Engaging with Earthquake Hazard and Risk

Hazards affect the built environment of our communities during an earthquake. Built environment refers to the human-made physical spaces where we live, recreate and work including buildings, furnishings, open and public spaces, roads, utilities and other infrastructure.

There are many factors that influence how much damage a particular structure may experience during an earthquake. Even during the same earthquake, shaking intensity can vary across a city due to local differences in such aspects as the soil or rock type, topography, and water saturation. In addition to differences in the geology, there are many factors related to structures themselves, such as building materials, construction design, building codes, and more.

Building damaged in 2011 Christchurch earthquake. Wikipedia, Martin Luff

This activity is designed to engage learners in the study of earthquake hazards and the risk these hazards pose to humans in the communities in which we live. Learners will compare three maps of Anchorage, AK, depicting spatial information related to seismic hazards to generate questions about the factors that influence shaking intensity and damage to the built environment during earthquakes.

Essential Questions:

- How do earthquakes impact humans and our environment?
- Why do some buildings become damaged from an earthquake?

Essential Understandings:

- Severity of shaking at a given location during an earthquake can vary with geologic site effects
- Severity of damage experienced by structures can vary due to factors related to their design and construction

Goals

Learners will:

- Recognize that shaking intensity varies with location during the same earthquake event
- Understand that seismic hazard maps are useful planning tools, but they are not predictive of damage to structures during an earthquake
- Generate questions about the factors, in addition to geologic site effects, that may contribute to severity of damage experienced by structures

Materials

- Washable markers
- Map A: Peak Ground Acceleration Readings in Anchorage, AK, During the 2016 M7.1 Pedro Bay (Iniskin) and the 2018 M7.1 Point Mackenzie earthquakes
- Map B: Anchorage, AK, Seismic Hazard Map (Department of Geological & Geophysical Surveys publication MP32)
- Map C: Structures damaged in the 2018 M7.1 Point Mackenzie (Anchorage) earthquake
- Animation Module 4 – Effect of Soil and Rock on Shaking https://www.iris.edu/hq/inclass/animation/module_4effect_of_rock_and_soil_on_shaking
- Computer simulation of the M7.1 Pedro Bay (Iniskin) Earthquake https://www.youtube.com/watch?v=KdiETNfyaUo

NGSS Science Standards

- **MS-ESS2-2** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales
- **HS-ESS3-1** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity
- **ESS2.B Plate Tectonics and Large-Scale System Interactions:** Plate tectonics is the unifying theory that explains the movements of rocks at Earth's surface and geologic history
- **ESS3.B Natural Hazards**. Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations

Teacher Background & Instructions

Teacher Background:

For more background on seismic intensity, see the Incorporated Research Institutions for Seismology animations Earthquake Intensity – Introduction to 4 Modules (note you may find these useful to show to your learners): https://www.iris.edu/hq/inclass/animation/intensityintroduction_to_4_modules

For more information about geologic Site Effects, see the Pacific Northwest Seismic Network article at https://pnsn.org/outreach/earthquakehazards/site-effects

Map A shows the local variation in shaking that can happen due to site effects. Figure a) shows the 2016 M7.1 San Pedro (Iniskin) earthquake, and Figure b) shows the 2018 M7.1 Point MacKenzie (Anchorage) earthquake. Note the differences in the maximum accelerations measured in these events: the 2016 Pedro Bay shows a maximum acceleration of 15% of the acceleration due to gravity (g), whereas the 2018 M7.1 shows a maximum acceleration of 40% g. The shaking in 2018 was much greater in Anchorage due to the much closer proximity to the rupture. Both earthquakes are included for comparison purposes: the 2018 earthquake (Map A, Figure b) is the same earthquake that caused the damage in Map C; the 2016 earthquake (Map A, Figure a) is the earthquake that was depicted in the computer simulation created by Carl Tape.

