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Revision 0

Hanford Seismic Report for Fiscal Year 2024 (October 2023 - September 2024)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000031

P.O. Box 943
Richland, Washington 99352

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Executive Summary

The Pacific Northwest Seismic Network (PNSN) and Hanford Mission Integration Solutions (HMIS) provide uninterrupted collection of high-quality raw and processed seismic data from the Hanford Seismic Network (HSN). The HSN includes both onsite and offsite [Eastern Washington Regional Sub-Network (EWRSN)] stations that are operated for the U.S. Department of Energy (DOE) and its contractors. The team is responsible for identifying and locating sources of seismic activity that might affect the Hanford Site, monitoring changes in the historical pattern of seismic activity surrounding the Hanford Site, and monitoring ground motion to provide data to constrain studies of earthquake effects on the Hanford Site. Seismic data are compiled, archived, and published for use by the Hanford Site for waste management, natural phenomena hazards assessments, and engineering design and construction. In addition, the team works with the Hanford Site Emergency Services Organization to provide assistance in the event of a significant earthquake on the Hanford Site. The HSN and the EWRSN together consist of 40 individual sensor sites and 14 radio relay sites maintained by the PNSN.

During FY2024, seismic activity increased slightly throughout eastern Washington. 474 earthquakes were cataloged in the region, of which about 50% (237) took place on or in the immediate vicinity of the Hanford Site. This is an increase from 429 earthquakes in the previous year. Several earthquakes took place in the historically active area of Entiat and Chelan. Within the vicinity of the Hanford Site, there was low to typical swarm-type activity in the previously identified swarm areas. However, a vigorous swarm of small (magnitude <= 2) earthquakes began in the 4th quarter in a newly designated swarm area, the Umtanum Ridge Swarm, further discussed in Section 5.2 of this report.

Abbreviations and Acronyms

ANSS	Advanced National Seismic System
AQMS	ANSS Quake Management System
BB	Broadband (type of seismic station)
BPA	Bonneville Power Administration
BWIP	Basalt Waste Isolation Project
CRBG	Columbia River Basalt Group
Dmin	Minimum distance (closest distance from an earthquake epicenter to a station)
DOE	U.S. Department of Energy
EEW	Earthquake early warnings
Etyp	Event type
EWRSN	Eastern Washington Regional Sub-Network
FY	Fiscal Year
g	typical value of gravitational acceleration at Earth's surface (~978 cm/sec/sec)
GPS	Global Positioning System
HLSMP	Hanford Lifecycle Seismic Monitoring Program
HMIS	Hanford Mission Integrated Solutions, LLC
HNF	Hanford Nuclear Facility
HSN	Hanford Seismic Network
IRIS	Incorporated Research Institutions in Seismology
LAT	Latitude
LON	Longitude
Km	kilometer
M_d	Coda-duration magnitude
M_L	Local magnitude
Mag	Magnitude of earthquake
MMI	Modified Mercalli Intensity
MOD	Wavespeed model
MSA	Mission Support Alliance
Mtyp	Magnitude type
NS/NP	Number of stations/number of phases
PNNL	Pacific Northwest National Laboratory
PNSN	Pacific Northwest Seismic Network
Q	Quality factor (of earthquake location)
RMS	Root Mean Square (error of earthquake location)
RSLW	Lower Rattlesnake (Mountain) data acquisition/telemetry site
SHPS	Safety and Health Programs Support
SMA	Strong Motion Accelerometer (type of seismic station)
USGS	U.S. Geological Survey
UTC	Coordinated Universal Time
UW	University of Washington
WHC	Westinghouse Hanford Company
WSUR	Washington State University Richland

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1.0 Introduction

This annual report documents the locations, magnitudes, and seismic interpretations of earthquakes recorded for the Hanford monitoring region of south-central Washington during the fiscal year (FY) 2024 (October 2023 through September 2024). Hanford Mission Integrated Solutions, LLC manages seismic monitoring for the Hanford Site with the monitoring work being performed by the Pacific Northwest Seismic Network (PNSN) at the University of Washington (UW) under a sub-contract.

1.1 Mission

The mission of the Hanford Lifecycle Seismic Monitoring Program (HLSMP) is to maintain seismic stations, report data from measured events, and to provide assistance in the event of an earthquake. This mission supports DOE and the other Hanford Site contractors in their compliance with DOE Order 420.1C, Chapter IV, Section 3.e, "Seismic Detection," and DOE Order G 420.1-1A, Section 5.4.8, "Design for Emergency Preparedness and Emergency Communications." DOE Order 420.1C requires facilities or sites with hazardous materials to maintain instrumentation or other means to detect and record the occurrence and severity of seismic events. The HLSMP maintains the seismic network located on and around the Hanford Site. The data collected from the seismic network can be used to support facility or site operations to protect the public, workers, and the environment from the impact of seismic events.

In addition, the HLSMP provides an uninterrupted collection of high-quality raw seismic data from the HSN and the EWRSN and provides interpretations of seismic events from the Hanford Site and the vicinity. The program locates and identifies sources of seismic activity, monitors changes in the historical pattern of seismic activity, and builds a "local" earthquake database (processed data) that is permanently archived. The focus of this report is the precise location of earthquakes and explosions proximal to or on the Hanford Site, specifically, between 46°-47° north latitudes (LAT) and between 119°-120° west longitudes (LON). Data from the EWRSN and other seismic networks in the Northwest provide the HLSMP with necessary regional input for the seismic hazards analysis at the Hanford Site. These seismic data are used to support Hanford Site contractors for waste management activities, natural phenomena hazards assessments, and engineering design and construction.

1.2 History of Monitoring Seismic Activity at Hanford

The U.S. Geological Survey (USGS) under a contract with the U.S. Atomic Energy Commission initiated monitoring seismic activity at the Hanford Site in 1969. In 1975, the UW assumed responsibility for the network and subsequently expanded it. In 1979, the Basalt Waste Isolation Project (BWIP) became responsible for collecting seismic data for the Hanford Site as part of site characterization activities. Rockwell Hanford Operations, followed by Westinghouse Hanford Company (WHC), operated the local network, and were the contract technical advisors for the EWRSN operated and maintained by UW. Funding ended for BWIP in December 1988; the seismic program (including the UW contract) was transferred to the WHC Environmental Division. Maintenance responsibilities for the EWRSN also were assigned to WHC, who made major upgrades to EWRSN sites. Effective

October 1, 1996, all seismic assessment activities were transferred to the Pacific Northwest National Laboratory (PNNL).

The Hanford Strong Motion Accelerometer (SMA) network was constructed during 1997, becoming operational in May 1997. It was shut down in FY 1998 due to lack of funding but became operational again in FY 1999 and has operated continuously since that time. During the third quarter of FY2011, administration of the seismic monitoring networks was assumed by HLSMP and contracted to be operated by the PNSN, University of Washington.

1.3 Documentation and Reports

The HLSMP issues annual reports of local and regional earthquake activity in southeastern Washington, and special-interest bulletins on local seismic events. This includes information and special reports as requested by DOE and Hanford Site contractors. Earthquake information provided in these reports is subject to revision as new information becomes available. An archive of all cataloged seismic event locations and magnitudes and related waveform data from the HLSMP is maintained by PNSN on computer servers at the UW. Continuous waveform data and associated station metadata from all available seismic stations are permanently archived and made available by the EarthScope Consortium's Data Services, previously known as the Incorporated Research Institutions in Seismology (IRIS).

2.0 Geology and Tectonic Analysis

The Hanford Site lies within the Columbia Basin, an intermontane basin between the Cascade Range and the Rocky Mountains filled with Cenozoic volcanic rocks and sediments. This basin forms the northern part of the Columbia Plateau physiographic province (Fenneman, 1931) and the Columbia River flood-basalt province (Reidel *et al.,* 1989). In the central and western parts of the Columbia Basin, the Columbia River Basalt Group (CRBG) overlies Tertiary continental sedimentary rocks and is overlain by late Tertiary, Quaternary fluvial, and glaciofluvial deposits (Campbell, 1989; Reidel *et al.,* 1989, 1994; DOE, 1988). In the eastern part, little or no sediment separates the basalt and underlying crystalline basement, and a thin (<10 m) veneer of eolian sediments overlies the basalt (Reidel *et al*., 1989, 1994).

The Columbia Basin has two structural subdivisions or sub-provinces—the Yakima Fold Belt and the Palouse Slope. The Yakima Fold Belt includes the western and central parts of the Columbia Basin and is a series of anticlinal ridges and synclinal valleys with major thrust faults typically along the northern flanks (Figure 2.1) (Reidel and Fecht, 1994a, 1994b). The Palouse Slope is the eastern part of the basin and is less deformed than the Yakima Fold Belt, with only a few faults and low-amplitude long-wave-length folds on an otherwise gently westward dipping paleo slope.

2.1 Earthquake Stratigraphy

Seismic studies at the Hanford Site have shown that the earthquake activity is related to crustal stratigraphy (large groupings of rock types) (Rohay *et al.,* 1985; DOE, 1988). The main geologic units important to earthquakes at the Hanford Site and the surrounding area are:

- Miocene Columbia River Basalt Group
- Sub-basalt sediments of Paleocene, Eocene, Oligocene, and Early Miocene age
- Precambrian and Paleozoic cratonic basement
- Mesozoic accreted terranes forming the basement west of the craton margin.

2.2 Geologic Structure Beneath the Monitored Area

Between the late 1950s and the mid-1980s, deep boreholes were drilled for hydrocarbon exploration in the Columbia Basin. These boreholes provided accurate measurements of the physical properties of the CRBG and the pre-basalt sediments (Reidel *et al.,* 1989, 1994), but the thickness of the sub-basalt sediments and nature of the basement are still poorly understood. Table 2.1, derived from Reidel, *et al.* (1994), was developed for the geologic interpretation in this report. The thicknesses of these units are variable across the monitored area. Table 2.1 summarizes the approximate thickness at the borders of the monitored area.

Table 2.1. Thicknesses of Stratigraphic Units in the Monitoring Area

(from Reidel et al., 1994)

Stratigraphy	North	South	East	West
Columbia River Basalt Group (includes suprabasalt sediments)	3.0 km	4.5 km	2.2 km	4.2 km
Pre-basalt sediments	3.0 km	>4.5 km	0	>6.0 km

The thickness of the basalt and the sub-basalt sediments varies because of different tectonic environments. The western edge of the North American craton (late Precambrian/Paleozoic continental margin and Precambrian craton) is located in the eastern portion of the monitored area (Reidel *et al.,* 1994). The stratigraphy on the craton consists of CRBG overlying basement; the basement is continental crustal rock that underlies much of western North America. The stratigraphy west of the craton consists of 4 to 5 km of CRBG overlying up to 6 km of pre-basalt sediments. This in turn overlies accreted terranes of Mesozoic age. The area west of the craton was subsiding during the Eocene and Oligocene, accumulating great thickness of pre-CRBG sediments. Continued subsidence in this area during the Miocene resulted in thicker CRBG compared to that on the craton. Subsidence continues today but at a greatly reduced rate (Reidel *et al.,* 1994).

2.3 Tectonic Pattern

Studies have concluded that earthquakes can occur in the following six different tectonic environments (earthquake sources) at the Hanford Site (Geomatrix, 1996):

Major Geologic Structures. Reverse/thrust faults in the CRBG associated with major anticlinal ridges such as Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge could produce some of the largest earthquakes.

Secondary Faults. These faults are typically smaller (1 to 20 km in length) than the main reverse/ thrust faults that occur along the major anticlinal ridges (up to 100 km in length). Secondary faults can be segment boundaries (tear faults) and small faults of any orientation that form along with the main structure.

Swarm Areas. Small geographic areas produce clusters of events (swarms); usually located in synclinal valleys not known to contain any mapped geologic faults. These clusters consist of a series of small shocks with no outstanding principal event. Swarms occur over a period of days or months, and the events may number into the hundreds and then quit, only to start again later. This differs from the sequence of foreshocks, mainshock, and trailing-off aftershocks that have the same epicenter or are associated with the same fault system. In the past, swarms were thought to occur only in the CRBG. Most swarm areas are in the basalt, but swarm events also appear to occur in all geologic layers. However, typically a swarm event at a specific time is usually restricted to one layer. It is traditional to regard swarms as occurring within one of seven earthquake swarm areas in the HSN area. The Saddle Mountains, Wooded Island, Wahluke, Coyote Rapids, Horse Heaven Hills, and newly designated Umtanum Ridge swarm areas are typically active at one time or another during the year. The other earthquake swarm areas are active less frequently. There is, however, no compelling theory to suggest a generative mechanism active within these swarm areas. They are deduced purely empirically, are rather conjectural, and will likely be updated or reconfigured as new swarm areas develop.

Entire Columbia Basin. The entire basin, including the Hanford Site, could produce a "floating" earthquake. A floating earthquake is one that, for seismic design purposes, can happen anywhere in a tectonic province and is not associated with any known geologic structure. Seismic interpretation classifies it as a random event for purposes of seismic design and vibratory ground motion studies.

Basement Source Structures. Studies (Geomatrix 1996) suggest that major earthquakes can originate in tectonic structures in the basement. Because little is known about geologic structures in the basement beneath the Hanford Site, earthquakes cannot be directly tied to a mapped fault. Earthquakes occurring in the basement without known sources are treated as random events.

Cascadia Subduction Zone. This source has been postulated to be capable of producing a magnitude 9 earthquake. Because this source is along the western boundary of Washington State and outside the HSN, the Cascadia subduction zone is not an earthquake source that is monitored at the Hanford Site, so subduction zone earthquakes are not reported here. Because any earthquake along the Cascadia subduction zone can have a significant impact on the Hanford Site or can be felt like the February 2001 Nisqually earthquake, UW monitors and reports on this earthquake source for the DOE. Ground motion from any moderate or larger Cascadia subduction zone earthquake is detected by Hanford SMAs and reported.

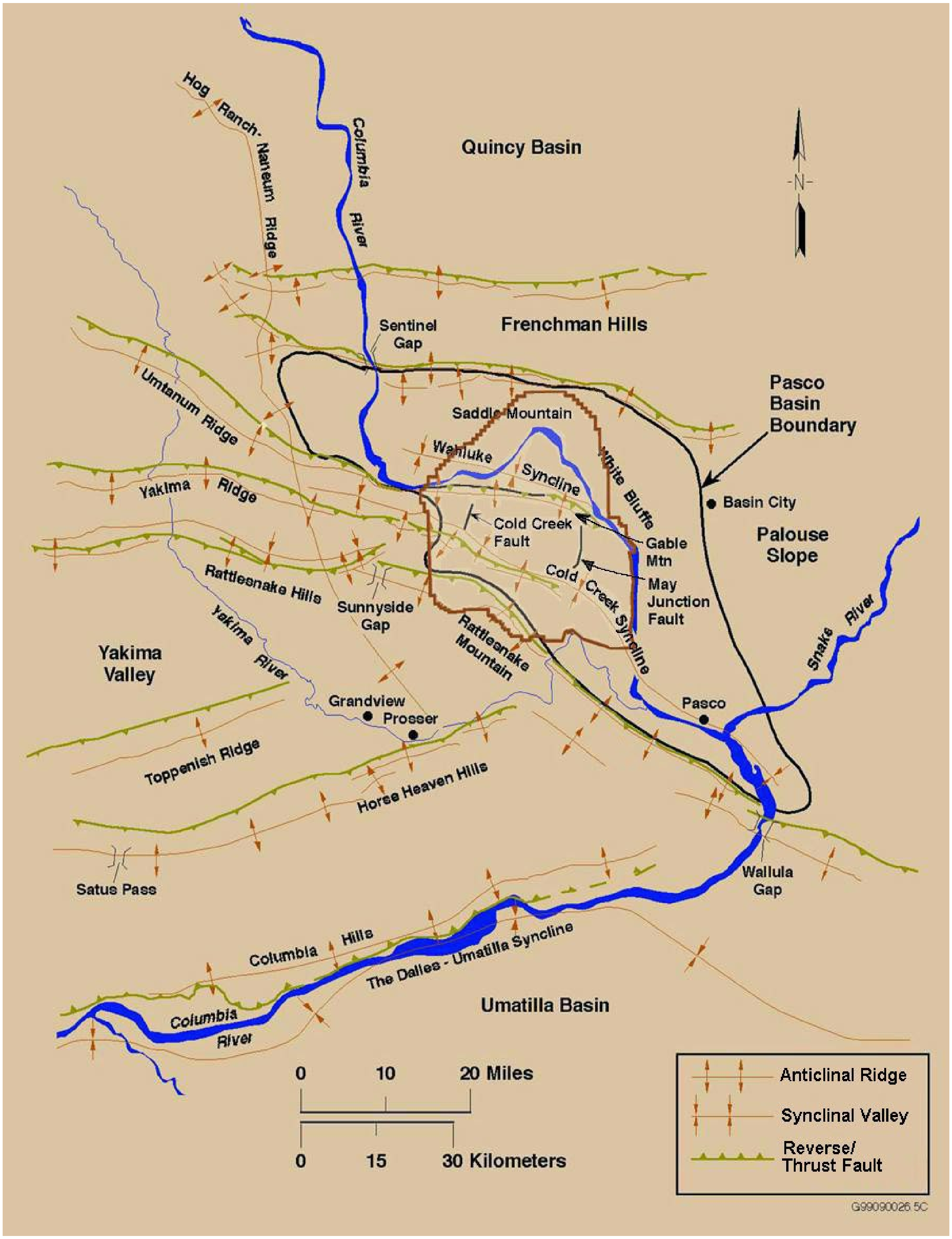

Figure 2.1. Tectonic Features of the Hanford Site within Eastern Washington

(from Rohay et al., 2010b)

3.0 Network Operations

3.1 Seismic Station Overview

The seismic network consists of three types of earthquake sensors—short-period seismometers, broadband seismometers, and strong motion accelerometers (SMAs).

