QUARTERLY NETWORK REPORT 2003-D

on

Seismicity of Washington and Oregon

October 1 through December 31, 2003

Pacific Northwest Seismograph Network

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

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

and

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

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INTRODUCTION

This is the fourth quarterly report of 2003 from the Pacific Northwest Seismograph Network (PNSN), at the University of Washington Dept. of Earth and Space Sciences, covering seismicity of Washington and western Oregon.

Comprehensive quarterlies have been produced by the PNSN since the beginning of 1984. Prior to that we published quarterly reports for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Dept. of Earth and Space Sciences. The complete PNSN catalog is available on-line, both through our web-site and through the ANSS catalog. In these reports we provide special coverage (figures, counts, listings, etc.) of earthquake swarms, aftershock sequences, etc.

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

NETWORK OPERATIONS

Figure 1A shows a map view of stations operating during the quarter. Figure 1B is a more detailed view of stations in the Puget Sound area. Table 1 gives approximate periods of time when individual stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals and automated and manual digital and analog signal checks, plus records of maintenance and repair visits. This quarter, the list of station outages is somewhat longer than usual. This is likely due to typical winter functionality problems, and may also reflect improved tracking of station functionality using SeisNetWatch (discussed in Software Update section).

Strong Motion Instrumentation Update

The primary activity for the strong motion network this quarter has been replacement of non-volatile memory in the Kinemetrics K2 seismographs. The K2 uses flash memory that fails after approximately 2 years of use. We have begun replacing all flash memory in older K2 units.

George Thomas provided seismic monitoring system designs to the Seattle DOT. S-DOT is currently planning on installing 5 strong motion seismographs along DOT facilities in the Seattle area. The efforts are being coordinated with the Duwamish array monitoring project.

Amy Lindemuth installed a temporary broadband sensor at station PNLK (Pine Lake Middle School) on November 7, 2003. Data are being digitized by the existing K2. This sensor is a research quality instrument developed by Guralp Systems for use in our school network. The sensor is considerably less expensive than traditional broadband sensors and can be purchased by schools to augment their existing strong motion station. Data from this sensor can be viewed on the web at: http://www.pnsn.org/WEBICORDER/K20B/welcome.html.

Staff from the USGS and PNSN met with engineers at the Puget Sound Naval Shipyard (PSNS) in Bremerton to plan an installation. An existing Terra Technology IDS-24 seismograph will be installed rather than purchasing a new instrument. The installation will be performed by Navy personnel in January, 2004.

Permitting and siting for new ANSS stations continued this quarter in the Duwamish Valley south of downtown Seattle. The priorities are to establish permanent seismographs at locations that recorded the 1965 Olympia earthquake and the 2001 Nisqually earthquake, and to install a 12-channel down-hole array of accelerometers and an accompanying array of piezometers. UW Civil Engineering is cooperating with other local engineers to seek funding for the piezometric array. There have been a number of permitting problems with these stations because of multiple jurisdictions and land owners. Slow progress is being made.

Computer Processing and Analysis Update

This quarter, scossa remained our main EARTHWORM computer, with milli serving as our primary backup and verme as the secondary backup. Milli and verme still serve as the principal computers for data acquisition for most of the digital stations. We are currently running EARTHWORM-V6.1. Pigia still serves as our primary digitizer.

A new high-speed, 2 CPU Linux box with RAID disc storage was brought online this quarter. This computer, grasso, will be used for research purposes and online storage of historical waveforms of frequent interest. Grasso will also be used for non time-critical processing to reduce the load on our primary processing computers.

Software Update/Product Development

Washington State Department of Transportation has funded a joint PNSN/ UW Civil Engineering proposal to improve ground-motion processing capabilities and develop fast damage estimates that would serve the emergency earthquake information needs of WSDOT. To make rapid notification much more useful for post-earthquake recovery and emergency response, we are working on the following:

- Automated ShakeMap and an associated information transmission system was implemented into our routine processing this quarter so that WSDOT will have maps of estimated peak ground acceleration with spectral breakdowns minutes after the earthquake. Since ShakeMap has been automated, we have not had a large enough earthquake in the area to test this new, automatic capability.
- Build the systems needed to provide estimated bridge damage based on ShakeMap ordinates, the Washington State Bridge Inventory, and WSDOT provided bridge fragility information. A ranked list of bridges will be produced to help prioritize bridge inspections based on probability of damage. This code has been written and will be tested and implemented early in 2004.
- ISTI (http://www.isti.com/) installed and configured **SeisNetWatch** software to monitor our real-time data quality and flow, and wrote a review report on our real-time operations including suggestions for improvements. We have evaluated their final report and have begun working on recommended areas of improvement.

CREST Instrumentation Update

A replacement site for CREST station RWW has been found at Wishkah Valley School where we can use IP connectivity. Unexpected siting problems involving power have delayed installation.

Use of PNSN Data

The IRIS Data Management Center reports 467 requests for PNSN trace-data this quarter. Nearly 106,000 traces were requested.

TABLE 1 - Station outages and installations

Station	Outage Dates	Comment
ALCT	10/17/03-10/28/03	No communications
BABE	12/17/03-End	No communications
BRO	02/04/03-End	Dead
BULL	09/08/03-11/24/03	IDS wiring problem
BUO	12/31/03-End	Dead
CDF	12/20/02-10/03/03	Power problem, aircells installed
CMM	07/25/03-12/03/03	Noisy, replaced the seismometer
ELK	07/07/03-10/21/03	Dead, animal chewed through seis. cable
ERW	09/22/03-10/01/03	No communications
EYES	08/21/03-10/20/03	IP address change
FINN	10/17/03-10/30/03	No communications
FRIS	12/29/03-End	Dead
GHW	10/09/03-End	Dead
GLK	12/09/03-End	Very noisy
GPW	12/04/03-12/23/03	Dead
HDW	12/19/03-End	Very noisy
HOLY	10/17/03-11/7/03	No communications
IRO	12/14/03-End	Dead
KNJH	09/30/03-10/16/03	K2 problem
KNJH	10/20/03-11/25/03	No communications, firewall problem
KOS	07/25/03-10/07/03	Dead
LEOT	09/01/03-11/13/03	Bad timing
LOC	06/19/03-10/03/03	Replaced seismometer cable
LON	09/23/03-12/10/03	Intermittent telemetry
MBKE	12/05/03-12/17/03	No communications
MEAN	12/20/03-End	Bad timing
MEGW	04/01/03-End	Bad timing
MPL	10/28/03-12/8/03	No communications

OBH	01/31/02-End	Temp. removed for logging
OPC	12/11/03-12/22/03	No communications
PCMD	10/31/03-11/24/03	K2 power problems
PIN	09/28/03-11/17/03	No communications
PGO	09/21/03-End	Dead
PGW	10/08/03-End	Dead
PNLK	11/7/2003	Installed a temp. broadband sensor
RCS	12/10/03-End	Intermittent
RRHS	10/17/03-11/07/03	No communications
RVC	12/05/03-End	Very noisy
RWW	10/24/02-End	Temporarily removed
SBES	10/17/03-11/10/03	No communications
SBES	12/01/03-End	No communications
SEA	12/05/03-End	Disconnected for renovation
SFER	12/30/03-End	No communications
SMW	06/20/03-End	Intermittent
SOPS	08/27/02-End	K2 flash problem
SWID	12/01/03-12/16/03	No communications
TKCO	09/30/03-10/08/03	Temporarily removed
TKCO	10/09/03-10/16/03	Bad timing, no data
TRW	07/14/02-End	Fire damage repaired, not seismic
UWFH	12/17/03-End	Temp. removed for construction
VBE	12/02/03-End	Dead
VG2	12/28/03-End	Dead
VIP	12/09/03-End	Dead
VLM	08/29/03-11/13/03	Installed new VCO & seismometer
VTH	12/13/03-End	Off freq., seis. needs to be changed

