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Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Annual Hanford Seismic Report for Fiscal Year 2006

A. C. Rohay
M. D. Sweeney
D. C. Hartshorn
S. P. Reidel
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December 2006

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The Hanford Seismic Assessment Program (HSAP) provides an uninterrupted collection of high-quality raw and processed seismic data from the Hanford Seismic Network for the U.S. Department of Energy and its contractors. The Hanford Seismic Assessment Team locates and identifies sources of seismic activity and monitors changes in the historical pattern of seismic activity at the Hanford Site. The 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 seismic monitoring organization works with the Hanford Site Emergency Services Organization to provide assistance in the event of a significant earthquake on the Hanford Site. The Hanford Seismic Network and the Eastern Washington Regional Network consist of 41 individual sensor sites and 15 radio relay sites maintained by the Hanford Seismic Assessment Team.

For the Hanford Seismic Network, there were 1,428 triggers on our seismic system during fiscal year 2006; however, only 117 were local earthquakes relevant to the Hanford Site. The largest earthquake for the year occurred during the first quarter; it was a magnitude 2.6 event on November 10, 2005 UTC. This earthquake was a random event and occurred in the crystalline basement southwest of the Hanford Site. Stratigraphically, 72 earthquakes occurred in the Columbia River basalt (approximately 0-5 km depth), 23 earthquakes were in the pre-basalt sediments (approximately 5-10 km depth), and 22 earthquakes were in the crystalline basement (approximately 10-25 km depth). Geographically, 78 earthquakes occurred in swarm areas, and 39 earthquakes were classified as random events. No earthquakes were classified as having occurred on major geological structures.

Acronyms

BWIP	Basalt Waste Isolation Project
CDPD	Cellular Digital Packet Data
CRBG	Columbia River Basalt Group
DOE	U.S. Department of Energy
ETNA	strong motion accelerometer manufactured by Kinemetrics
EWRN	Eastern Washington Regional Network
FY	fiscal year
GPS	Global Positioning System
HSAP	Hanford Seismic Assessment Program
HSAT	Hanford Seismic Assessment Team
HSN	Hanford Seismic Network
M_c	Coda-Length Magnitude
M_L	Local Magnitude
M_w	Moment Magnitude
PNNL	Pacific Northwest National Laboratory
RAW	Rattlesnake Mountain-Wallula Alignment
SMA	strong motion accelerometer
USGS	United States Geological Survey
UTC	Universal Time, Coordinated
UW	University of Washington
WHC	Westinghouse Hanford Company

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1.0 Introduction

This report covers seismic activity on and near the Hanford Site for fiscal year (FY) 2006, October 1, 2005 through September 30, 2006. This report locates seismicity within the monitored region and provides the geologic interpretations of the earthquakes.

1.1 Mission

The principal mission of the Hanford Seismic Assessment Program (HSAP) at the Hanford Site is to ensure compliance with DOE Order 420.1A, “Facility Safety” and DOE Order G 420.1-1, Section 4.7, “Emergency Preparedness and Emergency Communications.” DOE Order 420.1A establishes facility safety requirements related to nuclear safety design, criticality safety, fire protection, and natural phenomena hazards mitigation. For seismic assessment, this order states:

> 4.4.5 Natural Phenomena Detection.
> *Facilities or sites with hazardous materials shall have instrumentation or other means to detect and record the occurrence and severity of seismic events.*

The HSAP supports Hanford Site emergency services organizations in complying with DOE Order G 420.1-1, Section 4.7, “Emergency Preparedness and Emergency Communications,” by providing assistance in the event of an earthquake on the Hanford Site.

In addition, Seismic Assessment provides an uninterrupted collection of high-quality raw seismic data from the Hanford Seismic Network (HSN) located on and around the Hanford Site, and the Eastern Washington Regional Network (EWRN). This report provides interpretations of seismic events from the Hanford Site and vicinity. Hanford Seismic Assessment locates and identifies sources of seismic activity, monitors changes in the historical pattern of seismic activity at the Hanford Site, and builds a “local” earthquake database (processed data) that is permanently archived. The focus of this report is the precise location of earthquakes proximal to or on the Hanford Site, specifically between 46 degrees and 47 degrees north latitude and between 119 degrees and 120 degrees west longitude. Data from the EWRN and other seismic networks in the northwest provide the Seismic Assessment Project 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

Assessing seismic activity at the Hanford Site was initiated in 1969 by the United States Geological Survey (USGS) under a contract with the U.S. Atomic Energy Commission. In 1975, the University of Washington (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 EWRN operated and maintained by UW. Funding ended for BWIP in December 1988. Assessment of seismic activity and responsibility for the UW contract were then transferred to WHC's Environmental Division. Maintenance responsibilities for the EWRN also were assigned to WHC who made major upgrades to EWRN sites.

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

The Hanford Strong Motion Accelerometer (SMA) network was constructed during 1997 and came on-line in May 1997. It operated until September 30, 1997, when it was mothballed due to lack of funding. Funding was restored on October 1, 1998, by joint agreement between the U.S. Department of Energy (DOE) and PNNL. Operation of the SMA sites resumed on November 20, 1999, and has operated continuously since that time.

1.3 Documentation and Reports

The HSAP issues quarterly reports of local activity, an annual catalog of earthquake activity on and near the Hanford Site, and special-interest bulletins on local seismic events. The HSAP also provides information and special reports to other functions as requested. Earthquake information provided in these reports is subject to revisions if new data become available. In addition, an archive of all seismic data from the HSN is maintained by PNNL.

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[1] Pacific Northwest National Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy.

2.0 Network Operations

2.1 Seismometer Sites

The seismic network consists of two designs of equipment and sites: seismometer sites and strong motion accelerometer (SMA) sites. Seismometer sites are designed to locate earthquakes and determine their magnitude and hypocenter location. SMA sites are designed to measure ground motion and will be discussed in Section 2.2.

The HSN and the EWRN consist of 41 sensor sites. Most sites are in remote locations and require solar panels and batteries for power. The HSN uses 23 sites (Table 2.1 and Figure 2.1) and the EWRN uses 36 sites (Table 2.2 and Figure 2.2); both networks share 18 sites. The networks have 45 combined data channels because Gable Butte and Frenchman Hills East are three-component sites, each consisting of one vertical, one north-south horizontal, and one east-west horizontal data channel. Both networks use 15 additional telemetry relay sites. Data from all sites or relays are transmitted to the Sigma V building, Richland, Washington.

Table 2.1. Seismic Stations in the Hanford Seismic Network

The first column is the three-letter seismic station designator. The latitude and longitude, elevation above sea level in meters, and the full station name follow this. The locations of the stations are all in Washington; locations were derived from a Global Positioning System (GPS).

Station	Latitude Deg. Min. N	Longitude Deg. Min. W	Elevation (m)	Station Name
BEN	46N31.13	119W43.02	340	Benson Ranch
BLT	45N54.91	120W10.55	659	Bicklelton
BRV	46N49.12	119W59.47	920	Black Rock Valley
BVW	46N48.66	119W52.99	670	Beverly
CRF	46N49.50	119W23.22	189	Corfu
ET3	46N34.64	118W56.25	286	Eltopia Three
*FHE	46N57.11	119W29.82	455	Frenchman Hills East
*GBB	46N36.49	119W37.62	177	Gable Butte
GBL	46N35.92	119W27.58	330	Gable Mountain
H2O	46N23.75	119W25.38	158	Water
LOC	46N43.02	119W25.85	210	Locke Island
MDW	46N36.79	119W45.66	330	Midway
MJ2	46N33.45	119W21.54	146	May Junction Two
OT3	46N40.14	119W13.98	322	Othello Three
PRO	46N12.73	119W41.15	550	Prosser
RED	46N17.92	119W26.30	366	Red Mountain
RSW	46N23.67	119W35.48	1,045	Rattlesnake Mountain
SNI	46N27.85	119W39.60	312	Snively Ranch
VT2	46N58.04	120W58.95	1,270	Vantage Two
WA2	46N45.32	119W33.94	244	Wahluke Slope
WIW	46N25.76	119W17.26	128	Wooded Island
WRD	46N58.20	119W08.69	375	Warden
YPT	46N02.93	118W57.73	325	Yellepit

* Three-component station.

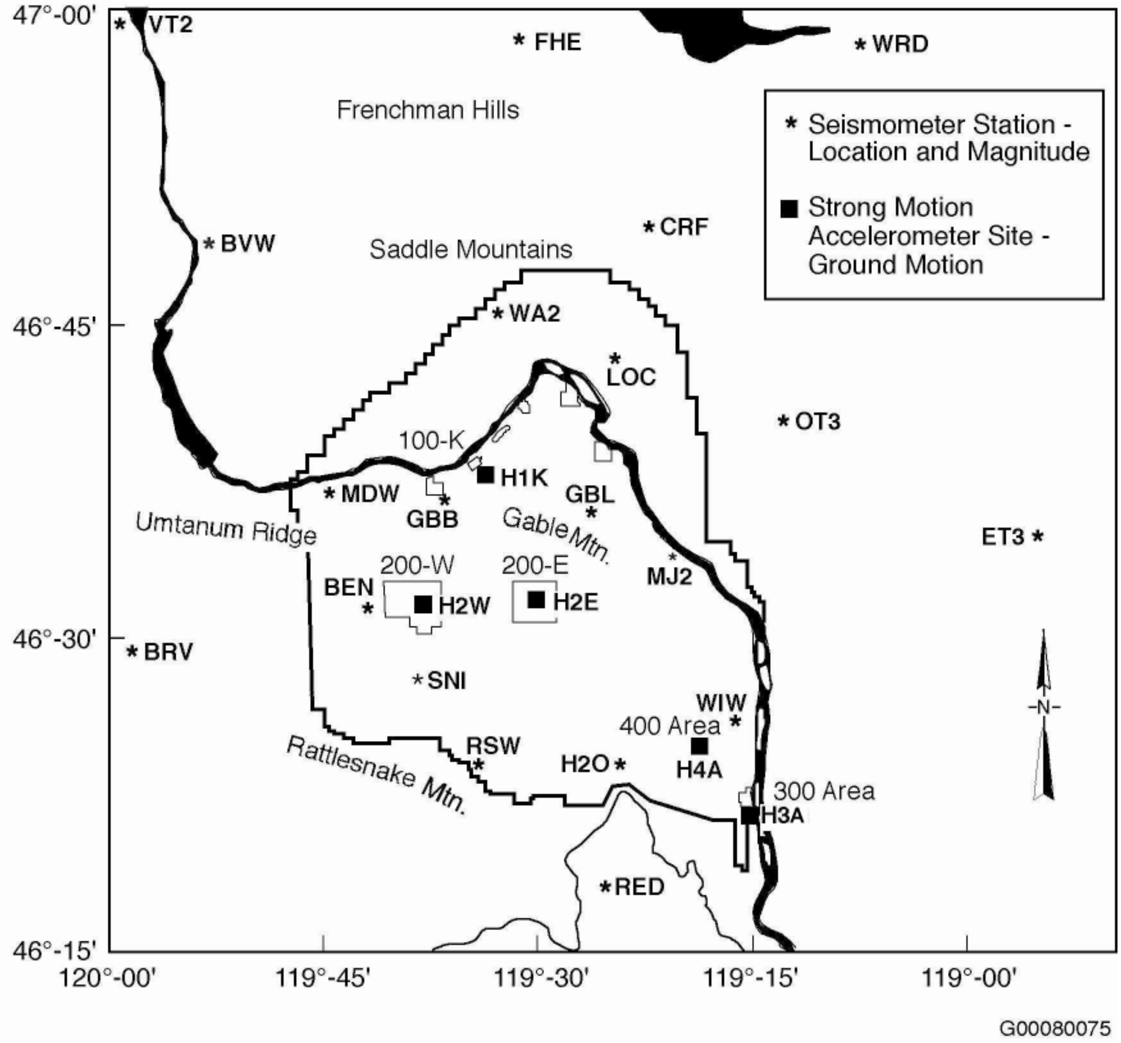

Figure 2.1. Locations of Seismograph Stations and Strong Motion Accelerometer Sites in the Hanford Seismic Network (see Tables 2.1 and 2.4 for description of locations). Bickelton (BLT), Prosser (PRO), and Yellepit (YPT) are shown on Figure 2.2.

Table 2.2. Seismic Stations in the Eastern Washington Regional Network

The first column is the three-letter seismic station designator. The latitude and longitude, elevation above sea level in meters, and the full station name follow this. The locations of the stations are all in Washington unless otherwise indicated; locations were determined from a Global Positioning System (GPS).

Station	Latitude Deg. Min. N.	Longitude Deg. Min. W.	Elevation (m)	Station Name
BLT	45N54.91	120W10.55	659	Bickleton
BRV	46N29.12	119W59.47	920	Black Rock Valley
BVW	46N48.66	119W52.99	670	Beverly
CBS	47N48.26	120W02.50	1,067	Chelan Butte, South
CRF	46N49.50	119W23.22	189	Corfu
DPW	47N52.25	118W12.17	892	Davenport
DY2	47N59.11	119W46.28	890	Dyer Hill Two
ELL	46N54.58	120W33.98	789	Ellensburg
EPH	47N21.38	119W35.76	661	Ephrata
ET3	46N34.64	118W56.25	286	Eltopia Three
ETW	47N36.26	120W19.94	1,477	Entiat
*FHE	46N57.11	119W29.82	455	Frenchman Hills East
GBL	46N35.92	119W27.58	330	Gable Mountain
LNO	45N52.31	118W17.11	771	Lincton Mountain, Oregon
LOC	46N43.02	119W25.85	210	Locke Island
MDW	46N36.79	119W45.66	330	Midway
MJ2	46N33.45	119W21.54	146	May Junction Two
MOX	46N34.64	120W17.89	501	Moxee City
NAC	46N43.99	120W49.42	728	Naches
NEL	48N04.21	120W20.41	1,500	Nelson Butte
OD2	47N23.26	118W42.58	553	Odessa Two
OT3	46N40.14	119W13.98	322	Othello Three
PAT2	45N53.03	119W45.40	259	Paterson Two
PRO	46N12.73	119W41.15	550	Prosser
RSW	46N23.67	119W35.48	1,045	Rattlesnake Mountain
SAW	47N42.10	119W24.03	701	St. Andrews
TBM	47N10.20	120W35.88	1,006	Table Mountain
TRW	46N17.32	120W32.31	723	Toppenish Ridge
TWW	47N08.29	120W52.10	1,027	Teanaway
VT2	46N58.04	119W58.95	1,270	Vantage Two
WA2	46N45.32	119W33.94	244	Wahluke Slope Two
WAT	47N41.92	119W57.24	821	Waterville
WIW	46N25.76	119W17.26	128	Wooded Island
WRD	46N58.20	119W08.69	375	Warden
YA2	46N31.60	120W31.80	652	Yakima Two
YPT	46N02.93	118W57.73	325	Yellepit

* Three-component station.

