FINAL TECHNICAL REPORT: 1989

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This is the final technical report for USGS Joint Operating Agreements 14-08-0001-A0622 'Regional Seismic Monitoring in Western Washington' and 14-08-0001-A0623 'Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon'. These two agreements cover network operations in western Washington and northern Oregon, routine data processing, and preparation of bulletins and reports. The objective of our work under these operating agreements is to gather data for use in evaluation of seismic and volcanic hazards in western Washington and to support research carried out under contract 14-08-0001-G1390 'Earthquake Hazard Investigations in the Pacific Northwest', as well as other projects. This report includes a review of station operations during the contract period, and an update on recent changes in our data acquisition and processing system.

Since 1984, we have issued quarterly bulletins for all of Washington and the northern part of Oregon. These include catalogs of earthquakes and blasts located in Washington and Northern Oregon, providing up-to-date coverage of seismic and volcanic activity. Appendix 1 is composed of quarterly bulletins covering the operating agreement period.

Operations

Twenty-eight stations covering much of western Washington are supported under JOA A0622. Forty stations covering the Olympic Peninsula and volcanos in the central Cascades are supported under JOA A0623. The locations of the stations are given in Table 1, and shown in Fig. 1. All stations are north latitude and west longitude, and coordinates are given in degrees, minutes and seconds.

The University of Washington digitally records over 100 seismic channels or stations in a triggered mode. Stations recorded include short and long period vertical components of WWSSN station LON and horizontal seismometers with Wood-Anderson-response at station SEA on the campus of the University of Washington.

TABLE 1
Stations supported under USGS Joint Operating Agreement A0622

NAME	LAT	LONG	ELEV(km)	LOCATION
APW	46 39 6.0	122 38 51.0	0.457	Alpha Peak
BHW	47 50 12.6	122 1 55.8	0.198	Bald Hill
BLN	48 0 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
CMW	48 25 25.3	122 7 8.4	1.190	Cultus Mtns.
CPW	46 58 25.8	123 8 10.8	0.792	Capitol Peak
FMW	46 55 54.0	121 40 19.2	1.890	Mt. Fremont
GHW	47 2 30.0	122 16 21.0	0.268	Garrison Hill
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.
HDW	47 38 54.6	123 3 15.2	1.006	Hoodsport
HTW	47 48 12.5	121 46 8.6	0.829	Haystack Lookout
JCW	48 11 36.6	121 55 46.2	0.616	Jim Creek
LMW	46 40 4.8	122 17 28.8	1.195	Ladd Mt.
MBW	48 47 2.4	121 53 58.8	1.676	Mt. Baker
MCW	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MEW	47 12 7.0	122 38 45.0	0.097	McNeil Island
NLO	46 5 18.0	123 27 0.	0.900	Nicolai Mt., Oregon
OHW	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OSD	47 49 15.0	123 42 6.0	2.010	Olympics - Snow Dome
PGW	47 49 18.8	122 35 57.7	0.122	Port Gamble
RMW	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RPW	48 26 54.0	121 30 49.0	0.850	Rockport
RVW	46 8 58.2	122 44 37.2	0.460	Rose Valley
SHW	46 11 33.0	122 14 12.0	1.423	Mt. St. Helens
SMW	47 19 10.2	123 20 30.0	0.840	South Mt.
SPW	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
STW	48 9 2.9	123 40 13.1	0.308	Striped Peak

