UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

EXPLANATION

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)
FLOOD INSURANCE RATE MAP (FIRM) ZONES

Zone A - Special Flood Hazard Area (SFHA) subject to inundation by the 1% annual chance flood (100-year flood). Base Flood Elevations (water-surface elevation of the 1% annual chance flood) not determined.

AE **Zone AE** - Special Flood Hazard Area (SFHA) subject to inundation by the 1% annual chance flood (100-year flood). Base Flood Elevations (water-surface elevation of the 1% annual chance flood) determined.

AE **Floodway Area in Zone AE** - The floodway channel of a stream plus any adjacent floodplain area that must be kept free of encroachments so that the 1% annual chance flood can be carried without substantial increase in flood height.

Base Flood Elevation line, elevation in feet above mean sea level.

Limit of FEMA study.

FLOOD-HAZARD CATEGORIES BASED ON GEOLOGIC DEPOSITS
MAPPED BY THE UTAH GEOLOGICAL SURVEY

Hazard Category	Geologic Units[1]	Description	Hazard Type	Comments
Very High (VH)	Qal_1, Qa_1, Qath, Qatm, Qats, Qat_2	Active floodplains and low terraces along perennial streams (large drainage basins) subject to periodic riverine and flash flooding and accompanying erosion.	Riverine flood, flash flood, debris flow	Virgin River, North and East Fork of the Virgin River, North Creek, South Creek, Shunes Creek.
High (H)	Qa_1, Qa_2 Qac, Qay, Qat_2, Qafc	Stream channels, floodplains, and low terraces along normally dry ephemeral streams (smaller drainage basins) and active alluvial fans that are periodically inundated by flash floods and debris flows during cloudburst storms.	Flash flood, debris flow	Normally dry streams and alluvial fans with comparatively small drainage basins subject to flooding during cloudburst storms.
Moderate (M)	Qaf_2, Qafc, Qat_2, Qae	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 (L)	Qaco, 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.
Undetermined	Bedrock	Bedrock badlands and mesa tops that may be subject to flood hazards during cloudburst storms, but could not be classified due to a lack of alluvial deposits.	Possible sheetflood, flash flood, and debris flow	Areas of active erosion in which flood hazards are undetermined due to a lack of mappable alluvial deposits.

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

INTRODUCTION

Historically, flooding is the most prevalent and destructive geologic hazard affecting the State Route 9 Corridor Geologic-Hazard Study Area (SR-9 study area). 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. Historic accounts of floods in Zion Canyon date back to the mid-nineteenth century (Woolley, 1946; Butler and Marsell, 1972; National Park Service [NPS], unpublished data) and provide ample evidence of the destructive power and life-threatening nature of flooding in the study area.

The high flood hazard results from the complex interaction of the area's rugged topography and southwestern Utah's seasonal weather patterns. Three principal types of floods occur in the study area: riverine (stream) floods, flash floods, and debris flows. All three flood types 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.

SOURCES OF INFORMATION

Sources of information used to evaluate flood hazards in the SR-9 study area include (1) the 12 Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRMs) that cover the study area (FEMA, 2009), (2) *Engineering Geologic Map Folio, Springdale, Washington County, Utah* (Solomon, 1996), and (3) the distribution of young, water-deposited geologic units shown on 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]).

FLOOD TYPES

Riverine Floods

Riverine flooding along major drainages in southwestern Utah is usually regional in nature, lasts for several hours or days, commonly takes place on perennial streams, and typically can be predicted days to weeks in advance. Riverine floods usually result from rapid melting of the winter snowpack or from prolonged heavy rainfall associated with major frontal storms, or from both conditions simultaneously. They typically occur in watersheds of over 200 square miles that include terrain high enough to accumulate a substantial snowpack. Where uncontrolled, riverine floods can inundate large areas along floodplains and cause extensive erosion and flood damage (including bridge scour) as was demonstrated in the study area along the Virgin River during large riverine floods in 2005 and 2010. Data were insufficient to prepare a separate flood-erosion-hazard map for the study area; therefore, when developing in flood-prone areas, erosion hazard should be evaluated on a site-specific basis.

