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Active Surficial-Geologic Processes and Related Geologic Hazards in Georgetown, Clear Creek County, Colorado

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INTRODUCTION

The narrative that follows is a description and discussion about the background of study, delineation, and evaluation of ongoing surficial-geologic processes that may present threats to people, structures, and infrastructure in Georgetown (town). As is the case with many of the Victorian-era mining towns in Colorado, this historic mountain community is being impacted by residential and commercial growth from the rapidly growing recreational-residential, service, and retirement-living sectors of the Colorado economy. The town boasts the transportation corridor of Interstate 70 (I-70), an historic, popular, tourist-oriented narrow-gauge railroad (Georgetown Loop Railroad), shopping and tourist-accommodation facilities, and easy access to skiing and other recreational opportunities of the Colorado mountains. Georgetown is the County Seat of Clear Creek County.

About 2.5 years ago, the Colorado Geological Survey (CGS) was asked by the Georgetown Planning Commission to study and evaluate geologic hazards in the town. This request was prompted, in part, by the town's ongoing development pressure. This report and the map with explanation that accompany it are the results of this work.

Several persons were most helpful in encouraging and helping with this study. Dr. William E. Wilson, Chair of the Georgetown Planning Commission and members of the Commission itself discussed the Commission's perception of the town's geologic hazards and the recent history of trying to deal with them.

Dr. Wilson spent some time in the field with me as well. Nancy Hemenway of the Clear Creek County Mapping Department and Christine Bradley, Clear Creek County Archivist, helped with photographic resources and historical information as did the staffs of the Western History Department, Denver Public Library and the Georgetown Library. Jeffrey A. Coe, U.S. Geological Survey (USGS), Denver, reviewed this report and supplied data and suggestions relevant to the study. The town supplied a 1:1,200-scale topographic base map. Many citizens also helped by allowing access to their private property and relating their knowledge and experiences regarding many of the topics discussed below.

SUMMARY OF TOWN HISTORY AND ITS GEOLOGIC CONDITIONS

Georgetown is located in a nearly north-south trending part of the valley of Clear Creek north and south of the confluence of Clear Creek and South Clear Creek in western Clear Creek County, Colorado.

Georgetown was founded in the mid nineteenth century as a mining camp and is named after George Griffith, an early successful miner. The Georgetown district produced predominantly silver and some gold (Spurr, Garrey, and Ball, 1908). There is essentially no mining taking place today. There are numerous remaining legacies of the mining era, however. These include mine shafts, mine dumps, tailings, some ruins of surface equipment and buildings, and over 200 historic buildings built during that time. As opposed to most of Colorado's historic mining towns, Georgetown has never had a major fire and many of the original buildings have survived until now for this reason.

Most of the slopes in this area are very steep, in many places ranging upwards to 75 to 100 percent. In places, they are considerably steeper than that. Some barren rock cliffs are nearly vertical. Most of the modern valley floor is gently sloping to nearly flat in many of the older parts of the modern townsite and near Georgetown Lake. Lower sideslopes immediately above the valley floor are underlain by coalescing debris fans and, on the east side of the valley, these areas are presently under the most pressure for new residential and other development.

Based on early photographs of Georgetown (Griswold, Kindig, and Trombly, 1988; Mangan, 1975; Denver Public Library, permanent collections), many of the now gentle slopes in the older parts of the town are probably largely the result of human regrading and fill placements associated with its early residential, commercial, and mine development. Placement of mine wastes from tailings and dumps as fills was commonplace. These old fills are frequently seen in modern excavations, primarily those for new houses in the older parts of the town. Mine dumps are still being exploited today for fill material. Although somewhat conjectural, the gross shape of this valley is probably due, in part, to glaciation (Ball, 1908) as well as the effects on slope failures and other erosional mechanisms owing to fracture patterns and weathering characteristics of the bedrock. All of the predominantly high-grade metamorphic bedrock in the area is heavily jointed and fractured. Also, a Pleistocene glacier probably extended a relatively short distance north of the modern town limits (Madole, et al., 1998), perhaps as far down valley as Lawson and possibly Dumont (about four miles eastbound on I-70). It may have oversteepened the valley sideslopes as they are somewhat steeper near the town than a short distance down Clear Creek valley from it. This may have exacerbated the tendency for major post-glacial slope failures of bedrock. No systematic study of these fractures and fracture patterns has ever been made nor was this attempted during the course of this work. The dangerous terrain conditions and generally apparent (from aerial photographs) numbers of fractures would make such a study extremely time consuming and difficult and, consequently, excessively costly.