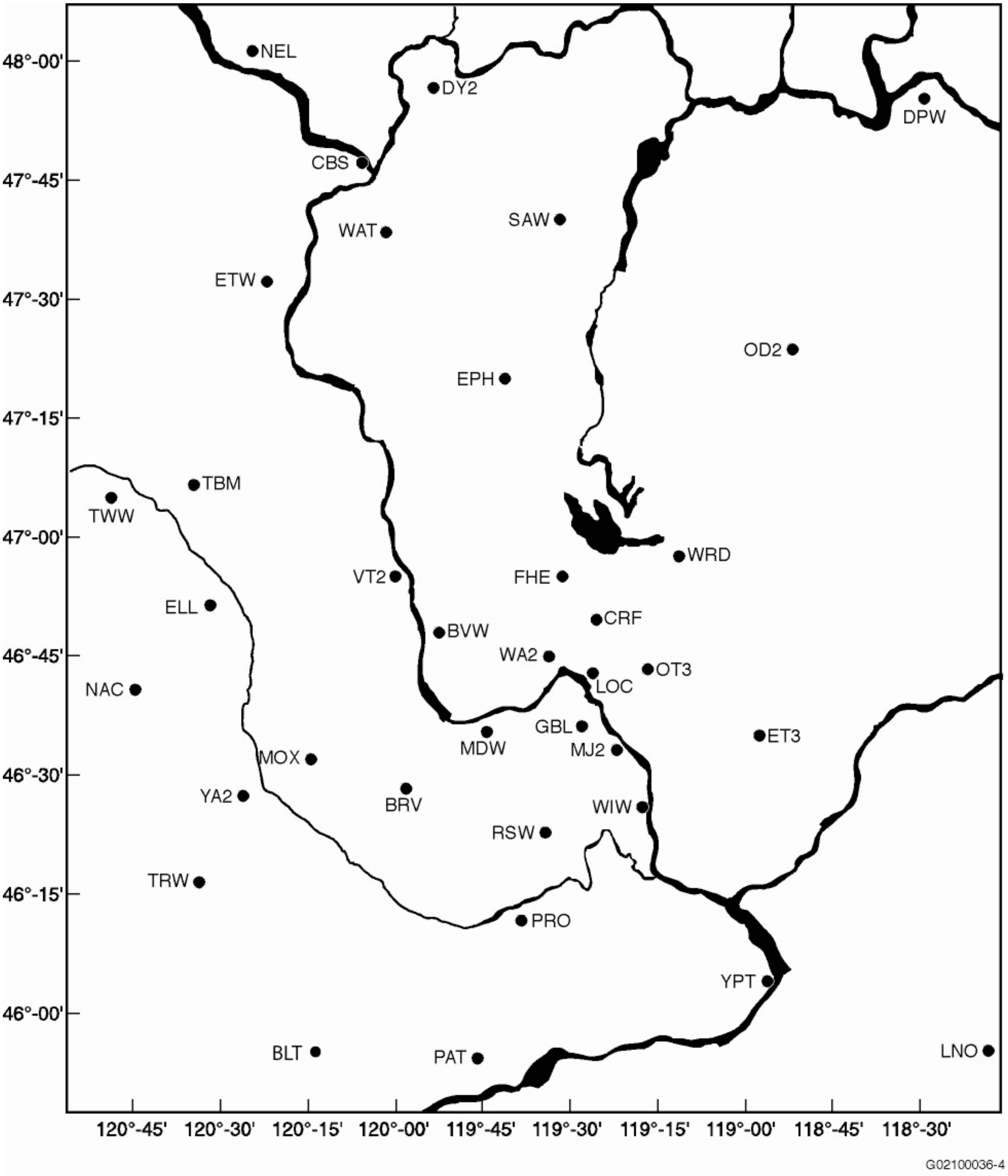

Figure 2.2. Locations of Seismograph Stations in the Eastern Washington Regional Network (see Table 2.2 for location descriptions)

2.1.1 Station Maintenance

The HSN's maintenance records for the seismic sensor and relay sites are on file in the HSAP office, Sigma V Building, Richland, Washington.

2.1.2 Data Acquisition

The signals from the seismometer sites are monitored for changes in signal amplitude that are expected from earthquakes. The seismic network is subdivided into spatial groupings of stations that are monitored for nearly simultaneous amplitude changes, resulting in 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 U.S. and Canada), and teleseisms (from farther distances around the world). Local and regional events are usually earthquakes, but quarry and mining explosions are also recorded. Quarry and mining explosions can usually be identified from wave characteristics, time of day, and through confirmation with local government agencies and industries. Frequently, military exercises at the U.S. Army's Yakima Training Center produce a series of acoustic shocks that unavoidably trigger the recording system. Sonic booms and thunder also produce acoustic signals that trigger the recording system.

A PC-based system (Earthworm system) adapted from a USGS program and the UW system was implemented at Hanford during FY 1999. One system has been in continuous operation since January 6, 1999. A second, backup PC system was installed in mid-March 1999, and both systems have been running in parallel since that time. The hardware and software have been periodically upgraded. Data from triggers are collected on a SUN™ (registered trademark of Sun Microsystems, Santa Clara, California) workstation that is used to determine earthquake locations and magnitudes (Section 3). Although the two systems are practically identical, there is enough granularity (signal-to-noise) in the trigger timing that they sometimes record exclusive events. In nearly all cases, these exclusive triggers are "false" triggers, not earthquakes or quarry blasts (i.e., from acoustic sources). The remainders are from barely detectable, small signals from regional and teleseismic earthquakes.

The types and numbers of triggers recorded during FY 2006 by the seismic acquisition system are summarized in Table 2.3.

2.2 Strong Motion Accelerometer Sites

2.2.1 Location

The Hanford SMA network consists of five free-field SMA sites (see Figure 2.1) (Table 2.4). There is one free-field SMA located in each of the 200 Separations Areas, one adjacent to the K Basins in the 100-K Area, one adjacent to the 400 Area where the Fast Flux Test Reactor is located, and one at the south end of the 300 Area. With the termination of the Fast Flux Test Reactor and draining of the liquid sodium coolant having taken place, plans have been made to terminate this site and move the instrument to a new location.

Table 2.3. Acquisition System Recorded Triggers

Event Type	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total	Description
Triggers	399	339	386	304	1,428	Total number of times the recording mechanism was activated.
South-Central Washington	71	47	38	20	176	Seismic events in south-central Washington and north-central Oregon that triggered the HSN.
Regional	56	57	65	90	268	Seismic events in the Western United States and Canada.
Teleseism	49	39	39	80	207	Seismic events at farther distances from around the world.
Total Earthquake Events	176	143	142	190	651	Total number of earthquake triggers.
Local Explosions	5	10	10	3	28	Quarry blasts, typically, within the 46-47 degrees north latitude and 119-120 degrees west longitude.
Local Earthquakes	57	29	20	11	117	Seismic events within the 46-47 degrees north latitude and 119-120 degrees west longitude.

Table 2.4. Free-Field Strong Motion Accelerometer Sites

Site	Site ID	Location	Latitude Longitude Elevation
100-K Area	H1K	South of K Basins outside 100 Area fence lines.	46° 38.51’ 119° 35.53’ 152 m
200 East Area	H2E	East of B Plant; northwest of Waste Treatment Plant; north of 7th Street and east of Baltimore Avenue.	46° 33.58’ 119° 32.00’ 210 m
200 West Area	H2W	West of Plutonium Finishing Plant (PFP) and 200-West Area tree barrier.	46° 33.11’ 119° 38.64’ 201 m
300 Area	H3A	South end of 300 Area inside fence lines (NE 1/4, SW 1/4, Sec. 11, T10N, R28E).	46° 21.83’ 119° 16.55’ 119 m
400 Area	H4A	500 ft from fence line on east side of facility and north of parking area).	46° 26.13’ 119° 21.30’ 171 m

The instrumentation locations were chosen based on two criteria (Moore and Reidel 1996): 1) instruments should be located in areas having the highest densities of people and 2) instruments should be located in areas having hazardous facilities. Some of the highest concentrations of employees at Hanford are 200-East and West Areas, 100-K Area, the Fast Flux Test Facility (400 Area), and the 300 Areas. The 200 Areas are where high-level radioactive waste from past processing of fuel rods is stored in single-shell and double-shell tanks. In addition, the Canister Storage Facility that holds encapsulated spent fuel rods is in 200-East Area and the new Waste Treatment Plant is being constructed in 200-East Area. The 100-K Area contains the K Basins where spent fuel rods from the N Reactor are stored prior to encapsulation. The Cold Vacuum Drying Facility, located in the 100-K Area, is used to encapsulate spent fuel rods from the K Basins prior to shipment to the Canister Storage Building in 200-East Area.

2.2.2 Site Design

All free-field SMA sites consist of a four-panel solar array and two 30-gallon galvanized drums. Each panel has a maximum 42-watt output. The two 30-gallon drums are set in the ground such that the base of the drum is about 1 m below the surface. One drum houses only the SMA; the other drum, which is connected via a sealed conduit to the SMA drum, contains the batteries. Communication is through a General Packet Radio Service (GPRS) system, which provides a continuous radio data-link with an internet service provider. This GPRS system along with the solar power regulator is housed in a small enclosure mounted at the rear of the solar array. The enclosure serves as a junction box for all cabling between equipment inside and outside of the drums through conduit. The antenna for the GPRS 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.

The SMA instruments are three-component units consisting of one vertical, one north-south horizontal, and one east-west horizontal data channel. The instruments in use are the ETNA™ system (registered trademark of Kinemetrics, Inc., Pasadena, California). Instrument specifications are summarized in Table 2.5. In addition to the three-component SMAs, each ETNA SMA unit contains a computer, and a Global Positioning System (GPS) receiver (Figure 2.3). These systems are housed in a watertight box.

The GPRS system provides the internet address connection to access the system. Stations can be monitored from any computer with appropriate access, and data can be downloaded to a dedicated computer in the Seismic Assessment laboratory. The data can also be downloaded directly at each site via a built in cable connection at the enclosure in case of communication failure.

Table 2.5. Instrument Parameters for the Kinemetrics ETNA™ System in the Hanford SMA Network

Parameter	Value or Range
Sensor	
Type	Tri-Axial Force Balance Accelerometer, orthogonally oriented
Full-Scale	±2 g[(a)]
Frequency Range	0–80 Hz
Damping	Approximately 70% critical[(a)]
Data Acquisition	
Number of Channels	3
Sample Rate	18-bit resolution @ 200 samples/second
Digital Output	Real-time, RS-232 Output Stream
Seismic Trigger	
Filter	0.1–12.5 Hz
Trigger level	0.02% g[(b)]
Alarm (call-out) Threshold	Not activated
Pre-Event Memory	10 sec
Post-Event Time	40 sec

(a) Setting is dependent on instrument calibration.
(b) See Section 2.2.4 for discussion of trigger thresholds.

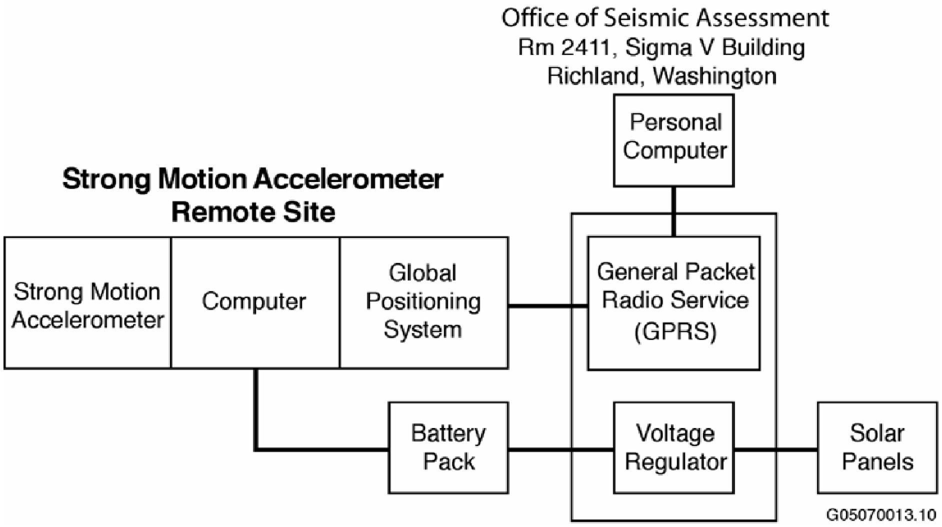

Figure 2.3. Schematic Diagram of a Strong Motion Accelerometer Installation

The SMAs have an internal GPS receiver used principally to link it to the National Bureau of Standards timing system.[2] The GPS is internally activated approximately every 4 hours and checks the "location of the instrument" and the time. Any differences between the internal clock and the GPS time are recorded and saved by the SMA. Any corrections to the internal timing are made automatically. Typically, the greatest correction recorded is approximately 4 milliseconds.