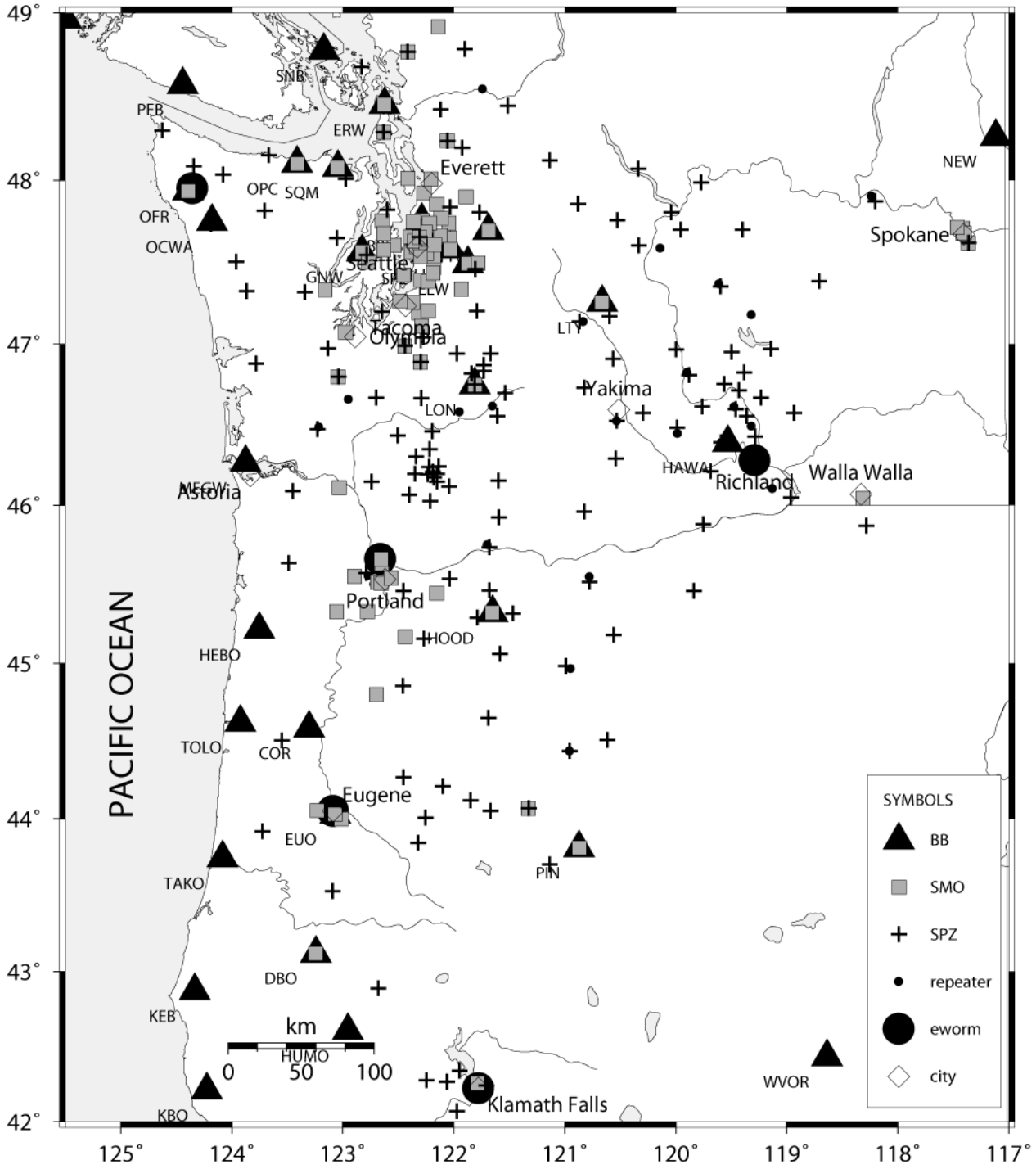

Figure 1 A. Seismograph Stations.

"BB" indicates broadband stations (Table 2B), "SMO" indicates strong motion stations (Table 2C), and "SPZ" indicates short-period stations (usually vertical component only) (Table 2A). Repeaters are sites with radio receivers and transmitters used in the transmission of seismic data to the UW via FM telemetry. "eworm" represents sites where a "mini-earthworm" system is running on a local computer to collect data for transfer to the UW via the internet.

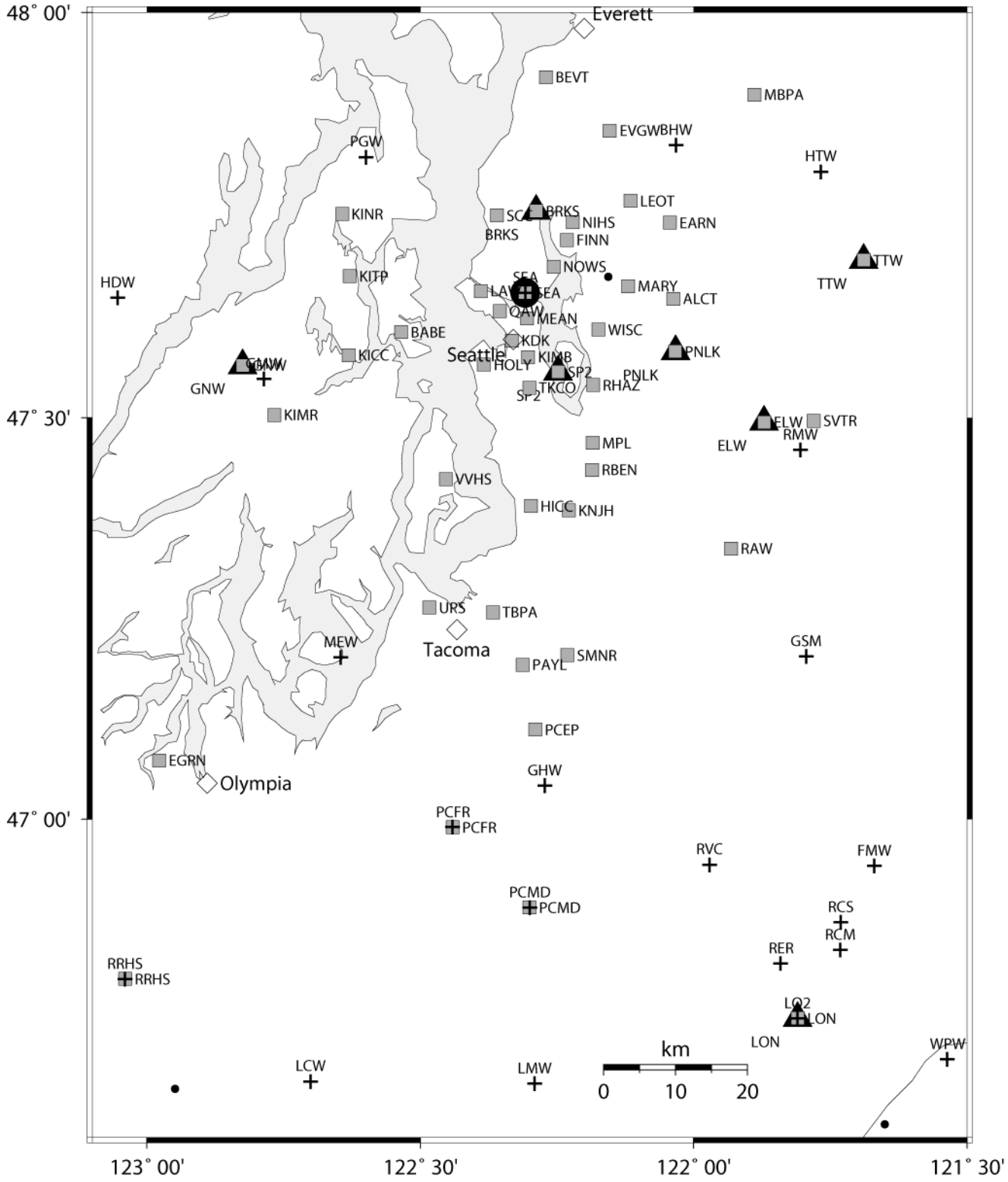

Figure 1 B. Puget Sound seismograph stations, detail of Fig. 1 A

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

TABLE 2A - Short-period Stations

STA	F	LAT	LONG	EL	NAME
		(deg. min. sec.)	(deg. min. sec.)	(km)	
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
ATES	%	48 14 10.9	122 03 33.0	0.062	Arlington Trafton ES ANSS-SMO
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, OR
BEN	H	46 31 12.0	119 43 18.0	0.335	PNNL station
BEND	%	44 04 00.8	121 19 36.0	-	UO Bend Office, DOGAMI SMO
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	0.87	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, OR
BRO	%	44 16 02.5	122 27 07.1	0.135	Big Rock Lookout, OR
BRV	+	46 29 07.2	119 59 28.2	0.92	Black Rock Valley
BSMT	M	47 51 04.8	114 47 13.2	1.95	Bassoo Peak, MT
BUO	%	42 16 42.5	122 14 43.1	1.797	Burton Butte, OR
BVW	+	46 48 39.5	119 52 56.4	0.67	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CHMT	M	46 54 51.0	113 15 07.0	-	Chamberlain Mtn, MT
CMM	%	46 26 07.0	122 30 21.0	0.62	Crazy Man Mt.
CMW	%	48 25 25.3	122 07 08.4	1.19	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.89	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	1.27	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat
FHE	+	46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
FRIS	%	44 12 44.0	122 06 01.8	1.642	Frissel Point, OR
GBB	H	46 36 31.8	119 37 40.2	0.185	PNNL Station
GBL	+	46 35 54.0	119 27 35.4	0.33	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	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, OR
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GPW	%	48 07 05.0	121 08 12.0	2.354	Glacier Peak

GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
H2O	H	46 23 44.5	119 25 22.7	0.175	Water PNNL Station
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., OR
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., OR
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., OR
HSO	%	43 31 33.0	123 05 24.0	1.02	Harness Mountain, OR
HSR	%	46 10 28.0	122 10 46.0	1.72	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
HUO	%	44 07 10.9	121 50 53.5	2.037	Husband OR (UO)
IRO	%	44 00 19.0	122 15 15.4	1.642	Indian Ridge, OR
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, OR
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., OR
KOS	%	46 27 46.7	122 11 41.3	0.61	Kosmos
KTR	N	41 54 31.2	123 22 35.4	1.378	CAL-NET
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, OR
LAM	N	41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM	M	45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 18.6	118 17 06.6	0.771	Lincton Mt., OR
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.21	Locke Island
LVP	%	46 03 58.0	122 24 02.6	1.13	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCMT	M	44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.33	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
MOON	%	44 03 05.5	121 40 05.5	2.27	Moon Mt, OR
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, OR
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, OR
NEL	+	48 04 12.6	120 20 24.6	1.5	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., OR
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
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2)
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
PCFR	%	46 59 23.3	122 26 27.4	0.137	PC Firing Range ANSS-SMO
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mt. Detachment ANSS-SMO
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, OR
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser

RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
RED	H	46 17 51.0	119 26 15.6	0.33	Red Mountain PNNL Station
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.85	Roman Nose, OR
RPW	%	48 26 54.0	121 30 49.0	0.85	Rockport
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS ANSS-SMO
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1	Mt. Rainier - Voight Creek
RVW	%	46 08 53.2	122 44 32.1	0.46	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.119	Silver Beach ES ANSS-SMO
SEA	%	47 39 15.8	122 18 29.3	0.03	UW Seattle (Wood Anderson BB)
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SFER	%	47 37 10.4	117 21 55.7	0.715	Spokane Schools, Ferris High
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens
SLF	%	47 45 32.0	120 31 40.0	1.75	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SNI	H	46 27 50.4	119 39 35.1	0.323	Snively PNNL station
SOS	%	46 14 38.5	122 08 12.0	1.27	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, OR
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
SVOH	%	48 17 21.8	122 37 54.8	0.022	Skagit Valley CC ANSS-SMO
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., OR
TDL	%	46 21 03.0	122 12 57.0	1.4	Tradedollar Lake
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, OR
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, OR
VDB	C	49 01 34.0	122 06 10.1	0.404	Canada
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, OR
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., OR
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, OR
VGZ	C	48 24 50.0	123 19 27.8	0.067	Canada
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., OR
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., OR
VLM	%	45 32 18.6	122 02 21.0	1.15	Little Larch, OR
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn, OR
VT2	+	46 58 02.4	119 59 57.0	0.385	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, OR
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
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, OR
WPW	%	46 41 55.7	121 32 10.1	1.28	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	1.75	Yellow Rock, Mt. St. Helens
YPT	+	46 02 55.8	118 57 44.0	0.325	Yellepit

Table 2B lists broad-band stations used in locating seismic events in Washington and Oregon, and Table 2C lists strong-motion stations. The format for station locations is the same for all station tables, as described above.

TABLE 2B - Broadband Stations

STA	F	LAT	LONG	EL	NAME
		(deg. min. sec.)	(deg. min. sec.)	(km)	
BRKS	%	47 45 19.1	122 17 17.9	0.02	Brookside ANSS-SMO
COR	U	44 35 08.5	123 18 11.5	0.121	Corvallis, OR USNSN
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, OR UO CREST BB
ELW	%	47 29 39.4	121 52 17.2	0.267	EchoLakeBPA BB-SMO-IDS20
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie SMO-IDS24 BB
EUO	%	44 01 45.7	123 04 08.2	0.16	Eugene,OR U0 CREST BB SMO
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mt CREST BB SMO
HAWA	U	46 23 32.3	119 31 57.2	0.367	Hanford Nike USNSN BB
HEBO	%	45 12 49.2	123 45 15.0	0.875	Mt. Hebo, OR CREST BB SMO
HLID	U	43 33 45.0	114 24 49.3	1.772	Hailey, ID USNSN BB
HOOD	%	45 19 17.8	121 39 07.8	1.52	Mt Hood Mdws., OR CREST BB SMO
HUMO		42 36 25.6	122 57 24.1	0.555	Hull Mountain,OR BB from UCB
KBO	N	42 12 45.0	124 13 33.3	1.008	Bosley Butte, OR CREST BB
KEB	N	42 52 20.0	124 20 03.0	0.818	Edson Butte, OR CREST BB
KRMB	N	41 31 23.0	123 54 29.0	1.265	Red Mtn, OR CREST BB
KSXB	N	41 49 51.0	123 52 33.0	-	Camp Six, OR CREST BB
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire CREST BB LONLZ SMO
LTY	%	47 15 21.2	120 39 53.3	0.97	Liberty BB CREST SMO
MEGW	%	46 15 57.4	123 52 38.2	0.332	Megler, WA CREST BB SMO
MOD		41 54 08.9	120 18 10.6	1.555	Modoc Plateau, CA
NEW	U	48 15 50.0	117 07 13.0	0.76	Newport Observatory USNSN BB
OCWA	U	47 44 56.0	124 10 41.2	0.671	Octopus Mtn. USNSN BB
OFR	%	47 56 00.0	124 23 41.0	0.152	OlympiRsrc. Center
OPC	%	48 06 01.0	123 24 41.8	0.09	Olympic Penn College CREST BB
OZB	C	48 57 37.1	125 29 34.1	0.671	Canada
PFB	C	48 34 30.0	124 26 39.8	0.465	P.Renfrew, Canada
PNLK	%	47 34 54.5	122 02 01.0	0.128	Pine Lake JH ANSS-SMO
PNT	C	49 18 57.6	119 36 57.6	0.55	Canada BB
SNB	C	48 46 33.6	123 10 16.3	0.408	Canada BB
SP2	%	47 33 23.3	122 14 52.8	0.03	Seward Park, Seattle SMO-IDS24
SQM	%	48 04 39.0	123 02 44.0	0.03	Sequim, WA CREST BB SMO
TAKO	%	43 44 36.6	124 04 52.5	0.046	Tahkenitch, OR CREST BB SMO
TOLO	%	44 37 19.3	123 55 16.6	0.021	Toledo BPA, OR CREST BB SMO
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Res, WA CREST BB SMO
WVOR	U	42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, OR USNSN BB
YBH		41 43 55.3	122 42 37.4	1.06	Yreka, CA from UCB

Table 2C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN. Several of these stations also have broad-band instruments, as noted.