Georgetown Lake is formed by a man-made impoundment (Harry M. Locke Dam) of Clear Creek approximately 100 yds south of the north town limit. A preexisting dam failed in 1956 and there are uncertain early reports of a another dam failure early in the history of the town. The existing one was built in the late sixties. A privately owned (Jerry B. Buckley) hydro plant has attempted to exploit the water head created by this dam. This water body covers about one third of the incorporated area of the town. Prior to this, there may have been a natural impoundment of the Creek in this area as evidenced by the large, prehistoric debris-slide landslide deposit into which the east abutment of the modern dam has been placed. This landslide originated on the west-facing slopes of Saxon Mountain, the prominent summit above the east side of the town. This lake is quite shallow and its lake-bed deposits reportedly consist largely of mine-mill tailings. These were placed in tailings ponds in this area early in the history of the town during the era of underground hard-rock mining and ore milling. When this landslide occurred is not known, but it may have occurred upon retreat of the glacier postulated above. From gross morphology of the landslide deposit, it appears as if it formed during a catastrophic landslide event. This would support my proposition that it also dammed, or at least diverted, Clear Creek for an unknown amount of time.

Prior to major development in the town during the late eighteen-hundreds, there was a low-gradient coalescing alluvial-fan complex at the confluence of Clear Creek and South Clear Creek. Remains of this feature are much more easily seen on early photographs than in anyplace in the town today. The natural feature was located approximately at the location of the mostly older south half of the town. Essentially nothing of the original form of this alluvial-fan complex remains today, as these materials were apparently regraded and/or used for fills for various purposes by the turn of the century. Additionally, it is doubtful that the modern locations of the streambeds in the town are where they were at the time of the town's founding. As seen in photographs made at that time, the apexes of this alluvial-fan complex were probably near the location of the Clear Creek County government-building complex (Clear Creek) behind a bedrock hill, and several hundred yards downstream from the town's covered water-reservoir tank south of the former Public Service Company of Colorado coal-fired power house (near the existing electric substation and hydro plant) and the ruins of the Pelican-Dives ore mill west of the intersections of modern 4th, 5th, and 6th Streets and Taos Street (South Clear Creek). Steep slopes and rock cliffs confine the streams to the west and east, respectively, at these locations.

From some early newspaper accounts, it can be inferred that the town was episodically subject to water flooding in its early years by both of these streams and possibly from drainages on the slopes above them. Mass movements of mud and rock debris, both in the stream regimens and on adjacent sideslopes, were also seen to frequently accompany this water flooding. From these same accounts, it appears as if the most common time for occurrence of such floods was in the late spring and early summer during snowmelt and during localized, heavy, early summer rainstorms.

Rapid mass movements of rocks and debris from the steep sideslopes above the town are as potentially problematical for the town as floods and flood-transported debris might move down into the presently developed townsite. The most noticeable extant, modern landforms that have been formed by deposition of materials from sideslopes are the two debris fans on the east side of the valley. These are presently sites of much of the recent and newer building construction in the town, almost exclusively for residential development. The sizes of clasts that comprise these debris fans range predominantly from small cobbles to large boulders, some of the largest being the size of an automobile or larger.

The ages of debris flows that formed these features are not known precisely although it appears as if, also based on newspaper accounts, no major debris-flow events have occurred in the recent history of the town. Possibly, some occurred there its very early history. However, these areas were not occupied until relatively recently and such early events may have not been recorded. The exceptions are on the west side of I-70 where debris flows have occurred recently (mid nineteen-eighties and mid nineteen-nineties) and have temporarily closed the westbound (to the south at this locality) lanes of I-70. Recent C-14 dating by the USGS (Coe and Godt, 1997) of carbonaceous materials taken from the southern debris fan on the east side of the valley in a roadcut near the end of Skyline Road suggests that the surface (i.e., most recent) deposits on parts of this debris fan may be only 500 to 700 years old. As evidenced by USGS C-14 dates from other parts of the Clear Creek valley, an episode of widespread debris-flow activity may have occurred, generally speaking, around this time. In the late seventies, the Colorado Geological Survey C-14-dated similar materials from several places in Clear Creek valley including materials from both of these debris fans. The range of ages is 9700+/-380 years before present (ybp), 2270+/-130 ybp, 2105+/-40 ybp, and 1670+/-125 ybp. All of the CGS dates were from carbonaceous materials that were taken at least a few feet below the surface. The gross morphology of the northern debris fan, where it has not been significantly modified by regrading and construction, and the weak soil development observed in numerous house-foundation excavations and other cuts made into both of these debris fans suggest that they are most likely about the same age and are relatively young, prehistoric Holocene features, at least insofar as the most recent deposits on them can be qualitatively dated. The older age dates indicate that the features are post-glacial and have been active during the Holocene climatic regime.