Short-period seismometers are very sensitive passive sensors (they do not use external electric power) designed primarily to detect micro-earthquakes. While most short-period stations have a single component, sensitive only to the vertical motion of the ground, one HLSMP short-period station records the ground in three orthogonal directions. In a regional network like the HLSMP networks, the time of arrival of waves, and the signal duration derived from short-period stations are used to determine the locations and magnitudes of seismic events; the polarities of ground motions may be used to constrain estimates of the geometry of fault that ruptured in an earthquake.

Broadband seismometers are active sensors (they use electricity to power advanced electronic circuitry that is integral to the sensor) that faithfully record ground motions over a wide frequency range. The data they produce are acquired digitally with 24-bit dynamic range; a broadband system will therefore stay "on-scale" over a much broader range of ground motions than a short-period sensor. In addition to locations and magnitudes derived from signal durations, details of the observed waveforms are used to reveal the source processes of small to moderately large earthquakes. HLSMP broadband stations are all 3-component.

Both short-period and broad-band sensors will ultimately "clip", or fail to record properly, if subjected to more than moderate levels of shaking (well below damaging levels). SMA stations, however, are designed to measure even the damaging ground motions from larger earthquakes. They are 3-component stations and must be carefully and strongly anchored to the ground so that the details of ground shaking up to 2g (twice the vertical acceleration of gravity) are accurately recorded. In addition to helping to characterize the earthquake source, they are critically important in measuring the ground motions that impact a particular site. They aid in determining what the built environment has been exposed to for earthquake response activities and engineers and others use them in designing appropriate structures. Because of their importance to seismic monitoring on the Hanford Site, the distribution, design, and operations of SMA stations within the HLSMP is discussed separately in Section 3.2.

Five HLSMP stations are now capable of recording 4 channels of seismic data. These sites will record 3 orthogonal components of strong motion and a vertical component of high-gain short-period motion. An additional 16 sites record 6 channels of seismic data, three components of strong motion accelerometer data and three components of high-gain broadband data. The high-gain data is used to detect and locate earthquakes too small to generate ground motions above the strong-motion channels' noise level.

The seismic stations supported by HMIS are further divided into two geographic sub-networks for discussion: HSN, which are sites located on the Hanford Site itself, and the EWRSN, which includes sites that surround the Hanford Site.

Combined, the HSN and the EWRSN include 40 stations. Most stations reside in remote locations and require solar panels and batteries for power. The HSN includes 18 stations (Table 3.1 and Figure 3.1), and the EWRSN consists of 22 stations (Table 3.2 and Figure 3.2).

Table 3.1. Hanford Seismic Network Onsite Stations

Station	Latitude	Longitude	Elevation (m)	Station Name
Strong Motion Accelerometer, 3-Channel Station				
H2E	46.5578	-119.5345	210	200 East Area (SMA)
H2W	46.5517	-119.6453	201	200 West Area (SMA)
H3A	46.3632	-119.2775	119	300 Area (SMA)
H4A	46.4377	-119.3557	171	400 Area (SMA)
Strong motion and Broadband, 6-Channel Station				
GBB	46.6087	-119.6290	185	Gable Butte
H2O	46.3956	-119.4241	175	Water Station
MDW	46.6130	-119.7622	330	Midway
NIKE	46.3919	-119.5327	369	Nike Missile Silo
SNI2	46.4648	-119.6552	267	Snively Ranch
WA2	46.7552	-119.5668	244	Wahluke Slope
Strong motion and Short Period, 4-Channel Station				
H1K	46.6447	-119.5929	152	100 K Area (SMA)
HGBL	46.5980	-119.4613	330	Gable Mountain
HWIW	46.4292	-119.2888	128	Wooded Island
GRUT	46.5512	-119.5102	219	Wet-Grout Plant
MJ2	46.5574	-119.3601	146	May Junction Two
Broadband, 3-Channel Station				
LIGO	46.4617	-119.4177	158	LIGO Observatory
Short Period, Single Channel Analog				
BEN	46.5186	-119.7185	335	Benson Ranch
LOC	46.7169	-119.4320	210	Locke Island
RSW	46.3944	-119.5925	1045	Rattlesnake Mountain

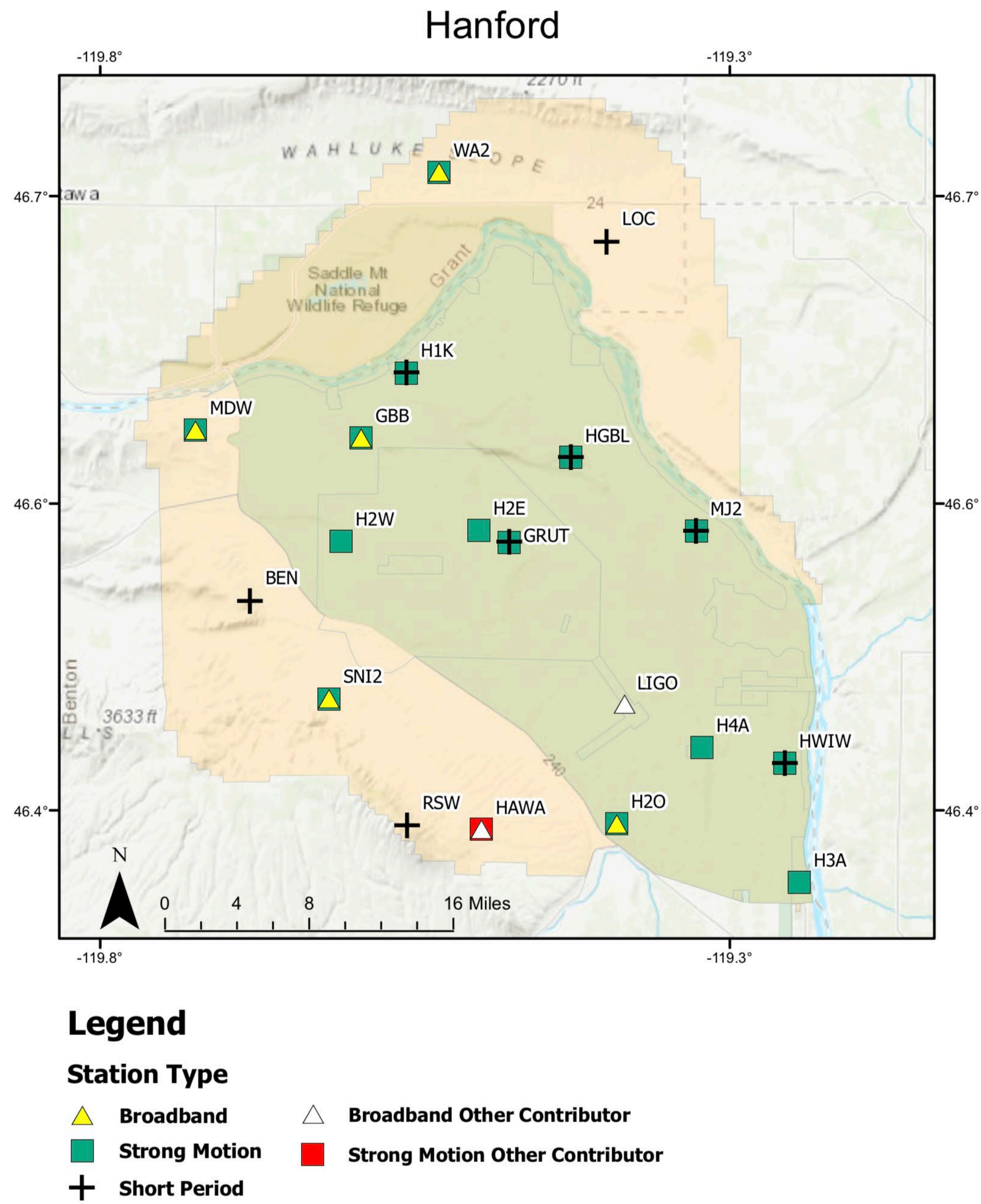

Figure 3.1. Hanford Seismic Network Onsite Stations

Table 3.2. Hanford Seismic Network Offsite Stations

Station	Latitude	Longitude	Elevation (m)	Station Name
Strong Motion and Broadband, 6-Channel Station				
CCRK	46.5585	-119.8548	561	Cold Creek
DDRF	46.4911	-119.0595	233	Didier Farms
EPH2	47.3562	-119.5972	661	Ephrata
LNO	45.8717	-118.2862	771	Lincton Mountain Oregon
MANO	46.9511	-120.7247	1200	Manatash Ridge Observatory
MOX	46.5772	-120.2993	501	Moxee City
OD2	47.388	-118.7108	553	Odessa 2
OT3	46.6689	-119.2341	322	Othello 3
PHIN	45.8950	-119.9280	227	Phinney Hill
PRO	46.2125	-119.6868	553	Prosser
YPT	46.0487	-118.9634	325	Yellepit
Short Period, Single-Channel Analog				
BRV	46.4852	-119.9923	920	Black Rock Valley
BVW	46.8108	-119.8835	670	Beverly
CRF	46.8249	-119.3881	189	Corfu
ELL	46.9095	-120.5675	789	Ellensburg
NAC	46.7330	-120.8249	728	Naches
PAT2	45.8836	-119.7578	259	Paterson 2
RED2	46.3053	-119.4526	330	Red Mountain 2
TRW	46.2921	-120.5431	723	Toppenish Ridge
VT2	46.9672	-120.0003	385	Vantage 2
WRD	46.9699	-119.1460	375	Warden
Short Period, 3-Channel Analog				
FHE	46.9518	-119.4981	455	Frenchman Hills East

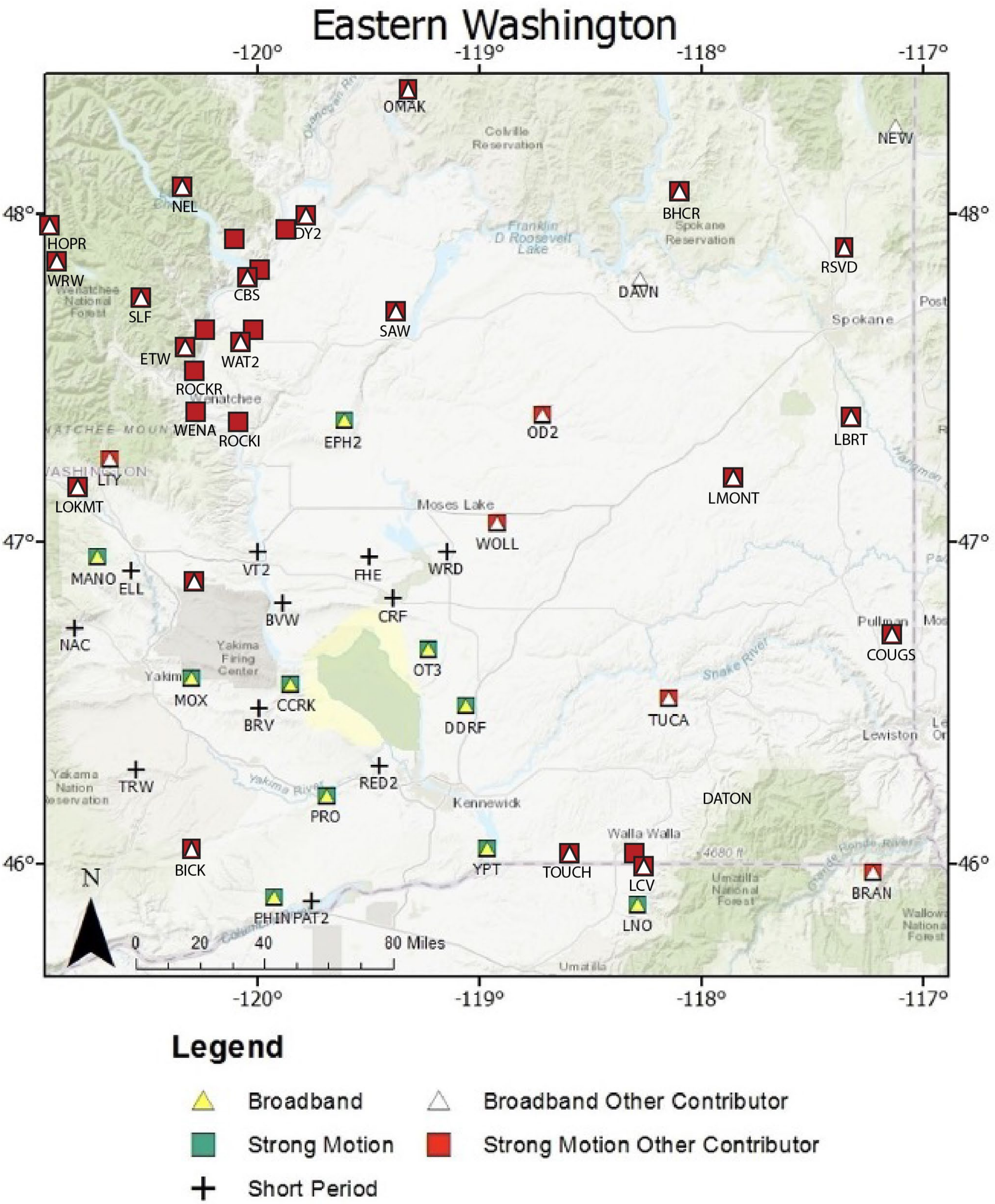

Figure 3.2. Hanford Seismic Network Stations of the Eastern Washington Region Sub-Network

The EWRSN is used by the HLSMP for two major reasons. A large earthquake located in the Pacific Northwest outside of Hanford could produce significant ground motion and damage to structures at the Hanford Site. For example, the magnitude 7.0 earthquake that occurred in 1872 near Chelan/Entiat or other earthquakes located in the region (*e.g.,* eastern Cascade Mountain Range) could have such an effect. The EWRSN would provide valuable information to help determine the impacts of such an event. Additionally, the characterization of seismicity throughout the surrounding areas, as required for the Probabilistic Seismic Hazard Analysis, supports facility safety assessments at the Hanford Site. Both the HSN and the EWRSN are fully integrated within the Pacific Northwest Seismic Network managed by the University of Washington.

The HSN and EWRSN networks have 145 combined data channels from: 14 single channel sites, 2 three-component seismometer sites (FHE and LIGO), 17 six-component sites (CCRK, DDRF, EPH2, GBB, H2O, LNO, MANO, MDW, MOX, NIKE, OD2, OT3, PHIN, PRO, SNI2, WA2, and YPT) and 9 other sites in the HSN (H1K, H2E, H2W, H3A, H4A, MJ2, GRUT, HGBL, and HWIW) that acquire additional data channels at each station. The three component sensors record motion in the vertical, north-south horizontal, and east-west horizontal directions. Fourteen radio telemetry relay sites are used by both sub-networks to transmit seismogram data continuously to the PNSN in Seattle, Washington, for processing and archiving.

3.2 Strong Motion Accelerometer Stations

3.2.1 Strong Motion Station Location

SMAs provided ground motion observations critical to understand the impacts of strong ground shaking that affect the Hanford Site itself. The Hanford SMA network consists of 15 free-field SMA stations (see Figure 3.1; Table 3.1). SMAs are located in the 200 East and 200 West Areas, in the 100-K Area adjacent to the K Basins, in the 400 Area near the former Fast Flux Test Facility, and at the south end of the 300 Area.