Measurements or careful estimates of historical peak flows on parts of the Virgin River system date to 1909 (U.S. Army Corps of Engineers, 1973), but are not available for every year. The largest recorded flood on the Virgin River (period of continuous record 1925–2012) occurred in December 1966; the U.S. Geological Survey (USGS, 2011) reported a maximum instantaneous discharge of 9150 cubic feet per second (cfs) on the North Fork of the Virgin River near Springdale. The two most recent major riverine floods on the Virgin River in January 2005 and December 2010 (figure 1) produced maximum daily discharges on the North Fork of the Virgin River near Springdale of about 2900 cfs and 3500 cfs, respectively (USGS, 2011). Both floods were regional events, and the 2005 flood is the most damaging flood on record in southwestern Utah, resulting in about $85 million in private property losses and an estimated $145 million in damage to roads, bridges, parks, and utility lines (FEMA, undated). Damage from the 1966 flood, which occurred when population densities in southwestern Utah were much lower, held the previous damage record of $14 million in 1966 dollars (U.S. Army Corps of Engineers, 1973).

Figure 1. Rockville home damaged by flooding on the Virgin River in December 2010 (photo credit Kurt Sparenberg).

Flash Floods

Flash floods are sudden, intense, localized events that occur in response to cloudburst rainfall that often accompanies convective, monsoonal thunderstorms. Because cloudburst storms result from strong convective cells produced by differential atmospheric heating, flash floods are typically a summertime phenomenon in desert regions. Flash floods in the SR-9 study area can affect both perennial and ephemeral drainages and alluvial fans. The Virgin River and its larger tributaries are subject to periodic flash flooding (figure 2), but the most intense and unpredictable floods often take place in small- to medium-sized watersheds characterized by ephemeral stream flow and normally dry stream channels.

Alluvial fans are a common geomorphic feature in the study area. Alluvial fans are relatively flat to moderately sloping fan-shaped surfaces underlain by loose to weakly consolidated sediment deposited by a stream at a topographic break, such as the base of a mountain front, escarpment, or valley side (National Research Council, 1996). Because of their topographic location, alluvial fans are particularly susceptible to flash floods generated by cloudburst storms centered over their drainage basins. Flash floods on alluvial fans are characterized by great flow path uncertainty and by abrupt sediment deposition, often causing channel avulsion (a sudden change in flow path) as the stream loses its ability to carry its sediment load (National Research Council, 1996).

Figure 2. Home damaged by flash flooding on North Creek near Virgin in August 2007.

Debris Flows

Floodwaters typically contain a large amount of sediment ranging in size from clay to boulders. As the proportion of sediment increases, flash floods transform into debris floods and finally debris flows. A debris flow moves as a viscous fluid capable of transporting large boulders, trees, and other heavy debris over long distances. Like flash floods, debris flows are fast moving and under some conditions can exceed 35 miles per hour (USGS, 1997). Their greater density and high speed make debris flows particularly dangerous to life and destructive to property. Debris flows are capable of destroying buildings, roads, and bridges, and of depositing thick layers of mud, rock, and other debris (figure 3).

The volume and frequency of debris flows depends on several factors, including the amount of sediment in a drainage basin that is available for erosion and transport, the magnitude and frequency of storms, the amount of vegetation in the drainage, and soil conditions (Costa and Wieczorek, 1987; Costa, 1988; Giraud, 2004, 2005; Coe and others, 2008). Drainage basins that have experienced a wildfire are generally more susceptible to debris flows (Gartner and others, 2005; Giraud, 2005). The sediment carried by a debris flow can be deposited anywhere on an active alluvial-fan surface. The active fan surface includes those areas where modern deposition, erosion, and alluvial-fan flooding may occur. In general, those parts of the fan surface where sediment has been deposited during the Holocene (past 11,700 years; Cohen and Gibbard, 2010) are considered active unless proven to be otherwise. Typically, the upper part of an active alluvial fan has a higher debris-flow hazard due to greater velocities, impact pressures, burial depths, and event frequency (Giraud, 2004, 2005).

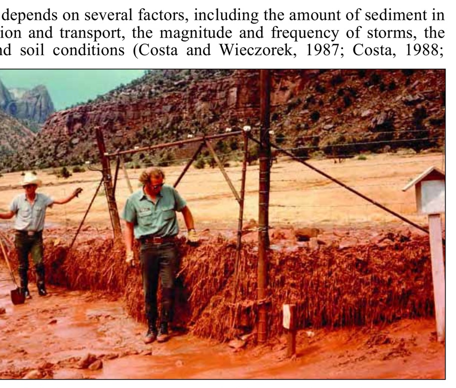

Figure 3. Sediment deposited by a small debris flow that discharged from an ephemeral drainage in Zion National Park in 1979. Such drainages are common in the State Route 9 Geologic-Hazard Study Area (photo courtesy of the National Park Service).

