UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
in cooperation with
National Park Service

FLOOD AND DEBRIS-FLOW HAZARDS
ZION NATIONAL PARK GEOLOGIC-HAZARD STUDY AREA

By

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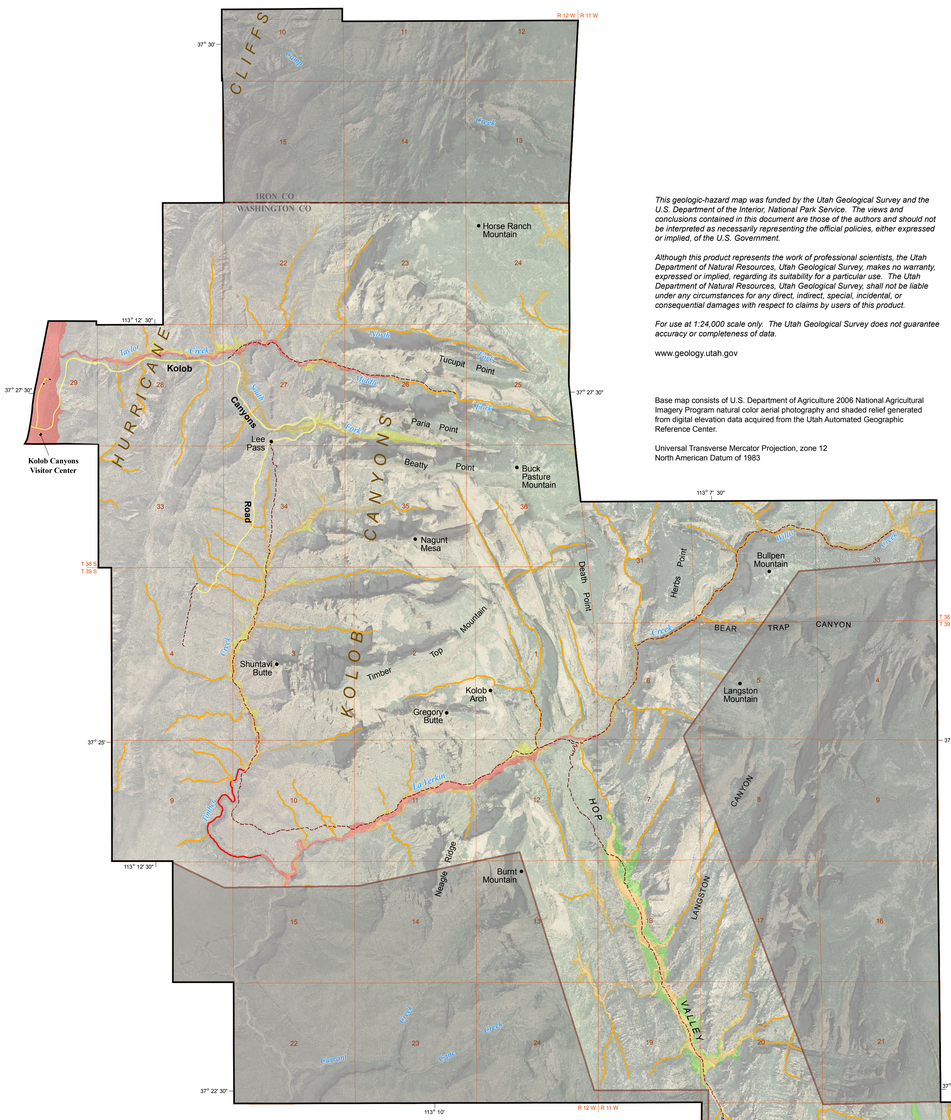

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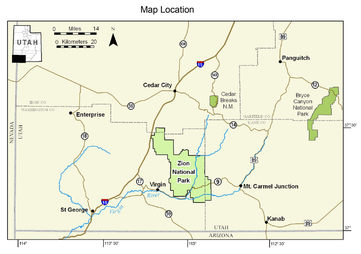
Base map consists of U.S. Department of Agriculture 2006 National Agricultural Imagery Program natural color aerial photography and shaded relief generated from digital elevation data acquired from the Utah Automated Geographic Reference Center.