The locations of SMA stations were chosen based on two criteria: 1) density of workers, and 2) sites of hazardous facilities (Moore and Reidel 1996). The 200 East and 200 West Areas contain single-shell and double-shell tanks in which high-level radioactive wastes from past processing of fuel rods are stored. In addition, the Canister Storage Facility (holding encapsulated spent fuel rods) and the new Waste Treatment and Immobilization Plant being constructed are both located in the 200 East Area. The 100-K Area contained the K Basins, where spent fuel rods from the N Reactor were stored prior to encapsulation. The now inactive Fast Flux Test Facility is located in the 400 Area.

3.2.2 Strong Motion Station Design

All free-field SMA stations consist of a four-panel solar array and two 30-gallon galvanized drums that contain equipment. Each panel has a maximum 42-watt output. The two drums are set in the ground such that the base of each drum is about 1 m below the ground surface. One drum houses only the SMA; the other drum, which is connected via a sealed conduit to the SMA drum, contains the batteries. Cellular modems provide communication from all five SMAs. The enclosure serves as a junction box for all cabling that is routed through conduits inside and outside the equipment drums. The antenna for the cell modem is mounted on top of the enclosure. The enclosure permits quick access to check battery conditions and a connection directly to the RS-232 port of the SMA without removing the drum lids. However, with continuous data telemetry via cell modem, most interrogation of the system is accomplished remotely.

Four of the SMA stations (H3A, H4A, H2E, H2W) are three-component units consisting of vertical, north-south horizontal, and east-west horizontal seismometers manufactured by Nanometrics, Inc., and known as the Titan system. Each Titan unit contains a digital recorder, a data storage unit, and a Global Positioning System (GPS) receiver with the equipment housed in a watertight box. Five sites (H1K, HWIW, HGBL, GRUT, and MJ2) had Kinemetrics Basalts with 3 SMA channels that are supplemented by a high-gain vertical short-period sensor. The Basalt at H1K failed and we replaced it with its modern replacement, a Kinemetrics Obsidian. Five sites have a broadband and strong-motion sensor packaged in a single casing that is deployed in a shallow posthole, Nanometrics Trillium Cascadia and a Centaur datalogger (GBB, H2O, MDW, SNI2, WA2).

A cell modem or digital radio system provides the Internet address connection to access the system. Stations can be monitored from any computer with appropriate access, and data are continuously telemetered to UW. The data also can be downloaded directly at each site, via a built-in cable connection at the enclosure in case of communication failure. The GPS receiver provides timing of the ground motions accurate to several microseconds, coordinated to Universal Coordinated Time (UTC). The GPS receiver antenna is mounted on the enclosure at the rear of the solar array. The GPS receiver is activated internally approximately every 4 hours and checks the "location of the instrument" and the time. The SMA records any differences between the internal clock and the GPS time. Any corrections to the internal timing are made automatically. Typically, the greatest correction recorded is approximately 4 milliseconds.

The combined operations, data recording, data interpretation, and maintenance facility is located in the PNSN offices at the UW in Seattle.

3.2.3 Strong Motion Operational Characteristics

Signals from the three-channel SMA stations use an 18-bit digitizer with data sampled at 200 samples/s. Data are sent continuously in real-time to the PNSN offices at the UW in Seattle. This permits the recording of ground motion data for smaller, non-damaging earthquakes that can be useful in estimating impacts of larger earthquakes. It also helps confirm the correct operation of the instruments.

For security and robustness, the Titan also stores triggered event files. When one of the accelerometer channels exceeds the trigger threshold (0.02%g), the recorders save information within the data buffers on memory cards within the Titan. Data recording begins 10 s before the actual trigger time, continues until the trigger threshold is no longer exceeded, and ends with an additional 40 s of data. The files created by a triggered event can be retrieved and examined by HLSMP staff, in the event of telemetry failure. The retrieval can be accomplished either remotely when telemetry is re-established, or manually by a technician traveling to the site.

Data from the SMA channels of the 4-channel and 6-channel stations are treated in a similar fashion. The primary difference is that the data from these channels (as well as the vertical high-gain channel) are digitized with 24-bit resolution.

3.3 Data Analysis

Signals from the seismometers are monitored in real time for changes in signal amplitudes and frequency that are expected from earthquakes. The seismic network is subdivided into spatial groupings of stations that are monitored for nearly simultaneous amplitude changes, triggering a permanent recording of the events. The groupings and associated weighting schemes are designed to allow very small seismic events to be recorded and to minimize false triggers. Events are classified as local (south-central Washington near the Hanford Site), regional (western United States and Canada), and teleseisms (from farther distances around the world). Local and regional events are usually earthquakes, but quarry and mining explosions also are recorded. Quarry and mining explosions usually can be identified from wave characteristics and the time of occurrence and may be confirmed with local government agencies and industries. Frequently, military exercises at the U.S. Army Yakima Training Center produce a series of acoustic shocks that trigger the recording system. Sonic booms and thunder also produce acoustic signals that may trigger the recording system. Acoustic signals are identified by their slower propagation across the network (soundwave speed) compared to seismic signals (elastic wave speed in rocks). All data are continuously telemetered, recorded, and saved in a permanent seismic data archive operated by the EarthScope Consortium's Data Services, previously known as the IRIS data management center, and is available for download and analysis.

The HLSMP uses Earthworm, an automated computer-based software system developed by the USGS and used throughout the region by the Pacific Northwest Seismic Network at the UW, to acquire seismic data and automatically detect and locate events (Hartog et al., 2020). We currently run Earthworm version 7.10 on a variety of computer servers. Redundant Earthworm systems run continuously at the PNSN. If one fails, a second one serves as a "backup." Two complete systems are located in different buildings on separate computer servers with redundant power supplies, backed up by different uninterruptable power supplies and a diesel-powered electric generator capable of powering the network until refueling is needed. Seismic data from triggered events are collected for assessment by HLSMP staff. This information is evaluated to determine if the event is "false" (for example, due to a sonic boom) or is an earthquake or ground-surface or underground blast. Earthquake events are evaluated to determine epicenter locations, focal depths, and magnitudes (Section 4).

Data from HLSMP-operated seismic stations are combined at the UW analysis center with seismic data from regional seismic stations operated by other entities and contributed in real-time to PNSN. The earthquake locations and ground motion we report in this catalog include these valuable contributed data. This contributed data improves the accuracy of the seismic products we provide at Hanford, and adds to the robustness of the entire network in the event that any particular portion of the network suffers temporary data loss from environmental or other causes.

4.0 Earthquake Catalog

Within the Advanced National Seismic System (ANSS) Quake Management System (AQMS) seismic network processing software, an interactive program called Jiggle is used to manually review and revise automatic phase arrival picks and signal durations, as well as their polarities, uncertainties and quality factors (Hartog et al., 2020). Arrival and duration times and uncertainties are used as input to an earthquake location program (Klein, 2002) to compute locations and magnitudes of the seismic events. Resulting locations for local earthquakes (44°-49° north latitude, 117°-121.5° west longitude) are reported in Table 4.2. Additional seismic events located outside the reporting region for this report are also evaluated. These surrounding events are not reported in this document, but are used as a check to confirm that the HSN and EWRSN are functioning properly (*e.g.,* quality checks on data recording). All processing results are available through the PNSN at www.pnsn.org.

4.1 Wave Speed Models

Earthquake location uses the arrival times of seismic phases at seismic stations and a model of the seismic wave speeds of crustal rocks of eastern Washington called a "wave speed model" (MOD), to solve for the most likely location for the earthquake source. AQMS divides the eastern Washington and Oregon region into 3 sub-regions. The wave speed models for each sub-region were developed using available geologic information and calibrated from seismic data recorded from accurately located earthquake and blast events in eastern Washington. Time corrections (delays) are incorporated into the wave speed models to account for significant deviations in station elevations or stations situated on sedimentary layers. Station delays are determined empirically from accurately located earthquakes and blast events in the region.

Table 4.1. Wave Speed Model for Eastern Washington
(from Rohay et al., 1985)

Depth to Top of Layer (km)	Layer	Wave speed (km/s)
0.0	Saddle Mountains and Wanapum Basalts and intercalated Ellensburg Formation	3.7
0.4	Grande Ronde Basalt and pre-basalt sediments	5.2
8.5	Basement, Layer 1	6.1
13.0	Basement, layer 2	6.4
23.0	Sub-basement	7.1
38.0	Mantle	7.9

4.2 Earthquake Magnitudes

AQMS computes several different magnitude estimates (Mtyp) for earthquakes. Table 4.1 shows the analyst-preferred value of either: 1) the coda-duration magnitude (M_d), or 2) the local magnitude (M_L) (Richter 1958). We report the median magnitude provided by all stations contributing estimates for an event.

The coda duration magnitude is based on a relationship developed for Washington State by Crosson (1972), modified for application within the AQMS software. The formula we use for M_d is:

$$M_d = -1.61 + 2.82 \log(D) - 2.46$$

Where D is the duration of the observed event (in seconds), starting from the P-wave arrival. Many earthquakes yield magnitude determinations that are very small ($M_d < 0$) and highly uncertain. Earthquakes with magnitudes (M_d) smaller than 3.0 are defined as "minor." Coda-duration magnitudes for events classified as explosions are reported although they may be biased by a prominent surface wave that extends the apparent duration in a way inconsistent with coda-length measurement.

M_L is computed from the maximum amplitudes of the signals on the horizontal components recording an event, filtered to mimic the instrument response of a Wood-Anderson torsion seismograph. The formula is:

$$M_L = \log(A) - \log(A_0) + S$$

Where A is the average zero-to-peak amplitude of the two horizontal components at a station after they have been converted to pseudo-Wood-Anderson traces. Log (A_0) is a distance correction, for which we use the Jennings and Kanamori (1983) values, and S is a site correction term that accounts for differences in local geological conditions amongst stations.

The choice of preferred magnitude type involves some subjectivity, as the relative strength of each depends on conditions that differ from event to event. In general, M_L is preferred for an event that is well-recorded on a sufficient number of suitable channels. [This is because there may be subjectivity in determining the durations used by the M_d algorithm (although AQMS does this in a largely automatic, and hence objective, way), and because the determination of the duration is biased by background noise levels.] In practice, this usually means that M_L is preferred for earthquakes sufficiently large to be observed at several three-component broadband stations. Although occasionally smaller earthquakes yield robust M_L estimates, depending on the background noise level at the time of the earthquake. M_d, on the other hand can be obtained from smaller earthquakes, even if the recording should "clip." For earthquakes larger than about M4.5, only the M_L should be used. The two magnitude scales are defined to be consistent for the events for which they overlap.

4.3 Quality Factors

Table 4.1 tabulates a two-letter **Quality factor** (Q) for each event that indicates the general reliability of the solution (**A** is best quality, **D** is worst). The first letter of the quality code is a measure of the hypocenter quality based primarily on arrival time residuals. For example, quality **A** requires a root-mean-square residual (**RMS**) less than 0.15 s, while a **RMS** of 0.5 s or more is **D** quality (other estimates of the location uncertainty also affect this quality parameter). The second letter of the quality code is related to the spatial distribution of stations that contribute to the event location, including the number of stations (**NS**), the number of p-wave and s-wave phases (**NP**), the largest gap in event-station azimuth distribution (**GAP**), and the closest distance from the epicenter to a station (**Dmin – not shown**). Quality A requires a solution with NP >8, GAP <90˚, and Dmin <5 km (or the hypocenter depth if it is greater than 5 km). If NP ≤ 5, GAP >180˚, or Dmin >50 km, the solution is assigned Quality D. Uncertainties associated with estimated depths depend upon the number of stations and number of phase measurements (NS/NP) utilized by the Hypoinverse location program. If the number of phases exceeds 10 measurements, the depth estimate is considered reliable. In this case, the second letter in the quality evaluation is either "A" or "B" (cf. Table 4.1). For example, the number of phase measurements from earthquakes ultimately classified as "deep" events typically falls within the 10-20 measurement range; these depth estimates are considered reliable. However, the number of phase measurements from earthquakes classified as "shallow" or "intermediate" may be less than 10 readings; in this case the depth estimate is less certain and the event could be classified as occurring in the CRBG or pre-basalt layers.

4.4 FY 2024 Earthquake Catalog for Eastern Washington

Table 4.2. Seismicity in the region 44° to 49° N latitude, -121.5° to -117° E longitude.

October 2023

Day	Time	Lat	Lon	Depth	Mag	Mtype	NS/NP	Gap	RMS	Q	Mod	Type
01	23:04:03	45.8408	-120.8340	9.2*	1.2	Ml	015/023	104	0.23	CC	C3	eq
02	16:43:03	46.8230	-121.1788	3.4	1.2	Ml	024/035	108	0.22	BC	C3	eq
03	00:18:01	44.3947	-121.0295	-1.5*	1.6	Ml	012/014	153	0.37	CC	C3	px
03	05:14:47	46.7513	-120.5943	5.5	0.8	Ml	010/011	89	0.11	AC	E3	eq
04	07:43:13	46.7503	-120.6202	10.5	0.7	Ml	010/014	115	0.38	CB	E3	eq
04	18:05:55	46.4652	-119.7380	17.3	0.2	Ml	008/011	203	0.06	AD	E3	eq
04	18:17:55	48.1179	-121.1379	-2.4*	-5.0	Mh	001/000	0	0.00	AD	C3	eq
04	19:11:55	46.9473	-120.5470	-0.5	1.7	Ml	017/023	93	1.02	DB	E3	eq
05	12:40:13	46.2453	-120.6288	-0.4	2.8	Ml	027/031	103	0.15	BB	E3	eq
05	21:12:24	47.3405	-117.8867	-0.7*	2.3	Ml	008/009	92	0.24	CC	N3	px
06	02:56:24	47.6728	-120.2588	3.3	0.3	Ml	006/011	111	0.04	AB	N3	eq
06	04:37:52	46.9252	-120.5015	-0.9	1.1	Ml	007/010	129	1.01	DB	E3	eq
08	00:12:59	46.6052	-119.8547	6.8	1.4	Ml	021/030	57	0.07	AA	E3	eq
08	14:37:12	46.6030	-119.8518	6.7	0.5	Ml	013/017	89	0.07	AA	E3	eq
10	08:10:13	46.6933	-119.4493	0.4*	0.7	Ml	011/018	82	0.14	CC	E3	eq
10	22:24:08	45.9040	-119.3168	-0.3*	2.1	Ml	014/020	109	0.15	CC	E3	px
11	02:37:37	46.2332	-119.5970	15.0	0.8	Ml	014/021	144	0.06	AC	E3	eq
13	02:27:58	46.4857	-119.6073	0.3*	0.3	Ml	007/012	157	0.05	CC	E3	eq
14	01:03:27	46.2383	-119.6113	6.2	0.7	Ml	010/013	155	0.10	AC	E3	eq
14	09:29:45	44.6272	-117.7290	7.0*	2.3	Ml	014/020	74	0.71	DD	E3	eq
15	03:51:53	47.7230	-120.3530	2.7	0.4	Ml	008/013	115	0.07	AC	N3	eq
15	18:36:30	46.9122	-120.5437	-0.9	1.0	Ml	006/009	115	0.96	DB	E3	eq
17	03:07:08	47.6307	-120.1802	5.5	0.9	Ml	009/014	133	0.04	AB	N3	eq
17	18:06:15	46.9640	-120.3567	-0.9*	1.7	Ml	011/011	89	0.39	CC	E3	px
17	23:39:02	46.3967	-120.9143	0.7*	1.4	Ml	013/014	86	0.17	CC	C3	eq
18	15:11:30	47.6708	-120.2848	-0.5*	0.9	Ml	008/014	93	0.07	CB	N3	eq
19	20:24:54	46.0875	-119.1702	9.0	1.7	Ml	027/034	48	0.21	BB	E3	eq
19	21:55:27	46.6023	-119.8617	6.7	1.1	Ml	013/022	90	0.08	AA	E3	eq
20	02:19:19	47.6747	-120.1563	2.7	2.1	Ml	034/033	47	0.11	AA	N3	eq
22	02:33:50	47.6688	-120.2988	2.7	0.8	Ml	009/014	89	0.07	AA	N3	eq
22	09:35:02	48.1677	-121.4927	10.5	0.5	Ml	008/013	125	0.18	BB	C3	eq
23	00:30:22	47.5677	-120.3198	4.4	1.0	Ml	014/020	95	0.14	AB	N3	eq
23	17:09:21	46.1637	-119.2745	-0.2*	1.2	Ml	013/020	114	0.20	CC	E3	px
25	19:41:17	46.2947	-117.9942	9.1	1.4	Ml	015/020	146	0.28	BC	E3	eq
26	10:18:29	46.7258	-120.9883	6.7	1.3	Ml	033/051	105	0.20	BB	C3	eq
27	23:40:16	46.7797	-120.7172	11.2	2.6	Ml	095/079	72	0.15	BA	C3	eq
29	06:50:45	47.6893	-120.2450	1.2	-0.0	Ml	006/012	79	0.06	AA	N3	eq
30	11:01:45	47.6737	-120.3060	-0.4*	0.9	Ml	016/019	94	0.06	CB	N3	eq
31	05:57:41	46.9198	-120.5615	-0.9	1.5	Ml	013/017	107	0.78	DB	E3	eq
31	05:58:22	46.9018	-120.5885	-0.8	0.6	Md	007/010	119	1.20	DB	E3	eq
31	08:08:09	46.8938	-120.5043	-0.8	0.4	Ml	006/009	116	0.90	DB	E3	eq
31	10:50:17	46.9020	-120.5220	-0.8	0.2	Ml	005/006	130	1.05	DC	E3	eq
31	10:50:25	46.8950	-120.5468	-0.9	0.5	Ml	006/009	109	1.19	DB	E3	eq
31	17:48:40	46.9153	-120.5738	-0.9	0.7	Ml	006/009	109	1.06	DB	E3	eq