A completely unproved speculation about the age of debris fans in Clear Creek valley is that this last postulated episode of debris-flow activity occurred after a major valley-wide wildfire denuded many of the forested slopes. Evidence supporting this speculation is the nature of occurrences of charcoal in the debris-fan deposits, which can consist of large fragments including pieces of logs, and the development of the very young (A horizon only) soils on them. Such soils can be seen in the town in exposures made for the cul-de-sacs of Muscovite Drive, Flat Iron Drive, and Bluebird Drive, the USGS-sampled exposure indicated above, and in a cut inside the east fence of the junkyard southeast of the intersection of Main Street and Sunburst Circle. Similarly, even younger or poorly documented debris flows may have occurred in places in Clear Creek valley during the late nineteenth and early twentieth century when much of the area was denuded of trees (again-?) by lumbering for fuel, construction materials, and mine timbers. Comparison of relatively recent aerial photographs and present ground conditions with turn-of-the-century ground photographs indicates that, except where they have been disturbed by modern construction, the forested slopes have largely recovered from this deforestation. This is especially evident in the vicinity of the Guanella Pass road (C.R. 381) and on the slopes of Leavenworth Mountain south of the town limits. Evidence (now covered by a gabion wall) for this spate of debris-flow activity has been seen by me during field work in the nineteen seventies (Soule, 1975) in a steep cut in the debris fan of Virginia Canyon in Idaho Springs and can also be seen (human artifacts in debris-flow deposits) on the south-facing slope behind a townhouse complex at the east end of Idaho Springs. Excellent exposures of debris-fan deposits which have also been studied by Coe can be seen at the Clear Creek Sportsman's Club shooting range near Dumont and a few hundred yards to the west of the Idaho Springs I-70 tunnels on a frontage road on the south side of Clear Creek near a concrete batch-mix plant (Camas).

As noted above, on the west side of the valley, and immediately upslope from the townsite and the modern alignment of I-70, is a complex of steeply sloping debris/alluvial fans (alluvial apron) which are composed of angular clasts which are typically 1-ft median diameter or less and, thus, mostly smaller than those found in the indicated debris-fans on the east side of the valley. This complex presently undergoes depositional episodes coincident with localized heavy summer thunderstorms over the drainage basins immediately above I-70.

At this locality, I-70 is founded mostly on fills composed of these (regraded) debris-fan materials. These storm events have temporarily inundated I-70 with water, mud, and rocks, most recently in the summer of 1996 and also prior to this. Naturally, and as seen in early photographs of this part of the town, the distal part of this alluvial/debris apron extended downslope from the I-70 alignment to the now essentially flat and level valley floor. It appears as if the I-70 fill prism acts a catchment for debris-flow material, in part because the Colorado Department of Transportation dug shallow (borrow-?) ditches on the upslope side of the freeway and below the gravel frontage road above it. A desirable effect of these ditches is to catch debris before it can impede traffic flow on I-70. In effect, these ditches and the freeway fill prism now partially protect the lower elevation developed part of the town from debris flows on the west side of the valley. Again, as seen in early photographs, this was not the case early in the town's history. An excellent, slightly older exposure of these deposits, with a very young soil and below the I-70 grade, can be seen in the cut for the parking lot and fill pad west of Alvarado Road at the Georgetown Super-8 Motel. Others can be seen in the very recently deposited materials west of I-70. along the indicated gravel frontage road. This road accesses a municipal-maintenance shop. This road ends farther to the north near some abandoned mine structures and the unclosed Georgetown (mine) Tunnel as well as the entrance gate to a wildlife-observation area maintained by the Colorado Division of Wildlife. Fortunately, there has been essentially no residential development (yet) on this east facing slope where vegetation is much more sparse than on the west facing slope on the opposite side of the valley. There is a small mobile-home park about 100 yds south-southwest of the I-70 interchange for the town. This mobile home park is located on regraded young alluvial-fan deposits and mine-dump materials that originated from the mine shaft immediately uphill from it. The fill prism on which this park is built appears to have deflected modern debris flows around it.