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

SYMBOLS

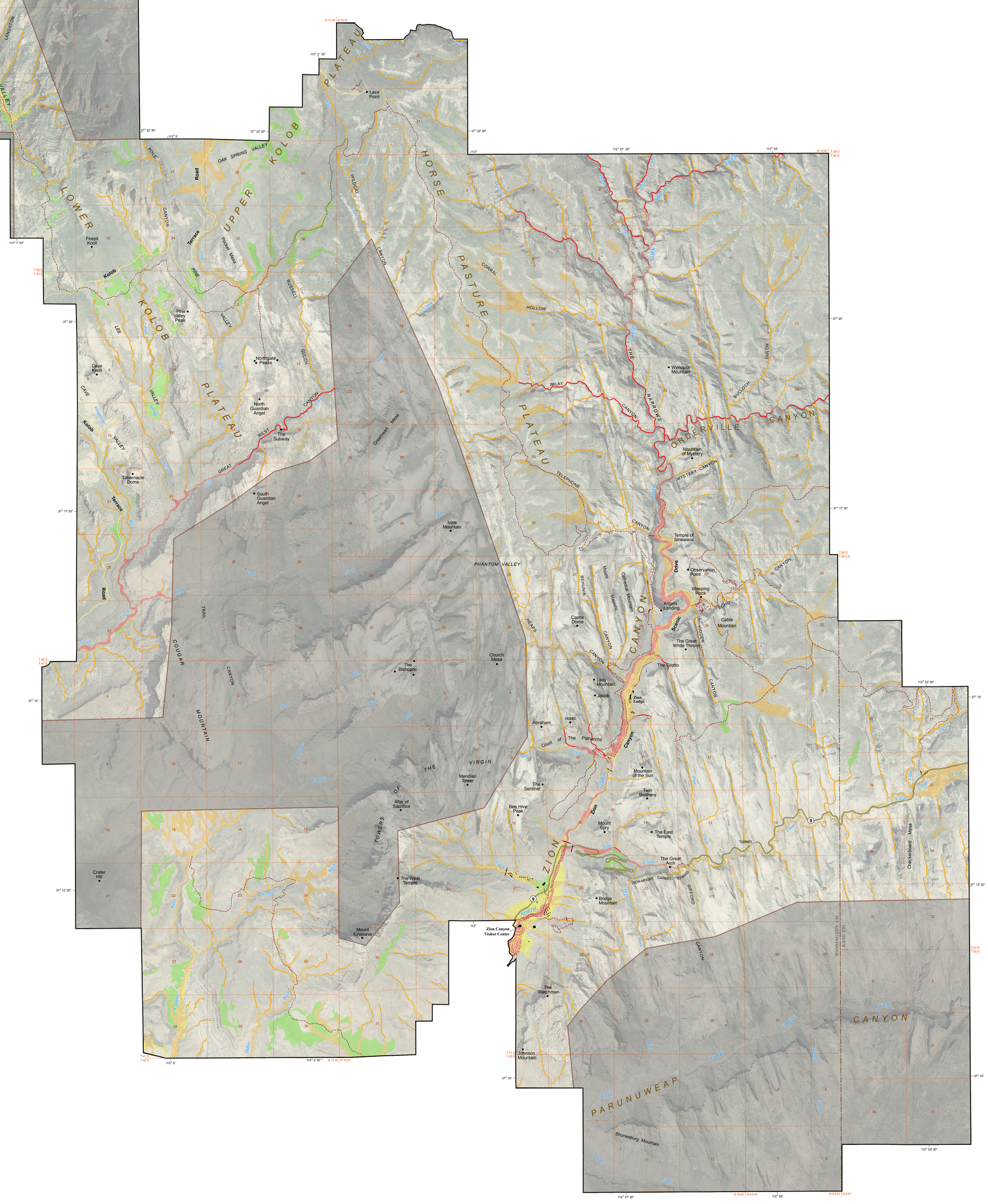
- Zion National Park Geologic-Hazard Study Area boundary
- Zion National Park boundary
- County boundary
- State highway
- Minor road
- Foot trail
- Existing park structure
- Area not studied
- Northern extent of Federal Emergency Management Agency Flood Insurance Rate Mapping along the North Fork of the Virgin River
- Extent of National Park Service 100-year and 500-year flood mapping in lower Zion Canyon

Map Location



SCALE 1:24,000

Approximate mean declination, 2009



DISCUSSION

Flooding is the overflow of water onto lands that are normally dry, and is the most universally experienced natural hazard (Keller and Blodgett, 2006). Damaging effects from flooding include inundation of land and property, erosion, deposition of sediment and debris, and the force of the water itself, which can damage property and take lives (CH2M HILL, 1997; JE Fuller Hydrology and Geomorphology, Inc., 2005, 2007; Barjenbruch and others, 2008). Historically, flooding is the most prevalent, destructive, and deadly geologic hazard affecting Zion National Park. Several existing structures in the park, many historic, are located in flood-hazard areas because the rugged park topography leaves few alternatives. Visitors to Zion National Park frequently travel in and through flood-hazard areas.

