

GEOGRAPHIC INFORMATION SYSTEM DATABASE SHOWING GEOLOGIC-HAZARD SPECIAL-STUDY AREAS, WASATCH FRONT, UTAH

by Gary E. Christenson and Lucas M. Shaw



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Cover Images: Maps showing liquefaction (upper left, southern Utah County), surface-fault-rupture (lower left, Salt Lake County), landslide (upper right, Davis and Weber Counties), and debris-flow/alluvial-fan-flooding (lower right, Tooele County) geologic-hazard special study area.



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The datasets in this GIS database are compiled from original geologic-hazard special-study-area maps by the UGS and Wasatch Front County Geologists, including GIS data compiled by others. The original maps have not been updated, re-digitized, or revised except as noted in the report. The original maps are unchanged because in many cases they have been adopted in ordinances or other local-government regulations, and therefore a formal revision process should be used to make and document any changes.

These datasets are designed to indicate areas where site-specific special studies should be completed to address hazards prior to most residential, commercial, and industrial development. Special studies for critical facilities (see Introduction for definition of critical facilities) should address all hazards, even where outside special-study areas shown on this map. These datasets do not replace the need for site-specific studies to determine whether a hazard exists.

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ABSTRACT

We compiled a Geographic Information System (GIS) database showing areas where special studies are recommended to address surface-fault-rupture, liquefaction, landslide, and debris-flow/alluvial-fan-flooding hazards prior to development. The database was compiled from existing geologic-hazard special-study-area maps for the urban parts of Davis, Salt Lake, Tooele, Utah, Wasatch, and Weber Counties, Utah. The content of the compiled datasets is relatively unchanged from the original sources, although some revisions have been made for uniformity and to preserve data.

The original maps and these compiled datasets do not show areas of actual known hazards, but were produced to assist local governments and other land-use managers in identifying areas where special studies to address each hazard should be completed as part of the development-approval process. In addition, the Tooele and Wasatch County datasets and the liquefaction dataset indicate the relative hazard (high, moderate, low, very low), which provides additional information useful to local governments in land-use planning. Maps derived from these datasets can also be used by homeowners, homebuyers, real-estate agents, and others to understand possible risks in an area.

INTRODUCTION

From 1988 to 1995, the Utah Geological Survey (UGS) and Wasatch Front County Hazards Geologists (see Christenson [1993] for a description of the county-geologist program) completed surface-fault-rupture, landslide, and debris-flow/alluvial-fan-flooding special-study-area maps for the urban parts of Davis, Salt Lake, Tooele, Utah, Wasatch, and Weber Counties (figure 1). These maps have been adopted in geologic-hazard ordinances by many Wasatch Front cities and counties. The maps were all at a scale of 1:24,000 but were in

a variety of formats ranging from hard-copy mylar overlays to modern Geographic Information System (GIS) digital datasets. Similarly, from 1982 to 1990, Utah State University and the consulting firm Dames and Moore completed liquefaction potential maps for much of northern Utah. These were hard-copy mylar maps at a scale of 1:48,000 that also included parts of Box Elder, Cache, and Summit Counties.

The purpose of this project is to compile these maps into a uniform GIS digital database. Such a database can benefit many potential users, particularly state and local governments, which can use them in developing pre-disaster mitigation plans, critical-lands maps, and geologic-hazard ordinances. The compiled database and maps derived from it can also be used by homeowners, homebuyers, real-estate agents, and others to assess relative risks at a particular location of interest. For ready access, the GIS database on this compact disk will also be posted on the UGS Web site and with the Utah Automated Geographic Reference Center, and will be made available to cities and counties for possible posting on their Web sites.

The original maps, as well as these compiled datasets, were produced to show areas where special studies are recommended prior to most residential, commercial, and industrial development. The one exception is for critical facilities (essential, hazardous, and special-occupancy facilities in Occupancy Categories III and IV in the International Building Code [International Code Council, 2006]), for which special studies should address all hazards even outside the special-study areas shown here.

This database is the starting point for implementation of the Governor's Geologic Hazards Working Group's (Christenson and Ashland, 2007) recommendation 2.1 to update and improve existing Wasatch Front geologic-hazards maps. New geologic maps and geologic-hazard reports produced since completion of the original maps used for this compilation can provide the basis for formal revisions.

