS EARTHWORM team, work has progressed on Y2K compliance. A new Sun workstation "milli", provided by the USGS last quarter, has provided an independent platform for upgrading and testing of PNSN software for the century roll-over. In addition to local EARTHWORM modules, nearly all of the PNSN data analysis and archive software needed modification. We have used this opportunity to clean out some old "cobwebs" and to improve the reliability of our systems against casualties such as power failure. By the end of the second quarter, nearly all the development work was completed and ready for testing. The University of Washington has provided extra support to fund the development and testing of the PNSN system for Y2K compliance.

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 1434-HQ-98-AG-01937. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. "C" indicates USGS Cal-net stations received via EARTHWORM. 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 operating during the second quarter 1999

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 39.6	119 52 59.4	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
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
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
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
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
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

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
KEB	C	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	C	41 49 51.0	123 52 33.0		CAL-NET
KTR	C	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	C	41 36 35.2	122 37 32.1	1.769	CAL-NET
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
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (BB,LONLZ)
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 Center
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	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
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
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
RC1	+	46 56 42.6	119 26 39.6	0.485	Royal City
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
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

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens Dome
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.
SND	%	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectified
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 second quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
CHE		45 21 16.0	122 59 19.0	0.436	Chehalem, Oregon (Operated by UO)
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
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)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire, WA (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 (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 (operated by UW)
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle (operated by UW)
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, BB = Guralp CMG-40T 3-D broadband velocity sensor. The "TELEMETRY" field indicates the type of telemetry used to recover the data. C = continuously telemetered via dedicated telephone lines, D = dial-up, I = Internet.

TABLE 2C

Strong-motion three-component stations operating at the end of the second quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	C
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	C
MBPA	%	47 53 56.6	121 53 20.2	0.186	Monroe BPA	A20	C,D
MPL	%	47 28 08.2	122 11 06.2	0.122	Maple Valley	A	C,D
NOWS	%	47 41 12.0	122 15 21.2	0.00	NOAA, Bldg 3	A20	I
QAW	%	47 37 53.2	122 21 15.0	0.140	Queen Anne	A	C
RAW	%	47 20 14.0	121 55 57.6	0.208	Raver BPA	A	C,D
SEA	%	47 39 18.0	122 18 30.0	0.030	Seattle	A,BB	C,D
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle	A,BB	C
TBPA	%	47 15 28.1	122 22 05.9	0.002	Tacoma WA BPA	A	C,D
UPS	%	47 15 56.1	122 28 58.4	0.113	U. Puget Sound	A	D,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.geophys.washington.edu/SEIS

Special Events

- The PNSN hosted the 94th Annual Meeting of the Seismological Society of America, held May 3-5 at the Seattle Center. The meeting was well attended by over 375 seismologists. Steve Malone was meeting chair, Ruth Ludwin chaired the Organizational Committee, and everyone in the UW seismology group was heavily involved. The SSA meeting had a special focus on current and ongoing work on the Pacific Northwest, including results from the 1998 SHIPS experiment. PNSN staff worked with the SSA to provide background information and set up interviews with scientists. In addition to the usual technical sessions, a special Public Forum on PNW Earthquake hazards was organized by Steve Malone and Bill Steele of the PNSN, and hosted by SSA '99 on May 3 from 7:30-9:30 pm in the largest of the meeting rooms. The Public Forum program consisted of 5 individual short presentations by scientists representing different areas of investigation. The presentations were followed by a poster viewing and individual question session in a neighboring room. We estimate that about 250 to 275 people attended the forum, near the room capacity. Besides members of the general public, there were a number of scientists without SSA or even seismological affiliation in attendance. The question session following the presentations was lively and well attended to the point it was hard to shut things down at 9:30 PM.
- At the request of the USGS, Bill Steele visited the Center for Earthquake Research and Information at the University of Memphis in Tennesee. Bill gave a presentation on PNSN Outreach activities and the Seattle Project Impact Program to the Memphis Seismic Hazard Mapping Advisory Board.
- Bill Steele participated in a number of other meetings and conferences this quarter including the "King County Emergency Management for Schools" Conference in Shoreline, where he presented an overview of regional geologic hazards and mitigation initiatives.
- The PNSN organized a natural hazards information fair for the Seattle Project Impact "Disaster Saturday" on May 10, which was attended by about 500 persons. USGS and UW scientists working in the Puget Sound region presented their work to the public.
- Some effort was expended related to the second phase of the SHIPS (Seismic Hazards in Puget Sound) active seismic experiment, which was supposed to take place in mid-May, but was rescheduled for September.

Press Interviews, Lab Tours, and Workshops

PNSN staff provided numerous television, radio, or press interviews this quarter. Press highlights included the SSA meeting (see Special Events), and the 50th Anniversary of the magnitude 7.1 1949 Olympia earthquake. During the second quarter, due to unusual time demands on Seismology Lab staff related to the SSA meeting and the SHIPS experiment that was planned for May, lab tours were curtailed. Although the spring quarter is usually our busiest for K-12 school groups, we scheduled only 10 groups for tours this quarter. In addition, 4 other groups toured the Seismology Lab.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 700 calls this quarter. 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. This quarter we responded in person to: Emergency Management and ~25 calls from emergency management and government, ~50 calls from the media, ~30 calls from educators, ~60 calls from scientists involved in the Urban Hazards Workshop (Feb.), ~60 calls from the business community, and about 100 calls from the general public.

The list of recent Pacific Northwest earthquakes can be accessed by a variety of methods beyond the audio library described above: via our World-Wide-Web site, through the Internet with the UNIX "finger" utility, or by e-mail or modem. The computer methods have an advantage over the audio library. Not only are more earthquakes listed, but update is automated, and the location and magnitude information is available more rapidly. Table 3 shows the number of times the computerized PNSN list of recent earthquakes magnitude 2.0 or larger was accessed. The Internet UNIX utility "finger quake@geophys.washington.edu" was most popular, followed by access over the WWW. For computer users without direct access to Internet, this information can be accessed via e-mail (by sending e-mail to "quake@geophys.washington.edu").

The PNSN recent earthquake list, and much more, is also available through the World-Wide-Web (WWW) at:

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

TABLE 3
Accesses of PNSN "Most recent earthquakes M>=2.0" list
Quarterly Comparison

Access Method	97-B	97-C	97-D	98-A	98-B	98-C	98-D	99-A	99-B
Finger Quake	95,000	97,000	118,000	124,000	113,367	122,429	113,430	105,557	99,451
World-Wide-Web	27,700	37,100	34,700	50,000	55,600	49,000	47,400	41,700	34,000

Web usage of the entire suite of PNSN web pages ranged from 96,392 visits in June to 112,000 visits during May.

The PNSN web-site offers web pages for Mt. St. Helens, Mt. Hood, and Mt. Rainier that include a map and list of the most recent PNW earthquakes, plus general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Quarterly summaries of seismicity extracted from these reports are also included.

"Webicorder" pages that allow Web visitors to view continuous data from six PNSN seismographic stations were implemented at the end of 1998:

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

The Webicorders are real-time continuous displays, similar to our in-lab helicorder records. Each Webicorder can display (in highly compact gif format) 24 hours of continuous data from a station. New files are initiated each day at 0:00 UTC, and updated every 10 minutes throughout the day. Files from the preceding seven days are also available for viewing.

For larger earthquakes, the PNSN has a standard set of web pages that are generated automatically using preliminary information, at the same time that the initial page is sent to seismologists. Features offered include a "felt form" that readers can fill out, several maps of the regional area and immediate vicinity of the earthquake, a list of other sizable earthquakes known historically, a list of the nearest strong-motion sites, focal mechanisms, and strong motion trace-data.

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

- **Seismosurfing** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. About 13,000 visits were made to this page each month. This page is mirrored at two sites in Europe.

  http://www.geophys.washington.edu/seismosurfing.html
- The **Council of National Seismic Systems** (CNSS) site features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system. The CNSS site was visited about 35,000 times per month this quarter.

  http://www.cnss.org
- The "**Tsunami!**" web site offers many pages of information, including an excellent discussion on the physics of tsunamis, and short movie clips. "**Tsunami!**" was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering). It is very popular, with about 170,000 visits a month.

  http://www.geophys.washington.edu/tsunami
- The UW Geophysics Program **Global Positioning System (GPS)** web site provides information on geodetic studies of crustal deformation in Washington and Oregon. The GPS site received about 1,500 visits per month this quarter.

  http://www.geophys.washington.edu/GPS/gps.html

EARTHQUAKE DATA - 1999-B

There were 776 events digitally recorded and processed at the University of Washington between April 1 and June 30, 1999. Locations in Washington, Oregon, or southernmost British Columbia were determined for 469 of these events; 407 were classified as earthquakes and 62 as known or suspected blasts. The remaining 307 processed events include teleseisms (120 events), regional events outside the PNSN (78), 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 and retrieve broad-band data for some of them.

Table 4 is a listing of all earthquakes reported to have been felt during the this quarter. Table 5, located at the end of this report, is this quarter's catalog of earthquakes and blasts, 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 ($M_c \geq 0$).

TABLE 4 - Felt Earthquakes during the 2nd Quarter of 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
99/04/03 17:29:22	48.35N	123.23W	46.3	3.1	11.4 km SE of Victoria, BC
99/04/11 00:05:37	48.18N	122.75W	20.3	2.6	39.5 km SW of Mount Vernon, WA
99/04/17 07:31:09	46.85N	121.95W	9.8	3.6	15.2 km W of Mount Rainier
99/06/29 04:51:43	48.93N	123.05W	19.6	2.7	20.6 km S of Vancouver,BC
99/06/29 13:31:46	48.91N	123.05W	19.6	2.2	23.6 km S of Vancouver,BC

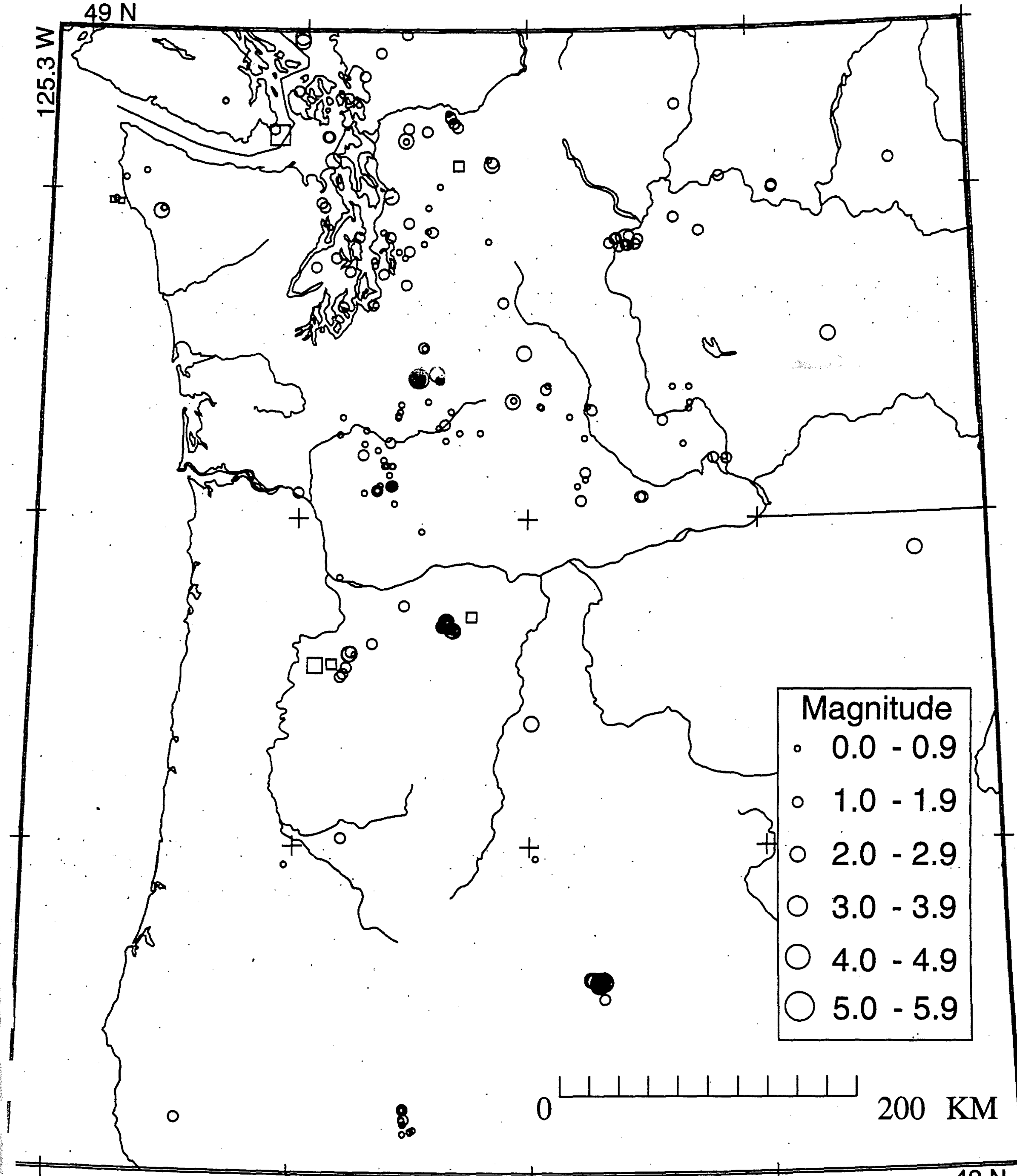

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than or equal to 0.0 during the second quarter of 1999. Square symbols indicate events located at depths of 30 km or more.

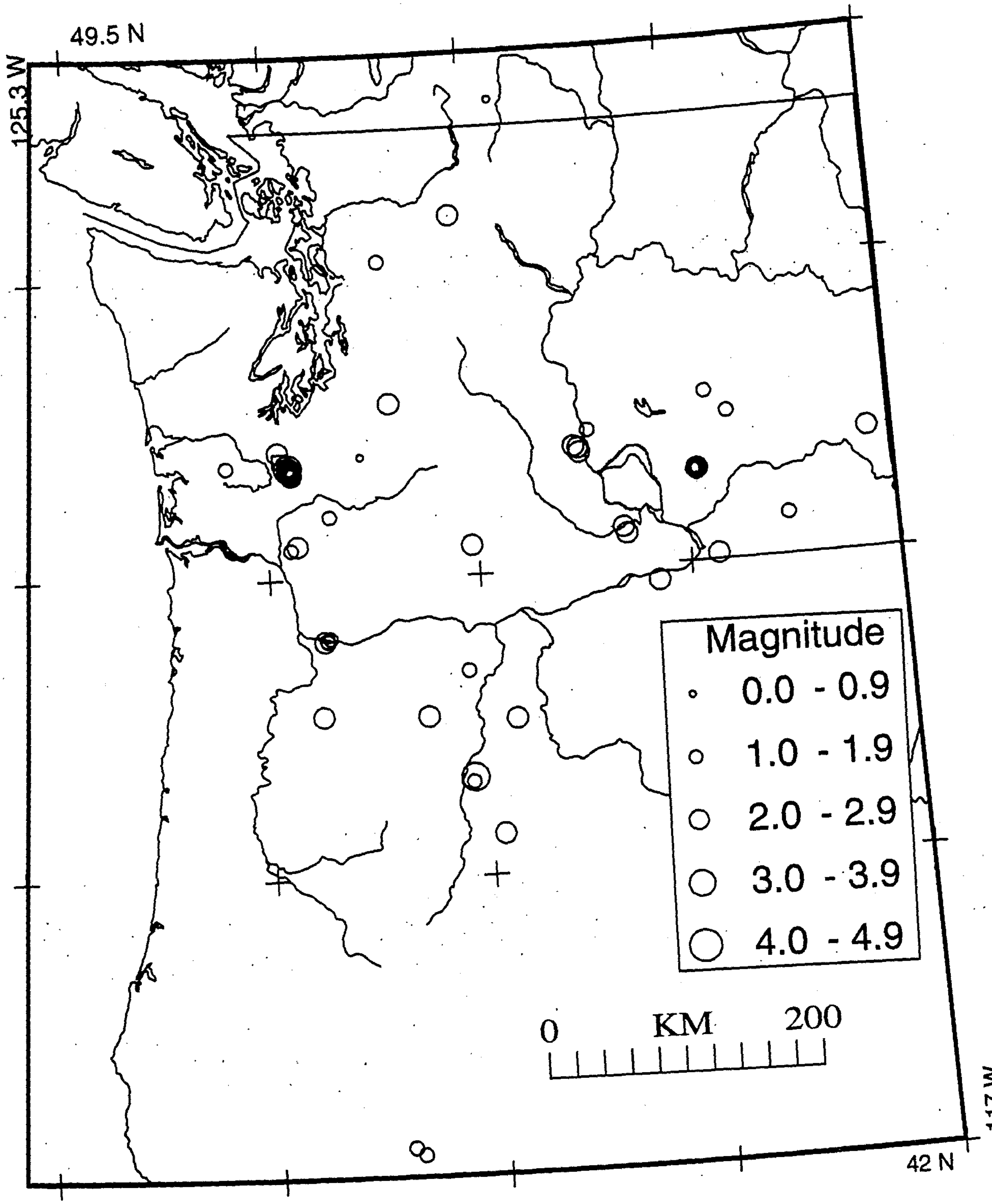

Figure 3: Blasts and probable blasts, second quarter, 1999.

