UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

EXPLANATION

Piping and Erosion

PE_S **Soil susceptible to piping and erosion** - Typically fine-grained, noncohesive, loose to poorly consolidated sand or silt, and landslide deposits consisting of similar materials. For piping to develop, a free face and percolating groundwater are also necessary.

PE_R **Rock susceptible to piping and erosion** - Typically fine-grained, poorly consolidated siltstone, mudstone, or claystone, and landslide deposits consisting of such rock types. For piping to develop, a free face and percolating groundwater are also necessary.

Wind-Blown Sand

Wind-Blown Sand - Geologically young, active or partially stabilized, wind-blown or mixed-unit sand deposits characterized by well-sorted, loose, sandy soil texture with few or no fines. Where disturbed, sandy soils may migrate across roads and bury structures, and wind erosion may expose foundations and underground utilities. These soils are also often susceptible to piping and erosion.

INTRODUCTION

Piping and Erosion

Piping refers to the subsurface erosion of permeable, fine-grained, unconsolidated or poorly consolidated deposits by percolating groundwater (Cooke and Warren, 1973; Costa and Baker, 1981; figure 1). 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 groundwater flow. Piping eventually leads to caving and collapse of the overlying surficial materials (figure 2), 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 groundwater 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 contribute to piping. Parker and Jenne (1967, in Costa and Baker, 1981) described 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.

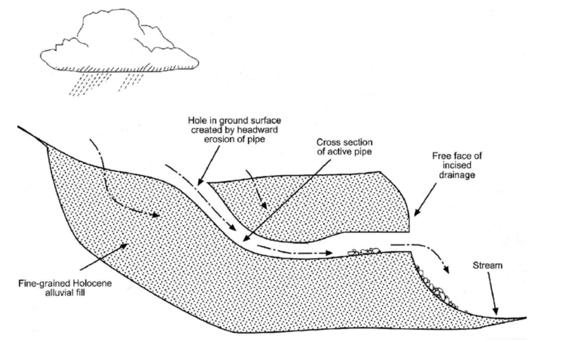

Figure 1. *Cross section of a pipe in fine-grained Holocene alluvium (after Black and others, 1999).*

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 (figure 3). If disturbed, highly erodible soil or rock become even more susceptible to erosion, particularly when stabilizing vegetation is removed.

Figure 2. *Collapsed pipe in fine-grained floodplain alluvium in southwestern Utah. Photo date: October 2005.*

Wind-Blown Sand

Unless stabilized by natural vegetation or by artificial means, loose sand will move in response to high-velocity and long-duration wind. Wind transport (e.g., saltation; deBlij and Muller, 1996) winnows the sand, producing a well-sorted (poorly graded) deposit that typically consists of subrounded to rounded sand grains with diameters ranging from very fine to coarse (0.1 to 1.0 mm; Bates and Jackson, 1987). The fines content (silt and clay fraction) in wind-blown sand is generally less than 10 percent. Depending on topography, wind characteristics, and sand availability, blowing sand may accumulate in dunes or sand sheets, both of which may cover large areas.

If development encroaches into areas with predominantly sandy soil and disturbs the natural vegetative cover, the wind may mobilize the disturbed material leading to erosion (figure 4) and redeposition of the sand. Stabilized sand dunes and sand sheets may react in the same manner when disturbed. High winds can move fines by suspension and produce sand and dust storms that reduce visibility to near zero and sandblast vehicles and structures.

Figure 3. *Gully formed in fine-grained material during a cloudburst thunderstorm in southwestern Utah. Photo date: February 2006.*

SOURCES OF INFORMATION

Sources of information used to evaluate piping, erosion, and wind-blown-sand susceptibility in the State Route 9 Corridor Geologic-Hazard Study Area (SR-9 study area) include (1) 40 geotechnical reports on file with the National Park Service (NPS), the Utah Department of Transportation (UDOT), and the towns of Springdale and Virgin, (2) Natural Resources Conservation Service (NRCS) (formerly Soil Conservation Service) *Soil Survey of Washington County Area, Utah* (Mortensen and others, 1977), (3) the four Utah Geological Survey (UGS) 1:24,000-scale geologic quadrangle maps that cover the study area (Virgin [Hayden and Sable, 2008], Springdale West [Willis and others, 2002], Springdale East [Doelling and others, 2002], and Smithsonian Butte [Moore and Sable, 2001]), (4) *Engineering Geology of the St. George Area, Washington County, Utah* (Christenson and Deen, 1983), (5) "Geologic Hazards of the St. George Area, Washington County, Utah" (Christenson, 1992), (6) *Engineering Geologic Map Folio, Springdale, Washington County, Utah* (Solomon, 1996), (7) *Geologic Hazards and Adverse Construction Conditions, St. George–Hurricane Metropolitan Area, Washington County, Utah* (Lund and others, 2008), and (8) *Geologic Hazards of the Zion National Park Geologic-Hazard Study Area, Washington and Kane Counties, Utah* (Lund and others, 2010).