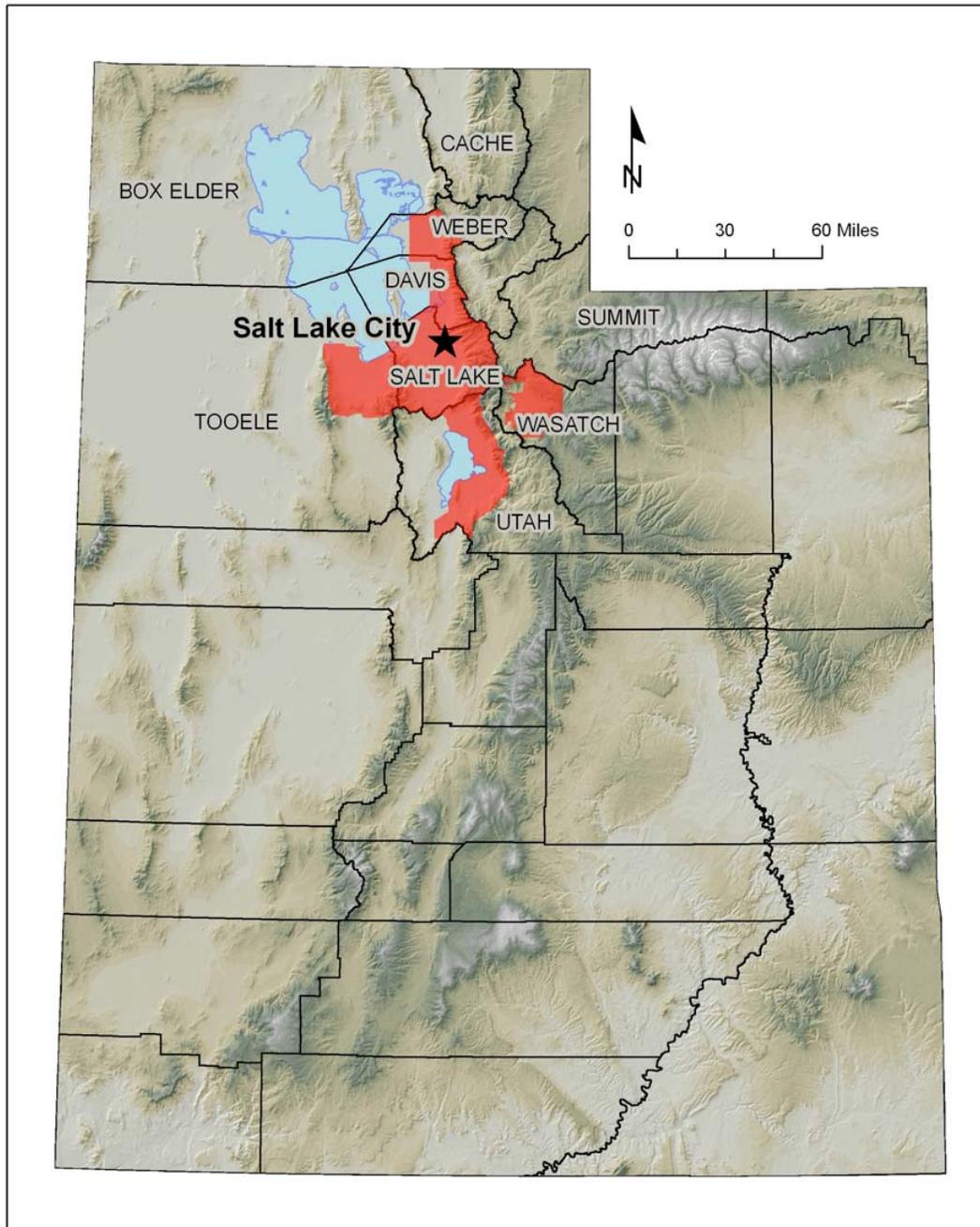


Figure 1. Area covered by the Wasatch Front GIS database compilation, shown in red; liquefaction dataset includes parts of adjacent counties.

