

**2024 Montana Geohazards Workshop—May 1–2, 2024 in Missoula**  
**University Center, Room 330/331, University of Montana, Missoula, MT**

## **Meeting Notes**

### **Day 1, Wednesday May 1, 2024**

#### **9:30AM—Opening remarks, John LaFave, MBMG Research Director**

- Overview of the MBMG as a state agency and its various research programs: Geological Mapping, Ground Water Assessment and Investigation Programs, Economic Geology, Data Preservation, Energy Resources (oil and gas, coal, geothermal), Geohazards Program, and Earthquake Studies Office.

#### **Yann Gavillot, MBMG GeoHazards Program**

- First installment of the annual Montana Geohazards Workshop was in 2022 and since then meetings have grown substantially in 3 years
- Introduced what geohazards are in MT and what can we do to understand and characterize them

#### **Mike Stickney, MBMG Director of Earthquake Studies Office**

- MBMG operates the Montana Regional Seismic Network (MSRN) with a network of 42 permanent seismic stations across the state
- Program started with 3 monitoring stations in the state
  - o USGS stopped funding the sites
  - o MBMG took over
- Yann joined the team and expanded geohazards program beyond seismic monitoring with earthquake hazards studies

#### **In-person quick intros and videos from Senators Tester and Daines**

#### **10:00 AM—Geohazards research and monitoring in Montana**

#### **Yann Gavillot (MBMG), Fault and landslide investigations in southwestern and western Montana**

- Geohazards Program is now close to 4 years old
  - o Active fault studies
  - o Landslide Hazard program
  - o Earthquake Studies Office
- Mapping active faults
  - o Active faults are where we can expect surface-rupturing earthquakes and significant damage
    - Major population growth in Missoula, Kalispell, Bozeman metropolitan areas are all near major active faults
  - o As population increases near earthquake hazards, earthquake risk increases
  - o We need to better tackle and characterize the many poorly understood faults to help our communities to be better prepared.
- Active faults and landslide projects
  - o Ravalli County

- Powell County
- Park County
- Lake County–Flathead Indian Reservation
- LiDAR is a technique that provides new high-resolution data to help identify and map previously unknown landslides and faults in our state.
  - With a combination of LiDAR data and site-specific studies, we can now characterize active faults in more detail for seismic hazards assessments
  - MBMG is producing Quaternary fault maps using county-wide LiDAR data
  - We now have LiDAR data for almost all counties and new faults continue to be discovered
- Landslides
  - MBMG is producing landslide inventory maps
  - Very time consuming as thousands of previously unknown landslides are being discovered across large counties
- MBMG Geohazards GIS Hub Site
  - Quaternary fault database
  - Landslide database
  - Both will be accessible to the public for use
- History of the initial efforts in creating the Montana Geohazards Workshop to bring together scientists, engineers, state agencies, local governments, and stakeholders to discuss geohazards and their potential risks to Montana.
  - Motivation to create a potential seismic safety commission to facilitate these efforts and partnership, which led to the creation of the Montana Earthquake Working Group (MEWG)
- Recap last year's meeting with focus on the Helena earthquakes.
  - Video of Taiwan earthquake and rock fall

#### Review outline and goals of the Missoula meeting

Updates from various agencies across Montana.

- Information session about new results and finding of earthquake hazards in the Bitterroot fault, followed by a discussion on possible mitigation, and preparedness measures in the Bitterroot and Missoula Valleys
- Inception meeting and ratification of the MEWG

#### **Mike Stickney (MBMG), Montana Regional Seismic Network and recent seismicity**

- Overview of historic seismicity in MT
- Broad view of earthquakes over 2.5 M in western U.S.
- Intro to Intermountain Seismic Belt
  - Goes from Utah up through western MT
- Map produced by MBMG of earthquakes in northern Intermountain Seismic Belt
  - Nowhere in MT is safe from earthquakes
  - Most earthquakes occur in western Montana
- Photos showing earthquake damage from past earthquakes
  - Three Forks, 1925