The "SENSOR" field designates what type of seismic sensor is used:

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

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

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

TABLE 2C - Strong-motion three-component stations

STA	F	LAT	LONG	EL	NAME	SENSOR	TEL.
		(deg. min. sec.)	(deg. min. sec.)	(km)			
ALCT	%	47 38 48.8	122 2 15.7	0.055	Alcott Elementary	K2	I
ALST	%	46 6 32.3	123 1 58.5	0.198	Alston	A20	E,M
ALVY	%	43 59 53.2	123 0 57.0	0.155	Alvey	K2	E,M
ATES	%	48 14 10.9	122 3 33.0	0.062	Trafton Elementary	K2	I
BABE	%	47 36 21.0	122 32 7.0	0.083	Blakely Elementary	K2	I
BEND	%	44 4 0.8	121 19 36.0	0	U of O Bend Field Office	K2	I
BEVT	%	47 55 12.0	122 16 12.0	0.17	Boeing Plant Everett	K2	I
BRKS	%	47 45 19.1	122 17 17.9	0.02	Brookside Elementary	K2,BBZ	I
BULL	*	45 26 45.8	122 9 16.9	0.222	Bull Run Dam	A	I
COLT	%	45 10 13.1	122 26 12.8	0.213	Colton High School	CMG5T	I
CSO	#	45 31 1.0	122 41 22.5	0.036	Canyon	FBA23	D
DBO	%	43 7 9.0	123 14 34.0	0.984	Dodson Butte (CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 27.2	122 2 37.7	0.159	East Ridge Elementary	K2	I
EGRN	%	47 4 24.0	122 58 41.0	0.057	Evergreen State College	K2	I
ELW	%	47 29 39.4	121 52 17.2	0.267	Echo Lake	A,BB	D,M,L
ERW	%	48 27 14.4	122 37 30.2	0.389	Mount Erie	A,BB	D,L,M
EUO	%	44 1 45.7	123 4 8.2	0.16	Eugene Golf Course (CREST)	EPI,BB	E,L-PPP
EVCC	%	48 0 27.0	122 12 15.3	0.03	Everett Community College	K2	I
EVGW	%	47 51 15.8	122 9 12.2	0.122	Gateway Middle School	K2	I
EYES	%	45 19 46.5	123 3 23.5	0.061	Ewing Young Elementary	CMG5T	I
FINN	%	47 43 10.2	122 13 55.9	0.121	Finn Hill Junior High	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison	FBA23	D
HEBO	%	45 12 49.2	123 45 15.0	0.875	Mt. Hebo (CREST)	EPI,BB	M,E
HICC	%	47 23 24.4	122 17 52.4	0.115	Highline Community College	K2	I
HOLY	%	47 33 55.4	122 23 1.0	0.106	Holy Rosary School	K2	I
HOOD	%	45 19 17.8	121 39 7.8	1.52	Hood Meadows (CREST)	EPI,BB	L-PPP,I
HUBA	%	45 37 51.0	122 39 4.9	0.023	Hudson's Bay High School	CMG5T	I
KDK	%	47 35 42.7	122 19 56.0	0.004	King Dome	K2	I
KFAL	%	42 15 27.7	121 47 6.5	1.326	Klamath Falls	CMG5T	Serial
KEEL	%	45 33 0.8	122 53 42.4	0.067	Keeler	A20	D,E,M
KICC	%	47 34 37.9	122 37 52.4	0.017	Kitsap County Central Comm.	K2	I
KIMB	%	47 34 29.3	122 18 10.1	0.069	Kimball Elementary	K2	I
KIMR	%	47 30 11.0	122 46 2.0	0.123	Mod. Risk Waste Coll. Fac.	K2	I
KINR	%	47 45 6.0	122 38 35.0	0.008	North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.076	Wastewater Treatment Plant	K2	I
KNJH	%	47 23 5.0	122 13 42.0	0.014	Kent Junior High	K2	I
LANE	%	44 3 6.5	123 13 54.8	0.12	Lane	K2	E,M
LAWT	%	47 39 23.4	122 23 21.9	0.05	Lawton Elementary	SLN-320	I
LEOT	%	47 46 4.4	122 6 56.2	0.115	Leota Junior High	K2	I
LON	%	46 45 0.0	121 48 36.0	0.853	Longmire Springs (CREST)	EPI,BB3	L-PPP
LTY	%	47 15 21.2	120 39 53.4	0.97	Liberty Heights Mine (CREST)	EPI,BB3	I
MARY	%	47 39 45.7	122 7 11.6	0.011	Marymoor Park	K2	I
MBKE	%	48 55 2.0	122 8 29.0	1.01	Kendall Elementary	K2	I
MBPA	%	47 53 54.7	121 53 20.2	0.186	Monroe	A20	D,M,L

MEAN	%	47 37 21.7	122 18 18.7	0.037	Meany Middle School	K2	I
MEGW	%	46 15 57.4	123 52 38.2	0.332	Megler (CREST)	EPI,BB	M,E
MPL	%	47 28 7.0	122 11 4.5	0.122	Maple Valley	A	D,M,L
MRIN	%	44 48 1.4	122 41 53.8	0.187	Marion	K2	M,E
MURR	%	47 7 12.0	122 33 36.0	0.082	Camp Murray	K2	None
NIHS	%	47 44 29.2	122 13 17.1	0.137	Inglemoore High School	K2	I
NOWS	%	47 41 12.0	122 15 21.2	0.002	NOAA Sand Point	A20	I
OFR	%	47 56 0.0	124 23 41.0	0.152	Olympic Nat. Rsrcs. Ctr. (CREST)	EPI,BB	I,E
OHC	%	47 20 2.0	123 9 29.0	0.006	Hood Canal Junior High	K2	I
OPC	%	48 6 1.0	123 24 41.8	0.09	Peninsula College (CREST)	EPI,BB	I
PAYL	%	47 11 34.0	122 18 46.0	0.009	Aylen Junior High	K2	I
PCEP	%	47 6 41.8	122 17 24.0	0.16	Puyallup East Sheriff Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	Roy Training Center	K2	I
PCMD	%	46 53 20.9	122 18 0.9	0.239	Mountain Detachment	K2	I
PERL	%	45 19 42.0	122 46 40.2	0.068	Pearl	K2	M,E
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mtn. (CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 54.5	122 2 1.0	0.128	Pine Lake Middle School	K2	I
QAW	%	47 37 54.3	122 21 15.5	0.14	Queen Anne	A20	L
RAW	%	47 20 14.0	121 55 53.2	0.208	Raver	A20	M,L
RBEN	%	47 26 6.7	122 11 10.0	0.152	Benson Hill Elementary	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte	FBA23	D
RHAZ	%	47 32 24.7	122 11 1.3	0.108	Hazelwood Elementary	A20	I
ROSS	%	45 39 43.0	122 39 25.0	0.061	Ross	A20	E
RRHS	%	46 47 58.6	123 2 25.4	0.047	Rochester High School	K2	I
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 5.9	122 24 54.2	0.119	Silver Beach Elem. School	K2	I
SCC	%	47 44 59.4	122 21 35.3	0	Shoreline Community College	CMG5T	I
SEA	%	47 39 15.8	122 18 29.3	0.03	University of Washington	A20,PMD2023	L
SFER	%	47 37 10.4	117 21 55.7	0.715	Ferris High School	K2	I
SGAR	%	47 40 37.8	117 24 50.3	0.579	Garfield Elementary	K2	I
SHIP	%	47 39 19.0	122 19 14.4	0.005	WashDOT Lake Union Shop	CMG5T	I,R
SHLY	$	47 42 30.4	117 24 57.7	0.626	Spokane Temp	K2	None
SMNR	%	47 12 16.6	122 13 53.4	0.022	Sumner High School	K2	I
SNIO	$	47 40 46.0	117 24 18.0	0.584	Spokane NIOSH	K2	None
SOPS	$	47 43 40.8	117 18 46.5	0.707	Orchard Prairie Elementary	K2	I
SP2	%	47 33 23.3	122 14 52.8	0.03	Seward Park	A,BB	L
SQM	%	48 4 39.0	123 2 44.0	0.03	Sequim Battelle Prop. (CREST)	EPI,BB	I,R
SVOH	%	48 17 21.8	122 37 54.8	0.022	Skagit Valley College Oak Harbor	K2	I
SVTR	%	47 29 45.4	121 46 49.3	0.146	Two Rivers School	CMG5T	I
SWES	%	47 42 51.0	117 27 53.2	0.623	Westview Elementary	K2	I
SWID	%	48 0 31.0	122 24 42.0	0.062	South Whidbey Primary School	K2	I
TAKO	%	43 44 36.6	124 4 52.5	0.046	Tahkenitch (CREST)	EPI,BB	M,E
TBPA	%	47 15 29.0	122 22 1.0	0.002	Tacoma	A20	M,L,D
TKCO	%	47 32 12.7	122 18 1.5	0.005	King County Airport	A20	I
TOLO	%	44 37 19.3	123 55 16.6	0.021	Toledo (CREST)	EPI,BB	M,E
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir (CREST)	EPI,BB3	I
UPS	%	47 15 50.2	122 29 1.1	0.113	University of Puget Sound	K2	I
UWFH	%	48 32 46.0	123 0 43.0	0.01	Friday Harbor Laboratories	K2	I
VVHS	%	47 25 25.1	122 27 13.1	0.095	Vashon High School	K2	I
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instr. Services Cntr.	K2	I
WWHS	%	46 2 43.5	118 19 2.0	0.01	Walla Walla High School	CMG5T	I

EARTHQUAKE DATA - 2003-D

There were 1,081 events digitally recorded and processed at the University of Washington between October 1 and December 31, 2003. Locations in Washington, Oregon, or southernmost British Columbia were determined for 534 of these events; 433 were classified as earthquakes and 101 as known or suspected blasts. The remaining 547 processed events include teleseisms (133 events), regional events outside the PNSN (74), and unlocated events within the PNSN. Unlocated events within the PNSN include surficial events on Mt. St. Helens and Mt. Rainier, very small earthquakes, and blasts. Frequent mining blasts occur near Centralia, Washington and we routinely locate them.