METHODS

Geographic Information Systems

To compile the database, the UGS (1) collected and converted existing digital files compiled by counties in various formats, (2) scanned and vectorized or digitized hard-copy-only maps, and (3) combined these digital files into a single uniform ArcGIS Personal Geodatabase. The format of the original maps (GIS data vs. hard copy), agencies from which the maps were obtained, cited references, and the person or group that scanned or digitized the maps are listed in table 1.

We used ArcGIS software to vectorize the hard-copy mylar maps. For Salt Lake, Utah, and Wasatch Counties, we obtained and merged the original GIS files. Metadata are included with the GIS data files.

Special-Study-Area Dataset Compilation

Using the original geologic-hazard maps for Davis, Salt Lake, Tooele, Utah, Wasatch, and Weber Counties, we compiled four GIS datasets showing areas where site-specific special studies are recommended for surface-fault-rupture, liquefaction, land-

Table 1. Information on data sources used to compile the Wasatch Front GIS database.

County ¹	Format	Agency	References	Input ²
Davis	hard copy	Davis County Community and Economic Development, Farmington	Lowe (1988a), Anderson and others (1982)	Joseph Serrao, UGS, 2007
Salt Lake	GIS	Salt Lake County Planning and Development Services, Salt Lake City	Salt Lake County Planning and Development Services (1989, 2005), Anderson and others (1986b)	Salt Lake County Planning, 1989; UGS, 2005
Tooele	hard copy	UGS, Salt Lake City, and Tooele County Planning, Tooele	Solomon and Black (1995)	Joseph Serrao, UGS, 2007
Utah	GIS	Utah County Public Works-GIS, and Utah County Planning, Provo	Utah County GIS (2007), Anderson and others (1986a)	Utah County, late 1980s
Wasatch	GIS	Wasatch County Information Systems Department-GIS, Heber City	Hylland and others (1995), Anderson and others (1990b)	Wasatch County, late 1990s
Weber	hard copy	Weber County Planning, Ogden	Lowe (1988b), Anderson and others (1990a)	Suzzie Swim, Wasatch Front Regional Council, 2007

¹ Liquefaction maps also include parts of Box Elder, Cache, and Summit Counties (Anderson and others, 1990a, 1990b).

² Person or group that scanned or digitized the maps.

slide, and debris-flow/alluvial-fan-flooding hazards. Relatively uniform data exist for these hazards for the entire Wasatch Front map area. Data for other hazards (e.g., rock fall, stream flooding, problem soils) exist in some but not all of the area of the compiled GIS database, so we did not compile datasets for these other hazards. The liquefaction dataset also includes parts of Box Elder, Cache, and Summit Counties because the original mapping included those areas.

The original maps for Davis, Salt Lake, Utah, and Weber Counties show geologic-hazard special-study areas for use by local governments to determine where detailed studies should be required prior to development, and do not differentiate areas of relative hazard. In contrast, the original maps for Wasatch and Tooele Counties and all of the liquefaction potential maps show areas of relative hazard (high, moderate, low, very low) and recommended special studies based on the relative hazard. Our compiled database primarily identifies special-study-areas, but we show relative hazard ratings where they exist to subdivide special-study areas.

The compiled datasets are relatively unaltered from the original maps completed in the late 1980s and early 1990s. Geologic interpretations and edge-matching adjustments were made where necessary to combine the original maps into a uniform database. Faults have been added to the surface-fault-rupture dataset, mainly in Utah County, where minor faults were

missed on the original maps or where new mapping in areas not covered by the original maps has become available (e.g., faults south of Santaquin in southern Utah County). These are highlighted and noted separately in the compiled dataset because these special-study areas have not been incorporated into existing local-government ordinances, as has been done with the original special-study-area maps. Also, in some cases the original maps have been replaced or revised by local governments, so for official special-study requirements, contact the county or city having jurisdiction in the area. In particular, Lindon City (Utah County) and Draper City (Salt Lake and Utah Counties) have recently produced updated, more detailed special-study-area maps that include additional special-study areas beyond those compiled here (Kleinfelder, Inc., 2006; Draper City GIS and Mapping, 2007). We include map-area boundaries of the Lindon and Draper maps in the database; the maps themselves are available from Lindon City and Draper City.