Stations supported under USGS Joint Operating Agreement A0623

ASR	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BPO	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
CDF	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
COW	46 29 27.6	122 00 43.6	0.305	Cowlitz River
ELK	46 18 20.0	122 20 27.0	1.270	Elk Rock
FL2	46 11 47.0	122 21 01.0	1.378	Flat Top 2
GLK	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GRO	45 21 04.5	123 39 43.0	0.945	Grindstone Mt., Oregon
GUL	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HSR	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
JBO	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JUN	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	46 27 40.8	122 11 25.8	0.828	Kosmos
LVP	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MTM	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NCO	43 42 18.2	121 08 06.0	1.908	Newberry Crater, 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
OFK	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OLQ	47 30 58.1	123 48 31.5	0.121	Olympics - Lake Quinault
ONR	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	47 44 12.0	124 11 22.0	0.743	Octopus West
OSP	48 17 05.5	124 35 23.3	-	Olympics - Sooes Peak
OTR	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PGO	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
RVC	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
SOS	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
STD	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
TCO	44 06 27.0	121 36 00.0	1.975	Three Creek Meadows, Or.
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
VBE	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	44 58 58.2	120 59 17.3	1.015	Criterion Ridge, Oregon
VFP	45 19 05.0	121 27 54.3	1.716	Flag Point, 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

JOA A0623 was originally budgeted at $230,000; because we originally proposed to expand the network into central Oregon to monitor the southern part of the Cascade Volcano Range. The U.S.G.S. was to conclude an agreement to provide telemetry links through the Bonneville Power Authority (BPA) microwave network. However, no agreement was reached, and because of this, and also due to a carryover of funds from the previous year, the budget amount on JOA A0623 was decreased to $140,000.

