Quake - Site Smart

***Putting Down Roots*, p. 18 - 23**

Idaho State Standards:

8th/9th Earth Science 1.2, 1.3.2, 1.6.1, 1.6.2, 1.6.4, 1.8, 4.1.3, 5.1, 5.2

Objectives:

Students will:

1. Interpret soil- and earthquake-related geologic maps.
2. Apply these interpretations in evaluating or choosing a building site.
3. Identify possible hazards associated with a location on the surface map due to the liquefaction Class, geology, or topography of a quadrangle section.
4. Generate a mitigation plan for the area of analysis.

RATIONALE

City planners, developers, builders, and buyers need information about soil and subsoil geology in order to choose sites and design structures that will best withstand ground shaking and other earthquake hazards. In this activity, students analyze maps displaying different types of data to determine the hazards associated with earthquakes present in Idaho communities.

FOCUS QUESTION(S):

- What are the important geologic considerations when choosing a building site and designing or reinforcing a building for earthquake survivability?
- Have these conditions been taken into account in the planning of towns and cities?

TEACHING CLUES AND CUES

Southeastern Idaho is more susceptible to liquefaction and has a higher probability of earthquakes than other parts of Idaho. For this reason, the maps that are included in this activity are from southeastern Idaho. Nevertheless, other cities in the state could also be subject to the same hazards, but at a different scale. It would be appropriate for students to correlate the hazards of Rexburg or Idaho Falls to other cities and towns in the state.

Read the background reading "Site Characteristics." Make copies of this for students to be given as homework prior to the activity. Review general and specific terminology for each map. In the legend, the letters PLSS stand for Public Lands Survey System and identify the sections of the quadrangle that are used. Project an image of each of the maps for discussion purposes. Utilizing the jigsaw technique would be a good method for classroom management for this activity. Group students into teams of 4-5 and have each student responsible for the information on one of the maps. Each student meets with students from other groups with the same map to discuss what they see and understand. In this way, the teacher can focus instruction for each group on their specific map. After instruction/discussion, students should return to their original group to share information on their map.

Project earthquake probability maps of the area or make copies of the map area. When using the USGS probability map site, type in the zip code (Rexburg: 83441, Idaho Falls: 83404) and set the "Time Span" for 100 years and the "magnitude" for 5.2 (the minimum magnitude needed for liquefaction to occur). Rexburg and Idaho Falls are shown in the same probability map area because they are within a 50 km. radius, but if you type in a Rexburg zip code a small triangle will be displayed for the position of Rexburg, north of Idaho Falls, without the printed name.

Making copies of the surface map on overhead transparency film will make it easier for students to correlate surface features to data on the liquefaction class, geology, and topographic maps. Students can then place the surface map on the other maps for analysis. Protecting the surface map with plastic covers will allow students to make marks on the cover while protecting the surface map.

Notes about the Maps:

- On the Surface map, some canals have breaks in their pattern when the canal goes underground. Canals can usually be identified by their straight linearity as compared to natural curves of rivers or streams.
- Accompanying this activity are two word documents titled "Idaho Falls Geologic Text Units" and "Rexburg Geologic Text Units." These contain information in greater depth about the geologic units shown on the Geologic Map. Their description had to be extremely abbreviated for the map legend.
- All maps are to scale, therefore, placement of a feature on one map would be located in the same position on another map even when not displayed.
- When printing the maps make sure that when using the print command, the Page Scaling is set to "Shrink to Printable Area" or "Fit to Printable Area." Otherwise, some information in the legends for the surface and geologic maps will be cut off.
- Assign each group of students to a specific PLSS section of the map, i.e. Sec. 24 or Sec. 18. There are 16 PLSS sections on the map that are within the area of analysis. Choose the most interesting sections to assign to student groups.

MATERIALS:
for teacher

- Background Reading "Site Characteristics," pp. 97 - 98
- Vocabulary, p. 98
- Copies of the following maps, one each per student group
  - -Surface (Color or B/W version), pp. 99 - 100
  - -Liquefaction Class (Color or B/W), pp. 101 - 102
  - -Geologic (Subsoil geology) (Color or B/W), pp. 103 - 104
  - -Topographic (Color only), pp. 105
- Computer and projection equipment to project maps
- *Putting Down Roots in Earthquake Country* booklet, BHS (see address below)
- USGS Seismic Probability map of the area (Rexburg or Idaho Falls) https://geohazards.usgs.gov/eqprob/2009/index.php
- USGS U.S. Seismic Hazard Map, *Putting Down Roots,* p. 19 (or see image in file)
- Idaho Seismic Probability Hazard Map, *Putting Down Roots,* p. 14 (or see images in file)

for student groups

- Copies of background reading, "Site Characteristics" (homework)
- Copies of the 5 maps (1 set of 5 maps)
- Colored pencils or colored transparency markers
- Pen or pencil
- Ruler
- *Optional* - Hand lens, for reading details on the Topographic map

PROCEDURE:

Teacher Preparation

The maps associated with this activity are from two different areas of southeastern Idaho--Rexburg and Idaho Falls. In these areas, the soil type is more likely to undergo liquefaction due to ground shaking. However, many areas of the state can be prone to hazards such as landslides, flooding, and liquefaction due to weather related events other than ground shaking caused by earthquakes.

A. Introduction

Assign students the Background Reading "Site Characteristics" as homework prior to class or read it with them in class. Explain and amplify any unfamiliar terms. Discuss the relationship between liquefaction soils, subsoil geology, and the suitability of a site for building. Explain that the locations of roads, utility lines, reservoirs, and other facilities also involve seismic considerations. (See *Putting Down Roots,* p. 14 , bottom left corner).

B. Lesson Development

1. Divide the students into small groups. Decide if you will be using the colored versions or the black and white versions. Give each group one copy of each of the following maps: Surface, Geology, Liquefaction Class, Geologic Province, and Topographic. Use the map keys to review the special symbols and markings on each map. Instruct students to interpret the information shown on the specialized maps. Assign each group to a specific PLSS section of the map, i.e. Sec. 24 or Sec. 18. There are 16 PLSS sections on the map which are within the area of analysis. Choose the sections that are the most interesting to assign to student groups. Copying the Surface map on transparency film will allow students to mentally or physically transfer data to the surface map. Use overhead markers to show this.