31	20:41:59	46.9340	-120.5433	-0.9	1.6	Ml	016/019	92	0.80	DB	E3	eq
November 2023												
01	09:20:55	46.6580	-120.6650	6.2	0.7	Ml	009/011	146	0.10	AC	E3	eq
01	21:37:08	47.6733	-120.3497	1.5	0.9	Ml	010/013	128	0.04	AB	N3	eq
02	07:04:40	45.5600	-119.7770	2.4	1.2	Ml	010/011	179	0.18	BC	E3	eq
02	15:38:59	47.6685	-120.0968	6.7	0.2	Ml	007/011	109	0.07	AB	N3	eq
04	18:54:41	48.0735	-119.7670	10.4	1.6	Ml	013/017	101	0.12	AB	N3	eq
05	19:40:59	47.6930	-120.1028	4.6	0.4	Ml	011/017	118	0.07	AB	N3	eq
06	19:36:22	46.8972	-120.5268	-0.9	0.7	Ml	004/005	188	1.30	DD	E3	eq
06	19:36:54	46.9243	-120.5450	-0.9	0.5	Md	004/004	119	1.06	DD	E3	eq
06	19:58:56	46.1660	-119.2295	-0.4*	1.5	Ml	009/012	263	0.30	CD	E3	px
06	20:26:53	46.6060	-119.8577	5.8	0.9	Ml	012/019	91	0.13	AB	E3	eq
06	23:30:28	46.9217	-120.5445	-0.9	1.5	Ml	008/012	99	0.90	DB	E3	eq
07	00:12:08	46.9343	-120.5448	-0.7	1.0	Ml	006/009	128	0.81	DB	E3	eq
07	18:43:57	46.4837	-119.9952	1.4*	1.6	Ml	006/008	304	0.07	CD	E3	eq
08	08:19:07	48.0720	-120.8872	8.9	1.1	Ml	008/015	100	0.21	BB	C3	eq
11	03:50:47	47.6670	-120.2512	-0.2*	0.4	Ml	005/009	106	0.08	CB	N3	eq
14	00:27:13	47.3985	-120.7085	7.8	1.4	Ml	017/021	102	0.23	BC	C3	eq
14	02:33:32	48.7893	-119.4125	7.0	1.3	Ml	007/013	117	0.33	CB	N3	eq
15	04:10:50	46.2098	-119.5798	7.3	0.4	Ml	011/017	231	0.09	AD	E3	eq
15	17:01:54	47.5678	-117.5328	-0.7*	2.1	Md	008/010	121	0.23	CC	N3	px
16	18:34:22	46.2415	-119.4458	-0.3*	2.1	Ml	027/036	93	0.19	CB	E3	px
17	21:24:49	47.4515	-119.9007	13.7	0.7	Ml	007/010	127	0.07	AB	N3	eq
19	07:33:52	45.5605	-119.7442	-0.1	1.6	Ml	013/018	130	0.11	AC	E3	eq
19	14:10:24	46.9523	-120.5622	-0.9	1.3	Ml	010/014	112	0.50	DC	E3	eq
20	18:59:45	46.1878	-121.4992	2.2	1.4	Ml	027/038	227	0.12	AD	C3	eq
21	06:53:47	48.4715	-118.3802	0.7*	1.7	Ml	014/018	123	0.26	CC	N3	eq
22	08:10:39	47.6677	-120.3030	3.7	0.6	Ml	009/014	99	0.10	AB	N3	eq
22	10:51:16	46.6083	-119.3162	13.1	0.9	Ml	024/034	66	0.13	AA	E3	eq
22	17:54:06	47.7375	-120.3180	3.9	1.6	Ml	024/026	73	0.11	AC	N3	eq
22	18:21:29	46.1548	-119.1313	-0.3*	1.9	Ml	012/012	173	0.07	CC	E3	px
25	03:27:21	47.7268	-120.2713	0.8	0.4	Ml	009/014	83	0.10	BB	N3	eq
27	08:48:35	47.6190	-120.2510	4.2	1.1	Ml	011/017	83	0.11	AA	N3	eq
29	12:28:42	47.6578	-120.2350	4.6	0.5	Ml	013/020	94	0.08	AB	N3	eq
29	22:56:30	47.7833	-120.8433	-0.3*	0.8	Ml	010/019	106	0.18	CB	C3	eq
30	02:38:05	47.7318	-120.1027	4.5	0.3	Ml	008/012	144	0.10	AC	N3	eq
30	09:32:58	47.7228	-120.0463	5.0	0.9	Ml	016/024	56	0.07	AB	N3	eq
December 2023												
01	15:51:27	46.8347	-120.9055	14.2	0.9	Ml	009/012	116	0.32	CB	C3	eq
02	23:30:58	44.6978	-117.7630	7.7*	1.7	Ml	005/008	173	0.42	CD	C3	eq
05	02:33:27	47.7847	-120.8603	5.3	1.0	Ml	007/010	183	0.06	AD	C3	eq
05	15:46:08	46.4687	-119.7003	16.5	1.0	Ml	012/020	177	0.07	AC	E3	eq
07	00:44:40	46.9005	-120.6657	8.9	1.5	Ml	022/033	65	0.27	BA	E3	eq
08	22:36:59	46.2535	-119.6503	-0.5*	1.6	Ml	013/014	143	0.08	CC	E3	px
12	19:41:42	46.3432	-120.5638	18.9	1.2	Ml	016/019	132	0.18	BB	E3	eq
12	22:38:00	46.5145	-119.5222	4.5*	-0.1	Md	003/006	341	0.06	CD	E3	eq
12	22:38:55	46.5117	-119.5397	4.3*	0.4	Ml	003/006	339	0.07	CD	E3	eq
12	23:28:31	45.8993	-119.3017	-0.3*	1.6	Ml	017/021	66	0.14	CC	E3	px
13	22:09:02	46.5082	-117.0065	-0.7*	1.7	Ml	009/014	210	0.43	CD	E3	px
14	16:55:07	46.6033	-120.7143	0.6*	1.9	Ml	013/014	113	0.41	CC	C3	eq

14	20:37:49	44.2617	-120.8853	-1.6*	2.8	Ml	018/017	148	0.11	CC	C3	px
14	22:30:02	46.6868	-120.4963	3.7	0.7	Ml	009/012	93	0.23	BC	E3	eq
20	17:01:03	44.5428	-117.4070	-1.1*	1.9	Ml	007/010	154	0.75	DC	E3	px
21	01:44:23	47.6515	-120.1722	3.8	0.7	Ml	010/016	119	0.04	AB	N3	eq
21	08:54:16	47.6960	-120.2853	4.0	0.1	Ml	007/013	92	0.14	AB	N3	eq
21	19:24:08	46.3797	-119.9355	-0.5*	1.5	Ml	016/019	125	0.11	CC	E3	px
23	08:21:53	46.6090	-119.9412	5.5	1.3	Ml	017/024	132	0.10	AB	E3	eq
23	08:30:02	48.2470	-120.7152	7.0	1.3	Ml	013/022	130	0.18	BC	C3	eq
24	05:35:20	46.8998	-120.7310	12.5	0.8	Ml	010/016	149	0.32	CC	C3	eq
24	10:59:10	46.7030	-120.7663	8.6	1.0	Ml	011/013	115	0.15	BB	C3	eq
24	20:22:55	47.7368	-120.0877	2.7	0.5	Ml	008/014	95	0.07	AB	N3	eq
25	23:02:26	48.2590	-120.7207	9.4*	0.8	Ml	010/018	133	0.29	CC	C3	eq
26	01:28:27	47.8632	-119.9740	2.2	0.3	Ml	007/011	171	0.06	AC	N3	eq
26	01:41:42	46.5638	-119.5483	14.9	0.3	Ml	012/018	92	0.10	AB	E3	eq
26	02:26:29	47.8545	-120.9125	3.1	0.9	Ml	007/009	248	0.17	BD	C3	eq
28	08:55:04	48.6448	-119.8940	0.0*	1.7	Ml	015/022	93	0.22	CC	N3	eq
28	08:59:25	48.6397	-119.8902	1.8	1.6	Ml	013/018	153	0.19	CC	N3	eq
28	09:32:25	46.8158	-120.5490	14.0	1.7	Ml	033/045	57	0.15	BA	E3	eq
31	08:18:34	47.8697	-119.9805	0.0*	0.3	Ml	013/023	63	0.10	CA	N3	eq
31	14:10:30	46.8123	-119.7098	0.2	1.3	Ml	024/030	126	0.08	AC	E3	eq
31	18:00:56	48.2618	-120.6995	5.3	1.7	Ml	020/031	109	0.31	CC	C3	eq
31	18:27:22	48.2675	-120.7070	9.1*	0.9	Ml	010/018	134	0.32	CC	C3	eq
January 2024												
01	09:51:59	47.8922	-120.8125	-0.5	1.0	Ml	008/010	110	0.09	AB	C3	eq
02	17:54:57	46.9838	-117.3567	-0.7*	2.0	Ml	009/010	142	0.47	CC	E3	px
04	00:14:32	47.2925	-117.8953	-0.7*	2.2	Md	006/008	106	0.80	DB	N3	px
04	05:36:38	47.7158	-120.2292	-0.1*	0.8	Ml	008/015	86	0.07	CB	N3	eq
05	17:58:38	44.6573	-117.7115	7.4*	1.9	Ml	006/008	135	0.20	CC	N3	eq
06	08:03:17	48.2577	-120.7278	9.4*	0.8	Ml	008/015	133	0.24	CC	C3	eq
08	09:42:01	44.6527	-117.7048	7.2*	2.5	Ml	011/014	178	0.36	CC	C3	eq
11	22:53:54	47.7280	-120.3232	3.1	-0.1	Md	005/008	101	0.06	BC	N3	eq
13	14:11:01	47.6305	-120.0565	9.7	0.4	Ml	011/019	126	0.10	AB	N3	eq
13	14:11:07	47.6333	-120.0658	10.2	0.6	Ml	010/017	119	0.17	BB	N3	eq
14	07:57:00	48.2393	-120.7127	6.9	0.9	Md	008/014	128	0.14	AC	C3	eq
14	09:34:44	47.6595	-120.2183	4.2	0.3	Ml	007/011	116	0.06	AB	N3	eq
16	02:45:28	47.6898	-120.1257	2.2	0.3	Ml	011/020	85	0.14	BB	N3	eq
16	13:46:08	48.7247	-120.0238	16.0	1.6	Ml	013/024	105	0.42	CB	N3	eq
17	06:51:27	47.4348	-119.8152	9.7	1.0	Ml	008/011	183	0.06	AD	N3	eq
17	23:45:27	47.2043	-121.3070	8.9*	1.5	Ml	028/041	120	0.14	CC	C3	eq
18	15:49:07	46.6852	-121.0683	11.0	0.9	Ml	017/031	140	0.22	BC	C3	eq
23	20:23:21	47.6480	-120.1358	2.5	0.1	Ml	005/009	129	0.03	AB	N3	eq
24	10:56:20	48.0657	-120.9878	0.1*	0.9	Ml	011/014	98	0.16	CC	C3	eq
25	22:36:13	46.4342	-119.0293	-0.2*	1.7	Ml	011/015	149	0.19	CC	E3	px
26	05:56:03	47.6737	-120.1793	1.7	0.4	Ml	007/011	151	0.09	AC	N3	eq
26	10:41:24	47.1082	-121.2302	4.9	1.0	Ml	015/020	118	0.41	CC	C3	eq
26	13:18:16	47.8437	-119.8500	4.2	1.2	Ml	015/023	81	0.06	AC	N3	eq
30	05:06:20	46.5505	-119.8827	6.7	1.3	Ml	022/030	149	0.11	AC	E3	eq
31	02:18:13	45.8933	-120.3477	16.6	2.1	Ml	022/030	63	0.17	BA	E3	eq
31	21:24:34	46.1418	-119.8257	0.7*	1.6	Ml	010/011	182	0.10	CD	E3	eq
February 2024												

02	00:54:01	44.1910	-121.2635	-1.7*	1.1	Ml	014/014	135	0.72	DC	E3	px
02	17:23:44	44.1197	-121.2995	-1.8*	1.4	Ml	014/013	116	0.23	CC	E3	px
06	04:11:06	47.7557	-120.2658	-0.1*	0.1	Ml	008/014	75	0.14	CC	N3	eq
08	11:52:54	45.1930	-117.5742	2.5	1.6	Ml	009/012	125	0.41	CC	N3	eq
09	00:54:16	44.1030	-121.3048	-1.6*	1.4	Ml	010/009	145	0.38	CC	N3	px
12	09:28:50	48.7522	-120.6397	9.0*	1.7	Ml	018/029	130	0.42	CC	C3	eq
12	18:22:02	46.8623	-119.5893	-0.3*	1.2	Ml	005/006	138	0.22	CC	E3	px
13	09:18:37	45.1992	-117.5785	-1.1*	1.2	Ml	008/016	124	0.92	DC	E3	eq
14	15:56:03	48.7513	-119.6933	0.4*	1.8	Ml	009/011	139	0.08	CC	N3	eq
14	22:20:02	46.2255	-119.7212	-0.4*	1.6	Ml	006/008	310	0.12	CD	E3	px
15	02:30:39	47.6840	-120.1875	-0.3*	0.4	Ml	006/012	134	0.12	CB	N3	eq
15	22:22:31	45.6225	-118.6267	-0.7*	1.1	Md	005/007	173	0.23	CC	E3	px
19	23:24:52	45.8185	-120.6473	-0.7*	1.9	Ml	013/015	204	0.23	CD	E3	px
21	21:35:26	48.0015	-119.8827	-0.8*	1.0	Ml	010/008	177	0.05	CC	N3	px
22	06:19:45	46.9478	-120.8673	8.7	1.0	Ml	016/030	104	0.16	BB	C3	eq
22	19:46:27	47.1420	-120.8020	-0.9*	1.5	Ml	017/017	96	0.41	CB	C3	px
23	23:38:22	46.5517	-119.8773	6.7	0.9	Ml	011/016	148	0.06	AC	E3	eq
24	18:39:43	46.1825	-119.6215	-0.5*	0.5	Ml	007/010	261	0.09	CD	E3	px
25	22:13:33	47.7503	-120.2178	0.4*	-0.1	Md	004/006	227	0.23	CD	N3	eq
28	17:58:30	46.2315	-119.7108	-0.5*	1.7	Ml	007/009	230	0.10	CD	E3	px
28	21:34:30	45.8923	-120.2748	-0.7*	1.9	Ml	008/009	247	0.09	CD	E3	px
March 2024												
01	21:43:09	47.6560	-120.2668	3.4	0.1	Ml	004/008	132	0.10	AB	N3	eq
02	11:07:15	47.6962	-120.0988	-0.5	0.7	Ml	010/016	70	0.13	AB	N3	eq
03	06:26:27	47.7007	-120.2882	0.9	0.2	Ml	007/012	93	0.11	BB	N3	eq
03	12:56:36	48.1788	-120.4253	9.3	0.4	Ml	007/013	132	0.21	BB	C3	eq
04	22:35:08	47.7417	-120.3048	-0.5*	0.5	Ml	010/017	90	0.08	CB	N3	eq
05	00:42:31	45.2508	-118.0135	-0.9*	1.8	Ml	008/013	88	0.65	DA	N3	px
05	18:26:28	47.6803	-120.1260	5.3	0.2	Ml	008/011	155	0.06	AC	N3	eq
05	21:27:15	47.3142	-117.8907	-0.6*	1.9	Ml	006/008	94	0.43	CC	N3	px
08	00:29:49	45.4265	-121.0665	2.4*	1.5	Ml	007/007	179	0.34	DC	N3	eq
08	14:55:50	44.1250	-121.3305	7.9*	1.4	Ml	011/010	172	0.19	CC	N3	px
09	14:06:18	48.6055	-119.6802	-0.2*	1.0	Ml	010/016	118	0.41	CC	N3	eq
11	16:56:57	47.7763	-120.1155	-0.2*	0.6	Ml	007/012	120	0.09	CB	N3	eq
11	22:19:01	46.3028	-118.0495	-0.5*	1.4	Ml	017/020	88	0.27	CB	E3	px
12	08:51:19	46.9235	-120.5252	-0.9	1.6	Ml	016/020	115	0.44	CC	E3	eq
13	17:51:36	44.6602	-117.7197	7.1*	1.9	Ml	007/012	133	0.24	CC	E3	eq
13	20:46:23	47.5958	-117.4953	-0.7*	1.5	Ml	009/014	105	0.42	CC	N3	px
15	19:51:50	46.0352	-119.8873	4.8	1.1	Ml	011/016	108	0.11	AC	E3	eq
15	20:06:57	47.6855	-120.3213	3.4	1.2	Ml	017/023	86	0.08	AB	N3	eq
16	06:56:12	46.6898	-120.7197	8.2	0.6	Ml	009/011	139	0.09	AC	C3	eq
18	07:23:54	47.5265	-120.2063	10.8	0.2	Ml	010/017	168	0.17	BC	N3	eq
18	18:59:36	47.0567	-117.0790	-0.8*	1.9	Ml	013/017	94	0.60	DC	N3	px
19	23:38:44	47.3427	-117.8857	-0.7*	2.3	Ml	009/009	57	0.40	CC	N3	px
21	17:38:02	46.9975	-119.2047	-0.3*	1.4	Ml	017/021	76	1.02	DA	E3	px
22	09:15:26	47.7303	-120.1872	-0.2*	2.0	Ml	030/035	59	0.14	CB	N3	eq
23	10:51:55	47.6993	-120.0772	-0.1*	2.2	Ml	058/036	53	0.14	CB	N3	eq
24	12:46:46	47.6932	-120.3212	2.2	0.7	Ml	007/010	118	0.06	AB	N3	eq
25	04:53:05	47.7127	-120.3195	-0.4*	1.1	Ml	011/018	104	0.09	CB	N3	eq
27	20:36:58	46.1255	-120.4620	19.9	1.2	Ml	016/017	115	0.14	AB	E3	eq