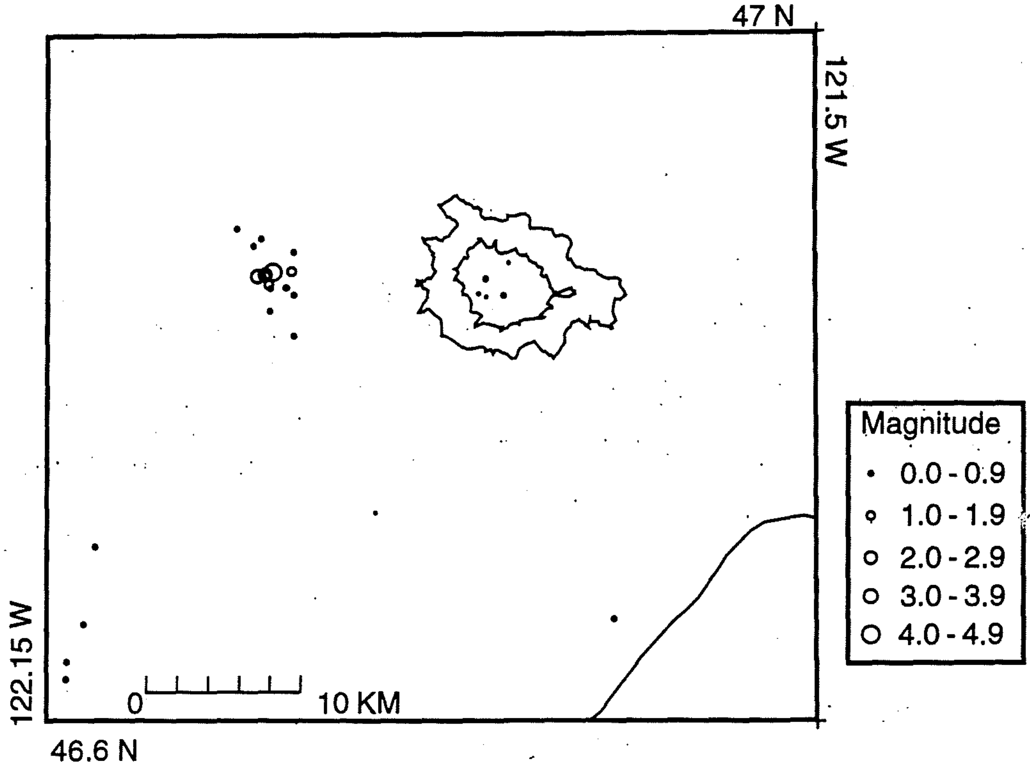

Figure 4: Earthquakes located in the Mt. Rainier area second quarter, 1999. All events shown are greater than magnitude 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper.

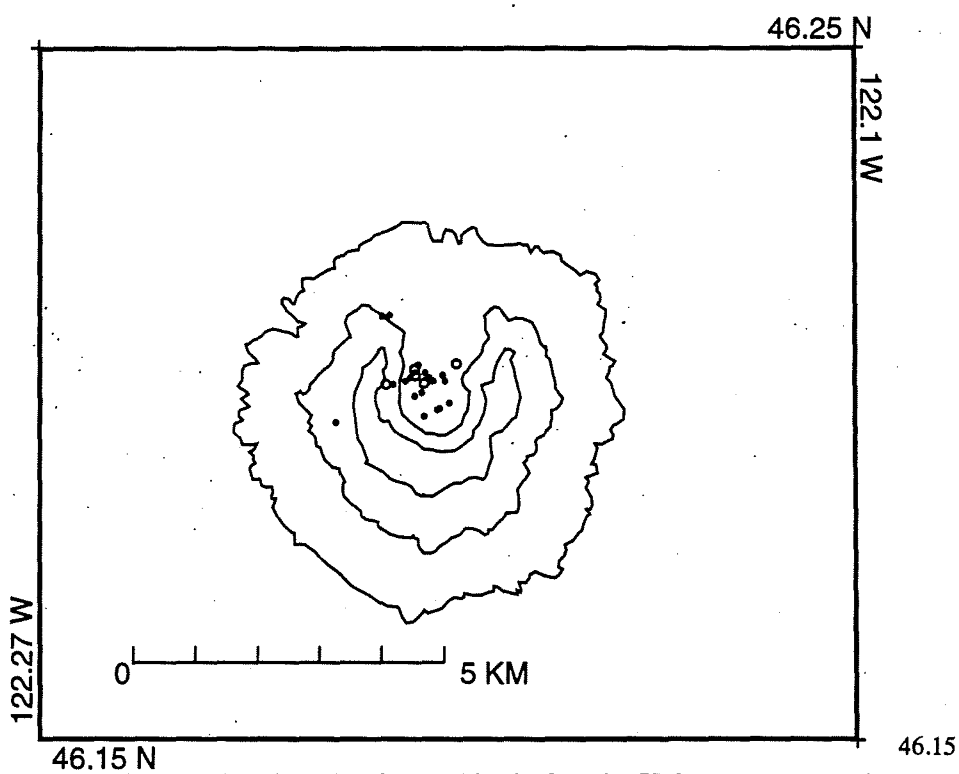

Figure 5: Earthquakes located in the Mt. St. Helens area second quarter, 1999. All events shown are greater than magnitude 0.0. Contours shown are at 5,000, 6,400 and 7,500 feet elevation. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper. Symbol scaling as in Fig. 4.

TABLE 4A 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" and "Blasts". The remaining numbers are counts of earthquakes only 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 at Mt. St. Helens (MSH) are between 46.15-46.25 degrees north latitude and 122.10-122.27 degrees west longitude, and earthquakes near Mt. Rainier are between 46.6-47.0 degrees north latitude and 121.5-122.15 degrees west longitude. "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.

TABLE 4A Comparison of quarterly earthquake counts over several years

Year	Q	Total	Quakes	Blasts	western WA	MSH	Rainier	eastern WA	OR
1993	A	457	380	77	267	34	77	32	72
	B	450	384	66	284	63	62	57	33
	C	727	579	148	368	82	75	65	141
	D	2616	2556	60	355	82	92	39	2157
1994	A	1585	1501	84	232	43	73	44	1222
	B	873	775	98	350	60	130	56	364
	C	822	656	166	379	67	81	62	208
	D	555	506	49	236	52	44	55	211
1995	A	488	426	62	273	18	38	47	101
	B	726	636	90	438	104	91	58	134
	C	1072	924	148	693	318	84	75	138
	D	687	610	77	484	264	41	41	70
1996	A	504	434	70	303	82	56	53	75
	B	967	864	103	752	68	57	39	72
	C	696	544	152	426	83	75	45	67
	D	476	387	89	312	65	59	45	29
1997	A	417	353	64	270	49	47	45	34
	B	525	473	52	386	70	31	65	21
	C	633	568	65	473	183	45	66	28
	D	680	614	66	505	292	47	56	45
1998	A	692	639	53	478	293	35	57	106
	B	1248	1183	65	1048	776	47	74	58
	C	1727	1635	92	1464	1107	76	84	86
	D	1373	729	43	620	349	69	60	49
1999	A	474	449	25	248	122	16	49	148
	B	469	407	62	277	134	31	45	84

OREGON SEISMICITY

During the second quarter of 1999 a total of 84 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. Activity this quarter included an unusually deep crustal event (magnitude 1.6) at 13:30 UTC on May 20. It was located about 14 km east-south-east of Woodburn at a depth of about 32 km.

A swarm of 31 earthquakes, ranging in magnitude from 1.5 to 3.8 were located about 20 km east south-east of Christmas Valley, Oregon. Estimated depths are around 20 km. Because these earthquakes lie at the edge of the PNSN network, their locations and depths are not very well constrained. The largest event in the cluster, magnitude 3.8, occurred on April 28 at 08:06 UTC. The

Christmas Valley area is rural, and these earthquakes were not reported to have been felt. In addition to the 3.8 earthquake there were two magnitude 3.0 earthquakes. Near Christmas Valley, there is an interesting geologic feature called "Crack-in-the-Ground", which consists of a NNW to SSE oriented two-mile-long tension fracture in basalt. The width of the crack varies from 10 to 15 feet, and the depth is as great as 70 feet in some parts. "Crack-in-the-Ground" appears to have been caused by normal faulting in the strata underlying the basalt. (The Ore Bin, V. 26, No. 9, pp. 158-166.). The focal mechanism for the largest of this quarter's shocks is consistent with this interpretation - it shows normal faulting on NNW-SSE striking planes.

In the Klamath Falls area, 14 earthquakes were located this quarter. Most earthquakes northwest of Klamath Falls are aftershocks of a pair of damaging earthquakes in September of *1993* (Sept. 21, 03:29 and 05:45 UTC; M_c 5.9 and 6.0 respectively). These earthquakes were followed by a vigorous aftershock sequence which has decreased over time.

WESTERN WASHINGTON SEISMICITY

During the second quarter of 1999, 277 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude.

This quarter, the deepest event recorded by the PNSN was a magnitude 1.0 earthquake at about 77 km depth. It occurred on June 12 at 13:44 UTC, about 9 km south of Darrington, WA. This location is about 50 km north of the area near Hyak where such deep events are most frequently located.

The largest earthquake in Washington this quarter was a magnitude 3.6 earthquake on April 17, located in the "Western Rainier Seismic Zone" (WRSZ). It was felt in Randle and Ashford, WA. Four other earthquakes were felt in western Washington or southern British Columbia this quarter. Three of them were actually closer to Canada than to the US. Details are provided in Table 4.

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). "L" and "S" type events are listed in the catalog, but not shown in Figure 4. Although no events flagged "L" or "S" events were located at Mount Rainier this quarter, 22 "L" or "S" events there were recorded, but were too small to locate reliably.

A total of 31 events (three 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, 18 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). The largest tectonic earthquake near Mt. Rainier this quarter was the 3.6 April 17 earthquake discussed above. See Table 4 for details.

This quarter, there were 6 higher-frequency tectonic-style earthquake 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 134 earthquakes were located at Mt. St. Helens in the area shown in Fig. 5. Of these 25 were magnitude 0.0 or larger and 71 were deeper than 4 km, including 10 larger than magnitude 0.0. The largest tectonic earthquake at Mount St. Helens this quarter was magnitude 1.5.

One type "S" or "L" event was located at Mount St. Helens, and 28 "S" events too small to locate were recorded.

Mt. St. Helens activity, 1998-1999						
	98-A	98-B	98-C	98-D	99-A	99-B
Located earthquakes	**293**	**776**	**1107**	**349**	**122**	**133**
Magnitude 0 or larger	**73**	**205**	**302**	**65**	**32**	**25**
Deeper than 4 km and M>0.0	**57**	**141**	**232**	**52**	**21**	**10**
Unlocated Crater Rockfalls	**21**	**120**	**565**	**115**	**26**	**28**

EASTERN WASHINGTON SEISMICITY

During the second quarter of 1999, 45 earthquakes were located in eastern Washington in the area described in Table 4A. The largest was a magnitude 2.6 earthquake on June 16 at a depth of about 2 km which located near Ritzville, WA in an area where seismicity is rare.

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

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail or FAX 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 is 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: Northwest Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephone: (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** $\leq 90°$ 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 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

Earthquakes and Blasts, Magnitude 2.0 or larger, Second Quarter, 1999.
Within an area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Apr 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	00:24:42.16	48 24.66	121 08.73	0.03*	2.5	5/05	203	1.98	DD	C3	P
2	22:42:13.68	46 44.90	122 48.62	0.86	2.6	8/08	122	0.10	AC	P3	P
3	17:29:22.34	48 21.02	123 14.62	46.28	3.1	29/30	68	0.16	BA	P3	F
7	22:18:11.59	45 04.84	122 31.84	3.42	2.2	7/08	141	0.23	BC	O0	P
8	00:15:35.08	46 13.11	119 35.69	0.04*	2.0	8/09	152	0.29	BC	E3	P
8	22:30:42.78	46 44.87	122 48.48	1.75	2.6	13/13	122	0.11	AC	P3	P
11	00:05:37.87	48 11.97	122 45.28	20.34	2.6	24/27	64	0.14	AB	P3	F
11	20:59:52.99	43 10.71	120 24.30	24.43	2.0	9/11	232	0.31	CD	O0	
11	21:58:41.42	43 11.05	120 28.68	26.44	2.4	11/12	225	0.44	CD	O0	
13	19:27:45.84	46 15.88	119 37.29	0.04*	2.2	10/10	138	0.41	CC	E3	P
15	18:12:35.04	46 45.03	122 48.29	1.74	3.2	11/11	116	0.11	AC	P3	P
16	21:57:33.94	46 44.58	122 47.34	5.50	2.4	13/13	66	0.21	BB	P3	P
17	00:07:51.79	46 37.00	118 53.44	2.70	2.3	7/07	210	0.08	AD	E3	P
17	07:31:09.86	46 51.77	121 57.50	9.77	3.6	36/37	53	0.18	BA	C3	F
17	19:56:03.96	45 05.90	122 50.04	30.93*	2.8	31/36	98	0.23	BB	O0	
17	21:23:40.14	46 48.43	117 14.36	5.91	2.4	18/23	214	0.40	CD	E3	P
20	21:45:14.57	46 45.11	122 48.60	1.14*	2.0	15/15	109	0.18	BC	P3	P
21	10:58:31.62	43 10.68	120 27.32	24.45	2.3	11/15	234	0.46	CD	O0	
21	22:02:23.96	46 42.48	122 46.43	2.20	2.0	16/16	105	0.32	CB	P3	P
23	03:11:24.73	45 10.20	122 32.78	23.17	2.1	23/24	135	0.34	CB	O0	
24	17:33:15.22	46 02.32	118 44.44	0.03*	2.3	11/11	134	0.36	CB	E3	P
27	12:33:17.70	46 51.67	121 57.89	10.36	2.3	27/33	61	0.10	AA	C3	
27	23:04:57.19	43 09.66	120 24.67	16.54	3.0	12/15	122	0.28	BD	O0	
28	08:06:16.04	43 10.24	120 22.93	24.01	3.8	13/16	123	0.35	CD	O0	
28	08:59:59.93	43 10.39	120 23.42	26.17	2.1	9/12	126	0.20	BD	O0	
28	11:56:35.01	43 10.07	120 23.47	24.18	3.0	12/14	123	0.43	CD	O0	
28	12:34:50.73	43 09.93	120 23.98	22.76*	2.5	12/13	126	0.52	DD	O0	
28	14:09:29.09	43 09.93	120 24.15	25.63	2.2	7/10	126	0.18	BD	O0	
28	21:23:14.68	46 44.73	122 48.56	6.67$	2.4	9/09	88	0.13	BC	P3	P
29	21:09:45.50	48 10.57	121 19.14	1.56	2.6	30/37	124	0.36	CC	C3	

May 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	13:45:36.45	43 09.98	120 24.29	20.44	2.5	13/16	125	0.28	BD	O0	
6	09:11:42.65	43 09.61	120 24.13	19.31	2.9	12/15	125	0.46	CD	O0	
6	09:22:23.83	43 09.33	120 24.36	8.30	2.0	6/08	125	0.21	BD	O0	
6	11:32:58.70	43 09.82	120 23.77	23.33	2.1	9/10	126	0.31	CD	O0	
6	20:49:22.40	46 45.05	122 48.19	7.11#	2.3	16/16	109	0.13	AC	P3	P
7	08:01:35.72	43 09.29	120 23.63	20.97	2.1	9/10	233	0.13	AD	O0	
7	20:39:21.14	45 03.89	121 33.07	2.45	2.4	4/04	157	0.00	AD	O0	P
8	21:13:27.38	47 59.00	122 13.47	23.69*	2.0	30/39	75	0.19	BA	P3	
9	06:02:54.57	43 09.78	120 23.89	8.93	2.0	11/14	126	0.19	BD	O0	
9	07:49:39.53	46 51.61	121 58.28	8.38	2.1	32/45	53	0.19	BB	C3	
10	07:24:23.88	46 53.50	121 47.85	0.02#	2.0	5/05	236	2.53	DD	C3	L
10	22:22:49.62	44 39.12	121 08.86	0.03*	3.0	12/12	115	0.19	BC	O0	P
11	20:44:05.80	46 48.48	120 00.51	1.03	2.1	6/06	148	0.38	CC	E3	P
12	20:43:58.67	46 45.16	122 48.11	6.60$	2.2	9/09	169	0.20	CC	P3	P
13	05:22:01.04	45 46.89	117 38.28	0.02*	2.3	13/15	322	0.44	CD	E3	
14	20:09:07.13	46 46.71	120 00.10	0.03*	2.3	15/15	75	0.40	CB	E3	P
18	21:22:09.71	46 42.43	122 46.80	9.12	2.2	9/09	140	0.13	AC	P3	P
19	23:59:53.81	47 01.14	121 01.70	1.14	2.2	41/49	56	0.23	BC	C3	
21	11:00:52.50	47 52.79	124 18.51	26.28	2.3	14/20	161	0.36	CC	P3	
23	06:31:17.38	43 09.83	120 24.24	24.56	2.4	13/16	122	0.49	CD	O0	
24	21:06:35.07	45 53.44	119 18.96	0.02*	2.2	13/13	128	0.26	BC	E3	P
27	22:05:01.48	44 16.17	120 53.65	0.04*	2.9	11/11	138	0.14	AC	O0	P
28	22:19:21.09	46 49.25	120 03.15	1.87	2.1	16/16	90	0.22	BC	E3	P
29	11:34:13.37	46 43.28	121 07.75	2.39	2.0	39/49	57	0.22	BC	C3	

June 1999 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	13:14:07.86	45 22.21	121 42.30	4.96	2.0	22/26	66	0.25	BC	O0	
1	13:25:08.13	45 21.82	121 42.55	5.50	2.2	30/34	53	0.33	CB	O0	
3	19:24:33.51	44 44.97	120 58.67	0.02*	2.7	7/07	136	0.26	BC	O0	
4	12:07:53.53	45 10.24	122 32.34	22.59	2.1	27/31	77	0.32	CA	O0	
8	21:15:10.00	46 43.41	122 48.07	0.62$	2.3	11/11	283	0.24	CD	P3	P
10	19:36:20.86	43 10.37	120 25.49	25.12	2.2	11/14	125	0.18	BD	O0	
10	21:42:58.51	45 01.77	120 43.59	0.02*	2.3	4/04	133	0.19	BD	O0	P
10	21:49:44.62	43 10.95	120 27.51	24.19	2.0	8/09	229	0.15	BD	O0	
14	23:39:18.74	47 09.95	121 48.55	0.04*	2.3	5/05	111	0.09	AD	C3	P
15	21:57:11.75	45 34.90	122 29.81	4.36	2.2	6/06	253	0.18	DD	C3	P
16	12:39:44.97	47 06.65	118 19.46	1.73*	2.6	11/11	212	1.19	DD	N3	
18	11:29:35.01	45 18.88	121 38.79	6.77*	2.1	25/26	60	0.25	BB	O0	
18	20:26:38.06	46 11.78	121 04.09	0.05*	2.1	6/06	149	0.24	BC	C3	P
18	23:43:14.34	46 13.61	122 43.74	0.03*	2.1	8/08	208	0.04	AD	C3	P
21	02:18:55.87	45 19.18	121 39.73	5.80	2.0	23/28	62	0.23	BB	O0	
26	21:01:54.35	48 19.38	122 05.78	7.88	2.2	26/33	126	0.27	BC	P3	
28	22:09:35.42	46 42.04	122 46.54	5.19*	2.5	9/09	114	0.15	AC	P3	P
29	04:51:43.17	48 56.71	123 03.17	19.61	2.7	17/18	251	0.16	BD	P3	F
29	13:31:46.93	48 55.10	123 03.17	19.61$	2.2	17/20	248	0.19	BD	P3	F
30	22:00:18.61	46 51.47	122 54.11	10.34	2.3	11/11	233	0.75	DD	R0	P

QUARTERLY NETWORK REPORT 99-C
on
Seismicity of Washington and Oregon

July 1 through September 30, 1999

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 third quarterly report of 1999 from the University of Washington Geophysics Program *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon. This quarter was exceptionally busy, due to significant earthquakes both locally and globally, extensive field operations, Y2K software upgrades, and personnel changes.