Figure 4. *Exposed block wall foundation in Virgin due to wind erosion of sandy soil (photo credit David Black).*

DESCRIPTION

Piping and Erosion

Utah Geological Survey geologic maps (see Sources of Information section) show that fine-grained, noncohesive, loose sand and silt deposits are present in many areas of the SR-9 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.

Wind-Blown Sand

Several sandstone formations crop out extensively within the SR-9 study area. Sand eroded from those bedrock units is the principal source of wind-blown sand in the study area. Chief among the sandstone formations is the Navajo Sandstone, which consists of a thick (~2000 ft) sequence of lithified, mostly wind-blown sand of Jurassic age. The sand released by weathering and erosion of the Navajo Sandstone is in effect "fossil" dune sand that has the same size, sorting, and grain-shape characteristics of sand comprising modern sand dunes and sand sheets. Other bedrock formations that are less prolific, but still important sources of sand include the Moenave and Kayenta Formations, and the Shinarump Conglomerate Member of the Chinle Formation.

Utah Geological Survey geologic maps (see Sources of Information section) show that loose sand deposits are of limited extent in the study area. The UGS mapping encompasses what are chiefly geologically young, active or partially stabilized, wind-blown or mixed-unit sand deposits characterized by well-sorted, loose, sandy soil texture with few or no fines.

HAZARD CLASSIFICATION

Piping and Erosion

This map shows the location of highly erodible soil and bedrock deposits susceptible to piping. Because piping only occurs where susceptible soil and rock exist in the presence of a free face and percolating groundwater, the presence of these units in and of themselves does not create a piping hazard. Conversely, a change in conditions brought about either naturally or through human activity can create the conditions necessary for piping to occur. While susceptible to erosion, these units are generally stable in their natural, undisturbed state, but can quickly erode if disturbed or if drainage conditions change in an uncontrolled manner.

We grouped geologic deposits in the SR-9 study area considered potentially susceptible to piping and erosion (table 1) into two susceptibility categories, one for unconsolidated deposits (soil) and the other for bedrock. The piping-and-erosion-susceptibility categories are described in the Explanation section.

Table 1. *Erosion hazard categories for geologic deposits in the SR-9 study area.*

Type of Deposit	Geologic Map Units[1]	Erosion Hazard Category
Stream Alluvium	Qa_1, Qa_2, Qal_1,	Soil
Alluvial/Terrace Deposits	Qay, Qae, Qac, Qat_2, Qatm, Qath, Qats	Soil
Eolian/Colluvial Sand Deposits	Qes, Qer, Qec, Qea, Qmts	Soil, Wind-Blown Sand
Lacustrine Deposits	Qlg	Soil
Poorly Consolidated Bedrock	Petrified Forest Mbr., Chinle Fm.; Shnabkaib Mbr. and red mbrs., Moenkopi Fm.; Whitmore Point and Dinosaur Canyon Mbrs., Moenave Fm.	Rock
Landslide Deposits	Qms, Qmsy, Qmsh, Qmsc, Qmso	Fine-grained Soil or Rock

[1]Refer to UGS 1:24,000-scale geologic maps (see Sources of Information section) for a description of map units.

Wind-Blown Sand

Where disturbed, sandy soils may migrate across roads and bury structures (Mulvey, 1992; Hayden, 2004; Lund and others, 2008) (figure 5), and wind erosion may expose foundations and underground utilities. During high wind events, blowing sand and dust may become a serious safety hazard to driving. We grouped wind-blown sand deposits and mixed-unit geologic deposits containing a high sand component into a single susceptibility category (table 1). Since wind-blown sand is nearly always also prone to piping and erosion, the wind-blown-sand and the soil-piping-and-erosion susceptibility categories overlap as shown in the Explanation section.

Figure 5. *Road buried by migrating sand deposit in southwestern Utah. Photo date: May 2008.*

USING THIS MAP

This map shows the location of geologic units in the SR-9 study area that are potentially susceptible to piping and erosion and/or reactivation by wind if disturbed. 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 erosion along with other geologic hazards should be addressed in these investigations. If a potential for piping and erosion and/or wind-blown sand is present at a site, appropriate design and construction recommendations should be provided.

HAZARD REDUCTION

Although potentially costly when not recognized and properly accommodated in project design and construction, problems associated with piping and erosion and/or wind-blown sand 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 and/or wind-blown sand 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 *International Building Code* (IBC) (International Code Council, 2009a) and chapter 4 (Foundations) of the 2009 *International Residential Code for One- and Two-Family Dwellings* (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 and/or wind-blown sand is confirmed, possible mitigation techniques include minimizing disturbance of vegetated areas, controlling the flow of shallow groundwater, and managing surface drainage onsite in a controlled manner.

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, erosion, and wind-blown sand 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, erosion, and wind-blown-sand 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.

