APPENDIX E
GEOLOGIC HAZARD MODEL ORDINANCE

Mississippian and Tertiary bedrock (left) is mantled by Lake Bonneville gravels above Salt Lake City. The Warm Springs fault scarp, where not removed by aggregate mining, trends along the right side of the photograph towards downtown. Photo by Adam McKean.

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GEOLOGIC HAZARD MODEL ORDINANCE

by Steve D. Bowman, Ph.D., P.E., P.G.

The Geologic Hazard Model Ordinance by the Utah Geological Survey (UGS) is based on work with Morgan County in updating their geologic hazards ordinance, and prior geologic hazard ordinances used in Draper City, Salt Lake City, and Salt Lake County, Utah. The current Morgan County ordinance was developed by Lance Evans, Elliott Lips, Andy Harris, Mark Miller, Rich Giraud, and Steve Bowman, based on the prior county ordinance and extensive new information. Many individuals too numerous to list here have aided in preparing and writing the prior ordinances over the years and their work was critical in developing the current model ordinance. The model ordinance reflects the statewide adopted 2018 International Building Code and related standards.

The Geologic Hazards Model Ordinance presented below was made to be easily adaptable to conditions in Utah cities and counties. The UGS has not published comprehensive geologic hazard maps for all of Utah. However, Geologic Hazard Study Areas are defined in the ordinance for areas where current mapping is not available, based upon specific geologic and other conditions.

Adapting and Using the Model Ordinance

Sections of text within the model ordinance that need to be customized for each city or county are denoted in brackets []. Bracketed text as [x] should have the city or county name inserted in its place, as [unincorporated x/City/County] should have one word selected, and [various text] should be adjusted to your specific requirements. Some [various text] bracket text can be deleted, depending upon your specific situation. Text indicated as [list of geologic units specific to your area] delineate a list of specific geologic units from recent UGS mapping of your city or county that have characteristics contributing to the specific listed hazard.

GEOLOGIC HAZARD MODEL ORDINANCE

1.1 – Purpose

The purpose of this geologic hazard ordinance is to promote and protect the health, safety, and welfare of the citizens of [x], protect the infrastructure and financial health of [x], and minimize adverse effects of geologic hazards to public health, safety, and property by encouraging wise land use and development.

1.2 – Definitions

As used in this geologic hazard ordinance, the following terms have the following meanings:

ACCEPTABLE AND REASONABLE RISK: No loss or significant injury to occupants, no release of hazardous or toxic substances, and minimal structural damage to buildings or infrastructure during a hazard event allowing occupants egress outside.

ACCESSORY BUILDING: Any structure not designed for human occupancy, which may include tool or storage sheds, gazebos, and swimming pools. Accessory dwelling units and businesses located in accessory buildings must comply with all requirements as buildings designed for human occupancy.

ACTIVITY CLASS OF FAULTS: The activity level of a fault is based on the latest Western States Seismic Policy Council (WSSPC) policy recommendation defining surface faulting (https://www.wsspc.org/public-policy/adopted-recommendations/). WSSPC Policy Recommendation 18-3 states that based on the time of most recent movement: latest Pleistocene-Holocene faults are defined as movement in the past 15,000 years, late Quaternary faults are defined as movement in the past 130,000 years, and Quaternary faults are defined as movement in the past 2,600,000 years.

ALLUVIAL FAN: A fan shaped deposit where a fast-flowing stream flattens, slows, and spreads, typically at the exit of a canyon onto a flatter plain.

AVALANCHE: A large mass of predominantly snow and ice, but may also include a mixture of soil, rock, and/or organic debris that falls, slides, and/or flows rapidly downslope under the force of gravity.

BUILDABLE AREA: Based on an accepted geologic hazard investigation report, the portion of a site not impacted by geologic hazards, or the portion of a site where it is concluded the identified geologic hazards can be mitigated to an acceptable and reasonable risk, and where structures may be safely located. Buildable areas must be clearly marked on approved site plans and/or final approved plats, as appropriate.

[CITY/COUNTY] COUNCIL: The [city/county] council of [x].

CRITICAL FACILITIES: Essential, hazardous, special occupancy, and all Risk Categories III and IV structures, as defined in the statewide adopted International Building Code (IBC), and lifelines, such as major utility, transportation, communication facilities, and their connections to critical facilities.

DEBRIS FLOW: A slurry of rock, soil, organic material, and water transported in an extremely fast and destructive manner that flows down channels and onto and across alluvial fans; includes a continuum of sedimentation events and processes, including debris flows, debris floods, mudflows, sheet flooding, and alluvial fan flooding.

DEVELOPMENT: All critical facilities, subdivisions, single-family dwellings, duplexes, and multi-family dwellings, commercial and industrial buildings; also includes additions to or intensification of existing buildings, storage facilities, pipelines and utility conveyances, and other land uses.

ENGINEERING GEOLOGIST: A Utah-licensed Professional Geologist, who, through education, training, and experience, practices in the field of engineering geology and geologic hazards meeting the requirements of Section 1.6.

ENGINEERING GEOLOGY: Geologic work that is relevant to engineering and environmental concerns, and the health, safety, and welfare of the public. Engineering geology is the application of geological data, principles, and interpretation affecting the planning, design, construction, and maintenance of engineered works, land use planning, and groundwater issues.

ESSENTIAL FACILITY: Buildings and other structures intended to remain operational in the event of an adverse geologic event, including all structures with an occupancy greater than 1000 shall also be considered IBC Risk Category III when not meeting the criteria for IBC Risk Category IV; and IBC Risk Category IV buildings and other structures are designated as essential (critical) facilities.

FAULT: A fracture in the Earth's crust forming a boundary between rock and/or soil masses that have moved relative to each other, due to tectonic forces. When the fracture extends to the Earth's surface, it is known as surface fault rupture, or a fault trace.

FAULT SCARP: A steep slope or cliff formed by movement along a fault.

FAULT SETBACK: A specified distance on either side of a fault within which structures for human occupancy or critical facilities and their structural supports are not permitted.

FAULT TRACE: The intersection of a fault plane with the ground surface, often present as a fault scarp, or detected as a lineament on aerial photographs or other imagery.

FAULT ZONE: A corridor of variable width along one or more fault traces, within which ground deformation has occurred as a result of fault movement.

GEOLOGIC HAZARD: A geologic condition that presents a risk to life, of substantial loss of real property, or of substantial damage to real property (Utah Code 17-27a-103[19]: https://le.utah.gov/xcode/Title17/Chapter27A/17-27a-S103.html) and includes, but not limited to surface fault rupture, liquefaction, landslides, slope stability, debris flows, rockfalls, avalanches, radon gas, and other hazards.

GEOLOGIC HAZARD STUDY AREA: A potentially hazardous area as defined in Section 1.4 of this ordinance within which geologic hazard investigations are required prior to development.

GEOTECHNICAL ENGINEER: A Utah-licensed Professional Engineer who, through education, training, and experience, is competent in the field of geotechnical or geological engineering meeting the requirements of Section 1.6.

GEOTECHNICAL ENGINEERING: The investigation and engineering evaluation of earth materials, including soil, rock, and manmade materials and their interaction with earth retention systems, foundations, and other civil engineering works. The practice involves the fields of soil and rock mechanics and the earth sciences, and requires the knowledge of engineering laws, formulas, construction techniques, and performance evaluation.

GOVERNING BODY: The [x], or a designee of the [Council/Commission].

HAZARDOUS FAULT: A fault with movement in the past 2,600,000 years (Quaternary).

INFRASTRUCTURE: Those improvements which are required to be installed and guaranteed in conjunction with an approved subdivision or other land use approval. Infrastructure may be public or private, on site or off site, depending on development design, and may include streets, curb, gutter, sidewalk, water and sanitary sewer lines, storm sewers, flood control facilities, and other similar facilities.

INTERNATIONAL BUILDING CODE (IBC): The latest, statewide adopted International Code Council International Building Code (Utah Code Title 15A, https://le.utah.gov/xcode/Title15A/15A.html). An online version of the 2018 IBC is available at https://codes.iccsafe.org/content/IBC2018 and the 2018 International Residential Code (IRC) is available at https://codes.iccsafe.org/content/IRC2018.

LANDSLIDE: The downslope movement of a mass of soil, surficial deposits, and/or bedrock, including a continuum of processes between landslides, earth flows, debris flows, debris avalanches, and rockfalls.

LEGAL LOT OF RECORD: A parcel of land which meets all zoning requirements to be eligible for the development of a dwelling, habitable structure, or other facility or structure, pursuant to all [x] requirements.

LIQUEFACTION: A sudden, large decrease in shear strength of a saturated, cohesionless soil (generally sand and silt) caused by a collapse of soil structure and temporary increase in pore water pressure during earthquake ground shaking. May lead to ground failure, including lateral spreads and flow-type landslides.

NON-BUILDABLE AREA: That portion of a site which a geologic hazard investigation report has concluded is impacted by geologic hazards that present an unreasonable and unacceptable risk, and where the siting of habitable structures, accessory structures which house an accessory dwelling unit or business, or critical facilities, are not permitted.

ROCKFALL: A rock or mass of rock, newly detached from a cliff or other steep slope which moves downslope by falling, rolling, toppling, and/or bouncing; includes rockslides, rockfall avalanches, and talus.

SETBACK: An area subject to risk from a geologic hazard within which habitable structures or critical facilities and their supports are not permitted.

SLOPE STABILITY: The resistance of a natural or constructed slope to failure by landsliding and assessed under both static and dynamic (earthquake-induced) conditions.

SNOW AVALANCHE: See definition of Avalanche.

STRUCTURE DESIGNED FOR HUMAN OCCUPANCY: Any residential dwelling or any other structure used or intended for supporting or sheltering any use or occupancy by humans or businesses, includes all Risk Category II structures as defined in the currently adopted International Building Code, but does not include an accessory building that houses no accessory dwelling unit or business.

TALUS: Rock fragments lying at the base of a cliff or a very steep rocky slope.

[x]: The [x] Public Works Director, Engineer, Planning and Development Services Director, Zoning Administrator, Building Official, Council Administrator, County Council, land use authority, or another [x] employee or designee.

1.3 - Applicability

The regulations contained in this ordinance shall apply to all lands under the jurisdiction of [x]. Every legal lot of record, lot in a proposed land subdivision, and parcel within a Geologic Hazard Study Area as defined by this ordinance must have a safe buildable area for the intended use. Each buildable area must also have access from the nearest existing public or private street which is free of unreasonable and unacceptable geologic hazards. Any geologic hazards which must be mitigated in order to provide a buildable area with acceptable and reasonable access must be mitigated prior to issuance of the final plat approval.

Detached accessory buildings that are not designed for human occupancy are not required to comply with the provisions of this ordinance. In addition, the remodeling of existing structures designed for human occupancy may occur without compliance with this ordinance, if no expansion of the existing structure footprint, foundation, and no structure use change is proposed. Complete or substantial demolition and replacement of structures shall comply with this ordinance.

As defined in the statewide adopted 2018 International Building Code (IBC), Table 1604.5, [x] considers IBC Risk Category III buildings and other structures to represent a substantial hazard to human life in the event of failure, except that any structure with an occupancy greater than 1000 shall also be considered IBC Risk Category III when not meeting the criteria for IBC Risk Category IV; and IBC Risk Category IV buildings and other structures are designated as essential (critical) facilities.

