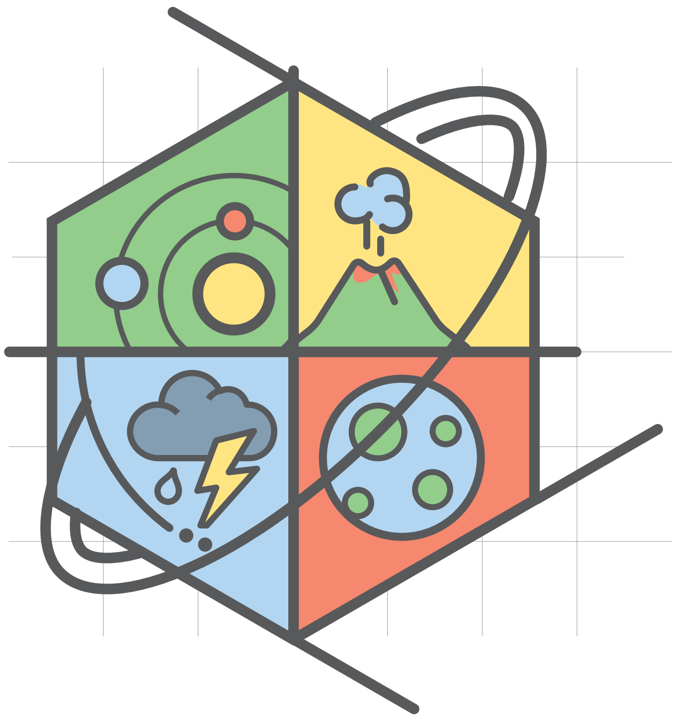

Is the Pacific Northwest a Safe Place to Live?

Middle School NGSS Unit

A digital copy of this document is available on the STEM Materials Center website at:
https://www.stemmaterials.org/is-the-pacific-northwest-a-safe-place-to-live/

STEM
Science
Technology
Engineering
Math

A program of Educational Service District 112 supporting Next Generation Science Standards

Background on the Core Scientific Ideas in this Unit

1. Major tectonic hazards in the Pacific Northwest (PNW) are due to the subduction of the Juan de Fuca plate beneath the North American Plate. Convection Currents / Slab Pull in the mantle material cause the Juan de Fuca plate to subduct under the North American Plate. Asperities cause motion to be rough, and elastic energy builds up when friction due to asperities is greater than the drag force / pulling force on the plates. Elastic deformation in the land also occurs; when plate movement forces become greater than the frictional forces due to asperities on the plate interface, elastic rebound occurs as the overriding plate 'snaps back' into position. This sudden motion can cause enormous displacement of water (hence propagation of tsunami waves) as well as mechanical dispersion of seismic waves through land (earthquakes). The sinking Juan de Fuca plate reaches a temperature at which pore water is liberated and causes melting of mantle rock as it rises. A plume of rising, melted mantle rock then erupts in a line of volcanic mountains (e.g. the Cascades).

www.youtube.com/playlist?list=PL8FDF28B8FD0C2E56

2. THE PACIFIC OCEAN TSUNAMI of January 26, 1700 arose from sudden displacement of the ocean floor off the Cascadia zone (PNW), during an earthquake of estimated magnitude 8.7-9.2. The earthquake focus was located in the shallow incline of the interface between the Juan de Fuca and North American plates. Convection Currents / Slab Pull in the mantle material cause the Juan de Fuca plate to subduct under the North American Plate. Asperities cause motion to be rough, and elastic energy builds up when friction due to asperities is greater than the drag force / pulling force on the plates. Elastic deformation in the land also occurs; when plate movement forces become greater than the frictional forces due to asperities on the plate interface, elastic rebound occurs as the overriding plate 'snaps back' into position. This sudden motion can cause enormous displacement of water (hence propagation of tsunami waves) as well as mechanical dispersion of seismic waves through land (earthquakes).

www.tsunami.noaa.gov/animations/tsunami_genesis.avi

BACKGROUND (cont.)