Debris flows are less common than flash floods in the SR-9 study area, but occur periodically in drainages where softer, more easily eroded bedrock crops out in the drainage headwaters. Such bedrock units include the Moenkopi, Chinle, Moenave, and Kayenta Formations, all of which weather to produce more sediment than the more-resistant Navajo Sandstone and Kaibab Formation. Debris flows typically occur in short, steep tributary channels, but not in the large river channels of the Virgin River and its major tributaries. The 1998 Sammy's Canyon debris flow in Zion National Park, which inundated part of the Watchman campground and the current locations of the Zion Canyon Visitor Center and shuttle maintenance facility, is a good example of a debris flow emanating from a small, ephemeral drainage with soft, sediment-producing bedrock formations in its drainage basin (Lund and Sharrow, 2005; Lund and others, 2007).

Unintentional Water Release from Water-Retention Structures

The unintentional release of water due to the failure of an engineered water-retention or conveyance structure is a rare occurrence, but may under some circumstances occur with little warning. There are two significant dams within the SR-9 study area: South Creek Dam (Trees Ranch Reservoir) on South Creek, a tributary to the East Fork of the Virgin River, and the Quail Creek Diversion on the Virgin River close to the western boundary of the study area (figure 4). Two additional significant water retention structures are present upstream from the study area: Kolob Creek Dam on Kolob Creek (a tributary to the North Fork of the Virgin River above Zion Narrows), and Blue Springs Dam on Blue Creek (a tributary to the Left Fork of the North Fork of the Virgin River) (figure 4). A failure of any of these dams is considered a rare and unexpected event, the possibility of which is mitigated by periodic inspections by the Utah Division of Water Rights, Office of Dam Safety. However, a dam failure could cause significant flooding downstream—how significant depends on reservoir volume and nature of the failure (Harty and Christenson, 1988; Solomon, 1996).

South Creek Dam was constructed in 1988. The dam is 91 feet high and 955 feet long. The impoundment behind the dam (Trees Ranch Reservoir) has a surface area of 63 acres and a storage capacity of 2250 acre-feet at the dam spillway crest (Utah Division of Water Rights, 2011a). South Creek Dam is classified as a "High Hazard" dam by the Utah Division of Water Rights, Office of Dam Safety. Utah Code 73-5a-106, "Dams classified according to hazard and use," defines high-hazard dams as "those dams which, if they fail, have a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities" (Utah State Legislature, 2011). The town of Rockville is 5 miles downstream from South Creek Dam. South Creek Dam experienced a "dam incident" in 2010, categorized by the Utah Division of Water Rights, Office of Dam Safety as a "shallow downstream slope failure" (Utah Division of Water Rights, 2011a). The maximum potential breach flow reported for South Creek Dam is 48,000 cfs (Utah Division of Water Rights, 2011a). The flood break map for South Creek Dam shows that the maximum flood flow at Rockville from a "rainy day" dam break would be 63,140 cfs, with a flood crest elevation of 3713 feet (Utah Division of Water Rights, 2011a).

The Quail Creek Diversion was constructed in 1984 and is 73 feet high and 95 feet long. Reservoir storage at the spillway crest is 295 acre-feet. The Quail Creek Diversion is classified as a "Low Hazard" dam by the Utah Division of Water Rights, Office of Dam Safety. Utah Code 73-5a-106, "Dams classified according to hazard and use," defines low-hazard dams as "those dams which, if they fail, would cause minimal threat to human life, and economic losses would be minor or limited to damage sustained by the owner of the structure." (Utah State Legislature, 2011). The Utah Division of Water Rights, Office of Dam Safety reports that "farms" are the first inhabited places about 0.5 mile below the dam. The maximum potential breach flow reported for the Quail Creek Diversion is 9000 cfs (Utah Division of Water Rights, 2011b). A flood break map is not available for the Quail Creek Diversion.

Kolob Creek Dam was constructed in 1956, and safety improvements were made in the 1990s. The dam is 61 feet high and 686 feet long. The impoundment behind the dam has a surface area of 234 acres and a storage capacity of 5586 acre-feet at the dam spillway crest (Utah Division of Water Rights, 2011c). Kolob Creek Dam is classified as a "High Hazard" dam. The town of Springdale is approximately 15 miles downstream from the dam. The maximum potential breach flow reported for Kolob Creek Dam (Utah Division of Water Rights, 2011c) is 92,330 cfs. The flood break map for Kolob Creek Dam shows that the maximum flood flow at Springdale from a "rainy day" dam break would be 65,548 cfs, with an estimated flood crest elevation of 3835.8 feet (Utah Division of Water Rights, 2011c).

