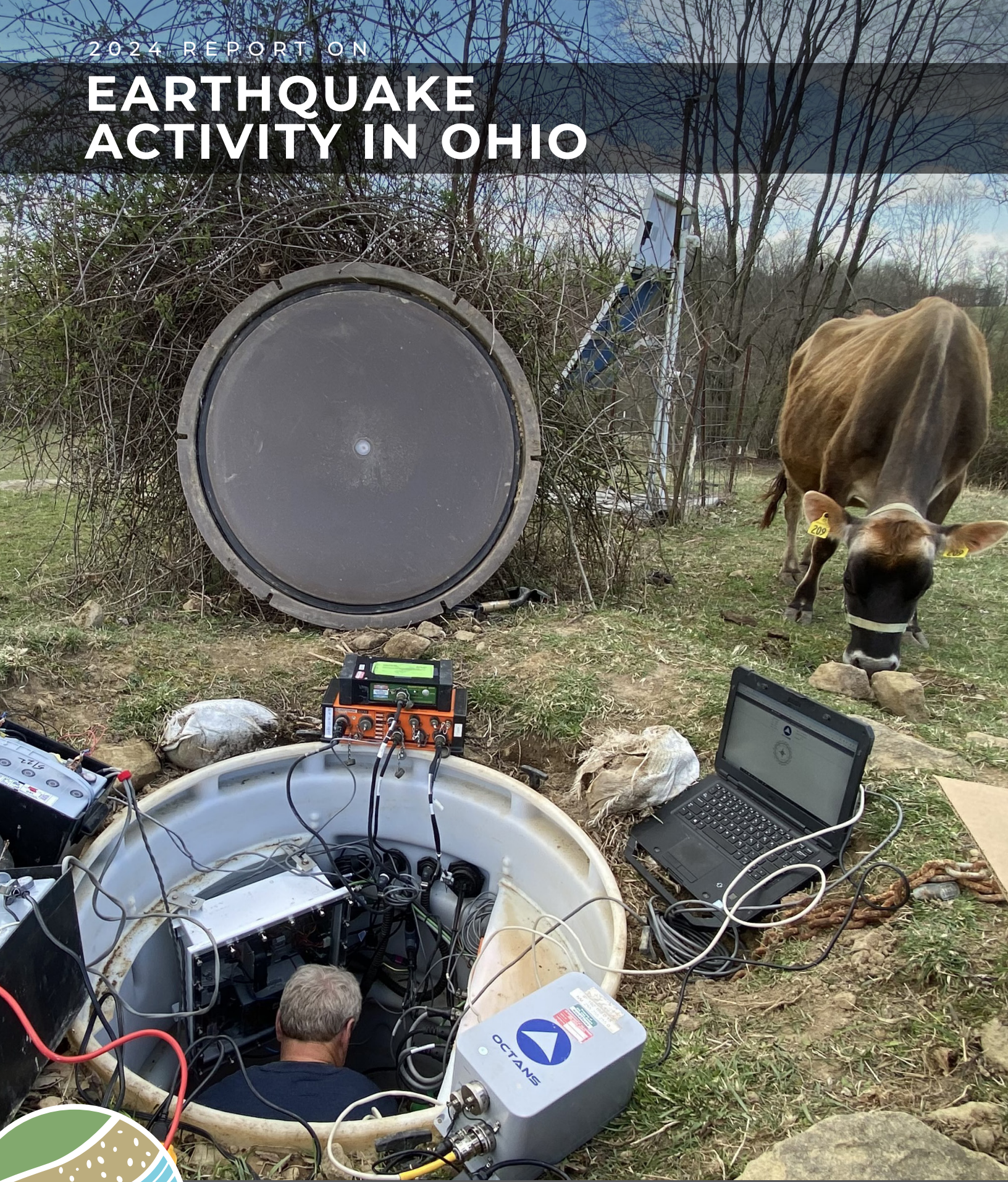
2024 REPORT ON

EARTHQUAKE ACTIVITY IN OHIO



compiled by Jeffrey L. Fox, Daniel R. Blake, and Jacqueline A. Thompson

OHIO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES

Graphic design & layout: Jeremy E. Gladden
Editing: Charles R. Salmons, Keni Brown
Front cover: A seismic station being serviced near Adamsville, Muskingum County, Ohio, 2024.

Recommended citation: Fox, J.L., Blake, D.R., and Thompson, J.A., 2025, 2024 Report on earthquake activity in Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey, 19 p.

2024 Report on earthquake activity in Ohio

compiled by
Jeffrey L. Fox, Daniel R. Blake, and Jacqueline A. Thompson

STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
D. Mark Jones, Chief

Columbus 2025

PREFACE

The 2024 Report on Earthquake Activity in Ohio continues the efforts of the Ohio Department of Natural Resources (ODNR), Division of Geological Survey's Ohio Seismic Network (OhioSeis) to present a clear and concise representation of all seismicity, natural and anthropogenic, in the state for the calendar year. This report presents the data in tables and figures, with brief discussions of significant earthquakes or seismic swarm activity. The computer program HYPOINVERSE-2000 (Klein, 2014) was used to process earthquake data in SEISAN and AQMS. The earthquake listing in Table 3 is estimated to be systematically complete above magnitude 1.5 M_L within the state for 2024. However, these data are preliminary—both the locations and magnitudes in this table are subject to revision. The catalog may include some anthropogenic seismic events that have not yet been identified.

The Ohio Earthquake Epicenters Locator interactive map is continually updated and is accessible at **ohiodnr.gov/earthquake-epicenters**. Seismic station lists and locations are current to the calendar year of this report. Seismic station information can also be found on the interactive map. Station metadata are available from the SAGE (Seismological Facility for the Advancement of Geoscience) Data Management Center (DMC). Station locations contained within this report are not accurate for privacy purposes. Interested scientists can obtain detailed location information for calculating earthquake locations from the SAGE DMC.

A complete copy of this report, including maps and earthquake catalog, is available on the OhioSeis website at **ohioseis.ohiodnr.gov**.

Jeff Fox
Seismologist

CONTENTS

Preface v
Earthquake activity in Ohio, January 1–December 31, 2024 1
Notable earthquake events, January 1–December 31, 2024 3
Felt earthquake events, January 1–December 31, 2024 6
Acknowledgments 12
References 12
Appendix 13

FIGURES

1. Map of Ohio earthquake epicenters detected and located by the Ohio Seismic Network seismograph stations, January 1–December 31, 2024 2
2. Map showing earthquake locations in eastern Lake County, Ohio, near the town of Madison during 2024 3
3. Scatter plot of earthquakes detected by OhioSeis and through waveform matching software algorithms in the Madison, Ohio, sequence since August 2023 4
4. Map showing the earthquake locations from November 2024 in the vicinity of Clendening Lake and Tappan Lake in Harrison County 5
5. Map of Defiance County, Ohio, and the December 29, 2024, M_L 3.3 earthquake 5
6. Felt reports map for the December 29, 2024, Defiance County M_L 3.3 earthquake 6
A-1. Map of percentage of data availability from each Ohio Seismic Network station during 2024 13
A-2. Photos of Ohio Seismic Network crews installing station KPOH at Knobbys Prairie Wildlife Area in Seneca County 14
A-3. Photos of ODNR interns installing station HROH in Lake County and performing maintenance at station CROH in Lorain County 15
A-4. Photos of interns and Ohio Seismic Network staff at station P49A near Miami University in Oxford, Ohio 15
A-5. Photos of drilling and upgrades to station O53A in Harrison County 16
A-6. Map of Ohio Seismic Network station locations for 2024 18
A-7. The Modified Mercalli Intensity Scale for earthquake shaking 19

TABLES

1. Earthquake magnitude statistics for calendar year 2024, all of Ohio 1
2. Earthquakes felt and/or generating a ShakeMap in the Ohio region for 2024 7
3. Catalog of all earthquakes in Ohio in 2024 8
A-1. Ohio Seismic Network operating seismograph stations in 2024 17

ABBREVIATIONS USED IN THIS REPORT

Units of Measure

kilometers . . . . . km
magnitude[1] . . . . . M_L or M_d
meters . . . . . m
miles . . . . . mi

Other

Advanced National Seismic System . . . . . ANSS
ANSS Quake Management System . . . . . AQMS
Community Internet Intensity Maps . . . . . CIIM
Seismological Facility for the Advancement of Geoscience . . . . . SAGE
Standard for the Exchange of Earthquake Data . . . . . SEED
Ohio Seismic Network . . . . . OhioSeis
SEISmic ANalysis software . . . . . SEISAN
United States Geological Survey . . . . . USGS

[1]Richter local magnitude (M_L) or coda magnitude (M_d) determined by OhioSeis.