For more information about the 2016 Pedro Bay (Iniskin) and/or 2018 Point MacKenzie (Anchorage) earthquakes, see the USGS Event Pages

2016 M7.1 San Pedro (Iniskin) earthquake: https://earthquake.usgs.gov/earthquakes/eventpage/ak01613v15nv/executive

2018 M7.1 Point MacKenzie (Anchorage) earthquake: https://earthquake.usgs.gov/earthquakes/eventpage/ak20419010/executive

Instructional Sequence:

Step 1: Group students in pairs or small groups. Distribute Map A and orient students to what the map is depicting. Explain that the map shows seismograms from 28 seismometers installed around Anchorage. The seismograms show the acceleration of the ground that was measured by the seismometers during two earthquakes: January 24, 2016, M7.1 Pedro Bay, and November 30, 2018 Point Mackenzie (Anchorage). Note that the scales are different for the two earthquakes: the 2016 Pedro Bay shows a maximum acceleration of 15% of the acceleration due to gravity (g), whereas the 2018 M7.1 shows a maximum acceleration of 40% g.

Step 2: Use the Think-Pair-Share strategy:

- Ask individual students: What do you notice about the seismograms?
- Have students share their initial thoughts in pairs and refine their observations.
- Ask one or two student groups to share their thinking with the class

Step 3: Have student pairs speculate on what might cause these differences in shaking. Compile their thoughts on chart paper or a white board.

Step 4: View the animation *Module 4 – Effect of Soil and Rock on Shaking* to introduce the idea that ground shaking can vary based on local site effects, such as the type of soil or rock, the saturation (wetness) of the soil. See the article on Site Effects for some teacher background.

Step 5: View the computer simulation of the Pedro Bay (Iniskin) earthquake on YouTube. Note how the waves focus along Cook Inlet, which illustrates site effects of the topography and depth of sediment in this geographical feature. Also note how the waves refract across geographical boundaries, and then recombine and superimpose in complicated ways. Such wave superposition would also result in some of the variation seen in the seismograms for this quake in Anchorage.

Step 6: Distribute Map B to students, and orient them to what the map is depicting. This map, produced by the Department of Geological & Geophysical Surveys, shows the projected susceptibility of the land to ground failure such as landslides and liquefaction during earthquake shaking.

Step 7: Use the Think-Pair-Share strategy:

- Ask individual students: Do you see any patterns to the high hazard (red & orange) areas?
- Have students share their initial thoughts in pairs and refine their observations.
- Ask one or two student groups to share their thinking with the class

Step 8: Distribute Map C to students, and orient them to what the map is depicting. This map shows the distribution of damaged buildings as determined by inspections after the 2018 M7.1 Point MacKenzie (Anchorage) earthquake.

Step 9: Use the Think-Pair-Share strategy:

- Ask individual students: Do you see any patterns to the building damage? What more would you want to know about these buildings?
- Have students share their initial thoughts in pairs and refine their observations and questions.
- Ask one or two student groups to share their thinking with the class

Step 10: Assign student pairs to compare two of the maps. Each group will compare the Anchorage Seismic Hazard Map (Map B) to either Map A (Shaking) or Map C (Damage).

Students compare various locations on both maps and make a claim based on evidence: How does the seismic hazard zone compare to the damage and/or shaking you might experience during an earthquake? *Note: if maps are provided in laminated hard copy, students may use the dry erase markers to annotate the maps to make comparisons easier.*

Use the following guiding questions:

- If the seismic hazard color is green or yellow, does that mean you WILL NOT experience higher shaking and/or damage during an earthquake?
- If the seismic hazard color is red or orange, does that mean you WILL experience higher shaking and/or damage during an earthquake?

Step 11: In whole group, discuss how the seismic hazard map might be used by city planners. Note: the shaking during the 2018 M7.1 Point MacKenzie earthquake only lasted ~30 seconds, and not many ground failures occurred. However, the potential for ground failures remains higher in the red and orange zones. Ask students, if you were the City Manager, would you allow schools or hospitals to be built in a red or orange zone?

Step 12: Wrap-up by setting the stage for future learning. The activity *Geologic Hazards and the Built Environment* provides the opportunity for more in-depth research on the factors that affect the seismic stability of the buildings and structures within communities. You may also choose to learn more about the geological effects of earthquake shaking by selecting activities in ANGLE Curricular Pathway 3: Magnitude & Intensity (https://serc.carleton.edu/ANGLE/educational_materials/pathways/path3.html)

Map A

The acceleration of shaking from sensors placed at various locations around Anchorage are shown in the following maps, produced by Lea Gardine, the Alaska Earthquake Center.