2. Within each group, discuss what type of building would be most earthquake resistant in each area of the maps the group has developed (see *Putting Down Roots,* p. 14 , bottom left diagram "Amplification of Earthquake Shaking" and accompanying information). Ask: "Are there some areas where construction is not advisable no matter what the building materials?" Instruct students to add these notations to the maps.

3. Have students identify water features (rivers/creeks, ponds, canals, etc.), roads, power transmission lines, railroad tracks, etc., that could pose a problem during an earthquake.

4. When all maps have been completed, site hazards have been noted, and mitigation recommendations have been made, inform groups they will need to select a representative within their group to present the group's findings and recommendations.

5. Ask for a volunteer from the group's representatives to report on their group's findings and recommendations. Have the surface map projected or on a transparency so that student presenters can mark on them.

C. Conclusion

Stack the specialized maps on the projector at the same time so various kinds of information are all displayed simultaneously. Discuss the conclusions drawn by students and answer any questions. Have each group submit a final copy of their surface map and a description of their recommendations, along with justification for the recommendations that were made.

Background Reading: Site Characteristics

"Earthquakes don't kill people, buildings do." Architects and engineers consider this a fair one-sentence summary of earthquake-related deaths, injuries, and damage. Yet, underneath every building is the Earth, which can shake and damage or destroy the buildings. In the final analysis, the cause of the death and destruction may not be the earthquake or the building, but rather someone's lack of knowledge about the soil and subsoil under the building.

Much of the scientific study surrounding earthquakes is focused on the geological characteristics of building sites, the relationship of building sites to earthquake damage, and how buildings respond to ground shaking induced by earthquakes. Location is just as important as building design for making sure that a building can survive an earthquake. Geological site considerations include the location and history of faults, sedimentary deposits, landfill, liquefaction, steep slopes and landslides, tsunami and seiche, and human-made hazards.

Faults: Displacement and Ground Shaking. Earthquakes happen when two sides of a fault are displaced, releasing energy in waves. Buildings can be damaged either by direct displacement on the fault or by ground shaking.

Geologists have mapped the locations of many of the most dangerous fault zones in the U.S., yet many faults are not yet recognized. A building within a fault zone can be severely damaged by an earthquake on that fault, but this kind of damage is rare. Most buildings are not in fault zones, and the recurrence interval for any particular fault may be hundreds or thousands of years. The most common cause of damage in earthquakes is the ground shaking caused by the earthquake waves. These attenuate, or die off, with distance, so the two most important factors controlling the amount of shaking are the magnitude of the earthquake and the distance of the building from the fault.

The distance from the fault, rather than from the epicenter, determines the amount of damage. Energy is produced by all the parts of the fault that move in an earthquake. In big earthquakes, the fault might be hundreds of miles long. Thus, a structure may be hundreds of miles from the epicenter and still lie within the quake's impact zone.

Several other factors can affect the amount of shaking. Waves do not travel evenly in all directions from the fault. The orientation of the fault and the way in which displacement on the fault occurs can change the characteristics of the waves. More importantly, variations in local topography – the lay of the land, including the Geology or subsoil layers – may trap or amplify seismic energy, as will the type of rock and soil that underlie buildings.

Sediments and Landfill. Ground shaking is greatest on soil that has arrived in place fairly recently, whether deposited by natural processes geologists call sedimentation, or by artificial ones, called landfill. Unfortunately, most of the world's urban centers are sited on relative young, loose, sedimentary deposits. Sediment age and particle size are important in predicting how soil will respond to shaking during an earthquake. Areas near the shores of rivers and oceans are especially likely to contain young sediments washed there by the water.

Structures located on former watercourses (such as old river beds) or on sites that have been artificially filled with sand dredged up from the bottom of a body of water are among the worst locations for construction in earthquake country because the soil can shift so easily. In Mexico's devastating 1985 earthquake, Mexico City, located 320 km (200 miles) from the epicenter, suffered far more damage than the shoreline towns closer to the epicenter. While the shoreline is made of solid rock, Mexico City is built on the sediments of an ancient lake bed.

Old watercourses are usually low and wet, so they are frequently filled when someone wants new land on which to build and sell. Landfill is usually a mixture of soil, rock, and decaying organic material in particles of varying sizes. Because it is not natural to the area where it has been deposited, landfill in one spot is likely to be of a different composition from landfill in a nearby spot. When seismic waves are transmitted through landfill, they are amplified and their period is lengthened. Long earthquake waves are particularly destructive to some types of surface structures. Landfills commonly settle and sink during a strong earthquake.

Liquefaction. Where poorly consolidated soil or fine sand becomes saturated, an earthquake is likely to cause soil liquefaction. Earthquake vibrations compact the soil, causing water mixed with sand to flow upward. Structures may settle several feet or even topple, causing considerable damage. In a related phenomenon, sand or muddy soils may behave like liquids, flowing out onto the surface as sand boils or mud boils. This was the case on the Lost River valley floor during the Borah Peak earthquake of 1983.

Slopes and Landslides. Structures on cliffs and ridges are also at high risk for earthquake damage; even if they are built on strong bedrock. Earthquake waves appear to be reflected and amplified by topographic highs like cliffs and ridges. Earthquakes also dramatically increase the potential for landslides in areas where landslides are common, such as those where sedimentary rocks lie just under the soil. The probability of an earthquake-related landslide depends on the strength of the slope materials, the steepness of the slope, and the severity and duration of ground shaking. Structures on cliffs and ridges need to be designed to the highest earthquake standards, and should be fully insured.

Tsunami and Seiche. Tsunami are caused by faulting and the abrupt movement of the ocean floor during an underwater earthquake. A wave generated by this movement can travel as fast as 640 km./hr. (400 mph) on the open ocean, where it may not be much above normal height. When it approaches the shore, however, it may attain a height of 15-20 m. (50 feet) – in some cases, even 32 m. (105 feet). Tsunami present a distinct hazard to low-lying coastal areas, particularly the west and northwest shorelines along the western North American coast and the northerly facing coast of Hawaii. Low-lying waterfront properties in these areas are at high risk from tsunami.