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

- Earthquakes, tsunamis and volcanic eruptions are natural hazards that change landscape morphology and can cause devastation to human settlements.
- Earthquakes, tsunamis and volcanic eruptions find a common causative mechanism in the plate tectonics model.
- Current understanding uses convection in the mantle powered by immense interior heat (residual heat from formation and radioactive decay) and slab-pull to explain plate movement.
- Uniformitarianism—"the past is the key to the present." Evidence of these events in the past, and the rate / frequency at which they occurred is a powerful tool for informing our understanding, knowledge and awareness of how these events will impact us today.
- We find evidence for these events in the geological record as well as the oral tradition and art of First Nation communities.
- Scientists and engineers use data from the past events, and current geological activity to help predict future tectonic events —this includes land—and ocean-based monitoring systems.
- Engineers are able to reduce the likelihood of loss of life, property and economic collapse by designing solutions to the huge amounts of seismic and volcanic energy these events can exert on structures of various kinds.

UNIT OVERVIEW

Lesson No.	Duration	Materials Needed	Focus	Assessment Options
1	1 class period	Student access to the Internet Student notebooks	**Engage** • Students interact with a number of online simulations, interactives and maps. • Student use a Question Formulation Technique to refine a driving question for the unit.	Classroom observation and participation in the QFT
2	4-5 class periods	Research Project Outline Student access to the Internet and other print resources Student notebooks	**Explore** • Students are introduced to the task, roles within the group and culminating presentation. • Based on their role within the group, students will conduct research to answer the questions their role is responsible for. • Students have choice of final presentation methods.	Collaboration Rubric CERR rubric
3	3 class periods	First Nation Oral History accounts QFT documents	**Explain** • Students investigate a second phenomenon – the "Orphan" Tsunami of 1700, as an outlier event • Students develop and use models to explain this event, and use primary source texts as a way to integrate the authentic voice and experiences of those who witnessed this event.	Presentation Rubric

UNIT OVERVIEW (cont.)

Lesson No.	Duration	Materials Needed	Focus	Assessment Options
4	4 class periods	Dendrochronology lab Ghost forests lab Catastrophic Events lab 15.1	**Expand** • Students dive deeper into evidence that supports the explanatory model for the orphan tsunami of 1700. • Students model earthquake data by location and depth and connect this evidence to their claim. Students revise their models and engage in peer gallery walks to gather feedback.	Student model rubric and peer review
5	3-4 class periods	Tsunami Attack & Survive that Tsunami materials	**Evaluate** • Student engage in the full engineering design process to design and test villages of home structures that can withstand or survive a tsunami. • Students read and watch simulations of tsunamis to understand how engineers monitor and warn communities of possible catastrophic events.	Engineering and collaboration rubrics based on student-developed criteria

LESSON 1: Introduce the Phenomenon

Strategy: Engage

Description/Summary

The opening lesson in this unit is to engage students in asking questions around a puzzling phenomenon or event that kids can observe and come to deep understanding of over the course of the unit. Throughout the course of the unit students will investigate and design projects that will help them answer the question - How safe do you think the PNW is in terms of natural hazards? Would you move here if you had the choice of any area in the US?

Students examine, compare and contrast 'Where to Live to Avoid a Natural Disaster' - NYTimes interactive, 'Locations of high-risk Natural Disaster areas from NOAA and RedCross' map and USGS: Hazard Information for U.S. Volcanoes. Students look at patterns in natural hazards across the US, and ask questions about their observations.

To engage students in establishing their own driving questions, utilize the Question Formulation Technique (QFT) Students will be presented with the 3 maps above as the Q-Focus and generate as many open-ended research questions as they can. Students discern the difference between open-ended and closed-ended questions, and determine which are the best type for driving a unit of inquiry. Prioritized and categorized questions from each team are transferred to a Driving Questions Board (e.g. Padlet) or cork board.