Table 3A is a listing of all earthquakes reported to have been felt during this quarter. Events with ShakeMaps or Community Internet Intensity Maps (CIIM) are indicated. This quarter, no events generated ShakeMap. ShakeMap **http://www.pnsn.org/shake/index.html** shows instrumentally measured shaking using data from accelerometers in the network. Peak ground acceleration (PGA) values are modeled using information from accelerometers, local geology, and distance to the epicenter. CIIM maps **http://pasadena.wr.usgs.gov/shake/pnw/** are made using "felt" reports relayed via Internet. The "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

Table 4 is this quarter's catalog of earthquakes M 2.0 or greater, located within the network - between 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Figure 2. Earthquakes with magnitude greater than or equal to 0.0 (M_c >=0).

Figure 3. Blasts and probable blasts (M_c >=0).

Figure 4. Earthquakes located near Mt. St. Helens (M_c >=0).

Figure 5. Earthquakes located near Mt. Rainier (M_c >=0).

Figure 6. Focal mechanisms computed for earthquakes M 2.5 or larger.

TABLE 3A - Felt Earthquakes during the 4thQuarter of 2003

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEP	MAG	COMMENTS	CIIM	ShakeMap
yy/mm/ddhh:mm:ss	deg.	deg.	km			-	-
03/10/01 13:27:36	44.73	117.48	22.1	3.1	27.7 km E of Baker, OR	-	-
03/10/13 01:11:58	47.58	121.86	7.7	1.6	2.2 km NE of Fall City, WA	-	-
03/10/25 23:35:21	47.53	121.89	18.6	2.3	3.7 km S of Fall City, WA	-	-
03/11/13 00:57:54	42.52	122.57	16.8	2.9	23.2 km WNW of Mt McLoughlin, OR	-	-
03/12/14 04:59:47	46.58	121.69	4.9	1.8	20.5 km WNW of Goat Rocks, WA	-	-
03/12/26 10:07:45	48.75	119.63	0.4	3.4	43.1 km N of Okanogan, WA	✓	-

OREGON

During the fourth quarter of 2003, a total of 29 earthquakes were located in Oregon between 42.0 degrees and 45.5 degrees north latitude, and between 117 degrees and 125 degrees west longitude. Two earthquakes were reported felt this quarter (see Table 3A for details). The largest was a poorly located magnitude 3.1 event on Oct. 1, about 28 km east of Baker.

OREGON CASCADE VOLCANOES

This quarter 5 earthquakes were located in the area around Mount Hood from 45.25 to 45.45 N latitude and 121.6 to 121.8 W longitude. The largest earthquake near Mt. Hood this quarter was a magnitude 2.4 event on December 31.

WESTERN WASHINGTON SEISMICITY

During the fourth quarter of 2003, 346 earthquakes were located between 45.5 degrees and 49.5 degrees north latitude and between 121 degrees and 125.3 degrees west longitude. Three earthquakes were felt this quarter in western Washington. Details are in Table 3A.

The largest felt earthquakes in western Washington was a magnitude 2.3 event on Oct. 25 (UTC), located about 4 km south of Fall City at a depth of about 19km. The deepest quake in western Washington this quarter was a magnitude 1.8 earthquake at about 63 km depth, located about 19 km west-southwest of Mount Vernon, WA on Nov. 20.

WASHINGTON CASCADE VOLCANOES

Mount Rainier

The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow activity is presumably ice movement or avalanching at the surface, which is seasonal in nature. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals, probably due to rockfalls or avalanches, are assigned type "S" (see Key to Earthquake Catalog). There were 2 located events flagged "L" or "S" at Mount Rainier this quarter although 88 "L" or "S" events were recorded, but were too small to locate reliably. Type L and S events are not shown in Fig. 4.

A total of 55 tectonic events (22 of these were smaller than magnitude 0.0, and thus are not shown in Fig. 4) were located within the region shown in Fig. 4. The largest tectonic earthquake located near Mt. Rainier this quarter was on Oct. 8; a magnitude 1.7 event at a depth of about 16 km located about 38 km southwest of the summit. This quarter, 28 tectonic earthquakes were located in the "Western Rainier Seismic Zone" (WRSZ), a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier (for counting purposes, the western zone is defined as 46.6-47.0 degrees north latitude and 121.83-122 west longitude). Within 5 km of the summit, there were 16 (9 of them smaller than magnitude 0.0 and thus not shown in Fig. 4) higher-frequency tectonic-style earthquakes, and the remaining events were scattered around the cone of Rainier as seen in Fig. 4.

Mount St. Helens

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

This quarter, 102 earthquakes were located at Mount St. Helens in the area shown in Fig. 5. Of these earthquakes, 26 were magnitude 0.0 or larger and 14 were deeper than 4 km. The largest tectonic earthquake at Mount St. Helens this quarter was a magnitude 2.3 event at about 2 km depth on Dec. 30 UTC. It was located about .3 km northeast of the summit.

One type "S" or "L" events was located at Mount St. Helens, and 134 "L" or "S" events too small to locate were recorded.

EASTERN WASHINGTON SEISMICITY

During the fourth quarter of 2003, 56 earthquakes were located in eastern Washington in the area between 45.5-49.5 degrees north latitude and 117-121 degrees west longitude. One earthquake was recorded near Spokane this quarter. The largest earthquake recorded in the PNSN coverage area was a magnitude 3.4 earthquake in north-eastern Washington on Dec. 26 (UTC). This crustal earthquake occurred not far from the Canadian border, about 43 km north of Okanogan, WA. It was poorly located and weakly felt over about 6,400 km^2.