2.2.3 Strong Motion Accelerometer Operations Center

The combined operations, data recording, data interpretation, and maintenance facility is located in the Sigma V Building and is operated by the HSAT.

2.2.4 Strong Motion Operational Characteristics

The signals from the three-accelerometer channels at each site are digitized with a 24-bit digitizer and temporarily stored in a memory buffer. The sampling rate of the digitizer is set to 200 samples/second. The three channels are monitored for signals that equal or exceed a programmable trigger threshold. When one accelerometer channel is triggered, the other channels automatically record. The nominal threshold that was used from 1998 to 2006 was 0.05% of the full-scale range of 2.0 g (g is the acceleration of gravity, 9.8 m/s^2 or 32 ft/s^2) or 0.001 g. Threshold trigger levels are adjusted to trigger infrequently on the noise sources (e.g., vehicles, sonic booms) near each site. In 2006, new SMA systems with larger storage allowed the trigger thresholds to be reduced to 0.01% full-scale or 0.0002 g (see Section 5). This provides ground motion data for smaller, non-damaging earthquakes that can be useful in estimating the ground motion expected from larger earthquakes, and to confirm correct operation of the instruments by analyzing the smaller-amplitude triggers. The recorders store information for 10 seconds before the trigger threshold is exceeded and for 40 seconds after the trigger threshold ceases to be exceeded.

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[2] The GPS antenna is mounted on the enclosure at the rear of the solar array.

3.0 Earthquake Catalog Description

Seismic Assessment Project staff uses an interactive program XPED developed at the University of Washington to determine earthquake locations and magnitudes. This program operates on the sections of time saved in files by the trigger algorithm of the Earthworm system. It provides the user with the ability to measure the arrival times and durations of seismic waves from earthquakes and determine the locations and magnitudes of the events. Locations of teleseismic and regional earthquakes are interpreted and saved for operational and quality review and documentation, and are not reported here. Local earthquakes near the Hanford Site (46º-47ºN latitude, 119º-120ºW longitude) are reported in this report (Table 3.1). Other earthquakes in southeast Washington are kept on file.

3.1 Coda Length Magnitude

Coda-length magnitude (M_c), an estimate of local magnitude (M_L) (Richter 1958), is calculated using the coda-length/magnitude relationship determined for Washington State by Crosson (1972).

This relationship is:

$$M_c = 2.82 \log (D) - 2.46,$$

where D is the duration of the observed signal. Many of the earthquakes have magnitude determinations that are very small, $M_c < 0$, and highly uncertain; earthquakes smaller than M_c 0.5 will be described as "approximately 0 M_c" in Section 4. Coda-length magnitudes for events classified as explosions are not reported because they are biased by a prominent surface wave that extends the apparent duration in a way inconsistent with coda-length measurement.

3.2 Velocity Model

The program XPED uses the velocities and layer depths given in Table 3.1. This model does not include a surficial layer for the Hanford formation or Ringold Formation sediments because most stations are located on basalt. Time corrections, which account for elevation, or local differences in the velocity model (i.e., stations on sedimentary layers), are determined empirically from sets of accurately-located earthquakes and explosions in the region.

3.3 Quality Factors (Q)

XPED assigns a two-letter **Quality factor** (Table 3.2) that indicates the general reliability of the solution (**A** is best quality, **D** is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter of the quality code is a measure of the hypocenter quality based primarily on travel time residuals. For example: Quality **A** requires a root-mean-square residual (**RMS**) less than 0.15 seconds while a **RMS** of 0.5 seconds 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's 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**). 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**.

Table 3.1. Local Seismic Data, October 1, 2005 to September 30, 2006

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
05100219330		05/10/02	19:33:34.57	46N29.10	119W21.61	6.15	1.2	14/17	112	8	0.10	AB	5.6 km N of 400 Area
05100603261		05/10/06	03:26:39.65	46N29.08	119W21.29	5.32	1.2	10/13	142	8	0.11	AC	5.5 km N of 400 Area
05101113302		05/10/11	13:30:44.19	46N34.58	119W47.39	0.44	-0.2	7/12	203	4	0.17	BD	11.8 km W of 200 West
05101117422		05/10/11	17:42:51.34	46N33.27	119W54.60	6.15	-0.2	5/07	196	13	0.30	CD	20.9 km W of 200 West
05101119433		05/10/11	19:43:58.31	46N34.79	119W48.40	4.09	-0.2	7/11	205	5	0.14	AD	13.2 km W of 200 West
05101119484		05/10/11	19:49:04.42	46N34.87	119W46.35	0.03	-0.3	4/08	193	3	0.20	BD	10.6 km WNW of 200 West
05101203550		05/10/12	03:55:31.02	46N37.30	119W45.42	14.18	-0.3	5/06	261	1	0.04	AD	11.6 km NW of 200 West
05101209092		05/10/12	09:09:50.61	46N33.39	119W44.32	10.09	-0.7	6/08	186	4	0.05	AD	7.7 km W of 200 West
05101504470		05/10/15	04:47:27.52	46N42.77	119W30.03	1.06	-0.2	8/11	81	5	0.09	BB	10.8 km NE of 100-K Area
05101615291		05/10/16	15:29:40.09	46N34.65	119W48.58	0.04	0.3	9/13	207	5	0.10	AD	13.3 km W of 200 West
05102021330	P	05/10/20	21:33:31.62	46N11.39	119W13.75	0.03		20/20	146	20	0.17	BC	8.3 km W of Kennewick
05102917081		05/10/29	17:08:30.08	46N41.57	119W39.82	7.90	-0.9	6/07	187	9	0.07	AD	7.6 km NW of 100-K Area
05111012453		05/11/10	12:45:59.25	46N08.30	119W55.75	11.45	2.6	34/37	71	20	0.18	BB	14.6 km WSW of Prosser
05111013052		05/11/10	13:05:47.57	46N08.95	119W55.60	8.27	1.2	14/14	113	19	0.06	AC	13.8 km WSW of Prosser
05111118533	P	05/11/11	18:53:58.39	46N25.87	119W01.45	0.02		9/09	151	17	0.28	BC	21.2 km ENE of 300 Area
05112119580	P	05/11/21	19:58:25.21	46N14.97	119W43.12	0.03		9/09	212	4	0.19	BD	6.1 km NE of Prosser
05112318531	P	05/11/23	18:53:39.29	46N16.06	119W23.98	2.75		12/12	208	4	0.12	AD	8.5 km WSW of Richland
05120107082		05/12/01	07:08:44.33	46N43.30	119W30.34	3.23	-0.7	7/11	89	5	0.11	AB	11.3 km NE of 100-K Area
05120113050		05/12/01	13:05:24.79	46N42.91	119W29.27	5.33	-0.9	3/05	225	4	0.04	AD	11.7 km NE of 100-K Area
05120305012		05/12/03	05:01:53.03	46N43.02	119W29.82	0.02	0.5	8/09	77	5	0.10	AB	11.3 km NE of 100-K Area
05120314524		05/12/03	14:53:13.27	46N43.19	119W29.95	3.61	0.4	12/15	68	5	0.12	AB	11.4 km NE of 100-K Area
05120314552		05/12/03	14:55:44.73	46N43.23	119W30.13	5.99	-0.1	8/09	88	5	0.11	AA	11.4 km NE of 100-K Area
05120319365		05/12/03	19:37:16.35	46N43.17	119W30.02	4.39	-0.6	7/09	87	5	0.09	AB	11.4 km NE of 100-K Area
05120323505		05/12/03	23:51:20.94	46N43.53	119W29.88	1.71	-0.1	6/07	157	5	0.04	AC	12.0 km NE of 100-K Area
05120404095		05/12/04	04:10:16.06	46N43.52	119W30.04	4.83	0.5	10/10	99	5	0.12	AB	11.8 km NE of 100-K Area
05120404482		05/12/04	04:48:43.57	46N43.49	119W30.34	5.08	-0.2	7/09	92	5	0.09	AB	11.6 km NE of 100-K Area

Table 3.1. (contd)

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
05120404551		05/12/04	04:55:45.57	46N43.12	119W30.10	0.05	1.2	16/17	70	5	0.09	AB	11.2 km NE of 100-K Area
05120404591		05/12/04	04:59:35.13	46N43.31	119W30.29	5.05	0.4	11/14	70	5	0.13	AB	11.3 km NE of 100-K Area
05120405004		05/12/04	05:01:02.68	46N43.27	119W29.90	0.04	1.5	20/22	66	5	0.11	AB	11.6 km NE of 100-K Area
05120405013		05/12/04	05:01:33.08	46N43.59	119W30.07	0.46	-0.3	5/07	95	5	0.15	AD	11.9 km NE of 100-K Area
05120405232		05/12/04	05:23:50.22	46N43.20	119W30.20	3.00	0.0	8/10	87	5	0.12	AB	11.3 km NE of 100-K Area
05120405512		05/12/04	05:51:50.80	46N43.52	119W30.86	5.76	-0.8	7/07	91	5	0.15	AB	11.2 km NE of 100-K Area
05120407205		05/12/04	07:21:18.99	46N43.24	119W30.48	4.41	-0.4	7/08	87	5	0.12	AB	11.1 km NE of 100-K Area
05120409360		05/12/04	09:36:29.47	46N44.16	119W29.99	4.14	-0.7	6/10	178	5	0.14	AC	12.8 km NE of 100-K Area
05120417210		05/12/04	17:21:20.51	46N18.25	119W31.51	17.08	-0.3	9/13	233	6	0.06	AD	18.1 km W of Richland
05120521125	P	05/12/05	21:13:16.57	46N16.30	119W23.10	0.02		12/12	127	4	0.09	AB	7.3 km W of Richland
05120709163		05/12/07	09:16:53.97	46N43.04	119W29.63	1.93	-0.3	8/11	86	4	0.13	AA	11.5 km NE of 100-K Area
05120709552		05/12/07	09:55:52.26	46N42.94	119W29.57	2.48	-0.4	7/09	85	4	0.10	AB	11.4 km NE of 100-K Area
05120819204		05/12/08	19:21:09.88	46N43.46	119W30.12	4.04	-0.2	7/10	92	5	0.12	AB	11.7 km NE of 100-K Area
05120902400		05/12/09	02:40:24.19	46N43.62	119W30.73	2.36	-0.2	8/09	152	5	0.16	BC	11.5 km NE of 100-K Area
05120905403		05/12/09	5:40:55.58	46N43.44	119W30.46	0.04	-0.4	7/09	91	5	0.15	AB	11.4 km NE of 100-K Area
05120911150		05/12/09	11:15:29.95	46N43.33	119W30.18	4.60	0.3	9/12	95	5	0.11	AB	11.5 km NE of 100-K Area
05120923194		05/12/09	23:20:07.25	46N43.75	119W30.88	6.08	-0.6	5/09	95	4	0.14	AD	11.6 km NNE of 100-K Area
05121012090		05/12/10	12:09:30.87	46N43.33	119W29.81	4.00	-0.2	7/08	91	5	0.07	AB	11.8 km NE of 100-K Area
05121014510		05/12/10	14:51:34.57	46N43.01	119W29.76	0.03	0.6	14/15	68	4	0.13	AA	11.4 km NE of 100-K Area
05121015262		05/12/10	15:26:49.76	46N43.17	119W29.69	3.37	0.7	11/12	88	4	0.13	AA	11.6 km NE of 100-K Area
05121015290		05/12/10	15:29:25.29	46N43.67	119W30.69	6.46	-0.5	7/07	94	5	0.09	AB	11.6 km NE of 100-K Area
05121015594		05/12/10	16:00:07.09	46N43.25	119W30.64	4.45	-0.3	9/11	86	5	0.10	AB	11.0 km NE of 100-K Area
05121515190		05/12/15	15:19:28.90	46N42.93	119W29.77	3.24	0.1	10/13	84	5	0.07	AB	11.2 km NE of 100-K Area
05121705165		05/12/17	05:17:14.52	46N29.19	119W21.27	5.91	-0.5	6/09	174	8	0.05	AC	5.7 km N of 400 Area
05121708131		05/12/17	08:13:37.47	46N42.85	119W30.12	2.11	0.	10/13	93	5	0.12	AB	10.8 km NE of 100-K Area
05121802155		05/12/18	02:16:18.01	46N43.51	119W30.79	6.20	-0.8	6/07	95	5	0.12	AC	11.3 km NE of 100-K Area

Table 3.1. (contd)