Materials Needed
Student science notebooks
Access to the Internet
Resources linked

LESSON 2: Individual and Group Research

Strategy: Explore

Description/Summary

Students are introduced to the research project, and choose a team of three - each has a role to play in obtaining and communicating their explanation of the question "Is the Pacific Northwest a Safe Place to Live?" Students will investigate a question based on their role in the group: Scientist, Historian or Engineer. The group will then synthesize their information to develop a detailed proposal that will inform state planners on steps that need to be taken to ensure the state of Washington is adequately prepared for a major tectonic event.

Introduction to acceptable research methods and project outcomes are described in the Researched Project Outline. Students will collect their information in their science notebooks and notes will be presented before the group begins their final proposal presentation. Groups will then have the chance to synthesize their research and prepare their proposal. Before presenting their final group presentation, groups will engage in a peer review process. The link below will take you to a sample Electronic Peer Review lesson plan that can be adapted for the level of your class. Teachers may choose which open-ended form best meets their students' needs. This portion can also be assigned as homework and conducted digitally over email or through your digital classroom. Lastly, groups will present their research. To increase the authenticity for this event, it is suggested to invite town planners, emergency response teams, and other local officials that have a role in providing safety and support in the event of a tectonic event to the presentations.

- Individual research – 3 class periods
- Group proposal – 2 class period
- Peer Review and Editing – 1 class period
- Group Presentations and Feedback – 2 class periods

Students will be assessed individually based on their responses to the research question for their role – using a Claims-Evidence-Reasoning-Rebuttal framework is suggested to help support students in utilizing the Science and Engineering Practice of Constructing Explanations and Arguing from Evidence. The group will also be evaluated based on their collaboration.

Materials Needed
Research Project Outline
Collaboration Rubric
CERR rubric
Rubric for Presentations
Access to the Internet
Access to other nonfiction print resources

LESSON 3: The Orphan Tsunami of 1700

Strategy: Explain

Description/Summary

Materials Needed
QFT handouts

Students are introduced to a second phenomenon – an outlier phenomenon to deepen their experience in asking questions and connect ELA reading/writing/speaking listening strategies.

Students examine evidence for orphan tsunami in stations. At each station, place First Nation resources taken from: https://media.up.edu/Physics/TOLE/CascadiaEarthquake&Tsunamis/LessonPlans/NativeAmericanOralTraditionTsunamis.pdf (e.g. 'Diary of James Swan for January 12, 1864', 'Ma'aTł, The flood',Makah Legend (as accounted by Swan, 1868).

Students use modified QFT to generate driving questions based on their observations.

Student develop an individual explanatory model for the cause of the Orphan Tsunami. Once students have developed individual models, they will gather with a small group to create a consensus model, pulling pieces together from each individual model to provide a cohesive explanation for the event. Students then post their initial thinking and conduct a gallery walk to provide peer feedback.

LESSON 4: Investigating Evidence

Strategy: Expand

Description/Summary

The following class period, introduce additional evidence for the orphan tsunami of 1700 from dendrochronology using the Cascadia Tsunami Dendrochronology Lesson Plan. Following the activity, student groups will revise their models to include new thinking, new wondering and add evidence. (1-2 class periods)

Continue building knowledge and evidence the following class session by examining additional evidence from the Ghost Forest/Sedimentary Deposits Lesson Plan. Again, students should use their models as a means to include additional evidence, revise and reflect new thinking and document additional questions. (1 class period)

To focus instruction on the foci of earthquakes, use Lesson 15 from the Catastrophic Events kit. Students will plot various earthquakes by depth and make connections to plate faults. For the final round, again have students revise their models, add evidence and reflect their current thinking. (1 class period)

On the final day after the above investigations, students will complete their final model revision and use the Peer Review process from Lesson 2 to gather feedback and make final claims supported by evidence. The teacher should use this process as a means to engage students in arguing their claims based on evidence. (1 class period)

Materials Needed
Sets of paper strips marked with ring patterns (see link)
Transparent tape
Student worksheets
Connection to the Internet and projector

LESSON 5: Tsunami Attack

Strategy: Evaluate

Description/Summary

Students apply their learning on tsunamis to developing a solution that can monitor, alert and protect homes and lives from possible devastation caused by tsunamis.