EARTHQUAKE ACTIVITY IN OHIO
JANUARY 1–DECEMBER 31, 2024

During the period January 1 through December 31, 2024, the Ohio Seismic Network (seismic network code: OH) located 129 earthquakes within Ohio (fig. 1, tables 1 and 3). The total includes 16 earthquakes of magnitude 2.0 M_L or greater, three of which are greater than magnitude 3.0 M_L. During the 2024 calendar year, 17 earthquakes were reported felt by Ohioans. The largest earthquake recorded within Ohio's borders in 2024 was the M_L 3.9 earthquake on December 16 in Lawrence County. A cumulative tabulation of earthquakes during 2024 that were either felt in the Ohio region or for which a Community Internet Intensity Map (CIIM) was produced, or both, is available in Table 2.[1] Additional information on earthquakes within the Ohio region is available from the Ohio Seismic Network online database **ohiodnr.gov/earthquakedatabase**.

Earthquake magnitude distributions show that most earthquakes (54 of 129) recorded in the state in 2024 were between M_L 1.0 and M_L 1.4. In terms of earthquake frequency distribution throughout the year, March and November were the most active months of seismic activity in the state. Seismicity in March was spread across nine different counties, while seismicity in November was concentrated mostly within Harrison County.

[1]A CIIM summarizes the responses, and an intensity number is assigned to each ZIP code for which a CIIM questionnaire is completed. The intensity values in each ZIP-code area are averaged, and the map is updated as additional data are received. ZIP-code areas for which data have been received are color-coded according to the intensity scale below the map; other areas are gray. A CIIM is automatically made after each widely felt earthquake in the United States. The system can start receiving responses about three minutes after the earthquake. Internet users can also enter data for U.S. earthquakes they have experienced in the past.

TABLE 1. ***Earthquake magnitude statistics for calendar year 2024, all of Ohio.***

2024 OHIO EARTHQUAKES SUMMARY	
Earthquakes > M_L 3.00	3
Earthquakes M_L 2.50–3.00	2
Earthquakes M_L 2.00–2.49	11
Earthquakes M_L 1.50–1.99	29
Earthquakes M_L 1.00–1.49	54
Earthquakes M_L < 1.00	30
Total Earthquakes (all magnitudes)	**129**

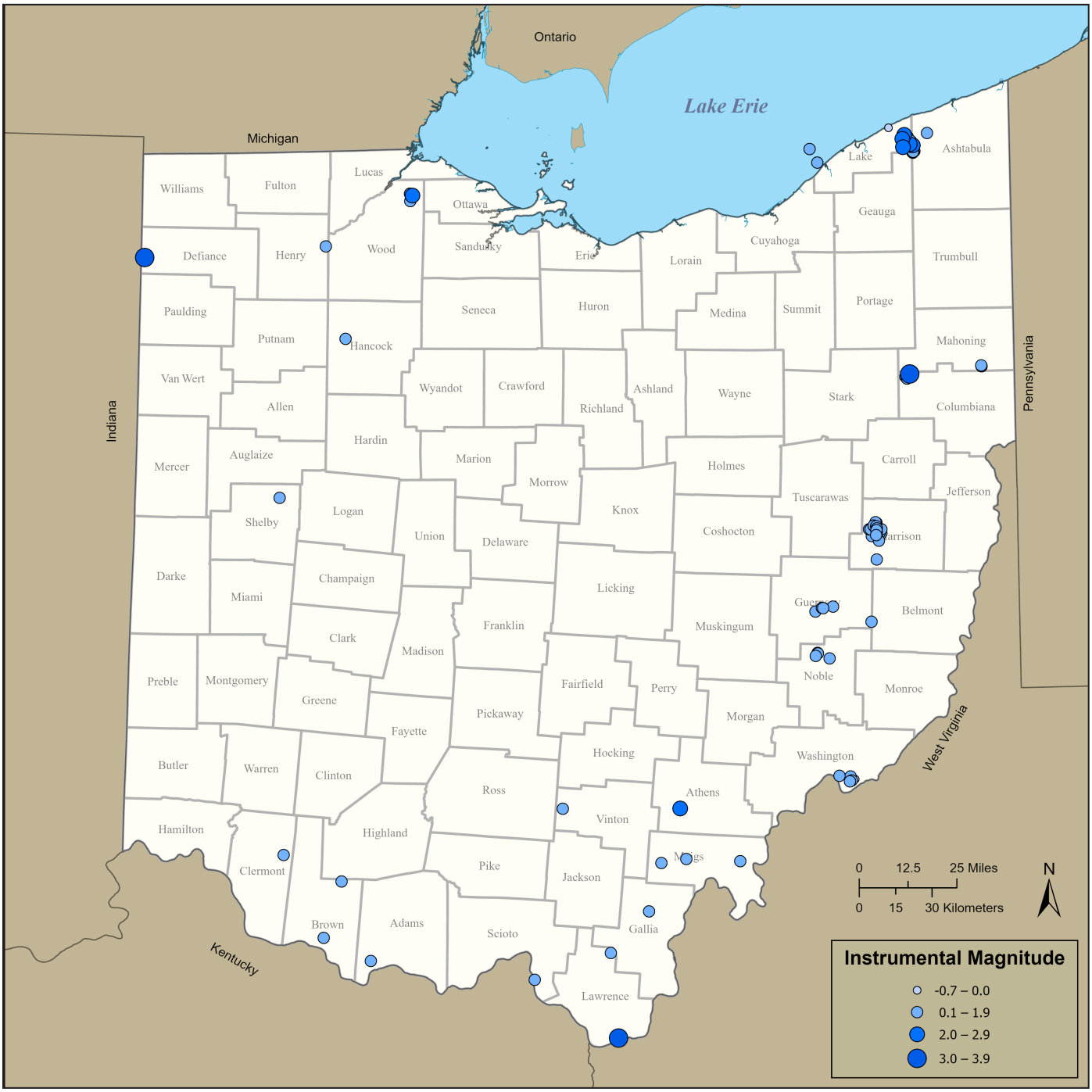


FIGURE 1. Map of Ohio earthquake epicenters detected and located by the Ohio Seismic Network seismograph stations, January 1–December 31, 2024.

NOTABLE EARTHQUAKE EVENTS, JANUARY 1–DECEMBER 31, 2024

Three notable earthquake events or sequences occurred in 2024 and are worthy of discussion. The first and most notable sequence of 2024 involves earthquakes associated with an ongoing swarm in eastern Lake County that continued throughout the entire calendar year of 2024. In all, 37 more earthquakes (fig. 2) were detected by the Ohio Seismic Network near the town of Madison. Through analysis with specialized software, nearly 500 earthquakes (M_L -0.2–2.8) have been detected in this sequence since it began in the summer of 2023 (fig. 3). The earthquakes are continually being felt and reported by local citizens in the Madison area who have become sensitized to the shaking. In July 2024, a temporary new seismic station was installed within the epicentral area of the swarm to better constrain the location and depths of these earthquakes. This is an area of active and ongoing research to determine the cause of this unique seismic sequence.