1.4 – Geologic Hazard Study Areas

Geologic Hazard Study Areas in [x] are defined as, but are not necessarily limited to:

A. Designated Special Study Areas by the Utah Department of Natural Resources, Utah Geological Survey (UGS, https://geology.utah.gov), including those areas designated per Utah Code 79-3-202(f) around hazardous faults and are in the *Utah Quaternary Fault and Fold Database* (https://geology.utah.gov/apps/qfaults/); and

B. Surface-fault-rupture hazard areas defined in Section 1.9-B.3; and

C. Landslide hazard areas defined in Section 1.9-C.1; and

D. Liquefaction hazard areas defined in Section 1.9-D.1 and;

E. Debris flow hazard areas defined in Section 1.9-E.1; and

F. Rockfall hazard areas defined in Section 1.9-F.1; and

G. Land subsidence and earth fissure hazard areas defined in Section 1.9-G.1; and

H. Radon gas hazard areas defined in Section 1.9-H.1; and

I. Problem soil and rock hazard areas defined in Section 1.9-I.1; and

J. Snow avalanche hazard areas defined in Section 1.9-J.1; and

K. Geologic-based flood hazard areas defined in Section 1.9-K.1; and

L. Other areas where the topography; geology, including soils and bedrock conditions, either on the subject property or adjacent indicate the presence of geologic hazards, other previously identified geologic hazards; and environmentally sensitive areas that [x] finds to be of significance to the health, safety, and welfare of the citizens of [x]; and

M. Site-specific surface-fault-rupture investigations are required for all critical facilities and structures for human occupancy (International Building Code [IBC] Risk Category II, III, and IV) along latest Pleistocene-Holocene faults and for critical facilities (IBC Risk Category IV) along late Quaternary and Quaternary faults. For noncritical facilities for human occupancy (IBC Risk Category II and III) along late Quaternary and Quaternary faults, investigations are recommended, but not required. See the UGS *Utah Quaternary Fault and Fold Database* (https://geology.utah.gov/apps/qfaults) to locate Quaternary age faults within [x] and to determine their activity class.

The applicant's professional consultants will find geologic information available from the UGS and other sources useful in planning site development, preparing for the scoping meeting, and in performing geologic hazard investigations and subsequent analysis. Available UGS information includes:

- Geologic maps (https://geology.utah.gov/apps/intgeomap/)
- Geologic hazard maps and data (https://geology.utah.gov/hazards/info/maps/)
- Aerial photographs (https://geology.utah.gov/resources/data-databases/aerial-photographs/)
- Prior geologic and geotechnical reports (https://geodata.geology.utah.gov)
- Other information (https://geology.utah.gov)

Lidar elevation data are available at https://gis.utah.gov/data/elevation-and-terrain/ and https://opentopography.org.

In areas where UGS geologic hazard maps are not available and where geologic maps are used to define Geologic Hazard Study Areas, note that geologic hazard maps are based on significant other data sources beyond geologic maps and that not all of a geologic unit may be prone to geologic hazard(s).

1.5 – Geologic Hazard Investigations and Reports Required for Development

Any applicant requesting land-use approval for a concept plan; preliminary or final plats; a commercial, institutional, or one-, two-, and multi-family dwelling conditional use permit; or site plan approval on a parcel or parcels of land within a Geologic Hazard Study Area or where there are known or readily apparent geologic hazards and the area is not included within a current Geologic Hazard Study Area, shall submit to [x] [three wet stamped paper copies and one] an unlocked PDF digital copy of a site-specific geologic hazard investigation report that specifically relates to the geologic hazards present on and adjacent to that may affect the site.

1.6 – Minimum Investigator Professional Qualifications

Geologic hazard investigations often involve both engineering geology and geotechnical engineering. Engineering geology investigations shall be performed under the direct supervision of a Utah-licensed Professional Geologist specializing in engineering geology as defined in Section 1.6. Geotechnical engineering investigations shall be performed under the direct supervision of a Utah-licensed Professional Engineer specializing in geotechnical engineering as defined in Section 1.6. Licenses may be verified with the Utah Division of Occupational & Professional Licensing (https://secure.utah.gov/llv/search/index.html).

Engineering geology and the evaluation of geologic hazards is a specialized discipline within the practice of geology requiring the technical expertise and knowledge of techniques not commonly used in other geologic investigations. Therefore, geologic hazard investigations involving engineering geology and geologic hazard investigations shall be conducted, signed, and sealed by a Utah-licensed Professional Geologist specializing in engineering geology and geologic hazards. Proof of qualifications shall be provided to [x] upon request.

The minimum qualifications required by [x] for an Engineering Geologist, include:

A. An undergraduate or graduate degree in geology, engineering geology, or geological engineering, or closely related field, from an accredited college or university; and

B. Five full-time years of experience in a responsible position in the field of engineering geology and geologic hazards in Utah, or in a state with similar geologic hazards and regulatory environment, and experience demonstrating the geologist's knowledge and application of appropriate techniques in geologic hazard investigations; and

C. An active Utah Professional Geologist license in good standing.

Evaluation and mitigation of geologic hazards often require contributions from a qualified Geotechnical Engineer, particularly in the design of mitigation measures. Geotechnical engineering is a specialized discipline within the practice of civil engineering requiring the technical expertise and knowledge of techniques not commonly used in civil engineering. Therefore, geologic hazard investigations that include engineering design and related tasks shall be conducted, signed, and sealed by a Utah-licensed Professional Engineer, specializing in geotechnical engineering and geologic hazards. Proof of qualifications shall be provided to [x] upon request.

The minimum qualifications required by [x] for a Geotechnical Engineer, include:

A. A graduate degree in civil or geological engineering, with an emphasis in geotechnical engineering; or a B.S. degree in civil or geological engineering with 12 semester hours of post B.S. credit in geotechnical engineering, or course content closely related to evaluation of geologic hazards, from an ABET accredited college or university program; and

B. Five full-time years of experience in a responsible position in the field of geotechnical engineering and geologic hazards in Utah, or in a state with similar geologic hazards and regulatory environment, and experience demonstrating the engineer's knowledge and application of appropriate techniques in geologic hazard investigations; and

C. An active Utah Professional Engineer license in good standing.

1.7 – Preliminary Activities

This section shall apply to any geologic hazard investigation for the purpose of determining the feasibility of land-use approval for a concept plan; preliminary or final plat approval; a commercial, institutional, or one-, two-, or multi-family dwelling conditional use permit; site plan approval; or for the purpose of exploring, evaluating, or establishing locations for permanent improvements. A geologic hazard report shall be submitted to [x] as part of the land-use application, pursuant to the requirements of this ordinance, for any proposed development in a Geologic Hazard Study Area.

A. Prior to a land-use application, the applicant shall schedule a scoping meeting with [x] to evaluate the Engineering Geologist's and Geotechnical Engineer's investigative approach and work plan. The investigation approach shall allow for flexibility due to unexpected site conditions. Field findings may require modifications to the work plan. At this meeting, the applicant shall present a work plan that includes the locations of anticipated geologic hazards and proposed subsurface exploratory excavations, such as test pits, trenches, borings, and cone penetrometer test (CPT) soundings, which meet the minimum acceptable regional standards of practice, this ordinance, and includes:

1. A property location map; and
2. A geologic map; and
3. A topographic map with contours; and
4. A slope map or lidar imagery, if available; and
5. A map showing the location of the proposed development, including structures, roads, depths of basements and foundations, etc.; locations of proposed subsurface exploration, such as trenches, borings, test pits, etc.; with a description of the proposed development; and
6. A map showing the slope stability analysis cross-section locations, if existing landslides are present on or near the proposed site and/or slope instability is anticipated.

Upon successful completion of a scoping meeting, an application for an [excavation or grading] permit, as necessary, may be submitted to [x].

B. [x] will arrange for a Utah-licensed Professional Geologist, specializing in engineering geology, to attend the scoping meeting on behalf of the [City/County, at the applicant's expense]. [x] geologist will provide verbal feedback to the applicant and their consultants regarding their proposed work plan and the requirements of this article. [Reimbursement to the City/County for the direct costs of any outsourced staff shall be paid by the applicant prior to the acceptance of a land-use or building permit application]; and

C. As required by this code and except as otherwise noted herein, no person shall commence or perform any land disturbance, grading, excavation, relocation of earth, or any other land disturbance activity, without first obtaining an excavation or grading permit. Application for an excavation or grading permit shall be filed with [x] on forms furnished by the [City/County] for such purposes only after a scoping meeting has taken place; and

D. The applicant shall specify a primary contact responsible for coordination with [x] during the land disturbance activities.

1.8 – Building Permits on Parcels Recorded Prior to the Effective Date of These Ordinances

A. The following submittals and processes are required prior to the issuance of a building permit for a new or replacement structure designed for human occupancy and additions to structures designed for human occupancy for all parcels recorded prior to the effective date hereof which are on property noted as [restricted (R) or otherwise designated] for geologic hazard reasons on a recorded plat or within designated Geologic Hazard Study Areas:

1. A statement from an Engineering Geologist identifying the presence or absence of any geologic hazards and describing the buildable area on the lot for the proposed structure; and

2. A statement from a Geotechnical Engineer verifying that the slope stability of the proposed structure location will have a ≥1.1 dynamic (pseudostatic) and ≥1.5 static factor of safety. The statement shall clearly identify the anticipated conditions, such as the seismic ground acceleration and pseudostatic coefficients used, and any required mitigation measures to achieve the required factors of safety; and

3. A statement from a Utah-licensed Professional Structural Engineer stating that they have reviewed the geologic and geotechnical reports, which may be combined into one report, and that they have designed the structure in accordance with the report recommendations, accounting for any identified geologic and geotechnical hazards in accordance with the currently statewide adopted International Building Code and related standards; and

4. Written verification from the consultant's issuer of professional errors and omissions liability insurance, in the amount of [$2,000,000.00] per consultant, which covers the licensed Professional Engineering Geologist, Geotechnical Engineer, and Structural Engineer, and which are in effect on the date of issuance of the building permit by the [City/County] Building Official; and

5. A Hold Harmless Agreement on a [city/county] approved form, which is executed and recorded on the subject property; and

6. A Geologic Hazards Disclosure on a [city/county] approved form, which is executed and recorded for the subject property; and

7. All conditions of the adopted statewide building and fire codes (see https://le.utah.gov/xcode/Title15A/15A.html) must be adhered to.

B. Prior to the issuance of a Certificate of Occupancy for a new or replacement structure designed for human occupancy, and additions to structures designed for human occupancy for all parcels recorded prior to the effective date hereof, and which are within a Geologic Hazards Study Area:

1. An Excavation Inspection Report shall be submitted by a Geotechnical Engineer to the [City/County] Building Official prior to footing placement, which verifies that the proposed building was in accordance with the recommendations of the geologic and geotechnical reports, which may be combined into one report; and

2. The [City/County] Building Official may require, at any time, written verification from a Geotechnical Engineer or a Utah-licensed Professional Structural Engineer, that the structure conforms to the recommendations of the original reports and designs, and if not, provides appropriate as-built drawings documenting the changes; and

3. All requirements of the statewide adopted Utah State Construction and Fire Codes Act (https://le.utah.gov/xcode/Title15A/15A.html) must be met.

1.9 – Geologic Hazard Investigations and Reports

Each geologic hazard investigation and report shall be site-specific and shall identify all known or suspected potential geologic hazards, whether previously identified or unrecognized, that may affect the subject property, both on and adjacent to the property. A geologic hazard report may be combined with a geotechnical report and/or contain information on multiple hazards.