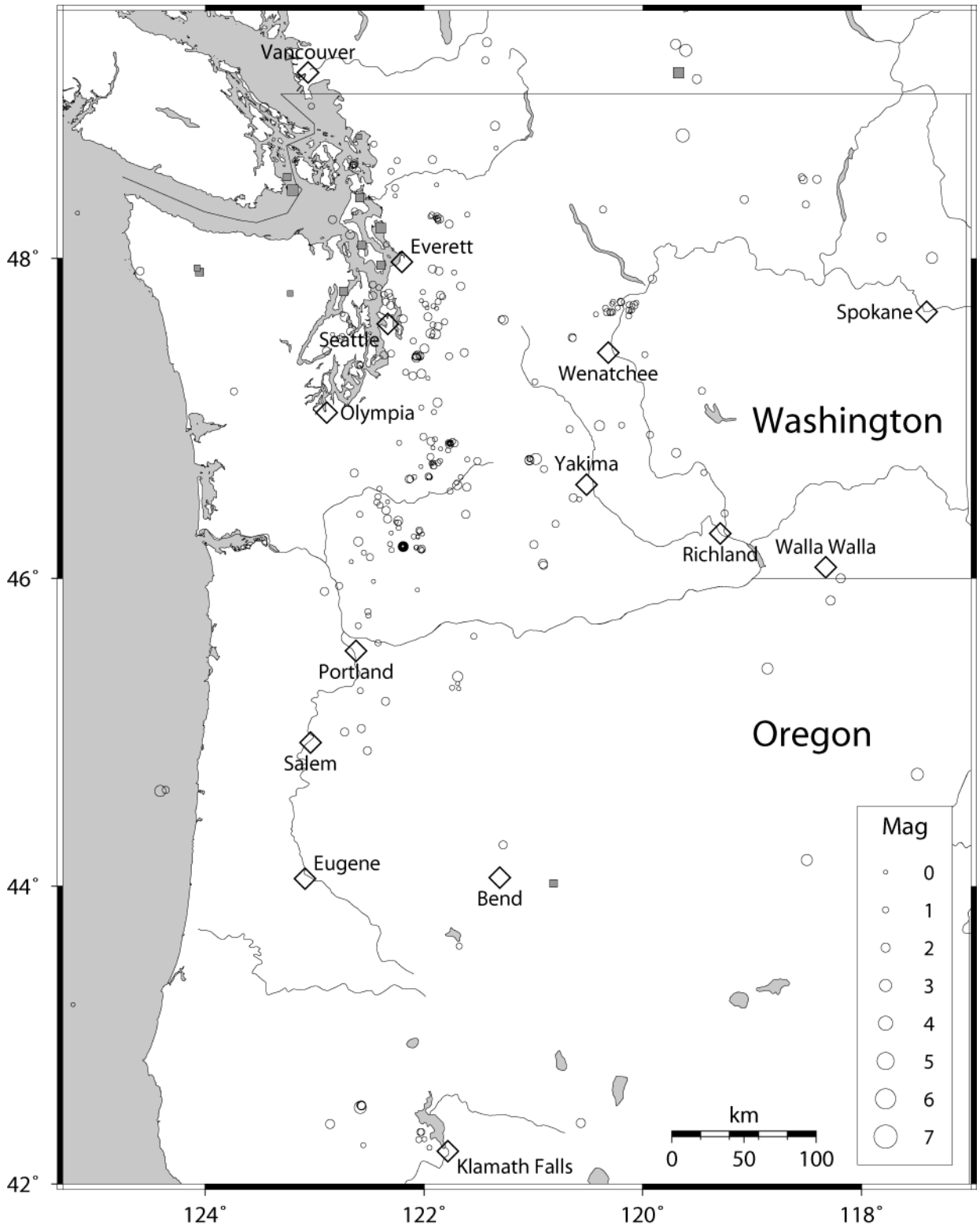

Figure 2. Earthquakes with magnitude greater than or equal to 0.0 (Mc>=0.0).

Unfilled diamonds represent cities.

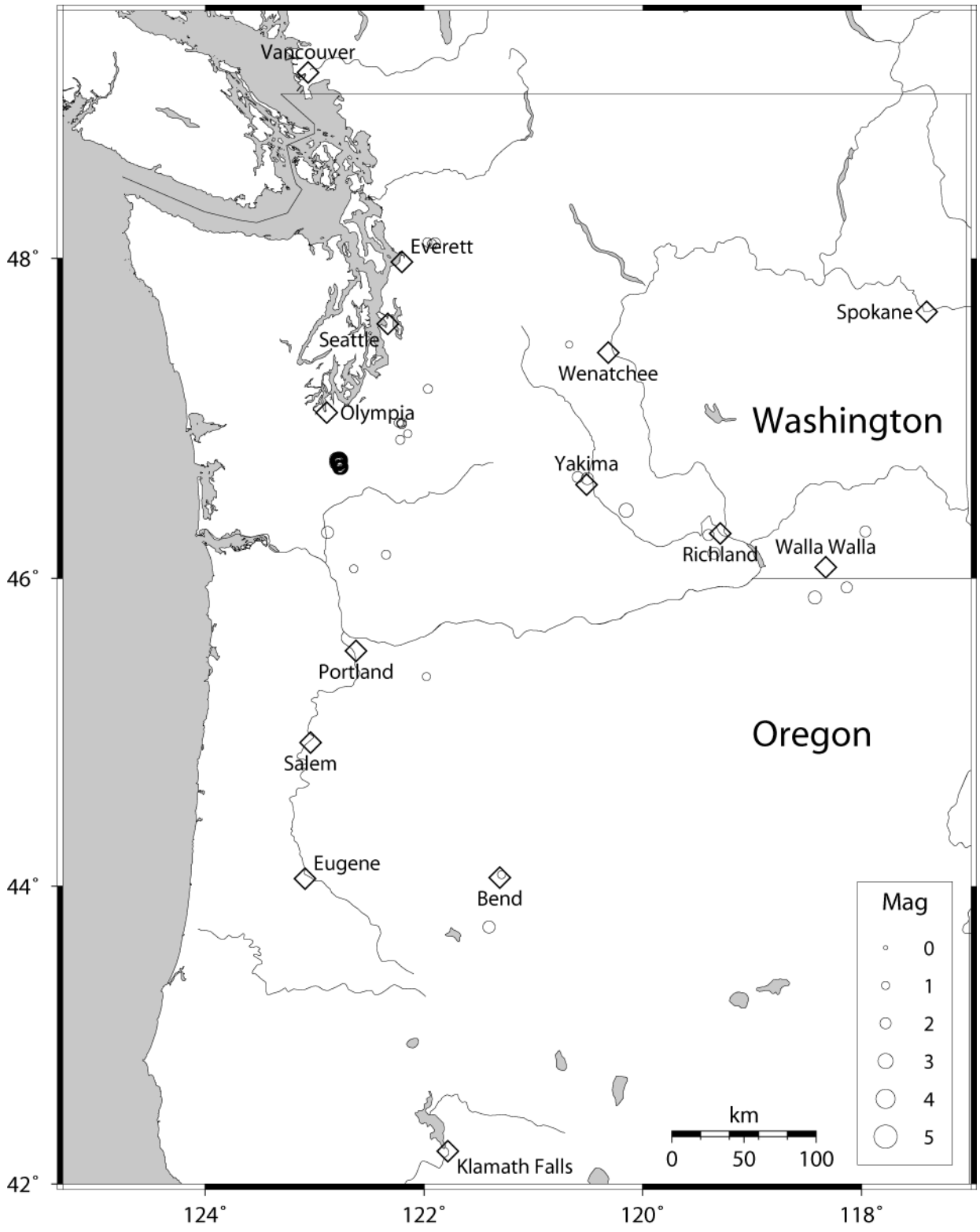

Figure 3. Blasts and probable blasts. Unfilled diamonds represent cities.

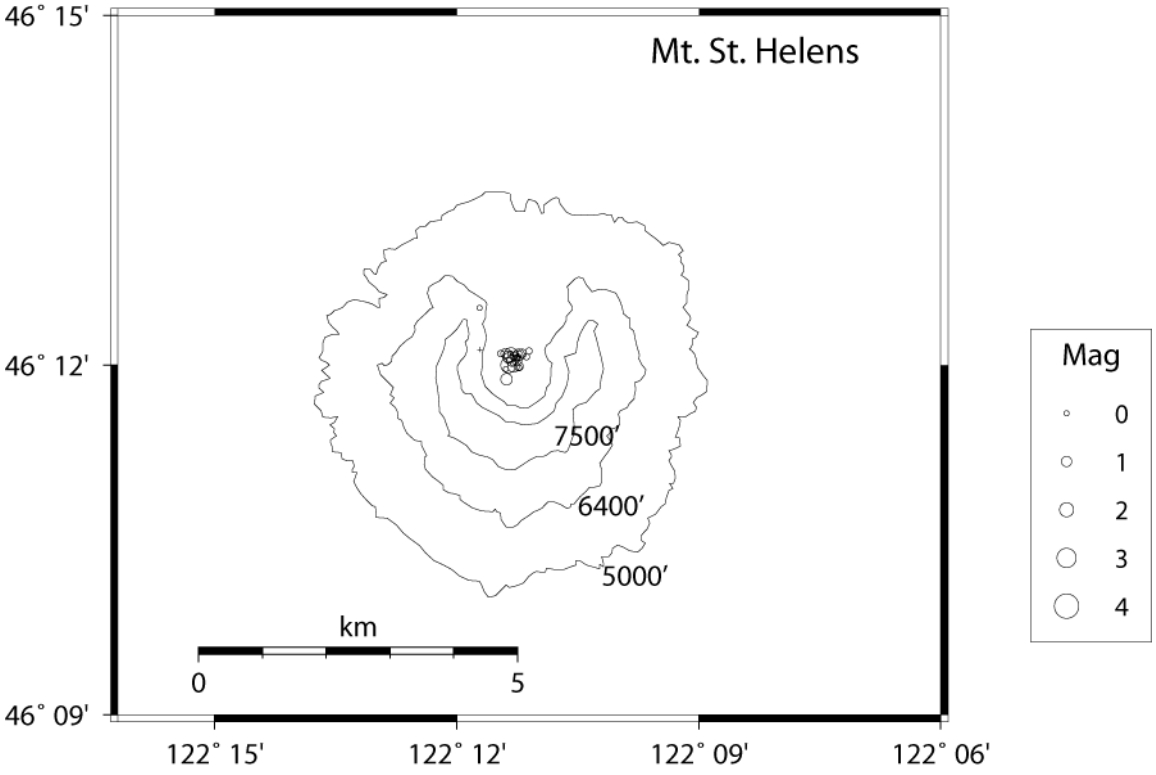

Figure 4. Earthquakes at Mt. St. Helens. M>0. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet