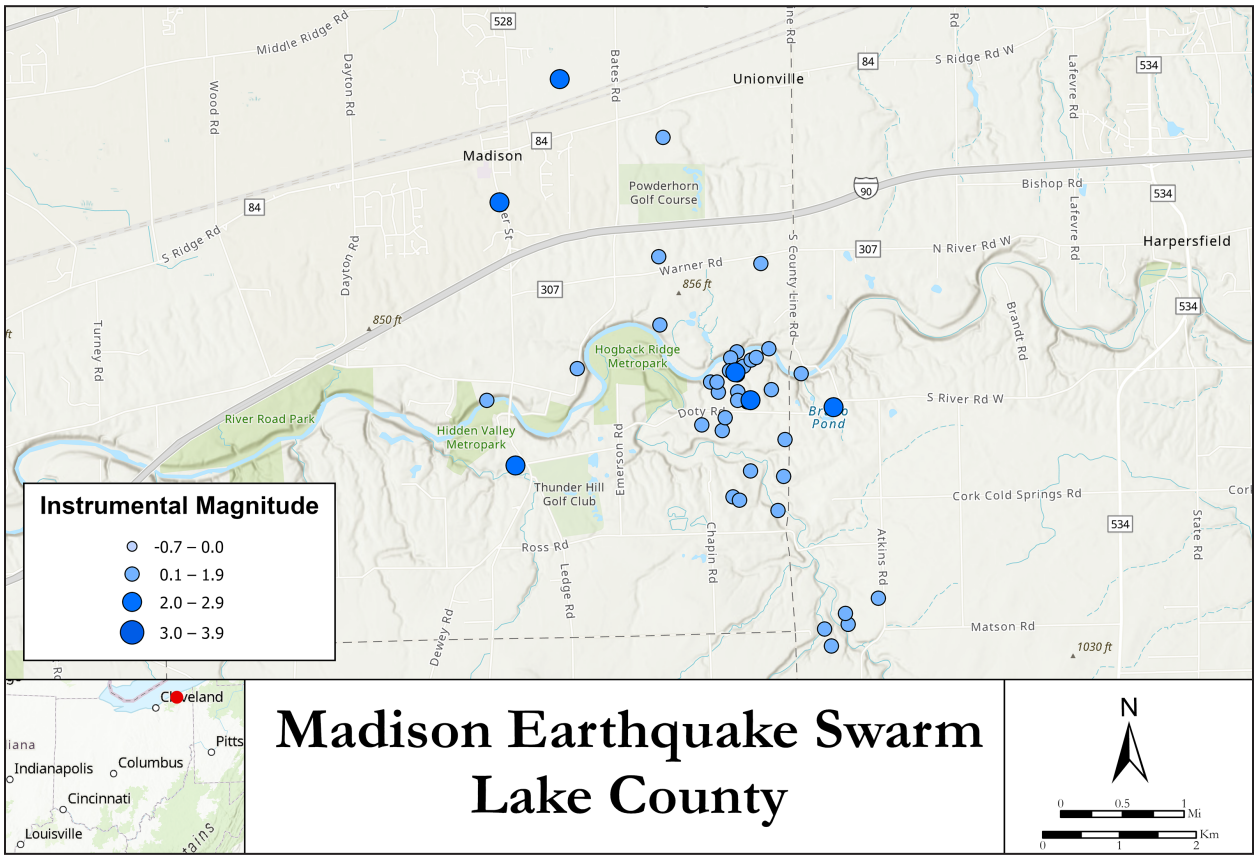


FIGURE 2. Map showing earthquake locations in eastern Lake County, Ohio, near the town of Madison during 2024.

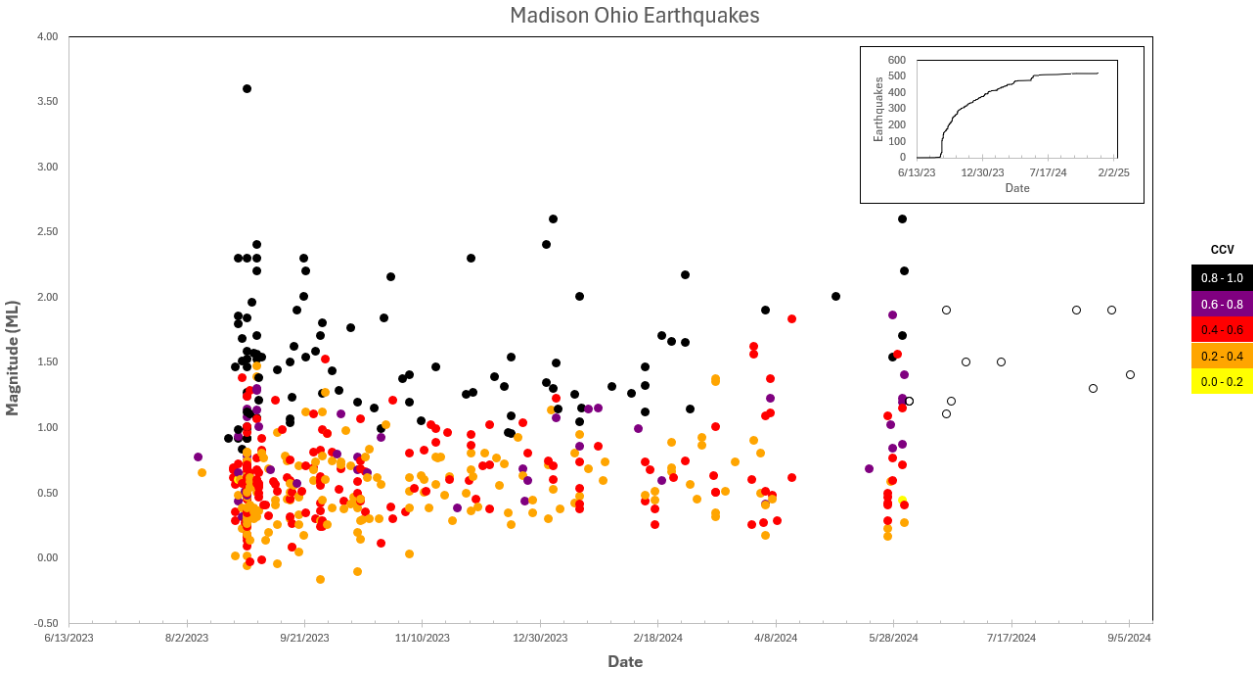


FIGURE 3. Scatter plot of earthquakes detected by OhioSeis and through waveform matching software algorithms in the Madison, Ohio, sequence since August 2023. Colors indicate how the smaller magnitude earthquakes correlate (CCV, Correlation Coefficient Value) with the largest earthquake in the sequence. Darker colors tend to reflect earthquakes with larger magnitudes that are a direct correlation between them and the larger main event. Open circles indicate earthquakes detected by the Ohio Seismic Network but not yet correlated with the 2023 mainshock at the time of this writing. These earthquakes are happening on the same fault and location as the mainshock of August 28, 2023. Inset chart shows the cumulative number of earthquakes with time. There is a steep and rapid increase in the number of earthquakes beginning in late August 2023. Waveform matching data provided by Dr. D. Yao, Chinese University of Geosciences.

The next earthquake sequence of importance in 2024 occurred during November in Harrison County. A total of 24 earthquakes (fig. 4) occurred within this sequence during November 6–16. The magnitudes for these earthquakes ranged from M_L 0.0 to M_L 2.0. The Harrison County region near Clendening Lake has experienced many earthquakes over the last couple of decades. Friberg and others (2014) studied these earthquakes but the regional geology is poorly understood. It is important to note that these occurrences are typically rare, and ongoing research aims to better understand the conditions under which they may occur.

The second largest and final earthquake of 2024 was the December 29 earthquake (fig. 5) in Defiance County. This is the first recorded earthquake in Defiance County. It was well recorded across the Ohio Seismic Network, and many residents of the town of Hicksville reported feeling the event. It was also the third earthquake of the year to reach or exceed M_L 3.0. This earthquake was widely felt throughout the area (fig. 6) with nearly 350 reports being submitted to the “Did You Feel It?” (DYFI) reporting system.

Earthquakes in northwestern Ohio are scarce and poorly understood. Earthquakes have been reported to the east along the Bowling Green Fault System and are associated with this feature and with the northern extent of the Fort Wayne Rift.