The high flood hazard results from the complex interaction of the area's rugged topography and southwestern Utah's seasonal weather patterns. Three types of floods typically occur in the study area: (1) riverine (stream) floods, (2) flash floods/debris flows, and (3) sheetfloods. All three types of floods are associated with natural climatic fluctuations and may, under certain circumstances, occur simultaneously. Two additional types of floods may also occur within the study area - unintentional water release from water-retention structures, and flooding due to the breach of rock-fall or landslide dams - neither of which are necessarily associated with precipitation events. The risk from flooding can be significantly increased by wildfires (Neary and others, 2005), and by human activities such as placing structures and constrictions in floodplains and erosion-hazard zones, developing areas without adequate flood and erosion control, and poor watershed management practices.

For additional information about the flood hazard in the Zion National Park Geologic-Hazard Study Area, refer to the Flood and Debris-Flow Hazards chapter in this report.

USING THIS MAP

This map shows flood-susceptible areas based upon topography and the presence of young, water-deposited geologic units as described in the table above. The extent of drainages in the study area covered by FIRMs, and NPS-defined 100-year and 500-year floodplains in lower Zion Canyon are also shown on the map. However, those data are depicted for information purposes only; readers requiring additional information regarding flood zone boundaries should consult the original FEMA (1986) and NPS (1993) documents.

This map provides a basis for conducting site-specific flood and debris-flow hazard investigations. Site-specific investigations can resolve uncertainties inherent in generalized hazard mapping and help ensure safety by identifying the need for flood-resistant design. However, because intense cloudburst storms create a potential for flash floods, debris flows, and sheetfloods anywhere in the Zion National Park Geologic-Hazard Study Area, even locations outside identified flood-prone areas could be subject to periodic flooding. This map also shows where existing developments lie in flood-prone areas, and, therefore, where flood-resistant-design measures may be required. An evaluation of existing flood-mitigation measures and their likely effectiveness is beyond the scope of this study.

MAP LIMITATIONS

This map is based on limited geological, geotechnical, topographic, and hydrological data; site-specific investigations are required to produce more detailed flood-hazard information. The map also depends on the quality of those data, which varies throughout the study area. The mapped boundaries of the flood-hazard categories are approximate and subject to change as new information becomes available. The flood hazard at any particular site may be different than shown because of geological and hydrological variations within a map unit, gradational and approximate map-unit boundaries, the generalized map scale, and topographic changes along drainages that postdate mapping. Small, localized areas of higher or lower flood hazard may exist within any given hazard 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 to indicate general hazard areas and the need for site-specific investigations.

HAZARD REDUCTION

Early recognition and avoidance of areas subject to flooding are the most effective means of flood-hazard reduction. However, avoidance may not always be a viable or cost-effective option, especially for areas of existing development. Other techniques available to reduce potential flood damage may include, but are not limited to, source-area stabilization, engineered protective structures, flood and debris-flow warning systems, and floodproofing. Some of these techniques can be expensive and their cost-versus-benefit ratio should be carefully evaluated along with effectiveness and reliability. With regard to sheetflooding, a properly sized and integrated drainage system is usually adequate to mitigate the hazard.

We recommend a flood-hazard investigation for new construction in all hazard categories shown. The first consideration in reducing the hazard from stream flooding and debris flows is the proper identification of hazard areas through detailed mapping, and qualitative assessment of the hazard (Giraud, 2005). The stream-flooding hazard assessment should determine the active flooding area, the frequency of past events, and the potential inundation and flow depths. The debris-flow hazard assessment should determine active depositional areas, the frequency and volume of past events, and sediment burial depths (Giraud, 2005). The level of detail for a hazard assessment depends on several factors, including (1) the type, nature, and location of the proposed development, (2) the geology and physical characteristics of the drainage basin, channel, and alluvial fan, (3) the history of previous flooding and debris-flow events, and (4) proposed risk-reduction measures.

Where development is proposed in areas identified on this map as having a potential flood hazard, a site-specific investigation should be performed early in the project design phase. The investigation should clearly establish whether a flood and/or debris-flow hazard is present at a site and provide appropriate design recommendations. Additionally, Zion National Park visitors often enter areas that are prone to flooding. The risk to visitors is short-term, but constitutes a significant threat due to the number of visitors and the fact that most come to the park lacking a full appreciation of the nature of rainfall and flooding in this area. To mitigate this threat, the park has a coordinated program to inform visitors of flood hazards, with particular attention to those who engage in backcountry hiking and canyoneering. This program should continue with periodic review of its effectiveness.