A. A field review by [x] is required during subsurface exploration activities (test pits, trenches, drilling, etc.) to allow the [City/County] to evaluate the subsurface conditions, such as the age and type of deposits encountered, the presence or absence of landslides and faults, etc. with the applicant's consultant. Discussions about questionable features or appropriate setback distances are appropriate, but [x] will not assist with field logging, explaining stratigraphy, or give approval of the proposed development during the field review. Exploratory trenches when excavated, shall be open, safe, and in compliance with applicable federal Occupational Safety and Health Administration, State of Utah, and other excavation safety regulations, have the walls appropriately cleaned, and a field log completed by the time of the review. The applicant must provide a minimum notice of [2 days] to [x] for scheduling the field review.

B. Surface fault rupture is a displacement of the ground surface along a tectonic fault during an earthquake. If a fault were to displace the ground surface beneath a building or other structure, significant structural damage or collapse may occur, possibly causing injuries and loss of life. As a result, [x] requires site-specific surface-fault-rupture hazard investigations and submittal of a report for all properties that contain Quaternary faults, depending on the fault activity level and the IBC Risk Category of proposed structures. These investigations and reports shall conform with the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 3, https://doi.org/10.34191/C-128), as appropriate, including:

1. The requirement for site-specific investigation of surface faulting depends on the fault activity level as defined by the most recent Western States Seismic Policy Council (WSSPC) Policy Recommendation (PR, https://www.wsspc.org/public-policy/adopted-recommendations/) for faults that cross properties with proposed structures. The current PR is 18-3: *Definitions of Recency of Surface Faulting for the Basin and Range Province* and defines latest Pleistocene-Holocene, late Quaternary, and Quaternary faults as:

   a. Latest Pleistocene-Holocene fault – A fault whose movement in the past 15 ka (15,000 years) has been large enough to break the ground surface.

   b. Late Quaternary fault – A fault whose movement in the past 130 ka (130,000 years) has been large enough to break the ground surface.

   c. Quaternary fault – A fault whose movement in the past 2.6 Ma (2.6 million years) has been large enough to break the ground surface.

   [x] requires site-specific investigation on parcels with latest Pleistocene-Holocene faults for all new critical facilities and structures for human occupancy (IBC Risk Category II, III, and IV structures), on parcels with latest Pleistocene-Holocene and late Quaternary faults for all new critical facilities (IBC Risk Category III and IV structures), and on parcels with the faults listed in item 2 below.

   Investigations are required for all critical facilities, whether near a mapped Quaternary fault or not, to ensure that previously unknown faults are not present. If evidence for a Quaternary fault is found, subsurface investigations are required and trenching to locate a suitable buildable area may be necessary (IBC Sections 1704.6.1 and 1803.5.11).

2. The UGS *Utah Quaternary Fault and Fold Database* (https://geology.utah.gov/apps/qfaults/) provides the latest information on Quaternary faulting in Utah to determine fault activity levels as defined above and where surface-fault-rupture Geologic Hazard Study Areas have been defined. Where data are inadequate to determine the fault activity class, the fault shall be assumed to be latest Pleistocene-Holocene, pending detailed surface-fault-rupture and/or paleoseismic investigations. The database currently includes the following mapped Quaternary faults within [x]:

   - [xxx] fault – [age]

   [x] may require a site-specific investigation if on-site and/or nearby fault-related features not shown in the database are identified during other geologic and/or geotechnical investigations and/or during project construction.

3. Surface-fault-rupture hazard maps show the locations of fault traces and recommended special study areas. These maps and data are published by the UGS in the *Utah Quaternary Fault and Fold Database* [but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, investigations are required within Geologic Hazard Study Areas as defined by:

   a. Areas that horizontally extend 500 feet on the downthrown and 250 feet on the upthrown side of well-defined Quaternary faults (solid lines) and 1000 feet on both sides of buried or inferred Quaternary faults (dotted lines). For traces of buried or inferred Quaternary faults less than 1000 feet long that lie between and on-trend with well-defined faults or lie at the tail end of a well-defined Quaternary faults, the well-defined Quaternary fault special-study-area zone is used (Figure 1A and 1B); and

   b. In areas where a buffer "window" exists, the window is filled in if its width is less than the greater of the two surrounding buffers (Figure 1C). In situations where the ground expression of the fault scarp is larger than the special-study zone, in which case the zone does not cover the entire fault scarp, the 1000-foot buffer is used; and

c. Well-defined Quaternary faults are those Quaternary fault traces that are clearly identifiable by a geologist qualified to conduct surface-fault-rupture hazard investigations as a physical feature at or just below the ground surface (typically shown as a solid line on geologic maps), and buried or inferred Quaternary faults are those Quaternary fault traces that are not evident at or just below the ground surface by a qualified geologist (typically shown as a dotted line for buried faults and a dotted line for inferred faults on geologic maps).

4. When an alternative subsurface exploration plan is proposed in lieu of paleoseismic trenching, a map and written description and plan shall be submitted to [x] for review, prior to the scoping meeting and exploration implementation. The plan must include at a minimum, a map of suitable scale showing the site limits, surface geologic conditions within 2000 feet of the site boundary, the location and type of the proposed exploration, the anticipated subsurface geologic conditions, and a through description of why the alternative exploration is being proposed.

5. Small-displacement faults with less than 4 inches of displacement are not exempted from structure setback requirements. However, if structural risk-reduction measures are proposed for these faults, the following criteria must be met:

   a. Reasonable geologic data indicating that future surface displacement along the faults will not exceed 4 inches following the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 3, https://doi.org/10.34191/C-128), and

   b. Specific structural mitigation to minimize structural damage and ensure safe occupant egress designed by a Utah-licensed Structural Engineer with plans and specifications reviewed and approved by [x].

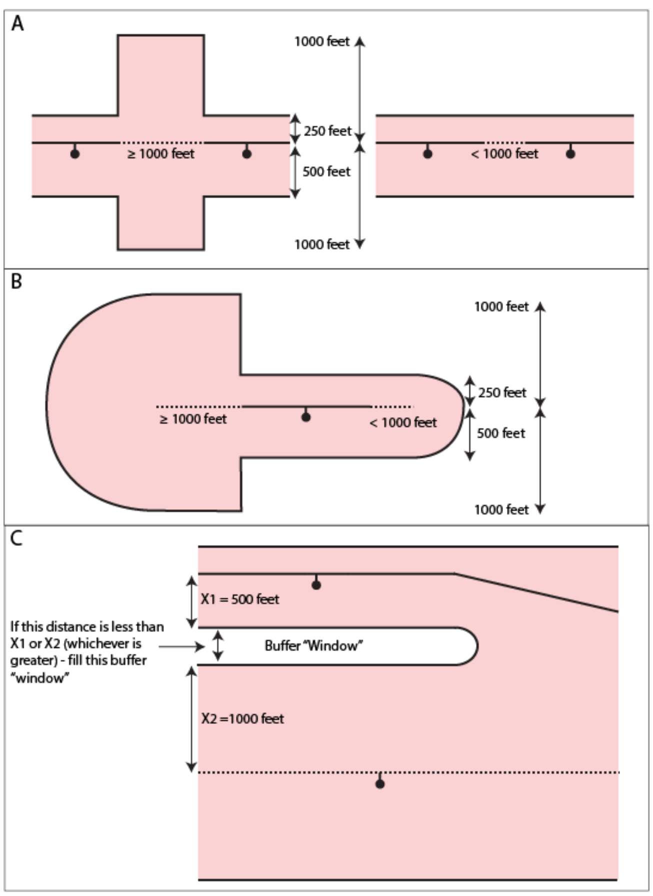

Figure 1. *Areas around Quaternary faults defining surface-fault-rupture Geologic Hazard Study Areas.*

C. Landslides are the downslope movement of earth (soil, rock, and/or debris) materials and can cause significant property damage, injury, and/or death. The evaluation of landslides generally requires quantitative slope stability analyses, involving Engineering Geologists and Geotechnical Engineers experienced in landslide investigation, analysis, and mitigation. Considering the complexity inherent in performing slope stability analyses, additional effort beyond the minimum standards presented herein may be required at some sites to adequately address slope stability. Slope stability and landslide hazard investigations and reports shall conform with the *Guidelines for Evaluating Landslide Hazards in Utah* (UGS Circular 128, Chapter 4, https://doi.org/10.34191/C-128), as appropriate, and

1. Landslide hazard maps show the location of previous landsliding, areas of potential landsliding, and recommended Geologic Hazard Study Areas. These maps are published by the UGS (https://geology.utah.gov/hazards/info/maps/) [but are not currently available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, investigations are required within Geologic Hazard Study Areas as defined by:

   a. Cut and fill slopes steeper than, or equal to, 50 percent (2H:1V) and natural slopes steeper than or equal to 30 percent (3.3H:1V); and

   b. Natural and cut slopes with geologic conditions, such as an existing landslide or other geologic hazard; bedding, foliation, or other structural features that are potentially averse to slope stability; and

   c. Buttresses and stability fills and cut, fill, and natural slopes of water-retention basins or flood-control channels; and

   d. Mapped landslide areas in the UGS *Utah Landslide Database,* (https://gis.utah.gov/data/geoscience/landslides/); and

e. Low, moderate, and high landslide susceptibility areas identified in the *Landslide Susceptibility Map of Utah* (Giraud and Shaw, 2007; UGS Map M-228, https://ugspub.nr.utah.gov/publications/maps/m-228/m-228.pdf); and

f. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal,* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.

1. Development of properties within these areas require submittal and review of a site-specific geologic hazard report discussing landslide hazards, prior to receiving a land-use or building permit from [x]. It is the responsibility of the applicant to retain a qualified Engineering Geologist and Geotechnical Engineer to perform the slope stability analysis.

2. When evaluating site conditions to determine the need for slope stability analyses, off-property conditions shall be considered (both up-slope to the tops of adjacent, ascending slopes and down-slope to and beyond the toes of adjacent, descending slopes). Also, the professionals shall demonstrate that the proposed hillside development will not affect adjacent sites or limit adjacent property owners' ability to develop their sites.

3. Investigations shall also address the potential for surficial instability, rock slope instability, debris/mudflows, rockfalls, and soil creep on all slopes that may affect the proposed development, be affected by the proposed development, and along access roads. Intermediate geomaterials (IGM), those earth materials with properties between soil and rock, if present, shall be appropriately investigated, sampled, and tested.

4. An Engineering Geologist shall provide appropriate input to the Geotechnical Engineer with respect to the potential impact of the geology, stratigraphy, and hydrologic conditions on slope stability. The shear strength and other geotechnical properties shall be evaluated by the Geotechnical Engineer. Qualified Engineering Geologists may assess and quantitatively evaluate slope stability; however, the Geotechnical Engineer shall perform all design stability calculations. Ground motion parameters for use in seismic stability analysis may be provided by either the Engineering Geologist or the Geotechnical Engineer.

5. Except for the derivation of the input ground motions for pseudostatic and seismic deformation analyses described below, slope stability analyses and evaluations shall be performed in general accordance with the latest version of *Recommended Procedures for Implementation of DMG Special Publication 117: Guidelines for Analyzing and Mitigating Landslide Hazards in California* (Blake and others, 2002). Procedures for developing input ground motions to be used in [x] are described below. If on-site sewage and/or stormwater or other water disposal exists or is proposed, the slope stability analyses shall also include the effects of the effluent plume on slope stability.

