UTAH GEOLOGICAL SURVEY
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# PIPING-AND-EROSION SUSCEPTIBILITY ZION NATIONAL PARK GEOLOGIC-HAZARD STUDY AREA

By

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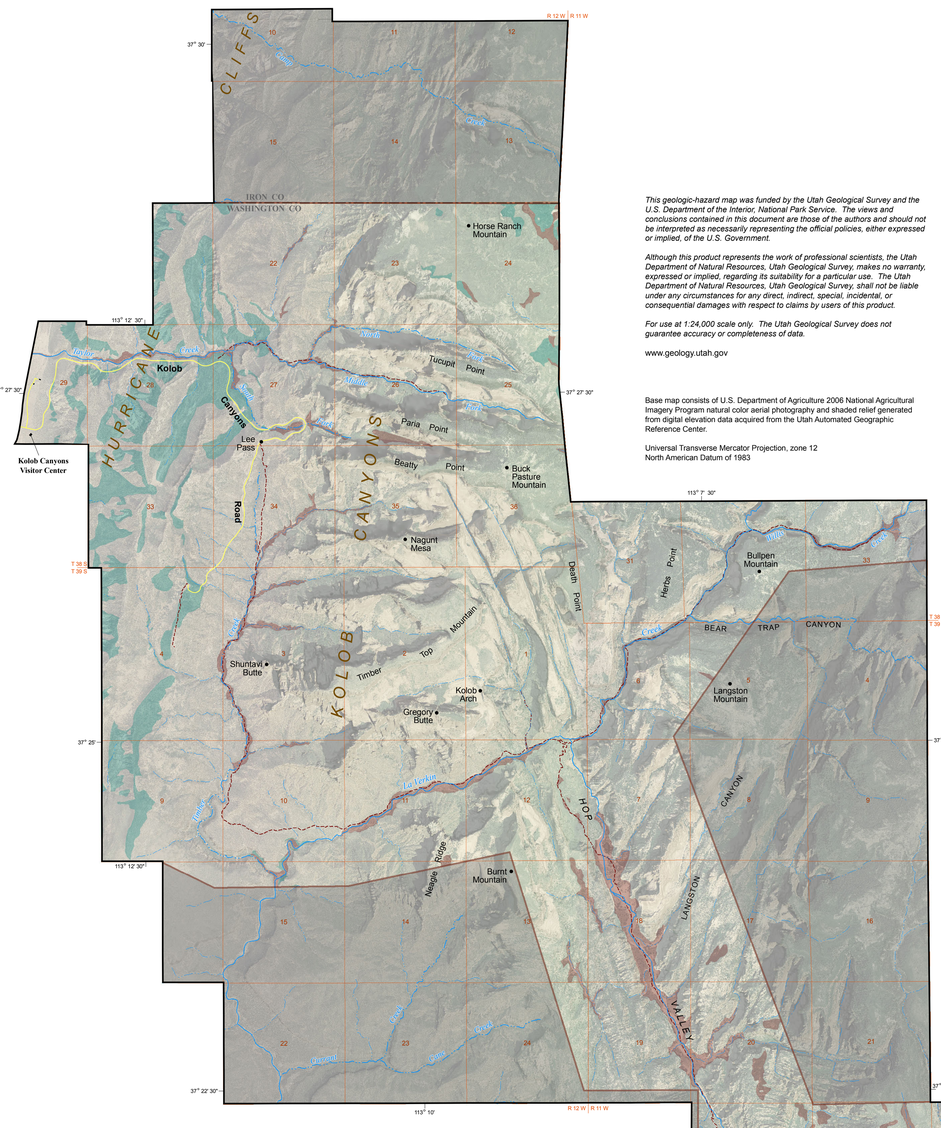


*This geologic-hazard map was funded by the Utah Geological Survey and the U.S. Department of the Interior, National Park Service. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.*

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Base map consists of U.S. Department of Agriculture 2006 National Agricultural Imagery Program natural color aerial photography and shaded relief generated from digital elevation data acquired from the Utah Automated Geographic Reference Center.

Universal Transverse Mercator Projection, zone 12
North American Datum of 1983

## SYMBOLS

- Zion National Park Geologic-Hazard Study Area boundary
- Zion National Park boundary
- County boundary
- State highway
- Minor road
- Foot trail
- Existing park structure
- Area not studied

Map Location

SCALE 1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

12°
TRUE NORTH
MAGNETIC NORTH

Approximate mean declination, 2009

## EXPLANATION

Soil susceptible to piping and erosion – Typically fine-grained, noncohesive, loose to poorly consolidated sand, silt, and landslide deposits consisting of similar material. For piping to develop, a free face and percolating ground water are additional necessary requirements.

Rock susceptible to piping and erosion – Typically fine-grained, poorly consolidated siltstone, mudstone, claystone, and landslide deposits consisting of such rock types. For piping to develop, a free face and percolating ground water are additional necessary requirements.

**Geologic Deposits Susceptible to Piping and Erosion**

| Type of Deposit | Geologic Map Units[1] | Piping and Erosion Category |
|---|---|---|
| Stream Alluvium | $Qa_1$, $Qa_2$, $Qal_1$, Qa, Qaly | Soil |
| Alluvial/Terrace Deposits | Qas, Qaso, Qay, Qae, Qac, $Qat_2$, Qatm, Qath, Qaec, Qaes | Soil |
| Eolian/Colluvial Sand Deposits | Qes, Qed, Qces, Qer, Qre, Qea, Qce, Qmts | Soil |
| Lacustrine Deposits | Qlbc, Qls, Qla | Soil |
| Poorly Consolidated Bedrock | Petrified Forest Mbr., Chinle Fm.; Shinabkaib Mbr. and red mbrs., Moenkopi Fm.; Moenkopi Fm. Undivided; Whitmore Point and Dinosaur Canyon Mbrs., Moenave Fm.; Crystal Creek Mbr., Carmel Fm. | Rock |
| Landslide Deposits | Qmsy, Qmsh, Qmsc, Qmso | Fine-grained Soil or Rock |

[1]Refer to UGS geologic quadrangle maps (see Sources of Information and References in accompanying text) for descriptions of map units.