A **seiche** (SAYSH) is the sloshing of an enclosed or partially enclosed body of freshwater, such as a reservoir or lake. Seiches are usually associated with weather phenomena but they are also associated with earthquakes and landslides. A seiche has the ability to cause dam failure as a result of over spilling of a dam. In 1959, a magnitude 7.3 earthquake struck Hebgen Lake, Montana. The seiche generated by the earthquake was the result of the lake bottom dropping 6.7 meters (22 feet). The resulting rock slide and seiche accounted for most of the 28 deaths of people camping in the Rock Creek public campground on the Madison River, about 9.5 km. (5.7 miles) below the Hebgen dam.

Lakes in seismically active areas, such as Lake Tahoe in California and Nevada, are significantly at risk from seiches. Geological evidence indicates that the shores of Lake Tahoe may have been hit by seiches as much as 10 m. (33 feet) high in prehistoric times. Visit http://unofficialnetworks.com/tahoe-tsunami-26376/ to see animation of the event. Local researchers have called for the risk to be factored into emergency plans for the region.[1]

The eruption of Mount Saint Helens in 1980 generated a seiche type of event called a "wave runup," in which the debris avalanche pushed the water of Spirit Lake up the surrounding basin walls a maximum of 250 m. (825 feet) above the 1980 lake level.

Human-Made Structures

Human-made structures, such as canals, dams, reservoirs, water tanks, and tall buildings, can present special earthquake hazards and need to be considered during site selection. Every building decision needs to consider the exposure to geologic hazard and the probability of an earthquake, bearing in mind that earthquakes are possible anywhere in the world at any time.

[1]Waitt, R.B., Geologist. Communication with Jon J. Major. U.S. Geological Survey, Cascade Volcano Observatory, Vancouver, WA. August 22, 2011, via email: jjmajor@usgs.gov.

Vocabulary

Fault: a break or fracture in Earth's crust along which movement has taken place.

Landfill: a site where soil has been deposited by artificial means – often, where garbage or rubbish has been disposed of, then covered with dirt and compacted.

Landslide: an abrupt movement of soil and bedrock downhill in response to gravity. Landslides can be triggered by an earthquake or other natural causes (see image, *Putting Down Roots*, p. 17).

Liquefaction: the process in which a solid (soil) takes on the characteristics of a liquid as a result of an increase in pore pressure and a reduction in stress.

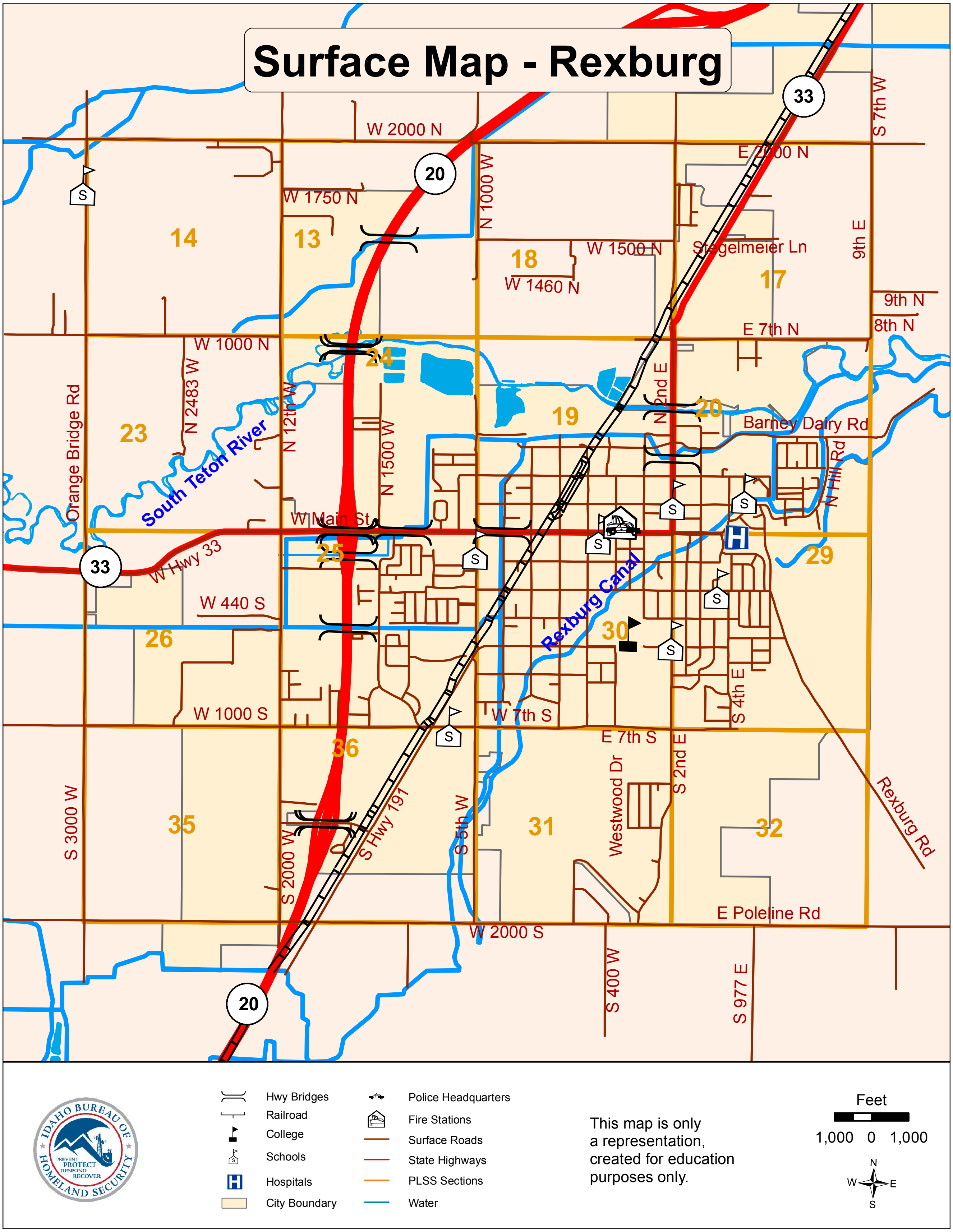
Sedimentary deposits: accumulation of solid particles that originated from the weathering of rocks and that have been transported or deposited by wind, water, and ice.