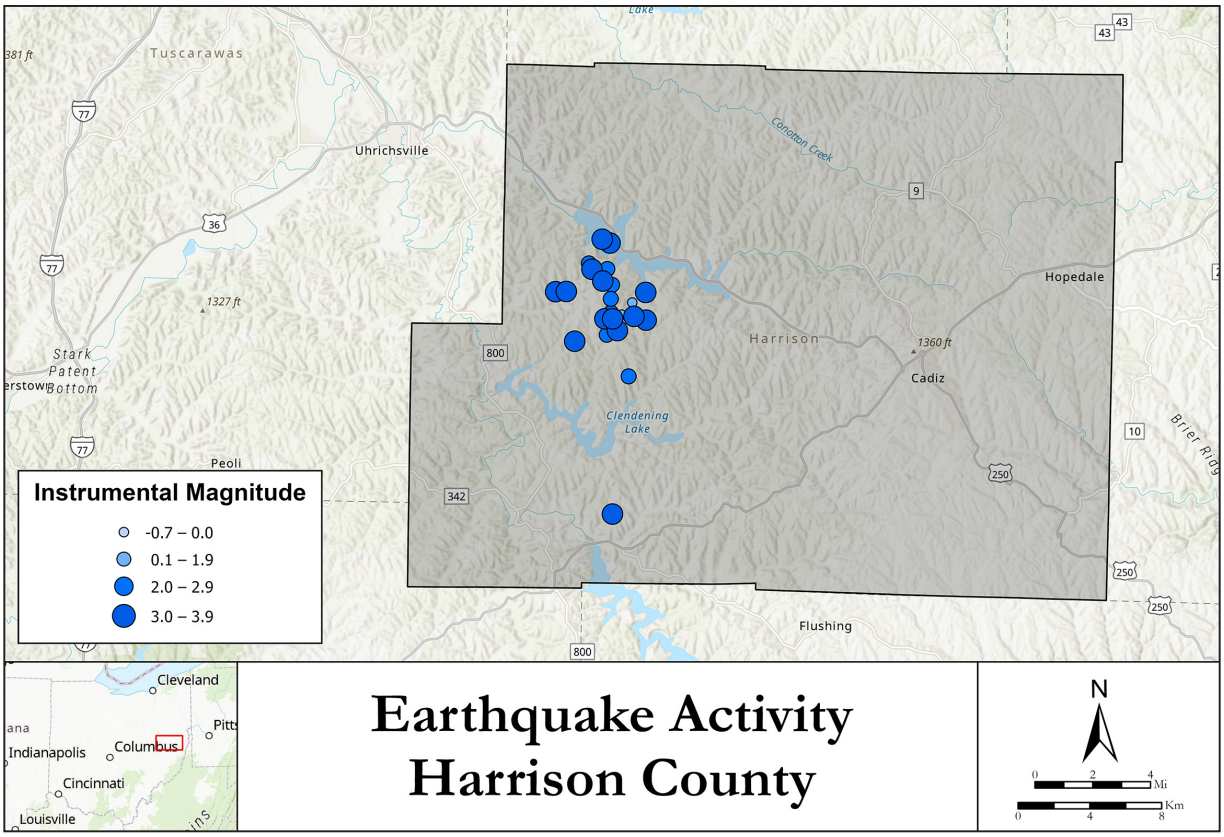


FIGURE 4. Map showing the earthquake locations from November 2024 in the vicinity of Clendening Lake and Tappan Lake in Harrison County.

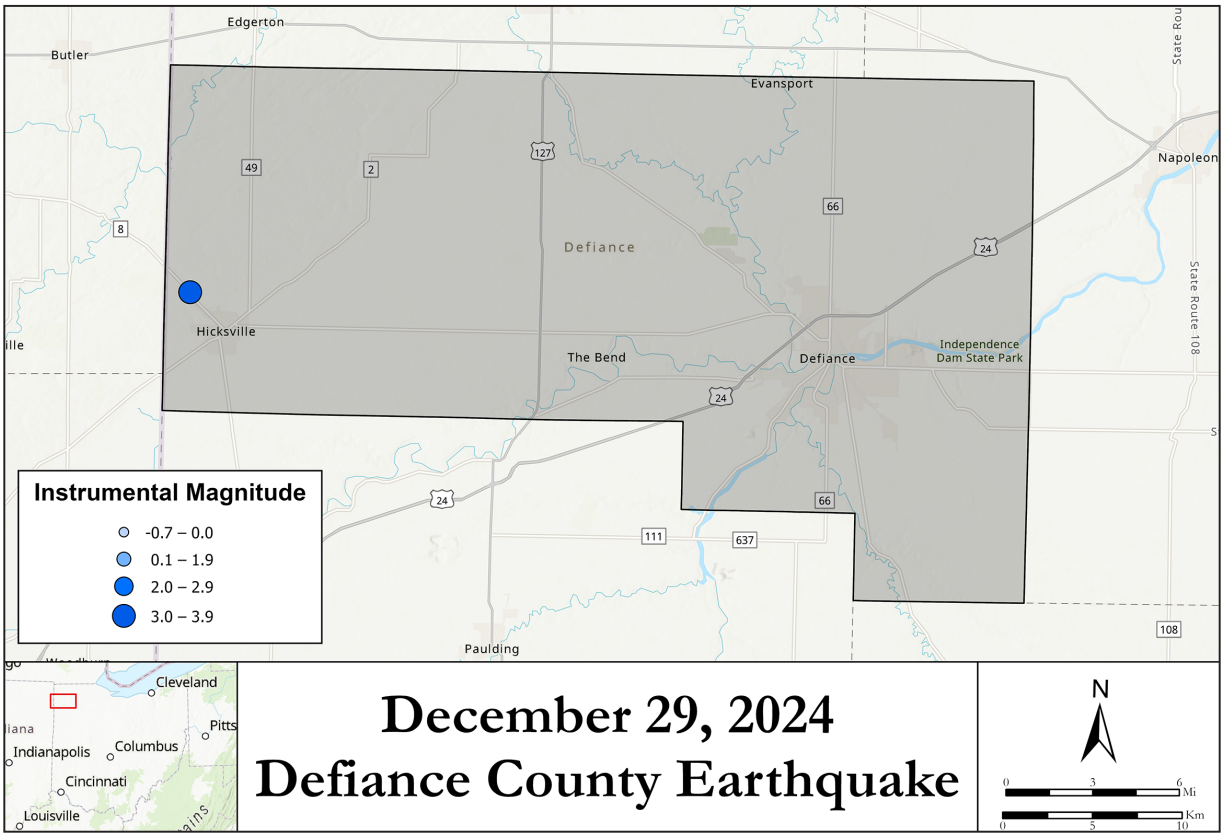


FIGURE 5. Map of Defiance County, Ohio, and the December 29, 2024, M_L 3.3 earthquake.