28	00:11:07	47.7418	-120.2730	-0.4*	1.3	Ml	015/022	68	0.11	CB	N3	eq
28	01:05:52	47.7377	-120.2750	-0.5*	0.7	Ml	012/019	81	0.07	CB	N3	eq
29	21:26:45	44.0278	-120.6458	1.6	1.3	Ml	012/017	219	0.18	CD	N3	eq
29	22:58:28	44.0205	-120.6408	1.9	0.8	Ml	010/015	210	0.19	BD	N3	eq
April 2024												
01	15:47:45	46.6173	-119.8400	6.7	0.6	Ml	006/010	162	0.07	AC	E3	eq
02	01:13:20	45.0832	-121.3153	-1.5*	1.9	Ml	014/020	139	0.18	CC	E3	px
02	12:55:50	46.2193	-119.5875	7.5	0.6	Ml	008/014	170	0.06	AC	E3	eq
02	22:52:38	46.6728	-120.6278	-0.8*	0.1	Md	005/005	132	0.80	DD	E3	px
04	19:17:15	44.1368	-121.3368	-1.6*	1.6	Ml	012/013	106	0.23	CC	E3	px
04	23:44:42	45.6353	-121.1208	-0.9*	1.6	Ml	010/014	147	0.62	DC	C3	px
05	06:52:53	45.5733	-121.2447	12.9	1.3	Ml	020/031	124	0.12	AB	C3	eq
05	09:50:12	45.5450	-120.2493	14.9	2.2	Ml	032/039	117	0.15	BC	E3	eq
05	23:41:21	45.6712	-120.2473	-0.6*	1.8	Ml	012/014	126	0.20	CC	E3	px
09	06:49:48	46.9500	-120.8883	11.1	1.4	Ml	014/021	105	0.13	AB	C3	eq
11	18:52:30	48.1553	-117.1332	-0.8*	1.8	Md	007/007	151	0.14	CC	N3	px
12	02:04:26	44.1180	-121.3268	-1.4*	1.4	Ml	010/011	172	0.30	CC	N3	px
12	17:57:47	46.9543	-120.3548	-0.9*	1.8	Ml	016/017	148	0.31	CC	E3	px
16	18:13:29	45.9148	-121.3277	-1.0*	1.2	Md	008/007	237	0.18	CD	C3	px
17	23:29:19	46.2708	-119.3860	-0.2*	1.7	Ml	022/019	181	0.09	CD	E3	px
18	12:39:01	47.6947	-120.2988	-1.1	0.2	Ml	006/012	99	0.08	AB	N3	eq
18	17:44:28	45.7960	-120.0013	-0.6*	1.8	Ml	011/011	98	0.32	CC	E3	px
18	22:29:46	45.6902	-118.8300	-0.6*	1.9	Ml	009/010	115	0.16	CC	E3	px
19	20:08:05	47.3432	-117.8893	-0.7*	2.2	Md	005/006	100	0.21	CC	N3	px
20	04:19:25	46.2455	-119.2785	8.1	2.8	Ml	068/054	68	0.12	AB	E3	eq
22	12:24:13	47.6772	-120.3235	-0.5*	0.5	Ml	009/015	93	0.09	CB	N3	eq
22	18:53:21	47.3982	-117.3062	-0.8*	1.9	Ml	010/011	101	0.62	DB	N3	px
23	05:35:47	46.2457	-119.5362	7.0	0.2	Ml	008/012	209	0.08	AD	E3	eq
24	04:13:40	47.6850	-120.1428	0.8	1.0	Ml	018/025	57	0.13	BB	N3	eq
24	23:22:43	46.2402	-119.5258	7.3	0.8	Ml	011/018	220	0.08	AD	E3	eq
26	00:21:26	47.9347	-117.2882	-0.8*	0.9	Md	004/005	165	0.21	CD	N3	px
May 2024												
01	17:12:30	46.1345	-119.4823	-0.3*	1.7	Ml	009/014	254	0.15	CD	E3	px
02	21:57:10	46.9268	-120.6127	-0.9*	1.2	Ml	011/013	100	0.50	DB	E3	px
03	20:38:36	47.9472	-120.9252	7.6	0.9	Ml	012/017	92	0.30	CB	C3	eq
05	07:39:40	46.2422	-119.4652	7.3	0.4	Ml	007/013	318	0.05	AD	E3	eq
05	07:57:31	46.2412	-119.4580	7.1	1.0	Ml	012/021	229	0.09	AD	E3	eq
06	00:04:46	46.5943	-119.7812	17.2	0.2	Md	007/012	108	0.09	AB	E3	eq
06	07:36:51	46.2537	-119.5165	7.3	0.4	Ml	010/016	211	0.07	AD	E3	eq
06	08:44:54	46.5567	-119.3662	15.1	0.9	Ml	016/027	87	0.09	AA	E3	eq
09	00:29:45	48.0005	-119.8778	-0.4*	1.5	Ml	017/012	64	0.13	CB	N3	px
10	02:16:28	47.3482	-117.8825	-0.5*	2.3	Ml	013/016	58	0.42	CC	N3	px
10	19:03:28	44.1392	-121.3333	-1.7*	1.4	Ml	017/015	102	0.16	CC	N3	px
10	19:05:18	44.1098	-121.3757	-1.5*	2.2	Ml	019/018	82	0.41	CC	N3	px
10	22:34:12	46.6015	-119.8510	6.6	0.3	Ml	008/013	170	0.08	AC	E3	eq
11	04:17:35	47.6168	-121.2832	9.6	0.9	Ml	011/018	98	0.18	BB	C3	eq
12	16:05:43	47.5242	-121.4298	9.6*	1.6	Ml	033/055	59	0.24	CC	C3	eq
13	01:01:45	47.6177	-120.2433	6.6	0.9	Ml	008/013	139	0.06	AC	N3	eq
14	01:33:58	47.5232	-121.4318	9.2	1.1	Ml	012/023	179	0.17	BC	C3	eq
14	16:36:39	45.9405	-118.3510	-0.5*	2.1	Ml	007/009	109	0.33	CB	E3	px

15	04:51:14	46.7445	-120.2695	7.2	1.1	Ml	011/015	84	0.05	AB	E3	eq
15	15:30:43	45.8093	-120.7858	-0.7*	2.0	Ml	012/014	144	0.22	CC	C3	px
18	21:27:59	48.1567	-119.2915	11.9	1.8	Ml	017/026	56	0.25	BB	N3	eq
19	03:49:05	44.9122	-121.2492	4.8*	1.2	Md	004/007	332	0.47	DD	N3	eq
19	20:06:45	46.8098	-121.1728	7.3	1.0	Ml	017/025	105	0.15	BC	C3	eq
19	21:33:05	47.7350	-120.0342	3.2	0.4	Ml	008/014	102	0.12	AB	N3	eq
20	21:09:57	47.5477	-120.2755	-1.1*	1.1	Ml	008/010	112	0.25	CB	N3	px
21	00:00:27	46.0862	-118.8772	9.7	1.0	Ml	014/019	82	0.11	AA	E3	eq
21	05:31:07	46.6223	-119.8895	5.5	1.1	Ml	011/019	103	0.12	AB	E3	eq
22	19:30:05	47.3008	-119.9057	-0.8*	1.5	Ml	014/020	73	0.37	CC	N3	px
22	23:34:59	46.1522	-119.2590	-0.3*	1.9	Ml	031/033	76	0.11	CC	E3	px
23	19:01:58	46.0828	-119.5117	-0.1*	0.7	Md	005/005	307	0.04	CD	E3	px
25	03:37:10	46.6012	-119.8613	7.0	0.7	Ml	011/019	93	0.07	AB	E3	eq
25	17:33:52	46.6252	-119.8838	5.2	0.9	Ml	011/019	158	0.08	AC	E3	eq
25	19:31:07	48.6963	-119.5062	16.3	1.0	Ml	004/004	112	0.00	AD	N3	eq
25	23:17:53	47.6522	-120.2327	3.9	1.1	Ml	014/022	69	0.11	AA	N3	eq
26	01:59:54	46.6113	-119.8687	4.7	0.9	Ml	008/011	279	0.08	AD	E3	eq
28	07:56:55	45.8503	-120.8333	8.2	1.1	Ml	017/023	125	0.19	BB	C3	eq
28	20:56:42	46.2685	-119.3832	-0.2*	1.8	Ml	018/018	104	0.13	CB	E3	px
28	22:12:17	46.9388	-120.0613	10.1	1.7	Ml	029/031	59	0.16	BA	E3	eq
29	22:59:13	47.8393	-120.8488	-1.4*	1.4	Ml	010/012	100	0.12	CB	C3	px
30	17:10:13	46.6257	-119.8755	6.1	0.5	Ml	008/010	191	0.05	AD	E3	eq
30	22:39:13	47.6772	-120.0287	2.3	0.7	Ml	009/016	135	0.09	AB	N3	eq
June 2024												
03	19:01:29	48.0862	-120.7490	4.3	1.0	Ml	007/012	103	0.24	BC	C3	eq
05	22:14:30	46.5548	-121.3810	-0.3*	1.3	Ml	012/018	314	0.10	CD	C3	eq
06	13:58:33	45.0798	-120.9922	16.5	1.4	Ml	017/027	91	0.39	CB	C3	eq
07	12:45:18	48.6008	-121.2683	7.2	1.5	Ml	018/032	106	0.27	BC	C3	eq
08	00:33:14	46.1457	-120.3938	13.8	1.2	Ml	014/023	165	0.17	BC	E3	eq
09	16:00:10	46.4977	-119.7050	18.3	0.2	Ml	013/019	158	0.07	AC	E3	eq
10	20:54:53	47.6503	-120.2480	3.7	1.9	Ml	039/035	69	0.14	AA	N3	eq
10	23:16:23	44.5658	-117.4507	-1.1*	1.8	Ml	006/005	150	0.43	CD	N3	px
12	15:44:48	46.6243	-119.8803	5.5	0.8	Ml	011/021	99	0.11	AB	E3	eq
12	16:10:32	47.6900	-120.2255	1.7	0.5	Ml	005/010	128	0.08	AB	N3	eq
12	16:25:29	46.6142	-120.5190	14.2	1.1	Ml	013/019	114	0.18	BB	E3	eq
12	17:08:07	44.4150	-121.0360	3.5*	1.9	Ml	009/009	172	0.12	CC	E3	px
12	17:56:10	46.6152	-120.5257	13.8	0.6	Ml	005/007	117	0.10	AB	E3	eq
12	17:56:16	46.6290	-120.5312	11.4	0.4	Md	004/006	175	0.23	BC	E3	eq
12	20:36:41	46.6132	-120.5183	15.1	1.5	Ml	042/039	85	0.13	AA	E3	eq
13	19:27:24	45.6238	-121.2215	3.3	1.7	Ml	014/016	83	0.11	AC	C3	eq
14	03:02:54	46.4120	-120.8983	1.6*	0.7	Ml	007/010	125	0.14	CC	C3	eq
17	05:08:43	46.0453	-118.7185	14.8	1.2	Ml	016/027	79	0.25	BA	E3	eq
19	00:13:55	44.2947	-121.2962	-1.7*	1.4	Ml	007/007	290	0.49	DD	E3	px
19	07:02:21	47.6760	-120.3322	-0.5*	0.2	Ml	006/010	122	0.10	CB	N3	eq
19	20:35:14	46.4158	-119.5868	17.1	0.3	Ml	007/012	131	0.08	BB	E3	eq
20	23:04:19	46.6397	-120.4875	-0.7*	1.2	Ml	005/007	182	0.26	CD	E3	px
24	19:05:17	46.8213	-121.1835	5.8	0.9	Ml	016/025	109	0.20	BC	C3	eq
24	21:22:22	44.5228	-117.4417	-1.2*	2.0	Ml	009/014	82	0.58	DC	C3	px
26	03:34:01	45.2923	-118.1635	7.1*	1.6	Ml	008/011	146	0.43	CD	C3	eq
27	01:21:46	46.3972	-119.7472	14.6	0.2	Ml	007/011	245	0.07	AD	E3	eq