*Seiche***:** the sloshing of an enclosed or partially enclosed body of freshwater, such as a reservoir or lake. Swimming pools often **have seiches during earthquakes.**

Seismic: of or having to do with earthquakes.

Slump: A type of landslide in which a block of rock or soil moves along a curved surface and rotates.

Tsunami: a potentially destructive ocean wave created by an earthquake or other large-scale disturbance on the ocean floor, a seismic sea wave. This Japanese word has the same form in both the singular and the plural.


Surface Map - Rexburg
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N 2483 W
N 12th W
N 1500 W
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N Hill Rd
Orange Bridge Rd
South Teton River
W Main St
W Hwy 33
W 440 S
Rexburg Canal
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Westwood Dr
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Hwy Bridges
Railroad
College
Schools
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created for education
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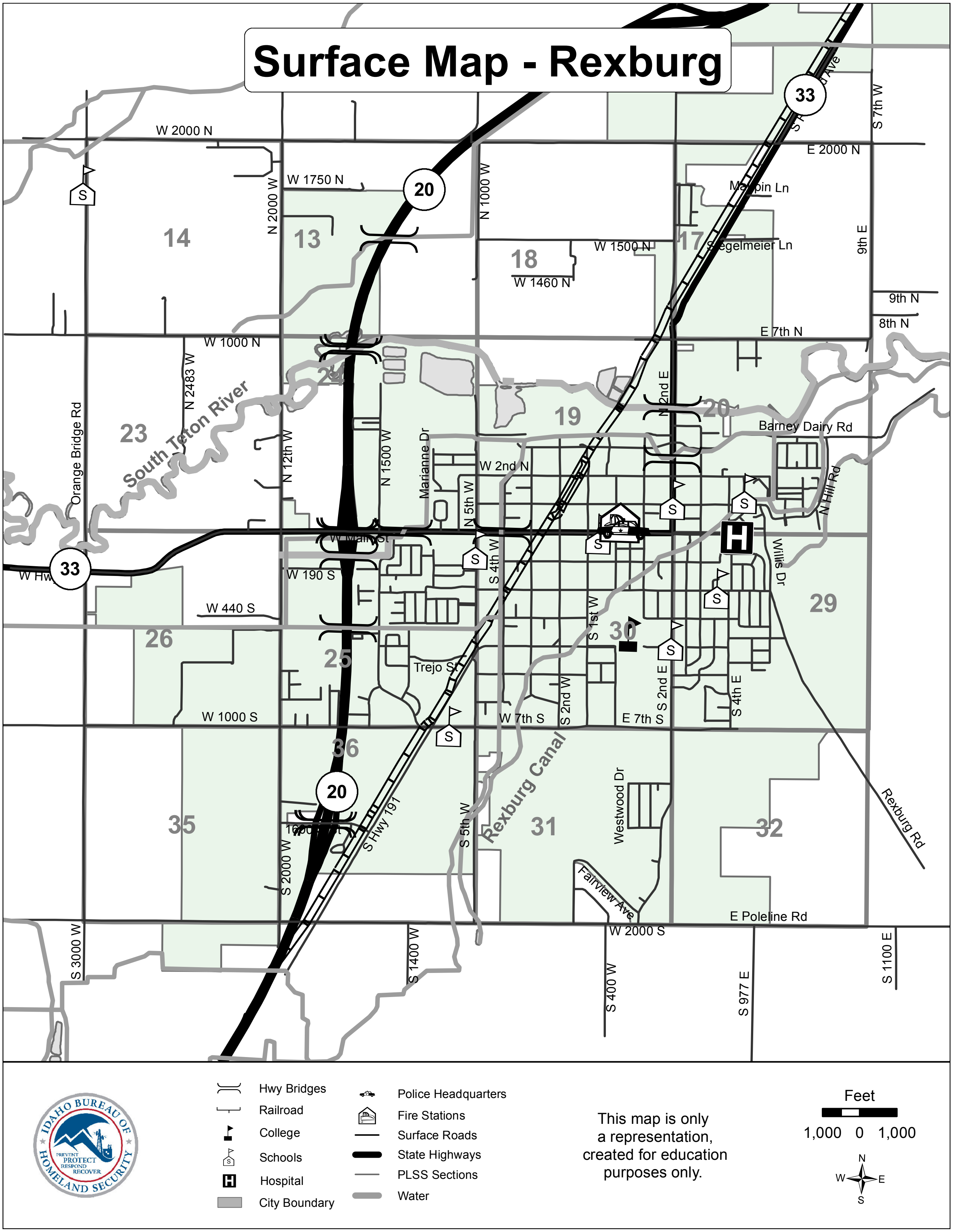
PREVENT PROTECT RESPOND RECOVER