6. The minimum acceptable static factor of safety (FS) is 1.5 for both overall and surficial slope stability and 1.1 for a calibrated pseudostatic analysis using Stewart and others (2003) or other method pre-approved by [x].

7. Soil and/or rock sampling and testing shall be based on current ASTM International and/or American Association of Highway Officials (AASHTO) standards, as appropriate. Laboratory tests shall be performed using current ASTM International or AASHTO standards, as appropriate, in a laboratory accredited by the AASHTO Materials Reference Laboratory and/or the U.S. Army Corps of Engineers to ensure compliance with current laboratory testing standards and quality control procedures. The final report shall include complete laboratory test results reported in conformance with current ASTM International or AASHTO standards, as appropriate.

8. Soil and/or rock properties, including unit weight and shear strength parameters (cohesion and friction angle), shall be based on conventional laboratory tests on appropriate samples. Where appropriate, such as for landslide slip surfaces, along bedding planes, for surficial stability analyses, etc., laboratory tests for saturated, residual shear strengths must be performed.

   Estimation of the shear resistance along bedding or landslide planes normally requires an evaluation of saturated, residual, along-bedding strength values of the weakest interbedded or slide plane material encountered during the subsurface exploration, or in the absence of enough exploration, the weakest material that may be present, consistent with site geologic conditions. Soil strength parameters derived solely from CPT data are most often not appropriate for slope-stability analysis in many cases, particularly for strengths along existing slip surfaces, where residual strengths have developed. Additional guidance on the selection of strength parameters for slope stability analyses is contained in Blake and others (2002).

9. Residual strength parameters may be determined using direct or ring shear testing equipment; however, ring shear tests are preferred. If performed properly, direct shear test results may approach ring shear test

results. The specimen must be subjected to enough deformation (such as, a significant number of shearing cycles in the direct shear test or a significant amount of rotation in the ring shear test) to assure that residual strength has been developed. In the direct and ring shear tests, stress-deformation curves can be used to determine when an enough shearing cycles have been performed by showing that no further significant drop in shear strength results with the addition of more cycles or rotation. The stress-deformation curves obtained during the shear tests must be submitted with the other pertinent laboratory test results. It shall be recognized that for most clayey soils, the residual shear strength envelope is curved and passes through the origin (for example, at zero normal stress there is zero shear strength). Any apparent shear strength increases resulting from a non-horizontal shear surface, such as ramping or bulldozing in residual direct shear tests, shall be discounted in the interpretation of the strength parameters.

10. Inherent in the analyses, the Geotechnical Engineer will need to use judgment in the selection of appropriate shear test methods and in the interpretation of the results to develop shear strength parameters commensurate with the slope stability conditions to be evaluated. Scatter plots of shear strength data may need to be presented to allow for assessment of idealized parameters. The report shall summarize shear strength parameters used for slope stability analyses and describe the methodology used to interpret test results and estimate those parameters, including:

    a. Peak shear strengths may be used to represent across-bedding failure surfaces or compacted fill, in situations where strength degradations are not expected to occur (see Blake and others, 2002). Where peak strengths cannot be relied upon, fully softened or lower strengths shall be used; and

    b. Ultimate shear strength parameters shall be used in static slope stability analyses when there has not been past deformation. Residual shear strength parameters shall be used in static slope stability analyses when there has been past deformation; and

    c. Averaged strength parameters may be appropriate for some across-bedding conditions, if enough representative samples have been carefully tested. Analyses for along bedding or along-existing-landslide slip surfaces shall be based on the lower-bound interpretations of residual shear strength parameters and comparison of those results to correlations, such as those of Stark and others (2005).

11. The potential effects of soil creep shall be addressed where any proposed structure is planned near an existing fill or natural slope. The potential effects on the proposed development shall be evaluated and mitigation measures proposed, including appropriate setback recommendations that consider the potential effects of creep forces.

12. Gross stability includes rotational and translational deep-seated slope failures or portions of slopes existing within or outside of, but potentially affecting the proposed development. The following guidelines, in addition to those in Blake and others (2002), shall be followed when evaluating slope stability:

    a. Stability shall be analyzed along cross sections depicting the most adverse conditions, such as the highest slope, most adverse bedding planes, shallowest likely groundwater table, steepest slope, etc. Often, analyses are required for different conditions and for more than one cross section to demonstrate which condition is the most adverse. When evaluating the stability of an existing landslide, analyses must also address the potential for partial reactivation. Inclinometers may be used to help determine critical failure surfaces, and along with high-precision GPS/GNSS, the activity state of existing landslides. The critical failure surfaces on each cross-section shall be identified, evaluated, and plotted on the large-scale cross section; and

    b. Rock slope stability shall be based on current rock mechanics practice, using the methods of Wyllie and Mah (2004), based on Hoek and Bray (1981); Practical Rock Engineering (https://www.rocscience.com/assets/resources/learning/hoek/Practical-Rock-Engineering-Full-Text.pdf); Federal Highway Administration (1989); and similar references, such as https://www.rocscience.com/learning/hoeks-corner/publications; and

    c. If the long-term static FS is ≤1.5, mitigation measures shall be required to bring the factor of safety up to the required level or the project may be redesigned to achieve a minimum FS of ≥1.5; and

    d. The temporary stability of excavations shall be evaluated, and mitigation measures shall be recommended as necessary to obtain a minimum FS of ≥1.3; and

    e. Long-term slope stability shall be analyzed using the highest known and anticipated groundwater level based upon a groundwater assessment as described in the *Guidelines for Evaluating Landslide Hazards in Utah* (Beukelman and Hylland, 2020; UGS Circular 128, Chapter 4, https://doi.org/10.34191/C-128), along with groundwater sensitivity analyses; and

    f. Slope stability and analysis input parameters, such as groundwater elevations and conditions, cannot be contingent on uncontrollable factors, such as limiting landscape irrigation, etc.; and

g. Where back-calculation is appropriate, shear strengths utilized for design shall be no higher than the lowest strength computed using back calculation. If a professional proposes to use shear strengths higher than the lowest back-calculated value, justification shall be required. Assumptions used in back-calculations regarding pre-sliding topography and groundwater conditions at failure must be discussed and justified; and

h. Reports shall describe how the shear strength testing methods used are appropriate in modeling field conditions and the long-term performance of the analyzed slope. The utilized design shear strength values shall be justified with laboratory test data and geologic descriptions and history, along with past performance history, if known, of similar materials; and

i. Reports shall include shear strength test plots consisting of normal stress versus shear resistance (failure envelope). Plots of shear resistance versus displacement shall be provided for all residual and fully softened (ultimate) shear tests; and

j. The degree of saturation for all test specimens shall be reported. Direct shear tests on partially saturated samples may grossly overestimate the cohesion that can be mobilized when the material becomes saturated in the field. This potential shall be considered when selecting shear strength parameters. If the rate of shear displacement exceeds 0.005 inches per minute, the Geotechnical Engineer shall provide data to demonstrate that the rate is sufficiently slow for drained conditions; and

k. Shear strength values higher than those obtained through site-specific laboratory tests will generally not be accepted; and

l. If direct shear or triaxial shear testing is not appropriate to model the strength of highly jointed and fractured rock masses, the design strengths shall be evaluated in a manner that considers overall rock mass quality and be consistent with current rock mechanics practice; and

m. Shear strengths used in slope stability analyses shall be evaluated considering the natural variability of engineering characteristics inherent in earth materials. Multiple shear tests on each site material are likely to be required; and

n. Shear strengths for proposed fill slopes shall be evaluated using samples mixed and remolded to represent anticipated field conditions. Tests to confirm strengths may be required during grading; and

o. Where bedding planes and/or discontinuities are laterally unsupported in slopes, potential failures along the unsupported bedding planes and/or discontinuities shall be analyzed. Similarly, stability analyses shall be performed where bedding planes and/or discontinuities form a dip-slope or near-dip-slope using composite, potential failure surfaces that consist of potential slip surfaces along bedding planes and/or discontinuities in the upper portions of the slope, in combination with slip surfaces across bedding planes and/or discontinuities in the lower portions of the slope; and

p. The stability analysis shall include the effect of expected maximum moisture conditions on unit weight; and

q. For effective stress analyses, measured groundwater conditions adjusted to consider likely unfavorable conditions with respect to anticipated future groundwater levels, seepage and pore pressure shall be included in the slope stability analyses; and

r. Tension crack development shall be considered in the analyses of potential failure surfaces. The height and location of the tension crack shall be determined by modeling; and

s. Anticipated surcharge loads, as well as external boundary pressures from groundwater, shall be included in the slope stability evaluations, as deemed appropriate; and

t. Generally, computer-aided modeling techniques should be used, so that the potential failure surface with the lowest factor of safety can be located. However, analytical chart solutions may be used, provided they were developed for conditions like those being analyzed. Examples of typical modeling techniques are illustrated on Figures 9.1a to 9.1f in Blake and others (2002). However, verification of the reasonableness of the analytical results is the responsibility of the Geotechnical Engineer and Engineering Geologist, and

u. The critical potential failure surface used in the analysis may be composed of circles, wedges, planes, or other shapes considered to yield the minimum FS most appropriate for the geologic site conditions. The critical potential failure surface having the lowest factor of safety with respect to shearing resistance must be sought. Both the lowest FS and the critical failure surface shall be documented.

13. Surficial slope stability refers to slumping and sliding of near-surface materials and is most critical during the snowmelt and rainy season or when excessive landscape irrigation is applied. The assessment of surficial slope stability shall be based on analysis

procedures for stability of an infinite slope with seepage parallel to the slope surface or an alternate failure mode that would produce the minimum factor of safety. The minimum acceptable saturation depth for surficial stability evaluation shall be 4 feet.

a. Residual shear strengths comparable to actual field conditions shall be used in surficial stability analyses. Surficial stability analyses shall be performed under rapid draw-down conditions, where appropriate, such as for debris and detention basins; and

b. Where 2H:1V or steeper slopes have soil conditions that can result in the development of an infinite slope with parallel seepage, calculations shall be performed to demonstrate that the slope has a minimum static FS of 1.5, assuming a fully saturated 4-foot thickness. If conditions will not allow the development of a slope with parallel seepage, surficial slope stability analyses may not be required if approved by [x]; and

c. Surficial slope stability analyses shall be performed for fill, cut, and natural slopes assuming an infinite slope with seepage parallel to the slope surface or other failure mode that would yield the minimum FS against failure. A suggested procedure for evaluating surficial slope stability is presented in Blake and others (2002); and

d. Soil properties used in surficial stability analyses shall be determined as noted for residual strengths above. Residual shear strength parameters for surficial slope stability analyses shall be developed for a stress range that is consistent with the near-surface conditions being modeled. It shall be recognized that for most clayey soils, the residual shear strength envelope is curved and passes through the origin (for example, at zero normal stress, there is zero shear strength). For sites with deep slip surfaces, the guidelines given by Blake and others (2002) should be followed; and

e. The minimum acceptable vertical depth for which seepage parallel to the slope shall be applied is 4 feet for cut or fill slopes. Greater depths may be necessary when analyzing natural slopes that have significant thicknesses of loose surficial material.