Station NEW, the longest continuously operating station in Washington ceased

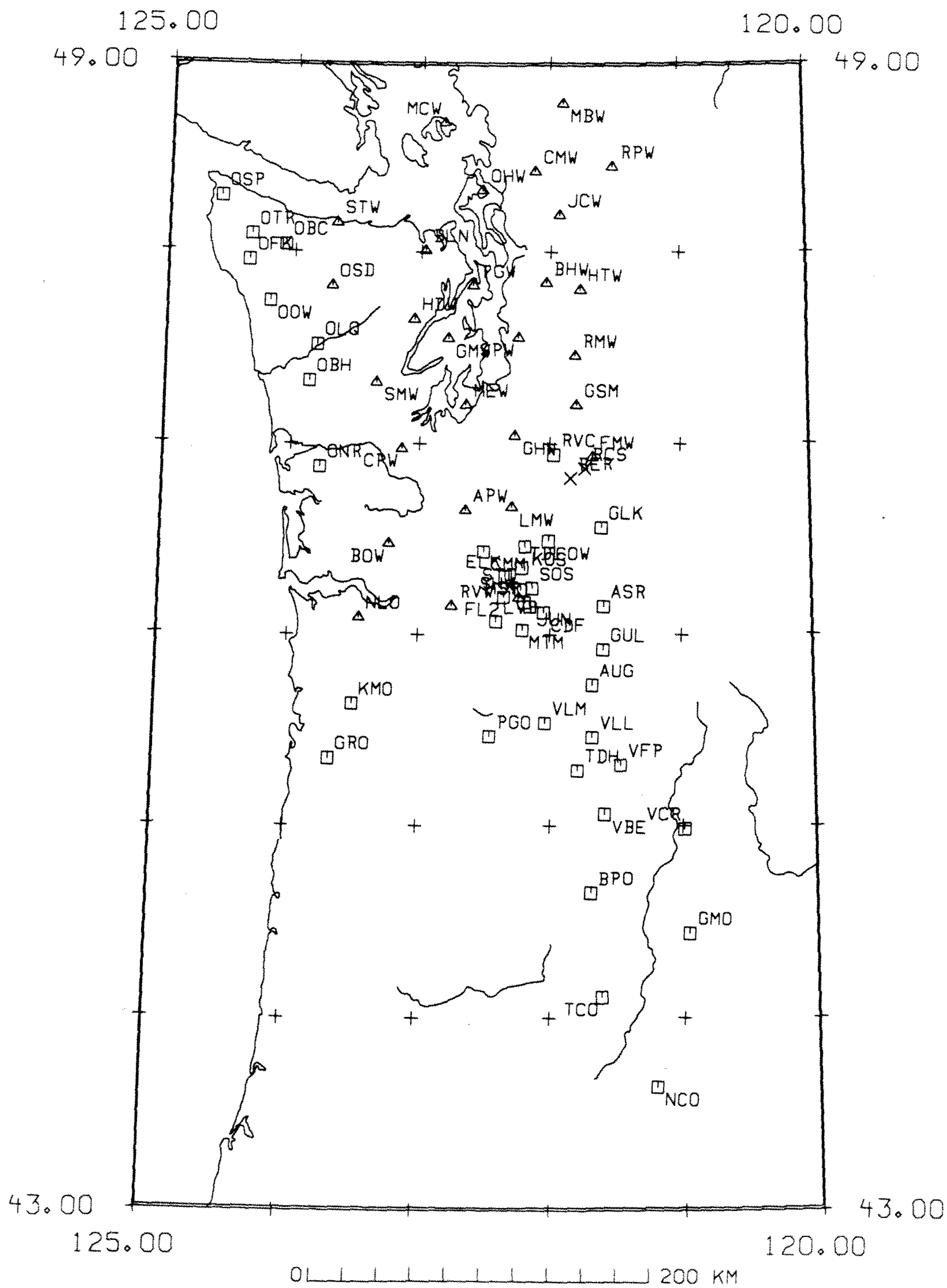

Figure 1. Map view of seismic stations supported under USGS JOA A0622 and A0623 between Nov. 1, 1988 and Oct. 31, 1989. Twenty-eight stations supported under JOA A0622 (triangular symbols) provide coverage of the Mount Baker, Glacier Peak and Mt. Rainier volcanos and western Washington, while 40 stations supported under JOA A0623 (square symbols) cover the Olympic Peninsula and Cascade Mountains, including Mount St. Helens and other Cascade volcanos into central Oregon. New stations RCS and RER (operated jointly under A0622 and A0623) are shown as "x" symbols.

recording at the UW in May of 1987 due to discontinuation of a phone link by the USGS. We had hoped to restore telemetry using the BPA microwave network, but that has not been possible. Although NEW was not supported under this agreement, its long standing makes it important to our network operation. We feel that it is important to restore telemetry from Newport.

A complete summary of station history for stations operated under these operating agreements from November 1988 through October 1989 is given in the quarterly reports in Appendix 1. Aside from station outages, normal maintenance includes a visit to each site at least every two years to replace batteries. In addition seismometers must be replaced every 4-6 years. 32 radio telemetry relay sites are also maintained independently of the seismograph stations.

This year, only a few unusual station outages occurred; station ETW (not supported under these agreements), near the southern end of Lake Chelan, was destroyed by a forest fire, and the Cowlitz station (COW) was entirely stolen, to the last scrap of wire. Other outages, usually of brief duration, were caused by all the ordinary failures; transmitters, receivers, VCOs, cable problems, and battery failure. Bad batteries are an increasing problem. Problems were experienced with both the air-cell type (1100 A-Hr) and deep-discharge batteries (100 A-Hr used with solar panels). More than a few air-cell batteries had premature failures, lasting less than 75% of their rated capacity. Since a set of 5 batteries is required at each site, the expense of early replacement is large.

Two new stations were installed on Mount Rainier in 1989; one to improve our ability to locate and determine depths of earthquakes under the volcano, the other to study damaging mudflows which originate near the foot of the South Tahoma glacier. The first station, RCS at Camp Schurman on Mt. Rainier, was installed on June 27th. U.S. Park Service personnel at Mount Rainier National Park were very cooperative and helpful in the siting and installation of the station, and allowed helicopter fly-in of the heavy batteries, antenna, solar panel etc.. The station will be supported cooperatively by JOAs A0623 and A0622. We hope that the combination of high capacity deep-discharge batteries and large solar panel will keep this station running with a minimum of field visits.