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. Some earthquake locations may be revised if new data become available, such as P and S readings from Canadian or USGS CALNET seismograph stations. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1 shows a map view of stations operating during the quarter, and 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. The third quarter is typically our heaviest season for field work. This year was no exception. In fact, an unusually high number of stations were damaged by snow, ice, and storms last winter and many stations required extensive repairs.

This quarter, station RWW was upgraded to meet USGS/NOAA CREST (Consolidated Reporting of EarthquakeS and Tsunamis) standards. However the telemetry, which uses a leased-line modem and PPP data transfer protocol, was still unreliable. By the end of the quarter the problems had been mostly solved.

A new station, RSU, was installed at the summit of Mt. Rainier on August 20, 1999. The installation was coordinated by PhD candidate Jeff Johnson. This installation was one of the most demanding field operations ever conducted by the PNSN. The high altitude and weather variability challenged the climbing skills and endurance of the participants. On August 17th thirteen volunteers carried 5 air cell batteries, the antenna, antenna mast, VCO, transmitter and supplies from Paradise parking lot (5,000') to Camp Muir (10,118'). Over the next two days, Jeff Johnson and seven of the volunteers carried the equipment from Camp Muir to the summit (14410'). Cell-phone contact difficulties occurred during the initial installation, and an additional trip to the summit was made on August 25th in order to fix a minor glitch which had prevented the station from working.

Three new strong-motion stations, ROSS, KEEL, and ALST were installed in the Portland area. The installation is discussed in more detail in the Strong Motion section of this Report.

Station CMM was restored on August 4. It had been temporarily disconnected in August of 1998 so that its telemetry path could be used for a crater microphone, SND. Lightning strikes on August 5 caused loss of communications with stations ERW, BLN, and STW. On the same day, station LMW was vandalized. The building housing LMW was reinforced and replacement components were installed. Station YEL was mistakenly listed in the previous quarterly report as being broken. It was, and is, operational.

RACE Update

The RACE (Rapid Alert for Cascadia Earthquake) system is a pager-PC combination designed to provide rapid earthquake location and magnitude information to emergency managers and others. RACE is based on the CalTech CUBE system. This quarter, five new PC's were acquired and their pagers have been programmed. These RACE machines are ready to be installed. An additional machine was installed at Washington Emergency Management, and is awaiting hook-up of an external antenna to receive the pager signal. Student Helper Dan Forshee has developed a manual on the manufacture and troubleshooting of a

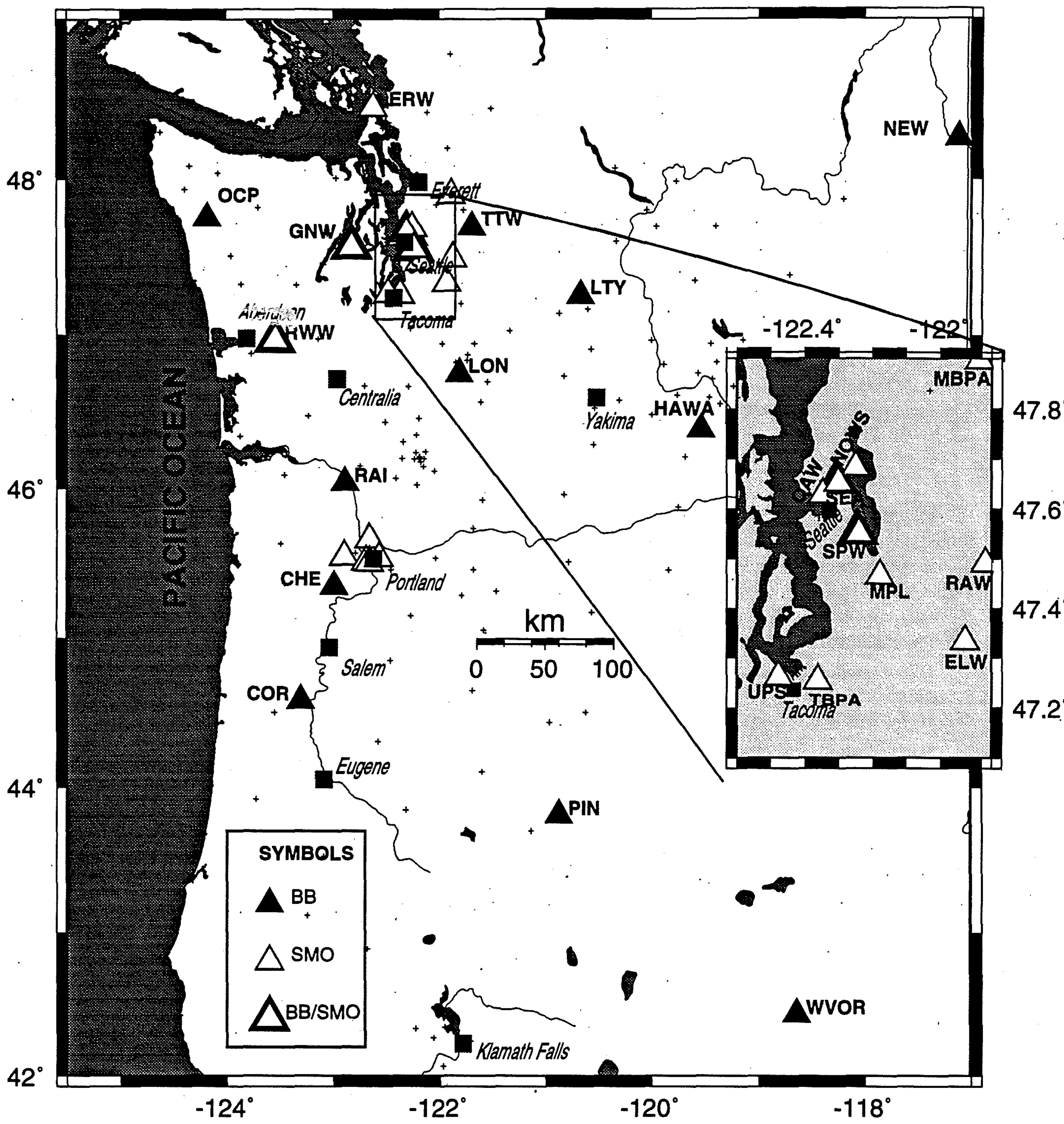

Figure 1: Stations operating at the end of the third quarter, 1999. Small + signs represent short period stations. Cities are shown as squares. Filled triangles represent broad-band stations. Strong motion stations are shown as unfilled triangles. Stations which have both broad-band and strong-motion components are shown as an unfilled triangle with a heavy border.

RACE system.

EARTHWORM Y2K Progress Report

In cooperation with the USGS EARTHWORM team, work has progressed on Y2K compliance. A new Sun workstation "milli", provided by the USGS last quarter, is being used as an independent platform for upgrading and testing of PNSN software for the millennial roll-over. In August "milli" replaced "verme" as our main, Y2K compatible, data acquisition computer. In addition to local EARTHWORM modules, nearly all of the PNSN data analysis and archive software needed modification. We have used this opportunity to clean out some old "cobwebs" and to improve the reliability of our systems against casualties such as power failure. By the end of the third quarter, nearly all the development work was completed and the Y2K compatible system is running quite smoothly. We are fixing minor residual problems on our "milli" Y2K system as they crop up. "Verme" continues to run as a backup system. The University of Washington provided extra support to fund the development and testing of the PNSN system for Y2K compliance. Peter Lombard, our earthworm expert, completed the critical programming just before he departed from the UW. He remains available for consultation, and is continuing to help us out. Routine monitoring of our earthworm system has been taken over by George Thomas.

TABLE 1
Station Outages, Repairs, and Installations 3rd quarter 1999

Station	Outage Dates	Comments
ALST	8/30	INSTALLED
BPO	1/15-9/21	Repaired solar panel and wiring
BLN	8/3-9/22	Dead - Lightning strike hung communication system
CMM	8/11/98-8/4	Replaced temporary sound station SND
CMW	1/13-7/22	Replaced battery
DBO	2/1-8/2	Replaced seismometer
ETW	4/2-end	Dead, searching for another site
ERW	8/5-End	Dead, Lightning strike caused communication system to hang
FL2	Feb.-9/28	Replaced and moved seismometer
GMW	9/1/98-end	Intermittent
HBO	2/23-7/28	Replaced battery
HDW	1/8-8/12	Fixed antenna and replaced battery
JCW	5/5-7/14	Replaced VCO
KEEL	8/30	INSTALLED
LCW	4/27-End	Dead
LMW	8/3-9/03	Vandalized; Reinstalled
LVP	3/1-End	Dead
MBW	1/29-9/11	Replaced battery
MEW	11/16/98-End	Dead - Bad Seismometer?
NLO	8/97-End	Intermittent
OCP	6/15-8/5	Added solar panel and battery
OSD	7/98-End	Dead
RCM	5/28-7/19	Replaced VCO
RER	1/30-9/8	Replaced antenna, solar panel and battery
RSU	8/20	INSTALLED
RWW	04/18-8/11	REINSTALLED as tsunami warning station
ROSS	7/21	INSTALLED
STW	08/24-9/22	Lightning strike - telemetry repaired at BLN
TKO	1/4-End	Dead - Winter damage

Strong-motion Instrumentation and Recording Update

Earlier this year the Bonneville Power Authority (BPA) agreed to provide space and Internet connections for a central receiving computer node in the **Dittmer** installation in Vancouver WA, and telemetry from several sites in the Portland area to the Dittmer node via the BPA microwave system. The PNSN agreed to supply strong motion information to the BPA, and to provide a SUN SPARC computer to run an EARTHWORM seismic system at Dittmer to collect and relay real-time data via the Internet to the PNSN. Installation of the hub computer and a strong-motion instrument (ROSS) at Dittmer took place this quarter. The Dittmer EARTHWORM system began operation, and data from ROSS were available on July 21. Data from stations at Alston (ALST) and Keeler (KEEL) began on Aug. 30. The telemetry from the Portland Water Bureau seismometer at Bull Run Dam to Dittmer is still being worked out.

Since 1993, the USGS has operated three strong-motion stations; CSO RBO, and HAO; in the Portland, Oregon area. The stations were installed just before the March 1993 "Scotts Mills" Oregon earthquake. Until about 1997 these stations operated in triggered mode only. More recently, larger storage disks and telephone installation has made it possible to record continuously. Data are retrieved via telephone dial-up. Because we occasionally integrate data from these instruments into the PNSN data stream for events in the Portland area, we have added them to the list of strong motion stations in Table 2C.

George Thomas re-joined our staff in July. George received his MS from the UW Geophysics Program several years ago, then worked for the PNSN in various capacities, including data analysis and the initial set-up of the PNSN's strong-motion hardware and software. Following that, George worked for NOAA for a year or so. George will be working with the strong motion data stream and software, and will also be involved in routine PNSN operations.

In Washington, King County has expressed interest in hosting one or more PNSN strong-motion stations in county facilities which have high-speed Internet connections. We are exploring this possibility.

Over 30 earthquakes or explosions this quarter were large enough, or near enough strong motion instruments, to produce picks on PNSN strong motion components. Special Table A lists events for which one or more channels of strong motion data was picked. See "Key to Earthquake Catalog" for a description of Quality factors.

SPECIAL TABLE A - Earthquakes and blasts with strong motion records during the 3rd Quarter of 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	QUALITY	TYPE	COMMENTS
99/07/02 05:22:19	47.36N	122.39W	27.1	3.1	CA	FELT	14.9 km N of Tacoma, WA
99/07/03 01:43:54	47.07N	123.46W	40.7	5.1	BA	FELT	8.0 km N of Satsop, WA
99/07/07 22:30:55	47.76N	121.84W	5.7	1.9	CB		10.5 km ENE of Duvall, WA
99/07/07 22:33:28	47.76N	121.84W	7.0	1.5	BB		10.5 km ENE of Duvall, WA
99/07/08 23:32:46	47.90N	122.68W	0.0	1.3	BC		18.8 km N of Poulsbo, WA
99/07/09 05:13:41	47.09N	123.45W	40.0	1.5	BA		10.8 km NNE of Satsop, WA
99/07/09 07:45:42	47.06N	123.46W	39.8	2.1	BA	FELT	6.8 km N of Satsop, WA
99/07/09 08:07:39	47.06N	123.45W	40.0	2.3	BA		6.7 km NNE of Satsop, WA
99/07/13 22:52:40	47.77N	122.27W	18.4	1.3	BB		11.1 km NNW of Kirkland, Wa
99/07/16 05:58:24	45.65N	122.77W	19.7	2.3	AA	FELT	17.7 km NW of Portland, OR
99/07/16 05:59:59	45.65N	122.77W	18.9	2.3	BA	FELT	17.7 km NW of Portland, OR
99/07/16 21:34:03	45.64N	122.76W	18.1	3.1	AA	FELT	17.2 km NW of Portland, OR
99/07/23 22:25:44	47.48N	121.85W	19.2	1.7	BA		5.3 km WSW of North Bend, WA
99/07/24 03:44:56	47.64N	122.16W	21.2	1.8	AA		4.7 km NNE of Bellevue, WA
99/08/01 01:36:07	45.65N	122.77W	18.7	1.4	AA		18.1 km NW of Portland, OR
99/08/13 01:45:16	47.20N	122.11W	8.9	1.9	BC		9.9 km W of Enumclaw, WA
99/08/19 13:16:54	47.62N	123.15W	46.8	3.1	BA		40.3 km WSW of Poulsbo, WA
99/08/23 06:11:23	47.31N	122.37W	22.6	1.5	AA		9.7 km NNE of Tacoma, WA
99/08/25 17:48:43	47.75N	121.86W	7.4	2.0	CB	FELT	9.5 km ENE of Duvall, WA
99/08/26 08:48:46	47.32N	122.33W	18.3	1.2	BB		12.7 km NE of Tacoma, WA
99/09/03 07:16:18	47.50N	123.12W	0.0	2.9	BC	FELT	38.2 km W of Bremerton, WA
99/09/03 12:15:48	47.77N	121.87W	6.8	1.8	BB		9.0 km ENE of Duvall, WA

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	QUALITY	TYPE	COMMENTS
99/09/05 10:36:56	47.79N	121.87W	7.5	1.8	BB		10.2 km NE of Duvall, WA
99/09/05 18:01:36	47.16N	123.12W	46.5	2.8	BA	FELT	22.3 km NW of Olympia, WA
99/09/06 01:17:46	47.82N	121.96W	2.5	1.7	BC		3.6 km S of Monroe, WA
99/09/20 09:31:59	47.72N	123.02W	15.4	1.1	AD	BLAST	28.6 km W of Poulsbo, WA
99/09/20 11:16:54	47.60N	121.76W	16.9	2.8	BA	FELT	10.4 km ENE of Fall City, WA
99/09/20 12:00:52	47.60N	121.76W	15.9	2.1	BA		9.9 km ENE of Fall City, WA
99/09/22 08:00:01	47.67N	122.25W	0.0	1.3	BA		3.5 km WSW of Kirkland, Wa
99/09/22 08:14:02	47.66N	122.43W	0.0	1.9	BB	BLAST	10.7 km NW of Seattle, WA
99/09/22 09:30:01	47.68N	122.24W	0.0	1.7	BA	BLAST	2.9 km W of Kirkland, Wa
99/09/22 09:34:01	47.63N	122.17W	0.0	1.0	BC	BLAST	3.6 km NNE of Bellevue, WA
99/09/22 09:44:02	47.63N	122.30W	0.0	1.9	DB	BLAST	4.7 km NNE of Seattle, WA
99/09/23 21:14:33	47.87N	121.98W	10.2	0.9	DD		2.2 km NNW of Monroe, WA
99/09/26 00:24:03	47.61N	122.18W	5.7	2.0	BB		1.2 km ENE of Bellevue, WA

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 1434-HQ-98-AG-01937. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. "C" indicates USGS Cal-net stations received via EARTHWORM. 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 operating during the third quarter 1999

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 39.6	119 52 59.4	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
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
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
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
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
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

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
KEB	C	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	C	41 49 51.0	123 52 33.0		CAL-NET
KTR	C	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	C	41 36 35.2	122 37 32.1	1.769	CAL-NET
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
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (BB,LONLZ)
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 Center
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	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
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
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
RC1	+	46 56 42.6	119 26 39.6	0.485	Royal City
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
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens Dome
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.
SND	%	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectified
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 third quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
CHE		45 21 16.0	122 59 19.0	0.436	Chehalem, Oregon (Operated by UO)
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
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)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire, WA (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 (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)
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle (operated by UW)
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.

