FINAL TECHNICAL REPORT: 1994 - 1995

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Investigations undertaken

This contract is for the purchase and installation of four new, high quality broad-band three-component digital seismograph stations as an addition to the Pacific Northwest Seismograph Network (PNSN) It also includes funding to develop software for recovering and integrating the broad-band data into our routine data analysis procedures. In addition to the four stations supported under this contract, a prototype station (LON), situated on the same pier as the DWWSSN station at Longmire WA (near Mount Rainier), has been operating since early 1993. By the end of the contract period, there were a total of 10 high quality broad-band seismograph stations operating in the Pacific Northwest (5 operated by the PNSN, two by USNSN, one by IRIS/USGS -- COR, and two by the University of Oregon; PIN and DBO). See Figure 1, showing all stations.

Results

In addition to the LON prototype, all four of the new stations are fully operational, and data from them are routinely merged with PNSN short-period data. Since July of 1993, we have recovered over 7,000 broad-band data traces for more than 3,000 different events. Installation of the final station (with on-site recording), at Green Mountain on the Kitsap Peninsula, was completed in early 1995. Station SSW, at Satsop, Washington was moved due to the termination of moth-balling of the Satsop WPPSS plant. The equipment was moved to a nearby location in May, 1995, and the station was renamed RRW. Figure 1 shows the current PNSN network configuration (both broad-band and short-period). names, and the name of the institution operating the equipment. Table 1 lists broad-band, three-component stations operating in Washington and Oregon that provide data to the PNSN. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by an asterisk(*) were installed under support of this grant (LON, previously installed, was the prototype). 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 1
Broad-band three-component stations operating at the end of the second quarter 1995

STA	F	LAT	LONG	EL	NAME
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
DBO		43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (Operated by UO)
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)
RWW	*	46 57 50.1	123 32 35.9	0.015	Ranney Well(operated by UW)
SSW	*	46 58 20.4	123 26 01.8	0.120	Satsop, WA (operated by UW) - REPLACED BY RWW
TTW	*	47 41 40.7	121 41 20.0	0.542	Tolt Res, WA (operated by UW)
PIN		43 48 40.0	120 52 19.0	1.865	Pine Mt. Oregon (operated by UO)

All five broad-band stations operated by the University of Washington have been upgraded to include GPS time-code receivers and 24 bits/sample dynamic range. Four of the stations (GNW at Green Mountain, LON at Longmire, LTY at Liberty, and RWW at Satsop; all in Washington) time-stamp, digitize, and record data on-site. We recover selected broad-band data from these stations via phone lines using automated procedures that run late at night (to minimize long-distance charges). The fourth station, (TTW) near Tolt, Washington, also digitizes and time-stamps data on-site, but continuously telemeters data to the UW Seismology Lab where it is recorded as a continuous data stream. Individual events are extracted from the data stream and, with data from other broad-band stations (including COR, PIN, and DBO as well as LTY, SSW, and LON), are merged and archived with data from PNSN short-period stations. The broad-band event data are also translated to IRIS-SEED format and submitted to the IRIS Data Management Center for archive and distribution.

To allow broad-band data to be merged into the PNSN short-period data stream, the PNSN has modified both trace data and pickfile (phase arrival times) formats, and associated data-processing software. The new working trace data format (UW-2) allows us to accommodate data of varying durations, sample rates, start times, and formats (e.g., integer, floating point, etc.), is extensible without affecting existing processing programs, and is backward-compatible with our original (UW-1) format.

The new UW-2 pickfile format provides full support for three-component stations, flexibility to represent arbitrary phase types (our old UW-1 format could only represent P and S phases) such as Pn and PmP, and a number of other advantages, and is also backward compatible. Interactive viewing of both trace and pickfile data is provided through **Xped** (X pick editor), an X window application that allows the user to display trace and pick information, modify picks, run location programs, and perform other data analysis functions.

The data provided by the broad-band instruments is being used by several researchers. John Nabelek's group at Oregon State University is routinely using PNSN broad-band data to compute moment tensor solutions for all earthquakes in the region with coda magnitudes greater than 3.0. G. Khazaradze, a graduate student in our Program, developed a technique to generate synthetic Wood-Anderson records from the broad-band data. An independent determination of local magnitude at each broad-band station will make magnitude estimates more robust. His abstract on this topic is attached as Appendix 1.

The operation of the broad-band stations is fully integrated into the routine operation of the PNSN, which is supported by cooperative agreement 1434-92-A-0963. We are continuously receiving (via VSAT) and recording USNSN data and software to allow the merger of USNSN data into our PNSN data files has been developed and implemented. The work proposed under this grant has been completed as planned.