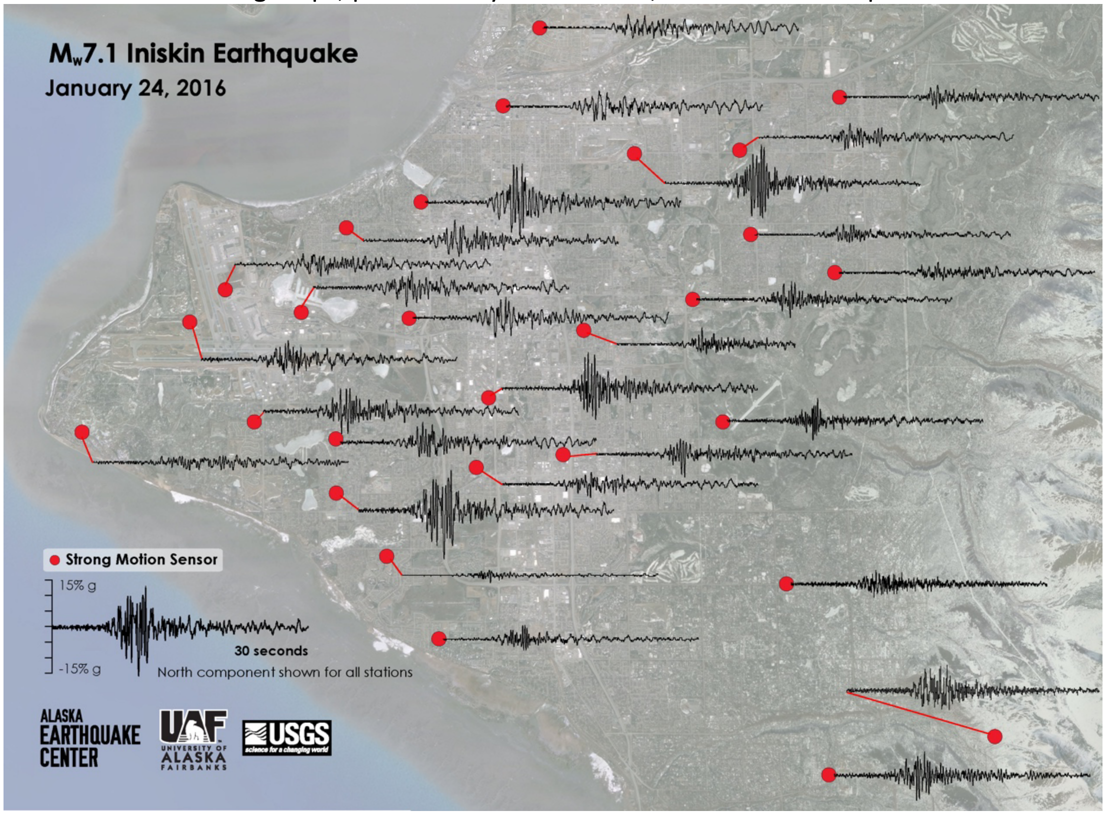


Figure a) Shaking during the M7.1 Pedro Bay (Iniskin) earthquake on January 24, 2016. In the scale, 15%g indicates acceleration 15% as strong as the acceleration due to gravity.