In addition to, but no less important and potentially dangerous than the alluvial apron and the debris fans, are the occurrences in the town of occasional catastrophic (large and sudden) rockfalls. These appear to be caused by possibly weather-influenced (e.g. periods of freeze-thaw cycles) slab releases of large rock masses from highly fractured bedrock cliffs. Smaller rockfall and rockslide events occur almost constantly on the slopes above the town and on the west side of the valley. This process appears to be accelerated by movements of the herds of Rocky Mountain Bighorn Sheep and possibly other larger wild animals that live there. Because of the fractures in the in-place cliffs and the typically large detached cliff pieces, these masses disintegrate upon falling, rolling, and bounding down sideslopes before the fragments come to rest, usually within a hundred yds or so of the base of the involved slope(s). Infrequently, they fall much farther downslope to near, and possibly on, the valley floor. A recent example of this is a rockfall which occurred in the late nineteen eighties-? from the near vertical cliffs about 250 yds above Saxon Mountain Road about 250 yds north of its intersection with Clear Creek Drive. A prominent cliff scar and rockfall debris can still be seen above this road. This can also be seen as road damage and a deposit of fresh rockfall debris on 1991 aerial photographs. Some of this rockfall debris, now man displaced, was seen below Saxon Mountain Road during fieldwork for this study. The naturally in-place debris is behind and immediately above a townhome complex (Major Anderson Millsite Townhomes) which has been under construction for about the last three years. The remainder of it has been (re) moved to facilitate construction of these townhomes. Other probable recent rockfall debris and its source areas in the cliffs above can be seen to the south of this locality near the intersection of 15th Street and Main Street and farther south along and east of Main Street behind several houses that front on this street. Several citizens indicated that other rocks have been found in the streets near this locality but that they are usually quickly removed because they are perceived to be a nuisance or a hazard (as they probably should be).

Because of the highly fractured bedrock and the steepness of most of the slopes around the town, virtually all of them are strewn with rock rubble. Probably owing to the angularity of most of the clasts, and the fractures in the bedrock, surface-water runoff appears to infiltrate these rubble deposits freely and apparently without causing a large hydrostatic-pressure increase(s) at their contact with the underlying bedrock. Water probably infiltrates bedrock fractures as well which may explain the abundance of small springs which issue from exposed fractured bedrock downslope from many rubble deposits during snowmelt. After study of numerous man-made cuts in these materials in the town, it appears as if most of them are relatively stable and not involved in small-scale landsliding. This conclusion was reached after an examination of essentially every roadcut and slope cut for building construction, both older and recent, in the town, on or near the Guanella Pass road, and on the slopes of Leavenworth Mountain. As mentioned above, a legacy of the era of underground mining in the town are the numerous mine dumps (waste-rock piles) as well as tailings from the numerous ore-processing mills that operated in the area. As also indicated above, many of these materials have been subsequently regraded or otherwise displaced and used as common-fill materials. Others, on steeper sideslopes, remain, while some have been partially to completely buried, moved, or otherwise obliterated by materials naturally mass wasted down slopes above them and then onto them. The slopes of these dumps appear to be for the most part stable except where cribbing walls which retain(ed) them have failed or are failing. The practice of using mining wastes for fills is continuing today, especially where such materials can be easily obtained near building sites. This activity is the most common south of the Capital Prize mine shaft and other mine dumps on the east side of the Town where considerable new residential development is taking place. Presently, construction activity is ongoing in many other places in the Town, much of it associated with restoration of mining-era houses and other older, historic buildings.