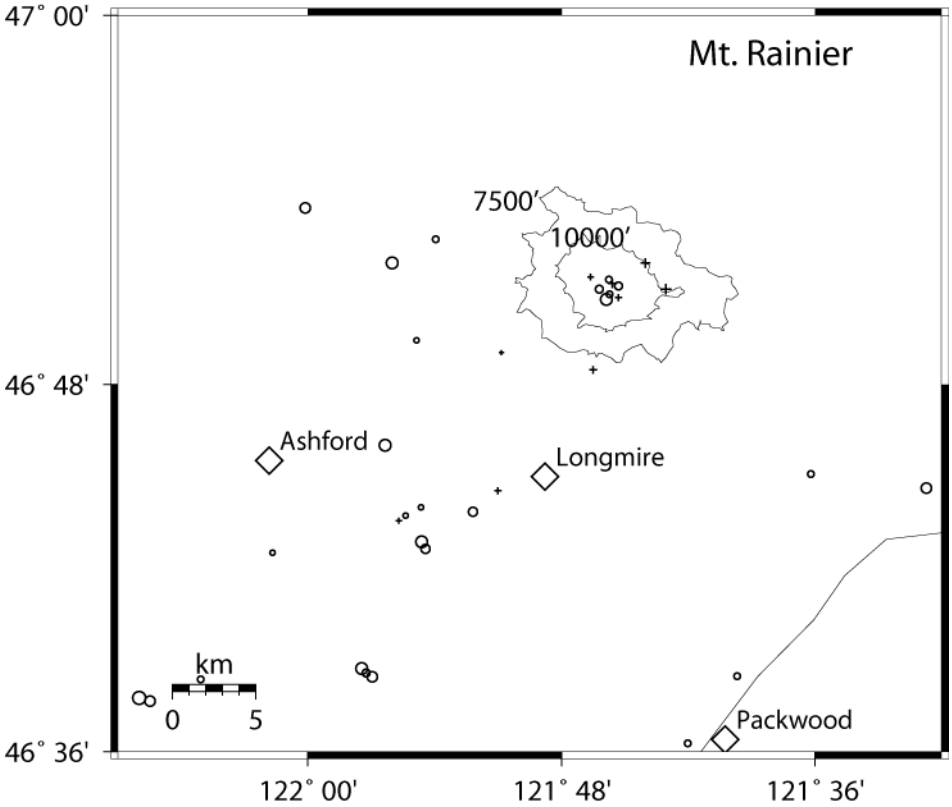

Figure 5. Earthquakes at Mt. Rainier. M>0.

OTHER SOURCES OF EARTHQUAKE INFORMATION

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

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

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

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

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C. http://www.pgc.nrcan.gc.ca/seismo/table.htm ; and other regional networks in the United States http://earthquake.usgs.gov/regional/ The US Geological Survey coordinates earthquake information nationally; http://earthquake.usgs.gov

KEY TO EARTHQUAKE CATALOG IN TABLE 4

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.

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

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

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.

Coda-length magnitude, Mc: an estimate of local magnitude ML (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). Magnitudes may be revised as we improve our analysis procedure.

NS: 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.

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

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.

Quality factors: Two 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.

First Quality factor is a measure of the hypocenter quality based on travel-time residuals. For example:

A quality requires an RMS less than 0.15 sec.

D quality has an RMS of 0.5 sec.

Second Quality factor 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. A quality requires a solution with 8 or more phases, GAP <= 90 degrees and DMIN <= 5 km or depth, whichever is greater. If the number of phases, NP, is 5 or fewer or GAP > 180 degrees or DMIN > 50 km the solution is assigned quality D.

Crustal velocity model: Layered velocity models appropriate to different geographic areas are used in location calculations (Ludwin, R.S., et al., 1994, Earthquake hypocenters in Washington and northern Oregon, 1987-1989, and Operation of the Washington Regional Seismograph Network, Information Circular 89, Washington State Dept. of Natural Resources).

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

Flagging: Events flagged in Table 4 use the following code:

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

EARTHQUAKE CATALOG, 2003-D

Complete catalog listings are available on-line through http://www.pnsn.org/CATDAT/catalog.html

TABLE 4. Tectonic earthquakes, 4th quarter, 2003, magnitude 2.0 and larger
Within the area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude

Oct-03

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	13.27.36.36	44 44.04	117 29.33	22.08	3.1	19/019	144	0.93	DD	O0	F
1	18.46.55.55	48 07.84	117 48.93	0.02*	2.0	6/006	180	0.36	CC	N3	
3	09.40.08.8	46 14.04	122 35.95	19.44	2.0	29/030	76	0.15	AB	C3	
7	00.17.49.49	44 10.32	118 29.83	0.02*	2.8	14/015	178	1.81	DD	O0	
12	03.42.37.37	48 25.09	123 12.09	43.83	2.5	41/041	82	0.23	BA	P3	
16	18.03.54.54	42 24.41	122 51.36	19.03	2.1	4/004	233	0.00	AD	K3	
20	03.35.38.38	49 18.07	119 41.91	17.11$	2.2	13/013	272	0.45	DD	N3	
25	02.08.55.55	44 37.57	124 24.70	14.97	2.6	10/010	271	0.33	DD	O0	
25	10.06.12.12	49 07.67	119 40.43	10.00*	2.5	11/011	235	0.25	CD	N3	
25	11.50.57.57	49 15.86	119 36.36	2.31	3.0	20/021	229	0.39	CD	N3	
25	23.35.22.22	47 32.02	121 53.56	18.62	2.3	47/048	43	0.21	BA	P3	F

Nov-03

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
5	16.00.07.7	46 45.30	120 58.41	6.13	2.6	53/053	45	0.30	BB	C3	
12	15.41.57.57	47 32.37	121 56.39	21.28	2.0	41/044	61	0.22	BA	P3	
13	00.57.54.54	42 31.34	122 34.73	16.84*	2.9	18/018	104	0.26	BB	K3	F
14	23.01.33.33	45 51.42	118 16.91	6.14	2.0	10/010	258	0.33	CD	E3	
20	23.36.15.15	46 57.91	120 23.67	0.03*	2.2	12/012	81	0.23	BC	E3	
24	14.58.11.11	47 26.68	121 59.63	19.19	2.0	40/041	32	0.18	BA	P3	
26	06.23.27.27	48 11.20	122 23.51	34.41	2.4	59/059	43	0.27	BA	P3	

Dec-03

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP

TABLE 4. Tectonic earthquakes, 4th quarter, 2003, magnitude 2.0 and larger
Within the area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude

1	20.08.37.37	45 25.28	118 51.43	16.71	2.5	29/031	192	0.38	CD	O0	
8	07.11.58.58	46 44.78	121 02.11	4.08	2.0	50/051	47	0.26	BC	C3	
9	03.34.45.45	49 05.51	119 30.16	0.28#	2.1	5/006	207	0.36	CD	N3	
9	12.24.37.37	48 08.74	122 40.26	24.10	2.0	26/027	59	0.26	BA	P3	
11	02.53.17.17	48 55.35	123 27.59	18.13	2.0	23/025	201	0.33	CD	P3	
13	15.55.23.23	47 17.33	122 01.19	18.95	2.1	52/053	40	0.26	BA	P3	
26	10.07.46.46	48 45.14	119 38.04	0.38*	3.4	27/027	105	0.63	DD	N3	F
28	20.55.23.23	48 00.23	117 21.25	0.82	2.5	3/004	204	0.08	BD	N3	
30	00.13.05.5	46 12.00	122 11.35	2.00	2.3	28/031	53	0.19	BA	S3	
31	17.03.14.14	45 22.00	121 41.30	3.89	2.4	21/024	59	0.28	BB	O0	

OUTREACH ACTIVITIES

The PNSN staff and faculty participate in an educational outreach program designed to better inform the public, educators, businesses, policy makers, government agencies, engineers, and the emergency management community about earthquake and related hazards. Our program offers lectures, classes, lab tours, workshops, and consultations and electronic and printed information products. Special attention is paid to the information needs of the media. We provide information directly to the public through information sheets, an audio library, email, and via the Internet at http://www.pnsn.org.