Dataset-Area Boundaries

The outer dataset-area boundaries of the four special-study-areas differ because of variations in the data coverage. The surface-fault-rupture, landslide, and debris-flow/alluvial-fan-flooding dataset boundaries generally follow county boundaries and ridge lines that were used as the basis for boundaries on

the original maps. Locally, study-area boundaries of particular technical data sources are used. The liquefaction dataset uses the map-area boundaries of the original maps.

GIS DATASETS

Surface Fault Rupture

The original surface-fault-rupture special-study-area maps showing Quaternary faults were similar for all counties, and are relatively unaltered in the dataset. In most cases the line patterns for the faults (solid—well-defined, dashed—approximately located, dotted—inferred or concealed) are from the original geologic-map data sources, except in most of Utah County (excluding the faults we added to the map south of Santaquin) where all fault line patterns (and patterns for folds connecting or on-trend with faults beneath Utah Lake) are shown as solid. Special-study areas generally extend 250 feet from the fault on the upthrown side and 500 feet from the fault on the downthrown side. In areas where this general guideline was not followed on the original maps, the boundaries from the original maps have been maintained; e.g., in some cases, the special-study area is symmetrical at 500 feet on each side, particularly where a high scarp exists on the upthrown side and the 250-foot-distance intersects the slope on the face of the scarp and does not extend to the top of the scarp. No special-study areas are defined for faults and folds beneath Utah Lake.

For Davis, Salt Lake, Utah, and Weber Counties, the original maps were compiled by the Wasatch Front County Hazards Geologists from preliminary, unpublished 1:24,000-scale draft surficial-geologic maps by the U.S. Geological Survey (USGS). These draft maps were ultimately used, in some places with significant revision and simplification, to compile the 1:50,000-scale published maps of the Wasatch fault zone (Personius, 1990; Machette, 1992; Personius and Scott, 1992; Nelson and Personius, 1993). In addition, the published, larger-scale maps by Scott and Shroba (1985) for the Wasatch fault zone and Keaton and others (1987) for the West Valley fault zone in Salt Lake County, and Brimhall and Merritt (1981) for the Utah Lake faults in Utah County, were also used. Thus, the special-study-area datasets may differ from the published USGS 1:50,000-scale maps, mainly in fault complexity and line patterns. Data for Tooele and Wasatch Counties are taken directly from the published maps in Solomon and Black (1995) and Hylland and others (1995), respectively.

In the Corner Canyon area of southern Salt Lake County, we added faults from Machette (1992) where the original Salt Lake County map predated Machette (1992) and used Cluff and others (1970, 1973). In southern Utah County, the original maps did not include the Wasatch fault south of Santaquin, so this was added from Harty and others (1997). As noted above, these revisions are differentiated in the GIS database because

they post-date the maps that have been officially adopted in some local-government ordinances. The southern extensions of faults beneath Utah Lake were also added, but the extensions are not differentiated in the database because special-study areas are not defined for these extensions.

Liquefaction

The liquefaction dataset is a compilation of liquefaction *potential* maps covering the Wasatch Front and Wasatch Range valleys (Anderson and others, 1982, 1986a, 1986b, 1990a, 1990b; Utah Geological Survey, 2004) and a liquefaction *susceptibility* map for Tooele County (Solomon and Black, 1995; Black and others, 1999). Both liquefaction potential and susceptibility maps show relative hazard (high, moderate, low, very low), and all areas of moderate to high hazard are represented in the dataset as special-study areas.

Liquefaction *potential* maps consider soil and ground-water conditions (susceptibility) and earthquake ground-shaking probabilities (opportunity) to yield the relative potential, whereas liquefaction *susceptibility* maps consider only the soil and ground-water conditions. Both types of maps show relative hazard, and the type is preserved in the compiled dataset as either liquefaction potential or susceptibility with relative hazard categories differentiated by color. All colored areas in the dataset are special-study areas (including areas of undetermined liquefaction potential in landslides along the Weber and Ogden Rivers and the tailings pond north of Magna); areas of low and very low liquefaction potential or susceptibility (labeled without colors) are areas where special studies are not needed (except for critical facilities).