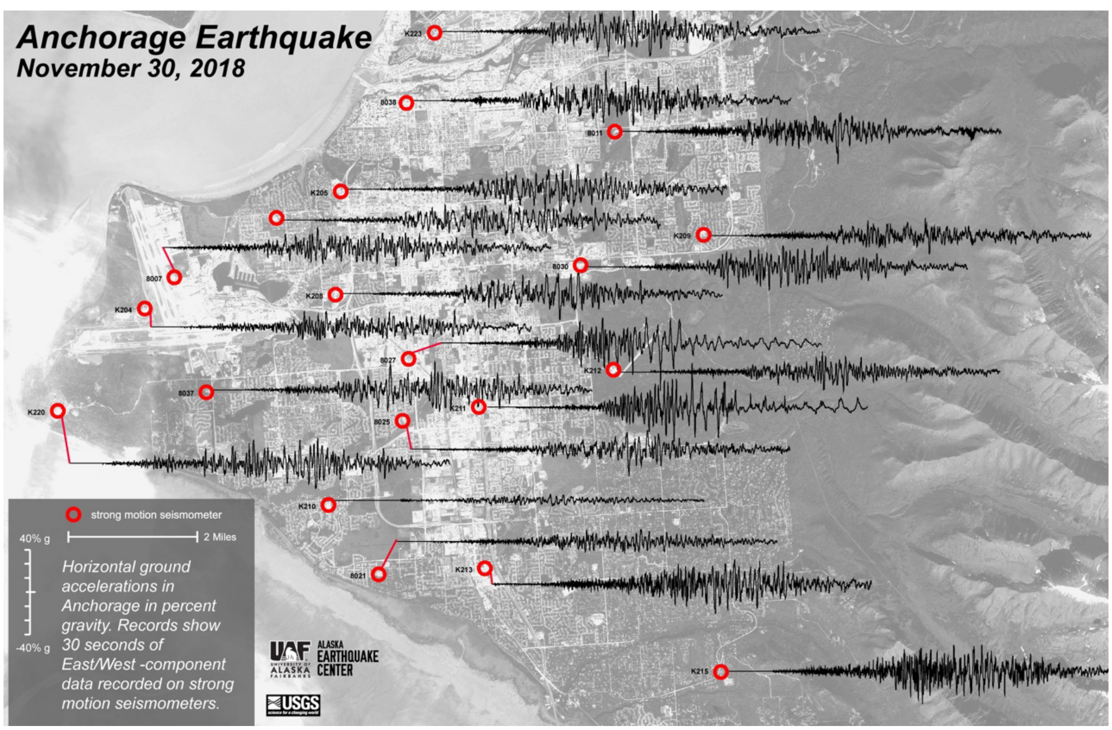
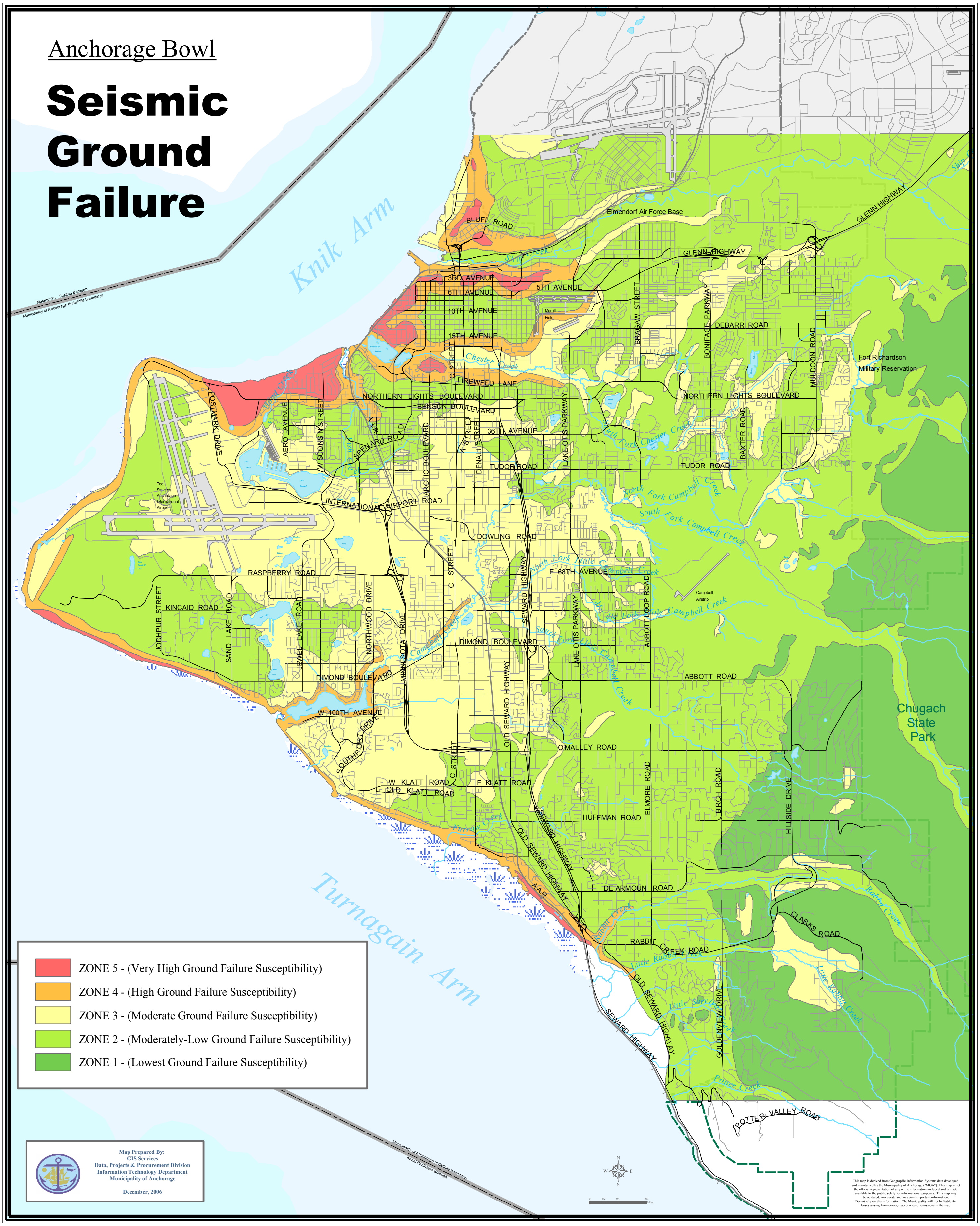