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
05121803540		05/12/18	03:54:26.31	46N43.01	119W30.30	3.57	0.0	7/09	84	5	0.05	AB	10.9 km NE of 100-K Area
05121902281		05/12/19	02:28:41.12	46N34.49	119W41.39	7.74	-1.1	4/06	109	6	0.03	AD	4.4 km WNW of 200 West
05121903221		05/12/19	03:22:44.02	46N34.16	119W41.44	7.99	-0.8	3/06	152	5	0.02	AD	4.2 km WNW of 200 West
05122009324		05/12/20	09:33:05.53	46N43.11	119W30.09	3.03	-0.2	8/12	86	5	0.11	AB	11.2 km NE of 100-K Area
05122312412		05/12/23	12:41:52.87	46N26.47	119W35.57	16.48	-0.3	9/11	117	5	0.06	AB	13.5 km SSE of 200 West
05122800143		05/12/28	00:15:01.17	46N29.12	119W21.16	0.14	-0.4	5/07	144	7	0.16	BD	5.6 km N of 400 Area
05122807352		05/12/28	07:35:43.28	46N43.50	119W30.45	3.42	-0.4	6/10	151	5	0.17	BC	11.5 km NE of 100-K Area
05122810593		05/12/28	10:59:57.45	46N43.36	119W30.02	4.06	0.6	9/13	70	5	0.07	AB	11.6 km NE of 100-K Area
05122910293		05/12/29	10:30:00.92	46N28.78	119W22.29	4.21	1.0	11/15	104	8	0.11	AB	5.1 km NNW of 400 Area
05123012341		05/12/30	12:34:40.46	46N43.19	119W30.07	3.14	-0.3	6/07	90	5	0.11	AC	11.3 km NE of 100-K Area
06010101454		06/01/01	01:46:13.58	46N28.87	119W21.58	5.02	0.7	11/15	111	8	0.12	AB	5.1 km N of 400 Area
06010101455		06/01/01	01:46:55.33	46N28.79	119W21.55	5.58	0.6	6/10	165	7	0.07	AC	5.0 km N of 400 Area
06010609525		06/01/06	09:53:15.21	46N43.50	119W31.05	1.90	-0.4	8/10	89	4	0.06	AA	11.1 km NNE of 100-K Area
06010808155		06/01/08	08:16:07.65	46N06.28	119W28.58	11.46	0.3	10/16	284	20	0.15	BD	24.5 km SW of Richland
06010810222		06/01/08	10:22:48.80	46N06.58	119W29.07	8.58	0.7	11/13	283	19	0.07	AD	24.4 km SW of Richland
06010814561		06/01/08	14:56:34.13	46N06.43	119W28.76	9.08	0.3	8/11	297	19	0.10	AD	24.4 km SW of Richland
06011203481		06/01/12	03:48:34.87	46N35.09	119W27.03	16.31	-0.6	5/07	167	1	0.05	AD	7.0 km ENE of 200 East
06012020382	P	06/01/20	20:38:41.59	46N56.63	119W31.64	2.15		7/07	223	2	0.05	AD	27.5 km SW of Moses Lake
06012511072		06/01/25	11:07:47.05	46N29.11	119W22.21	4.05	1.0	11/15	107	8	0.08	AB	5.7 km N of 400 Area
06012820442		06/01/28	20:44:51.46	46N08.22	119W17.52	3.37	0.6	13/13	174	21	0.16	BC	15.0 km WSW of Kennewick
06013121213		06/01/31	21:21:50.16	46N59.75	119W35.40	0.03	0.7	5/07	287	8	0.26	BD	27.5 km WSW of Moses Lake
06020316483		06/02/03	16:48:49.48	46N50.48	119W26.04	2.09	-0.4	11/13	78	4	0.10	AA	20.5 km W of Othello
06020616562		06/02/06	16:56:46.68	46N58.46	119W28.75	4.24	1.1	8/09	199	2	0.06	AD	22.6 km SW of Moses Lake
06020621091	P	06/02/06	21:09:36.76	46N10.48	119W15.50	0.74		8/08	192	19	0.18	BD	10.9 km WSW of Kennewick
06020719421	X	06/02/07	19:42:32.27	46N07.62	119W05.43	0.03		6/06	174	13	0.15	BC	8.9 km SSE of Kennewick
06020721250	X	06/02/07	21:25:30.66	46N11.36	119W28.01	0.05		11/11	213	12	0.08	AD	17.1 km SW of Richland

Table 3.1. (contd)

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
06021314302		06/02/13	14:30:48.17	46N46.88	119W41.30	3.35	1.6	20/23	85	9	0.12	AB	17.0 km NNW of 100-K Area
06021609435		06/02/16	09:44:16.39	46N46.62	119W41.48	0.03	1.2	16/17	112	9	0.13	AB	16.7 km NNW of 100-K Area
06022007484		06/02/20	07:49:13.88	46N43.22	119W29.71	2.92	1.0	13/15	66	4	0.06	AA	11.7 km NE of 100-K Area
06022119521	P	06/02/21	19:52:32.88	46N05.25	119W29.75	0.02		12/12	125	20	0.14	AC	24.9 km ESE of Prosser
06022221244		06/02/22	21:24:50.87	46N07.30	119W18.47	8.51	0.0	4/06	305	21	0.17	BD	16.9 km WSW of Kennewick
06022501185		06/02/25	01:19:13.15	46N08.11	119W03.27	13.07	0.5	7/07	110	11	0.09	AB	9.3 km SE of Kennewick
06022501585		06/02/25	01:59:10.19	46N07.98	119W03.46	12.68	0.8	9/10	144	11	0.09	AC	9.3 km SSE of Kennewick
06022613453		06/02/26	13:46:02.01	46N28.87	119W21.16	7.58	0.1	8/11	142	7	0.11	AC	5.2 km N of 400 Area
06030201383		06/03/02	01:38:59.22	46N13.04	119W29.67	5.88	0.4	6/09	233	9	0.24	BD	17.3 km WSW of Richland
06030404363		06/03/04	04:36:59.53	46N29.71	119W22.72	2.94	0.7	7/11	106	7	0.13	BB	6.9 km NNW of 400 Area
06031021474	P	06/03/10	21:48:00.50	46N09.55	119W02.28	0.03		5/05	187	13	0.02	AD	8.2 km SE of Kennewick
06031316055		06/03/13	16:06:14.16	46N34.40	119W47.27	0.03	0.0	4/06	206	4	0.11	AD	11.6 km W of 200 West
06031321345	P	06/03/13	21:35:11.17	46N08.45	119W04.62	0.66		5/05	164	13	0.05	BD	7.8 km SSE of Kennewick
06031322161		06/03/13	22:16:40.83	46N43.16	119W29.64	3.98	0.1	8/10	88	4	0.07	AA	11.7 km NE of 100-K Area
06031407323		06/03/14	07:33:00.63	46N29.06	119W22.18	0.48	0.3	6/08	128	8	0.13	AC	5.6 km N of 400 Area
06031408123		06/03/14	08:12:55.17	46N28.60	119W21.58	10.60	-0.4	4/05	133	7	0.12	BD	4.6 km N of 400 Area
06031419574	P	06/03/14	19:57:58.77	46N07.29	119W06.00	1.12		5/05	181	13	0.10	CD	9.3 km S of Kennewick
06032304540		06/03/23	04:54:30.90	46N27.22	119W34.92	14.91	-0.5	7/10	129	6	0.06	AB	12.4 km SSW of 200 East
06032319134		06/03/23	19:14:06.27	46N43.22	119W26.95	0.05	0.0	5/05	88	1	0.07	AD	14.3 km NE of 100-K Area
06032701523		06/03/27	01:53:03.07	46N29.07	119W21.88	0.85	-0.7	6/06	132	8	0.05	AC	5.5 km N of 400 Area
06032714445		06/03/27	14:45:16.33	46N42.51	119W58.58	10.55	0.7	12/12	117	13	0.16	BB	27.8 km S of Vantage
06032822010	P	06/03/28	22:01:05.80	46N07.72	119W04.76	0.03		5/05	172	12	0.48	CD	9.0 km SSE of Kennewick
06033020012	P	06/03/30	20:01:30.86	46N08.36	119W04.01	0.02		4/04	168	12	0.12	AD	8.3 km SSE of Kennewick
06040200033		06/04/02	00:03:57.13	46N29.07	119W21.85	8.40	-0.3	4/07	133	8	0.06	AD	5.5 km N of 400 Area
06041101493		06/04/11	01:49:51.34	46N46.68	119W23.81	13.82	-0.7	9/13	92	5	0.10	AB	18.4 km WSW of Othello
06041412272		06/04/14	12:27:48.23	46N47.25	119W41.14	1.67	0.5	8/08	201	9	0.03	AD	17.5 km NNW of 100-K Area

Table 3.1. (contd)

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
06041605131		06/04/16	05:13:41.82	46N44.61	119W20.40	0.40	0.0	5/05	156	7	0.01	AD	16.2 km SW of Othello
06041612531		06/04/16	12:53:26.52	46N48.56	119W53.01	21.15	0.4	9/10	125	0	0.09	AB	18.2 km SSE of Vantage
06041719053		06/04/17	19:05:59.02	46N29.06	119W21.66	0.40	1.5	15/15	64	8	0.05	AB	5.5 km N of 400 Area
06041807223		06/04/18	07:23:00.35	46N44.72	119W20.51	0.77	1.0	20/20	90	7	0.09	AB	16.2 km SW of Othello
06041821451	P	06/04/18	21:45:29.88	46N07.80	119W04.67	0.03		7/07	171	12	0.19	BC	8.9 km SSE of Kennewick
06042212384		06/04/22	12:39:10.71	46N29.21	119W22.71	0.54	0.9	14/16	59	7	0.08	AB	6.0 km NNW of 400 Area
06042409183		06/04/24	09:18:57.40	46N44.85	119W20.86	5.31	0.3	7/10	154	7	0.09	AC	16.4 km WSW of Othello
06042522243	P	06/04/25	22:24:51.46	46N08.30	119W03.83	0.03		10/10	138	12	0.13	AC	8.6 km SSE of Kennewick
06042907031		06/04/29	07:03:28.93	46N47.27	119W08.48	0.45	-0.5	5/05	285	14	0.22	BD	4.7 km SSE of Othello
06042911041		06/04/29	11:04:34.34	46N46.40	119W18.41	10.81	-0.3	6/08	190	8	0.13	AD	12.2 km WSW of Othello
06050215280		06/05/02	15:28:30.16	46N44.72	119W20.80	6.29	-0.1	7/09	153	7	0.08	AC	16.5 km WSW of Othello
06050219100	P	06/05/02	19:10:06.65	46N11.27	119W05.32	0.49		7/07	179	18	0.16	BC	3.2 km ESE of Kennewick
06050818101	P	06/05/08	18:10:32.49	46N08.97	119W27.90	0.34		4/04	125	18	0.40	CD	20.0 km SW of Richland
06051019113	P	06/05/10	19:11:30.89	46N06.79	119W06.50	1.63		10/10	186	13	0.21	CD	10.1 km S of Kennewick
06051511282		06/05/15	11:28:50.25	46N28.04	119W38.31	5.28	-1.0	5/08	162	1	0.09	BD	10.1 km S of 200 West
06051820012	P	06/05/18	20:01:38.62	46N09.04	119W03.76	0.05		5/05	174	13	0.09	AD	7.5 km SE of Kennewick
06052202324		06/05/22	02:33:03.35	46N49.64	119W46.24	0.55	1.0	15/15	104	8	0.09	AB	21.8 km SE of Vantage
06052601575		06/05/26	01:58:21.63	46N29.22	119W21.58	7.66	0.3	8/10	138	7	0.09	AC	5.8 km N of 400 Area
06053020575	P	06/05/30	20:58:17.15	46N18.66	119W40.48	3.37		12/12	164	10	0.07	AC	13.6 km NNE of Prosser
06060120012	P	06/06/01	20:01:43.51	46N05.53	119W06.98	3.26		8/08	174	12	0.31	CC	12.4 km S of Kennewick
06060318161		06/06/03	18:16:41.43	46N29.60	119W22.82	2.81	0.4	14/15	104	7	0.07	AB	6.7 km NNW of 400 Area
06060410113		06/06/04	10:11:58.71	46N29.09	119W23.07	0.49	0.3	11/11	116	8	0.08	AB	5.9 km NNW of 400 Area
06060521071	P	06/06/05	21:07:28.13	46N06.51	119W07.42	0.05		4/05	206	14	0.24	BD	10.5 km S of Kennewick
06060814232		06/06/08	14:23:48.12	46N29.32	119W22.39	0.03	0.1	5/06	127	7	0.12	AD	6.1 km N of 400 Area
06061408072		06/06/14	08:07:53.91	46N29.60	119W22.57	4.04	0.9	11/13	106	7	0.06	AB	6.6 km NNW of 400 Area
06061817572		06/06/18	17:57:47.18	46N21.81	119W34.69	19.80	0.7	20/25	122	3	0.10	AB	18.7 km WSW of 400 Area

Table 3.1. (contd)

Event ID	Type	Date	Time	Latitude	Longitude	Depth	Mag	NS/NP	Gap	Dmin	RMS	Q	Location
06063018280	P	06/06/30	18:28:17.64	46N05.96	119W08.61	0.02		5/05	214	15	0.48	CD	11.7 km S of Kennewick
06070718200	P	06/07/07	18:20:13.86	46N07.44	119W05.50	0.02		7/07	178	13	0.13	AC	9.2 km SSE of Kennewick
06070806261		06/07/08	06:26:37.55	46N49.33	119W36.76	18.29	1.8	31/31	41	8	0.15	BA	20.1 km N of 100-K Area
06072304561		06/07/23	04:56:37.53	46N39.02	119W23.70	16.14	0.1	10/11	156	7	0.06	AC	14.7 km NE of 200 East
06080508190		06/08/05	08:19:27.59	46N46.29	119W32.95	13.23	0.0	14/18	148	2	0.06	AC	14.9 km NNE of 100-K Area
06081219455		06/08/12	19:46:22.68	46N42.88	119W30.19	2.59	0.6	11/15	73	5	0.05	AB	10.8 km NE of 100-K Area
06082418191		06/08/24	18:19:42.62	46N43.06	119W30.28	3.04	0.3	9/10	85	5	0.10	AB	11.0 km NE of 100-K Area
06082513042		06/08/25	13:04:42.14	46N35.97	119W51.49	7.69	-0.1	8/10	136	7	0.04	AC	17.5 km WNW of 200 West
06082722225		06/08/27	22:23:15.61	46N29.56	119W22.04	7.70	0.3	6/08	196	7	0.12	AD	6.5 km N of 400 Area
06082921075	P	06/08/29	21:08:21.27	46N13.11	119W27.07	0.56		4/04	261	8	0.01	AD	14.3 km WSW of Richland
06090212512		06/09/02	12:51:53.74	46N13.09	119W32.47	17.22	0.8	19/21	122	11	0.09	AB	17.6 km E of Prosser
06090623163		06/09/06	23:17:00.03	46N55.12	119W36.44	18.44	0.7	23/27	83	9	0.15	AA	29.0 km E of Vantage
06092100144		06/09/21	00:15:06.20	46N10.04	119W39.50	8.43	0.8	14/16	143	5	0.06	AC	9.6 km ESE of Prosser
06092222054	P	06/09/22	22:06:10.87	46N09.06	119W11.21	0.97		12/12	186	20	0.14	AD	7.6 km SW of Kennewick
06092320060		06/09/23	20:06:28.70	46N44.88	119W22.55	0.02	0.8	16/17	83	5	0.06	AB	18.2 km WSW of Othello

Explanation of Table 3.1

Event ID:	The Earthworm Recording System creates the identification number. XPED uses the year, month, day, and time to create a unique number for each event.
Type:	P is Probable Blast; X is Confirmed Blast; F is Felt Earthquake; blank is local earthquake.
Date:	The year and day of the year in Universal Time Coordinated (UTC). UTC is used throughout this report unless otherwise indicated.
Time:	The origin time of the earthquake given in UTC. To covert UTC to Pacific Standard Time, subtract eight hours; to Pacific Daylight Time, subtract seven hours.
Latitude:	North latitude, in degrees and minutes, of the earthquake epicenter.
Longitude:	West longitude, in degrees and minutes, of the earthquake epicenter.
Depth:	The depth of the earthquake in kilometers (km).
Mag:	The magnitude is expressed as Coda-Length magnitude M_c, an estimate of local magnitude M_L (Richter 1958). If magnitude is blank, a determination was not made.
NS/NP:	Number of stations/number of phases used in the solutions.
Gap:	Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.
DMIN:	The distance from the earthquake epicenter to the closest station
RMS:	The root-mean-square residual (observed arrival times minus the predicted arrival times) at all stations used to locate the earthquake. It is only useful as a measure of quality of the solution when five or more well-distributed stations are used in the solution. Good solutions are normally characterized by RMS values of less than about 0.3 seconds.
Q:	The Quality Factors indicate the general reliability of the solution/location (A is best quality, D is worst). See Section 3.3 of this report, “Quality Factors.”