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COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO

ACTIVE SURFICIAL–GEOLOGIC PROCESSES AND RELATED GEOLOGIC HAZARDS IN GEORGETOWN, CLEAR CREEK COUNTY, COLORADO

OPEN FILE REPORT 99-13
PLATE 1
1999
Booklet accompanies map

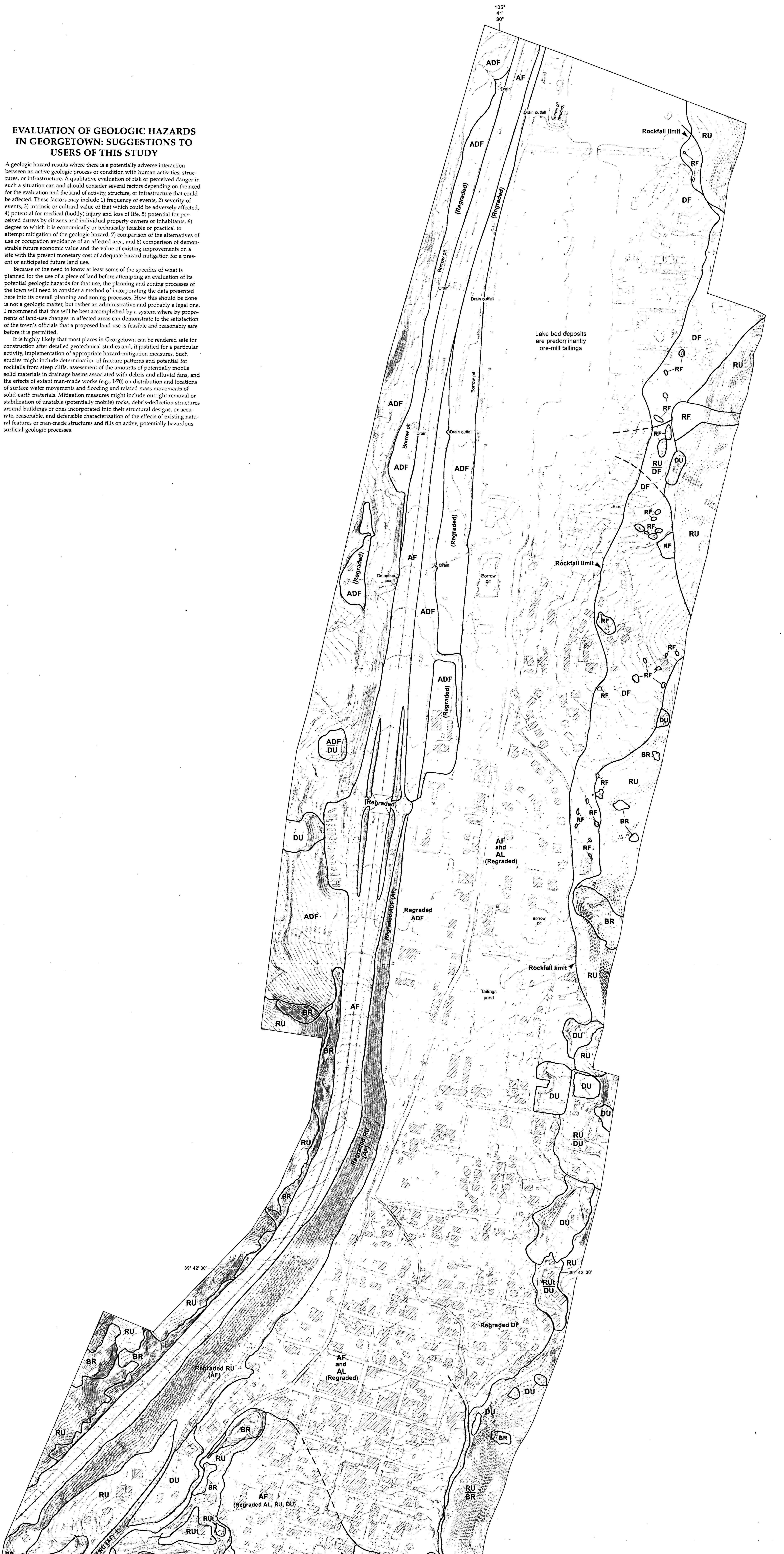
By James M. Soule

EVALUATION OF GEOLOGIC HAZARDS IN GEORGETOWN: SUGGESTIONS TO USERS OF THIS STUDY

A geologic hazard results where there is a potentially adverse interaction between an active geologic process or condition with human activities, structures, or infrastructure. A qualitative evaluation of risk or perceived danger in such a situation can and should consider several factors depending on the need for the evaluation and the kind of activity, structure, or infrastructure that could be affected. These factors may include 1) frequency of events, 2) severity of events, 3) intrinsic or cultural value of that which could be adversely affected, 4) potential for medical (bodily) injury and loss of life, 5) potential for perceived duress by citizens and individual property owners or inhabitants, 6) degree to which it is economically or technically feasible or practical to attempt mitigation of the geologic hazard, 7) comparison of the alternatives of use or occupation avoidance of an affected area, and 8) comparison of demonstrable future economic value and the value of existing improvements on a site with the present monetary cost of adequate hazard mitigation for a present or anticipated future land use.

Because of the need to know at least some of the specifics of what is planned for the use of a piece of land before attempting an evaluation of its potential geologic hazards for that use, the planning and zoning processes of the town will need to consider a method of incorporating the data presented here into its overall planning and zoning processes. How this should be done is not a geologic matter, but rather an administrative and probably a legal one. I recommend that this will be best accomplished by a system where by proponents of land-use changes in affected areas can demonstrate to the satisfaction of the town's officials that a proposed land use is feasible and reasonably safe before it is permitted.

It is highly likely that most places in Georgetown can be rendered safe for construction after detailed geotechnical studies and, if justified for a particular activity, implementation of appropriate hazard-mitigation measures. Such studies might include determination of fracture patterns and potential for rockfalls from steep cliffs, assessment of the amounts of potentially mobile solid materials in drainage basins associated with debris and alluvial fans, and the effects of extant man-made works (e.g., I-70) on distribution and locations of surface-water movements and flooding and related mass movements of solid-earth materials. Mitigation measures might include outright removal or stabilization of unstable (potentially mobile) rocks, debris-deflection structures around buildings or ones incorporated into their structural designs, or accurate, reasonable, and defensible characterization of the effects of existing natural features or man-made structures and fills on active, potentially hazardous surficial-geologic processes.