The failure of a water-retention structure or breach of a natural dam represents a low-probability but high-hazard event in the Zion National Park Geologic-Hazard Study Area. Monitoring and periodic inspection of constructed dams and reservoirs help ensure their safety, and Emergency Action Plans that include a notification plan for downstream communities are required for each dam. Similarly, existing and future natural dams within or upstream of the study area should be evaluated for safety and receive periodic inspections. Natural dams from landslides or rock falls are considered to be particularly hazardous, and should be regularly monitored to determine their vulnerability to overtopping or catastrophic breaching.

REFERENCES

Barjenbruch, K., McInerney, B., Watanabe, J., and Siebeneck, L., 2008, Floods,*in* Utah natural hazards handbook – understanding the hazard: Utah Division of Homeland Security, Online, <http://publicsafety.utah.gov/homelandsecurity/documents/HazardsHandbookDraft8.pdf>, accessed November 2, 2009, p. 58-67.

CH2M HILL, 1997, River stability study – Virgin River, Santa Clara River, and Fort Pierce Wash: Consultant's report prepared for the City of St. George, variously paginated.

Federal Emergency Management Agency, 1986, Flood Insurance Rate Map community-panel number 490224 0550 B: National Flood Insurance Program, approximate scale 1"=2000'.

Giraud, R.E., 2005, Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah: Geological Survey Miscellaneous Publication 05-6, 16 p.

JE Fuller Hydrology & Geomorphology, Inc., 2005, River stability study, Santa Clara & Virgin Rivers, Washington County, Utah: Tempe, Arizona, unpublished consultant's report prepared for the Washington County Water Conservancy District, 50 p., 3 appendices.

JE Fuller Hydrology & Geomorphology, Inc., 2007, Virgin River stability study update, Washington County, Utah: Tempe, Arizona, unpublished consultant's report prepared for the Washington County Water Conservancy District, 47 p., 5 appendices.

Keller, E.A., and Blodgett, R.H., 2006, Natural hazards – Earth's processes as hazards, disasters, and catastrophes: Upper Saddle River, New Jersey, Pearson Prentice Hall, 395 p.

National Park Service, 1993, Draft development concept plan environmental assessment, Zion Canyon Headquarters, Zion National Park: Denver, Colorado, Branch of Planning, Rocky Mountain Region, 143 p.

Neary, D.G., Ryan, K.C., and DeBano, L.F., editors, 2005, Wildland fire in ecosystems – effects of fire on soils and water: Ogden, Utah, U.S. Department of Agriculture, Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-42, v. 4, 250 p.

EXPLANATION

Hazard Category	Geologic Units[1]	Description	Hazard Type	Comments
Very High	Qal_1, Qaf, Qaf_1, Qafy, Qaly, Qath, Qat_2, Qac, Qa, Qa_1, Qa_2, Qafc	Active floodplains and low terraces along perennial streams (large drainage basins) subject to periodic riverine and flash flooding and accompanying erosion, active alluvial fans subject to flash floods and debris flows, and slot canyons containing perennial streams that are periodically inundated by flash floods and debris flows, which may occur in response to distant cloudburst storms.	Riverine flood, flash flood, debris flow	North Fork of the Virgin River, North Creek, lower Pine Creek, Deep Creek, Kolob Creek, La Verkin Creek, lower Timber Creek, Orderville Canyon Creek, Imlay Canyon Creek, Goose Creek, and active alluvial fans.
High	Qafc, Qa_1, Qac, Qay, Qaes, Qas	Stream channels, floodplains, and low terraces along normally dry ephemeral streams (smaller drainage basins) and slot canyons that are periodically inundated by flash floods and debris flows during cloudburst storms in their smaller drainage basins.	Flash flood, debris flow	Normally dry streams with comparatively small drainage basins subject to flooding during cloudburst storms.
Moderate	Qaf_2, Qla, Qc, Qca, Qat_2	Active pediments and sloping depositional surfaces flanking ridges and other upland areas that are chiefly inundated by sheetfloods, but possibly by flash floods and debris flows during cloudburst storms.	Chiefly sheetflood, possible flash flood and debris flow	Active depositional surfaces on the flanks and at the base of upland areas subject to flooding during cloudburst storms.
Low	Qaco, Qae, Qaeo, Qafo, Qea, Qafco	Valley bottoms and minor ephemeral drainages subject to possible sheetfloods and minor flash floods from adjacent upland areas during cloudburst storms.	Sheetflood, minor flash flood	Valley bottoms subject to infrequent flooding from adjacent upland areas during cloudburst storms.

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

Very High: Narrow, bedrock-floored canyons with perennial streams subject to very high flood hazard, but that lack mappable alluvial deposits.

High: Narrow, bedrock-floored canyons with ephemeral streams subject to high flood hazard, but that lack mappable alluvial deposits.