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 an Internet earthworm system

TABLE 2C

Strong-motion three-component stations operating at the end of the third quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALST	%	46 6 31.2	123 01 47.4	0.000	Alston, Oregon BPA	A20	E
CSO	#	45 31 01.0	122 41 22.5	0.036	Canyon Substation, Oregon	FBA23	D
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	L
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	L
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
KEEL	%	45 33 0.0	122 53 44.40	0.000	Keeler, Oregon BPA	A20	E
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	0.00	NOAA, Bldg 3	A20	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
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte, Oregon	FBA23	D
ROSS	%	45 39 46.2	122 39 37.0	0.100	Ross BPA	A20	L,E
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SEA	%	47 39 18.0	122 18 30.0	0.030	Seattle	A,BB	L,D
SPW	%	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle	A,BB	L
TBPA	%	47 15 28.1	122 22 05.9	0.002	Tacoma WA BPA	A	L,D
UPS	%	47 15 56.1	122 28 58.4	0.113	U. Puget Sound	A	D,I

THE SHIPS experiment

The second phase of the U.S. Geological Survey's (USGS) SHIPS (Seismic Hazards in Puget Sound) active seismic experiment, originally scheduled for May, took place in September 20-22. This phase consisted of about 40 explosions at 33 shot-points along a 100 km long east-west line running from the Cascade foothills to the Olympic Peninsula.

Seismic waves were generated by explosions in deep boreholes. Waves reflected from underground layers were recorded by about 1,000 seismic recorders spaced at 100 meter intervals along the same line, and also by the permanent stations of the PNSN. The combined SHIPS data, from water and land, will provide a complete three-dimensional view of the Seattle basin, allowing researchers to construct computer models of how strong earthquake shaking will affect the Puget Sound basin. Special Table B is a list of the size, time, and location of the 1999 "Dry SHIPS" explosions; in the time column, the date is given as a Julian Day; where day 263 is September 20, day 264 is Sept. 21, etc.
Special Table C lists SHIPS blasts located by the PNSN; "Shot #" refers to the time order of the shots, while "SP #" refers to the geographic location of the shot. See Special Table B for details.

SPECIAL TABLE B - 1999 SHIPS EXPLOSIONS - in Order of Shot time

SHOT No.	SHOT POINT	EXPLOSIVE (lbs)	TIME UTC	LAT(N) N	LON(W) W	ELEVATION (m)
1	SP02	250	263:08:00:00	47.741223	-123.056398	155
2	SP06	50	263:08:02:00	47.707970	-122.892340	5
3	SP30	250	263:08:04:00	47.660151	-121.812390	224
4	SP31	250	263:08:06:00	47.655139	-121.758625	355
5	SP34	250	263:08:08:00	47.653562	-121.642726	467
6	SP01	2800	263:09:30:00	47.729520	-123.086529	238
7	SP05	2000	263:09:32:00	47.730716	-122.947215	414
8	SP29	800	263:09:34:00	47.657893	-121.860752	129
9	SP32	2000	263:09:36:00	47.651181	-121.717902	389
10	SP35	2400	263:11:08:00	47.660939	-121.616558	468
11	SP04	250	264:08:00:00	47.716137	-122.991552	136
12	SP09	50	264:08:02:00	47.693580	-122.779130	86
13	SP33	250	264:08:06:00	47.652125	-121.672736	526
14	SP10	150	264:08:10:00	47.699421	-122.724739	121
15	SP11	500	264:08:12:00	47.680029	-122.718209	117
16	SP24	500	264:08:14:00	47.682420	-122.022710	171
17	SP01	2800	264:09:30:00	47.729520	-123.086529	238
18	SP08	250	264:09:32:00	47.705836	-122.801583	44
19	SP05	2000	264:09:34:00	47.729511	-122.945819	404
20	SP32	2000	264:09:36:00	47.651181	-121.717902	389
21	SP12	500	264:09:38:00	47.675732	-122.740495	84
22	SP11	500	264:09:42:00	47.679773	-122.718313	117
23	SP24	500	264:09:44:00	47.682420	-122.022710	171
24	SP12	500	264:11:08:00	47.675732	-122.740495	84
25	SP21	400	265:08:00:00	47.682904	-122.249409	17
26	SP27	250	265:08:04:00	47.672020	-121.930550	9
27	SP26	500	265:08:06:00	47.644160	-121.946420	158
28	SP14	50	265:08:08:00	47.677027	-122.631557	73
29	SP15	50	265:08:10:00	47.661350	-122.578149	45
30	SP19	25	265:08:12:00	47.668744	-122.345883	79
31	SP18	325	265:08:14:00	47.664491	-122.419736	73
32	SP21	400	265:09:30:00	47.682955	-122.248809	16
33	SP22	400	265:09:34:00	47.651400	-122.174900	155
34	SP26	500	265:09:36:00	47.644160	-121.946420	158
35	SP13	125	265:09:38:00	47.672731	-122.687674	12
36	SP17	375	265:09:40:00	47.654140	-122.548039	85
37	SP20	125	265:09:44:00	47.650912	-122.298710	4
38	SP19	25	265:11:12:00	47.668744	-122.345883	79

SPECIAL TABLE C: SHIPS EXPLOSIONS LOCATED BY THE PNSN Some additional explosions were recorded on a few PNSN stations, but not enough to determine the blast location.

SPECIAL TABLE C - SHIPS EXPLOSIONS LOCATED BY THE PNSN

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	QUALITY	COMMENTS
99/09/20 08:04:00	47.66	121.83	0.0	1.2	BC	5.9 km ENE of Carnation-SP30; Shot 3, 250 lbs.
99/09/20 09:30:00	47.70	123.04	1.4	1.5	BB	30.1 km W of Poulsbo-SP01; Shot 6, 2,800 lbs.
99/09/20 09:31:59	47.72	123.02	15.4	1.1	AD	28.6 km W of Poulsbo-SP05; Shot 7, 2,000 lbs.
99/09/20 09:36:00	47.65	121.70	0.0	1.6	BA	15.5 km E of Carnation-SP32; Shot 9, 2,000 lbs.
99/09/20 11:08:00	47.66	121.61	4.3	2.7	BB	19.2 km WSW of Skykomish-SP35; Shot 10, 2,400 lbs.
99/09/21 08:12:01	47.70	122.76	14.6	0.9	CC	9.5 km WSW of Poulsbo-SP11; Shot 15, 500 lbs.
99/09/21 09:34:00	47.71	122.92	0.1	1.6	BC	21.4 km W of Poulsbo-SP05; Shot 19, 2,000 lbs.
99/09/21 09:36:00	47.65	121.71	4.0	1.7	CB	14.9 km E of Carnation-SP32; Shot 20, 2,000 lbs.
99/09/21 09:42:01	47.67	122.73	1.3	1.6	AC	9.0 km SW of Poulsbo-SP11; Shot 22, 500 lbs.
99/09/22 08:00:01	47.67	122.25	0.0	1.3	BA	3.5 km WSW of Kirkland-SP21; Shot 25, 400 lbs.
99/09/22 08:14:02	47.66	122.43	0.0	1.9	BB	10.7 km NW of Seattle-SP18; Shot 31, 325 lbs.
99/09/22 09:30:01	47.68	122.24	0.0	1.7	BA	2.9 km W of Kirkland-SP21; Shot 32, 400 lbs.
99/09/22 09:34:01	47.63	122.17	0.0	1.0	BC	3.6 km NNE of Bellevue-SP22; Shot 33, 400 lbs.
99/09/22 09:38:01	47.68	122.72	0.7	1.3	AD	8.1 km SW of Poulsbo-SP13; Shot 35, 375 lbs.
99/09/22 09:40:02	47.66	122.56	2.9	1.2	AC	10.2 km SE of Poulsbo-SP17; Shot 36, 375 lbs.
99/09/22 09:44:02	47.63	122.30	0.0	1.9	DB	4.7 km NNE of Seattle-SP20; Shot 37, 125 lbs.

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

Special Events

- This quarter, devastating earthquakes in Turkey, Greece, and Taiwan led to heightened interest and numerous requests for information from the press and public.
- Bill Steele, the PNSN lab coordinator, was interviewed for NBC World News Tonight, a national program.
- The SHIPS Project: The PNSN provided teams of volunteers that worked long hours deploying, servicing, and collecting instruments. The Seismology Lab organized a press conference before the experiment and coordinated communications with the media and public during and following the experiment.

Some of the shot points were at parks within the city of Seattle, and several of the in-city explosions were felt by many near-by residents. Some of the shaking was quite strong and a few people became quite alarmed. This was completely unexpected by the experimenters, as the shot sizes had been carefully calibrated to be neither felt nor heard. The fact that the shots were felt widely indicates that the attenuation formulas applied in the shot size calculations did not work well for the Seattle region. The unique glacial near surface geology in the Seattle region may have trapped energy and enhanced shaking. The USGS offered a public apology to those impacted by the shots and will analyze the data collected in the hope of better understanding this phenomenon.

- During the SHIPS experiment, Bill Steele hosted a visit by Gary Patterson, Information Services Director/Geologist from the Center for Earthquake Research and Information (CERI), at The University of Memphis. Gary and Bill are collaborating on the development of educational outreach/ hazard mitigation programs for The Pacific Northwest and Central States regions.
- The ASCE 5th US Conference on Lifeline EQ Engineering was held in Seattle on August 11th and 12th. Bill Steele distributed information on the PNSN instrument modernization plans and managed press

relations for the release of USGS open file report. 99-387, "Lifelines and Earthquake Hazards in Seattle", by Haugerud, Ballantyne, Weaver, Meagher, and Barrnett. The report was published as a color digital elevation map of the Central Puget Sound Region with regional power, water, gas, and sewer transmission lifelines overlain. Geologic features such as the Seattle Fault Zone, unconsolidated young deposits, and the limits of the Seattle Basin were identified. The back of the map includes text and explanatory illustrations. The report stimulated much attention by the press, public policy makers, and businesses.
• On September 10, members of the PNSN staff visited Bainbridge Island to view three trenches that cut across the Toe Jam Hill strand of the Seattle fault. The trenching operation was carried out by a sizable group of geologists under the direction of the USGS. About 30 representatives of various organizations, including the USGS, NASA, the Washington Dept. of Natural Resources, Kitsap County, and the UW viewed the trenches and discussed the exposed geology. The surface trace of the Toe Jam Hill strand of the Seattle fault was first identified from LIDAR images taken for the Kitsap County water company.
• Peter Snow, a well-known British journalist, spent several days with his BBC crew in the PNSN lab, shooting a segment about the Seattle Fault for a show called "Tomorrow's World". On their last day in the area they chartered a small plane from Kenmore air, and had the misfortune to crash on Bainbridge Island. Luckily, no one was seriously injured.
• Bill Steele participated in a number of other meetings and conferences this quarter including Board Meetings of CREW and the Seattle and King-Pierce Co. Project Impact, and The Pemco Disaster Fair.
• The PNSN organized a natural hazards information fair for the Seattle Project Impact "Disaster Saturday" on Oct. 2. These twice-yearly meetings provide USGS and UW scientists working in the Puget Sound region an opportunity to present their work to the public. Information on home retrofitting is available, and general disaster preparedness is also emphasized. About 900 people attended, and Seattle's Mayor Schell opened the plenary session.
• Steve Malone presented a program on volcanos at Mount Rainier National Park as part of their centennial celebration.

Press Interviews, Lab Tours, and Workshops

PNSN staff provided numerous television, radio, or press interviews this quarter. Press highlights included the SHIPS experiment in September and the disastrous earthquakes in Turkey and Taiwan. We provided 4 lab tours this quarter and three other community presentations. presentations.

The Ms 5.5 July 3, 1999 Benioff zone earthquake occurred on a Friday evening at 6:43 PM local time. PNSN staff responded rapidly with information about the earthquake, including the fact that sizable aftershocks were unlikely due to the source depth. The Bonneville Power Administration used this information, and sent night-time repair crews to their damaged Satsop facility to restore power. The relatively new PNSN real-time strong motion network provided strong motion data almost immediately. All five of the local TV stations sent camera crews, and a variety of print and radio representatives were also present in the Seismology Lab. Numerous telephone interviews were also conducted. Media coverage quieted rapidly after the 11 PM news because of the 3-day holiday weekend and the lack of aftershocks.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 1,300 calls this quarter. 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. This quarter we responded in person to: Emergency Management and ~60 calls from emergency management and government, ~180 calls from the media, ~40 calls from educators, ~55 from the business community, and about 165 calls from the general public.

The list of recent Pacific Northwest earthquakes can be accessed by a variety of methods beyond the audio library described above: via our World-Wide-Web site, through the Internet with the UNIX "finger" utility, or by e-mail or modem. The computer methods have an advantage over the audio library. Not only

are more earthquakes listed, but update is automated, and the location and magnitude information is available more rapidly. Table 3 shows the number of times the computerized PNSN list of recent earthquakes magnitude 2.0 or larger was accessed.
The Internet UNIX utility "finger quake@geophys.washington.edu" was most popular, followed by access over the WWW. For computer users without direct access to Internet, this information can be accessed via e-mail (by sending e-mail to "quake@geophys.washington.edu").

The PNSN recent earthquake list, and much more, is also available through the World-Wide-Web (WWW) at:

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

TABLE 3
Accesses of PNSN "Most recent earthquakes M>=2.0" list
Quarterly Comparison

Access Method	97-C	97-D	98-A	98-B	98-C	98-D	99-A	99-B	99-C
Finger Quake	97,000	118,000	124,000	113,367	122,429	113,430	105,557	99,451	87,981
World-Wide-Web	37,100	34,700	50,000	55,600	49,000	47,400	41,700	34,000	64,000

Web usage of the entire suite of PNSN web pages ranged from 121,000 visits in August to 257,000 visits during July.

The PNSN web-site offers web pages for Mt. St. Helens, Mt. Hood, and Mt. Rainier that include a map and list of the most recent PNW earthquakes, plus general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Quarterly summaries of seismicity extracted from these reports are also included.

"Webicorder" pages that allow Web visitors to view continuous data from six PNSN seismographic stations were implemented at the end of 1998:

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

The Webicorders are real-time continuous displays, similar to our in-lab helicorder records. Each Webicorder can display (in highly compact gif format) 24 hours of continuous data from a station. New files are initiated each day at 0:00 UTC, and updated every 10 minutes throughout the day. Files from the preceding seven days are also available for viewing.

For larger earthquakes, the PNSN has a standard set of web pages that are generated automatically using preliminary information, at the same time that the initial page is sent to seismologists. Features offered include a "felt form" that readers can fill out, several maps of the regional area and immediate vicinity of the earthquake, a list of other sizable earthquakes known historically, a list of the nearest strong-motion sites, focal mechanisms, and strong motion trace-data.

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

- **Seismosurfing** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. About 21,000 visits were made to this page each month. This page is mirrored at two sites in Europe.

  http://www.geophys.washington.edu/seismosurfing.html
- The **Council of National Seismic Systems** (CNSS) site features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system. The CNSS site was visited about 41,000 times per month this quarter.

  http://www.cnss.org
- The **"Tsunami!"** web site offers many pages of information, including an excellent discussion on the physics of tsunamis, and short movie clips. **"Tsunami!"** was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering). It is very popular, with about 170,000 visits a month.

  http://www.geophys.washington.edu/tsunami
- The UW Geophysics Program **Global Positioning System (GPS)** web site provides information on geodetic studies of crustal deformation in Washington and Oregon. The GPS site received about

1,300 visits per month this quarter.

http://www.geophys.washington.edu/GPS/gps.html

EARTHQUAKE DATA - 1999-C

There were 1661 events digitally recorded and processed at the University of Washington between July 1 and Sept. 30, 1999. Locations in Washington, Oregon, or southernmost British Columbia were determined for 592 of these events; 505 were classified as earthquakes and 87 as known or suspected blasts. The remaining 1069 processed events include teleseisms (161 events), regional events outside the PNSN (85), 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 and retrieve broad-band data for some of them.

Table 4 is a listing of all earthquakes reported to have been felt during the this quarter. Table 5, located at the end of this report, is this quarter's catalog of earthquakes and blasts, 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 a contour map of peak accelerations recorded during the July 3 (UTC) (M_b 5 Satsop earthquake.

TABLE 4 - Felt Earthquakes during the 3rd Quarter of 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
99/07/02 05:22:19	47.36N	122.39W	27.1	3.1	14.9 km N of Tacoma, WA
99/07/03 01:43:54	47.07N	123.46W	40.7	5.1	8,0 km N of Satsop, WA
99/07/09 07:45:42	47.06N	123.46W	39.8	2.1	6.8 km N of Satsop, WA
99/07/16 05:58:24	45.65N	122.77W	19.7	2.3	17.7 km NW of Portland, OR
99/07/16 05:59:59	45.65N	122.77W	18.9	2.3	17.7 km NW of Portland, OR
99/07/16 21:34:03	45.64N	122.76W	18.1	3.1	17.2 km NW of Portland, OR
99/08/25 17:48:43	47.75N	121.86W	7.4	2.0	9.5 km ENE of Duvall, WA
99/09/03 07:16:18	47.50N	123.12W	0.0	2.9	38.2 km W of Bremerton, WA
99/09/05 18:01:36	47.16N	123.12W	46.5	2.8	22.3 km NW of Olympia, WA
99/09/20 11:16:54	47.60N	121.76W	16.9	2.8	10.4 km ENE of Fall City, WA

OREGON SEISMICITY

During the third quarter of 1999 a total of 58 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude.

On July 16 (UTC) three earthquakes were felt in the Portland area. Two magnitude 2.3 earthquakes within less than two minutes were followed by a magnitude 3.1 quake in the same location about 16 hours later. The focal mechanism suggests oblique strike-slip movement on a NNW or ENE striking fault. See Table 4 for other details.

In the Klamath Falls area, 13 earthquakes were located this quarter. Most earthquakes northwest of Klamath Falls are aftershocks of a pair of damaging earthquakes in September of *1993* (Sept. 21, 03:29 and 05:45 UTC; M_c 5.9 and 6.0 respectively). These earthquakes were followed by a vigorous aftershock sequence which has decreased over time.