- School building stayed up but lots of falling hazards
    - Jail in White Sulphur Springs (~60 miles away) damaged
    - Railroad system heavily damaged by rockfall and landslides
  - Helena, 1935
    - M 6.3 and M 6 earthquakes
    - Masonry buildings heavily damaged
    - Some total collapse
    - Four casualties, all from falling debris
    - The State Arsenal, built to shelter folks, was heavily damaged and not usable
  - Hebgen Lake, 1959
    - M 7.3
    - Fault ruptured to surface and formed scarp
    - Scarp up to 21 feet of vertical displacement
    - Occurred in a sparsely populated area, but in a popular summer camping area
    - Many fatalities
    - Roads literally shaken apart
    - Major rockfall blocked roads
    - Hebgen Dam remained intact despite heavy damage
    - NE side of valley dropped and the lake outline changed in response
    - Triggered the Madison Slide, the largest seismically triggered landslide in North America
    - Created Earthquake Lake
    - Many strong aftershocks
- Modern Earthquakes
  - Dillon earthquake
    - Felt in Idaho
    - Lots of minor structural damage
  - Lincoln M 5.8
    - Felt Canada to Utah and into South Dakota
    - Strong shaking, cracking of unconsolidated fill
    - Butte buildings had some damage and falling hazards
- Current seismic network
  - We have 45 seismic stations in MT
  - Also record stations in the surrounding states (ID, WA, SD, WY, OR, Canada) and in Yellowstone National Park
- Not all seismicity occurs along recognized faults
  - 9-mile fault
    - no associated earthquakes
  - Jocko fault
    - no associated earthquakes
  - Mission fault
    - Maybe one earthquake
  - There are earthquakes surrounding the above three faults, but no earthquakes are directly attributed to them

- One week ago, a swarm started near Yellowstone National Park and Hebgen Lake
- People like to live near earthquakes
  - o Western MT has had lots of growth

### **John Sanford (MBMG), MBMG GIS Hub Site overview and subsurface fault mapping**

- MBMG GIS Data Hub has links to web apps
- You can view and download data from these web apps
- Query for data
  - o Locations, data type, etc.
  - o Metadata pops up when you click on points
- Metadata also links to info from other agencies
- New project to explore for geothermal energy development
  - o Major powerplants for MT
  - o Using oil + gas exploration techniques
  - o Buying seismic data to characterize subsurface
- Seismic data
  - o Cat scan of the earth
  - o Send sound waves into earth
  - o Changes in lithology change velocity of the waves as they travel
  - o Faults can be easy to spot
  - o Most faults do not break the surface so we cannot map them without seismic data
  - o There are extensive fault networks that don't reach the surface and thus are not mappable
  - o Data are expensive (\$2,000 per linear mile)
  - o Not all earthquakes are proximal to known faults at the surface

### **Hilary Martens (UM), Updates on the University of Montana Seismic Network and on Water-Resource Monitoring in the Western United States**

- First portable seismic recording station deployed following July 2017 earthquake in Lincoln
  - o Multiple stations around Lincoln measured aftershocks
- USGS "Did you feel it?" map of citizens who feel the shaking of earthquakes shows how wide the earthquake was felt
- Most aftershocks aligned N-S, which was a surprise
  - o Expected shocks to be E-W on Lewis and Clark line faults
- After years, noticed there are a series of parallel faults trending N-S perpendicular to the Lewis and Clark line faults
  - o Likely a bookshelf faulting mechanism in effect here
- We can use seismic data to understand structure in the earth
- Created velocity models and compared modern to historic models

### **Water Resource Monitoring**

- Geodetic monitoring
  - o Shape of the earth and how it changes with time
- GNSS
  - o Stations deployed into bedrock to watch ground deformation over time

- Water is sufficient to deform earth
  - o Snow load in mountains can change earth's shape by a couple mm
  - o Ocean tides can flex earth's crust based on where high tide (more water) is
- In Sierra mountains it takes about 1 m of water to displace earth's crust

**Robb Moss (CalPoly), Living with seismic hazards—lessons learned, challenges, and outlook for communities and infrastructure in Montana**