27	01:22:02	46.3973	-119.7668	13.7	0.1	Md	007/011	249	0.10	AD	E3	eq
28	02:53:11	46.1133	-118.5112	13.3	1.2	Ml	008/015	70	0.26	BB	E3	eq
July 2024												
02	16:12:02	44.6542	-117.6952	22.4	2.4	Ml	009/014	73	0.34	CB	E3	eq
02	19:00:14	46.4123	-119.5727	1.7	1.1	Ml	011/015	95	0.10	AB	E3	eq
02	19:09:14	46.6225	-120.5038	-0.6*	1.1	Ml	011/016	105	0.39	CC	E3	px
03	22:40:57	45.7042	-119.0907	6.2	1.7	Ml	026/032	80	0.22	BC	E3	eq
05	14:53:29	46.4180	-119.5648	2.8	0.2	Ml	006/009	156	0.05	AC	E3	eq
06	05:45:50	46.3190	-121.0725	4.5	1.6	Ml	030/039	53	0.17	BC	C3	eq
06	08:05:39	46.3103	-121.0657	6.7	1.1	Ml	015/025	58	0.18	BC	C3	eq
06	20:50:07	46.7948	-120.7817	13.1	0.8	Ml	008/012	112	0.08	AB	C3	eq
07	03:28:25	48.2920	-117.7820	0.6*	1.3	Ml	010/013	121	0.22	CC	N3	eq
09	00:03:00	45.9055	-119.2957	-0.3*	1.5	Ml	013/017	158	0.17	CC	E3	px
09	06:30:59	46.6042	-119.8583	6.9	1.4	Ml	030/037	39	0.08	AA	E3	eq
09	16:54:45	46.2648	-118.0770	-0.6*	1.8	Ml	011/015	111	0.57	DC	E3	px
09	23:57:25	47.8027	-117.3993	-0.7*	2.1	Ml	013/019	115	0.36	CC	N3	px
11	23:30:25	48.2933	-120.5435	-0.2*	0.9	Ml	007/011	172	0.22	CC	C3	eq
12	12:28:49	48.2215	-120.6930	6.3	1.0	Md	008/013	124	0.21	BC	C3	eq
12	18:16:17	46.2017	-119.2628	-0.2*	1.1	Ml	015/012	170	0.18	CC	E3	px
14	07:58:59	46.6003	-119.8477	7.0	0.4	Ml	009/013	167	0.07	AC	E3	eq
14	19:43:10	47.7798	-120.7922	6.6	1.1	Ml	009/012	103	0.21	BB	C3	eq
15	07:04:11	46.1545	-119.0552	9.2	1.1	Ml	016/026	103	0.18	BB	E3	eq
16	12:29:13	46.2685	-119.5918	0.7*	0.2	Ml	006/010	306	0.32	CD	E3	eq
16	16:19:26	46.5887	-120.4113	9.7	1.3	Ml	016/022	76	0.09	AA	E3	eq
16	21:51:25	47.3407	-117.9107	-0.6*	2.1	Ml	010/012	57	0.55	DC	N3	px
17	18:16:47	48.5860	-117.9625	-0.9*	1.4	Ml	007/007	196	0.20	CD	N3	px
18	20:59:34	46.6922	-117.1625	-0.8*	1.8	Ml	007/006	155	0.41	CC	E3	px
18	21:46:14	46.9128	-120.5640	-0.9*	1.7	Ml	013/013	107	0.58	DB	E3	px
20	12:00:44	47.8198	-120.9300	3.3	0.9	Ml	010/014	107	0.11	AB	C3	eq
20	12:07:27	47.6867	-120.0940	3.7	0.6	Ml	009/018	71	0.18	BA	N3	eq
20	22:08:36	44.9968	-117.3342	6.9*	2.7	Ml	007/011	113	0.39	CC	N3	eq
21	17:09:07	46.6152	-120.5995	1.1	0.9	Ml	017/020	98	0.20	BC	E3	eq
22	08:04:07	46.6077	-119.8432	7.1	0.5	Ml	013/020	88	0.06	AA	E3	eq
22	10:31:53	46.5573	-119.6120	11.3	-0.1	Md	008/012	106	0.12	AB	E3	eq
24	17:39:30	46.1508	-119.2062	-0.2*	1.4	Ml	015/016	197	0.11	CD	E3	px
27	10:54:22	47.8248	-120.7227	5.2	0.6	Ml	009/013	140	0.09	AC	C3	eq
28	05:53:36	47.6803	-120.0250	-0.3*	0.7	Ml	009/014	135	0.14	CB	N3	eq
29	03:26:28	46.3393	-121.1593	3.2	1.2	Ml	035/053	60	0.19	BC	C3	eq
29	18:13:11	47.7090	-120.0760	3.1	0.5	Ml	011/016	107	0.08	AB	N3	eq
29	19:27:46	46.6180	-119.8402	6.7	0.6	Ml	014/017	118	0.07	AB	E3	eq
29	20:25:26	44.5757	-117.4542	-1.1*	1.8	Ml	010/015	78	0.54	DC	E3	px
30	18:01:07	44.3863	-121.0418	-1.5*	1.6	Ml	011/011	128	0.16	CC	E3	px
30	23:56:03	46.1380	-119.6740	7.8	1.2	Ml	017/025	175	0.10	AC	E3	eq
31	10:06:42	46.1707	-118.0948	12.3	1.9	Ml	012/016	154	0.11	AC	E3	eq
31	20:26:17	44.3698	-121.0402	-1.6*	1.5	Ml	010/014	163	0.49	CC	E3	px
31	23:14:10	46.6195	-119.8425	7.1	2.4	Ml	056/052	38	0.09	AA	E3	eq
31	23:35:17	46.6207	-119.8373	6.3	0.7	Ml	011/016	160	0.08	AC	E3	eq
August 2024												
01	01:31:23	46.6192	-119.8440	6.6	0.8	Ml	015/025	89	0.07	AA	E3	eq
01	04:33:30	46.6170	-119.8455	6.7	0.3	Ml	007/013	100	0.09	AB	E3	eq

02	01:15:39	46.4167	-119.5682	-0.1*	0.5	Ml	004/007	185	0.05	CD	E3	eq
02	06:06:53	47.6587	-120.2300	4.1	0.2	Ml	006/011	117	0.09	AB	N3	eq
02	07:23:26	47.6845	-120.3092	-0.4*	0.6	Ml	012/017	85	0.07	CB	N3	eq
02	11:24:57	47.6862	-120.2415	1.6	0.1	Ml	006/010	114	0.08	AB	N3	eq
02	23:26:15	45.9120	-119.3342	-0.3*	1.4	Ml	013/015	155	0.15	CC	E3	px
03	15:54:16	45.9888	-119.4607	3.2	0.6	Ml	011/012	150	0.11	AC	E3	eq
03	18:49:28	45.4118	-117.5590	19.4	1.6	Ml	007/013	102	0.49	CB	E3	eq
04	02:47:06	46.9105	-120.5690	-0.8*	0.7	Ml	007/008	113	0.50	DB	E3	px
05	11:26:38	47.6910	-120.0833	5.4	0.5	Ml	010/020	109	0.18	BB	N3	eq
05	11:44:22	47.7143	-120.2660	-1.1	-0.1	Md	005/010	133	0.10	AB	N3	eq
06	12:34:42	46.9765	-120.8978	5.0	1.4	Ml	018/029	113	0.22	BC	C3	eq
07	00:48:05	44.2572	-120.8900	-1.6*	2.4	Ml	022/023	148	0.18	CC	C3	px
07	08:03:05	48.8073	-119.4215	13.7	1.7	Ml	011/021	119	0.43	CB	N3	eq
07	15:15:54	46.1412	-119.1955	-0.2*	1.6	Ml	015/022	194	0.20	CD	E3	px
07	15:17:42	47.7480	-120.0708	-0.1*	1.4	Ml	022/038	55	0.15	CB	N3	eq
07	17:01:27	47.7268	-117.6357	0.1*	1.5	Ml	010/017	72	0.23	CC	N3	eq
08	11:58:32	47.6803	-120.1582	-0.9	0.4	Ml	005/010	140	0.14	AC	N3	eq
09	05:58:17	47.7208	-120.0898	2.7	0.8	Ml	012/021	77	0.11	AB	N3	eq
09	07:53:47	46.1180	-120.4907	15.2	1.8	Ml	034/044	44	0.19	BA	E3	eq
09	18:56:18	46.9092	-120.5685	-0.9*	0.9	Md	008/008	66	0.83	DA	E3	px
09	20:05:42	47.7163	-118.4372	-0.7*	0.6	Ml	007/010	158	0.68	DC	N3	px
10	03:55:18	46.8270	-120.9248	12.4	0.9	Md	008/012	116	0.13	AB	C3	eq
10	14:48:07	45.7115	-120.3518	17.8	1.2	Ml	009/016	91	0.23	BB	E3	eq
11	18:34:45	46.8672	-120.8250	3.3	0.9	Ml	010/016	103	0.18	BC	C3	eq
12	06:56:28	46.1057	-120.5172	15.1	1.3	Ml	018/022	121	0.13	AB	E3	eq
12	21:10:43	46.1658	-119.1107	-0.2*	1.8	Ml	015/017	163	0.38	CC	E3	px
12	21:35:00	44.5123	-117.4603	-1.1*	1.8	Ml	005/005	188	0.69	DD	E3	px
13	00:15:32	47.4840	-120.6752	-1.0*	0.9	Ml	006/007	234	0.29	CD	C3	px
13	01:24:08	47.7292	-117.6360	-0.0	2.2	Ml	020/027	73	0.27	CC	N3	eq
13	01:50:54	47.7262	-117.6428	0.1*	1.8	Ml	016/024	72	0.31	CC	N3	eq
13	20:04:11	47.1212	-120.8078	-0.9*	1.9	Ml	016/021	131	0.36	CC	C3	px
15	19:26:31	46.7100	-120.3758	5.7	1.3	Ml	013/019	64	0.14	AC	E3	eq
16	18:38:25	46.2878	-118.0597	-0.3*	1.8	Ml	012/011	133	0.13	CC	E3	px
19	19:15:33	45.9080	-119.1450	-0.4*	1.2	Ml	008/010	99	0.29	CC	E3	px
20	23:42:57	47.0048	-120.6575	7.6	1.0	Ml	009/012	108	0.17	BB	N3	eq
23	10:11:33	47.6953	-120.1150	-0.3*	0.8	Ml	011/015	60	0.14	CB	N3	eq
25	05:31:46	47.7612	-119.8755	5.3	0.6	Ml	012/018	74	0.14	AC	N3	eq
26	23:08:21	47.2875	-121.2438	-1.1*	0.8	Ml	016/016	92	0.14	CC	C3	px
27	21:11:58	47.3172	-117.9030	-0.7*	2.1	Ml	007/009	100	0.36	CC	N3	px
28	18:10:48	47.8307	-118.2235	-0.7*	1.6	Ml	006/008	158	0.08	CC	N3	px
29	15:22:55	44.9378	-120.9430	-1.4*	1.2	Ml	007/009	103	0.18	CB	N3	px
31	03:10:42	46.2698	-120.5105	17.6	0.7	Ml	011/015	106	0.23	BB	E3	eq
31	03:48:36	46.1718	-119.8865	8.1*	0.9	Ml	012/018	113	0.11	CB	E3	eq
September 2024												
02	04:19:51	47.5770	-120.2837	5.3	0.4	Ml	009/018	110	0.22	BB	N3	eq
02	11:08:59	47.8942	-120.7997	-0.0*	0.8	Ml	004/008	124	0.10	CB	C3	eq
02	11:10:15	47.7042	-120.3357	-0.2*	0.1	Ml	006/011	116	0.11	CB	N3	eq
04	20:08:12	46.1610	-119.1610	-0.3*	1.5	Ml	009/012	152	0.13	CC	E3	px
06	20:48:51	45.0865	-121.3043	-1.3*	1.0	Md	010/015	117	0.33	CC	E3	px
07	10:13:41	47.7170	-120.0693	4.6	0.6	Ml	010/019	90	0.17	BB	N3	eq

08	07:20:24	46.7307	-120.8517	11.7	1.3	Ml	023/034	92	0.17	BB	C3	eq
09	04:35:48	47.6712	-120.3363	-0.1*	0.6	Ml	008/011	128	0.08	CB	N3	eq
09	22:51:02	46.1882	-121.4948	-1.0	1.4	Ml	005/008	216	0.18	BD	C3	eq
12	11:43:50	46.6208	-119.8820	5.9	0.6	Ml	010/017	99	0.10	AB	E3	eq
12	13:51:10	47.8033	-120.1000	4.8	1.1	Ml	014/022	51	0.11	AA	N3	eq
13	09:12:28	48.4888	-119.9840	-0.4	2.6	Ml	036/046	102	0.42	CC	N3	eq
13	10:00:04	47.6237	-120.2793	5.7	0.6	Ml	013/019	63	0.23	BA	N3	eq
14	16:54:40	46.8475	-120.6900	15.1	0.4	Ml	004/007	167	0.06	AC	E3	eq
16	13:30:06	47.7497	-118.9000	0.7*	1.3	Ml	007/010	104	0.31	CC	N3	eq
16	19:43:48	47.7273	-119.5112	18.1	0.6	Ml	007/012	99	0.21	BB	N3	eq
17	04:05:13	47.6633	-120.1887	1.3	0.9	Ml	017/025	89	0.10	AA	N3	eq
21	14:40:39	46.6062	-119.7983	7.8	1.2	Ml	023/032	67	0.10	AA	E3	eq
21	15:57:44	46.6045	-119.7973	7.6	0.9	Ml	018/026	74	0.10	AA	E3	eq
21	16:01:40	46.6060	-119.7977	8.1	1.8	Ml	036/046	67	0.10	AA	E3	eq
21	16:24:57	46.6017	-119.7995	8.1	0.1	Ml	005/008	203	0.07	AD	E3	eq
21	17:32:32	46.6050	-119.7997	7.7	1.1	Ml	018/028	99	0.10	AB	E3	eq
21	17:36:10	46.6032	-119.7990	8.1	0.7	Ml	011/016	124	0.11	AB	E3	eq
21	18:14:38	46.6052	-119.8033	8.2	0.6	Ml	008/013	128	0.09	AB	E3	eq
21	18:14:43	46.6052	-119.8063	8.5	0.7	Ml	010/013	191	0.08	AD	E3	eq
21	18:20:41	46.6038	-119.7970	7.2	0.5	Ml	007/014	206	0.14	AD	E3	eq
21	18:20:58	46.6040	-119.7957	7.7	0.7	Ml	008/012	206	0.12	AD	E3	eq
21	18:39:46	46.6025	-119.7975	8.0	0.7	Ml	016/020	79	0.07	AA	E3	eq
21	19:32:33	46.6083	-119.8052	8.7	0.2	Ml	008/010	220	0.07	AD	E3	eq
21	19:35:07	46.6028	-119.7958	7.4	0.5	Ml	009/012	121	0.07	AB	E3	eq
21	20:03:11	47.7180	-120.2962	1.7	0.5	Ml	010/015	93	0.08	BB	N3	eq
21	20:13:55	47.7253	-120.3270	3.6	1.4	Ml	024/026	78	0.14	AB	N3	eq
21	21:43:16	46.6035	-119.7983	8.0	1.0	Ml	021/029	75	0.09	AA	E3	eq
21	22:36:51	46.6035	-119.7995	8.4	0.5	Ml	007/011	124	0.08	AB	E3	eq
21	23:53:40	46.6017	-119.7953	7.7	0.5	Ml	010/015	198	0.08	AD	E3	eq
21	23:54:20	46.6023	-119.7945	7.7	0.5	Ml	008/014	199	0.11	AD	E3	eq
21	23:54:29	46.6033	-119.7995	8.2	0.4	Ml	010/011	185	0.07	AD	E3	eq
21	23:55:13	46.6002	-119.7893	7.5	0.3	Ml	010/018	115	0.12	AB	E3	eq
22	01:17:03	46.6003	-119.7953	7.9	0.5	Ml	009/015	119	0.10	AB	E3	eq
22	06:48:53	46.6032	-119.7952	7.7	0.5	Ml	011/015	121	0.08	AB	E3	eq
22	13:55:51	46.6013	-119.7967	7.6	0.5	Ml	010/015	121	0.08	AB	E3	eq
22	17:40:41	46.6017	-119.7993	8.1	0.5	Ml	010/016	123	0.09	AB	E3	eq
22	18:44:06	46.6028	-119.7878	7.0	0.5	Ml	014/025	77	0.14	AA	E3	eq
22	18:47:20	46.6010	-119.7960	7.0	0.5	Ml	009/015	198	0.11	AD	E3	eq
22	19:26:12	46.6055	-119.7980	8.1	2.1	Ml	058/059	33	0.09	AA	E3	eq
22	19:40:57	46.6017	-119.7950	7.7	1.1	Ml	012/018	120	0.08	AB	E3	eq
22	20:37:08	46.6043	-119.7955	7.9	0.7	Ml	013/019	122	0.08	AB	E3	eq
22	20:53:00	46.6020	-119.7942	7.0	0.4	Ml	008/014	181	0.11	AD	E3	eq
22	20:56:32	46.6018	-119.7988	7.9	0.9	Ml	016/025	76	0.09	AA	E3	eq
22	21:07:39	46.6023	-119.7988	8.2	1.4	Ml	028/037	76	0.08	AA	E3	eq
22	21:27:51	46.6018	-119.7935	6.9	0.2	Ml	008/012	155	0.07	AC	E3	eq
22	21:51:52	46.6043	-119.8018	8.1	0.7	Ml	009/013	126	0.05	AB	E3	eq
22	21:59:56	46.6028	-119.8003	7.6	0.3	Ml	008/013	124	0.15	BB	E3	eq
22	22:03:12	46.6043	-119.8017	8.0	0.4	Ml	009/015	126	0.08	AB	E3	eq
22	22:08:15	46.6038	-119.7982	8.1	0.4	Ml	007/010	208	0.05	AD	E3	eq
22	22:52:24	46.6067	-119.7987	7.9	1.2	Ml	022/032	72	0.10	AA	E3	eq