New maps of liquefaction potential and liquefaction-induced lateral-spread displacement and settlement are being prepared for Salt Lake County by the University of Utah, Brigham Young University, and the UGS (Olsen and others, 2007; Erickson and others, in press). The new liquefaction potential map for Salt Lake County has not yet been incorporated into the compiled mapping shown in the liquefaction dataset, but has been used in Draper City in place of the Anderson and others (1986b) map to delineate liquefaction special-study areas.

Landslides

The landslide dataset is a composite of both special-study-area and relative-hazard maps. The dataset shows areas of potential for both shallow and deep-seated landslides, but does not show areas of potential for debris flows (see Debris Flow/Alluvial-Fan Flooding section below) or rock falls. In Davis, Utah, and Weber Counties, the dataset shows special-study areas consisting of all mapped landslides at the time of compilation (late 1980s) and areas of slopes of 30% or steeper determined by hand measurement of distances between topographic contour lines at the mountain front. Because of this generalized mapping

technique, local areas of slopes less than 30%, particularly in mountain areas in these counties, are included in special-study areas. Modern GIS techniques could differentiate these areas, but we did not change the original maps because they have been adopted in various local government ordinances.

In Salt Lake County, the landslide dataset also shows both mapped landslides and slopes of 30% or steeper, but shows them separately. This is because the special-study requirement for 30% or steeper slopes is only listed in the Salt Lake County Geologic Hazards Ordinance (Chapter 19.75.030C), and the areas are not shown on the Salt Lake County landslide and debris-flow special-study-area map (Salt Lake County Planning and Development Services, 2005). The areas of 30% and steeper slopes shown in our dataset were derived by us from the 30-meter National Elevation Dataset (NED) using ArcGIS Spatial Analyst software. As such, the steep-slope areas in our dataset exclude local areas where slopes are less than 30% in the Wasatch Range and Oquirrh Mountains, but special studies may still be required in these areas if they are within Salt Lake County's Foothills and Canyons Overlay Zone.

In Tooele and Wasatch Counties, the original relative landslide-hazard maps are used to show special-study areas based on relative hazard as recommended in the original reports (Hyland and others, 1995; Solomon and Black, 1995). Special-study areas are subdivided to show relative hazard (high, moderate).

Debris-Flow/Alluvial-Fan Flooding

The debris-flow/alluvial-fan-flooding dataset shows areas subject to debris flows and alluvial-fan flooding based on geologic maps showing Holocene-age alluvial-fan deposits and debris-flow deposits on alluvial fans and upstream in channels. In Davis, Salt Lake, Utah, and Weber Counties, slopes of 30% or steeper are included in the debris-flow/alluvial-fan-flooding special-study area, although here again the 30% or steeper slopes in Salt Lake County were mapped by us (as discussed above in the Landslides section) and are shown separately. In Davis, Salt Lake, Tooele, and Weber Counties, areas of deposition on Holocene alluvial fans and along channels are mapped separately from source areas. In Wasatch County, only Holocene-age alluvial-fan-deposition areas are shown, and source areas are not included in the special-study area. However, areas of potential landsliding, which could generate debris flows, are included in the landslide dataset.

In Tooele County, source areas in mountains surrounding Tooele Valley are subdivided based on relative susceptibility (high, moderate) to shallow debris slides that typically mobilize into debris flows. Also, in Tooele County large areas of relatively low-gradient, fine-grained alluvial-fan deposits are shown far out into the valley. These represent areas of shallow debris and sheet flooding on distal alluvial fans that may be periodically flooded with sediment-laden floodwaters, but likely not thick, coarse-grained debris flows. Such areas are generally absent in other counties.

CONCLUSIONS

We compiled surface-fault-rupture, liquefaction, landslide, and debris-flow/alluvial-fan-flooding special-study-area GIS datasets for the urban parts of Davis, Salt Lake, Tooele, Utah, Wasatch, and Weber Counties along the Wasatch Front (the liquefaction dataset also includes parts of Box Elder, Cache, and Summit Counties). The datasets were compiled from existing sources (with only minor modifications) into a uniform, multiple-use GIS database.

The datasets are principally designed to assist local governments and other land-use managers in identifying areas where special studies to address each hazard should be completed prior to development. Maps derived from the datasets can also be used by homeowners, homebuyers, real-estate agents, and others to understand possible risks in areas of interest, but the datasets do not show areas of actual known hazards. In some cases, relative hazards are shown.

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