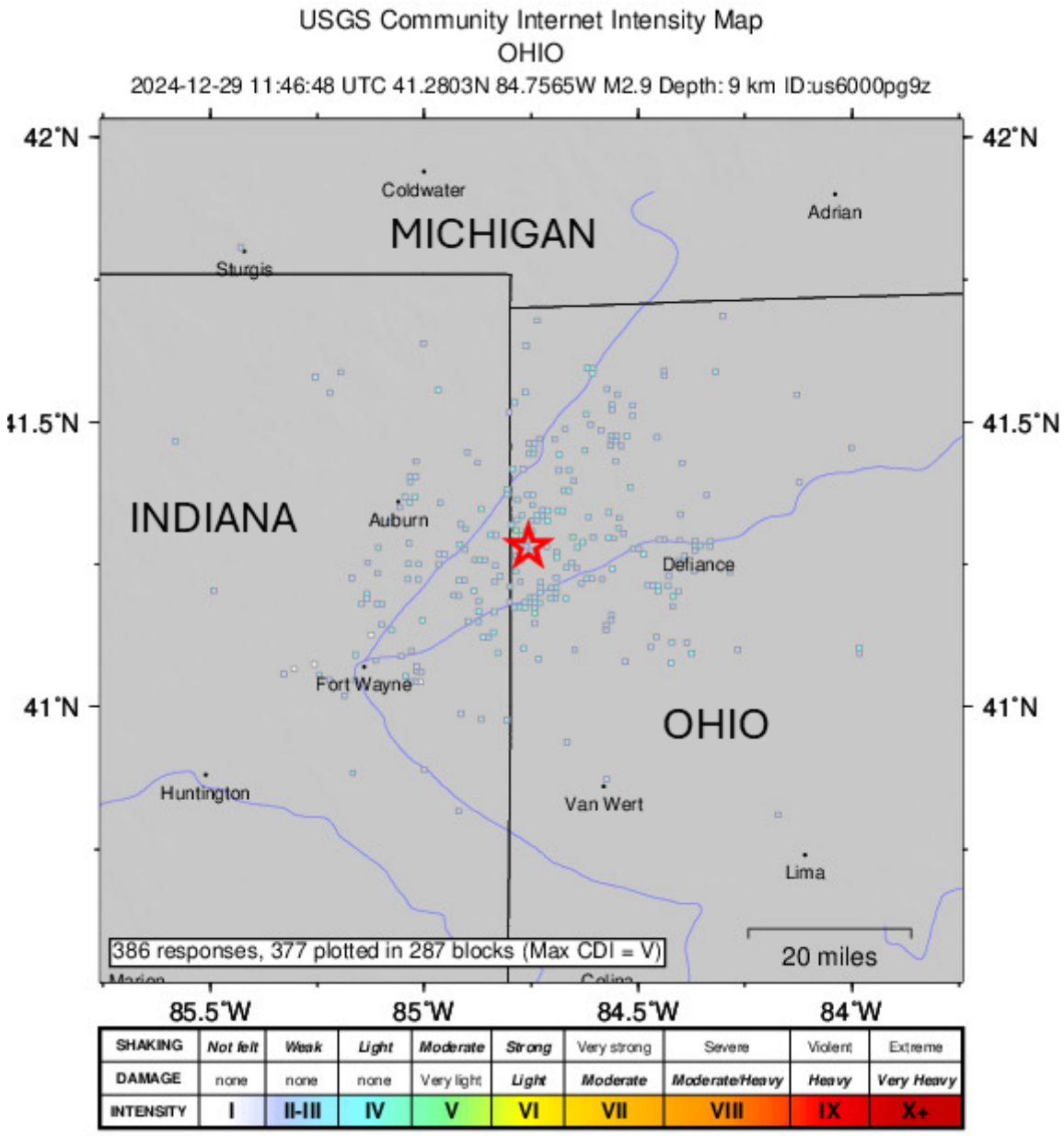


FIGURE 6. Felt reports map for the December 29, 2024, Defiance County M_L 3.3 earthquake. Red star indicates epicenter. Nearly 350 area residents reported feeling this earthquake.

FELT EARTHQUAKE EVENTS, JANUARY 1–DECEMBER 31, 2024

For earthquakes M_L 3.0 and larger in the Ohio region, the U.S. Geological Survey (USGS) automatically posts a Community Internet Intensity Map (CIIM) on its "Did You Feel It?" web page at **earthquake.usgs.gov/earthquakes/dyfi**. Earthquakes of smaller magnitude that are felt and those reported by regional seismic networks will also be posted to the USGS CIIM pages. We encourage anyone who feels an earthquake to report their observations on this interactive website. Felt information is available by zip code on the CIIM site or can be obtained directly from the Ohio Seismic Network.

TABLE 2. ***Earthquakes felt and/or generating a ShakeMap in the Ohio region for 2024.***

DATE	TIME[1]	FELT INFORMATION[2]	LATITUDE	LONGITUDE	MAGNITUDE (M_L)[3]
Jan 2	20:58 (Jan 1 EST) 1:58 UTC	USGS Shakemap. CIIM. Felt (III) at Madison and Geneva, OH.	41.741	-80.997	2.2
Jan 5	03:47 EST 08:47 UTC	USGS Shakemap. CIIM. Felt (III) at Madison and Geneva, OH, and (II) Conneaut, OH.	41.745	-81.012	2.2
Jan 16	12:39 EST 17:39 UTC	USGS Shakemap. CIIM. Felt (III) at Eastlake, Alliance, and Madison, OH, and (II) at Mentor and Wickliffe, OH.	41.766	-81.049	2.1
Jan 28	12:13 EST 17:13 UTC	USGS Shakemap. CIIM. Felt (III) at Ewing, KY, and (II) at East Liverpool, OH, and (I) at Cortland, OH.	38.570	-83.802	2.1
Mar 18	16:58 EDT 20:58 UTC	USGS Shakemap. CIIM. Felt (III) at Genoa, OH, Flat Rock and Monroe, MI, and (II) at Toledo, OH.	41.567	-83.484	2.9
Mar 30	04:42 EDT 08:42 UTC	USGS Shakemap. CIIM. Felt (III) at Alliance, Salem, and Sebring, OH, and (II) at Akron and Beloit, OH.	40.892	-81.031	3.2
Apr 4	17:55 EDT 21:55 UTC	USGS Shakemap. CIIM. Felt (IV) at Madison, OH, and (III) at Geneva, OH.	41.739	-81.015	1.8
Apr 22	20:12 (Apr 21 EDT) 00:12 UTC	USGS Shakemap. CIIM. Felt (III) at Perrysburg, Rossford, and Walbridge, and Genoa, OH, and (II) at Oregon, OH.	41.560	-83.472	2.5
May 4	20:01 (May 3 EDT) 00:01 UTC	USGS Shakemap. CIIM. Felt (IV) at Madison, OH, and (II) at Geneva, OH.	41.744	-81.016	1.9
Jun 1	06:11 EDT 10:11 UTC	USGS Shakemap. CIIM. Felt (III) at Madison, Perry, and Thompson, OH, and (II) at Painesville and Geneva, OH.	41.742	-81.010	2.8
Jun 1	07:14 EDT 11:14 UTC	USGS Shakemap. CIIM. Felt (III) at Madison, Thompson, and New Madison, OH and (II) at Geneva, OH.	41.745	-81.012	1.7
Jun 2	00:23 EDT 4:23 UTC	USGS Shakemap. CIIM. Felt (III) at Madison and Geneva, OH.	41.756	-81.023	2.2
Aug 14	22:26 (Aug 13 EDT) 02:26 UTC	USGS Shakemap. CIIM. Felt (III) at Eastlake, OH and (I) at Bowling Green and Cortland, OH.	41.683	-81.469	1.9
Aug 29	18:38 EDT 22:38 UTC	USGS Shakemap. CIIM. Felt (II) at Madison, OH.	41.768	-81.007	2.0
Nov 7	00:38 EST 05:38 UTC	USGS Shakemap. CIIM. Felt (IV) at Cincinnati, OH, and (III) at Ripley, OH, and (II) at Georgetown, OH.	38.801	-83.855	1.9
Dec 16	16:39 EST 21:39 UTC	USGS Shakemap. CIIM. Felt (IV) at Huntington, WV and Chesapeake, Proctorville, and South Point, OH, and (III) in Ashland, KY, and Barboursville, WV, and Ironton, OH.	38.434	-82.457	3.9
Dec 29	06:46 EST 11:46 UTC	USGS Shakemap. CIIM. Felt (III) at Hicksville, Antwerp, and Edgerton, OH, and (II) at Bryan, Defiance, and Paulding, OH.	41.312	-84.787	3.3

[1]Times are listed both as Local Time—Eastern Standard Time (EST) or Eastern Daylight Time (EDT)—and as Coordinated Universal Time (UTC).
[2]CIIM is Community Internet Intensity Map (earthquake.usgs.gov/earthquakes/dyfi), compiled by the U.S. Geological Survey (USGS); ShakeMap indicates the availability of computer-generated maps of ground shaking (earthquake.usgs.gov/earthquakes/search/), produced by the OhioSeis Seismograph Stations (OH). Roman numerals correspond to the Modified Mercalli intensity scale (see fig. A-7). Unless otherwise indicated, felt information is from the USGS (1) CIIM reports and/or (2) PDE Monthly (or) Weekly Listing Files (earthquake.usgs.gov/data/comcat/catalog/us/).
[3]Richter local magnitude (M_L) or coda magnitude (M_d) determined by OhioSeis.

A catalog of all recorded earthquakes in Ohio for 2024 can be found in Table 3. Earthquakes are listed in chronological order.