Table 3.2. Seismic Velocities for Columbia Basin Stratigraphy (from Rohay et al. 1985)

Depth to Top of Velocity Layer (km)	Stratigraphy	Velocity (km/sec)
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	Crystalline Basement, Layer 1	6.1
13.0	Crystalline Basement, Layer 2	6.4
23.0	Sub-basement	7.1
38.0	Mantle	7.9

4.0 Geology and Tectonic Analysis

The Hanford Site lies within the Columbia Basin, which is an intermontane basin between the Cascade Range and the Rocky Mountains that is 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 and Hooper 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 and Quaternary fluvial and glaciofluvial deposits (Campbell 1989; Reidel et al. 1989, 1994; DOE 1988). In the eastern part, a thin (<100 m) sedimentary unit separates the basalt and underling 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 subprovinces: 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 along the northern flanks (Figure 4.1) (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 wavelength folds on an otherwise gently westward dipping paleoslope. Figure 4.2 shows north-south (B-B’) and east-west (A-A’) cross sections through the Columbia Basin based on surface mapping (Reidel and Fecht 1994a, 1994b), deep boreholes (Reidel et al. 1994), geophysical data (Rohay et al. 1985; DOE 1988), and magnetotelluric data obtained as part of BWIP (DOE 1988).

4.1 Earthquake Stratigraphy

Studies of seismicity at the Hanford Site have shown that the seismic activity is related to crustal stratigraphy (layers 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:

- The Miocene Columbia River Basalt Group (CRBG)
- Pre-basalt sediments of Paleocene, Eocene, Oligocene, and Early Miocene age
- The crystalline basement consisting of two layers composed of Precambrian and Paleozoic craton
- Mesozoic accreted terranes.

4.2 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 pre-basalt sediments and nature of the crystalline basement are still poorly understood. The difference between the thicknesses listed in Table 4.1 and the thicknesses of the crustal layers in the velocity model in Table 3.1 reflect data specific to UW’s crustal velocity model for eastern Washington. Table 4.1 is derived from Reidel et al. (1994) and was developed for the geologic interpretation in this report. The thicknesses of these units are variable across the monitored area. Table 4.1 summarizes the approximate thickness at the borders of the monitored area.

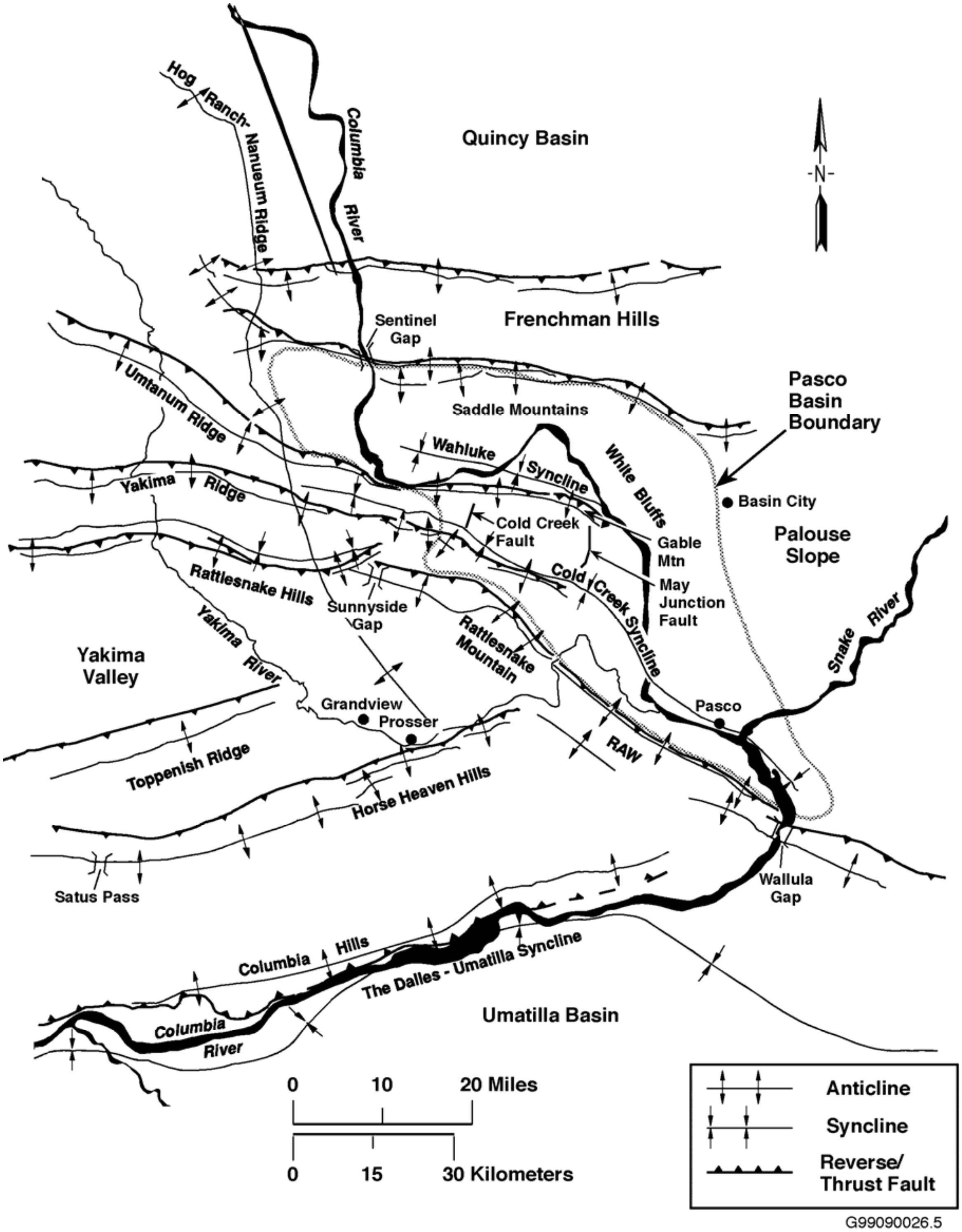

Figure 4.1. Tectonic Map of Columbia Basin Showing Major Seismic Source Structures

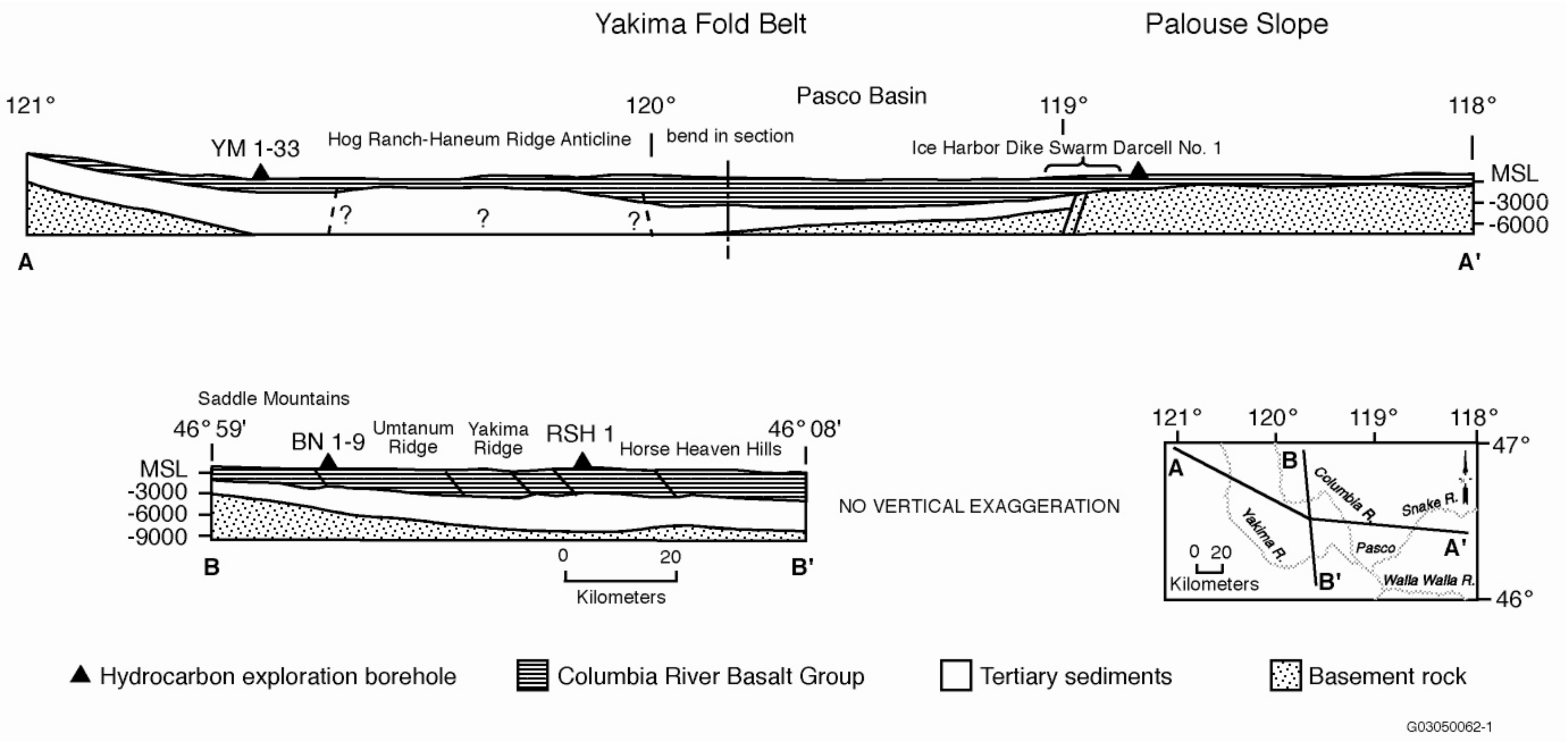

Figure 4.2. Geologic Cross Sections Through the Columbia Basin (Reidel et al. 1994)

Table 4.1. 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 pre-basalt sediments varies as a result 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 crystalline basement; the crystalline basement is continental crustal rock that underlies much of the western North America. The stratigraphy west of the craton consists of 4 to 5 km of CRBG overlying at least 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).

4.3 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) than the main reverse/thrust faults that occur along the major anticlinal ridges (up to 100 km). Secondary faults can be segment boundaries (tear faults) and small faults of any orientation that formed along with the main structure.

- **Swarm Areas**. Small geographic areas not known to contain any geologic structures produce clusters of events (swarms), usually in the CRBG in synclinal valleys. 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 at a later date. 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. There are seven earthquake swarm areas that are recognized in the Hanford Seismic Network area but this list will be updated as new swarm areas develop. The Saddle Mountains swarm area, Wooded Island swarm area, Wahluke swarm area, Coyote Rapids swarm area, and Horse Heaven Hills swarm area are typically active at one time or another during the year. The other earthquake swarm areas are active less frequently.

- **The 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 crystalline basement. Because little is known about geologic structures in the crystalline basement beneath the Hanford Site, earthquakes cannot be directly tied to a mapped fault. Earthquakes occurring in the crystalline basement without known sources are treated as random events.

- **The 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 (see Section 5.0).

4.4 Depth of Earthquakes

Since records have been kept, most of the earthquakes at the Hanford Site have originated in the CRBG layer. The crystalline basement has had the next greatest amount of earthquakes followed by the pre-basalt sediments. The stratigraphic units for local earthquakes recorded during FY 2006 are listed in Table 4.2.

Table 4.2. Number of Local Earthquakes Occurring in Stratigraphic Units

Unit	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	FY 2006
Basalt	44	14	11	3	72 (61%)
Pre-Basalt Sediments	7	8	5	3	23 (20%)
Crystalline Basement	6	7	4	5	22 (19%)
Total	57	29	20	11	117

4.5 Tectonic Activity

4.5.1 Annual Summary

During FY 2006, there were 117 earthquakes that occurred within the Hanford Seismic Monitoring Network (Tables 3.1, 4.2, and 4.3; Figure 4.3). Seventy-two (61%) events occurred in the CRBG; twenty-three (20%) occurred in the pre-basalt sediments; and twenty-two (19%) events occurred in the crystalline basement. No events are interpreted as occurring along major geologic structures; seventy-eight (67%) events are interpreted as occurring in earthquake swarms; and thirty-nine (33%) events are interpreted as random events.