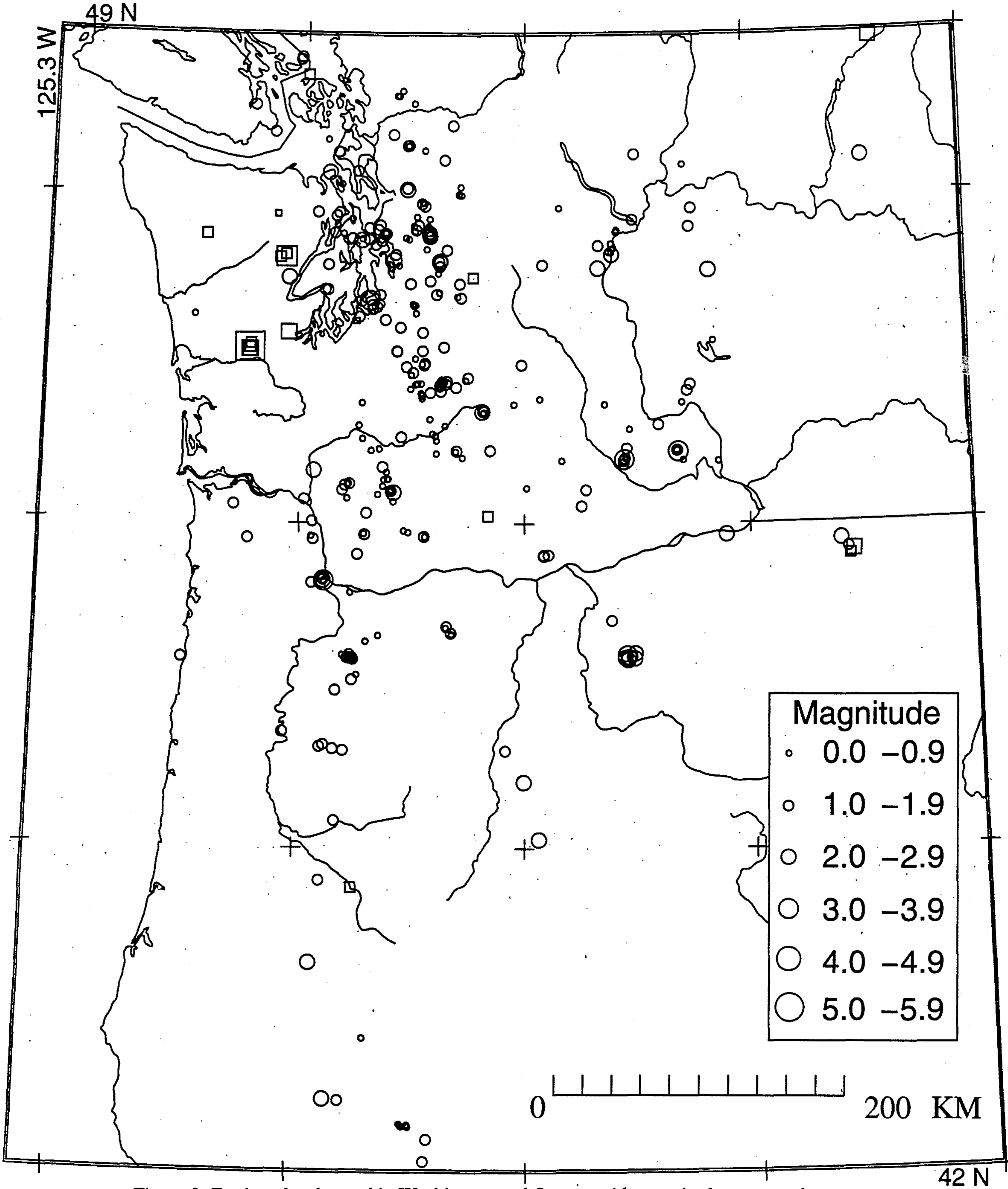

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than or equal to 0.0 during the third quarter of 1999. Square symbols indicate events located at depths of 30 km or more.

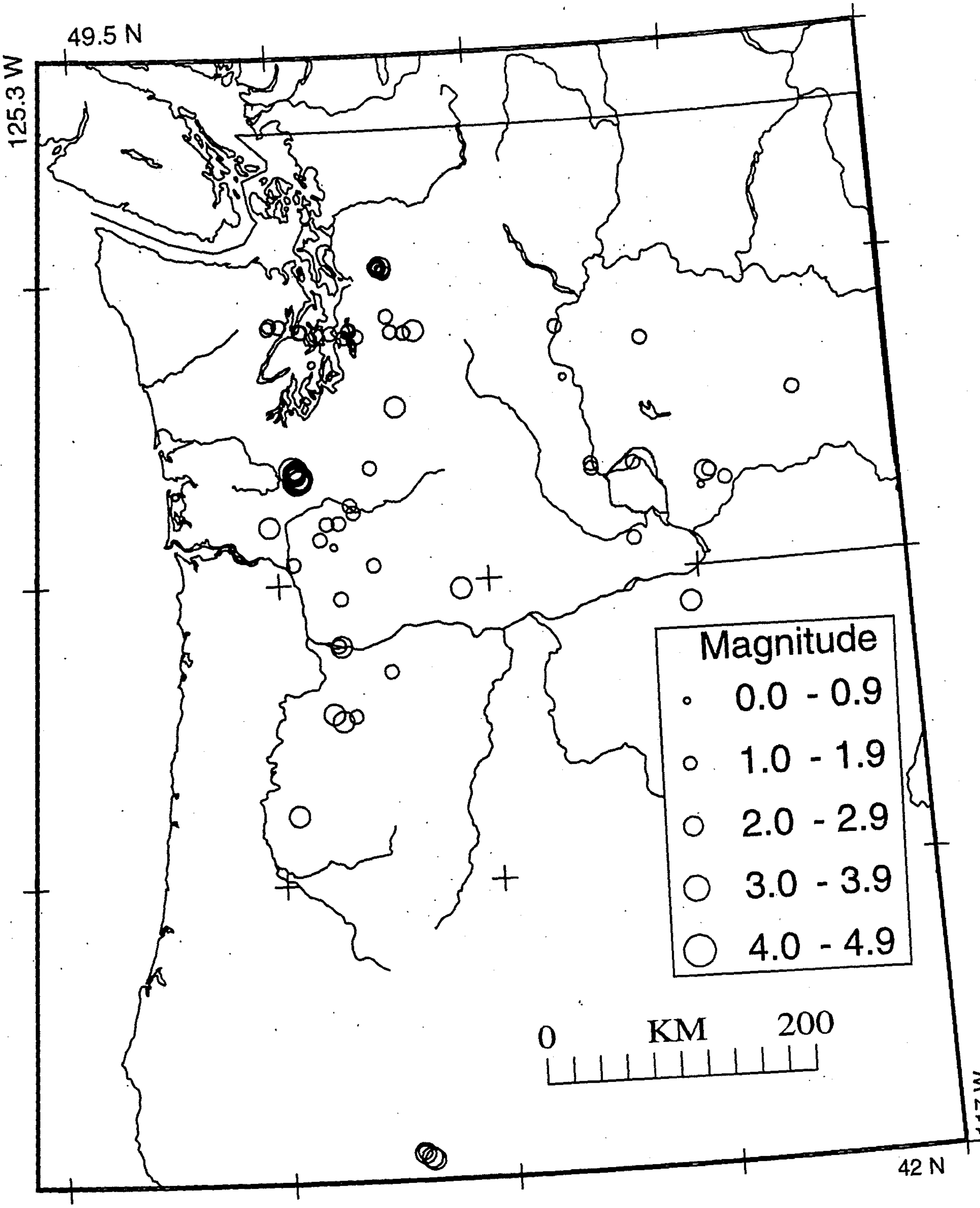

Figure 3: Blasts and probable blasts, third quarter, 1999.

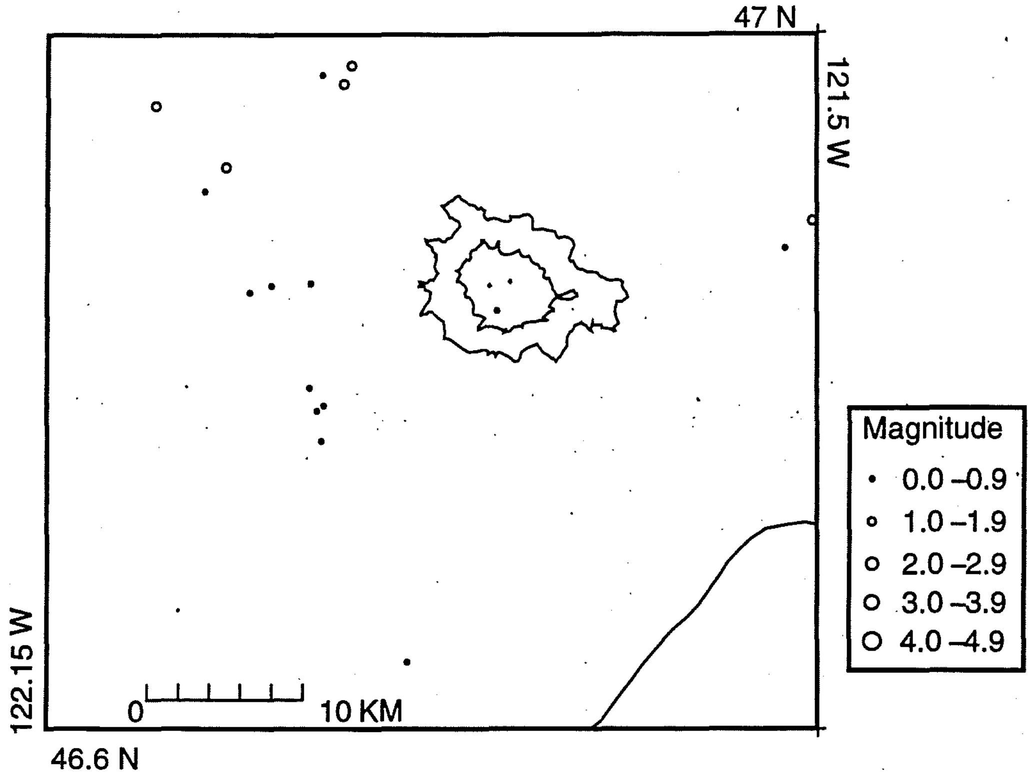

Figure 4: Earthquakes located in the Mt. Rainier area third quarter, 1999. All events shown are greater than magnitude 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper.

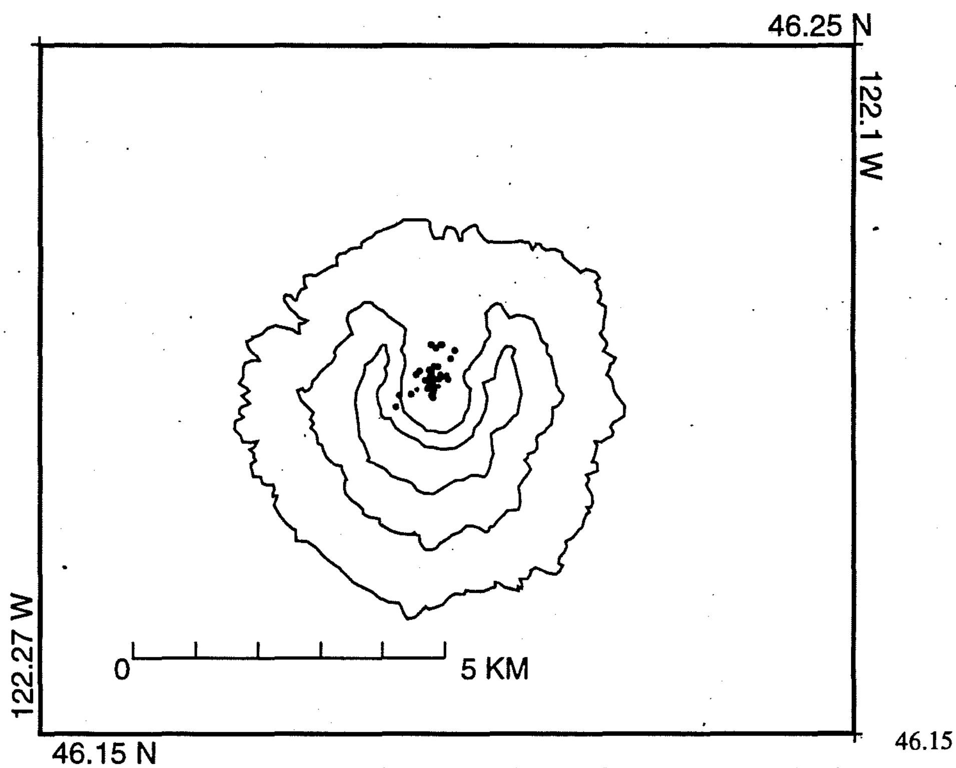

Figure 5: Earthquakes located in the Mt. St. Helens area third quarter, 1999. All events shown are greater than magnitude 0.0. Contours shown are at 5,000, 6,400 and 7,500 feet elevation. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper. Symbol scaling as in Fig. 4.

TABLE 4A 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" and "Blasts". The remaining numbers are counts of earthquakes only 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 at Mt. St. Helens (MSH) are between 46.15-46.25 degrees north latitude and 122.10-122.27 degrees west longitude, and earthquakes near Mt. Rainier are between 46.6-47.0 degrees north latitude and 121.5-122.15 degrees west longitude. "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.

TABLE 4A Comparison of quarterly earthquake counts over several years

Year	Q	Total	Quakes	Blasts	western WA	MSH	Rainier	eastern WA	OR
1993	A	**457**	380	77	**267**	34	77	**32**	**72**
	B	**450**	384	66	**284**	63	62	**57**	**33**
	C	**727**	579	148	**368**	82	75	**65**	**141**
	D	**2616**	2556	60	**355**	82	92	**39**	**2157**
1994	A	**1585**	1501	84	**232**	43	73	**44**	**1222**
	B	**873**	775	98	**350**	60	130	**56**	**364**
	C	**822**	656	166	**379**	67	81	**62**	**208**
	D	**555**	506	49	**236**	52	44	**55**	**211**
1995	A	**488**	426	62	**273**	18	38	**47**	**101**
	B	**726**	636	90	**438**	104	91	**58**	**134**
	C	**1072**	924	148	**693**	318	84	**75**	**138**
	D	**687**	610	77	**484**	264	41	**41**	**70**
1996	A	**504**	434	70	**303**	82	56	**53**	**75**
	B	**967**	864	103	**752**	68	57	**39**	**72**
	C	**696**	544	152	**426**	83	75	**45**	**67**
	D	**476**	387	89	**312**	65	59	**45**	**29**
1997	A	**417**	353	64	**270**	49	47	**45**	**34**
	B	**525**	473	52	**386**	70	31	**65**	**21**
	C	**633**	568	65	**473**	183	45	**66**	**28**
	D	**680**	614	66	**505**	292	47	**56**	**45**
1998	A	**692**	639	53	**478**	293	35	**57**	**106**
	B	**1248**	1183	65	**1048**	776	47	**74**	**58**
	C	**1727**	1635	92	**1464**	1107	76	**84**	**86**
	D	**1373**	729	43	**620**	349	69	**60**	**49**
1999	A	**474**	449	25	**248**	122	16	**49**	**148**
	B	**469**	407	62	**277**	134	31	**45**	**84**
	C	**592**	505	87	**391**	133	44	**55**	**58**

WESTERN WASHINGTON SEISMICITY

During the third quarter of 1999, 391 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude, including the largest Benioff zone earthquake since 1965.

Special Report on the July 3 UTC magnitude 5.1 earthquake

The largest earthquake in Washington this quarter was a coda magnitude 5.1 earthquake on July 3 UTC (July 2 6:43 PM PDT). It occurred at a depth of about 41 km, about 8 km north of Satsop, WA. Location details are provided in Table 4.

Magnitude estimates for this earthquake varied considerably. The coda magnitude scale used by the PNSN has not been well calibrated for large and deep earthquakes in the Pacific Northwest since they occur so infrequently. The National Earthquake Information Center (NEIC) has assigned this earthquake a magnitude of 5.5 based on the body wave scale and the surface wave scale. NEIC gives a moment magnitude of 5.9 for this event.

The hypocentral depth indicates that this event is a Benioff Zone earthquake, occurring in the subducted Juan de Fuca plate. The PNSN's P-wave first-motion focal mechanism for this event is consistent with the moment-tensor focal mechanism determined by Oregon State University, and indicates normal faulting with a nearly horizontal T axis. No aftershocks were recorded immediately following the event but on July 9 there were 3 small earthquakes with similar hypocentral coordinates occurring at 05:13UT (Mag 1.5), 07:45UT (Mag 2.3), and 08:07UT (Mag 2.3 - reported felt). Another aftershock occurred on August 11 at 17:37 UT (Mag 1.7). Both the focal mechanism and lack of sizable aftershocks are typical of Benioff Zone earthquakes.

The July 3 UTC earthquake was felt throughout most of western Washington and northwest Oregon, and in parts of southwest British Columbia, Canada. The strongest shaking corresponded to a level of about VI on the Modified Mercalli Intensity scale. Structural damage included cracked chimneys and broken windows. The three-story Grays Harbor County Courthouse, built in 1910 and located in Montesano, suffered extensive structural damage to its cupola. Interior walls were also cracked. The Montesano fire station, built around 1979, also suffered structural damage. oriented east-west. In Aberdeen, some structural cracks of walls and beams were reported. In addition, power outages and water main breaks occurred. The wood-framed roof of a furniture store collapsed. An engineering firm, EQE, has provided a summary of damage information at:

http://www.eqe.com/revamp/wash/index.html

Figure 6 shows a contour map of peak accelerations. Some were recorded by on-line (11 stations; data available on internet within an hour) or dial-up (2 stations, data available within a day or so) PNSN stations. Data from eighteen other sites, operated by various groups, were not available until much later.