14. In addition to static slope stability analyses, slopes shall be evaluated for seismic slope stability. Acceptable methods for evaluating seismic slope stability include using calibrated pseudostatic limit-equilibrium procedures and simplified methods, such as, those based on Newmark (1965), to estimate permanent seismic slope movements and are summarized in Blake and others (2002). Nonlinear, dynamic finite element/finite difference numerical methods also may be used to evaluate slope movements resulting from seismic events, if the procedures, input data, and results are thoroughly documented, and deemed acceptable by [x].

a. Regarding design ground accelerations for seismic slope-stability analyses, [x] prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a site within a given time period. To more closely represent the seismic characteristics of the region, design ground motion parameters for seismic slope stability analyses shall be based on the peak accelerations with a 2% probability in 50 years (2,500-year return period); and

b. Peak ground accelerations (PGA) shall be used from the most recent USGS National Seismic Hazard Maps (https://www.usgs.gov/natural-hazards/earthquake-hazards/maps) and adjusted for effects of soil/rock (site-class) conditions in accordance with Seed and others (2001) or other appropriate methods that consider the site-specific soil conditions and their potential for amplification or de-amplification of the high-frequency strong motion. Site-specific response analysis may also be used to develop PGA values if the procedures, input data, and results are thoroughly documented, and deemed acceptable by [x]; and

c. Pseudostatic methods for evaluating seismic slope stability are acceptable if minimum factors of safety are satisfied, and due consideration is given in the selection of the seismic coefficient (k) reduction in material shear strengths, and the factor of safety for pseudostatic conditions; and

d. Pseudostatic seismic slope stability analyses can be performed using the "screening analysis" procedure described in Blake and others (2002). For that procedure, a k-value is selected from seismic source characteristics (modal magnitude and distance, and firm rock PGA) and ≤ 2 inches (5 cm) of deformation is specified. For that procedure, a factor of safety of ≥ 1.0 is considered acceptable; otherwise, an analysis of permanent seismic slope deformation shall be performed.

15. For seismic slope stability analyses, estimates of permanent seismic displacement are preferred and may be performed using the procedures outlined in Blake and others (2002). It should be noted that Bray and Rathje (1998), referenced in Blake and others (2002), has been updated and superseded by Bray and Travasarou (2007), which is [x] currently preferred method. For those analyses, calculated seismic displacements shall be ≤ 2 inches (5 cm), or mitigation measures shall be proposed to limit calculated displacements to ≤ 2 inches (5 cm).

For specific projects, different levels of tolerable displacement may be possible, but site-specific conditions, which shall include the following, must be considered:

a. The extent to which the displacements are localized or broadly distributed; broadly distributed shear deformations would generally be less damaging, and more displacement could be allowed; and

b. The displacement tolerance of the foundation system–stiff, well-reinforced foundations with lateral continuity of vertical support elements would be more resistant to damage and could potentially tolerate larger displacements than typical slabs-on-grade or foundation systems with individual spread footings, and;

c. The potential of the foundation soils to experience strain softening–slopes composed of soils likely to experience strain softening should be designed for relatively low displacements if peak strengths are used in the evaluation of the yield coefficient (ky) due to the potential for progressive failure, which could involve very large displacements following strain softening.

To consider a threshold larger than 2 inches, the project professional shall provide prior, acceptable justification to [x] and obtain the [City's/County's] approval. Such justification shall demonstrate, to the satisfaction of [x], that the proposed project will achieve acceptable performance.

16. Slope stability analyses shall be performed for cut, fill, and natural slopes of water-retention basins or flood-control channels. In addition to analyzing typical static and seismic slope stability, those analyses shall consider the effects of rapid drawdown, if such a condition could occur.

17. When slope stability hazards are determined to exist on a project, measures to mitigate impacts from those hazards shall be implemented. Some guidance regarding mitigation measures is provided in Blake and others (2002) and methods include:

a. Hazard avoidance; or

b. Grading to improve slope stability; and/or

c. Reinforcement of the slope and/or improvement of the soil within the slope, and/or;

d. Reinforcement of the structures built on the slope to tolerate anticipated slope displacements.

Where mitigation measures that are intended to add stabilizing forces to the slope are to be implemented, consideration may need to be given to strain compatibility. For example, if a compacted fill buttress is proposed to stabilize laterally unsupported bedding or a landslide, the amount of deformation needed to mobilize the recommended shear strength in the buttress shall be considered to confirm that it will not result in adverse movements of the upslope bedding or landslide deposits. Similarly, if a series of drilled piers is to be used to support a potentially unstable slope and a structure will be built on the piers, pier deformations resulting from movements needed to mobilize the soil's shear strength shall be compared to tolerable deflections in the supported structure.

18. Full mitigation of slope stability hazards shall be performed for developments in [x]. Remedial measures that produce static FS ≥1.5 and acceptable seismic displacement estimates shall be implemented as needed.

19. On some projects or portions of, such as small structural additions, residential infill projects, non-habitable structures, and non-structural natural-slope areas, full mitigation of seismic slope displacements may not be possible, due to physical and/or economic constraints. In those cases, partial mitigation, to the extent that it prevents structural collapse, injury, and loss of life, may be possible if consistent with IBC design criteria, and if it is approved by [x]. The applicability of partial mitigation to specific projects shall be evaluated on a case-by-case basis.

20. For developments when full mitigation of seismic slope displacements is not implemented, a Notice of Geologic Hazard shall be recorded with the proposed development describing the displacement hazard at issue and the partial mitigation employed. The Notice shall clearly state that the seismic displacement hazard at the site has been reduced by the partial mitigation, but not eliminated. In addition, the owner shall assume all risks, waive all claims against [x] and its consultants, and indemnify and hold [x] and its consultants harmless from any and all claims arising from the partial mitigation of the seismic displacement hazard.

D. Liquefaction is a process by which strong shaking during an earthquake causes the ground to temporarily lose its strength and to behave like a viscous liquid rather than a solid material. Liquefaction can cause buildings to tip and settle; roads to crack, deform and flood; buried storage tanks to rise towards the surface; and other types of damage to buildings and infrastructure. Liquefaction hazard investigation reports shall conform with the requirements described below and be prepared by a qualified Geotechnical Engineer as defined above.

1. Liquefaction hazard maps show the location and relative anticipated severity of liquefaction during an earthquake. These maps are published by the UGS[but are not currently available for [x]. Once these

maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

a. Within Federal Emergency Management Agency (FEMA)-defined flood Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, and Zone AR/A areas; and

b. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online; and

c. For all IBC Risk Category III and IV facilities, regardless whether the site lies within a designated Geologic Hazard Study Area or not.

2. A liquefaction-hazard investigation shall be performed in conjunction with any geotechnical and/or geologic hazards investigation prepared within [x].

3. For all structures where liquefaction-hazard analyses indicate that ground settlement and/or lateral spread may be anticipated, the project Structural Engineer must provide documentation that the building is designed to accommodate the predicted ground settlements and displacements in such a manner as to be protective of life (collapse prevention) during and after the design seismic event.

4. The investigation of liquefaction hazard is an interdisciplinary practice. The site investigation report must be prepared by a qualified Geotechnical Engineer, who must have competence in the field of seismic hazard evaluation and mitigation.

   Because of the differing expertise and abilities of qualified Engineering Geologists and Geotechnical Engineers, the scope of the site investigation report for a project may require that both types of professionals prepare and review the report, each practicing in the area of their expertise. Involvement of both a qualified Engineering Geologist and Geotechnical Engineer will generally provide greater assurance that the hazard is properly identified, assessed, and mitigated.

   Liquefaction-hazard analyses are the responsibility of the Geotechnical Engineer, although the Engineering Geologist should be involved in the application of screening criteria and general geologic site evaluation to map the likely extent of liquefiable deposits and shallow groundwater. Engineering properties of earth materials shall be evaluated and the performance of quantitative liquefaction-hazard analyses resulting in a numerical factor of safety and quantitative assessment of settlement and liquefaction-induced permanent ground displacement shall be performed by the Geotechnical Engineer. The Geotechnical and Structural Engineers shall develop all mitigation and design recommendations. Ground motion parameters for use in quantitative liquefaction-hazard analyses may be provided by either the Engineering Geologist or Geotechnical Engineer.

   Except for the derivation of input ground motion, liquefaction-hazard investigations shall be performed in general accordance with the latest version of *Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California* (Martin and Lew, 1999). Additional protocol for liquefaction-hazard investigations is provided in Youd and Idriss (1997, 2001), *Assessment of the Liquefaction Susceptibility of Fine-Grained Soils* (Bray and Sancio, 2006), *SPT-Based Liquefaction Triggering Procedures* (Idriss and Boulanger, 2010), and the *State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences* (Committee on State of the Art and Practice in Earthquake Induced Soil Liquefaction Assessment, 2016). Acceptable factors of safety for liquefaction are shown in Table 1.

5. Soil liquefaction is caused by strong seismic ground shaking where saturated, cohesionless, granular soil undergoes a significant loss in shear strength that can result in settlement and permanent ground displacement. Surface effects of liquefaction include settlement, bearing capacity failure, ground oscillations, lateral spread, and flow failure. It has been well documented that soil liquefaction may occur in clean sands, silty sands, sandy silt, non-plastic silts, and gravelly soils. The following conditions must be present for liquefaction to occur:

   a. Soils must be saturated, either below the water table or above a confining layer, and

   b. Soils must be loose to moderately dense, and

   c. Earthquake ground shaking must be relatively intense, and

   d. The duration of ground shaking must be large enough for the soils to generate seismically induced excess pore water pressure and lose their shearing resistance.

6. The following screening criteria may be applied to determine if further quantitative evaluation of liquefaction hazard is required:

Table 1. *Minimum factors of safety for various International Building Code facility types.*

<table>
<tr><th>Type of Facility</th><th>Minimum Factor of Safety (FS)</th></tr>
<tr><td>Critical Facilities, including essential or hazardous facilities and special occupancy structures</td><td rowspan="2">1.3</td></tr>
<tr><td>IBC Category III and IV Structures</td></tr>
<tr><td>Industrial and Commercial Structures</td><td rowspan="2">1.25</td></tr>
<tr><td>IBC Category II(b) Structures</td></tr>
</table>

a. If the estimated maximum past-, current-, and maximum-future-groundwater-levels (i.e., the highest groundwater level applicable for liquefaction-hazard analyses) are determined to be deeper than 50 feet below the existing ground surface or proposed finished grade (whichever is deeper), liquefaction-hazard assessments are not required. For soil materials that are located above the groundwater level, a quantitative assessment of seismically induced settlement is required; and

b. If bedrock underlies the site, those materials need not be considered liquefiable and no analysis of their liquefaction potential is necessary; and

c. If the corrected Standard Penetration Test (SPT) blow count, $(N_1)60$, is ≥ 33 in all samples with an acceptable number of blow counts recorded, liquefaction-hazard assessments are not required. If CPT soundings are made, the corrected CPT tip resistance, q_{c1N}, should be ≥ 180 in all soundings in sandy soils; otherwise, liquefaction-hazard assessments are needed; and

d. If plastic soils with a Plasticity Index (PI) ≥ 18 are encountered during site exploration, those materials may be considered non-liquefiable. Additional acceptable screening criteria regarding the effects of plasticity on liquefaction susceptibility are presented in Boulanger and Idriss (2004), Bray and Sancio (2006), and Seed and others (2003). Youd and others (2002) provide additional guidance on analyzing lateral spreads.

If the screening investigation clearly demonstrates the absence of liquefaction hazards at a project site and [x] concurs, the screening investigation will satisfy the site investigation report requirement for liquefaction hazards. If not, a quantitative evaluation is required to assess the liquefaction hazards.