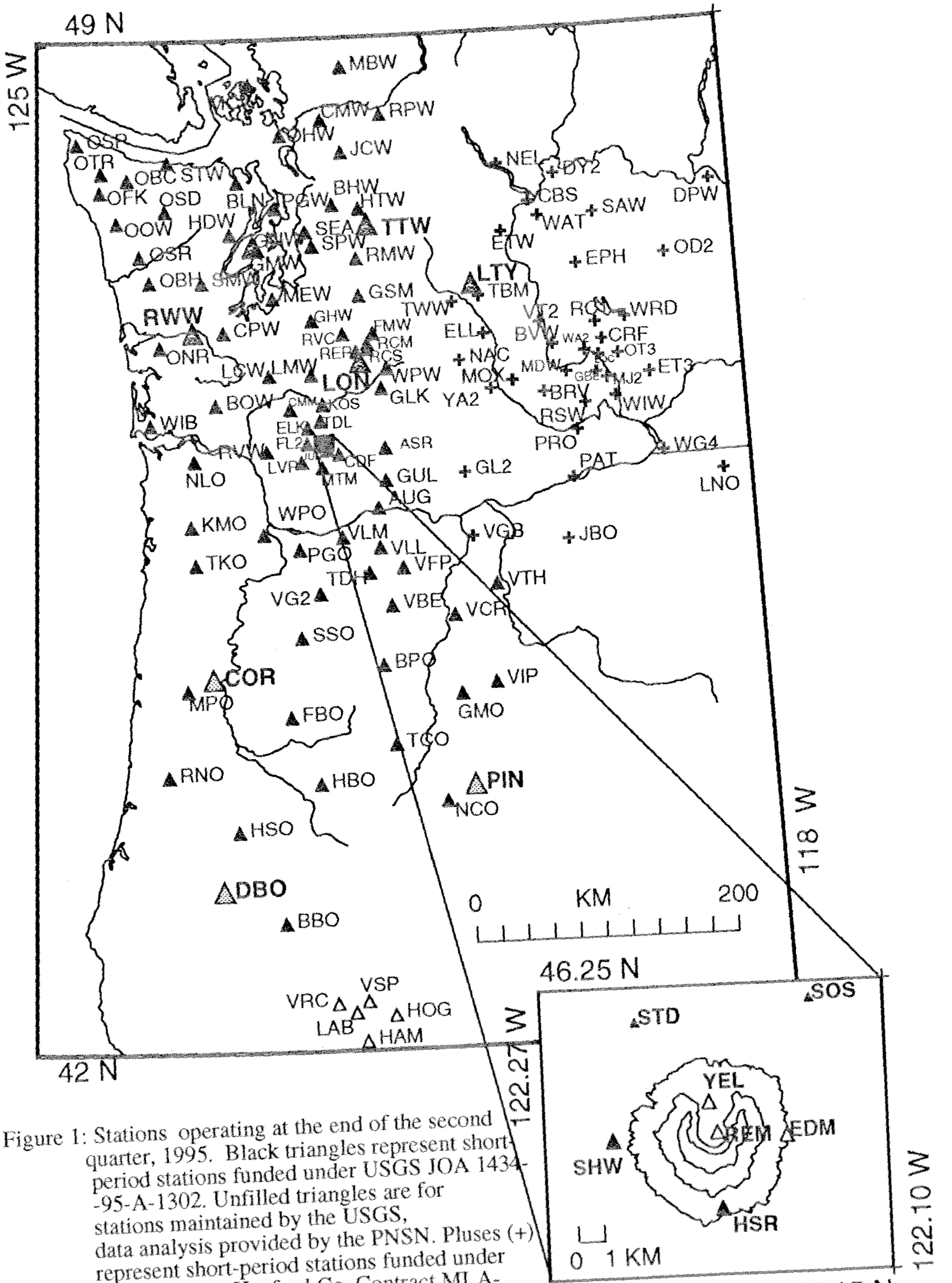

Figure 1: Stations operating at the end of the second quarter, 1995. Black triangles represent short-period stations funded under USGS JOA 1434-95-A-1302. Unfilled triangles are for stations maintained by the USGS, data analysis provided by the PNSN. Pluses (+) represent short-period stations funded under Westinghouse Hanford Co. Contract MLA-SVV-208775, and large shaded triangles show the locations of broad-band three-component instruments. Installation of broad-band stations in Washington was supported under this grant.

APPENDIX

Khazaradze, G. and S.D. Malone, 1994 (abstract), Determination of local magnitude using Pacific Northwest Seismic Network Broadband Data, EOS, Vol. 75, Supplement to No. 44, p. 460.

Determination of Local Magnitudes Using Pacific Northwest Seismic Network Broadband Data

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The Pacific Northwest Seismic Network (PNSN) includes four broadband (BB) digital seismographs in Washington. Based on data recorded by these stations, we developed a program which automatically generates synthetic Wood-Anderson seismograms and computes corresponding local magnitudes (M_{Ls}). We found that the computed M_{Ls} magnitudes for the larger events are systematically higher than coda duration magnitudes (M_D) published by PNSN.

We studied the above inconsistency between the M_{Ls} and M_D for 30 events, chosen by the following criteria: i) Availability of at least two station records, ii) $M_D > 2$, iii) Epicentral distance < 850 km. We found that the two could be related by the equation $M_{Ls} = -0.66 + 1.23*M_D$, which implies that for events with $M_D > 3$, M_D has been underestimated with respect to M_{Ls}. On the other hand, comparison of M_{Ls} with local magnitudes determined from the standard Wood-Anderson torsion seismograph located in Seattle showed that the two are the same, as expected.

Another independent test came from the comparison of M_{Ls} and M_D with the moment magnitudes (M_w) determined by Oregon State University. While M_w was well correlated with M_{Ls}, M_D was again underestimated.

Based on our observations, we conclude that the existing equation for M_D determination in the Pacific Northwest, $M_D = -2.46 + 2.82*\log(\tau)$, is underestimating actual local magnitudes for $M_D > 3$ events, and their values published in PNSN catalogues since 1972, might need to be reevaluated.