The utility of station RCS became apparent on August 16 when a large rock avalanche, with volume estimated at 1 million cubic meters, occurred at Russell Cliff within 1 km of the new station. The high-amplitude signal was observed at the U.W., and U.W. and U.S.G.S. personnel notified officials at the park. Based on the seismogram, we were concerned about hikers in the area. Fortunately the weather was miserable, and no climbing parties were in the area. The bad weather also prevented visual confirmation of the rockfall until the next day, although an audible report was received from Paradise visitor's center. An abstract "Seismograms from the 16 August 1989 rockfall from Russell Cliff, Mount Rainier" by R.D. Norris of the U.S.G.S. was presented at the fall PNAGU meeting.

The second new Mount Rainier station, RER, was installed on Emerald Ridge on the south-east flank of the mountain on July 12. Equipment for this station was funded by the U.S.G.S. Water Resources Division, while operational support will be provided under JOAs A0622 and A0623. RER was needed to study lahars, probably caused by glacial outburst floods originating near the toe of the South Tahoma glacier. Such debris flows have damaged a road and campground in the area, and pose a hazard to the Park visitors. These flows are also of interest because geologic evidence shows that past lahars have flowed all the way to the Puget Basin. Large lahars have been assumed to have accompanied eruptions, but such an assumption may not be correct. Study of the source mechanism of these flows is necessary to estimate the degree of hazard. A small lahar was recorded by station RER in September.

Data Processing

The seismographic network operated by the University of Washington consists of over a hundred short-period, vertical component, telemetered seismographic stations. The seismic recording system operates in an 'event triggered' mode, recording data at 100 samples per sec. per channel. The digital recording system is closely modeled after the CEDAR system developed at the California Institute of Technology by Carl Johnson. Arrival times, first motion polarities, signal durations, signal amplitudes, locations and focal mechanisms (when possible) are determined in postprocessing. 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.

Our on-line seismic recording system was updated during 1988. when a Masscomp-5600 minicomputer was acquired to replace an outdated PDP 11/34. The 11/34 continued running as a backup system until March of 1989. In late 1988 we implemented a complete backup of all system triggers to high-capacity (2.3 G-byte) exabyte tape. Each tape holds several months worth of compressed data. This system protects us against losing data due to inadvertent removal of files.

We also implemented a two-part alarm system that notifies us when a sizable local earthquake occurs. The first part is a very fast preliminary locator and magnitude estimator which runs dynamically as part of the real-time system. This method uses trigger buffer start times as preliminary P-wave arrival times, and an amplitude envelope to estimate coda lengths. If the earthquake appears to be within the network, and the magnitude exceeds 2.7, a call to a paging beeper is sent, including the location and magnitude estimates. The second alarm method uses a more sophisticated arrival-time picking algorithm which is run as soon as the event is demultiplexed to disk. If an earthquake meets magnitude and location criteria, an auto-dialer begins dialing though a list of 4 phone numbers, and continues to call every 15 minutes until deactivated by a call-back. The autodialer also starts its calling sequence when disk space is filling up, or if the data acquisition software or the Masscomp stops functioning. This "watch-dog" capability ensures that technical help will be notified immediately in the case of any problems.

For teleseisms, we are experimenting with using our preliminary location to reactivate recording to capture later phases which might not trigger the recording system.

Publications

Publications wholly or partly supported under these operating agreements are listed in Appendix 2.

Acknowledgements

Laurens Engel, Jim Ramey, and Jack Libby maintained seismic stations and telemetry links in the field, and operated acquisition equipment in the laboratory. Routine seismic analysis for the entire network, and quarterly reports, were done by Rick Benson. Chris Jonientz-Trisler helped compile quarterly reports, monitored moment release at Mt. St. Helens, and dealt with the public; taking reports of felt earthquakes, and giving out information. Ivar Mundal assisted with routine processing and archiving of earthquake data. Ruth Ludwin merged Canadian data into the pick files, wrote reports, provided data to investigators at other institutions, and handled miscellaneous administrative tasks. We particularly appreciate the cooperation of the U.S. National Parks Service at Mount Rainier during the installation of stations RCS and RER.

APPENDIX 1

U. W. Seismic Network Quarterly Reports

88-D, 89-A, 89-B, 89-C