Surface Map - Rexburg
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South Teton River
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Barney Dairy Rd
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Willis Dr
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Trejo St
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W 7th S
S 2nd W
E 7th S
S 2nd E
S 4th E
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S 5th W
Westwood Dr
Fairview Ave
Rexburg Rd
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Railroad
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Schools
Hospital
City Boundary
Police Headquarters
Fire Stations
Surface Roads
State Highways
PLSS Sections
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created for education
purposes only.
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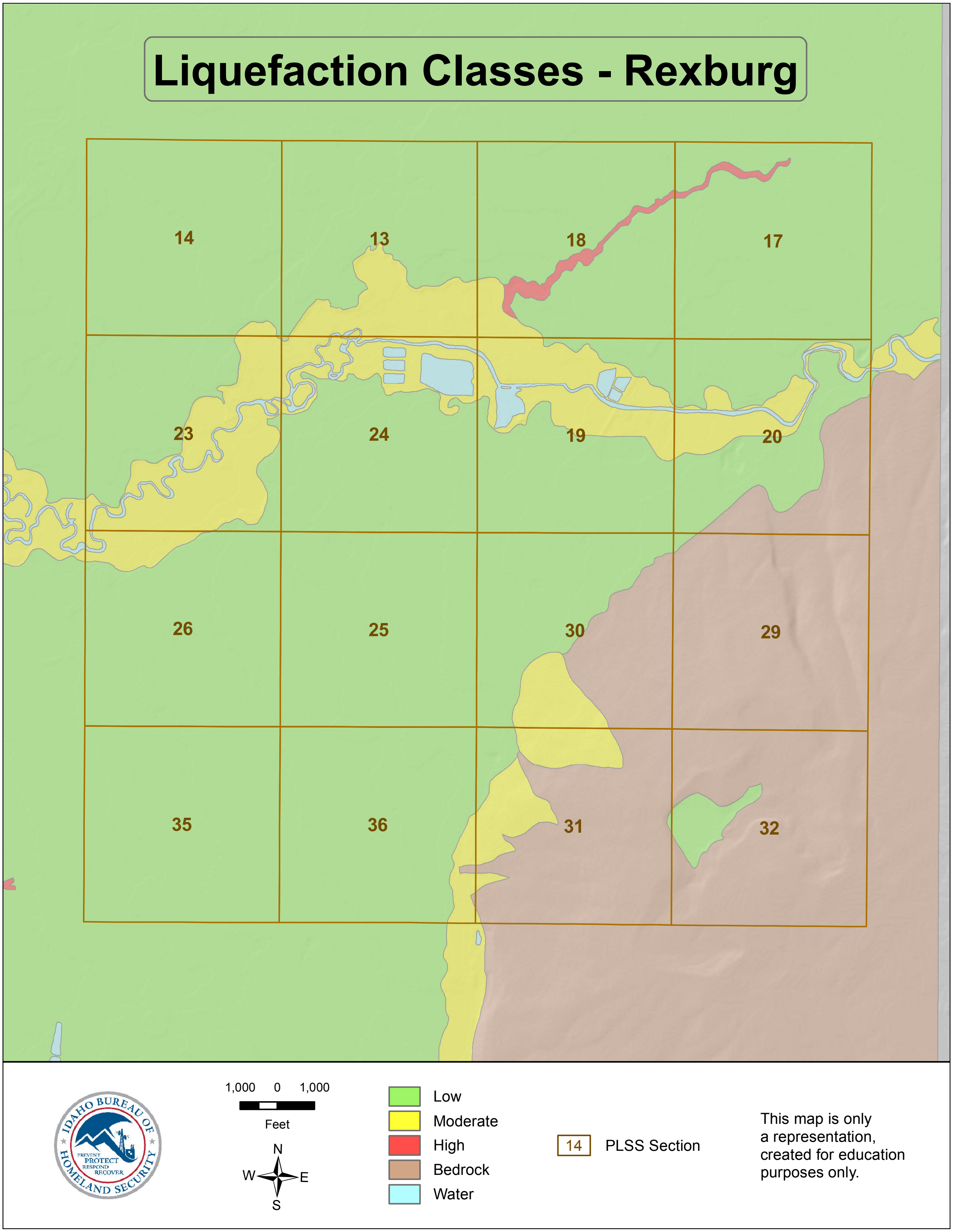
Liquefaction Classes - Rexburg
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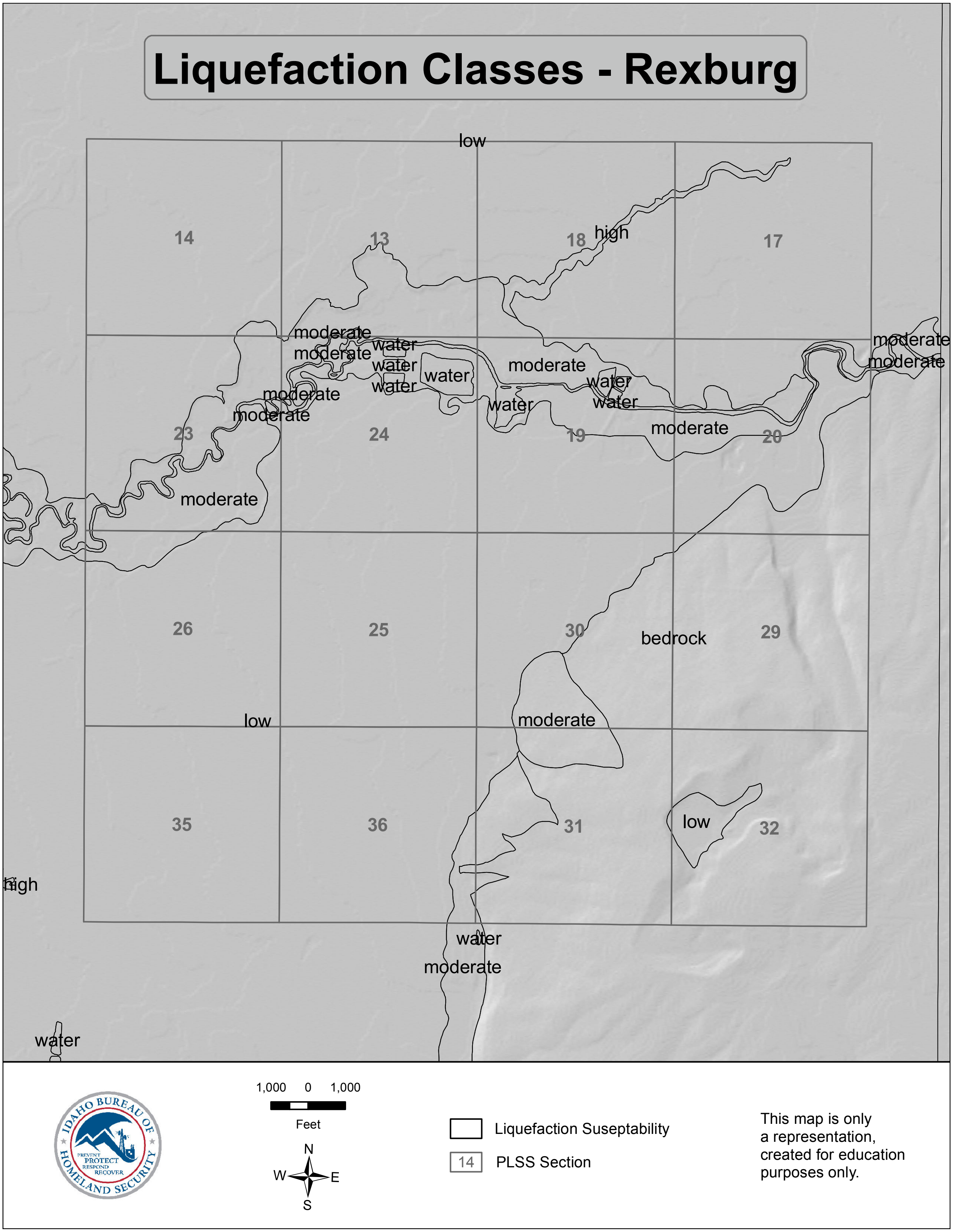
Liquefaction Classes - Rexburg