- Critical infrastructure
  - o Rail systems are essential to MT economy and many freight trains come through MT
  - o Many dams and hydro dams in MT
  - o Many fiberoptic lines running across the state
- What's critical to have after an emergency?
  - o Communication
  - o In Chile a massive earthquake wiped out communication in a whole region. People didn't know what was happening and there was mass panic
- Potential failures in a large earthquake
  - o Highways, railroads, buildings
  - o Pipelines cross faults often, sometimes they rupture and explode
  - o Dams on faults
  - o Ground shaking induces landslides and blocks rivers, roads, etc.
  - o Liquefaction
    - Tailings dams fail, airport runways destroyed, highways and bridges damaged
    - Sewer mains become buoyant
    - Can be the costliest hazard
- Be cognizant of possible hazards and what we're trying to protect
- Redundancy, Resilience, and Repairability are the three R's
- Generating money beforehand is really hard, generally it takes a tragic event to get us thinking about it. Post-event readiness is more doable. There's a 6-month window after an event when politicians are happy to give money.

**Becks Bendick (EarthScope), Overview of the EarthScope Consortium and GPS/GNSS network in Montana**

- EarthScope organization supports geophysical infrastructure
- Non-profit consortium of about 250 U.S.-based and about 200 international organizations
- Seismic Advancement of Geosciences (SAGE)
- Geodetic Advancement of Geosciences (GAGE)
- Operates global seismic network, Global geodetic network, and Network of the Americas (GNSS constellations)
- General science support
- Cyber infrastructure
  - o Real-time monitoring data for landslides, water loads, general sensor data streams, etc.
- ShakeAlert
  - o All of western U.S. (Pacific coast) has seismic monitors connected to a centralized database, and if an event happens an early alert will be sent out. It will shut down nuclear plants, rail lines, etc.

- Global Seismic
  - o Tsunami warnings
  - o Response to large events
- Space weather
  - o Forecasting and warnings for solar storms and such
- Real-time positioning
  - o Real-time GNSS from Network of the Americas
  - o Used in self-driving cars, etc.

## **1:00 PM—Presentations and updates from agencies across Montana**

### **Andrew Long (MT-DES)**

- Grant programs
  - o Disaster funding (presidentially declared)
  - o Non-disaster funding
  - o BRIC and HMGP
  - o Grants can be used for outreach, research, mapping, infrastructure, etc.
    - As long as there are tangible deliverables
    - 10% of costs can be allocated to dissemination of info (workshops, outreach, etc.)
  - o Project types
    - Structural Retrofits
      - Automated isolation valves with seismic sensors for reservoirs, etc.
    - Mapping
      - NEHRP
    - Non structural
      - Anchoring bookshelves
      - Water heater stabilization
      - Chimney bracing
    - Scoping
      - Mapping and surveying
      - Inventory of URM buildings
- Nearly \$2 million for mitigation of fire and two flooding events last year came from BRIC

### **Jeff Jackson (Montana Department of Transportation)**

- Transportation hazards encountered include landslides, rockslides, rockfalls, earthquakes, avalanches, subsidence, frost heaves, swelling clays, flooding, erosion
- Management style has been reactive so far
  - o Not much maintenance
  - o Mostly replacing things
- Collect data on pavement and bridges every year to monitor stability
- No real geo-asset management
- Recently created position for Geohazard assessment program manager
- Rockfall asset management program (RAMP)
  - o Inventory and rate each rock slope adjacent to MT highways (about 1,800)

- Cost to replace all is \$4–5 billion if needed to replace now
- Could save around \$7 million per year with proactive preservation of rock slope
- GIS database with hazard rankings, risks, traffic, road curves, etc.
- Other hazard programs
  - Rockslide projects
  - Landslide projects
  - Retaining wall program starting
  - Seismic design near bridges
  - LiDAR on MDoT maintained slopes
  - Drones to frequently monitor areas
- Future
  - Pursue dedicated funding to Geotech asset management
  - Aging infrastructure, where does funding come from? Highways, etc.