Ground motions from this earthquake were recorded by 11 PNSN strong motion stations. Peak accelerations and a list of the PNSN stations is available at:

http://www.geophys.washington.edu/SEIS/EQ_Special/WEBDIR_99070301435p/strong_motion.html

The maximum acceleration recorded was 8%g at Wynoochee dam (see Fig. 6). The estimated acceleration at the epicenter is 17%g. The strongest horizontal ground acceleration recorded by the PNSN real-time stations was about 2%g, at station TBPA in Tacoma, at 88 km epicentral distance. Station UPS, also in Tacoma, and at 77 km epicentral distance, recorded 0.5%g horizontal ground motions. RWW, the nearest PNSN station with an accelerometer, at 14 km epicentral distance, was in the process of being upgraded to a CREST station, and was not functioning at the time that the earthquake occurred.

Other earthquakes in western Washington this quarter

This quarter, the deepest event recorded by the PNSN was a magnitude 1.3 earthquake at about 96 km depth. It occurred on September 10 at 02:04 UTC, about 13.5 km NNW of Hyak, WA. This location is in the area where such deep events are most frequently located.

On July 2 (UTC), a magnitude 3.1 earthquake 15 km north of Tacoma was widely felt in the Puget Basin. Four other small earthquakes were felt in western Washington this quarter. See Table 4 for details.

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). "L" and "S" type events are listed in the catalog, but not shown in Figure 4. Although 11 events flagged "L" or "S" events were located at Mount Rainier this quarter, 292 additional "L" or "S" events were recorded, but were too small to locate reliably.

A total of 33 tectonic events (14 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, 19 were located in the "Western Rainier

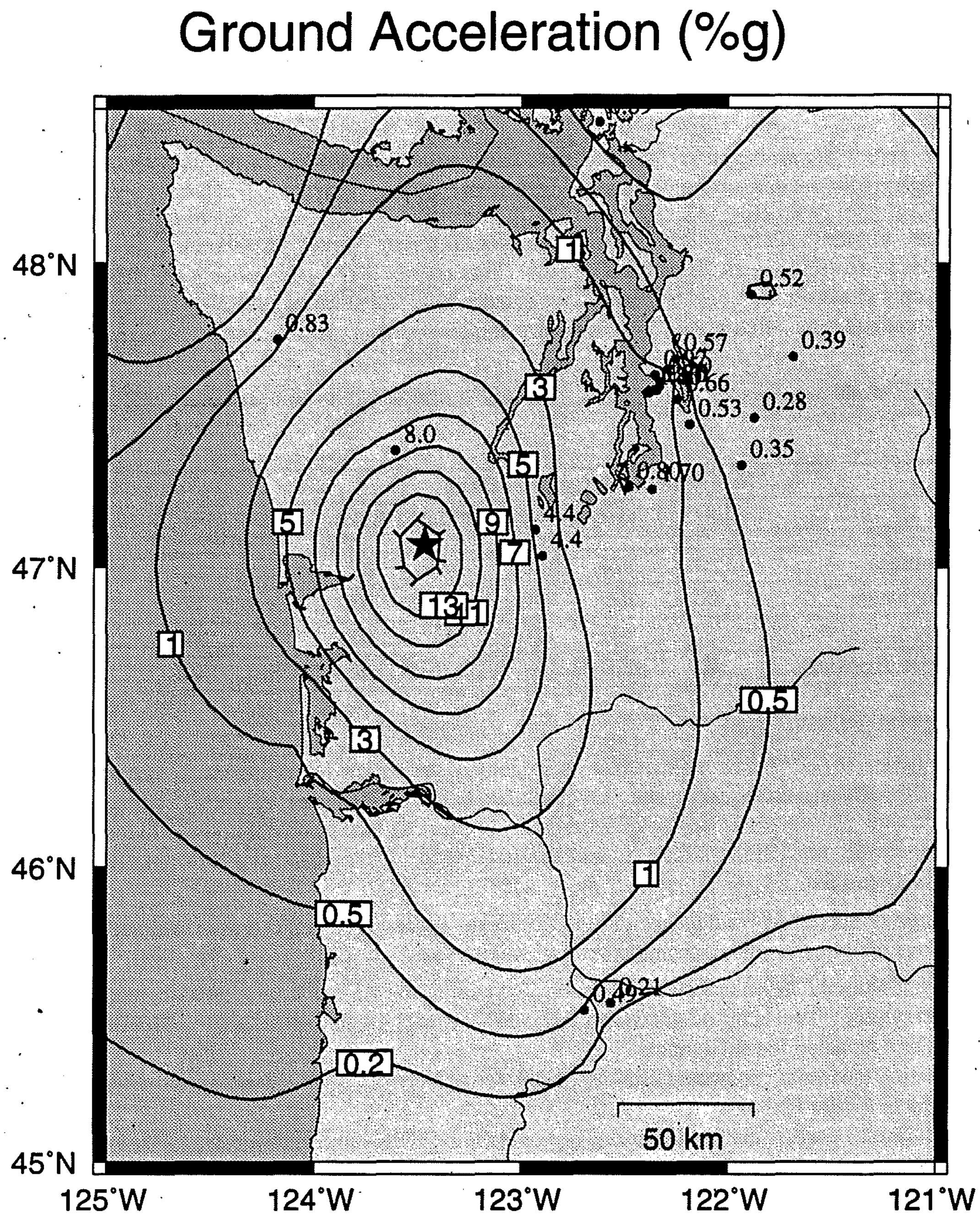

Figure 6. Draft map of peak ground accelerations for the July, 3, 1999 Satsop earthquake that occurred at a depth of 42 kilometers. The focus of this earthquake was in the subducting Juan de Fuca plate, not in the overlying North America plate. The map shows recorded ground accelerations in percent of g (1 g = 9.8 m/sec**2). The measured accelerations were determined from a combination of the PNSN's digital real-time accelerographs and broad band seismic stations, plus information from old-style USGS accelerometers. Some of the stations used to contour the data lie off the map in Oregon, Canada, and eastern Washington. The star shows the epicenter of the earthquake. The contours show a smoothed version of the expected ground accelerations modified by the actual observations.

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 earthquakes near Mt. Rainier this quarter was magnitude 1.7.

This quarter, there were 8 higher-frequency tectonic-style earthquake 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 133 earthquakes were located at Mt. St. Helens in the area shown in Fig. 5. Of these 35 were magnitude 0.0 or larger and 50 were deeper than 4 km, including 7 larger than magnitude 0.0. The largest tectonic earthquake at Mount St. Helens this quarter was magnitude 1.2

Two type "S" or "L" event was located at Mount St. Helens, and 409 "S" events too small to locate were recorded.

Mt. St. Helens activity, 1998-1999							
	98-A	98-B	98-C	98-D	99-A	99-B	99-C
Located earthquakes	**293**	**776**	**1107**	**349**	**122**	**133**	**133**
Magnitude 0 or larger	**73**	**205**	**302**	**65**	**32**	**25**	**35**
Deeper than 4 km and M>0.0	**57**	**141**	**232**	**52**	**21**	**10**	**8**
Unlocated Crater Rockfalls	**21**	**120**	**565**	**115**	**26**	**28**	**409**

EASTERN WASHINGTON SEISMICITY

During the third quarter of 1999, 55 earthquakes were located in eastern Washington in the area described in Table 4A. The largest earthquakes were on Sept. 19; at 04:21 UTC and 11:11 UTC; magnitudes 3.1 and 3.2 respectively. Both were at depths of more than 12 km; quite deep for this area. The earlier event was located about 28 km NNE of Prosser, and the later about 33 km NW of Prosser. Neither event was reported to have been felt.

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

During the first six months of 1999, the PNSN located 67 events in the E3 model area, which encompasses the Hanford Reservation. The Hanford Network located 77 events in the same area. A cursory examination of the locations revealed the following:

- Some events that were designated "E3" by the Hanford Network were located in other velocity model areas by the PNSN
- For well located events (quality factors AB or better), the PNSN and Hanford Network locations compared well, usually within a kilometer of one another. However, depths sometimes showed considerable variation between the two networks, as much as 7 km difference in some cases, and magnitudes also varied - by as much as .4 units.
- For less well located events, particularly for those with a poor distribution of stations around the event, both the location and depth differences were larger. The location difference for an event for which both networks had an azimuthal gap of over 200 degrees (near Prescott, WA) was more than 7 km.
- For an event near Yakima that was completely outside the Hanford area, but was very well located by the PNSN, the difference in location was nearly 10 km, with a similar disagreement in the depth determination.
- The worst magnitude discrepancy noted was .6 units, for a probable blast with poor station coverage in both networks.

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail or FAX 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 is 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: Northwest Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephone: (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** ≤ 90° and **DMIN** ≤ (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 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

Earthquakes and Blasts, Magnitude 2.0 or larger, Third Quarter, 1999.

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

July 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	05:22:19.30	47 22.10	122 23.95	27.08	3.1	66/72	26	0.33	CA	P3	F
2	19:12:45.79	44 03.30	120 52.57	0.03*	2.6	11/11	157	0.21	BC	O0	
3	01:43:54.37	47 04.44	123 27.82	40.65#	5.1	51/52	85	0.21	BA	P3	F
8	23:27:42.20	45 49.54	118 05.25	34.56$	2.4	20/27	286	0.43	CD	E3	
9	07:45:42.51	47 03.80	123 28.07	39.80	2.1	51/57	86	0.22	BA	P3	F
9	08:07:39.39	47 03.67	123 27.50	40.05	2.3	56/61	84	0.27	BA	P3	
16	05:58:24.03	45 39.04	122 46.51	19.69	2.3	31/33	62	0.14	AA	C3	F
16	05:59:59.94	45 39.06	122 46.53	18.85	2.3	33/33	62	0.18	BA	C3	F
16	21:34:03.74	45 38.93	122 46.17	18.11	3.1	33/39	62	0.14	AA	C3	F
18	00:41:59.62	48 02.63	122 04.19	0.87	2.1	28/35	71	0.38	CC	P3	
22	18:56:44.60	48 13.33	117 55.18	0.05#	2.0	6/07	307	0.42	CD	N3	
23	18:21:14.68	44 24.68	121 00.29	6.12	2.3	5/05	222	0.14	BD	O0	
24	08:51:37.65	45 55.68	119 12.82	2.66$	2.5	27/29	155	0.31	CC	E3	
27	12:59:53.73	47 46.39	121 51.96	4.50	2.2	26/34	64	0.18	BB	P3	
28	23:46:58.73	45 10.19	120 01.53	17.19	2.1	7/09	187	0.25	BD	O0	

Aug 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	20:14:31.91	42 27.20	122 41.94	10.40	2.0	7/08	98	0.12	BC	K3	
19	10:09:27.19	48 56.93	117 48.45	38.62*	2.3	7/08	328	0.92	DD	N3	
19	13:16:54.59	47 37.79	123 09.53	46.76	3.1	36/37	67	0.16	BA	P3	
20	15:19:32.58	47 32.82	119 20.09	10.80$	2.1	20/26	83	0.54	DB	N3	
22	19:36:51.50	48 08.80	122 46.88	21.27	2.0	29/34	48	0.47	CB	P3	
24	20:53:33.06	46 19.46	122 52.57	7.46	2.3	11/11	124	0.07	AC	P3	
25	17:48:43.49	47 45.53	121 51.68	7.43	2.0	29/40	80	0.30	CB	P3	F
31	23:03:07.08	45 11.17	120 05.45	3.55*	3.5	30/35	163	0.35	CC	O0	

Sept 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	20:33:21.90	45 12.07	120 01.28	15.87	2.0	5/05	240	0.06	BD	O0	
3	07:16:18.70	47 30.27	123 07.67	0.02*	2.9	38/44	80	0.30	BC	P3	F
4	01:51:06.27	45 10.65	120 04.62	1.28	2.9	29/36	148	0.40	CC	O0	
5	18:01:36.50	47 10.06	123 07.31	46.47	2.8	54/62	50	0.19	BA	P3	F
7	01:05:08.05	45 09.57	120 05.14	0.02*	2.1	8/08	149	0.14	BC	O0	
8	07:41:17.16	47 33.77	120 20.02	7.91	2.6	38/44	48	0.24	BC	N3	
8	19:17:35.21	45 10.36	120 06.56	0.92$	2.0	8/08	174	0.31	DC	O0	
13	22:39:30.78	47 44.11	122 28.78	22.05	2.2	38/51	59	0.20	BA	P3	
14	19:24:54.47	43 17.76	122 50.52	0.02*	2.0	4/05	145	0.30	BD	O0	
19	04:21:44.41	46 26.48	119 37.54	19.88	3.1	36/39	35	0.25	BA	E3	
19	11:11:52.92	46 23.55	120 06.37	12.38*	3.2	44/47	32	0.21	BB	E3	
20	11:16:54.06	47 36.41	121 45.86	16.93	2.8	55/72	34	0.23	BA	P3	F
20	12:00:52.08	47 36.26	121 46.19	15.95	2.1	49/58	34	0.25	BA	P3	
22	10:21:52.21	45 53.54	118 11.96	5.21	2.3	18/27	297	0.38	CD	E3	
23	13:24:37.53	46 11.49	122 09.80	0.04*	2.3	8/08	72	0.87	DA	S3	S
24	15:50:36.97	46 41.06	121 22.41	7.28	2.2	48/56	67	0.15	BB	C3	
24	23:12:59.35	47 38.77	120 12.46	0.83	2.2	5/05	172	0.12	AD	N3	
26	00:24:03.48	47 36.96	122 11.14	5.68	2.0	25/27	38	0.22	BB	P3	

QUARTERLY NETWORK REPORT 99-D
on
Seismicity of Washington and Oregon

October 1 through December 31, 1999

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 1434-HQ-98-AG-01937

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 fourth quarterly report of 1999 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. Some earthquake locations may be revised if new data become available, such as P and S readings from Canadian or USGS CALNET seismograph stations. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1 shows a map view of stations operating during the quarter, and 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. As is typical, stations generally functioned well during the fourth quarter, after the end of the maintenance season, and before the worst of the winter weather.

Station, RSU, installed at the summit of Mt. Rainier on August 20, 1999, ceased operating at the end of September. We will strengthen the antenna next summer, as soon as the station becomes accessible.

Strong-motion Instrumentation and Recording Update

A new strong motion station, TKCO, was installed at the King County Emergency Operations Center, located at the King County Airport.

A GPS survey of the location of our broad-band and strong-motion equipment at Seward Park (previously called SPW) led to the station being renamed SP2. Prior to1997, this site consisted of a short-period seismometer at the SPW location. Since July, 1997 the broad-band and strong-motion equipment have been located at the SP2 site.

CREST Instrument Update

The PNSN configured and tested an EARTHWORM node for Oregon, named dweezle, to be run at the University of Oregon (UO) by technician Pat Ryan. The new node, plus CREST equipment for two stations was shipped to UO, and installation is expected early in 2000.

EARTHWORM Y2K Progress Report

Y2K compliance efforts paid off at the end of this quarter, when the new millennium arrived without major software or hardware problems.

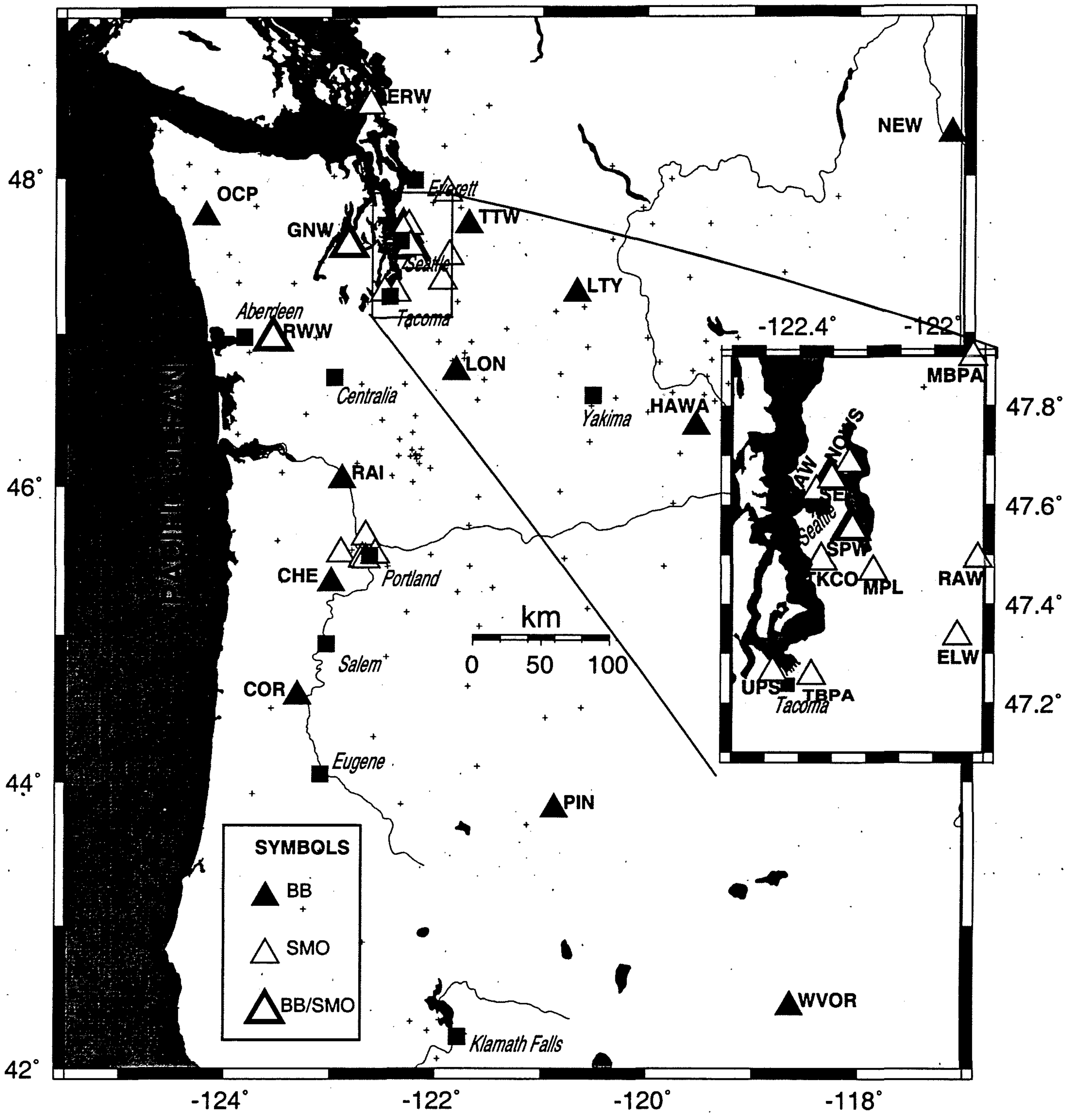

Figure 1: Stations operating at the end of the fourth quarter, 1999. Small + signs represent short period stations. Cities are shown as squares. Filled triangles represent broad-band stations. Strong motion stations are shown as unfilled triangles. Stations which have both broad-band and strong-motion components are shown as an unfilled triangle with a heavy border.