TABLE 3. ***Catalog of all earthquakes in Ohio in 2024.***[1]

Date	Hour[2]	Minute	Second	Latitude	Longitude	Depth[3] (km)	Mag (M_L)
1/2/24	1	58	59.63	41.741	-80.997	2.75	2.2
1/5/24	8	39	9.94	41.758	-81.008	2.96	1.0
1/5/24	8	47	8.09	41.745	-81.012	2.91	2.2
1/5/24	8	53	4.62	41.783	-80.923	2.67	1.0
1/6/24	1	11	55.16	41.747	-81.013	2.74	1.3
1/7/24	9	8	12.51	41.747	-81.009	3.23	1.0
1/16/24	10	29	37.54	41.807	-81.117	11.90	0.0
1/16/24	17	39	39.28	41.766	-81.049	10.51	2.1
1/26/24	17	11	6.30	39.385	-81.348	3.50	0.2
1/30/24	2	26	4.52	41.774	-81.012	5.08	1.1
2/7/24	9	44	35.17	41.717	-80.996	7.00	0.8
2/9/24	21	5	24.75	39.087	-82.252	9.86	0.7
2/13/24	2	44	39.38	41.715	-80.999	2.79	1.0
2/13/24	4	47	45.18	41.713	-80.998	2.69	1.3
2/15/24	4	23	54.40	40.017	-81.504	3.33	2.0
2/20/24	7	57	30.80	41.716	-80.995	3.06	1.3
2/24/24	4	12	3.95	41.719	-80.991	2.72	1.5
2/27/24	15	2	37.03	40.034	-81.492	2.00	1.7
3/1/24	22	22	7.10	41.747	-81.010	2.63	1.8
3/2/24	19	47	13.20	40.028	-81.468	0.20	0.5
3/2/24	20	25	46.00	40.028	-81.468	0.10	0.6
3/2/24	23	45	9.60	40.029	-81.469	0.50	-0.5
3/3/24	7	8	39.78	41.746	-81.013	2.63	1.0
3/3/24	16	6	19.00	39.406	-81.401	2.60	-0.3
3/3/24	22	22	10.51	40.020	-81.504	2.82	1.5
3/3/24	23	49	48.50	40.029	-81.472	1.80	-0.3
3/18/24	20	58	9.68	41.567	-83.485	2.67	2.0
3/21/24	13	4	9.63	38.753	-82.493	17.49	1.1
3/25/24	22	33	11.57	40.884	-81.053	11.09	1.8
3/27/24	8	35	5.45	40.881	-81.037	7.37	1.6
3/27/24	19	25	49.11	40.880	-81.044	7.50	1.3
3/30/24	8	42	40.21	40.893	-81.031	7.03	3.2
3/30/24	11	26	37.49	40.887	-81.044	2.67	1.9

Date	Hour[2]	Minute	Second	Latitude	Longitude	Depth[3] (km)	Mag (M_L)
3/30/24	21	54	45.78	41.748	-81.007	2.68	1.2
3/30/24	21	55	12.62	41.745	-81.003	2.72	1.3
3/31/24	18	27	29.80	39.386	-81.343	3.00	-0.2
4/1/24	17	57	15.30	40.893	-81.038	2.90	1.4
4/1/24	21	26	9.51	39.101	-82.133	10.40	1.2
4/2/24	4	25	40.50	39.384	-81.346	2.90	-0.6
4/2/24	23	58	28.61	40.886	-81.023	7.30	1.6
4/4/24	2	38	10.89	40.876	-81.045	5.29	1.1
4/4/24	17	10	41.52	41.732	-81.508	7.80	1.9
4/4/24	21	55	26.13	41.739	-81.015	2.50	1.8
4/15/24	5	17	32.05	41.735	-81.047	1.35	2.1
4/22/24	0	12	15.20	41.558	-83.472	2.28	2.5
4/30/24	23	39	53.80	39.409	81.394	3.10	0.0
5/4/24	0	1	3.03	41.744	-81.016	3.10	1.9
5/4/24	10	10	56.49	41.026	-83.792	10.40	2.0
5/12/24	1	27	36.10	39.386	-81.345	2.90	-0.1
5/13/24	4	34	7.30	39.389	-81.343	3.40	-0.5
5/25/24	17	22	53.25	38.653	-82.853	3.18	1.0
5/28/24	1	13	34.60	41.773	-81.023	6.18	1.6
5/30/24	20	54	30.68	41.751	-81.024	6.37	1.4
6/1/24	10	11	44.26	41.809	-81.044	3.21	2.8
6/1/24	10	23	39.44	41.794	-81.058	3.45	1.0
6/1/24	11	14	9.71	41.792	-81.056	2.92	1.7
6/2/24	4	23	26.85	41.802	-81.029	1.43	2.1
6/2/24	11	50	30.40	41.768	-81.027	1.29	1.4
6/4/24	2	5	13.44	41.757	-81.020	7.61	1.2
6/19/24	1	48	43.34	39.403	-81.345	2.50	1.4
6/20/24	13	32	19.70	41.729	-81.006	2.20	1.1
6/20/24	21	49	10.00	41.742	-81.011	1.40	1.9
6/21/24	20	13	23.50	39.383	-81.342	3.00	-0.3
6/22/24	0	16	19.39	41.743	-81.007	5 (fixed)*	1.2
6/28/24	16	48	7.11	41.743	-81.051	3 (fixed)*	1.5
7/13/24	2	9	16.60	39.976	-81.235	4.50	1.2
7/13/24	10	55	20.09	41.733	-81.005	2.17	1.5
7/14/24	7	18	5.50	39.384	-81.345	3.00	-0.7
8/9/24	3	17	54.80	39.389	-81.342	2.70	-0.3

Date	Hour[2]	Minute	Second	Latitude	Longitude	Depth[3] (km)	Mag (M_L)
8/9/24	3	18	0.00	39.389	-81.343	2.90	0.0
8/14/24	2	26	54.62	41.682	-81.471	1.85	1.9
8/20/24	11	43	4.82	39.092	-81.877	5.10	0.8
8/21/24	1	44	30.29	41.744	-81.015	2.03	1.3
8/21/24	11	2	54.00	39.404	-81.405	2.20	-0.6
8/29/24	7	26	54.96	40.432	-84.101	2.60	1.4
8/29/24	22	38	57.83	41.746	-81.011	2.23	1.9
8/30/24	11	26	30.68	39.289	-82.162	5.31	2.0
8/31/24	12	3	37.47	38.718	-83.630	12 (fixed)*	1.4
9/6/24	1	9	42.32	41.743	-81.015	2.20	1.4
9/12/24	20	58	36.18	40.920	-80.680	3.50	1.6
9/27/24	12	3	25.27	41.368	-83.895	2.18	1.7
9/27/24	23	16	12.32	41.731	-81.013	1.68	1.4
9/28/24	4	21	45.03	41.730	-81.013	1.96	1.3
10/4/24	7	50	35.10	39.392	-81.324	1.90	-0.1
10/11/24	9	47	45.35	41.734	-81.010	4.50	1.2
10/16/24	3	26	6.82	41.737	-81.005	4.00	1.1
10/21/24	2	13	28.20	38.646	-82.860	7.90	1.0
10/31/24	4	28	29.17	39.011	-83.774	2.40	1.5
11/2/24	20	2	53.73	39.288	-82.723	5.67	1.3
11/6/24	1	20	16.00	40.343	-81.204	2.10	1.3
11/6/24	1	22	0.20	40.313	-81.190	2.00	0.0
11/6/24	17	17	13.00	40.299	-81.200	3.20	1.6
11/7/24	0	55	3.74	40.319	-81.220	2.41	1.5
11/7/24	2	47	56.58	40.148	-81.505	7.00	0.0
11/7/24	3	4	23.60	40.304	-81.205	5.20	1.1
11/7/24	5	38	8.74	38.800	-83.855	8.50	1.9
11/7/24	10	13	41.60	40.297	-81.207	6.00	0.4
11/7/24	15	34	5.50	40.307	-81.205	8.10	1.2
11/7/24	17	26	51.67	40.324	-81.209	9.77	1.3
11/8/24	2	44	11.80	40.306	-81.189	7.00	1.3
11/8/24	14	50	55.70	40.300	-81.204	5.90	1.0
11/8/24	15	4	19.30	40.345	-81.209	2.10	1.3
11/8/24	15	18	55.30	40.305	-81.203	6.20	1.2
11/8/24	22	23	42.10	40.330	-81.206	2.20	1.0
11/9/24	4	9	49.20	39.405	-81.398	3.00	-0.4