Table 4.3. Summary of Earthquake Locations for FY 2006

Seismic Sources		First Quarter 10/01- 12/31	Second Quarter 1/01 - 3/31	Third Quarter 4/01 - 6/30	Fourth Quarter 7/01 - 9/30	FY 2006
Geologic Structure		-	-	-	-	-
Swarm Areas	Frenchman Hills	-	2	-	-	2
	Saddle Mountains/ Royal Slope	-	1	1	-	2
	Wahluke Slope	-	-	7	1	8
	Coyote Rapids	38	4	-	2	44
	Wye	5	8	8	-	21
	Wooded Island	-	-	-	-	-
	Cold Creek	-	-	-	-	-
	Rattlesnake Mt.	-	-	-	-	-
	Horse Heaven Hills	-	-	-	1	1
	Total for swarm areas	43	15	16	4	78 (67%)
Random Events		14	14	4	7	39 (33%)
Total for all earthquakes		57	29	20	11	117

4.5.2 First Quarter Earthquakes of FY 2006

Fifty-seven earthquakes occurred in the Hanford Area during the first quarter of FY 2006 (October 1, 2005 through December 31, 2005 [Figure 4.4; Table 4.3]).

4.5.2.1 Location and Depth of Earthquakes

During the first quarter of FY 2006, forty-three events occurred in swarm areas, no events were classified as having some association with major geologic structures, and fourteen events were classified as random.

4.5.2.1.1 Major Anticlinal Ridges

During the first quarter of FY 2006, we interpret no seismic events to have occurred on major geologic structures.

4.5.2.1.2 Earthquake Swarm Areas

Forty-three earthquakes were located in swarm events (Figure 4.4).

Coyote Rapids Swarm Area

Thirty-eight earthquakes occurred in the first quarter of FY 2006 as an earthquake swarm located at the northeastern end of the Coyote Rapids swarm area. This swarm began on October 15, 2005 and continued into later quarters. The earthquakes were concentrated at the ‘horn’ of the Columbia River (inset Figure 4.3). Most of the earthquakes occurred in December; fifteen of these events occurred in an

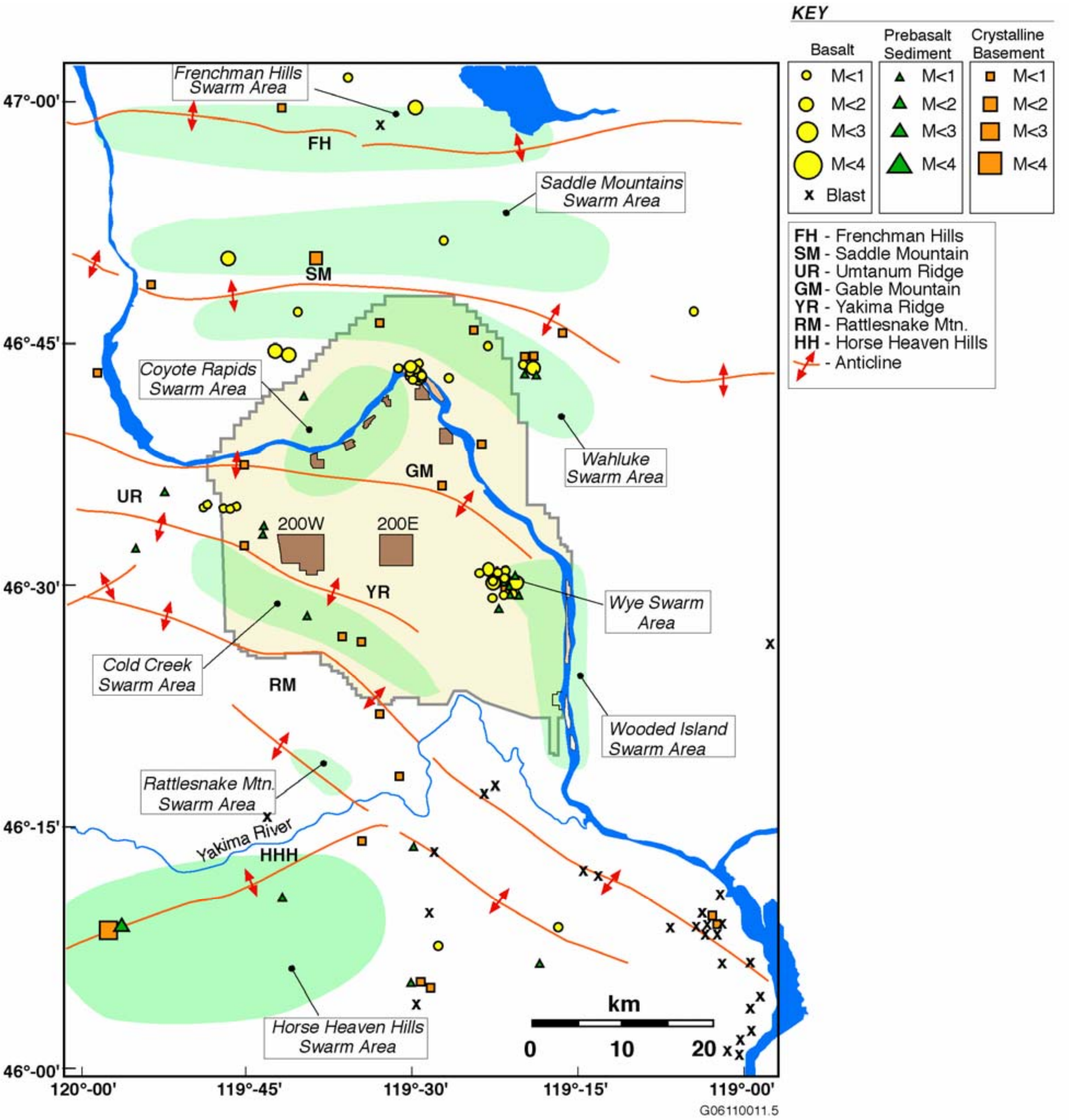

Figure 4.3. All Earthquakes Recorded Within the Hanford Monitoring Area during FY 2006 (October 1, 2005-September 30, 2006)

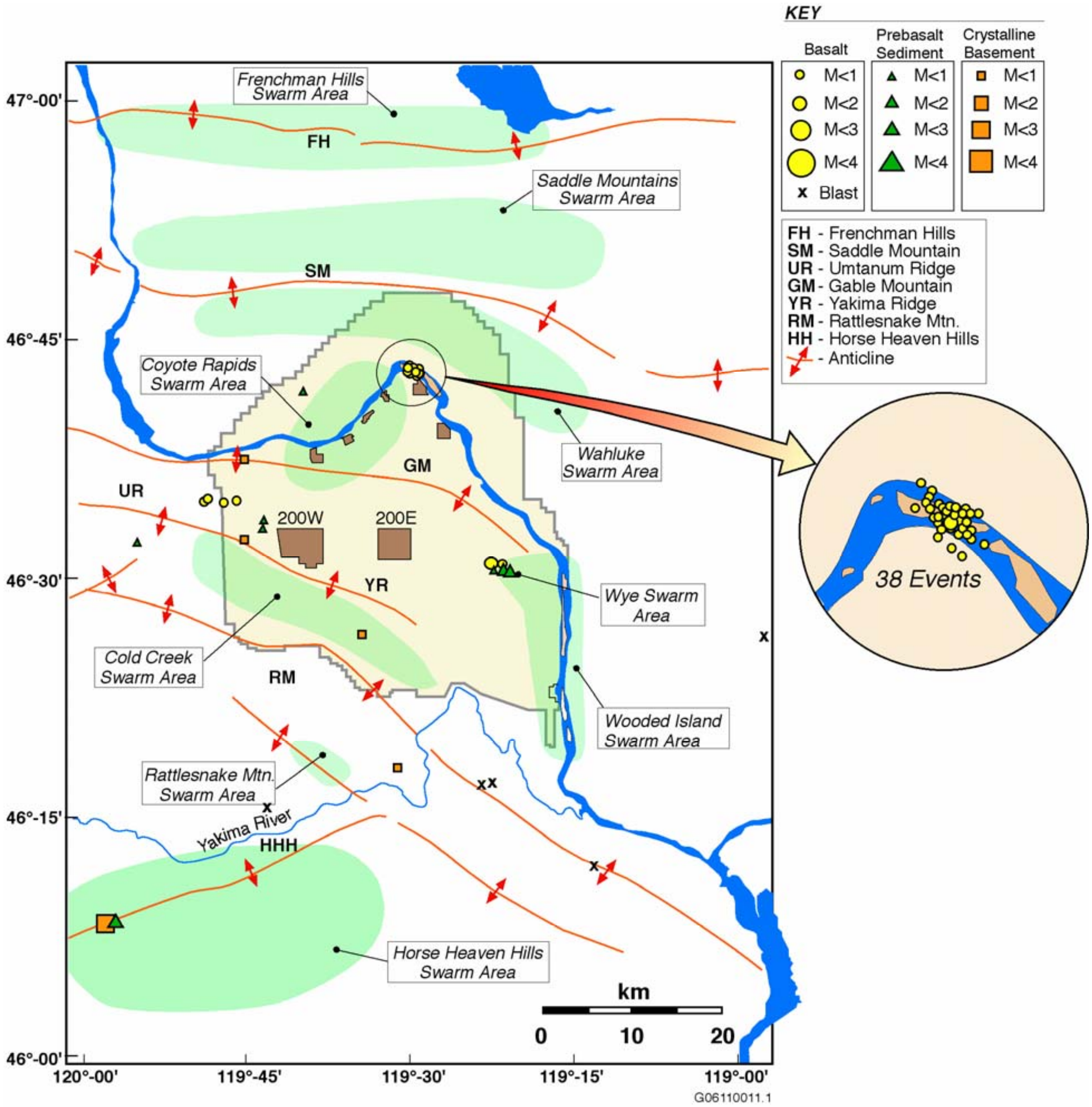

Figure 4.4. Location of all Earthquakes Located in the Hanford Monitoring Area Between October 1, 2005 and December 31, 2005

intense period of swarm activity December 3-4. Two of these swarm earthquakes were larger than 1.0 M_c and occurred on December 4 (M_c 1.2 and 1.5). The depth of the earthquake locations, especially for the better located, larger events, indicates that this swarm occurred within the basalt, and although a few of these locations are deeper than 5 km, these events are classified as occurring in the basalt.

Wye Swarm Area

Five earthquakes occurred in the Wye Barricade swarm area during the first quarter of FY 2006. The first two occurred on October 2 and October 6 and both had magnitudes of 1.2 M_c. A third, smaller event (approximately M_c 0) occurred December 17. These three events occurred in the pre-basalt sediments. The last two earthquakes occurred on December 28 and 29 in the basalt. The first basalt event was small (approximately M_c 0) and occurred in the basalt, and the second had a magnitude of 1.0 M_c.

4.5.2.2 Random or Floating Events

During the first quarter of FY 2006, we interpret fourteen random events to have occurred in the monitoring area. Events that occurred in the pre-basalt sediments and in the crystalline basement are typically classified as random events. This is because there are no known geologic structures that have been identified in the rocks that occur below the Columbia River Basalt Group. However, we now recognize that some events that occur at depths that places them in the pre-basalt sediments and crystalline basement occur in temporal patterns that fit our definition of earthquake swarms (Section 4.3).

The two largest random events occurred at 12:45 and 13:05 UTC on November 10 beneath the Horse Heaven Hills southwest of Prosser, Washington. Both were deep events (>8 km) in crystalline basement. The first event had a magnitude of 2.6 M_c, the largest of all earthquakes observed this quarter and the largest for the entire FY 2006 period. The second had a magnitude of 1.2 $M_{c,}$.

All the remaining random events were small (approximately M_c 0). Four events in basalt occurred on October 11 and 16 between Umtanum Ridge and Yakima Ridge. Four events were located in the sub-basalt sediments, one on October 11 near the western edge of the study area, one on October 29 on Wahluke Slope near the Coyote Rapids swarm area, and a pair of events just northwest of 200W on December 12. Four additional random events occurred in the crystalline basement, including one beneath Umtanum Ridge and another beneath Yakima Ridge (both on October 12), and two deep events south and north of Rattlesnake Mountain (December 4 and December 23, respectively).

4.5.3 Second-Quarter Earthquakes of FY 2006

Twenty-nine earthquakes occurred during the second quarter of FY 2006 (January 1, 2006 through March 31, 2006 [Figure 4.5; Table 4.3]).

4.5.3.1 Location and Depth of Earthquakes

During the second quarter of FY 2006, fifteen events occurred in swarm areas, no events were classified as being associated with major geologic structures, and fourteen events were classified as random.

4.5.3.1.1 Major Anticlinal Ridges

During the second quarter of FY 2006, we did not classify any seismic events to have occurred on a major geologic structure in the monitoring area. However, there were five events that were candidates for such a classification that were ultimately classified as random (see Section 4.5.3.1.3 below).