TABLE 1
Station Outages, Repairs, and Installations 4th quarter 1999

Station	Outage Dates	Comments
BLN	8/3-9/21	Repaired - Rebuild station
ETW	4/2-end	Dead, searching for another site
ERW	8/5-09/10	Repaired - communication system repaired
GBL	10/12-End	Dead
GMW	9/1/98-9/22	Came back by itself
LCW	4/27-End	Dead
LVP	3/1-08/10	Repaired
MEW	11/16[illegible]-end	Dead - Bad seismometer
NLO	8/97-End	Intermittent
OSD	7/98-10/10	Repaired - Replaced VCO, Battery and seismometer
TKO	1/4-End	Dead - Winter damage
RCS	11/15-End	Dead - Winter conditions
RSU	09/30-End	Dead - Winter conditions
SPW		NAME CHANGED TO SP2
TKCO		INSTALLED

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 1434-HQ-98-AG-01937. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. "C" indicates USGS Cal-net stations received via EARTHWORM. 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 operating during the fourth quarter 1999

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 39.6	119 52 59.4	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
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
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
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
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
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

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
KEB	C	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	C	41 49 51.0	123 52 33.0		CAL-NET
KTR	C	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	C	41 36 35.2	122 37 32.1	1.769	CAL-NET
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	Linction 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
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (BB,LONLZ)
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 Center
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	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
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
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
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
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
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens Dome
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.
SND	%	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectified
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 fourth quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
CHE		45 21 16.0	122 59 19.0	0.436	Chehalem, Oregon (Operated by UO)
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU).
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)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire, WA (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 (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)
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.

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 an Internet earthworm system

TABLE 2C

Strong-motion three-component stations operating at the end of the fourth quarter 1999. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALST	%	46 6 31.2	123 01 47.4	0.000	Alston, Oregon BPA	A20	E
CSO	#	45 31 01.0	122 41 22.5	0.036	Canyon Substation, Oregon	FBA23	D
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	L
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	L
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
KEEL	%	45 33 0.0	122 53 44.40	0.000	Keeler, Oregon BPA	A20	E
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	0.00	NOAA, Bldg 3	A20	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
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte, Oregon	FBA23	D
ROSS	%	45 39 46.2	122 39 37.0	0.100	Ross BPA	A20	L,E
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
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
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 56.1	122 28 58.4	0.113	U. Puget Sound	A	D,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.geophys.washington.edu/SEIS

Special Events

- The PNSN participated in an all-day long geologic hazards and mitigation fair "Disaster Saturday", on October 2nd. This event was sponsored by Seattle Project Impact and took place at Seattle Central Community College. The event was opened by Seattle Mayor Paul Schell and was attended by about 800 people. The PNSN coordinated the hazards and engineering program mounting a poster session with 20 exhibits developed by UW, USGS, and WA Dept. of Natural Resources scientists and City of Seattle GIS engineers.
- Bill Steele and Brian Atwater made presentations to the Makah Emergency Response Committee in Neah Bay on earthquake and tsunami hazards and will continue to serve the tribe as geologic hazards scientific resources. Rangers from the Olympic National Park were also briefed.
- Ruth Ludwin and Brian Atwater attended a meeting of the Intertribal Cultural Advisory Commitee at Port Angeles on the Olympic Peninsula.

- Ruth Ludwin, Bill Steele, and Brian Atwater have begun work to develop an exhibition for the Burke Natural History Museum to open in the summer of the year 2002.
- Bill Steele is participating in the development of 8/2001 conference of the International Tsunami Society to be held on the campus of the University of Washington.
- The US Navy Emergency Preparedness Liaison Officers (EPLO) Western Regional Group received a briefing at Sub Base Bangor. PNSN staff also addressed the November meeting of the Society of Military Engineers in Seattle.
- The PNSN participated in meetings with public officials and the public of Grays Harbor County in Aberdeen WA, to review newly developed tsunami inundation maps developed for coastal communities as part of The National Tsunami Hazard Mitigation Program.
- Bill Steele consulted with faculty in the Department of Urban Design and Planning in development of the new UW Institute for Hazard Mitigation Planning and Research. (see: http://www.depts.washington.edu/mitigate/)
- The PNSN continues to contribute to the Seattle and Pierce, King County Project Impact Programs and the Cascadia Regional Earthquake Workgroup.

Press Interviews, Lab Tours, and Workshops

PNSN staff provided a few television, radio, or press interviews this quarter. We provided 16 lab tours for K-12 students this quarter with a total of 470 participants, and 5 other public presentations to ~150 people this quarter.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 600 calls this quarter. 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. This quarter we responded in person to: Emergency Management and ~45 calls from emergency management and government, ~70 calls from the media, ~45 calls from educators, ~45 from the business community, and about 160 calls from the general public.

The list of recent Pacific Northwest earthquakes can be accessed by a variety of methods beyond the audio library described above: via our World-Wide-Web site, through the Internet with the UNIX "finger" utility, or by e-mail or modem. The computer methods have an advantage over the audio library. Not only are more earthquakes listed, but update is automated, and the location and magnitude information is available more rapidly. Table 3 shows the number of times the computerized PNSN list of recent earthquakes magnitude 2.0 or larger was accessed.
The Internet UNIX utility "finger quake@geophys.washington.edu" was most popular, followed by access over the WWW. For computer users without direct access to Internet, this information can be accessed via e-mail (by sending e-mail to "quake@geophys.washington.edu").

The PNSN recent earthquake list, and much more, is also available through the World-Wide-Web (WWW) at:

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

TABLE 3
Accesses of PNSN "Most recent earthquakes M>=2.0" list
Quarterly Comparison

Access Method	97-D	98-A	98-B	98-C	98-D	99-A	99-B	99-C	99-D
Finger Quake	118,000	124,000	113,367	122,429	113,430	105,557	99,451	87,981	111,000
World-Wide-Web	34,700	50,000	55,600	49,000	47,400	41,700	34,000	64,000	42,000

Web usage of the entire suite of PNSN web pages was about 230,000 visits per month.

The PNSN web-site offers web pages for Mt. St. Helens, Mt. Hood, and Mt. Rainier that include a map and list of the most recent PNW earthquakes, plus general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Quarterly summaries of seismicity extracted from these reports are also included. "Webicorder" pages allow Web visitors to view continuous data from six PNSN seismographic stations at:

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

For larger earthquakes, the PNSN has a standard set of web pages that are generated automatically using preliminary information, at the same time that the initial page is sent to seismologists. Features offered include a "felt form" that readers can fill out, several maps of the regional area and immediate vicinity of the earthquake, a list of other sizable earthquakes known historically, a list of the nearest strong-motion sites, focal mechanisms, and strong motion trace-data.

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

- **Seismosurfing** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. About 26,000 visits were made to this page each month. This page is mirrored at two sites in Europe.

  http://www.geophys.washington.edu/seismosurfing.html
- The **Council of National Seismic Systems** (CNSS) site features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system. The CNSS site was visited about 43,000 times per month this quarter.

  http://www.cnss.org
- The **"Tsunami!"** web site offers many pages of information, including an excellent discussion on the physics of tsunamis, and short movie clips. **"Tsunami!"** was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering). It is very popular, with about 239,000 visits a month.

  http://www.geophys.washington.edu/tsunami
- The UW Geophysics Program **Global Positioning System (GPS)** web site provides information on geodetic studies of crustal deformation in Washington and Oregon. The GPS site received about 1,500 visits per month this quarter.

  http://www.geophys.washington.edu/GPS/gps.html

EARTHQUAKE DATA - 1999-D

There were 1313 events digitally recorded and processed at the University of Washington between October 1 and Dec. 31, 1999. Locations in Washington, Oregon, or southernmost British Columbia were determined for 660 of these events; 610 were classified as earthquakes and 50 as known or suspected blasts. The remaining 653 processed events include teleseisms (148 events), regional events outside the PNSN (74), 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 and retrieve broad-band data for some of them.

Table 4 is a listing of all earthquakes reported to have been felt during the this quarter. Table 5, located at the end of this report, is this quarter's catalog of earthquakes and blasts, 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 ($M_c \geq 0$).

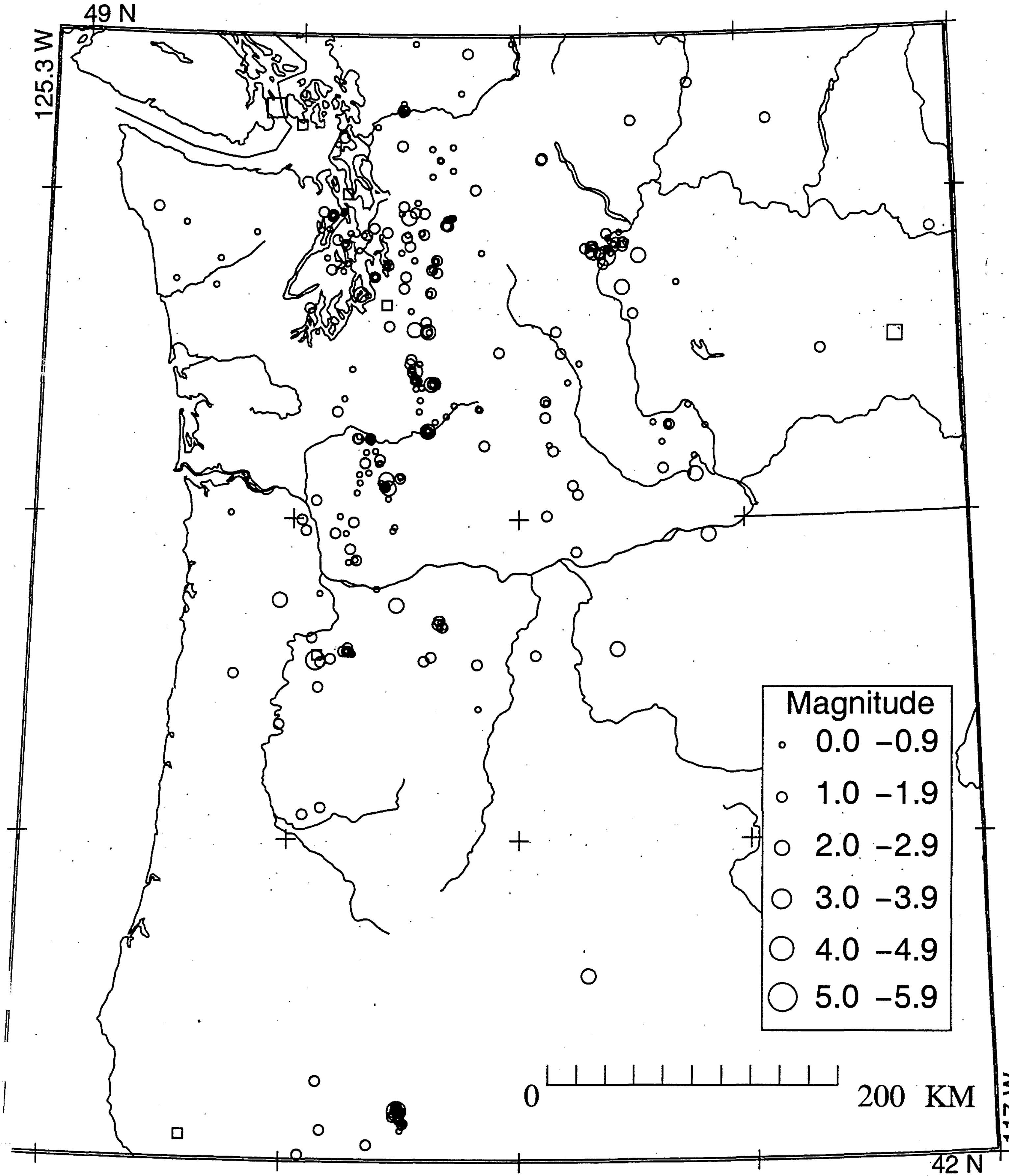

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than or equal to 0.0 during the fourth quarter of 1999. Square symbols indicate events located at depths of 30 km or more.

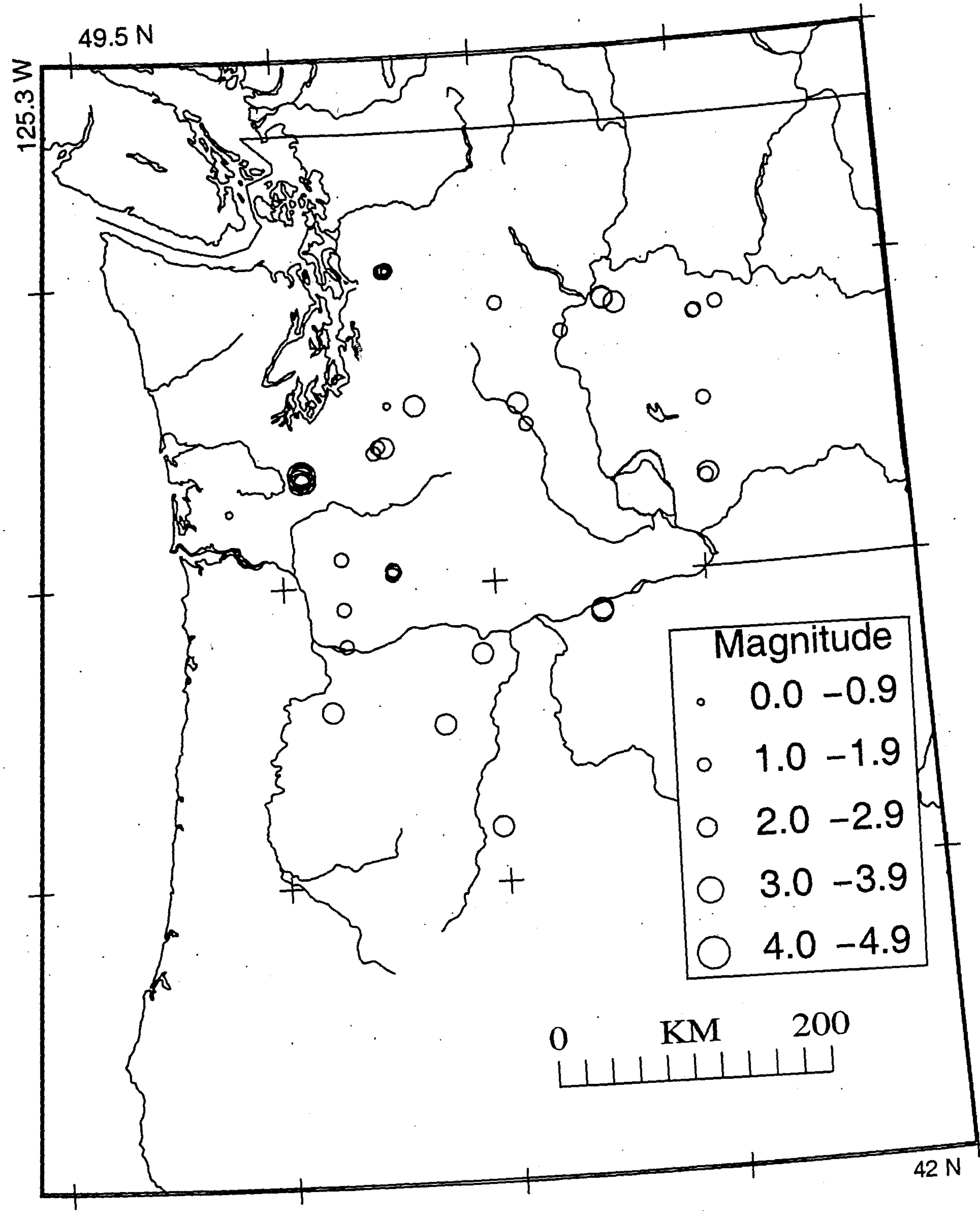

Figure 3: Blasts and probable blasts, fourth quarter, 1999.