Figure b) Shaking during the M7.1 Point MacKenzie earthquake on November 30, 2018. In the scale, 40%g indicates acceleration 40% as strong as the acceleration due to gravity.

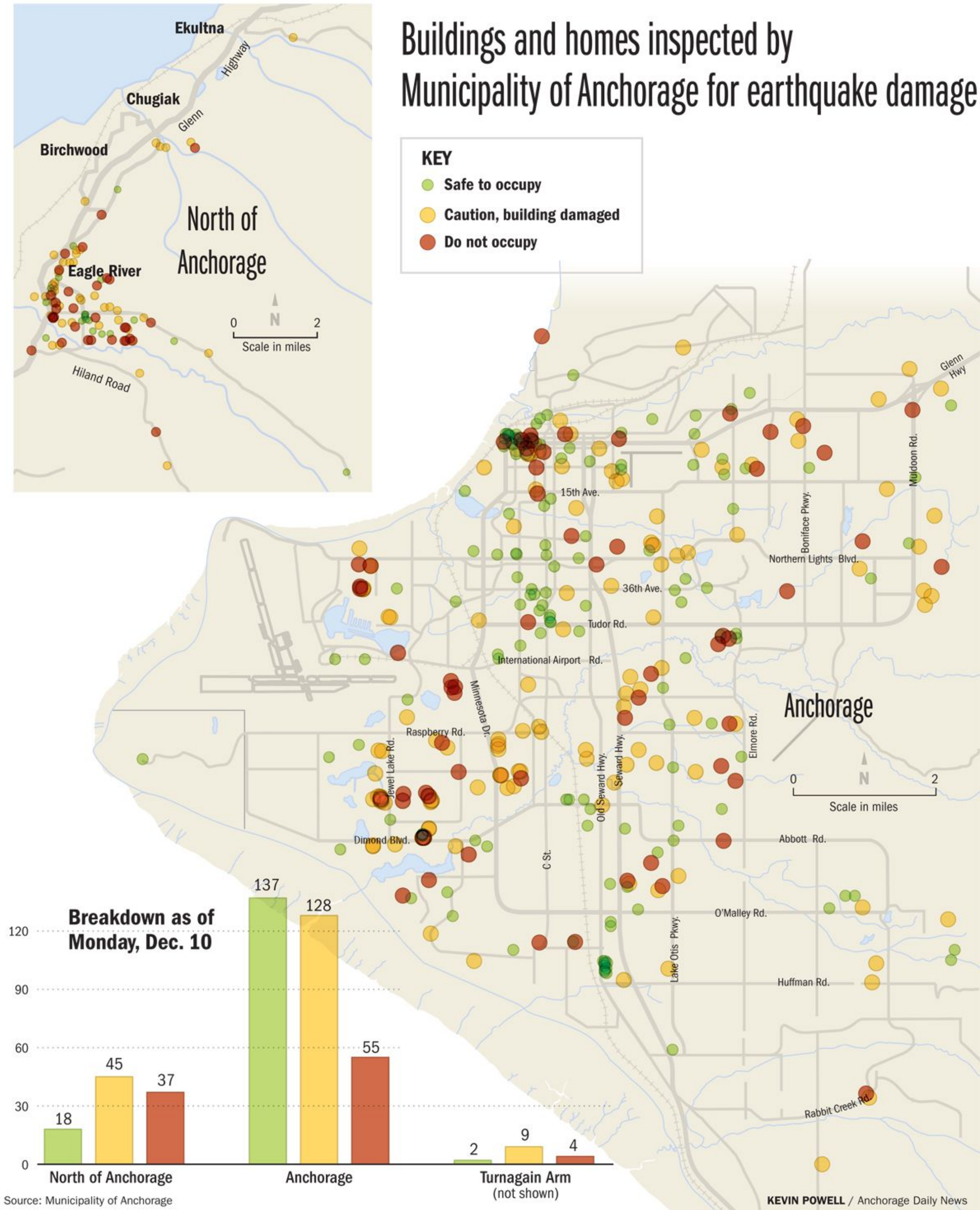
MAP B



Anchorage Bowl
Seismic Ground Failure
Knik Arm
Turnagain Arm
Elmendorf Air Force Base
Fort Richardson Military Reservation
Chugach State Park
Ted Stevens Anchorage International Airport
Merrill Field
Campbell Airstrip
GLENN HIGHWAY
BLUFF ROAD
3RD AVENUE
5TH AVENUE
6TH AVENUE
10TH AVENUE
15TH AVENUE
FIREWEED LANE
NORTHERN LIGHTS BOULEVARD
BENSON BOULEVARD
36TH AVENUE
TUDOR ROAD
DEBARR ROAD
BRAGAW STREET
BONIFACE PARKWAY
BAXTER ROAD
MULDOON ROAD
LAKE OTIS PARKWAY
POSTMARK DRIVE
AERO AVENUE
WISCONSIN STREET
SPENARD ROAD
ARCTIC BOULEVARD
A STREET
DENALI STREET
C STREET
INTERNATIONAL AIRPORT ROAD
DOWLING ROAD
RASPBERRY ROAD
E 68TH AVENUE
KINCAID ROAD
JODHPUR STREET
SAND LAKE ROAD
JEWEL LAKE ROAD
NORTHWOOD DRIVE
MINNESOTA DRIVE
SEWARD HIGHWAY
OLD SEWARD HIGHWAY
DIMOND BOULEVARD
ABBOTT LOOP ROAD
ABBOTT ROAD
W 100TH AVENUE
SOUTHPORT DRIVE
O'MALLEY ROAD
W KLATT ROAD
OLD KLATT ROAD
E KLATT ROAD
ELMORE ROAD
BIRCH ROAD