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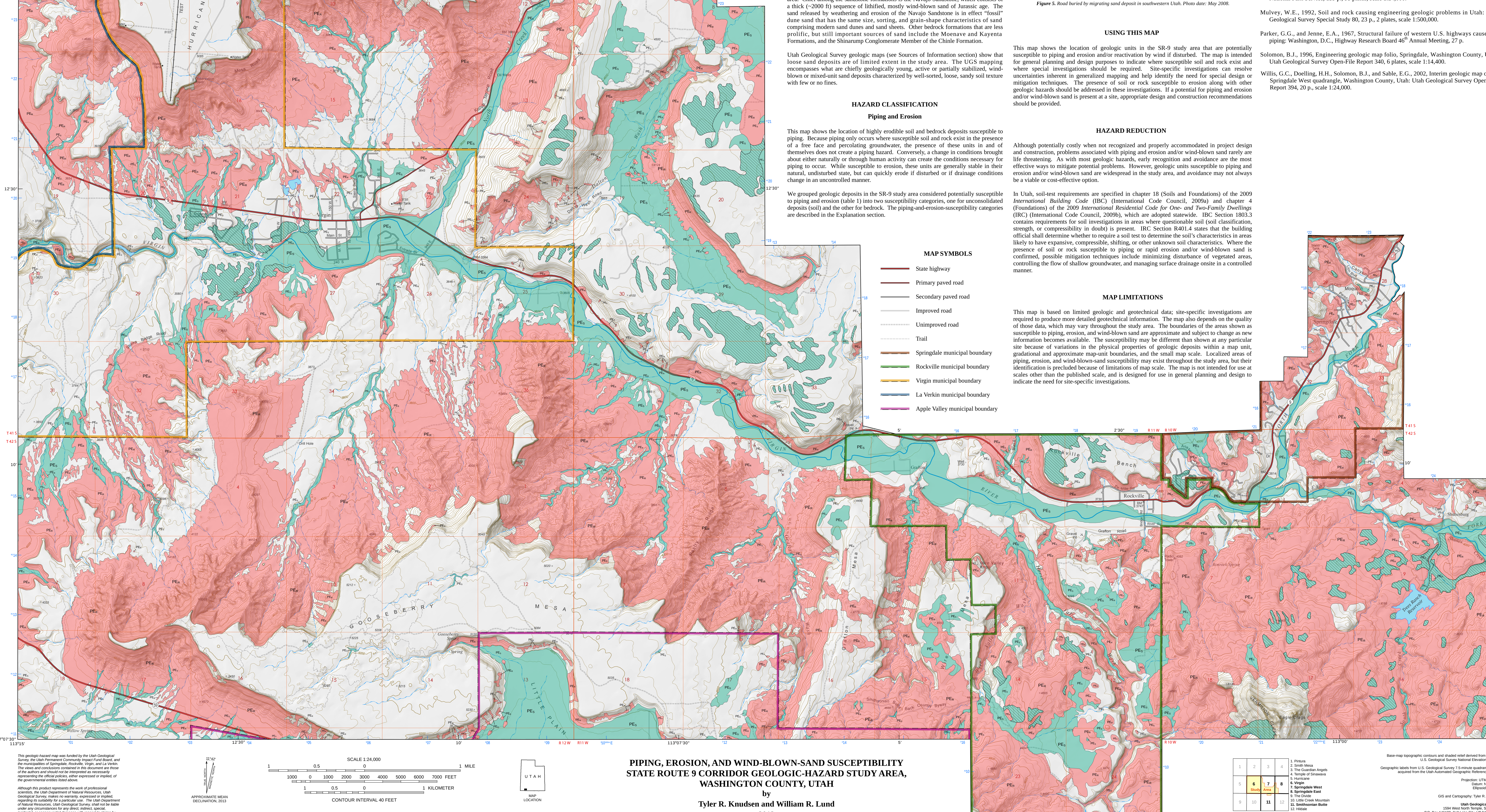

MAP SYMBOLS

- State highway
- Primary paved road
- Secondary paved road
- Improved road
- Unimproved road
- Trail
- Springdale municipal boundary
- Rockville municipal boundary
- Virgin municipal boundary
- La Verkin municipal boundary
- Apple Valley municipal boundary

This geologic-hazard map was funded by the Utah Geological Survey, the Utah Permanent Community Impact Fund Board, and the municipalities of Springdale, Rockville, Virgin, and La Verkin. 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 governmental entities listed above.

11°42'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2013

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
CONTOUR INTERVAL 40 FEET

UTAH
MAP LOCATION

PIPING, EROSION, AND WIND-BLOWN-SAND SUSCEPTIBILITY STATE ROUTE 9 CORRIDOR GEOLOGIC-HAZARD STUDY AREA, WASHINGTON COUNTY, UTAH

by
Tyler R. Knudsen and William R. Lund
2013

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7.5' QUADRANGLE INDEX

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2. Smith Mesa
3. The Guardian Angels
4. Temple of Sinawava
5. Hurricane
6. **Virgin**
7. **Springdale West**
8. **Springdale East**
9. The Divide
10. Little Creek Mountain
11. **Smithsonian Butte**
12. Hildale

Base-map topographic contours and shaded relief derived from 10 meter U.S. Geological Survey National Elevation Dataset.

Geographic labels from U.S. Geological Survey 7.5-minute quadrangle maps acquired from the Utah Automated Geographic Reference Center.

Projection: UTM Zone 12
Datum: NAD 1983
Ellipsoid: GRS 80

GIS and Cartography: Tyler R. Knudsen

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