N

0 400 800 1200 1600 FT

SCALE: 1" = 400'
CONTOUR INTERVAL = 2 FEET

MAPPING OF GEOLOGIC-HAZARD AREAS IN GEORGETOWN

As the discussion in the booklet indicates, most of Georgetown's geologic hazards are related to mass earth movements and deposition of solid earth materials resulting from these movements. Virtually all of the resulting deposits have been subsequently man-modified during the past and current development of the town. This situation makes conventional geologic mapping of these deposits very difficult to impossible and conjectural as the natural boundaries of the affected areas have been mostly greatly modified or obliterated altogether. This is most problematical in all of the older parts of the town and in many places undergoing residential development at the present time. Also, the effects of existing major infrastructure (e.g., I-70 and other roads), regrades, and fill placements are virtually impossible to quantify and incorporate into mapping units that can be used to define exact boundaries. Therefore, the mapping units proposed below are necessarily somewhat qualitative in nature and, in most cases, are not mutually exclusive (discrete). An example of this is the common occurrences of rockfall debris on debris-flow deposits (see discussion below). The delineation boundaries shown should be considered to be gradational in most places and the enclosed mapped areas as zones where unquantified variation in the mapped attributes is typical. The relatively large scale of the base map and the ongoing construction activities in the town may make boundary changes and topographic revisions necessary when investigating specific sites. Notes on the map (e.g., regraded) indicate area-specific variations in the mapped units.

DESCRIPTION OF MAP UNITS

BR **In Place Bedrock**—Localities where bedrock is exposed or is within a foot or so of the surface. Most of the bedrock in the Georgetown area is composed of several high grade metamorphic-rock types with some smaller bodies of intrusive igneous rocks contained within them, most commonly pegmatites. As it would serve little purpose in identifying areas susceptible to active surficial geologic processes, no attempt was made in this study to differentiate bedrock by lithologic type. The most important relevant characteristic of the bedrock is that it is highly fractured by several sets of joints (fractures on which there has been essentially no displacement). This condition can make steep exposures very unstable (i.e., prone to rockfalls) and greatly affects and accelerates rate(s) of cliff disintigration and rubble accumulation on slopes. Most bedrock exposures grade at the surface to rubble deposits indicated below.