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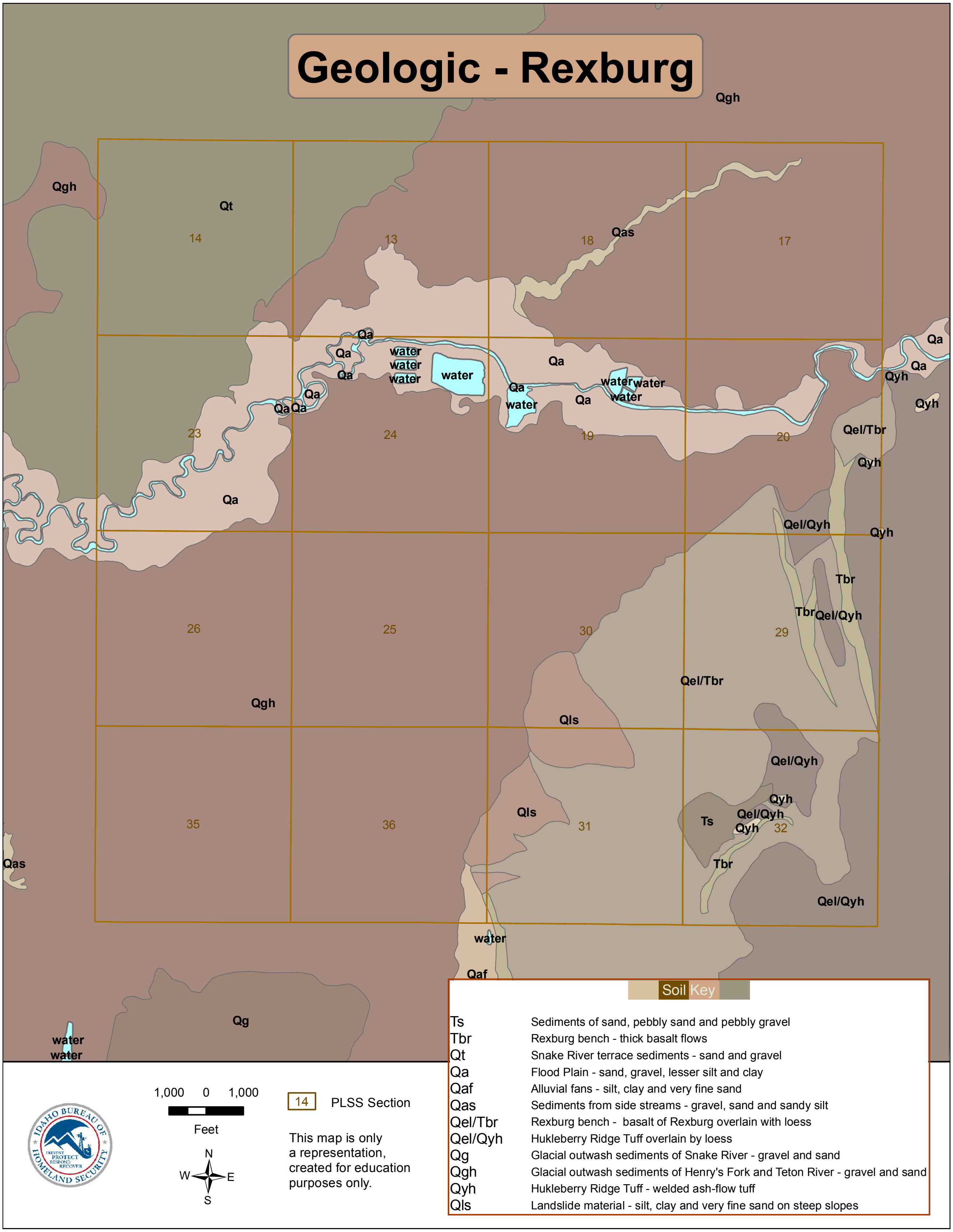
Geologic - Rexburg
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Soil Key
Ts Sediments of sand, pebbly sand and pebbly gravel
Tbr Rexburg bench - thick basalt flows
Qt Snake River terrace sediments - sand and gravel
Qa Flood Plain - sand, gravel, lesser silt and clay
Qaf Alluvial fans - silt, clay and very fine sand
Qas Sediments from side streams - gravel, sand and sandy silt
Qel/Tbr Rexburg bench - basalt of Rexburg overlain with loess
Qel/Qyh Hukleberry Ridge Tuff overlain by loess
Qg Glacial outwash sediments of Snake River - gravel and sand
Qgh Glacial outwash sediments of Henry's Fork and Teton River - gravel and sand
Qyh Hukleberry Ridge Tuff - welded ash-flow tuff
Qls Landslide material - silt, clay and very fine sand on steep slopes
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14 PLSS Section
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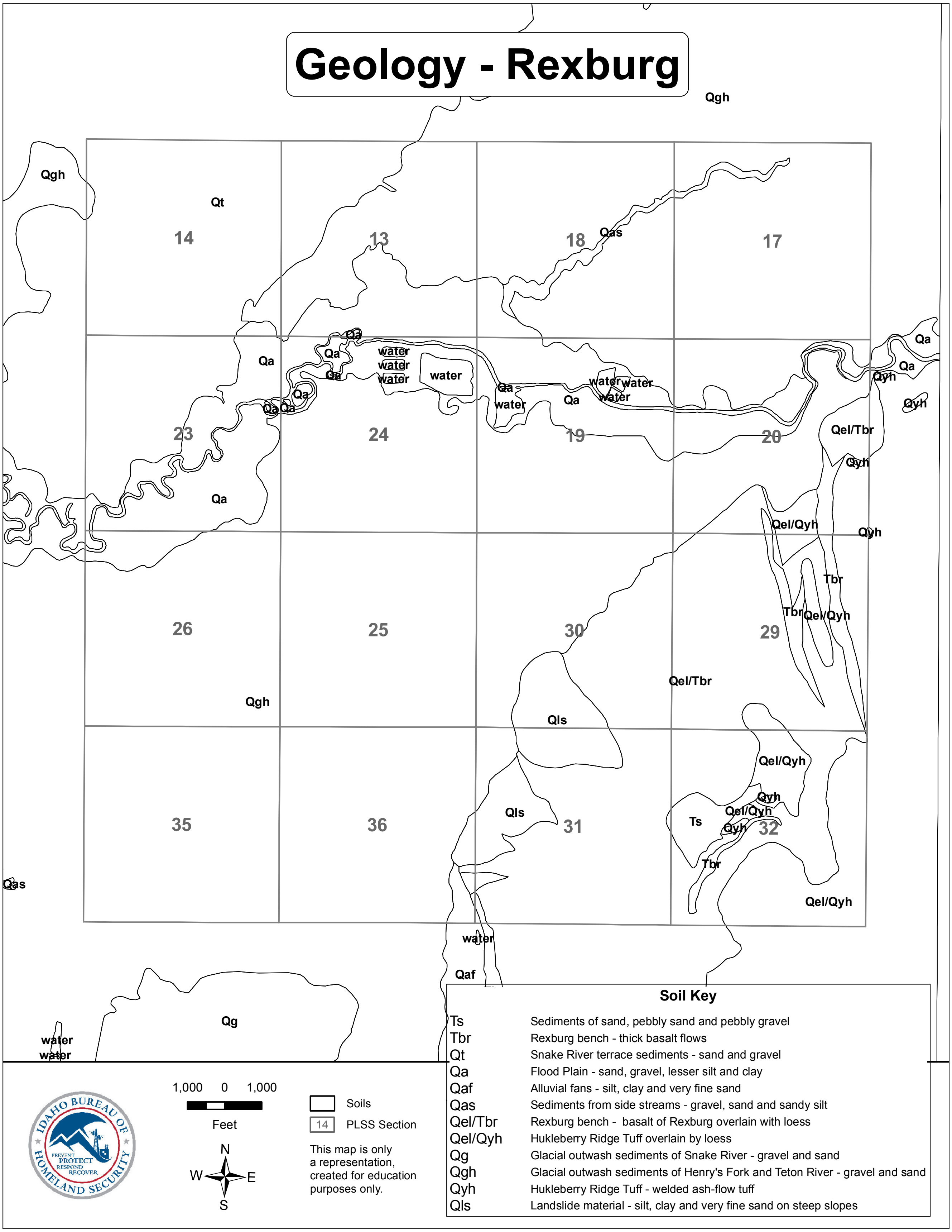
PREVENT PROTECT RESPOND RECOVER