7. Geologic research and reconnaissance are important to provide information to define the extent of unconsolidated deposits that may be prone to liquefaction. Such information shall be presented on geologic maps and cross sections and provide a description of the formations present at the site that includes the nature, thickness, and origin of Quaternary deposits with liquefaction potential. There shall also be an analysis of groundwater conditions at the site that includes the highest recorded water level and the highest water level likely to occur under the most adverse foreseeable conditions in the future, including seasonal changes.

   During the field investigation, the Engineering Geologist shall map the limits of unconsolidated deposits with liquefaction potential. Liquefaction typically occurs in cohesionless silt, sand, and fine-grained gravel deposits of Holocene to late Pleistocene age, in areas where the groundwater is shallower than about 50 feet, but other soil types are may also be liquefiable.

   Shallow groundwater may exist for a variety of natural and/or manmade reasons. Landscape irrigation, on-site sewage disposal, and unlined manmade lakes, reservoirs, and storm-water detention basins may create a shallow groundwater table in soils that were previously unsaturated.

8. Subsurface exploration shall consist of drilled borings and/or CPT soundings. The exploration program shall be planned to determine the soil stratigraphy, groundwater level, and indices that could be used to evaluate the potential for liquefaction by in-situ testing or laboratory testing of soil samples. If borings are utilized, the use of mud-rotary drilling methods is highly recommended to achieve minimal disturbance of the in-situ soils. If mud-rotary drilling is not used, a through explanation is required in the submitted report. Borings and CPT soundings must penetrate a minimum of 45 feet below the final ground surface. If during the investigation, the liquefaction evaluation indices the liquefaction potential may extend below 45 feet, the exploration shall be continued for a minimum of 10 feet, to the extent possible, until non-liquefiable soils are encountered.

   For saturated cohesionless soils where the SPT $(N_1)60$ values are < 15 or where CPT tip resistances are < 60 tsf, grain-size analyses, hydrometers tests, and Atterberg Limits tests shall be performed on these soils to further evaluate their potential for permanent ground displacement (Youd and others, 2002) and other forms of liquefaction-induced ground failure and settlement. In addition, it is also recommended that these same tests be performed on saturated cohesionless soils with SPT $(N_1)60$ values between 15 and 30 to further evaluate the potential for liquefaction-induced settlement.

Where a structure may have below grade construction and/or deep foundations, such as drilled shafts or piles, the investigation depth shall extend to a minimum of 20 feet below the lowest expected foundation level (e.g., drilled shaft or pile tip) or to 45 feet below the existing ground surface or lowest proposed finished grade, whichever is deeper. If during the investigation, the liquefaction evaluation indices indicate that liquefaction potential may extend below that depth, the exploration shall be continued at least 10 additional feet, to the extent possible, until non-liquefiable soils are encountered.

9. For the design ground accelerations used in liquefaction analyses, [x] prefers a probabilistic approach to determining the likelihood that different levels of ground motion will be exceeded at a site within a given time period. To more closely represent the seismic characteristics of the region, design ground motion parameters for seismic slope stability analyses shall be based on the peak accelerations with a 2% probability in 50 years (2,500-year return period). PGA values shall be obtained from the USGS *National Seismic Hazard Maps and Site-Specific Data* webpage (https://www.usgs.gov/natural-hazards/earthquake-hazards/maps) using the latest long-term model. PGAs obtained from the USGS shall be adjusted for effects of soil/rock (site-class) conditions in accordance with Seed and others (2001) or other appropriate and documented methods that are deemed acceptable by the [x] that consider the site-specific soil conditions and their potential for amplification or deamplification of the high frequency strong ground motion.

   Site specific response analysis may also be used to develop PGA values if the procedures, input data, and results are thoroughly documented and deemed acceptable by [x].

10. Sites, facilities, buildings, structures, and utilities that are founded on or traverse liquefiable soils may require further remedial design and/or relocation to avoid liquefaction-induced damage. These shall be investigated and evaluated on a site-specific basis with appropriate geologic and geotechnical investigation to support the remedial design and/or mitigative plan. This design or plan may include changes/modifications to the soil, permanent dewatering, earthquake drains, foundation systems, building structural frame or support, etc. Remedial design and/or mitigation measures shall be reviewed and approved by [x].

11. Liquefaction hazard reports shall include: boring logs, geologic cross-sections, laboratory data, a detailed explanation pertaining to how idealized subsurface conditions and parameters used for the analyses were developed, analytical results and software output files, and summaries of the liquefaction-hazard analyses and conclusions regarding liquefaction potential and likely types and magnitudes of ground failure in addition to the other report requirements detailed in this chapter.

    Subsurface geologic and groundwater conditions developed by the Engineering Geologist must be illustrated on geologic cross sections and must be utilized by the Geotechnical Engineer for the liquefaction-hazard analyses. If on-site sewage or storm-water disposal exists or is proposed, the liquefaction-hazard analyses shall include the effects of the effluent plume on liquefaction potential.

    The results of any liquefaction-hazard analyses must be submitted with pertinent documentation, including calculations, software output, etc. Documentation of input data, output data, and graphical plots must be submitted for each computer-aided liquefaction-hazard analysis and included as an appendix to the report. Additional information and/or data may be requested to facilitate [x] review.

E. Debris flows are fast-moving, flow-type landslides composed of a slurry of rock, mud, organic matter, and water that move down drainage basin channels onto alluvial fans. In addition to threatening lives, debris flows can damage structures and infrastructure by sediment burial, erosion, direct impact, and associated water flooding. Debris flow hazard investigations and reports shall conform with the *Guidelines for the Geologic Investigation of Debris-Flow Hazards on Alluvial Fans in Utah* (Giraud, 2020; UGS Circular 128, Chapter 5, https://doi.org/10.34191/C-128); and

Debris flow hazard maps show the locations of previous debris flows, areas of potential debris flows, and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

1. All properties located on alluvial fans and drainage channels subject to flash flooding and debris flows; and

2. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS

(https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.

F. Rockfall is a type of landslide and a natural mass-wasting process that involves the dislodging and rapid downslope movement of individual rocks and rock masses. Rockfall hazard investigations and reports shall conform with the *Guidelines for Evaluating Rockfall Hazards in Utah* (Lund and Knudsen, 2020; UGS Circular 128, Chapter 7, https://doi.org/10.34191/C-128); and

1. Rockfall hazard maps show the locations of known rockfall, areas of potential rockfall, and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

a. All properties containing or directly below bedrock cliffs; and

b. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.

G. Land subsidence is the sinking of the ground surface caused by groundwater depletion and/or underground mine subsidence or collapse. Subsidence often causes earth fissures which are permanent, linear tension cracks in the ground that extend upward from the groundwater table. Land subsidence and earth fissure investigations and reports shall conform with the *Guidelines for Evaluating Land-Subsidence and Earth Fissure Hazards in Utah* (Lund, 2020; UGS Circular 128, Chapter 6, https://doi.org/10.34191/C-128) and:

1. Land subsidence and earth fissure maps show the location of known land subsidence and earth fissures and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by the:

- [Escalante Desert in Iron County]
- [Parowan Valley in Iron County]
- [Cedar Valley in Iron County]

H. Radon is a radioactive gas that emanates from uranium-bearing rock and soil and may concentrate in enclosed spaces in buildings. Radon is a major contributor to the ionizing radiation dose received by the general population, is the second leading cause of lung cancer after smoking and has resulted in the majority of geologic hazard related deaths in Utah. Radon gas hazard investigations and reports shall conform with the *Guidelines for Site-Specific Evaluation of Radon Hazard in Utah* (Lund and others, 2020; UGS Circular 128, Chapter 8, https://doi.org/10.34191/C-128); and

1. Radon gas hazard maps show the location of known radon gas hazard and recommended special study areas. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

a. Carbon, Duchesne, Grand, Piute, Sanpete, Sevier, and Uinta Counties as listed in Table AF101(1) of the 2018 International Residential Code, Appendix F of high radon potential (EPA Zone 1); and

b. All other Utah counties are considered at least a moderate potential for radon.

I. Problem soil and rock hazards consist of caliche, collapsible soils, corrosive soils, expansive soil and rock, piping and erosion, shallow bedrock, soluble soil and rock, wind-blown sand, and other similar geologic hazards. While the UGS has not prepared guidelines for these problem soil and rock hazards, investigations of these hazards shall conform to *Guidelines for Investigating Geologic Hazards and Preparing Engineering-Geology Reports, With a Suggested Approach to Geologic-Hazard Ordinances in Utah, Second Edition* (Bowman and Lund, editors, 2020; https://doi.org/10.34191/C-128).

1. Specific problem soil and rock hazard maps show the location of known hazards and recommended special study zones. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined for specific problem soil and rock hazards below, or for those geologic hazards not listed, in Section 1.4:

a. Caliche: [list of geologic units specific to your area].

b. Collapsible Soils: [list of geologic units specific to your area].

c. Corrosive Soils: [list of geologic units specific to your area].

d. Expansive Soil and Rock: [list of geologic units specific to your area].

e. Piping and Erosion: [list of geologic units specific to your area].

f. Soluble Soil and Rock: Units [list of geologic units specific to your area].

g. Wind-Blown Sand: [list of geologic units specific to your area].

h. Geologic units listed above are those on the most recent geologic maps published by the UGS (https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.

J. Snow avalanches are landslides consisting mainly of snow and ice, but can contain soil, rock, and/or debris. These investigations and reports shall be prepared by a qualified snow avalanche expert Utah-licensed as a Professional Geologist and/or Engineer, conform with the guidelines and methods described in Colorado Geological Survey Bulletin 49: *Snow-Avalanche Hazard Analysis for Land Use Planning and Engineering* (Mears, 1992); and

1. Avalanche hazard maps show the locations of previous avalanches, areas of potential avalanches, and recommended special study areas. These maps are currently not available for [x]. Once these maps are available, at that time they will be adopted to become part of this ordinance. As a result, investigations are required within Geologic Hazard Study Areas as defined by those areas within [x] above elevations of [5000] feet with an adequate snow supply to produce snow avalanches and which include slopes greater than 47 percent (2.1H:1V, 25 degrees); and

2. Avalanche areas shall be delineated on a detailed site avalanche map, at a scale equal to or more detailed than 1 inch = 100 feet. The site avalanche map shall include the location and boundaries of the property, locations of avalanche areas, avalanche-source areas, avalanche-runout areas, and buildable and non-buildable areas; delineation of recommended setback distances from the hazard; and recommended locations for structures. Avalanche-source areas may be off-site, and in areas of steep terrain, may be at great distances from the site; and

3. If the avalanche analysis indicates that the site may be impacted by avalanches, the report shall delineate the following areas:

a. A "red zone" of high avalanche potential corresponding to a return period of 25 years or less, and/or impact pressures ≥ 600 pounds per square foot (psf) within which critical facilities or structures for human occupancy are not permitted; and

b. A "blue zone" corresponding to a return period between 25 and 300 years, and impact pressures less than 600 psf within which critical facilities or structures for human occupancy shall only be permitted when at least one of the following requirements has been met:

i. The structure is designed to incorporate direct protection measures that address the estimated impact forces of flowing snow/debris and powder blast loading. The estimated impact forces shall be calculated by the avalanche expert and the structure shall be designed by, and the plans stamped by, a qualified, Utah-licensed Professional Structural Engineer, or;

ii. Appropriate engineering controls (such as, deflection structures, snow retention nets, dams, etc.) are designed and installed to mitigate the avalanche hazard. Design or performance criteria for engineered mitigation measures, including estimated impact forces, flow heights, location, and dimensions of the mitigation structures and all supporting modeling or other analyses, calculations, and assumptions, shall be calculated by the avalanche expert and included in the report. Final design plans and specifications for engineered mitigation must be signed and stamped by a qualified, Utah-licensed Geotechnical or Professional Structural Engineer, as appropriate.