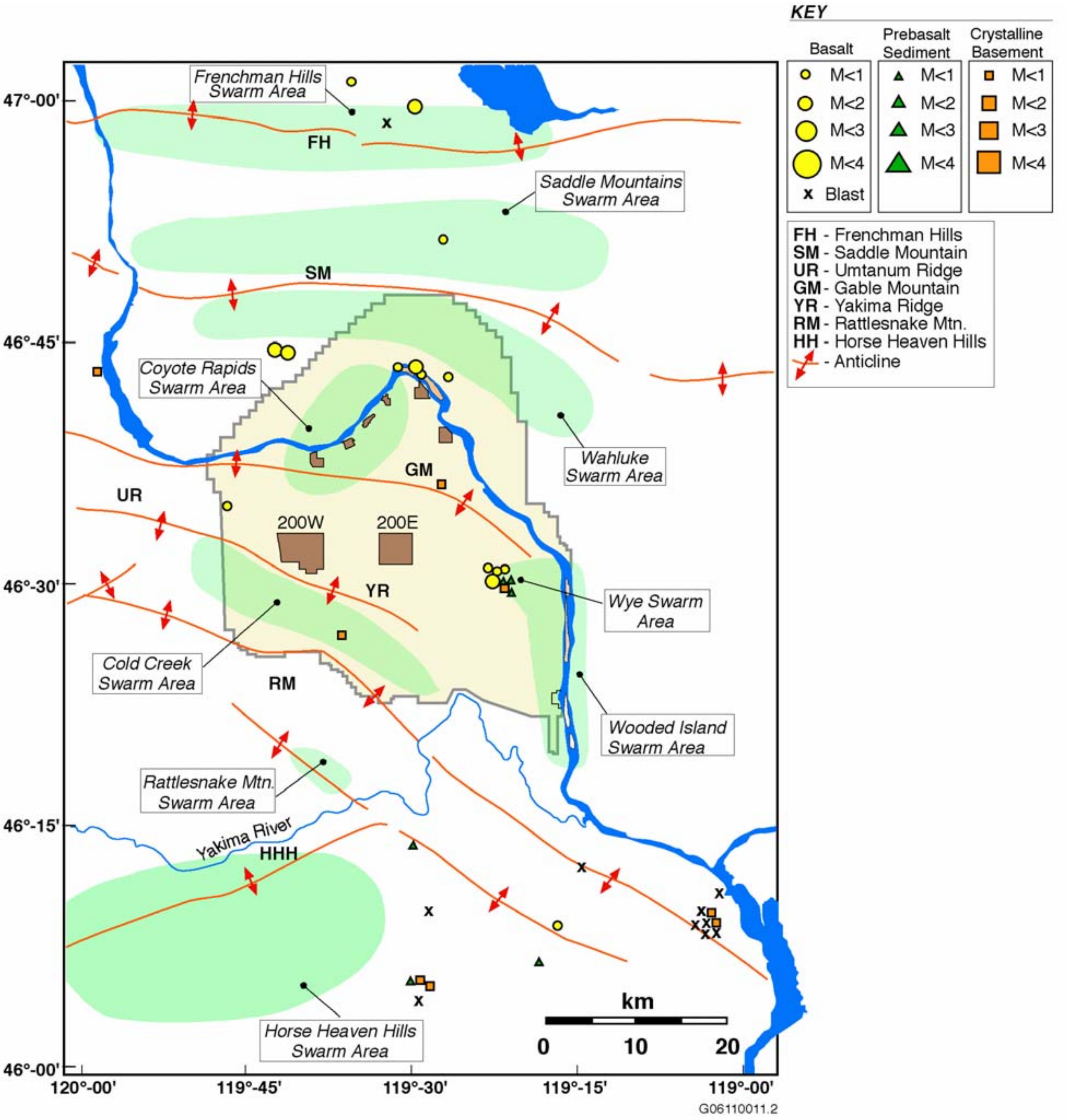

Figure 4.5. All Earthquakes Located Within the Hanford Monitoring Area Between January 1, 2006 and March 30, 2006

4.5.3.1.2 Earthquake Swarm Areas

During the second quarter of FY 2006, we interpret fifteen seismic events to have occurred in swarm areas (Figure 4.5).

Frenchman Hills Swarm Area

Two events were recorded in the Frenchman Hills swarm area during the second quarter. On January 31, a small (approximately 0.7 M_c) earthquake occurred near the north flank of the Frenchman Hills. A second event with a magnitude of 1.1 M_c occurred northeast of the first event on February 6. Both events were in the basalt.

Saddle Mountains Swarm Area

Only one earthquake was recorded in the Saddle Mountains swarm area in the second quarter. An event of approximately 0 M_c occurred in the eastern part of the Saddle Mountains swarm area. This earthquake was in the basalt and was recorded on February 3.

Coyote Rapids Swarm Area

Four more events occurred in the 'horn' region of the Coyote Rapids swarm area, continuing the swarm activity observed in the first quarter (Figure 4.4). The largest, measuring 1.0 M_c, was recorded on February 20. Three smaller events (approximately M_c 0) occurred on January 6, March 13, and March 23.

Wye Swarm Area

Eight small earthquakes occurred in the Wye swarm area, which was the most active swarm in the second quarter, continuing the swarm activity that was located here in the first quarter. Four events were located in the shallow basalt, three events were located in the pre-basalt sediment layer, and one event was located in the crystalline basement. In this case we consider the earthquakes in the pre-basalt sediment and crystalline basement to be related swarm events. Two earthquakes occurred on January 1 having magnitudes of 0.7 and 0.6 M_c, and a third event occurred on January 25 with magnitude 1.0 $M_{c,}$ (the largest event in this swarm area this quarter). A smaller event with $M_{c,}$ 0.7 occurred March 4. The remaining four events on February 26, March 14 (two events), and March 27 all had magnitudes of approximately M_c 0.

4.5.3.1.3 Random or Floating Events

Fourteen earthquakes were classified as random events in the second quarter. Two events were located in the basalt at the southern boundary of the Wahluke swarm area on February 13 and February 16. These events had magnitudes of M_c 1.6 and M_c 1.2, respectively, and were the two largest magnitude events to occur this quarter.

All the rest of the random earthquakes had magnitudes less than M_c 1. Three deep events occurred on January 8, south of Horse Heaven Hills, near the top of the crystalline basement. Two events on February 25 in crystalline basement near Wallula Gap (these events are distinct from co-located explosions by their signal character and time of occurrence). These events could be associated with the Rattlesnake-Wallula structure, but are too deep to make such an association.

Two events occurred near the southeast striking portion of the Horse Heaven Hills (one in basalt, one near the base of the pre-basalt sediments, on January 28 and February 22, respectively). The shallow event occurred near the base of the basalt, and could be classified as associated with the Horse Heaven

Hills structure, but it appears to be north of the projected fault. The deeper event was not classified as associated with that structure because of the greater depth. A third event occurred March 2 near the northern tip of Horse Heaven Hills in pre-basalt sediments, and could similarly be associated with that structure, but is not classified as such due to the depth of the hypocenter.

Three additional events occurred in crystalline basement, one near Gable Mountain on January 12, one in the Cold Creek Valley on March 23, and one west of Priest Rapids Lake on March 27. Another random event occurred in the basalt on March 13 south of Vernita on March 13.

4.5.4 Third Quarter Earthquakes of FY 2006

Twenty earthquakes occurred in the Hanford Area during the third quarter of FY 2006, which was April 1, 2006 through June 30, 2006 (Figure 4.6; Table 4.3).

4.5.4.1 Location and Depth of Earthquakes

During the third quarter of FY 2006, sixteen events occurred in swarm areas and four events were classified as random. No earthquakes occurred on major structures this quarter.

4.5.4.2 Major Anticlinal Ridges

We interpret no earthquakes to have occurred on major structures during the third quarter of FY 2006.

4.5.4.2.1 Earthquake Swarm Areas

Sixteen earthquakes occurred in swarm areas during the third quarter of FY 2006.

Saddle Mountain Swarm Area

One event was located in the western part of the Saddle Mountains swarm area on May 22 in the basalt, and had a magnitude of M_c 1.0 (Figure 4.6).

Wahluke Swarm Area

Seven additional earthquakes occurred in the third quarter in the Wahluke swarm area (Figure 4.6). Six of these occurred in a tight cluster in the eastern part of the swarm area. The largest was a magnitude M_c 1.0 in the basalt on April 18. The other five events were all near magnitude M_c 0, and ranged in depth from the surface to over 10 km, with one more in the basalt, and two each in the pre-basalt sediments and in the crystalline basement. These deeper depths may be in error due to the small size of the signals from these events and resultant difficulty in accurate picking of arrival times. A single additional earthquake, separate from the swarm described above, occurred northwest of that swarm on April 14 in the basalt and had a magnitude M_c 1.0.

Wye Swarm Area

Eight earthquakes were located in the Wye swarm area (Figure 4.6), continuing the activity there from the first and second quarters. The largest event had a magnitude of M_c 1.5 occurring on April 17; this was the largest earthquake recording in the monitoring region this quarter. Two additional events on

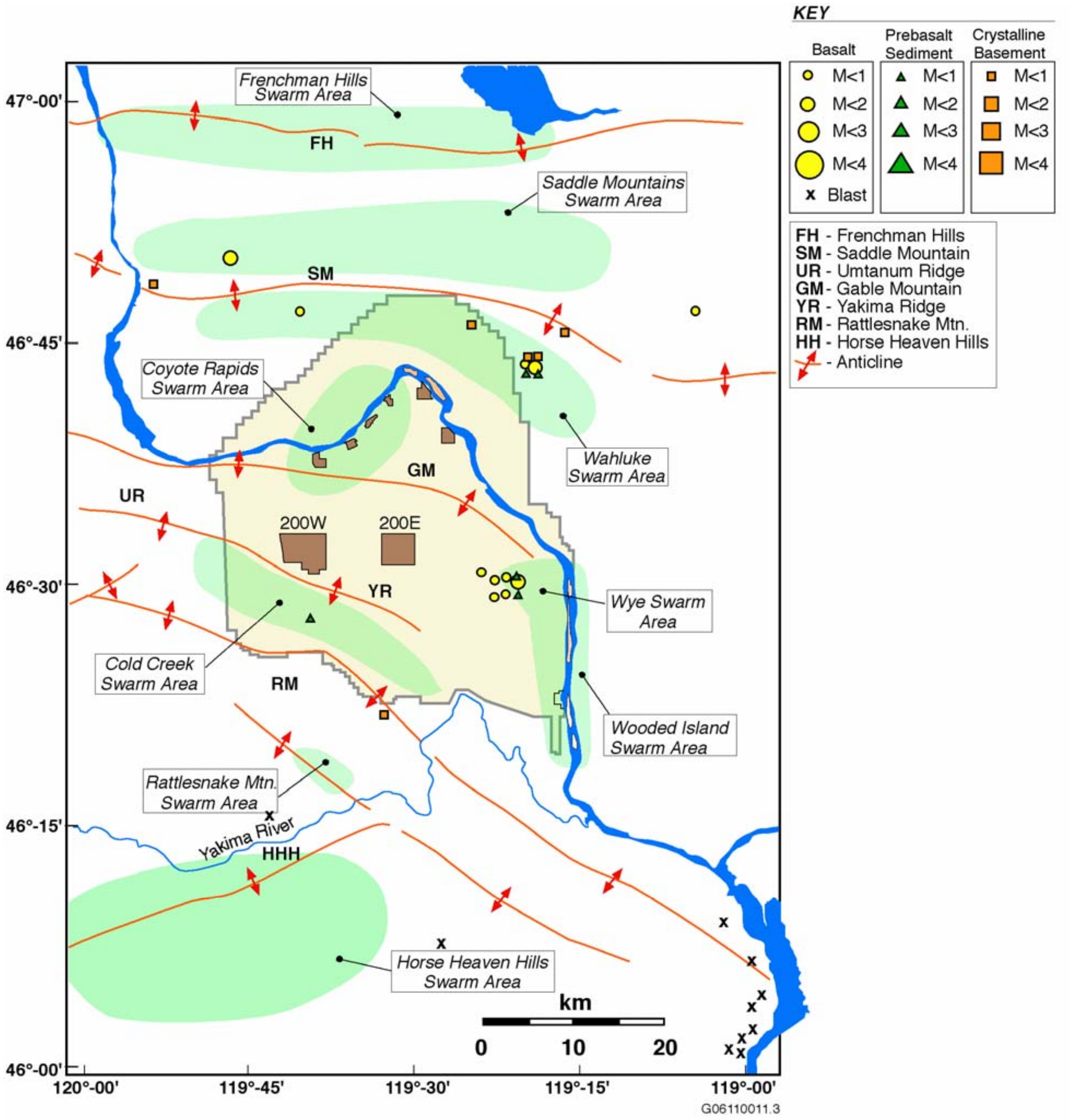

Figure 4.6. Location of all Earthquakes Located in the Hanford Monitoring Area Between April 1, 2006 and June 30, 2006

April 22 and on June 14 had magnitudes of M_c 0.9. The remaining 5 events all had magnitudes of approximately M_c 0. Six of the events were located in basalt, and two were located near the base of the pre-basalt sediments. The depth estimates of these smaller events is more uncertain than for the larger events that were well-located events in basalt, and may be in error due to low signal strength and resulting difficulty in picking accurate arrival times.

4.5.4.2.2 Random or Floating Events

Four earthquakes were classified as random events in the third quarter. Events that occurred in the pre-basalt sediments and in the crystalline basement are typically classified as random events. This is because there are no known geologic structures that have been identified in the rocks that occur below the Columbia River Basalt Group. However, we now recognize that some events that occur at depths that places them in the pre-basalt sediments and crystalline basement occur in patterns that fit our definition of earthquake swarms (Section 4.3). Those events are now reported in the appropriate sections on earthquake swarms.

One basement event on April 16 was located just north of the western end of the Saddle Mountain structure that had a magnitude of M_c 0.4. A very small event (approximately M_c 0) was located in pre-basalt sediments beneath the Cold Creek Valley and swarm area on May 15. A magnitude M_c 0.7 event was located in the crystalline basement on June 18, near the Rattlesnake Mountain structure. The last random event (approximately M_c 0) was located in basalt in the far northeast portion of the monitoring area.

4.5.5 Fourth Quarter Earthquakes of FY 2006

Eleven earthquakes occurred in the Hanford Area during the fourth quarter of FY 2006, which occurred July 1, 2006 through September 30, 2006 (Figure 4.7; Table 4.3).

4.5.5.1 Location of Earthquakes

During the fourth quarter of FY 2006, four earthquakes occurred in swarm areas, and seven were classified as random. No earthquakes occurred on major structures this quarter.

4.5.5.1.1 Major Anticlinal Ridges

We interpret no earthquakes to have occurred on major structures during the fourth quarter of FY 2006.

4.5.5.2 Earthquake Swarm Areas

Four earthquakes occurred in swarm areas during FY 2006.

Wahluke Swarm Area

One earthquake occurred within the Wahluke earthquake swarm area on September 23. It was a small earthquake (M_c 0.8) and occurred in the basalt.