Geology - Rexburg
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PREVENT PROTECT RESPOND RECOVER
Soil Key
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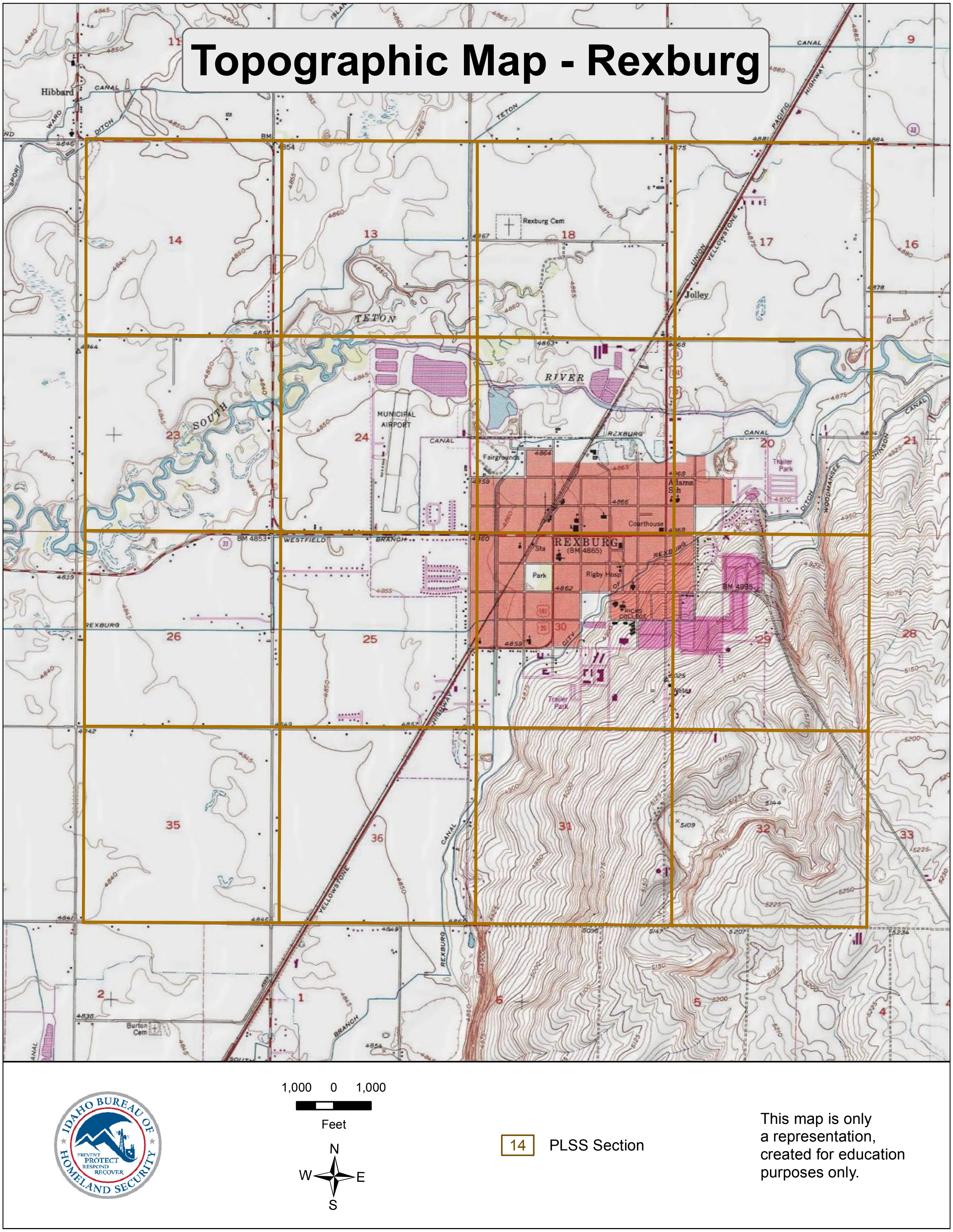
Qyh Hukleberry Ridge Tuff - welded ash-flow tuff
Qls Landslide material - silt, clay and very fine sand on steep slopes