22	22:58:50	46.5998	-119.7975	7.8	0.2	Ml	008/013	121	0.08	AB	E3	eq
22	23:06:27	46.5988	-119.7965	8.0	0.3	Ml	010/015	120	0.06	AB	E3	eq
22	23:25:52	46.6068	-119.7967	8.1	2.0	Ml	042/049	51	0.10	AA	E3	eq
22	23:29:46	46.6022	-119.7968	7.7	0.3	Ml	006/009	201	0.07	AD	E3	eq
22	23:30:04	46.6010	-119.7910	6.3	-0.2	Md	007/011	178	0.14	AC	E3	eq
22	23:32:55	46.6017	-119.7955	7.5	0.7	Ml	010/015	181	0.06	AD	E3	eq
23	00:19:55	46.6062	-119.7980	7.8	0.6	Ml	014/023	78	0.09	AA	E3	eq
23	00:22:37	46.6008	-119.7993	8.1	1.2	Ml	019/030	78	0.08	AA	E3	eq
23	00:23:50	46.6047	-119.7940	7.8	0.8	Ml	016/025	78	0.08	AA	E3	eq
23	00:24:33	46.6017	-119.7978	7.8	0.5	Ml	011/016	122	0.09	AB	E3	eq
23	00:26:31	46.6055	-119.7970	7.6	0.5	Ml	014/017	123	0.07	AB	E3	eq
23	00:56:26	46.6053	-119.7965	7.7	0.8	Ml	014/022	78	0.08	AA	E3	eq
23	01:10:28	46.5998	-119.7933	7.2	0.4	Ml	009/012	191	0.07	AD	E3	eq
23	01:21:36	46.6052	-119.7980	7.8	0.8	Ml	012/018	140	0.09	AC	E3	eq
23	01:54:06	46.6030	-119.7970	7.9	0.7	Ml	012/019	85	0.09	AA	E3	eq
23	02:02:55	46.6018	-119.7950	8.0	1.0	Ml	013/021	104	0.09	AB	E3	eq
23	02:23:13	46.6047	-119.7960	7.6	0.2	Ml	008/013	184	0.12	AD	E3	eq
23	03:13:52	46.6050	-119.7968	8.1	2.2	Ml	084/060	37	0.09	AA	E3	eq
23	03:16:09	46.6010	-119.7992	7.8	0.7	Ml	011/017	79	0.08	AA	E3	eq
23	03:16:36	46.6043	-119.7957	7.6	0.0	Md	006/010	206	0.17	BD	E3	eq
23	03:20:55	46.5983	-119.7955	7.5	0.3	Ml	010/016	179	0.09	AC	E3	eq
23	03:21:52	46.6060	-119.7965	7.8	1.1	Ml	020/029	73	0.09	AA	E3	eq
23	03:23:00	46.6087	-119.7968	8.0	2.9	Ml	066/052	27	0.08	AA	E3	eq
23	03:28:45	46.6032	-119.7982	7.9	0.3	Ml	007/012	206	0.12	AD	E3	eq
23	03:29:33	46.6065	-119.8025	8.6	0.3	Ml	009/012	219	0.08	AD	E3	eq
23	03:32:44	46.6025	-119.7973	8.0	1.0	Ml	013/021	81	0.08	AA	E3	eq
23	03:37:39	46.6047	-119.8003	7.7	0.8	Ml	015/024	74	0.09	AA	E3	eq
23	03:38:17	46.6033	-119.7972	7.9	0.7	Ml	013/021	75	0.09	AA	E3	eq
23	03:40:29	46.6078	-119.8017	7.5	0.8	Ml	012/017	128	0.13	AB	E3	eq
23	03:43:04	46.5985	-119.7920	7.4	0.4	Ml	009/013	185	0.07	AD	E3	eq
23	03:44:10	46.5995	-119.7947	7.9	0.6	Ml	009/016	151	0.09	AC	E3	eq
23	03:51:11	46.5988	-119.7925	7.4	0.6	Ml	008/014	188	0.07	AD	E3	eq
23	04:17:33	46.5983	-119.7927	8.1	0.7	Ml	007/011	186	0.05	AD	E3	eq
23	04:22:07	46.6018	-119.7942	7.9	0.7	Ml	013/020	78	0.09	AA	E3	eq
23	04:23:59	46.6003	-119.7945	7.9	1.1	Ml	015/024	78	0.09	AA	E3	eq
23	04:31:03	46.5995	-119.7978	7.9	0.9	Ml	012/017	121	0.09	AB	E3	eq
23	04:53:22	46.6003	-119.7958	6.9	0.1	Ml	007/010	195	0.07	AD	E3	eq
23	05:29:45	46.6022	-119.7952	8.0	0.5	Ml	008/012	120	0.05	AB	E3	eq
23	06:17:58	46.6018	-119.8003	8.1	0.6	Ml	015/023	76	0.08	AA	E3	eq
23	06:46:37	46.6037	-119.7980	8.0	0.4	Ml	006/011	208	0.04	AD	E3	eq
23	08:28:18	46.6023	-119.7915	7.4	0.3	Ml	011/017	77	0.13	AA	E3	eq
23	09:21:50	46.6058	-119.7980	8.1	0.3	Ml	007/011	213	0.05	AD	E3	eq
23	09:29:10	46.6012	-119.7942	7.8	0.3	Ml	009/013	180	0.07	AC	E3	eq
23	09:30:52	46.6038	-119.7952	7.8	1.2	Ml	033/038	75	0.10	AA	E3	eq
23	09:46:24	46.6037	-119.7935	7.9	0.6	Ml	011/016	120	0.07	AB	E3	eq
23	11:39:27	46.6028	-119.7977	7.7	0.6	Ml	011/018	81	0.08	AA	E3	eq
23	12:14:31	46.6047	-119.7972	8.3	0.3	Ml	006/009	209	0.03	AD	E3	eq
23	12:17:00	46.6082	-119.7918	6.9	0.5	Ml	012/019	121	0.15	BB	E3	eq
23	12:47:35	46.6053	-119.7975	7.8	0.4	Ml	007/011	211	0.04	AD	E3	eq
23	13:08:03	46.5998	-119.7950	8.0	0.4	Ml	011/015	119	0.10	AB	E3	eq

23	14:21:08	46.6018	-119.7968	7.5	0.8	Ml	012/015	122	0.10	AB	E3	eq
23	14:28:27	46.6005	-119.8007	8.2	0.7	Ml	010/013	123	0.07	AB	E3	eq
23	15:56:45	46.6017	-119.8015	8.1	0.5	Ml	008/011	124	0.06	AB	E3	eq
23	17:47:29	46.6020	-119.7975	7.0	0.4	Ml	008/012	122	0.13	AB	E3	eq
23	17:48:36	46.6005	-119.7987	8.1	0.6	Ml	009/013	122	0.05	AB	E3	eq
23	18:42:40	46.6060	-119.7972	8.0	0.7	Ml	009/013	124	0.06	AB	E3	eq
23	19:06:56	46.5975	-119.7988	7.9	0.6	Ml	012/015	97	0.08	AB	E3	eq
23	21:55:22	46.6015	-119.8022	8.0	1.2	Ml	019/024	69	0.08	AA	E3	eq
23	23:42:40	46.6037	-119.8015	8.0	1.6	Ml	032/037	75	0.13	AA	E3	eq
24	01:54:10	46.6003	-119.7997	8.0	0.7	Ml	012/019	122	0.10	AB	E3	eq
24	02:10:02	46.6018	-119.7995	8.1	0.8	Ml	013/019	105	0.10	AB	E3	eq
24	03:35:19	46.6017	-119.7993	8.1	1.7	Ml	037/051	68	0.08	AA	E3	eq
24	03:48:23	46.5980	-119.7947	7.1	0.5	Ml	012/021	81	0.14	AA	E3	eq
24	03:51:09	46.5998	-119.8025	8.0	1.2	Ml	024/030	78	0.07	AA	E3	eq
24	04:33:04	46.5962	-119.7937	7.7	0.6	Ml	010/019	115	0.12	AB	E3	eq
24	05:15:49	46.6033	-119.7927	7.7	0.8	Ml	014/021	120	0.09	AB	E3	eq
24	06:39:35	46.5977	-119.7912	7.4	0.4	Ml	015/023	82	0.11	AA	E3	eq
24	07:26:37	46.5995	-119.7972	8.2	0.6	Ml	012/019	120	0.07	AB	E3	eq
24	08:18:36	46.6017	-119.7998	8.0	0.3	Ml	009/012	123	0.05	AB	E3	eq
24	10:01:46	46.5998	-119.7973	8.1	0.7	Ml	013/019	121	0.06	AB	E3	eq
24	10:12:35	46.6062	-119.8045	8.0	0.7	Ml	015/022	72	0.09	AA	E3	eq
24	12:17:12	46.6015	-119.8035	7.3	0.2	Ml	006/011	207	0.13	AD	E3	eq
24	12:30:10	46.6032	-119.7970	7.6	0.3	Ml	010/014	82	0.09	AA	E3	eq
24	13:43:39	47.7317	-120.2748	-0.4*	0.6	Ml	009/018	82	0.12	CB	N3	eq
24	16:25:01	46.6068	-119.7977	8.4	0.6	Ml	008/011	215	0.05	AD	E3	eq
24	17:10:10	46.6010	-119.7933	7.7	0.9	Ml	010/016	119	0.09	AB	E3	eq
25	07:24:10	46.6002	-119.7940	8.0	1.1	Ml	016/026	109	0.07	AB	E3	eq
25	07:37:21	46.6010	-119.7903	7.5	0.3	Ml	011/018	117	0.13	AB	E3	eq
25	07:59:03	46.5990	-119.7960	8.1	0.3	Ml	010/014	151	0.07	AC	E3	eq
25	08:08:19	46.6045	-119.8058	8.1	1.2	Ml	024/031	70	0.09	AA	E3	eq
25	10:23:31	46.6073	-119.7975	8.0	2.4	Ml	052/052	52	0.09	AA	E3	eq
25	10:38:45	46.6037	-119.7942	8.0	0.3	Ml	009/013	121	0.06	AB	E3	eq
25	11:07:47	47.7372	-117.6327	0.1	1.6	Ml	011/016	82	0.33	CC	N3	eq
25	11:46:05	47.7317	-117.6243	-0.1	1.4	Ml	015/023	97	0.30	CC	N3	eq
25	13:00:30	46.5987	-119.7915	7.7	0.6	Ml	010/016	116	0.09	AB	E3	eq
25	17:09:52	46.6068	-119.7945	7.8	1.2	Ml	016/022	86	0.08	AA	E3	eq
25	17:36:16	46.6037	-119.7950	7.7	1.0	Ml	011/015	121	0.07	AB	E3	eq
25	19:34:46	46.6007	-119.7995	7.6	1.0	Ml	008/014	182	0.07	AD	E3	eq
25	21:02:45	46.6025	-119.7965	8.6	0.9	Ml	006/009	202	0.03	AD	E3	eq
25	22:43:38	46.6062	-119.7980	8.0	1.4	Ml	018/031	73	0.09	AA	E3	eq
26	04:36:22	46.6018	-119.7987	8.0	1.7	Ml	031/046	76	0.09	AA	E3	eq
26	04:38:30	46.6065	-119.8048	7.3	0.6	Ml	007/011	130	0.09	AB	E3	eq
26	05:02:06	46.6052	-119.8010	8.4	0.7	Ml	006/010	214	0.05	AD	E3	eq
26	06:00:59	46.6092	-119.8060	7.7	0.6	Ml	013/017	81	0.10	AA	E3	eq
26	06:47:48	46.6030	-119.7993	8.0	1.6	Ml	026/037	75	0.09	AA	E3	eq
26	07:28:16	46.6027	-119.7952	7.0	0.6	Ml	009/014	121	0.08	AB	E3	eq
26	08:46:03	46.6032	-119.8020	7.8	1.6	Ml	027/039	69	0.10	AA	E3	eq
26	08:46:17	46.5995	-119.8012	7.9	1.8	Ml	011/015	113	0.07	AB	E3	eq
26	09:05:40	46.6005	-119.8008	7.8	0.8	Ml	013/017	78	0.10	AA	E3	eq
26	09:31:34	46.6040	-119.8065	7.3	0.7	Ml	013/020	141	0.13	AC	E3	eq

26	10:12:32	46.6028	-119.8040	8.1	1.6	Ml	028/038	70	0.08	AA	E3	eq
26	10:14:38	46.6007	-119.8013	7.7	1.1	Ml	013/020	123	0.08	AB	E3	eq
26	10:14:53	46.6002	-119.7995	7.7	0.6	Md	011/017	122	0.11	AB	E3	eq
26	11:33:39	46.6027	-119.8042	7.4	0.3	Ml	008/015	127	0.14	AB	E3	eq
26	11:44:50	46.6045	-119.7992	7.5	1.0	Ml	014/020	79	0.08	AA	E3	eq
26	11:48:34	46.6028	-119.8028	7.8	1.2	Ml	016/022	126	0.09	AB	E3	eq
26	13:06:19	46.6038	-119.7947	7.5	0.5	Ml	010/014	121	0.10	AB	E3	eq
26	13:35:38	46.5995	-119.8018	7.8	0.8	Ml	014/018	78	0.09	AA	E3	eq
26	13:37:48	46.5992	-119.8007	7.6	0.5	Ml	007/011	122	0.08	AB	E3	eq
26	13:54:55	46.6060	-119.8023	7.6	1.2	Ml	019/027	72	0.13	AA	E3	eq
26	14:19:10	46.5995	-119.8023	7.5	0.6	Ml	009/014	124	0.09	AB	E3	eq
26	14:20:05	46.6005	-119.8003	7.9	1.1	Ml	018/022	77	0.10	AA	E3	eq
26	15:26:11	48.5545	-121.3302	8.8	1.3	Ml	010/016	100	0.25	BC	C3	eq
26	18:03:35	46.6030	-119.8032	8.2	1.3	Ml	018/027	74	0.08	AA	E3	eq
26	18:13:06	46.5985	-119.7968	7.3	0.3	Ml	007/009	193	0.07	AD	E3	eq
27	02:21:24	46.5960	-119.8020	7.0	0.6	Ml	010/017	121	0.09	AB	E3	eq
27	02:41:33	46.5985	-119.8035	8.1	0.4	Ml	006/010	124	0.03	AB	E3	eq
27	03:06:25	46.5998	-119.8013	8.1	0.4	Ml	006/010	124	0.04	AB	E3	eq
27	04:13:22	46.6012	-119.8040	7.5	0.5	Ml	008/014	186	0.11	AD	E3	eq
27	04:56:32	46.5982	-119.8038	8.0	1.3	Ml	030/040	78	0.09	AA	E3	eq
27	05:39:31	46.5980	-119.8045	8.1	0.6	Ml	007/011	124	0.05	AB	E3	eq
27	08:02:34	46.5990	-119.8048	8.1	0.5	Ml	009/012	125	0.07	AB	E3	eq
27	08:17:43	46.5968	-119.7977	8.0	0.3	Ml	005/009	189	0.06	AD	E3	eq
27	09:10:23	46.6002	-119.8027	8.1	1.3	Ml	027/037	77	0.11	AA	E3	eq
27	09:36:43	46.6028	-119.8065	8.1	0.6	Ml	012/020	129	0.11	AB	E3	eq
27	09:56:42	46.6022	-119.8035	7.5	0.6	Ml	010/017	127	0.11	AB	E3	eq
27	12:28:51	46.5977	-119.8008	7.8	0.5	Ml	011/017	80	0.14	AA	E3	eq
27	12:43:14	46.6080	-119.7972	7.8	0.5	Ml	009/011	219	0.09	AD	E3	eq
27	13:52:49	46.6052	-119.7990	7.3	0.4	Ml	009/016	186	0.14	AD	E3	eq
27	13:53:27	46.6020	-119.7943	7.2	-0.0	Md	006/008	198	0.09	AD	E3	eq
27	14:16:42	46.6062	-119.8037	8.2	0.7	Ml	012/017	141	0.10	AC	E3	eq
27	14:57:29	46.5993	-119.7992	8.1	1.0	Ml	012/018	79	0.05	AA	E3	eq
27	15:27:28	46.6000	-119.8053	8.1	1.1	Ml	015/024	126	0.09	AB	E3	eq
27	15:33:36	46.6005	-119.8045	7.6	0.8	Ml	012/015	126	0.08	AB	E3	eq
27	15:37:19	46.6030	-119.8040	8.0	1.7	Ml	030/033	75	0.09	AA	E3	eq
27	17:20:58	46.6042	-119.8022	7.5	0.7	Ml	010/018	126	0.13	AB	E3	eq
27	19:46:29	46.6033	-119.8052	8.6	0.6	Ml	009/013	128	0.07	AB	E3	eq
27	20:29:29	46.2452	-119.4682	-0.5*	0.6	Md	006/008	247	0.13	CD	E3	px
27	22:33:35	46.5987	-119.8022	7.7	0.5	Ml	009/014	123	0.07	AB	E3	eq
28	02:43:49	46.2000	-121.4648	0.2*	0.9	Md	004/006	321	0.06	CD	C3	eq
28	08:00:36	46.6013	-119.8035	8.1	1.5	Ml	027/033	76	0.10	AA	E3	eq
28	15:15:04	46.5977	-119.7978	7.8	0.4	Ml	008/013	119	0.07	AB	E3	eq
28	16:36:25	46.5987	-119.8030	7.5	0.8	Ml	016/026	79	0.17	BA	E3	eq
28	19:49:50	46.6078	-119.7955	7.3	0.5	Ml	009/012	124	0.06	AB	E3	eq
29	04:58:35	46.5993	-119.8020	7.8	0.7	Ml	012/020	79	0.09	AA	E3	eq
30	22:51:57	46.2843	-118.0645	-0.5*	1.7	Ml	012/016	99	0.25	CC	E3	px

5.0 Discussion of Seismic Activity – FY 2024

5.1 Summary

During FY2024, seismic activity slightly increased throughout eastern Washington. 474 earthquakes were cataloged in the region, of which about 50% (237) took place on or in the immediate vicinity of the Hanford Site. This is an increase from 429 earthquakes in the previous year. Several earthquakes took place in the historically active area of Entiat and Chelan. Within the vicinity of the Hanford Site, there was low to typical swarm-type activity in the previously identified swarm areas. However, a vigorous swarm of small earthquakes began in the 4th quarter in a newly designated swarm area, the Umtanum Ridge Swarm, that is discussed in Section 5.2 of this report.