Blue Springs Dam was constructed in 1957, and is 31 feet high and 326 feet long. The impoundment behind the dam has a surface area of 24 acres and a storage capacity of 275 acre-feet at the dam spillway crest (Utah Division of Water Rights, 2011d). Blue Springs Dam is classified as a "Moderate Hazard" dam. Utah Code 73-5a-106, "Dams classified according to hazard and use," defines moderate-hazard dams as "those dams which, if they fail, have a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities" (Utah State Legislature, 2011). The town of Virgin is 18 miles downstream from Blue Springs Dam. The maximum potential breach flow reported for the dam (Utah Division of Water Rights, 2011d) is 6200 cfs. A flood break map is not available for Blue Springs Dam.

Additional information for South Creek, Kolob Creek, and Blue Springs Dams, and the Quail Creek Diversion is available from the Utah Division of Water Rights, Office of Dam Safety at http://www.waterrights.utah.gov/daminfo/default.asp. Municipalities in the SR-9 study area should access these documents directly and determine what effect a breach of any of the four dams may have on their communities.

Flooding Associated with Rock-Fall or Landslide Dams

Hamilton (1995) and Biek and others (2010) identified as many as 14 natural lakes and ephemeral ponds that formed in canyons in and near Zion National Park due to the impounding effects of landslides, rock falls, and lava flows. The impoundments ranged from a few acres in area and a few feet deep, up to miles long and hundreds of feet deep. The most notable were Lake Grafton and Coalpits Lake, which formed behind lava-flow dams and flooded portions of the SR-9 study area, and Sentinel, Hop Valley, and Trail Canyon Lakes that formed behind rock-fall/landslide dams. The natural dams have been breached by erosion, and the former lakes were recognized chiefly by the fine-grained lacustrine sediments deposited behind the dams.

Future volcanic eruptions and lava flows are very low-probability events; however, the abundance of narrow canyons and the prevalence of rock falls and landslides in and upstream from the SR-9 study area make the likelihood of future natural water impoundments a near certainty. Impoundment of a stream by a rock-fall or landslide dam can produce a potentially significant flood hazard, both from inundation upstream of the dam due to ponding and flooding downstream of the dam due to overtopping or breaching of the dam. The degree of hazard depends on the size of the impoundment, the characteristics of the impounding material, and the hydrology of the impounded drainage. If a rock fall or landslide is large enough to block a perennial stream or an ephemeral stream subject to large flash floods or high seasonal flows, and the natural dam consists chiefly of impermeable material, then upstream inundation could be extensive and overtopping and subsequent rapid erosion of the impounding mass could result in a catastrophic water release. Conversely, if the rock fall/landslide is relatively small and/or consists of highly permeable material, impoundment of a large volume of water would be unlikely, and both the upstream and downstream hazard would be reduced.

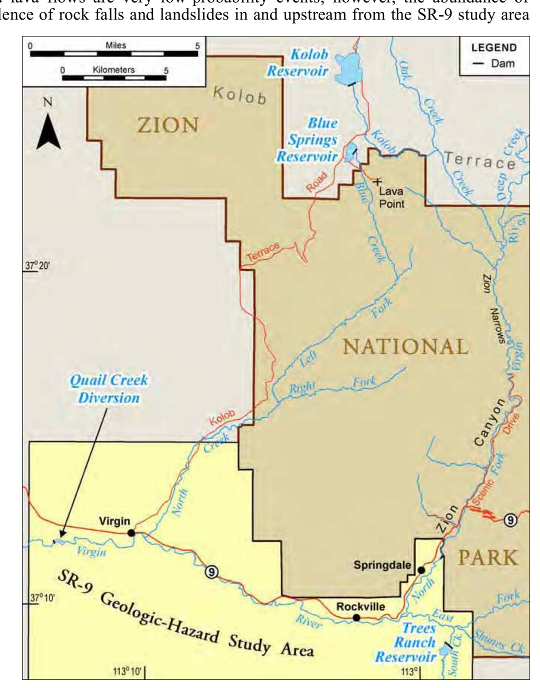

Figure 4. Major reservoirs in and near the study area.