Use the Tsunami Attack lesson plans to first model for students how waves form in shallow water, and then in water that has a simulated landslide. Using the simulations and information in the lesson plan, discuss tsunami hazards. As a class, construct a set of criteria for a house to successfully survive a tsunami. (Day 1)

*Prior to the engineering activity, you will need to construct model houses and set up a tsunami generator.

Students in each group will use the provided materials to design a different type of house. Test each village of houses separately against the class criteria and record test data. (Day 2)

On the final day, discuss materials that best withstood the tsunami generator. Allow students to redesign heir models using new materials, and combinations of materials, in order to better meet the criteria. (Day 3)

Materials Needed

Tsunami Attack Lesson plans

Survive that Tsunami Lesson plan

Model house template

Divide the class into three groups. Students in group A need:

- 2 sheets of tissue paper (the gift wrap type)

Students in group B need:

- 3 sheets of cardstock or manila envelope material

Students in group C need:

- 3 sheets of notebook paper
- 40 toothpicks

To share with the entire class:

- Masking tape
- Scissors
- Model House Template

For the table-top-sized tsunami generator:

- 1 large, shallow, plastic waterproof tub (8-in x 14-in x 30-in or 20-cm x 36-cm x 76-cm, clear plastic is better but not necessary)
- 20 to 30-pound (9 to 14 kg) bag of sand
- 1 piece of sheet metal, ~20-in x 10-in x 0.1-in thick (as long as it is rigid, it is thick enough) or 51-cm x 25-cm x .25-cm thick
- Duct tape

How This Unit Supports Next Generation Science Standards

MS-ESS2 Earth's Systems

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required. NGSS connections are derived from the Evidence Statements for the Performance Expectations listed below.

Peformance Expectation	**Connections to Classroom Activity** *Students:*
MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. MS-ETS1-1 - 1-4 Engineering Design Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	• Articulate the evidence for a phenomena as its related to the idea that geoscience processes have changed the Earth's surface at varying time and spatial scales. • Organize given data that represent the type of natural hazard event and features associated with that type of event, including the location, magnitude, frequency, and any associated precursor event or geologic forces. • Develop solutions to minimize the impact of a natural disaster, and revise this solution based on evidence from testing.

How This Unit Supports Next Generation Science Standards (cont.)

SCIENCE & ENGINEERING PRACTICES	
Asking Questions and Defining Problems Developing and Using Models Constructing Explanations and Designing Solutions Analyzing and Interpreting Data	• Students develop their own driving questions for both the phenomenon in the unit, using a refining protocol. • Students develop explanatory and engineering models, and revise based on newly acquired information and feedback. Students identify and describe relationships (crosscutting concepts) between components of the model. • Students state a claim to the driving question of the unit, identify and describe the evidence to support that claim, and base their claim in scientific reasoning based in the assumption that laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for how geoscience processes have changed the Earth's surface at a variety of temporal and spatial scales. • Students organize data from primary source documents and other sources, organize that data and interpret data in light of areas that are susceptible to the natural hazard events, including areas designated as at the greatest and least risk for severe events.

How This Unit Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
ESS2.A: Earth's Materials and Systems ESS2.C: The Roles of Water in Earth's Surface Processes ESS3.B: Natural Hazards	• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations (secondary). • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.
CROSSCUTTING CONCEPTS	
Patterns Scale Proportion and Quantity Influence of Science, Engineering, and Technology on Society and the Natural World	• Using patterns in the data, students make a forecast for the potential of a natural hazard event to affect an area in the future, including information on frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event. • Students identify the corresponding timescales for each identified geoscience process, including rapid and slow changes and natural processes. • Students give examples of the technologies that engineers have developed to mitigate the effects of a tsunami.