4. The report shall include:

a. The probability of avalanche occurrence, if possible, estimates of avalanche volumes, and the likely effects of avalanches on the proposed development; and

b. A description of the avalanche expert's qualifications to perform the investigation; and

c. Engineering design parameters for avalanche mitigation, as appropriate, implications of the risk-reduction measures on the development and adjacent properties, and the need for long-term maintenance.

K. While flooding hazards are typically addressed by locally adopted Federal Emergency Management Agency regulations, many areas outside of federally designated 100-year flood zones (Zone A and related) are susceptible to flooding and cause significant damage in Utah. While the UGS has not prepared guidelines for flooding hazards, investigations of these hazards shall conform to the *Guidelines for Conducting Engineering-Geology*

Investigations and Preparing Engineering-Geology Reports in Utah (Bowman and Lund, 2020; UGS Circular 128, Chapter 2, https://doi.org/10.34191/C-128).

1. Geologic-based flooding hazard maps show the location of known young flood-related geologic materials (deposits) and recommended special study zones. These maps are published by the UGS[but are currently not available for x. Once these maps are available, at that time they will be adopted to become part of this ordinance]. For areas where maps are not available, Geologic Hazard Study Areas are defined by:

   a. Units [list of geologic units specific to your area] on the most recent geologic maps published by the UGS (https://geology.utah.gov/). Most maps are available in the UGS *Interactive Geologic Map Portal* (https://geology.utah.gov/apps/intgeomap/), but contact the UGS for interim, progress update, and other non-final maps that may be available, but not online.

L. All geologic hazard reports shall meet the submittal and preparation requirements of this ordinance, the *Guidelines for Conducting Engineering-Geology Investigations and Preparing Engineering-Geology Reports in Utah* (Bowman and Lund, 2020; UGS Circular 128, Chapter 2, https://doi.org/10.34191/c-128), and the following:

1. A 1:24,000-scale geologic map with references, showing the general surface geology, including landslides, rockfall, alluvial fans, bedrock geology where exposed, bedding attitudes, faults, other geologic structural features, and the location of any other known geologic hazards; and

2. A detailed site geologic map and geologic cross section(s), at a scale equal to or more detailed than 1 inch = 100 feet to illustrate local geologic structure. The site geologic map shall include locations of all subsurface exploratory trenches, test pits, borings, etc., and site-specific geologic mapping performed as part of the geologic hazard investigation, including boundaries and features related to any geologic hazards, topography, and drainage. The site geologic map must show the location and boundaries of the property, geologic hazards, delineation of any recommended setback distances from hazards, and recommended locations for structures. Buildable and non-buildable areas shall be clearly identified; and

3. Trench and test pit logs, when applicable, with standard geologic nomenclature at a scale equal to or more detailed than 1 inch = 5 feet. Field logs shall be kept by the consultant and may be requested by [x] for further review during the project; and

4. Boring logs, when applicable, shall be prepared with standard geologic and engineering nomenclature and format; and

5. Conclusions and recommendations, clearly supported by adequate data included in the report, that summarize the characteristics of the geologic hazards, and that address the potential effects of the geologic conditions and geologic hazards on the proposed development and occupants thereof, particularly in terms of risk and potential damage; and

6. An evaluation of whether mitigation measures are required, including an evaluation of multiple, viable mitigation options that include specific recommendations for avoidance or mitigation of the effects of the hazards, consistent with the purposes set forth in Section 1.1, including design or performance criteria for engineered mitigation measures and all supporting calculations, analyses, modeling or other methods, and assumptions. Final design plans and specifications for engineered mitigation must be signed and stamped by a qualified, Utah-licensed Engineer (specializing in geotechnical or civil) and/or Structural Engineer, as appropriate; and

7. A statement by the Engineering Geologist shall be provided regarding the suitability of the site for the proposed development from a geologic hazard perspective; and

8. All geologic hazard reports shall be signed and stamped by the Utah-licensed professional(s) that prepared the reports in accordance with Utah Code 58-76-603 (Professional Geologists, https://le.utah.gov/xcode/Title58/Chapter76/58-76.html) and 58-22-603 (Professional Engineers, https://le.utah.gov/xcode/Title58/Chapter22/58-22.html).

When a submitted report does not contain adequate data to support its findings, additional or more detailed investigations shall be required by [x] to explain and/or quantify the geologic hazard and/or to describe how mitigation measures recommended in the report are appropriate and adequate.

When a final geologic hazard report indicates that a geologic hazard does not exist within an adopted Geologic Hazard Study Area indicated by a map referenced by this article, [x] will consider the new geologic information in potentially revising the adopted hazard maps to remove the specific area from the adopted Geologic Hazard Study Area. [x] will also forward this information to the Utah Geological Survey for potential update of their hazard maps.

1.10 – Geologic Hazard Investigation Field Review

A field review by [x] is required during subsurface exploration activities (test pits, trenches, drilling, etc.) to allow the [City/County] to evaluate the subsurface conditions, such as the age and type of deposits encountered, the presence or absence of faulting, etc. with the applicant's geologic consultant. Discussions about questionable features or appropriate setback distances are acceptable, but [x] will not assist with field logging, explaining stratigraphy, or give verbal approval of the proposed development during the field review. Exploratory trenches when excavated, shall be open, safe, and in compliance with applicable federal Occupational Safety and Health Administration, State of Utah, and other excavation safety regulations, have the walls appropriately cleaned, and a field log completed by the time of the review. The applicant must provide [x] with a minimum notice of [2 days] to schedule the field review.

1.11 – Submittal and Certification of Geologic Hazard Reports

A. All applicants for land use approval within a Geologic Hazard Study Area shall prepare and submit a geologic hazard report (may be combined with geotechnical and/or other geologic reports) pursuant to the requirements of this article prior to any consideration for a concept plan; preliminary or final plat; commercial, institutional, or one-, two-, and multi-family dwelling; or any conditional use permit which requires site plan approval. Additionally, the applicant is required to submit the following additional information with the report:

1. A written, stamped certification from a Utah-licensed Professional Geologist that the geologic hazard report has been prepared pursuant to the requirements of this ordinance; and

2. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer that every proposed development lot, building pad, and parcel does not present an unreasonable or unacceptable risk to the health, safety, and welfare of persons or property, including buildings, storm drains, public streets, culinary water facilities, utilities, or critical facilities, whether off site, on adjacent properties, or on site, because of the presence of geologic hazards or because of modifications to the site due to the proposed land use; and

3. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer that every proposed development lot, building site, and parcel layout demonstrates that, consistent with regional standards of practice, the identified geologic hazards can be mitigated to a level where the risk to human life and damage to property are reduced to an acceptable and reasonable level in a manner which will not violate applicable federal, state, and local statutes, ordinances, and regulations. Mitigation measures shall consider in their design, the intended aesthetic functions of other governing ordinances of [x]; and

4. A written, stamped certification from a Utah-licensed Professional Geologist and a Professional Engineer along with a mitigation plan, if necessary, that demonstrates that the identified hazards or limitations will be addressed without impacting or adversely affecting off site areas, including adjacent properties. Mitigation measures must be reasonable and practical to implement and shall not require ongoing maintenance by property owners; and

5. Written verification from the issuer of professional errors and omissions liability insurance, in the amount of [$2,000,000.00] each, which covers the Utah-licensed Professional Geologist and Professional Engineer, and which are in effect on the date of preparation and submittal of all required reports and certifications.

B. [x] may set other requirements as are necessary to mitigate any geologic hazards and to ensure that the purposes of this article are met. These requirements may include, but are not limited to:

1. Additional or more detailed investigations and professional certifications to understand or quantify the hazards and/or determine whether mitigation measures recommended in the report are adequate; and

2. Specific mitigation requirements, establishing buildable and non-buildable areas, limitations on slope grading, controls on grading, and/or revegetation; and

3. Prior to receiving a grading, excavation, or building permit, final grading plans, when required, shall be prepared, signed and sealed by the Utah licensed Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard and geotechnical report(s) to verify that their recommendations have been appropriately incorporated in the final grading plan and that building locations are approved; and

4. As built grading plans, when required, shall be prepared, signed, and sealed by the Utah licensed Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard and geotechnical report(s) to verify that their recommendations have been appropriately incorporated and that building locations are approved, prior to the issuance of a building permit; and

5. Grading plans, when required, shall include, at a minimum, the following:

a. Maps of existing and proposed contours and the source and accuracy of topographic data used; and

b. Present and proposed slopes for each graded area; and

c. Existing and proposed drainage patterns; and

d. Location and depth of all proposed cuts and fills; and

e. Description of the methods to be employed to achieve soil and/or rock stabilization and compaction, as appropriate; and

f. Location and capacities of proposed structures, and drainage and erosion control measures based on maximum runoff for a 100-year storm or greater; and

g. Location of existing buildings, structures, roads, wells, retention and other basins, and on-site sewage disposal systems on or within 100 feet of the site that may be affected by the proposed grading and construction; and

h. A plan for construction monitoring and documentation of testing, field inspection during grading, and reporting to [x]; and

6. Installation of monitoring equipment for surface and subsurface geologic conditions, including determining groundwater levels; and

7. Other requirements, such as time schedules for completion of the mitigation and phasing of development.

C. [x] may also set requirements necessary to protect the health, safety, and welfare of the citizens of [x], protect the infrastructure and financial health of [x], and minimize potential adverse effects of geologic hazards to the public health, safety, and property as a condition of approval of any development which requires a geologic hazard report.

D. [x] may require the Engineering Geologist and Geotechnical Engineer that prepared the geologic hazard and/or geotechnical report(s) be on site, at the cost of the applicant, during certain phases of construction, particularly during grading phases, the construction of retaining walls in excess of 4 feet in exposed height, and geologic hazard mitigation.

E. [x] shall review any proposed land use that requires preparation of a geologic report under this article to determine the possible risks to the health, safety, and welfare of persons, property, and [City/County] infrastructure from geologic hazards.

1. Prior to consideration of any request for preliminary plat approval or site plan approval, the geologic report, if required, shall be submitted to [x] for review.

2. [x] will complete each review in a reasonable time frame, not to exceed [45 days].

3. All direct costs associated with the review of the geologic report shall be paid by the applicant.

4. [x] shall determine whether the report complies with the following standards:

a. A suitable geologic hazards report has been prepared by qualified, Utah-licensed professionals; and

b. The proposed land use does not present an unreasonable risk to the health, safety, and welfare of persons or property, including buildings, storm drains, public streets, culinary and other water facilities, utilities or critical facilities, whether off-site or on-site, or to the aesthetics and natural functions of the landscape, such as slopes, streams or other waterways, drainage, or wildlife habitat, whether off-site or on-site, because of the presence of geologic hazards or because of modifications to the site due to the proposed land use; and

c. The proposed land use demonstrates that, consistent with the current, regional state of practice, the identified geologic hazards can be mitigated to a level where the risk to human life and damage to property are reduced to an acceptable and reasonable level in a manner which will not violate applicable federal, state, and local statutes, ordinances, and regulations. Mitigation measures should consider in their design, the intended aesthetic functions of other governing ordinances, such as the [x] Sensitive Lands Overlay Zone. The applicant must include with the geologic report, a mitigation plan that defines how the identified hazards or limitations will be addressed without impacting or adversely affecting off-site areas. Mitigation measures must be reasonable and practical to implement, especially if such measures require on-going maintenance by property owners; and

d. Should a geologic report be found deficient with respect to this ordinance and/or the current, regional state of practice, a letter will be provided to the applicant summarizing the specific deficiencies. If a submitted report is found deficient three times or a report was excessively deficient, [x] will notify the Utah Division of Occupational & Professional Licensing about the licensed professional(s) deficient reports that were submitted to a public entity that were not in compliance with Utah Rules R156-76-502 (Professional

Geologists, https://rules.utah.gov/publicat/code/r156/r156-76.htm) and/or R156-22-502 (Professional Engineers, https://rules.utah.gov/publicat/code/r156/r156-22.htm).