Date	Hour[2]	Minute	Second	Latitude	Longitude	Depth[3] (km)	Mag (M_L)
11/10/24	2	29	12.80	40.330	-81.216	2.10	1.4
11/10/24	3	17	40.16	40.305	-81.208	2.52	1.6
11/10/24	16	45	38.61	40.318	-81.181	3.50	1.3
11/10/24	23	16	44.70	40.294	-81.228	2.10	2.0
11/12/24	5	53	36.60	40.315	-81.204	4.00	0.9
11/13/24	0	1	44.24	40.319	-81.240	6.90	1.8
11/13/24	8	51	23.90	40.333	-81.215	4.40	1.0
11/16/24	7	17	58.79	40.304	-81.181	7.00	1.8
11/16/24	15	6	11.40	40.308	-81.204	3.70	1.0
11/22/24	20	51	14.80	39.385	-81.349	3.30	0.5
11/22/24	22	14	58.10	39.388	-81.340	2.90	0.4
11/25/24	5	36	4.72	40.917	-80.679	1.80	2.0
12/2/24	4	54	51.71	40.319	-81.233	9.74	1.5
12/10/24	5	46	37.90	39.851	-81.505	4.60	1.0
12/10/24	10	51	56.80	39.842	-81.439	3.30	1.3
12/10/24	20	57	4.20	39.861	-81.495	4.70	1.2
12/13/24	6	49	24.70	39.863	-81.497	2.20	1.3
12/16/24	15	31	23.39	41.748	-81.012	4.57	1.6
12/16/24	20	29	29.30	41.739	-81.018	3.03	1.4
12/16/24	21	39	20.00	38.437	-82.457	25.00	3.9
12/18/24	3	52	2.70	41.539	-83.482	2.16	1.3
12/23/24	7	51	22.34	38.907	-82.311	7.23	0.4
12/24/24	19	34	56.07	39.107	-84.052	7.00	0.9
12/29/24	11	46	48.20	41.312	-84.787	5.00	3.3

[1] Earthquakes listed in chronological order.
[2] UTC: Coordinated Universal Time. All earthquake origin times are given in UTC time by hour. UTC is similar to GMT (Greenwich Mean Time). To convert to local time, subtract 5 hours for Eastern Standard Time (EST) and 4 hours for Eastern Daylight Time (EDT).
[3] Earthquake depth listed in km below datum.
* An accurate earthquake depth was not resolved for this event. The earthquake was assigned an average depth of previous seismicity within the Precambrian basement.

ACKNOWLEDGMENTS

The Ohio Seismic Network thanks the following regional seismic operators, institutions, and scientists who assist in the monitoring of earthquake activity in Ohio, in no particular order:

- Ohio Department of Natural Resources, Division of Mineral Resources Management
- Ohio Department of Natural Resources, Division of Oil & Gas Resources Management
- Dr. Paul Friberg, Instrumental Software Technologies, Inc.
- Dr. Mike Brudzinski, Miami University, Oxford, Ohio
- Dr. Dongdong Yao, Chinese University of Geosciences, Wuhan, China

REFERENCES

Friberg, P.A., Besana-Ostman, G.M., Dricker, I., 2014, Characterization of an Earthquake Sequence Triggered by Hydraulic Fracturing in Harrison County, Ohio: Seismological Research Letters, v. 85, no. 6, 13 p.

Klein, F.W., 2014, User's Guide to HYPOINVERSE-2000, a Fortran Program to Solve for Earthquake Locations and Magnitudes (ver. 1.4): USGS Open File Report 02–171, 148 p., last accessed March 11, 2024, at <https://escweb.wr.usgs.gov/content/software/HYPOINVERSE/doc/hyp1.40.pdf>.

APPENDIX

Seismic Network Discussion

Network Performance for 2024

Seismic network performance can be summarized by the availability of the data that it produces to end-product users. There are many reasons seismic data may not be available from a seismic station, mainly owing to communication problems. However, weather-related issues from flooded vaults, lightning strikes, and other power disruptions can also cause outages. Each seismic station has methods of backing up data during power or communication losses such that it can be sent again once these links are reestablished. The Ohio Seismic Network uses tools available from the SAGE DMC to monitor and grade overall network state-of-health and performance. Figure A–1 provides information on network data availability during 2024. Overall, the Ohio Seismic Network exceeded its goal of 80% network data availability for the year with a rating of 90% data availability.

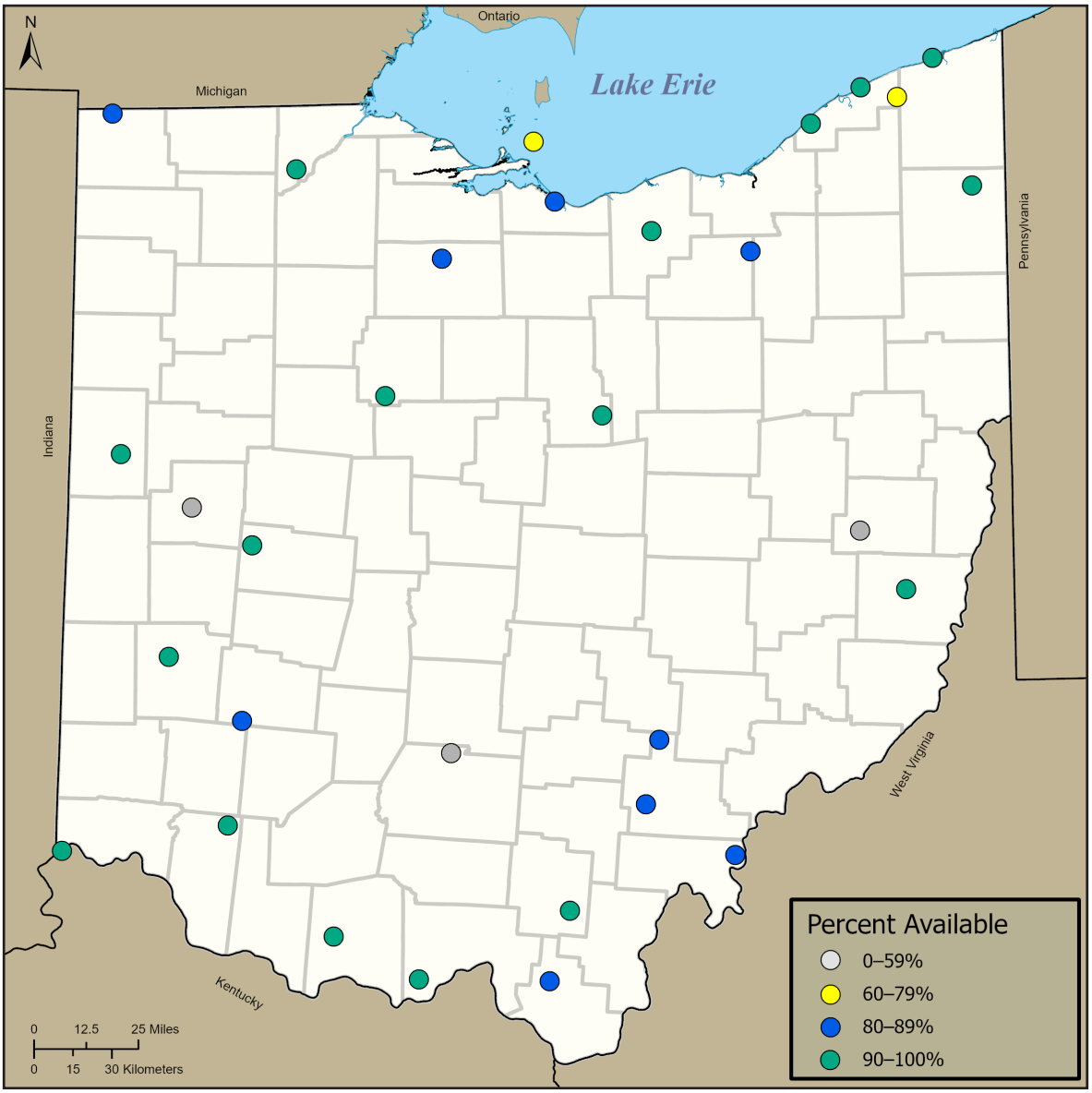


FIGURE A-1. Map of percentage of data availability from each Ohio Seismic Network station during 2024.

Network Maintenance Performed and Installations Completed

In 2024, the Ohio Seismic Network team had another busy summer. One new seismic station was installed (KPOH) in Seneca County (figs. A–2 & A–6) near the city of Tiffin. Several borehole vaults were repaired after water infiltration was discovered, and modems were updated or replaced at all 31 stations. Several stations were converted from either Transportable Array (TA)-style or surface vaults to borehole vaults. Routine annual maintenance of all 31 sites was also completed during the 2024 field season. Another seismic station was installed temporarily, in Lake County (HROH) near the town of Madison to monitor an ongoing swarm of earthquakes occurring there.