## DISCUSSION

Piping refers to the subsurface erosion of permeable, fine-grained, unconsolidated or poorly consolidated deposits by percolating ground water (Cooke and Warren, 1973; Costa and Baker, 1981). Piping creates narrow, subterranean conduits that enlarge both in diameter and length as increasingly more subsurface material is removed and as the cavities trap greater amounts of ground-water flow. Piping eventually leads to caving and collapse of the overlying surficial materials, and is an important process in the headward extension of gullies in the arid southwestern United States (Costa and Baker, 1981).

For piping to take place, the following conditions are required: (1) fine-grained, noncohesive or poorly consolidated, porous materials, such as some silt and clay; fine sand; poorly consolidated, typically sandy siltstone, mudstone, or claystone; and volcanic ash or tuff, (2) a sufficient thickness of susceptible material in which pipes may form, (3) a sufficiently steep hydraulic gradient to cause ground water to percolate through the subsurface materials, and (4) a free face that intersects the permeable, water-bearing horizon and from which the water can exit the eroding deposit. The walls of an incised stream channel commonly provide the necessary free face, but human-made excavations such as canal banks or road cuts may also induce piping. Parker and Jenne (1967, in Costa and Baker, 1981) describe extensive damage to U.S. Highway 140 where it traverses dissected and extensively piped valley fill along Aztec Wash in southwestern Colorado. Christenson and Deen (1983) reported piping at several locations in the St. George area.

The characteristics that make soil or rock susceptible to piping (fine-grained texture, little or no internal cohesion, and loose or poor consolidation) are also typical of highly erodible materials. Consequently, piping often develops in and is an indicator of otherwise highly erodible deposits. In southern Utah, most erosion occurs during cloudburst storms and is caused by sheetwash and eventual channelization of runoff. If disturbed, highly erodible soil or rock become even more susceptible to erosion, particularly when stabilizing vegetation is removed.

Utah Geological Survey geologic maps (see Sources of Information section in accompanying text) show that fine-grained, noncohesive, loose sand and silt deposits are present in many areas of the Zion National Park Geologic-Hazard Study Area. They include eolian, alluvial, and lacustrine deposits, and mixed-unit geologic deposits that contain a high percentage of wind-blown sand derived from the weathering and erosion of sandstone bedrock that crops out in the study area. Poorly consolidated, often highly weathered, fine-grained bedrock units also crop out over portions of the study area.

For additional information about piping and highly erosive soils in the Zion National Park Geologic-Hazard Study Area, refer to the Problem Soil and Rock Hazards chapter in this report.

## USING THIS MAP

This map shows the location of geologic units in the Zion National Park Geologic-Hazard Study Area that are potentially susceptible to piping and erosion. The map is intended for general planning and design purposes to indicate where susceptible soil and rock exist and where special investigations should be required. Site-specific investigations can resolve uncertainties inherent in generalized mapping and help identify the need for special design or mitigation techniques. The presence of soil or rock susceptible to piping and erosion along with other geologic hazards should be addressed in these investigations. If a potential for piping and erosion is present at a site, appropriate design and construction recommendations should be provided.

## MAP LIMITATIONS

This map is based on limited geologic and geotechnical data; site-specific investigations are required to produce more detailed geotechnical information. The map also depends on the quality of those data, which may vary throughout the study area. The boundaries of the areas shown as susceptible to piping and erosion are approximate and subject to change as new information becomes available. The susceptibility may be different than shown at any particular site because of variations in the physical properties of geologic deposits within a map unit, gradational and approximate map-unit boundaries, and the small map scale. Localized areas of piping and erosion susceptibility may exist throughout the study area, but their identification is precluded because of limitations of map scale. The map is not intended for use at scales other than the published scale, and is designed for use in general planning and design to indicate the need for site-specific investigations.

## HAZARD REDUCTION

Although potentially costly when not recognized and properly accommodated in project design and construction, problems associated with piping and erosion rarely are life threatening. As with most geologic hazards, early recognition and avoidance are the most effective ways to mitigate potential problems. However, geologic units susceptible to piping and erosion are widespread in the study area, and avoidance may not always be a viable or cost-effective option.

In Utah, soil-test requirements are specified in chapter 18 (Soils and Foundations) of the 2009 IBC (International Code Council, 2009a) and chapter 4 (Foundations) of the 2009 IRC (International Code Council, 2009b), which are adopted statewide. IBC Section 1803.3 contains requirements for soil investigations in areas where questionable soil (soil classification, strength, or compressibility in doubt) is present. IRC Section R401.4 states that the building official shall determine whether to require a soil test to determine the soil's characteristics in areas likely to have expansive, compressible, shifting, or other unknown soil characteristics. Where the presence of soil or rock susceptible to piping or rapid erosion is confirmed, possible mitigation techniques include minimizing disturbance of vegetated areas, controlling the flow of shallow ground water, and managing surface drainage onsite in a controlled manner.

## REFERENCES

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Parker, G.G., and Jenne, E.A., 1967, Structural failure of western U.S. highways caused by piping: Washington, D.C., Highway Research Board 46th Annual Meeting, 27 p.