RU **Rubble**—Localities where rock fragments derived from underlying rock outcrops or nearby exposures predominate at the surface. These are sloping areas where typically the bedrock is so fractured that it is virtually impossible to differentiate in-place materials from those which may in the Holocene (within the last 10,000 years-post glacial time) have moved a relatively short distance downslope from their source(s). Sizes and angularity of clasts in these areas can be highly variable and the sloping areas can be the source, particularly where vegetation is sparse, of the debris deposited on the debris and alluvial fans indicated below. On lesser slopes and especially in places where the modern vegetation cover is relatively dense, these areas, as discussed in the booklet, are apparently not particularly susceptible to slope movements, even in places where cuts have been made in them. This may be due, in part, to modern reforestation as old photographs suggest that slope movements in these areas were common and most likely frequent early in the history of the town.

RUt **Terraced Rubble**—Rubble in several places at the south end of the town which has been regraded to form nearly level or gently sloping sites for buildings and roads.

AL **Young Stream Alluvium**—Deposits formed in the active modern floodplains of streams. The major streambeds in Georgetown are Clear Creek and South Clear Creek and, except in places at the south side of the Town where they are entrenched in bedrock, probably not in their original natural locations. These locations are essentially unknown and consequently unmapped. Includes a mapped area at the south end of the town where, as seen in old photographs, alluvial fans formed by deposition of materials by Clear Creek and South Clear Creek coalesced.

ADF **Alluvial/Debris Fan/Apron**—Localities on the west side of the Clear Creek valley where rubble from the slopes above has been moved downslope rapidly during heavy rainstorms and possibly snowmelt runoff into steep drainageways and then deposited, forming alluvial fans and/or a series of coalescing alluvial fans (alluvial apron). This is an episodic, active ongoing process and essentially all of the area upslope from I-70 west of the townsite and Georgetown Lake is susceptible to it. Because of the potential for rapid mass movements of rocks, mud, and water, this area should be considered to be highly hazardous to many human activities, including permanent habitation. The fill prism of I-70, the gravel frontage road west of it, and borrow ditches appear to reduce the potential hazards caused by such mass movements below and east of I-70.

DF **Debris Fan**—Localities on the east side of Clear Creek Valley that are subject to rapid mass movements (debris flows) of bouldery debris derived ultimately from cliff disintigration and rockfalls from the steep, fractured cliffs above them. This debris is deposited in steep, rock-rubble-strewn chutes in drainages above the debris fan(s). The debris-flow events are thought to occur during short duration, very intense rainfall events, although, as opposed to the west side of Clear Creek valley, no such event in the history of the town has been documented. Larger rock blocks, some as large as automobiles, occur on these debris fans. Some of these larger rocks are the result of rockfalls (see below) onto the debris-fan deposits whereas others were incorporated into the debris-fan deposits during the debris-flow events that produced them. Where naturally in place, those transported by debris flows can be distinguished from fallen rocks by their surficial weathering patterns, positions with respect to pedogenic soils that surround them, their lichen cover and its position, and, where seen in the matrix that contains them, their sedimentologic relationships with smaller clasts near them.

RF **Modern Rockfall Debris**—Deposits of larger rock block(s) that can be seen on aerial photographs and/or seen in the field to be the result of rockfalls. These are mapped only where expressed on the 1:2,400-scale base map of the town or where naturally in place fallen rocks can be positively identified in the field. As indicated above, rockfalls occur frequently in many places on the steeper slopes and quantifying their severity, frequency, and extents is practically impossible without instrumental monitoring and very detailed mapping in their source areas and possibly other types site-specific studies of relatively small areas. This can include computer-software-based modeling of the dynamics of rock movement. For example, the Colorado Geological Survey has available the Colorado Rockfall Simulation Program (CRSP) which, after acquisition of appropriate field data, can be used to simulate the dynamics of potential rockfalls in specific areas.

The rockfall-limit delineation shown on the map is an estimate of the probable maximum extent of runout of fallen rocks based on the occurrence of natural rockfall-derived debris on lower slopes and the slope and amount of fracturing in the higher cliffs above them that are their sources of the fallen rocks. There is undoubtedly much more rockfall-derived debris in the vicinity of this boundary, but whether it is in its natural location cannot be proved with reasonable certainty. Therefore it is unmapped. This situation exists because of regrading, construction, road maintenance, and other activities of people which have displaced many, if not most fallen rocks on lower slopes. As indicated above, many of the larger rocks near the surface on debris fans may have been deposited in their present locations by the debris-flow events that produced the debris fans.