HILLSIDE DRIVE
HUFFMAN ROAD
DE ARMOUN ROAD
RABBIT CREEK ROAD
CLARKS ROAD
GOLDENVIEW DRIVE
POTTER VALLEY ROAD
A.A.R.
Chester Creek
North Fork Campbell Creek
South Fork Campbell Creek
Campbell Creek
Furrow Creek
Rabbit Creek
Little Rabbit Creek
Potter Creek
ZONE 5 - (Very High Ground Failure Susceptibility)
ZONE 4 - (High Ground Failure Susceptibility)
ZONE 3 - (Moderate Ground Failure Susceptibility)
ZONE 2 - (Moderately-Low Ground Failure Susceptibility)
ZONE 1 - (Lowest Ground Failure Susceptibility)
Map Prepared By:
GIS Services
Data, Projects & Procurement Division
Information Technology Department
Municipality of Anchorage
December, 2006

MAP C

Figure from article from the Anchorage Daily News after the 7.1M earthquake on November 30, 2018, titled ***New maps and data show widespread Anchorage earthquake damage and more than 100 unsafe buildings,*** by Devin Kelly and Zaz Hollander.



Buildings and homes inspected by the Municipality of Anchorage for earthquake damage.

Accessed at https://www.adn.com/alaska-news/2018/12/11/new-maps-and-data-show-widespread-anchorage-earthquake-damage-and-more-than-100-unsafe-buildings/#_