Coyote Rapids Swarm Area

Two shallow earthquakes occurred in basalt within the ‘horn’ area of the Coyote Rapids swarm area, continuing the swarm activity that has been observed through the first, second, and third quarters. The first of these earthquakes was recorded on August 12 with a magnitude of 0.6 M_c. The second occurred on August 24 and had a magnitude of 0.3 M_c.

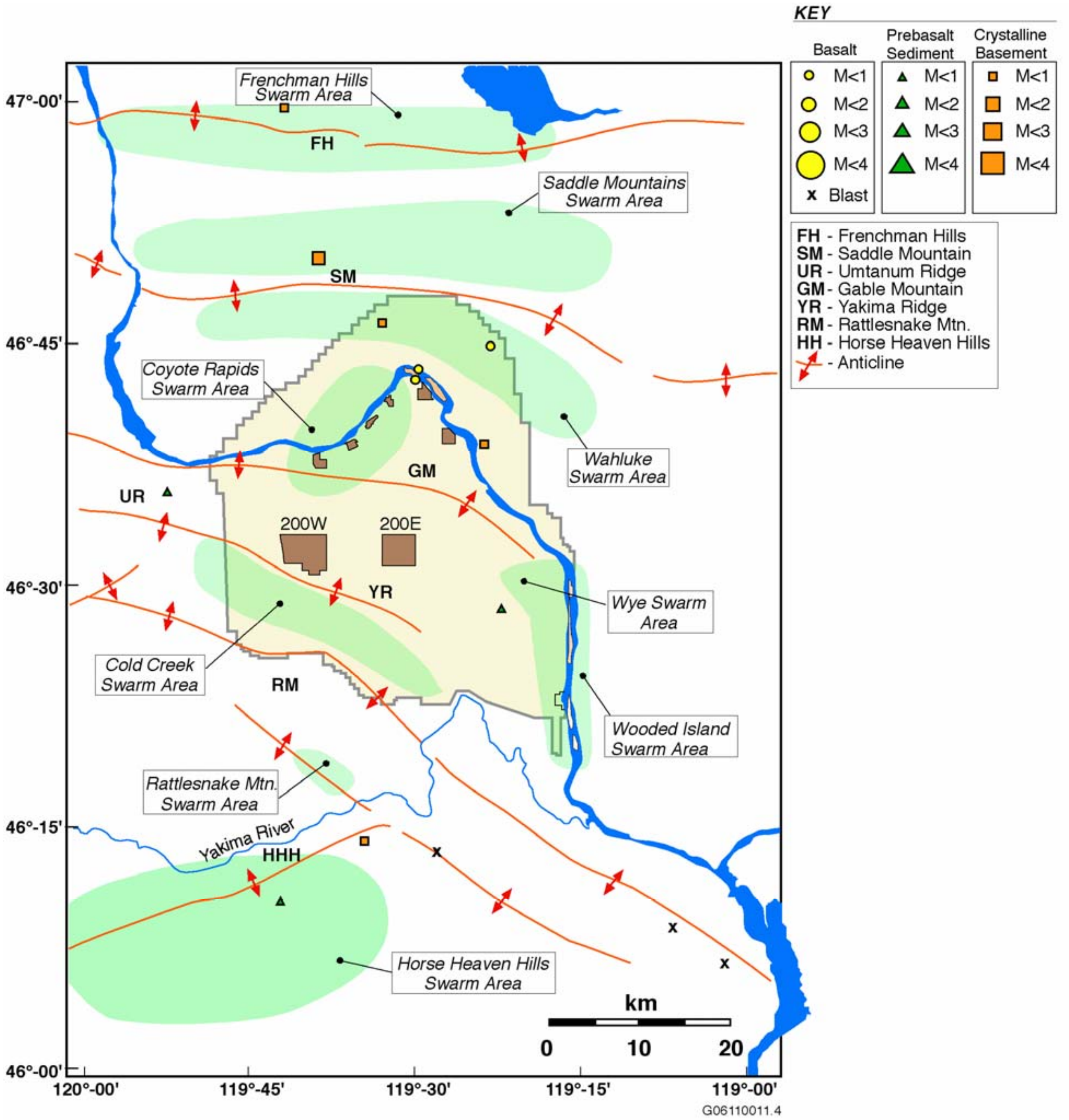

Figure 4.7. Location of all Earthquakes Located in the Hanford Monitoring Area Between July 1, 2006 and September 30, 2006

Horse Heaven Hills Swarm Area

One earthquake occurred in the pre-basalt sediments on September 21 in the Horse Heaven Hills swarm area. The magnitude was 0.8 M_c and was located at a depth of approximately 8.5 km. Because we have had other earthquake swarms in this area at this depth, we classify this earthquake as occurring in a swarm area.

4.5.5.3 Random or Floating Events

Seven earthquakes are classified as random events during the fourth quarter of FY 2006. Events that occurred in the pre-basalt sediments and in the crystalline basement are typically classified as random events. This is because there are no known geologic structures that have been identified in the rocks that occur below the Columbia River Basalt Group. However, we now recognize that some events that occur at depths that places them in the pre-basalt sediments and crystalline basement occur in patterns that fit our definition of earthquake swarms (Section 4.3). Those events are now reported in the appropriate sections on earthquake swarms.

On July 8, a deep earthquake in crystalline basement occurred below the Wahluke swarm area. This earthquake was 1.8 M_c and was the largest event recorded this quarter. Additional deep random earthquakes in the crystalline basement were recorded on September 2 below the Horse Heaven Hills (0.8 M_c), in the Frenchman Hills on September 6 (0.7 M_c).

Four additional random events occurred in the fourth quarter and all had magnitudes of approximately M_c 0. One event was located in crystalline basement near the White Bluffs (south of the Wahluke swarm area) on July 23. Another event in crystalline basement occurred below the central part of the Wahluke swarm area on August 5. An event located in pre-basalt sediments was located south of Umtanum Ridge (in the western part of the monitoring area) on August 25. The last event with approximate magnitude M_c 0 occurred August 27 in pre-basalt sediments west of the Wye swarm area and slightly south of the swarm activity noted in the first three quarters of the reporting period.

5.0 Strong Motion Accelerometer Operations

The Hanford SMA network has been in continuous operation since November 20, 1998. The nominal threshold used in the SMA network has been 0.001 g in order to provide ground motion for smaller, non-damaging earthquakes that can be useful in estimating the ground motion expected from larger earthquakes, and to confirm correct operation of the instruments by analyzing the smaller-amplitude triggers (see Section 2.2). In 2006 the trigger threshold was reduced to 0.0002 g when new instruments with greater storage capacity were installed, allowing more noise triggers to be saved without exceeding disk capacity.

5.1 FY 2006 Triggers of the Hanford SMA Network

One station of the Hanford SMA network did trigger from a local magnitude 1.5 earthquake during FY 2006, after the trigger threshold was reduced. This event was recorded on April 17, 2006 at the strong-motion accelerometer located in the 400 Area (Figure 5.1). The record was downloaded from the accelerometer the week of April 25, 2006. Peak accelerations recorded barely exceeded 0.001 g, so it is not certain whether the old settings would have recorded this event (considering the filtering that is done on the trigger system).

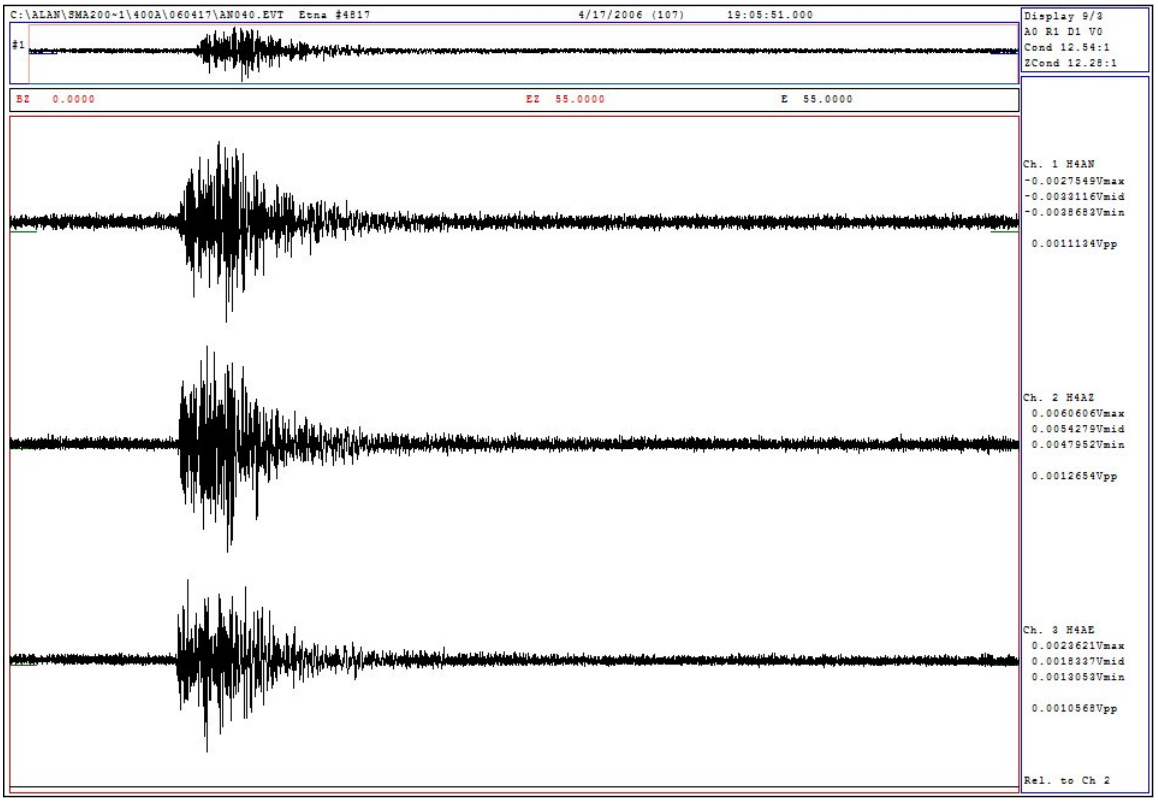

Figure 5.1. April 17, 2006 Event from the 400 Area SMA

5.2 FY 2006 SMA Field Activities

Three distinct field activities were accomplished in FY 2006 that addressed the strong motion accelerometers: installation of new instruments, downloading event logs from the instruments, and updating internal software or firmware.

The new systems were purchased and installed this fiscal year. The first was installed on February 8 at the 300-Area station. The other four were installed on February 14. The new instrument have much higher storage capacity that allowed their operation with a much lower trigger threshold -0.01% full-scale, or 0.0002 g. Events from seismic triggers are recorded by the strong motion accelerometers as digitized signals from the detectors. These signals are stored on factory-installed removable electronic media that have approximately sixty-four megabytes of capacity. These electrostatic, or flash, media hold their data even if the power to the instrument is disrupted.

Downloading the event logs, or the recorded signals, from the instruments requires that staff from the Seismic Assessment Project visit each location and attach a serial cable to the instrument and retrieve the data to a laptop computer. The Seismic Assessment Team can then analyze the events and the events subsequently deleted from the instrument so that capacity for future events is maintained.

Firmware updates are software patches installed on the instruments either to enhance software performance or improve security. Updates are installed on both the accelerometers and the GPRS modems. Firmware updates are posted for both the instruments and the modems on the vendor websites. The newly installed SMA systems did not require software installation but a patch was available for the modems in April of 2006. The patch was applied to three of the five modems in July 2006. The remaining modems were updated in September 2006.

6.0 Capabilities in the Event of a Significant Earthquake

The SMA network was designed to provide ground motion data in areas at the Hanford Site that have high densities of people and/or facilities containing hazardous materials in order to insure the Hanford Site is in compliance with DOE Order 420.1A, “Facility Safety.” The network also allows the HSAP to support Hanford Site emergency services organizations in complying with DOE Order G 420.1-1, Section 4.7, “Emergency Preparedness and Emergency Communications,” by providing area ground motion data in the event of an earthquake on the Hanford Site. This section summarizes the capabilities of the HSAT in the event of an earthquake at Hanford.

6.1 Use of the SMA Network in the Event of an Earthquake

Historically, only a few facilities at the Hanford Site had instruments to provide data on peak ground accelerations or any type of ground motion. The present SMA instruments were located so that if an earthquake occurred, ground motion data would be readily available to assess the damage at the 100-K Area, the 200-East and West Areas, and the 300 and 400 Area facilities, which have the greatest concentration of people and also contain hazardous materials (Moore and Reidel 1996).

Many facilities at the Hanford Site have undergone various degrees of seismic analysis either during design or during re-qualification. Although the seismic design of a building may be known, when an earthquake is “felt” in a facility on the Hanford Site, a determination must be made as to the extent of damage before it can be re-occupied and the systems restarted. A “felt” earthquake may not cause any significant damage to a building but, without adequate characterization of the ground motion, initial determination of the building’s possibility of having damage may be impossible.

In the event of an earthquake such as the 2001 Nisqually earthquake, building managers, emergency directors, and engineers can obtain ground motion data recorded by the SMA network from the HSAT in the Sigma V Building. This is done through the Hanford Site Emergency Services Organization. Normal hours of operation for the HSAP are between 6 a.m. and 4:30 p.m., Monday through Friday. If a SMA is triggered, the HSAT will download events that were recorded and determine the peak ground accelerations. This information is then passed on to Hanford Emergency Services personnel where the facility engineers can use the data to determine if the ground motion exceeded, is equal to, or is less than the building design. This, along with assessments from trained engineers, allows the facility manager to make a rapid and cost-effective determination on whether a building is safe to re-occupy or should not be used until it has been inspected in more detail. Buildings that have designs exceeding the recorded ground motion could be put back into service very quickly; buildings with designs that are very close to or less than measured ground motion could be given priority for onsite damage inspections.

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