DU **Mining-Waste Dumps**—Deposits, typically immediately below mine shafts or near sites of former ore mills, which are underlain by rock rubble and/or tailings. They are not mapped where they have been relocated and used as fill. In many places in the modern townsite this is the case. From old photographs, it appears as if most of these deposits have either been (re) moved or buried by materials mass wasted downslope from above them. Similar, although typically finer grained, materials (mill tailings), underlie essentially all of Georgetown Lake and many built on places in the nearly flat and level parts of the town.

AF **Artificial Fill**—Human-placed deposits. These occur in virtually all of the developed parts of the town. The composition and distribution of these materials is complex and cannot be determined with sufficient accuracy for conventional geologic mapping without detailed drilling and trenching which was not done as part of this study. Only the larger and easily recognized deposits are mapped or noted on the map. Most of these include the fills placed for the construction of I-70 and some other larger roads. The I-70 fills consist largely of materials originated in alluvial-debris fan/apron and rock rubble deposits indicated above and many of the other fills consist of rock rubble, waste rock from mine dumps, and moved and regraded debris-fan deposits and stream alluvium, especially from the alluvial-fan complex at the south end of the town.

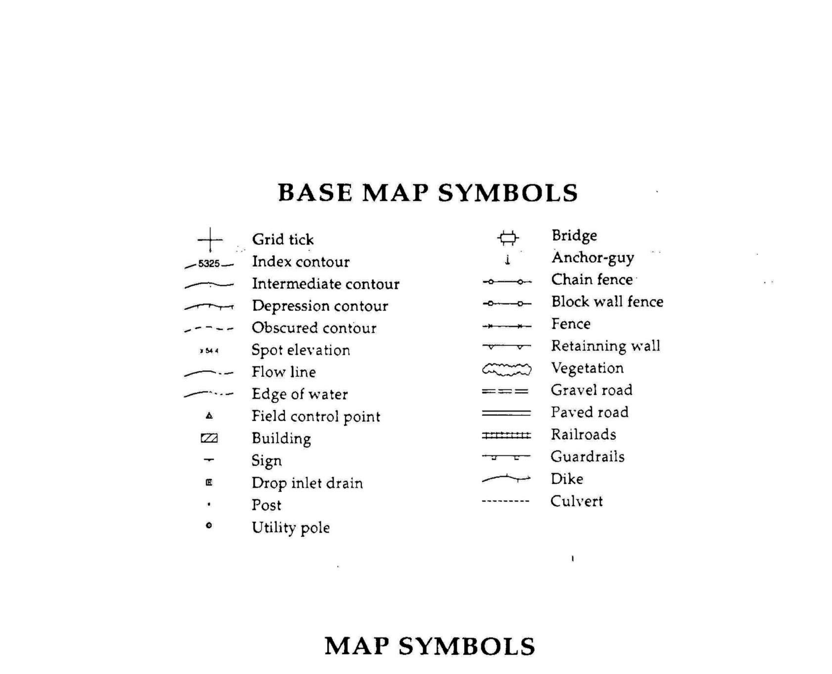
BASE MAP SYMBOLS

Grid tick
Index contour
Intermediate contour
Depression contour
Obscured contour
Spot elevation
Flow line
Edge of water
Field control point
Building
Sign
Drop inlet drain
Post
Utility pole
Bridge
Anchor-guy
Chain fence
Block wall fence
Fence
Retainning wall
Vegetation
Gravel road
Paved road
Railroads
Guardrails
Dike
Culvert

MAP SYMBOLS

Unit boundary—Dashed where uncertain

INDEX MAP



Base map notes:

— Control used for original mapping was furnished by TRI Consultants, Inc.
— Revised mapping photo identified control points were supplied by the town of Georgetown.
— Base map prepared by Koogle and Pouls Engineering, Albuquerque, N.M.
— Compiled by photogrammetric methods utilizing 1:6000 aerial photography acquired June 8, 1991.
— This map compiles with national map accuracy standards.
— Coordinates shown heron are based on a modified local ground coordinate system tied to the Colorado Department of Highway's Interstate 70 monumentation.

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