F. For any real property with respect to which development has proceeded on the basis of a geologic hazard and/or geotechnical report which has been accepted by [x], no final inspection shall be completed, Certificate of Occupancy issued, or performance bond released until the Engineering Geologist and Geotechnical Engineer who signed, stamped, and approved the report(s), certifies in writing, that the completed development, improvements, and structures conform to the descriptions and requirements contained within the report, and that all the required inspections were made and approved by the Engineering Geologist and Geotechnical Engineer that prepared said report(s). If the preparing Engineering Geologist and Geotechnical Engineer are unavailable, an Engineering Geologist and Geotechnical Engineer, similarly qualified and licensed in Utah, shall provide the certifications.

G. An applicant may appeal any decision made under the provisions of this article only after the land-use authority has issued a final decision and shall set forth the specific grounds or issues upon which the appeal is based. The appeal shall be submitted in writing to [x] in accordance with the appeals provision ordinances of [x] and current State of Utah code.

H. [x] shall retain a copy of each geologic hazard and/or geotechnical report in the [xx project file] that will be available for public inspection and will provide a copy to the UGS for archiving. Currently, the UGS archives these reports in the *GeoData Archive System* (https://geodata.geology.utah.gov).

1.12 – Disclosure Required When a Geologic Hazard Report is Required

A. Whenever a geologic hazard report is required under this article; the owner of the parcel shall record a notice running with the land on a form provided by [x] prior to the approval of any development or subdivision of such parcel or commencement of construction activity. Disclosure shall include signing a *Disclosure and Acknowledgment Form* provided by [x], which includes:

1. Notice that the parcel is located within a Geologic Hazard Study Area or as otherwise defined in this article; and

2. Notice that a geologic hazard report was prepared and is available for public inspection in [x] files.

3. Where geologic hazards, related setbacks, and non-buildable areas are delineated in a subdivision, the owner shall also place additional notification on the plat stating the above information, prior to final approval of the plat by [x].

1.13 – Warning and Disclaimer

The Geologic Hazard Study Areas designated herein represent only those potentially geologic hazardous areas known to [x] and should not be construed to include all possible potential hazard areas. The geologic hazard ordinance and the Geologic Hazard Study Areas may be amended as new information becomes available, pursuant to procedures set forth in this ordinance. The provisions of this ordinance do not in any way assure or imply that areas outside the Geologic Hazard Study Areas are free from the possible adverse effects of geologic hazards. This article shall not create any liability on the part of [x], its officers, reviewers, or employees thereof, for any damages from geologic hazards that result from reliance on this ordinance or any administrative requirement or decision lawfully made hereunder.

1.14 – Change of Use

No change in use which results in the conversion of a building or structure from one not used for human occupancy to one that is so used shall be permitted unless the building or structure complies with the provisions of this article.

1.15 – Hold Harmless Agreement

Applicants receiving any permit or approval within a Geologic Hazard Study Area shall be required to sign and record on the property a *Hold Harmless Agreement* available from [x].

1.16 – Conflicting Regulations

In cases of conflict between the provisions of existing zoning classifications, building codes, the subdivision ordinance, or any other ordinance of [x] and this geologic hazard ordinance, the most restrictive provision shall apply.

1.17 - References

Bartlett, S.F. and Youd, T. L., 1995, Empirical prediction of liquefaction-induced lateral spread: Journal of Geotechnical Engineering, v. 121, n. 4-April, American Society of Civil Engineers, p. 316–329.

Beukelman, G.S., and Hylland, M.D., 2020, Guidelines for evaluating landslide hazards in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 59–73, https://doi.org/10.34191/c-128.

Blake, T.F., Hollingsworth, R.A. and Stewart, J.P., editors, 2002, Recommended procedures for implementation of DMG Special Publication 117, Guidelines for analyzing and mitigating landslide hazards in California: Southern California Earthquake Center, 110 p., http://www-scec.usc.edu/resources/catalog/LandslideProceduresJune02.pdf.

Boulanger, R.W., and Idriss I.M., 2004, Evaluating the potential for liquefaction resistance or cyclic failures of silts and clays: University of California, Davis Center for Geotechnical Modeling Report UCD/CGM-04/01, https://faculty.engineering.ucdavis.edu/boulanger/wp-content/uploads/sites/71/2014/09/Boulanger_Idriss_CGM04-01_2004.pdf.

Bowman, S.D., and Lund, W.R., editors, 2020, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, 203 p., https://doi.org/10.34191/c-128.

Bowman, S.D., and Lund, W.R., 2020, Guidelines for conducting engineering-geology investigations and preparing engineering-geology reports in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 15–30, https://doi.org/10.34191/c-128.

Bray, J.D., and Rathje, E.M., 1998, Earthquake-induced displacements of solid-waste landfills: Journal of Geotechnical and Geoenvironmental Engineering, v. 124, no. 3, p. 242–253.

Bray J. D. and Sancio R. B., 2006, Assessment of liquefaction susceptibility of fine-grained soils: ASCE Journal of Geotechnical and Geoenvironmental Engineering, September 2006.

Bray, J.D., and Travasarou, T., 2007, Simplified procedure for estimating earthquake-induced deviatoric slope displacements: Journal of Geotechnical and Geoenvironmental Engineering, v. 133, no. 4, April 1, 2007, pp. 381–392.

Federal Highway Administration, 1989, Rock slopes-design, excavation, stabilization: Federal Highway Administration Publication FHWA-TS-89-045, variously paginated: Online, https://geodata.geology.utah.gov/pages/view.php?ref=58219.

Giraud, R.E., 2020, Guidelines for the geologic investigation of debris-flow hazards on alluvial fans in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 75–91, https://doi.org/10.34191/c-128.

Giraud, R.E., and Shaw, L.M., 2007, Landslide susceptibility map of Utah: Utah Geological Survey Map M-228, 11 p., 1 plate, scale 1:500,000, https://doi.org/10.34191/m-228.

Hoek, E., Bray, J.W., 1981, Rock slope engineering, revised third edition: E & FN Spon, London, 358 p.

Idriss, I.M., and Boulanger, R.W., 2010, SPT-based liquefaction triggering procedures: University of California, Davis Center for Geotechnical Modeling Report No. UCD/CGM 10/02, 259 p., https://faculty.engineering.ucdavis.edu/boulanger/wp-content/uploads/sites/71/2014/09/Idriss_Boulanger_SPT_Liquefaction_CGM-10-02.pdf.

International Code Council, Inc., 2017, International building code [2018]: International Code Council, Country Club Hills, Illinois, 728 p., https://codes.iccsafe.org/content/IBC2018.

International Code Council, Inc., 2017, International residential code–for one and two story dwellings [2018]: International Code Council, Country Club Hills, Illinois, 964 p., https://codes.iccsafe.org/content/IRC2018.

Lund, W.R., 2020, Guidelines for evaluating land-subsidence and earth-fissure hazards in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 93–110, https://doi.org/10.34191/c-128.

Lund, W.R., Castleton, J.J., and Bowman, S.D., 2020, Guidelines for evaluation of geologic radon hazard in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 125–136, https://doi.org/10.34191/c-128.

Lund, W.R., Christenson, G.E., Batatian, L.D., and Nelson, C.V., 2020, Guidelines for evaluating surface-fault-rupture hazards in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 31–58, https://doi.org/10.34191/c-128.

Lund, W.R., and Knudsen, T.R., 2020, Guidelines for evaluating rockfall hazards in Utah, *in* Bowman, S.D. and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah, Second Edition: Utah Geological Survey Circular 128, p. 111–123, https://doi.org/10.34191/c-128.

Martin, G.R., and Lew, M., editors., 1999, Recommended procedures for implementation of DMG Special Publication 117, Guidelines for analyzing and mitigating liquefaction potential in California: Southern California Earthquake Center, University of Southern California, 63 p., http://scecinfo.usc.edu/resources/catalog/LiquefactionproceduresJun99.pdf.

Mears, A.I., 1992, Snow-avalanche hazard analysis for land use planning and engineering: Colorado Geological Survey Bulletin B-49, 55 p., https://coloradogeologicalsurvey.org/publications/avalanche-hazard-analysis-land-use-planning-engineering/.

Committee on State of the Art and Practice in Earthquake Induced Soil Liquefaction Assessment, 2016, State of the art and practice in the assessment of earthquake-induced soil liquefaction and its consequences: The National Academies Press, National Academies of Sciences, Engineering, and Medicine, https://doi.org/10.17226/23474.

Newmark, N.M., 1965, Effects of earthquakes on dams and embankments: Geotechnique, v. 25, no. 4.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., and Riemer, M.F., 2001, Recent advances in soil liquefaction engineering and seismic site response evaluation: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, University of Missouri-Rolla, Rolla, Missouri, 2001, Paper No. SPL-2, 45 p.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., and Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., and Faris, A., 2003, Recent advances in soil liquefaction engineering, A unified and consistent framework: Earthquake Engineering Research Institute Report No. EERC 2003-06, 71 p., https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1007&context=cenv_fac.

Stark, T.D., Choi, H., and McCone, S., 2005, Drained shear strength parameters for analysis of landslides: Journal of Geotechnical and Geoenvironmental Engineering, v. 131, no. 5, p. 575–588.

Stewart, J.P., Blake, T.M., and Hollingsworth, R.A., 2003, Development of a screen analysis procedure for seismic slope stability: Earthquake Spectra, v. 19, no. 3, p. 697–712.

Youd, T.L., and Idriss, I.M., editors., 1997, Proceedings of the NCEER workshop on evaluation of liquefaction resistance of soils: National Center for Earthquake Engineering Research Technical Report NCEER 97-0022.

Youd, T.L., and Idriss, I.M., 2001, Liquefaction resistance of soils, Summary Report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils: Journal of Geotechnical and Geoenvironmental Engineering, v. 127, no. 4, http://www.ce.memphis.edu/7137/PDFs/Reference2/Youd%20ad%20Idriss.pdf.

Youd, T.L., and Gilstrap, S.D., 1999, Liquefaction and deformation of silty and fine-grained soils: Proceedings of the Second International Conference on Earthquake Geotechnical Engineering, Lisboa, Portugal, 21-25 June 1999, Seco e Pinto, p. 1013–1020.

Youd, T.C., Hansen, C.M., and Bartlett, S.F., 2002, Revised MLR equations for predicting lateral spread displacement, ASCE Journal of Geotechnical and Geoenvironmental Engineering, December 2002.

Watry, S.M., and Lade, P.V., 2000, Residual shear strengths of bentonites on Palos Verdes Peninsula, California: Proceedings of the session of Geo-Denver 2000, American Society of Civil Engineers, p. 323–342.

Wyllie, D.C., and Mah, C.W., 2004, Rock slope engineering, civil and mining, 4th edition: Spon Press, New York, 431 p.