Topographic Map - Rexburg
Hibbard
Rexburg Cem
Jolley
TETON
RIVER
SOUTH
MUNICIPAL AIRPORT
Fairgrounds
REXBURG
Courthouse
Park
Rigby Hosp
Trailer Park
WESTFIELD
BRANCH
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YELLOWSTONE
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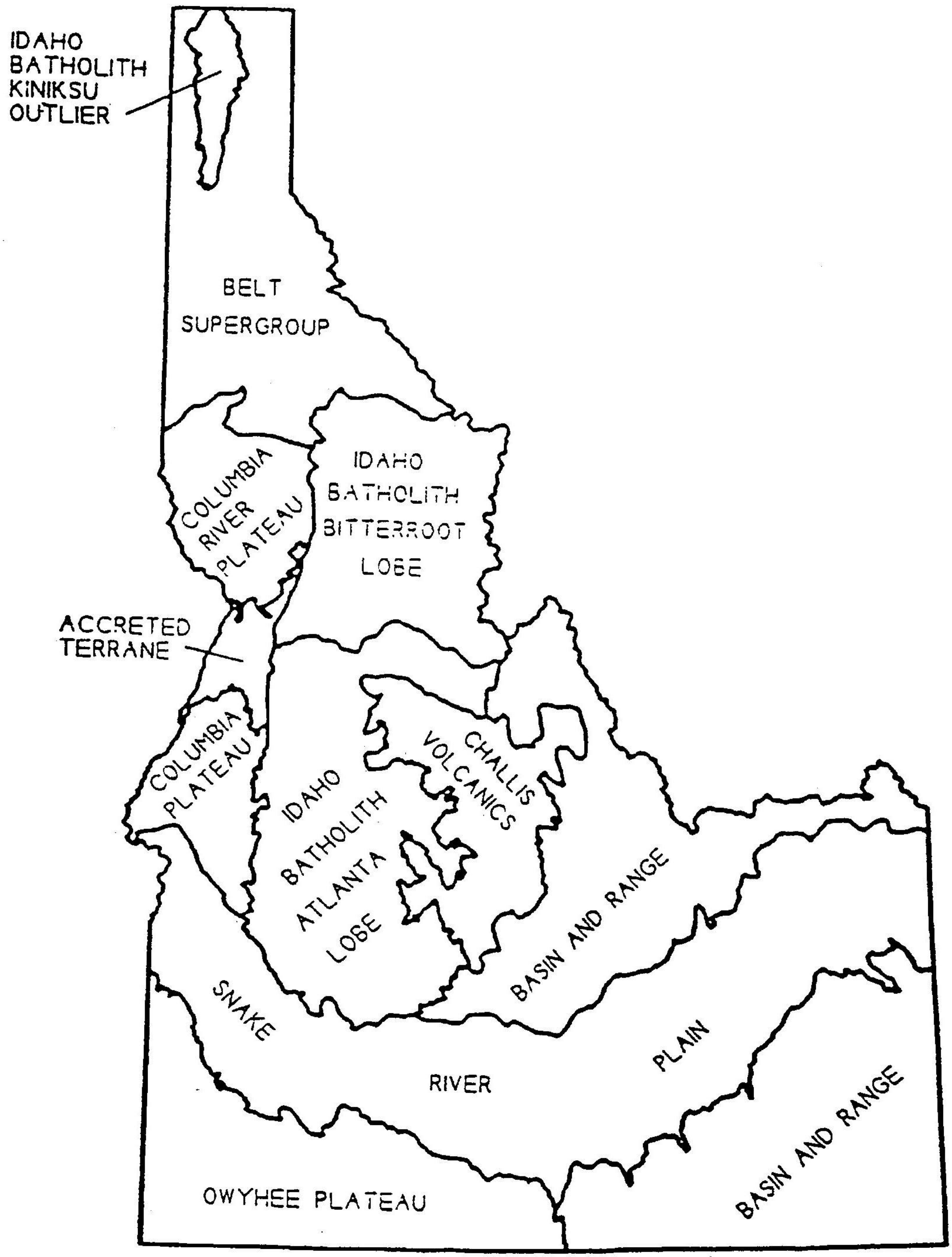

Figure 2. Geologic provinces of Idaho.