### **Jeff Blend (MT-DEQ)**

- Purpose and scope
  - Coordinates state's efforts in restoration and protection of Montana's critical electric, gas, and liquid fuels infrastructure
  - Energy emergency is a shortage or price spike in energy that curtails supply of energy
    - Can be small and last a few hours or a major disaster
- Stakeholders include anyone who has ever used energy
- Liquid fuels
  - Natural gas transmission systems are in high-consequence areas, seismically speaking
  - There is little to no redundancy in these pipelines
  - One refined product pipeline supplies most of western MT

### **Troy Blandford (Montana State Library)**

- Montana LIDAR started as small projects along waterways
- In 2019 a MT LIDAR plan was established to complete statewide LIDAR
- Many funding partners at local, state, and federal levels
- The entire state has been flown in QA/QC
- All LIDAR available through MSL and LIDAR inventory and USGS national map
- MSL
  - Online application with a county-wide mosaic
  - Bare earth DEM, Hillshade, DSM 1-meter, canopy height, intensity image
  - NO point cloud data (can request it), 1 ft contours, flight lines and date
  - LIDAR for the full state of MT has been flown and is currently being processed
- USGS
  - If LIDAR falls outside MT
  - Newest of new data will be USGS first
  - Single counties may show up first in USGS
  - USGS only has what meets 3DEP specs
- Montana state reference network—Surveyors may like this

### **Sean McGowan/Michael Sawyer (FEMA)**

- If you identify a hazard, how do you get to mitigation funding?
  - o Identify hazard
  - o BRIC Direct technical assistance
    - 3-year partnership to pursue funding
  - o Hazard mitigation plan
  - o Partnership development
    - Need to use relationships and coordinate with FEMA
  - o Project scope
    - Benefit cost analysis
    - FEMA can help get your organization ready
  - o Application support and review
    - There is a specific program in Region 8 to provide application support and review
    - They will review the application to be sure it's competitive and meets requirements
- Funding Streams
  - o Disaster cycle
    - Public assistance
    - Hazard mitigation
- Examples
  - o Davis County, Utah
    - Pipeline retrofit
    - 20 million
  - o UM Western
    - Seismic retrofit to a 120-year-old brick building
  - o LA Hospital
    - Non-structure retrofit to bolt equipment to walls
  - o Alaska building codes
    - Earthquake devastated the region
    - New building codes were created
    - In 2018 a large earthquake happened and there were no deaths and no large-scale damage
  - o Montana
    - Adopted new building codes in 2021

**Matt Wagner (Resilience Action Partners)**

- FEMA, Utah K-12 public schools unreinforced masonry (URM) risk reduction
  - o 43% chance M 6.7 earthquake in SLC in the next 50 years
  - o Estimated \$80 billion in damage
- A M 5.3 earthquake happened in SLC just after COVID started...no fatalities because no one was in public spaces
- How do we reduce this risk?
  - o People who get fearful and sad dig in and don't create change
  - o People who get a little fired up/mad do create change



- After the M 5.3, folks got a little fired up and created Utah K-12 public schools URM risk reduction
- Reduce URM in public schools
- Workshop
  - What's the risk and what can be done
  - What can the school district do?
  - Community engagement, risk communication workshop so schools can talk to the parents
- Three school districts have applied to and/or received grants from FEMA to solve their issues
- Examples of CERC activities in Montana
  - Workshops and trainings
  - Materials and guides
  - Community engagement projects
- Sharing stories of how disaster events changed lives is the best way to get others involved and want to be prepared.
- How to support earthquake safety in MT
  - Operationally support a MT earthquake working group or Safety commission
    - Keep the organization alive and schedule meetings
  - Rapid visual screenings assistance
    - Take inventory of schools to see how many URM schools we have
  - Communication and community awareness plan
    - When there is no info out there, people like to make things up, let's prevent that
  - Community equity screening to help inform solution avenues
    - Develop a dashboard for schools identified as risky
  - School district engagement
    - How to talk to folks so they don't get scared
    - Risk communication
  - Inventory release support
    - Support the development of a hazard mitigation plan and connect to funding sources

**Anna Lang (Zylient, Inc.; EERI)**

- Earthquakes are the highest risk hazard in all the U.S., but the funding does not match that
- Montana's biggest hazard is wildfire, then earthquake, then flooding
- We don't have big earthquakes every year, but when we have them, they are devastating
- Vulnerabilities
  - Existing buildings
    - Public buildings
    - Residential buildings
  - Capacity
    - Building codes are locally governed and inconstantly followed
    - New airport in Kalispell has structural flaws
  - New buildings
    - Built to code does not mean built to last