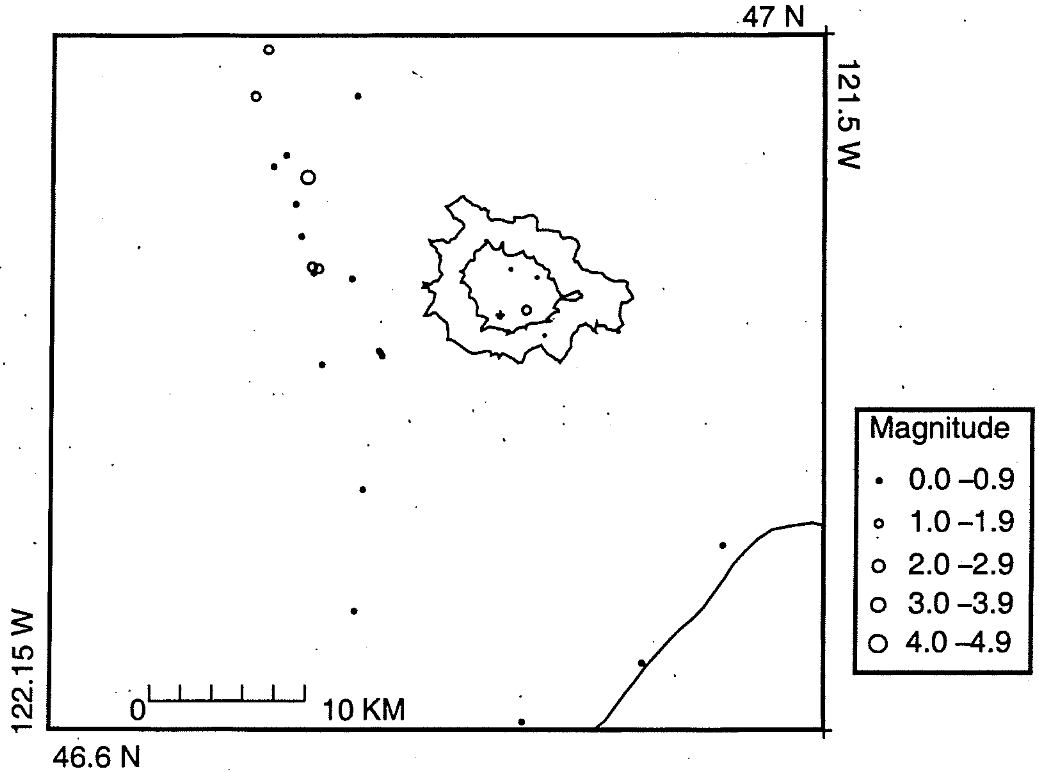

Figure 4: Earthquakes located in the Mt. Rainier area fourth quarter, 1999. All events shown are greater than magnitude 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper.

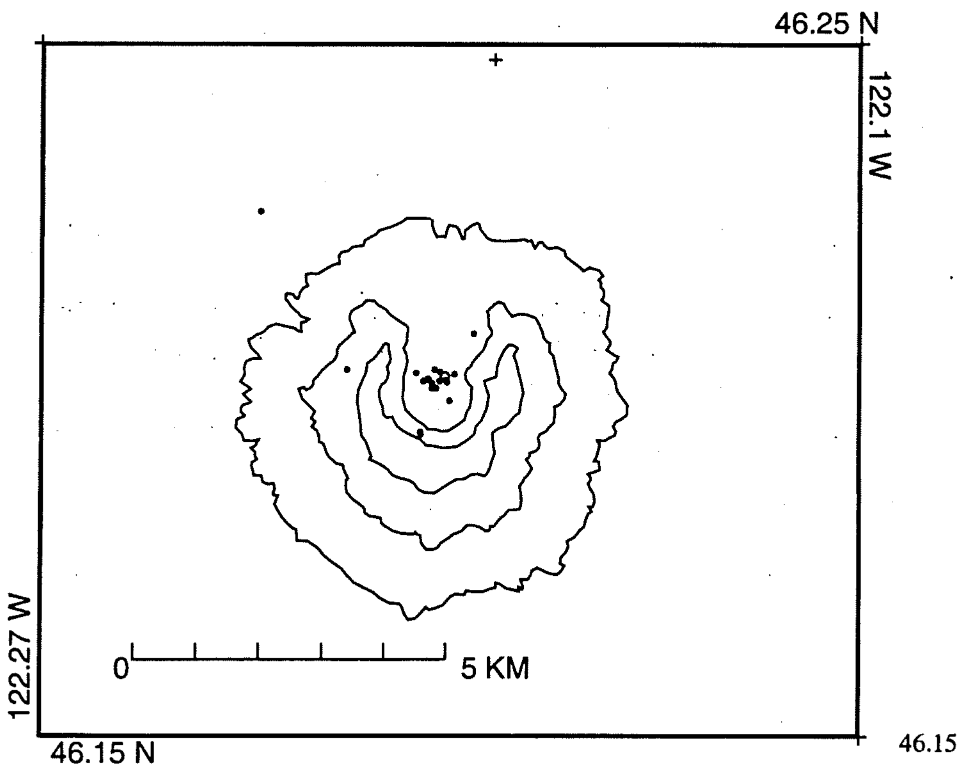

Figure 5: Earthquakes located in the Mt. St. Helens area fourth quarter, 1999. All events shown are greater than magnitude 0.0. Contours shown are at 5,000, 6,400 and 7,500 feet elevation. "Plus" symbols represent earthquakes shallower than 1 km depth, while circles represent earthquakes at 1 km or deeper. Symbol scaling as in Fig. 4.

TABLE 4 - Felt Earthquakes during the 4th Quarter of 1999

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
99/10/03 10:50:29	46.54N	121.81W	3.7	2.5	28.2 km W of Goat Rocks
99/11/16 20:51:16	47.86N	122.00W	19.7	2.5	2.7 km WNW of Monroe, WA
99/11/21 11:33:45	45.46N	122.07W	13.6	2.6	31.3 km WNW of Mount Hood, OR
99/11/25 14:46:15	45.11N	122.78W	28.3	3.4	6.5 km ESE of Woodburn, OR
99/11/29 04:04:15	42.31N	122.01W	7.0	3.4	22.2 km WNW of Klamath Falls, OR
99/12/11 12:53:40	48.53N	123.24W	49.2	3.7	14.4 km NNE of Victoria, BC
99/12/25 06:49:58	48.70N	125.91W	10.0	4.0	49.0 km S of Tofino, BC
99/12/25 07:01:49	48.62N	125.93W	10.0	3.2	58.3 km S of Tofino, BC

OREGON SEISMICITY

During the fourth quarter of 1999 a total of 153 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. Three earthquakes were reported felt in Oregon this quarter; near Mt. Hood, near Woodburn, and near Klamath Falls. See Table 4 for details.

In the Klamath Falls area, 118 earthquakes were located this quarter. This is the largest number of earthquakes located in the Klamath Falls area since the third quarter of 1994.

Since 1994, most earthquakes northwest of Klamath Falls have been considered aftershocks of a pair of damaging earthquakes in September of *1993* (Sept. 21, 03:29 and 05:45 UTC; M_c 5.9 and 6.0 respectively). The 1993 earthquakes were followed by a vigorous aftershock sequence which decreased over time.

The earthquakes this quarter may be independent of the 1993 activity, as at least some of the locations appear to be on a completely different fault segment. This quarter, a felt earthquake of magnitude 3.4 (see Table 4 for details). was followed by 84 aftershocks on November 29 (UTC), all smaller than magnitude 2.0. This quarter's earthquake was the largest near Klamath Falls since 1996.

WESTERN WASHINGTON (and southern British Columbia) SEISMICITY

During the fourth quarter of 1999, 394 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 this area, the largest was in British Columbia. On December 11, at 12:53 UTC, a magnitude 3.7 (the Canadia Pacific Geoscience Centre (PGC) reports this event as a magnitude 4.0) earthquake at a depth of nearly 50 km occurred about 14 km NNE of Victoria, British Columbia. This earthquake, in a well-populated area, was felt by quite a few people. PGC reports that most people in Victoria were awakened. Many reported a noise, and some pictures were knocked askew. A few unstable items fell off shelves, but no damage was reported. The earthquake was also felt in greater Vancouver, Abbotsford, Gibsons Bellingham (WA), Duncan, Chemainus, Nanaimo, Sooke, and Mill Bay. Two other smaller events, near Monroe and the Goat Rocks Wilderness, were reported felt in western Washington this quarter. Table 4 gives details.

Also worthy of brief mention are two other felt earthquakes outside the area we usually cover (they are listed in Table 4, but not shown in Figure 2). These were located west of Vancouver Island. The first event, PNSN magnitude 4.0 (the PGC reports this event as magnitude 4.2) on Dec. 25 (UTC), was reported felt in British Columbia (to the PGC). The reporting locations were Ucluelet and Tofino on the west coast of Vancouver Island; and Nanaimo, Duncan, Parksville, and Hornby Island on the east coast of the Island. It was followed by two aftershocks (PGC magnitudes 3.2 and 3.3), one of them felt, within 30 minutes of the mainshock.

This quarter, the deepest event recorded by the PNSN was a magnitude 1.5 earthquake at approximately 64 km depth. It occurred on October 24 at 13:33 UTC, about 14.8 km SW of Maple Valley, WA.

TABLE 4A 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" and "Blasts". The remaining numbers are counts of earthquakes only 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 at Mt. St. Helens (MSH) are between 46.15-46.25 degrees north latitude and 122.10-122.27 degrees west longitude, and earthquakes near Mt. Rainier are between 46.6-47.0 degrees north latitude and 121.5-122.15 degrees west longitude. "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.

TABLE 4A Comparison of quarterly earthquake counts over several years

Year	Q	Total	Quakes	Blasts	western WA	MSH	Rainier	eastern WA	OR
1993	A	**457**	380	77	**267**	34	77	**32**	**72**
	B	**450**	384	66	**284**	63	62	**57**	**33**
	C	**727**	579	148	**368**	82	75	**65**	**141**
	D	**2616**	2556	60	**355**	82	92	**39**	**2157**
1994	A	**1585**	1501	84	**232**	43	73	**44**	**1222**
	B	**873**	775	98	**350**	60	130	**56**	**364**
	C	**822**	656	166	**379**	67	81	**62**	**208**
	D	**555**	506	49	**236**	52	44	**55**	**211**
1995	A	**488**	426	62	**273**	18	38	**47**	**101**
	B	**726**	636	90	**438**	104	91	**58**	**134**
	C	**1072**	924	148	**693**	318	84	**75**	**138**
	D	**687**	610	77	**484**	264	41	**41**	**70**
1996	A	**504**	434	70	**303**	82	56	**53**	**75**
	B	**967**	864	103	**752**	68	57	**39**	**72**
	C	**696**	544	152	**426**	83	75	**45**	**67**
	D	**476**	387	89	**312**	65	59	**45**	**29**
1997	A	**417**	353	64	**270**	49	47	**45**	**34**
	B	**525**	473	52	**386**	70	31	**65**	**21**
	C	**633**	568	65	**473**	183	45	**66**	**28**
	D	**680**	614	66	**505**	292	47	**56**	**45**
1998	A	**692**	639	53	**478**	293	35	**57**	**106**
	B	**1248**	1183	65	**1048**	776	47	**74**	**58**
	C	**1727**	1635	92	**1464**	1107	76	**84**	**86**
	D	**1373**	729	43	**620**	349	69	**60**	**49**
1999	A	**474**	449	25	**248**	122	16	**49**	**148**
	B	**469**	407	62	**277**	134	31	**45**	**84**
	C	**592**	505	87	**391**	133	44	**55**	**58**
	D	**660**	610	50	**394**	148	50	**62**	**118**

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). "L" and "S" type events are listed in the catalog, but not shown in Figure 4. Although only 2 events flagged "L" or "S" events were located at Mount Rainier this quarter, 61

additional "L" or "S" events were recorded, but were too small to locate reliably.

A total of 48 tectonic events (21 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 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 earthquakes near Mt. Rainier this quarter was magnitude 2.0.

This quarter, there were 14 higher-frequency tectonic-style earthquake 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 148 earthquakes were located at Mt. St. Helens in the area shown in Fig. 5. Of these 23 were magnitude 0.0 or larger and 61 were deeper than 4 km, including 4 larger than magnitude 0.0. The largest tectonic earthquake at Mount St. Helens this quarter was magnitude 2.4

Two type "S" or "L" event were located at Mount St. Helens, and 236 "L" or "S" events too small to locate were recorded.

Mt. St. Helens activity, 1998-1999							
	98-B	98-C	98-D	99-A	99-B	99-C	99-D
Located earthquakes	**776**	**1107**	**349**	**122**	**133**	**133**	**148**
Magnitude 0 or larger	**205**	**302**	**65**	**32**	**25**	**35**	**23**
Deeper than 4 km and M>0.0	**141**	**232**	**52**	**21**	**10**	**8**	**4**
Unlocated Crater Rockfalls	**120**	**565**	**115**	**26**	**28**	**409**	**236**

EASTERN WASHINGTON SEISMICITY

During the fourth quarter of 1999, 62 earthquakes were located in eastern Washington in the area described in Table 4A. The largest earthquake in eastern Washington this quarter occurred about 4 km south of Entiat, Washington on December 25 at 22:49 UTC. It had a magnitude of 3.0 and a depth of about 7 km and was not reported to have been felt.

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

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail or FAX 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 is 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: Northwest Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephone: (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

Earthquakes and Blasts, Magnitude 2.0 or larger, Fourth Quarter, 1999.

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

Oct 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	14:40:15.60	46 11.65	122 09.27	0.01#	2.5	6/06	128	1.37	DC	S3	S
3	10:50:29.80	46 32.83	121 48.89	3.72	2.5	52/60	59	0.14	AC	C3	F
4	20:04:18.15	45 31.40	121 09.27	1.05	2.4	4/04	106	0.46	CD	C3	P
4	22:31:53.00	46 45.17	122 48.06	5.31	3.0	7/09	114	0.29	CC	P3	P
5	22:21:13.28	45 03.73	121 32.10	0.02*	2.4	5/06	150	0.47	CD	O0	P
10	19:53:48.30	43 09.29	120 24.32	6.38	2.6	12/13	125	0.64	DD	O0	
11	04:36:32.48	46 50.31	121 47.03	0.05*	2.1	22/23	65	0.17	BA	C3	L
18	21:21:41.27	46 44.72	122 48.01	0.02*	2.6	9/10	83	0.15	AC	P3	P
18	23:17:18.25	46 16.62	119 25.12	1.01*	2.2	20/21	93	0.39	CC	E3	
19	12:12:54.90	47 39.28	120 19.19	4.85	2.8	41/52	50	0.33	CC	N3	
19	16:56:47.28	45 29.39	123 06.36	16.05	2.8	16/17	154	0.41	CC	O0	
21	23:44:32.88	45 53.90	119 18.93	0.24	2.4	19/23	127	0.30	BC	E3	
22	12:56:39.75	46 14.85	122 10.54	0.02*	2.4	6/06	210	0.70	DD	S3	
22	20:56:34.64	46 42.49	122 46.56	4.12	2.4	11/11	99	0.18	BC	P3	P
28	21:13:18.17	47 37.96	119 54.16	0.03*	2.3	8/08	89	0.20	BB	N3	

Nov 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	01:51:30.53	47 11.30	121 41.69	0.16	2.3	11/11	89	0.64	DB	C3	P
2	21:36:38.33	47 10.26	120 41.29	2.65	2.5	15/17	78	0.43	CB	C3	P
3	23:21:18.66	46 42.04	122 49.27	23.62*	2.7	13/13	105	0.21	BB	P3	P
5	19:24:02.63	47 26.42	120 03.51	0.02*	2.5	13/15	72	0.42	CC	N3	
10	22:14:08.41	46 45.76	122 47.94	4.55$	2.7	8/09	77	0.26	BC	P3	P
16	20:51:16.84	47 52.03	122 00.26	19.72	2.5	45/49	38	0.18	BA	P3	F
19	20:26:58.14	47 49.99	119 48.53	0.40	2.3	9/09	106	0.16	BC	N3	P
21	11:33:45.87	45 27.94	122 04.50	13.59	2.6	49/53	65	0.27	BA	O0	F
22	23:27:07.71	46 37.42	118 54.21	0.78	2.0	17/17	196	0.17	BD	E3	P
24	23:36:19.67	47 06.15	117 36.05	36.06#	2.1	8/10	319	0.50	DD	N3	
25	14:46:15.63	45 07.00	122 46.84	28.31	3.4	51/52	94	0.34	CB	O0	F
26	21:31:40.21	45 11.56	120 07.79	0.02*	2.0	13/16	185	0.41	CD	O0	
29	04:04:15.47	42 19.15	122 01.06	6.97	3.4	17/20	106	0.34	CB	K3	F
29	07:47:28.05	47 23.64	122 26.08	17.89	2.0	41/51	52	0.14	AB	P3	
30	22:54:02.61	46 43.52	122 49.47	7.28	2.9	13/13	253	0.22	CD	P3	P

Dec 1999

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	23:54:55.96	45 46.37	119 59.69	0.02*	2.3	14/16	127	0.30	CC	E3	P
3	20:54:12.71	45 10.23	122 34.51	0.03*	2.5	5/06	211	0.22	BD	O0	P
7	06:19:54.44	47 09.80	121 49.30	15.41	2.1	47/59	35	0.16	BA	C3	
8	20:16:04.85	49 08.38	118 44.64	0.03*	2.1	8/08	239	0.05	AD	N3	
9	23:11:44.68	46 42.62	122 46.13	6.55	2.4	16/16	116	0.16	BC	P3	P
11	12:53:40.55	48 32.18	123 14.89	49.20	3.7	34/35	167	0.37	CC	P3	F
13	23:04:35.40	46 44.89	122 48.17	6.83	2.4	17/17	81	0.14	AC	P3	P
14	17:32:01.51	47 49.64	119 48.46	0.03*	2.1	9/10	105	0.12	AC	N3	P
15	00:31:00.14	47 47.57	119 41.42	0.37	2.6	15/15	130	0.42	CC	N3	P
20	16:28:15.30	47 10.52	121 56.59	18.05*	2.2	48/62	56	0.15	BA	P3	
21	22:30:30.90	46 42.37	122 46.13	0.03*	2.9	20/20	83	0.21	BC	P3	P
21	23:34:18.99	45 45.27	120 00.01	2.59	2.7	12/12	75	0.60	DC	E3	P
22	21:01:06.43	46 42.52	122 46.59	0.02*	2.4	15/15	83	0.17	BC	P3	P
22	23:56:45.26	44 21.90	121 02.67	0.02*	2.8	11/11	120	0.41	CC	O0	P
23	17:11:36.43	46 55.09	122 00.27	0.04*	2.0	8/08	162	0.11	AC	C3	P
23	23:12:03.42	46 42.68	122 46.15	8.69	2.2	15/15	84	0.15	BC	P3	P
25	03:50:31.83	46 55.07	121 56.08	13.53	2.0	36/49	54	0.15	BA	C3	
25	22:50:08.74	47 38.00	120 12.09	6.91*	3.0	31/31	44	0.33	CC	N3	

APPENDIX 2

Publications supported fully or partially under this operating agreement

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