FLOOD DISCHARGE AND FREQUENCY ESTIMATES

Limited estimates of flood discharge and frequency have been made for selected drainages upstream from the SR-9 study area. The estimates either pertain directly to perennial drainages that flow through the study area, or are illustrative of the kinds of flows that might be expected from ephemeral drainages that are similar in size to some of those within the study area. Martin (NPS, unpublished internal report, 1996) made a floodplain analysis for the North Fork of the Virgin River in the vicinity of Zion Lodge and determined the following discharge values: 100-year discharge = 9150 cfs, 500-year discharge = 13,500 cfs, probable maximum flood = 100,000 cfs. A floodplain analysis by Smillie (NPS, unpublished internal report, 1988) determined the following flood discharge values for Oak Creek: 100-year discharge = 3200 cfs, 500-year discharge = 5500 cfs, probable maximum flood = 24,000 cfs. Sharrow (NPS, unpublished internal report, 2008) reported a 100-year discharge estimate for Sammy's Canyon of about 2000 cfs. Table 1 summarizes adjusted flood frequency and discharge data compiled by the NPS for the North Fork of the Virgin River at Springdale (NPS, unpublished internal report, 1998).

Table 1. Adjusted flood discharge and frequency data, North Fork of the Virgin River at Springdale (after NPS, Water Resources Division, internal report, 1998).

Frequency[1]	Return Period (years)	Adjusted Discharge (cfs) North Fork Virgin River at Springdale gage
0.9900	—	352
0.9800	—	422
0.9500	—	555
0.9000	—	709
0.8000	1.25	956
0.5000	2.0[2]	1710
0.2000	5	3090
0.1000	10	4230
0.0500	20	5490
0.0400	25	5930
0.0200	50	7390
0.0100	100	9020
0.0050	200	10,800
0.0020	500	13,500

[1]Based on 70 years of record between 1913 and 1993 (no record for 1915 to 1925). [2]Bank-full flow typically has a return period of ≤ 2 years.

FLOOD-PRONE-AREA CLASSIFICATION

National Flood Insurance Program 100-Year Flood Map

The Federal Emergency Management Agency (FEMA), through the National Flood Insurance Program (NFIP), has updated (effective date of April 2, 2009) Flood Insurance Rate Maps (FIRMs) that show the boundaries of the expected 100-year flood (flood with a 1 percent annual chance of occurring in any given year) along selected drainages in the SR-9 study area. The boundaries and descriptions for the 100-year flood zones are shown in the Explanation section. The NFIP uses the FIRMs to make federally subsidized flood insurance available to homeowners in participating communities. Where development is contemplated within or near the boundaries of a NFIP 100-year flood zone, the most recent version of the applicable FIRM should be consulted.

Other Flood-Prone Areas

FIRM coverage in the SR-9 study area is limited to perennial streams and a few large ephemeral drainages. Flood hazards remain unidentified over much of the remainder of the FIRMs. Additionally, those portions of the study area not covered by FIRMs contain numerous ephemeral streams, alluvial fans, and other areas subject to periodic flooding, chiefly as a result of cloudburst storms. We used the distribution of geologically young alluvial deposits shown on UGS 1:24,000-scale geologic maps (see Sources of Information section) to identify flood-prone areas and their relative susceptibility to flooding throughout the SR-9 study area. Additionally, the study area contains large areas of exposed bedrock (chiefly badlands and mesa tops) undergoing active erosion that lack mappable alluvial deposits. Flood hazard in these areas is undetermined, but flash floods in bedrock channels are possible.

The probability of flooding, particularly flash flooding, at a particular location over a fixed period of time is uncertain; however, relative flood hazard can be estimated from the distribution of historical flooding in the study area and southwestern Utah in general (Woolley, 1946; Butler and Marsell, 1972; Utah Division of Comprehensive Emergency Management, 1981; Lund, 1992). The five flood-hazard categories based on distribution of water-deposited geologic units are listed in the Explanation section.

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 Explanation section. The FEMA 100-year floodplains covered by FIRMs in the study area are also shown on the map. Readers requiring additional information regarding flood zone boundaries (e.g., cross-section lines, map amendments, etc.) should consult the latest versions of the FIRMs.

This map provides a basis for conducting site-specific flood, debris-flow, and erosion 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 floods, and sheetfloods anywhere in the SR-9 study area, even locations outside identified flood-prone areas could be subject to periodic flooding. The map also shows where existing development lies 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.

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- and erosion-hazard investigation for new construction in all hazard categories listed in the Explanation. 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 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/debris-flow/erosion hazard is present at a site and provide appropriate design recommendations.

The failure of a water-retention structure or breach of a natural dam represents a low-probability, but high-hazard event in the SR-9 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 by the Utah Division of Water Rights, Office of Dam Safety. Similarly, 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.