Telephone, Mail, and On-line outreach

The PNSN audio library system received 575 calls this quarter. Our audio library provides several recordings; we have resumed regular updating of messages concerning current seismic activity. This service was suspended for a quarter to reassess need and was resumed due to demand from a few loyal callers without Internet access. Additionally, there is currently a recording describing 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 issued and we encourage others to reproduce and further distribute this flyer. Our information sheet discussing earthquake prediction is also frequently requested. Callers to the audio library have the option of being transferred to the Seismology Lab for additional available information. This quarter the Seismology Lab responded in person to:

- 20 calls from emergency managers and government,
- 15 calls from the media,
- 20 calls from k-12 educators,
- 15 calls from the business community,
- 40 calls from the general public.

Internet outreach:

This quarter, the URL for the PNSN web-site changed to http://www.pnsn.org. The change to a shorter name should make it easier for visitors to our web-site. The previous URLs will continue to work, and the transition has been smooth.

PNSN staff replied to 50 e-mail messages from the public seeking information on a variety of topics via the seis_info@ess.washington.edu email address. Routine questions are typically responded to within a day; complex or sensitive questions are routed to the appropriate staff person for a more in-depth response. These replies include assistance with hazard assessments and legal issues, consultations with government agencies, and support for engineering issues related to strong motion data.

The PNSN web site offers many pages, including maps and lists of the most recent PNW earthquakes, general information on earthquakes and PNW earthquake hazards, information on past notable PNW earthquakes, and searchable catalogs of earthquake summary cards. Automatically updated Web pages on seismicity of Cascade Volcanos, and Quarterly Reports are also available. Additionally:

- **Recent Earthquake List:** http://www.pnsn.org/recenteqs/ provides lists of all recent significant earthquakes.

- **"Webicorders":** http://www.pnsn.org/WEBICORDER/ provide pages displaying continuous data from PNSN seismographic stations.
- **"ShakeMap":** http://www.pnsn.org/shake/index.html shows maps of instrumentally measured shaking. Table 3A indicates which events this quarter generated ShakeMaps.

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

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

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

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

K-20 Education Outreach:

PNSN and USGS staff provided 12 Seismology Lab tours and presentations for K-20 students and teachers serving about 200 people this quarter. Tours were also provided to visiting scientists and the IRIS Data Management Centers Executive Committee.

- **Educational Resources Page:** http://www.pnsn.org/EDHOME/index.html.

Amy Lindemuth maintains an email list-service with over 50 local K-20 educators, subscribers interested in earth sciences education. PNSN analyst Amy Wright has produced and distributed monthly newsletters to this list since January 2003. Topics include interesting records available on the webicorders, classes and workshops for teachers, and other current events in seismology and science education.

Media Relations:

PNSN staff frequently provides interviews, research support, and referrals to radio, television, film, and print media. The PNSN organizes press conferences, contributes to TV and radio news programs and talk shows, and provides field opportunities linking reporters with working scientists. Staff members also assist news organizations, authors, television producers, and independent documentary makers to design accurate and informative stories and programs related to earthquake and volcano hazards. PNSN staff work to link reporters and producers developing stories with the appropriate research institutions, agencies, and scientists working in the areas to be covered by the piece. The PNSN also welcomes media representatives to participate in regional earthquake monitoring planning efforts including the PNWANSS Advisory Committee.

Meetings and Presentations:

A workshop, on October 21, 2003. The "Workshop on Current USGS Earthquake Hazard Studies in Puget Sound," featured recent USGS findings on earthquake hazards in Puget Sound, and was co-hosted by the United States Geological Survey, The PNSN, the University Of Washington Department Of Earth and Space Sciences, the Structural Engineers Association of Washington and the Geotechnical Committee of the Seattle Section of the American Society of Civil Engineers. The workshop was intended to update structural, geotechnical, and geological engineers and geologists working in the area, and "sold out" with 125 participants the day after registration opened. Participants' comments indicated it was very successful and requests were made for annual workshops of this type in a larger venue to accommodate the large number of engineering professionals wishing to participate.

Another workshop was held at the request of the Seattle Monorail Project Engineers. Kathy Troost of the Seattle Geologic Mapping Project in UW Earth and Space Sciences coordinated and moderated the half-day meeting attended by 60 participants. The PNSN and the USGS Seattle Field Office assisted in development and public relations.

The Geological Society of America held their annual meeting in Seattle, and many PNSN researchers participated. A special public presentation, "Faults beneath Our Feet: Earthquake Hazards in the Seattle Area", was moderated by UW's Kathy Troost and included talks by USGS scientists Ralph Haugerud, Brian Sherrod, Rick Blakely and Tom Brocher. Bill Steele worked with USGS public affairs staff assisting with press conference organization and media relations at the GSA Conference, and in organizing and advertising the public presentation.

The AGU meeting was also attended by several PNSN researchers. Steve Malone participated in a number of other meetings held in conjunction with the AGU, including an IRIS meeting, a ShakeMap meeting, an ANSS-NIC meeting, and an ad hoc meeting of people interested in deep tremor.

GSA and AGU presentations by PNSN researchers include:

Barberopoulou, A., A. Qamar, T.L. Pratt, K. Creager, W. Steele, 2003,
Local amplification of seismic waves from the Mw7.9 Alaska earthquake and damaging water waves in Lake Union, Seattle, Washington, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 263-9, p. 646.

Crider, J.G. R.S. Crosson, and J. Brooks, The Chelan seismic zone, the great terrace and the December 1872 Washington state earthquake, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 263-3, p. 645.

Crosson, R.S., 2003, Geophysical constraints on the deep structure of the Washington Cascades, a tectonic implications, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 126-1, p. 305.

Crosson, R.S. and R.J. Stewart, 2003, Implications of high resolution seismic tomography for the structure and evolution of the Puget basins, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 127-11, p. 309.

Hill, D.P., S. Prejean, D. Oppenheimer, S.D. Malone, K, Richards-Dinger,
2002, Activity remotely triggered in volcanic and geothermal centers in California and Washington by the 3 November 2002 Mw=7.9 Alaska earthquake Eos Trans. AGU, 83(47), S72F-1357.

Jones, J.P., S. Malone, 2002, Mount Hood Earthquake Activity: Volcanic or Tectonic Origins?, Eos Trans. AGU, 83(47), S12A-1179.

Ludwin, R.S., K. James, D. Buerge, K. Troost, J. Pickens, M. Skaret, 2003, Water-Serpent myths of Puget Sound Natives may refer to the A.D. 900 Seattle Earthquake, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 27-9, p. 80.

McCausland, W.A., S. Malone, 2003, Deep tremor along the Cascadia Subduction Zone, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 127-2 2003, p. 308.

Moran, Seth C., S.D. Malone, J.M. Lees, 2003, Mid-crustal velocity anomalies in the central Washington cascades: evidence for structures affecting regional tectonics and volcanism?, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper# 262-8, p. 644

Preston, L., K. Creager, R. Crosson, Intraslab earthquakes in Cascadia caused by dehydration embrittlement, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper #127-5, p. 308.

Qamar, A., A. Wright, G. Thomas, 2003, Do Richter magnitudes reveal seismic site response?, Geoscience Horizons Seattle 2003, Abstracts with Programs, Geol. Soc. Am. Annual Meeting November 2-5 2003, Paper #263-9, p. 646

Other Talks and Events:

Steve Malone attended an IRIS PDCC toolkit workshop. Ruth Ludwin made a presentation to Northwest Geologic Society. The PNSN remains an active participant in a number of organizations whose goals and objectives are complementary to the PNSN mission to reduce loss of life and property due to earthquakes. Bill Steele serves on the Board of Directors and as Secretary of the Cascade Region Earthquake Workgroup (**CREW**) and represents the PNSN in The Contingency Planners and Recovery Managers (**CPARM**). Bill serves as an advisor to a number of Project Impact Communities and is a member of **The Washington State Emergency Management Association**. Tony Qamar is an active member of the **Washington State Seismic Safety Committee**. Steve Malone is the Regional Coordinator for the **ANSS** and participates in monthly **National Implementation Committee** conference calls and meetings.