The depth distribution and geographic pattern of the earthquakes for the year are tabulated in Tables 5.1 and 5.2 and plotted in Figure 5.1.

Table 5.1. Depth Distribution of Eastern Washington Earthquakes for FY 2024

Category	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	FY 2024
Shallow (0-4 km deep)	50	31	12	37	130
Intermediate (4-9 km deep)	31	14	25	205	275
Deep (greater than 9 km deep)	18	11	24	16	69
Total	**99**	**56**	**61**	**258**	**474**
Felt	0	0	1	1	2
Probable Blast	15	23	34	33	105

Table 5.2. Earthquake Counts for FY 2024 for Earthquakes near the Hanford Site

Seismic Source Zones	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	FY 2024
Frenchman Hills	0	0	0	0	0
Saddle Mountains	0	0	0	0	0
Wahluke Slope	1	0	0	0	1
Coyote Rapids	1	0	0	0	1
Wye	0	0	0	0	0
Cold Creek	2	0	1	3	6
Rattlesnake Mountain	0	0	0	0	0
Horse Heaven Hills	0	1	0	2	3
Umtanum Ridge	5	2	9	185	201
Total for swarm areas	9	3	10	190	212
Random Events	10	1	11	3	25
Total For All Earthquakes	**19**	**4**	**21**	**193**	**237**

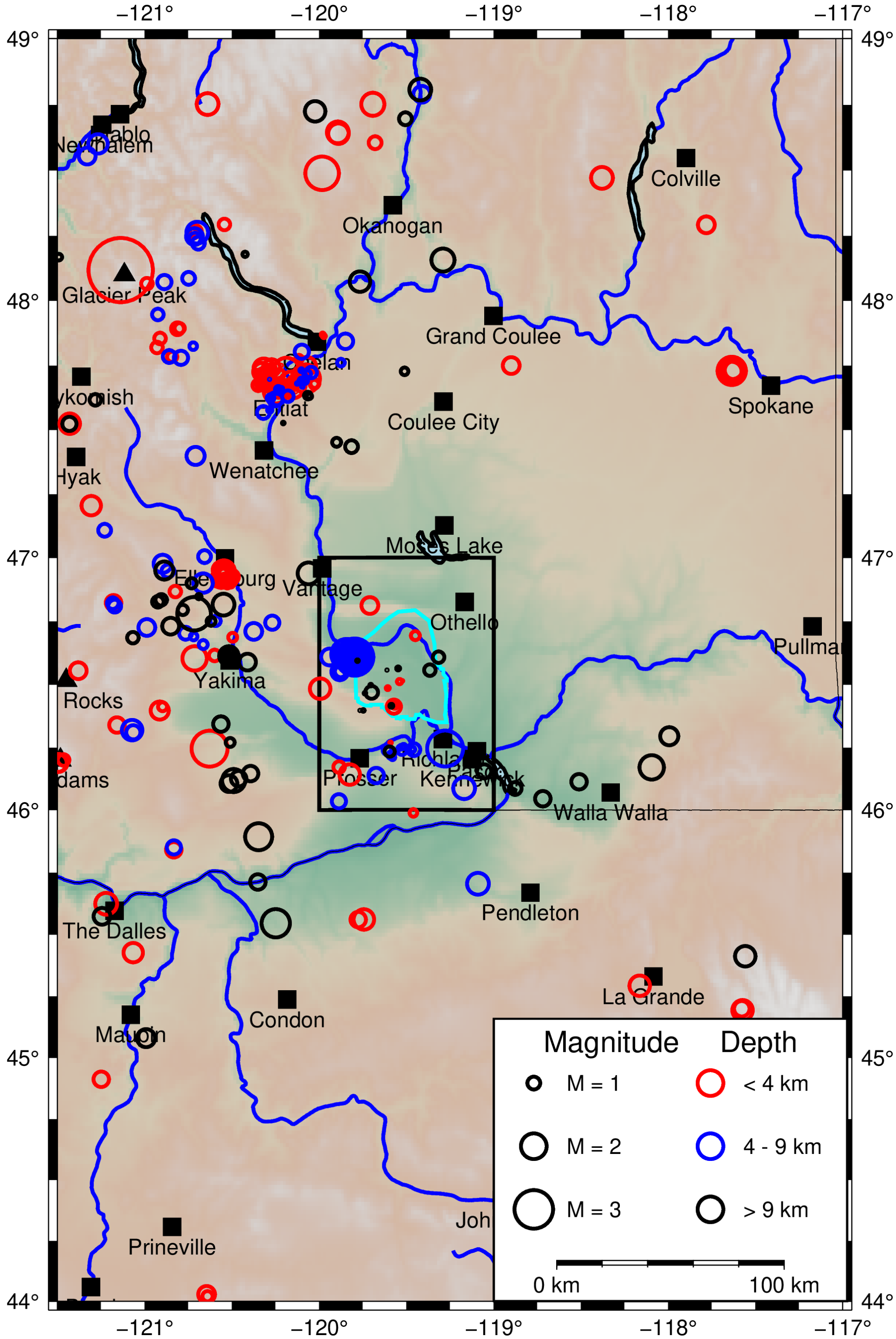

Figure 5.1. Hanford and Regional Epicenters of Earthquakes Recorded during FY 2024.Background color indicates elevation. Red circles stand for shallow earthquakes (0-4 km). Blue circles for intermediate-depth earthquakes (4-9 km). Black circles denote earthquakes deeper than 9 km.

5.2 Umtanum Ridge Swarm

A swarm of small earthquakes below Umtanum Ridge near the western boundary of the Hanford Reach National Monument started in the fourth quarter of FY24, see Figure 5.2 for its location. The earthquakes occur at a depth of ~7.8 +/- 1 km below sea level, likely below the basalt layers. When seismologists refer to a sequence of earthquakes as a “swarm” it means that there is no clear mainshock with significantly smaller fore- or aftershocks, instead, the larger events in the sequence all have similar magnitudes. The University of Washington catalog for Eastern Washington contains just a few events per year within the yellow polygon until ~2012, after which the number of events detected per year within the yellow polygon steadily increased, then decreased, followed by the vigorous swarm that started in September 2024 (the swarm continues beyond the period of this report), see Figure 5.3. Interpreting changes in seismicity rate over time requires careful consideration. It is essential to first rule out the possibility that these changes are due to improved detection capabilities resulting from advances in network coverage or methodological adjustments.

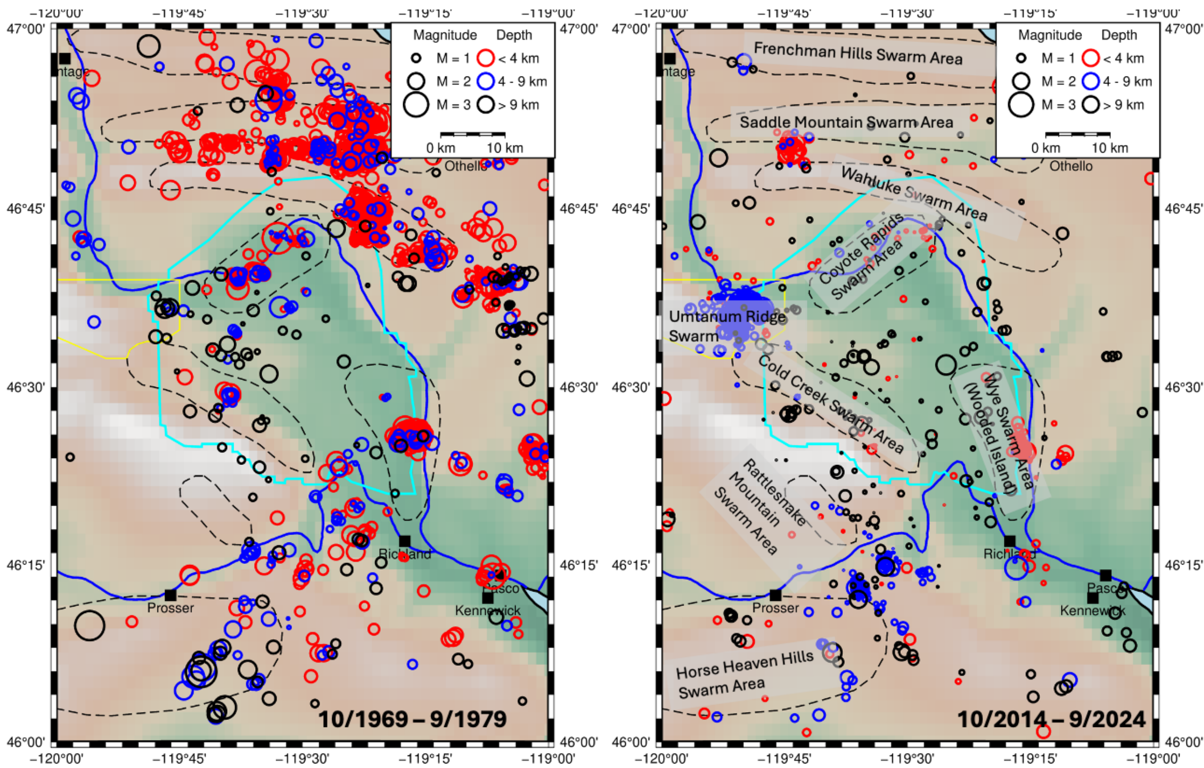

Figure 5.2 Epicenters of earthquakes catalogued in and around the Hanford Site during the decades 1969-1979 and 2014-2024. The cyan polygon outlines the Hanford Site including the Hanford Reach National Monument**,** whereas the dashed line polygons indicate the previously named (Malone et al., 1979) swarm areas, drawn after Figure 5.3 in Bodin et al., 2011., which was drawn after Rohay et al., 2010. The new Umtanum Ridge swarm area, defined solely for the purposes of this report, is outlined in yellow.

Swarms of earthquakes were detected as soon as seismic instruments were installed in and around Hanford in 1969 (Bingham et al., 1970; Pitt, 1972; Malone, 1975, 1979; NRC, 1980). Most of the early swarms occurred at very shallow depth (red symbols in Figure 5.2). Although a few shallow swarms occurred during the most recent ten years (2014-2024, right-hand-side panel), many of the areas that were very active in the early years have had fewer events. Conversely, areas west of the Hanford Site appear to be more active.

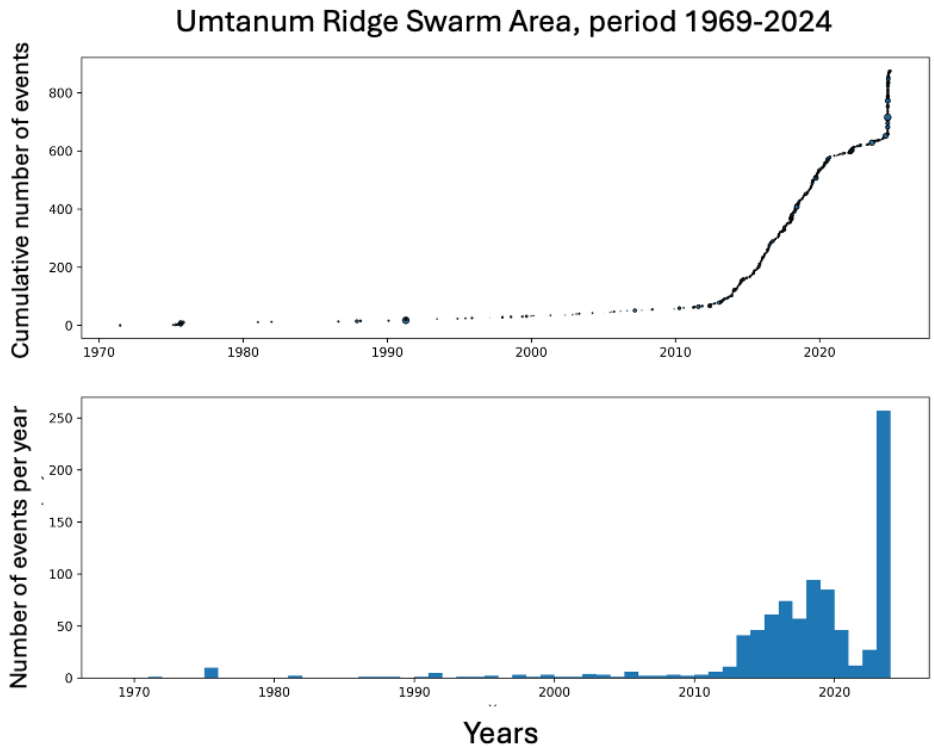

Figure 5.3 Temporal variation in seismicity rate in the Umtanum Ridge swarm area. I.e., events within the yellow polygon shown in Figure 5.2. Top panel shows the cumulative number of earthquakes, and bottom panel shows the number of events per calendar year

Swarms of earthquakes happen in a wide variety of settings, including elsewhere in the Pacific Northwest. They are thought to be caused by transient changes to the stress field which might be caused by fluid flow or fault creep (aseismic slip) or dike intrusions, etc. (e.g., Llenos et al., 2009). One swarm in the Hanford vicinity has been well studied, the Wooded Island swarm of 2009. Thanks to the availability of interferometric synthetic aperture radar (InSAR) data in addition to seismic event data, Wicks et al., 2011, were able to conclude that this swarm was due to aseismic slip on a thrust fault and near-horizontal bedding plane fault located between basalt flows. It is rare that the deformation pattern due to small earthquakes can be observed using InSAR, in this case it was possible because the aseismic slip and associated swarm occurred at very shallow depths. Whether the Umtanum Swarm is also caused by aseismic slip is unclear and will be investigated in the coming year. A careful re-analysis of the temporal and spatial patterns of the swarms in the Columbia Basin is beyond the scope of this report but would be a worthwhile endeavor.

6.0 Status of Monitoring

Overall, the monitoring capability of seismicity in the region surrounding the Hanford Site has stayed the same. In recent years, PNSN (UW) has densified the seismic network in Eastern Washington using non-DOE funding. On the Hanford Site, HSN station UW.NIKE, installed in late 2017, will have to be removed due to water leaking into the Nike Missile Silo that houses the station. Despite repeated power outages in the past year, it is currently sending data again. US National Net seismic station US.HAWA is co-located and will need to be removed, it is no longer sending data because it needed maintenance (expired satellite contract). The nearest station to NIKE is an old-fashioned, vertical-component, short-period station, RSW, that cannot be upgraded in place. Losing both NIKE and RSW would likely be detrimental to the monitoring effort.

In the past year, PNSN produced a plan for HMIS to upgrade the remaining analog, short-period stations, and mitigate the removal of NIKE, and potentially, HGBL. At the locations of NIKE and HGBL, PNSN also operates relay sites. The Lower Rattlesnake Relay next to NIKE will be moved to the top of Rattlesnake Mountain, and if HGBL has to go, we would like to establish a new relay site on the White Bluffs.

Several instruments of the HSN and EWRSN are reaching end-of-life and exhibit (intermittent) issues. The five Kinemetrics Basalt dataloggers with internal Episensor ES-T accelerometers were purchased in 2012 and are now 10+ years old. We have replaced one (s/n 1597 at H1K) that failed with a new Kinemetrics Obsidian instrument. The equipment purchased from IRIS in 2008 is 15+ years old; we had to replace the Q330 at DDRF, station PHIN still has all the original IRIS equipment. CCRK was rebuilt after it was destroyed by wildfire and has relatively new FY2017 equipment. We expect that more of the older instruments will start to fail over time and will need to be replaced.

7.0 References

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