The Ohio Seismic Network team had the help of several interns in 2024, who assisted in the installation of the HROH temporary seismic station within the epicentral region of an ongoing swarm of earthquakes (fig. A–3), the repairs of several posthole vaults, general station maintenance, as well as other network activities.

The interns were also involved in the overhaul and upgrades performed at station P49A in southwest Ohio near Oxford (fig. A–4). P49A is a cooperative station belonging to Miami University. This station was a former Transportable Array (TA) site that was adopted by Miami University and is integrated into the Ohio Seismic Network. It provides valuable data about the southwest corner of Ohio and local seismicity there.

The Division of Mineral Resources Management assisted the Geological Survey again by drilling an additional posthole vault in the fall. Station O53A in Harrison County (fig. A–6) was upgraded from a TA vault to a 10-ft-deep posthole-style vault (fig. A–5). New equipment was installed, and the site became operational in late November 2024.

FIGURE A–2. Left: Ohio Seismic Network crews installing station KPOH at Knobbys Prairie Wildlife Area in Seneca County. Right: The seismometer within its surface-style vault enclosure.

FIGURE A–3. Left: ODNR intern installing station HROH in Lake County. Right: ODNR intern performing maintenance at station CROH in Lorain County.

FIGURE A–4. Interns (left) and Ohio Seismic Network staff (right) at station P49A near Miami University in Oxford, Ohio. Several students from Miami University and ODNR were part of this station overhaul.

FIGURE A–5. Drilling and upgrading station O53A in Harrison County.

TABLE A-1. ***Ohio Seismic Network operating seismograph stations in 2024.***

Station Code	Station Name	Latitude	Longitude	Start
BCOH	Blue Creek Metropark	41.5	-83.8	6/14/2019
BGOH	Bowling Green State University Firelands Campus	41.4	-82.6	9/25/2019
BSPO	Barkcamp State Park	40.0	-81.0	4/30/2018
CHOH	Chagrin River Park	41.7	-81.4	8/30/2023
CHWO	Cooper Hollow Wildlife Area	38.9	-82.5	6/8/2018
CPOH	Chaparral Prairie State Nature Preserve	38.8	-83.6	8/26/2019
CROH	Carlisle Reservation	41.3	-82.2	8/8/2023
DSFO	Dean State Forest	38.7	-82.6	10/19/2021
FOXO	Fox Lake Wildlife Area	39.3	-82.2	10/27/2021
HINO	Hinckley Reservation	41.2	-81.7	6/9/2021
HROH	Hogback Ridge Park	41.8	-81.0	7/28/2024
KDOH	Killdeer Plains Wildlife Area	40.7	-83.4	8/8/2019
KIOH	Kelleys Island State Park	41.6	-82.7	7/28/2021
KLOH	Kiser Lake State Park	40.2	-84.0	7/9/2019
KPOH	Knobbys Prairie Wildlife Area	41.2	-83.1	10/23/2024
LEBO	Lake Erie Bluffs Metropark	41.8	-81.2	8/24/2016
LLSO	Lake La Su An Wildlife Area	41.7	-84.6	11/3/2021
M53A	Farmdale	41.4	-80.7	10/16/2015
MFOH	Malabar Farm State Park	40.7	-82.4	7/2/2019
MWLO	Mercer Wildlife Area	40.5	-84.6	5/9/2018
O53A	Freeport	40.2	-81.2	12/13/2012
P51A	Williamsport	39.5	-83.1	9/28/2018
RBOH	Red Brook Metropark	41.9	-80.8	8/29/2023
SLOH	Shawnee Lookout	39.1	-84.8	10/3/2023
SLSO	Stonelick State Park	39.2	-84.1	7/6/2018
SROH	Shade River State Forest	39.1	-81.8	8/26/2019
SSF2	Shawnee State Forest	38.7	-83.1	10/28/2020
SSPO	Sycamore State Park	39.8	-84.3	6/28/2019
SVWO	Spring Valley Wildlife Area	39.6	-84.0	9/1/2021
VLOH	Vernon A Luthman Tecumseh Wildlife Area	40.3	-84.2	7/24/2019
WODO	Wallace H. O'Dowd Wildlife Area	39.5	-82.1	10/20/2021

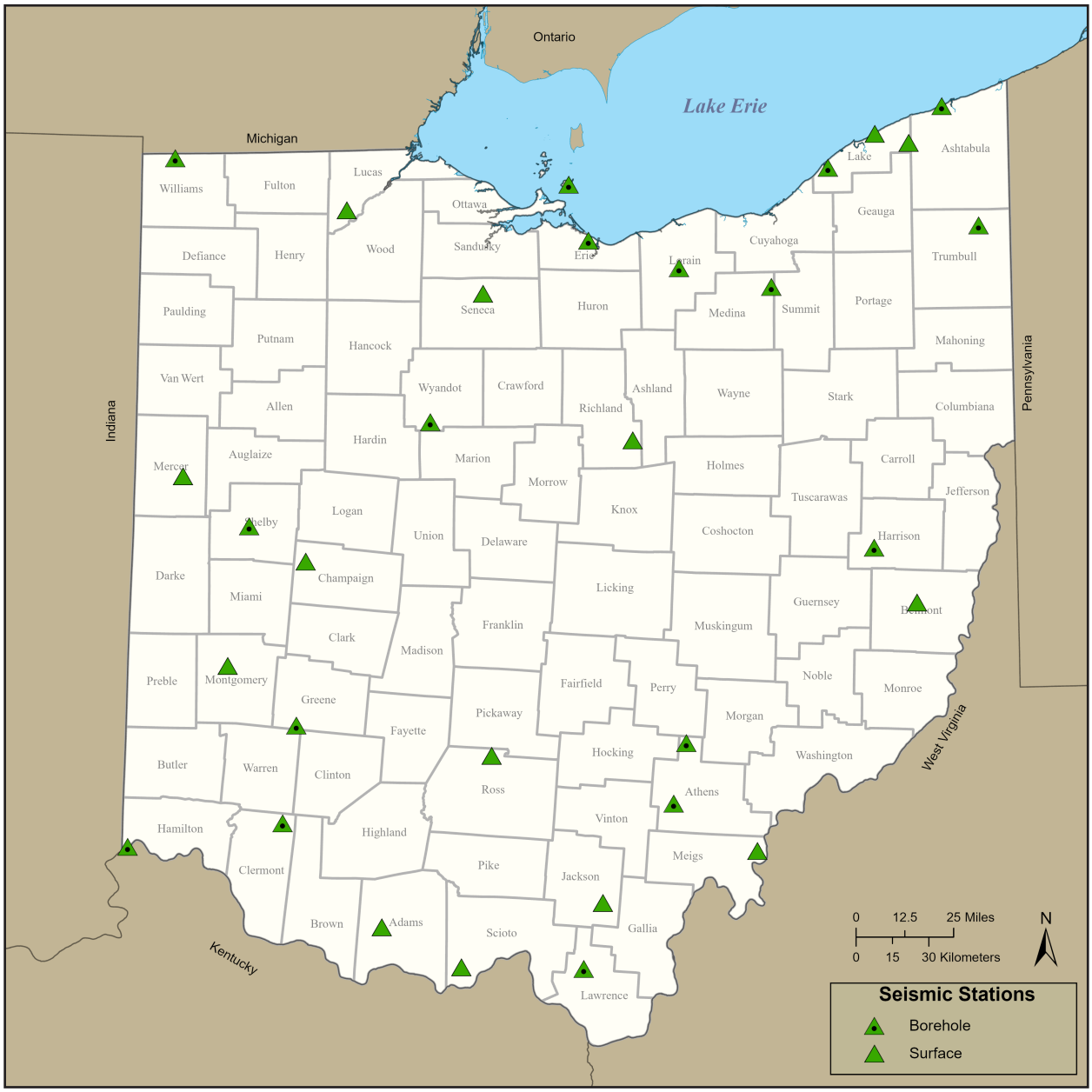


FIGURE A-6. Map of Ohio Seismic Network station locations for 2024.

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

FIGURE A-7. The Modified Mercalli Intensity Scale for earthquake shaking.

OHIO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES

geo.survey@dnr.ohio.gov
(614) 265-6576
geology.ohiodnr.gov