- A building built to code has a 10% probability to collapse
- Christchurch
  - 50% of new buildings were destroyed
  - Did building codes perform as expected
    - General public: No
    - Structural engineers: Yes
  - Community resilience is key
- How do we reduce our risk?
  - Existing buildings
    - Retrofit buildings, outreach with community, lots of meetings
    - Parapet ordinance
  - New buildings
    - Political reports
    - Building departments need help
    - Adopt latest codes
  - Capacity building
  - Community Resilience

### 3:15PM—Earthquake Hazards for the Bitterroot Valley and Missoula metropolitan area

**Yann Gavillot (MBMG)**, Recent results from Bitterroot fault earthquake hazards studies in geological mapping, slip rates, and prehistoric earthquakes

- Bitterroot fault
  - About 60 miles long (100 km)
  - The longer the fault, the higher potential for earthquakes
  - There's a growing population around the fault
  - Slips at 0.2–0.3 mm/yr
  - Does an ice load change the slip rate?
- Trenching
  - Dig large trenches to look for prehistoric earthquake history
  - Likely there are least two earthquake events, with one at ~17 ka and the other at ~11 ka
  - Suggest the fault could generate full-length rupturing earthquake as a single event as opposed to separate segmented fault ruptures
- Lake Como coring
  - Collected lake bed sediments involved with shaking
  - Found two discrete events (turbidites)
- Fault subsurface geometry is a big unknown with end-member fault models (low versus high angle) significantly affecting the severity of the risk across the Bitterroot Valley.

**Robb Moss (CalPoly)**, Preliminary results for probabilistic fault displacement hazards mapping in the Bitterroot Valley

- Historical events
  - Borah peak M6.9
  - Hebgen Lake M 7.2
  - Pleasant Valley M 7.2

- Displacement doesn't always happen on the faults; it can happen meters away from the faults
- Slip rates really affect offset models. 2 mm slip rate is ~2 m offset while 3 mm offset is 4 m offset
- Primary displacement of the Bitterroot fault shows ~3 m offset in the middle of the fault and ~2 m at the ends
- Path forward
  - o Create new models
  - o Calibrate with paleo-seismic info from trenches
  - o Present fine resolution maps

**Missoula DES office:** Mitigation and Disaster planning strategies for the city of Missoula and Bitterroot Valley

- We likely are not ready for earthquakes
- Earthquakes are always in the top five hazards in the county but we don't often have resources to investigate and improve our readiness because budget gets eaten by fires and floods.

## **Day 2, Thursday May 2, 2024**

### **9:30 AM—Inception Meeting of the Montana Earthquake Working Group (MEWG)**

#### *Montana Earthquake Working Group (MEWG)*

- After 2023 meeting a Letter of Intent was drafted and is now signed by multiple agencies
- The letter requested partnership approval: *“I support the effort to better understand geohazards and mitigate geohazards risk”* and is non-binding. This letter served to confirm their interest to join MEWG as a member.

#### *Current Members*

- MBMG
- MT DES
- University of Montana (UM)
- MT DOT
- MSL (Montana State Library)

#### *Prospective Members*

- EERI (Earthquake Engineers Research Institute; now a member)
- DNRC
- RML (Rocky Mountain Lab; now a member)
- MT Association of Counties (MACo)
- Office of Indian Affairs
- Helena School District (now a member)
- Ravalli School District
- Missoula schools
- Missoula County
- Beaverhead County
- Lewis and Clark County
- Montana Insurance Commissioner's office
- Montana Public Services Commission
- Montana Rail Link
- Montana Department of Labor and Industry
- NW Energy

#### *Three components*

1. Earthquake research
2. Mitigation
3. Public education/outreach

#### *Draft of a Mission statement modeled after Utah seismic safety commissions*

- We want to bring together multiple state agencies and private sectors to better understand earthquake risk and reduce losses in MT.