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 these data, which vary 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 the 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.

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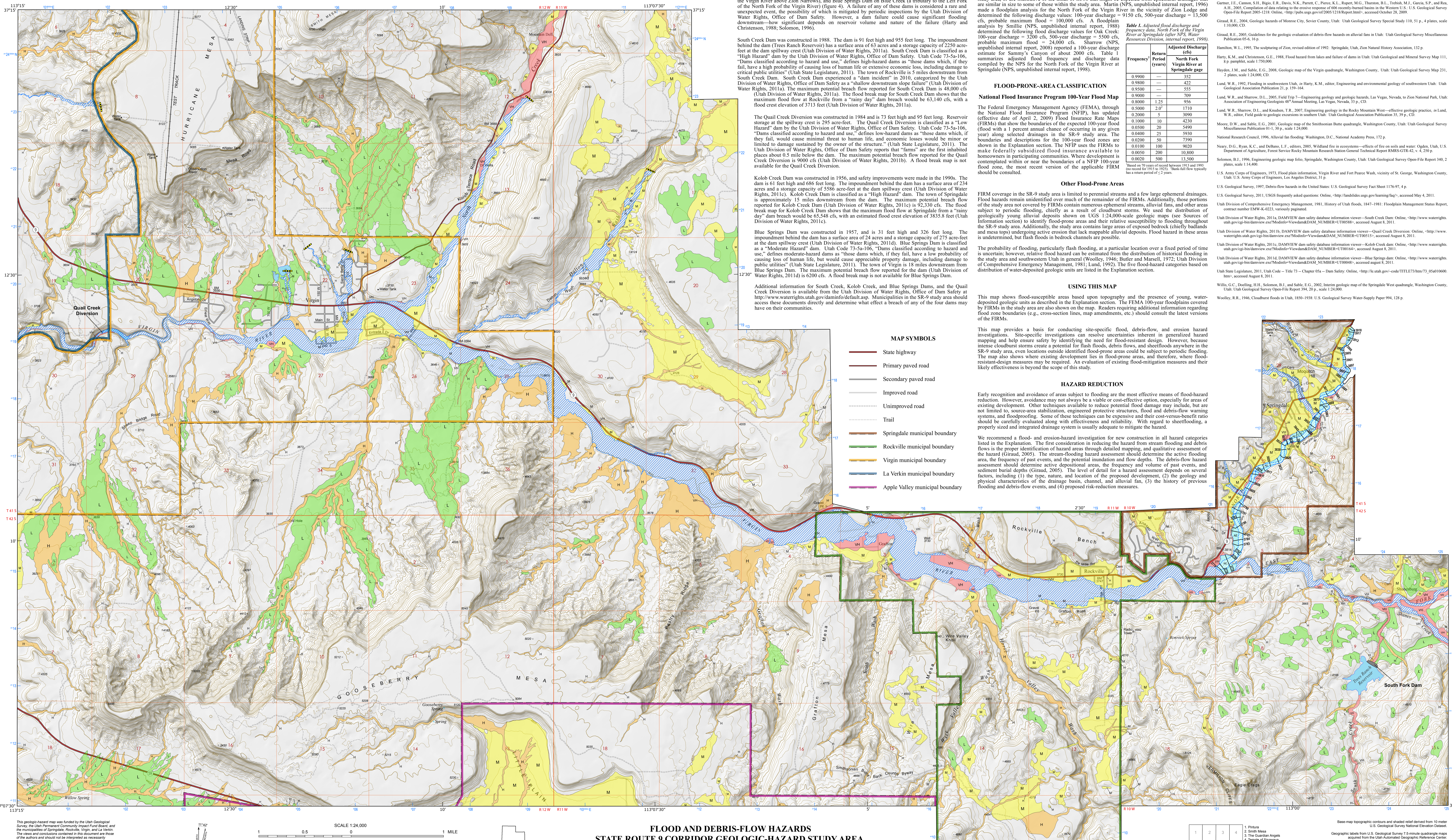

SCALE 1:24,000
CONTOUR INTERVAL 40 FEET
APPROXIMATE MEAN DECLINATION, 2013

FLOOD AND DEBRIS-FLOW HAZARDS
STATE ROUTE 9 CORRIDOR GEOLOGIC-HAZARD STUDY AREA, WASHINGTON COUNTY, UTAH

by
Tyler R. Knudsen and William R. Lund
2013

7.5' QUADRANGLE INDEX
1. Pintura
2. Smith Mesa
3. The Guardian Angels
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8. Springdale East
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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
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