#### *MEWG structure*

- Pyramid hierarchy
- MBMG cannot legally be the leader of MEWG because we are a non-regulatory agency and this working group conflicts with the MBMG mission statement and functionality.
- MBMG is happy to be the face of MEWG for now and to house a MEWG webpage in the interim but this has to be short term
- Core Members
  - o MBMG
  - o DES
  - o UM
- Contributors

- MDOT
- MSL
- Others
- Facilitators
  - FEMA
    - BRIC for 3 years of funding, but can this be a sustainable, long-term funding source?
    - Can we get legislature to authorize funding for MEWG after the 3 years?
    - FEMA doesn't think they can do a good job facilitating and it should be a MT agency
- Chair or Co-Chair
  - New staff? Existing group leaders?
- Subcommittees
  - Earthquake research
  - Mitigation strategies
  - Awareness activities

#### *Funding*

- If you're legislatively enacted, your recommendations have more weight
- If we become a regulatory commission, we have to worry about funding year after year
- If we stay as a Working Group, we need to keep chasing grants, but we don't have to be so involved in politicking to have funding
- Do we make members pay a membership fee?

#### *We need an inventory of buildings in MT that don't meet safety standards*

- But we need to have a list of action items to give to these schools/building owners to help them

#### *We need to be welcoming to other entities so they can readily join if an event happens. We don't want another similar group to form with the same or slightly similar goals and take resources*

#### *Preparedness*

- We need a MT plan for what happens after an event and who is involved in the response
- Need an earthquake clearinghouse plan
- We need to run tabletop exercises every few years and make sure to train folks on what happens after the 72-hour mark following an event. Most exercises end around 72 hours post-event. When events happen, things fall apart after 72 hours because people aren't trained
- Can we run a public-facing tabletop exercise and what would that look like?
- Prepositioning equipment and how can we do that?
  - Raspberry Shake at every school? What else?
- We need a strategic plan
  - We can have sub-plans that lead to an overall plan

#### *How can we limit the burden and workload on schools and other orgs?*

- FEMA has resiliency dollars that can offset the 25% cost share of the school/org.

#### *Geohazards working group vs. earthquake working group*

- What about volcanic hazards? What about landslides? What about other geohazards?
- Is MEWG an earthquake-only working group?

- MEWG will cover earthquakes and landslides and other similar events; earthquake is just the face of the working group because earthquakes are the “sexier science.”
- YVO and CVO cover the volcanic hazards

*How do we get people engaged and on our side?*

- Risk communication training for MEWG members
- It’s a proven method to communicate emergency response steps
- FEMA has this training plan and it’s free
- What about crisis communication?
  - o What are the likely major events to happen?
  - o What do we do when a crisis hits?
- Risk communication
  - o Are people aware?
  - o Do they believe in a solution?
  - o Sticking around long enough to meet solution
- Educate the public

*Where do we go from here?*

- Build a strategic plan with objectives
- While working toward the objectives, there will be action items
- This will eventually lead to a tabletop with high-level folks (legislators, military, etc.)

*How do we assign people to roles? Are we at that point now?*

- For an incident management team
- Assign roles and divisions
- Are we ready for that? Do we need a core group with sub-committees first?
- Then engage a strategic plan
- There are free modules by FEMA that can help us with a framework and creating/filling roles

*We need someone to step up and take on some responsibility*

- This doesn’t have to be a major project right away
- Small pilot projects are a good place to start and trial run things
- But overall, we NEED someone or an agency to take this on
- DES doesn’t think they have the capabilities to host the MEWG website
- DES is happy to participate but doesn’t want to chair

*How do we avoid having this same conversation next year?*

- **Establish core members by 30 June**
- **Establish sub-committees by 30 August**
- We need strong local and state buy-in
- We need to think about multi-year funding for the chair of the group
- The minute FEMA leaves, things die out
  - o How do we keep that from happening?
  - o LOCAL BUY IN
- We’ve missed the 2025 legislature money ask
  - o Citizens can talk to reps and get bills pushed forward
- We can use grants to get us to the 2027 legislature and get funding for the chair

- Make sure we have the right state agencies at the table to ask

*Create sign-up sheets for the three components*