3.5 Geologic Hazards

3.5.1 What are the geologic hazards in the Corridor and why are they important?

Geology in the Corridor includes highly complex and varied ground conditions found in both the natural and man-made settings. Numerous conditions influence the mountainous Corridor, such as geologic structure, slope configuration, precipitation, wind, and extreme temperature fluctuations that contribute to geologic hazards in the Corridor. Some of the hazards include faults, adverse rock structure, landslides, rockfalls, debris flows, avalanches, and collapsible soil. Steep, unstable slopes limit engineering options for improvements, and most slopes are highly susceptible to erosion because of sparse vegetative cover. The initial construction of the I-70 highway intensified some of these hazards.

Geologic Hazards in the Corridor

- **Adverse faulting** – Fault that tends to decrease the stability or coherence of a rock mass or decrease the stability of a structure to be constructed in a rock mass.
- **Adverse rock structure** – A structure in a rock mass that potentially detracts from the performance of the mass itself or from a structure constructed in the rockmass if not accommodated for.
- **Poor rock quality** – Rock that by virtue of its fracturing, alteration, or inherent characteristics has a low or unreliable mechanical strength.
- **Debris flow and mudflow** – A moving mass of rock fragments, soil, and mud.
- **Rockfall** – Falling of boulders or detached blocks of rock from a cliff or very steep slope.
- **Landslides** – Downward movement of rock masses and soil.
- **Avalanche** – Large mass of snow or ice that moves rapidly down a slope.
- **Erosion/collapsible soil** – Fine sandy and silty soils with a loose, open structure that collapse when wet.

3.5.2 What study area and process was used to analyze geologic hazards?

The study area for geologic hazards includes the areas surrounding the Corridor that may be encountered during construction or operation of the Action Alternatives, including the proposed construction footprints. These areas are generally found immediately adjacent to the I-70 highway or its associated infrastructure. Locations of geologic hazards are well-known in the Corridor.

The lead agencies identified existing geologic conditions in the Corridor using information from geologic maps, United States Geological Survey reports, Colorado Geological Survey publications, topographic maps, aerial photographs, drilling, field mapping, literature reviews, and information from the *I-70 Georgetown Incline Rockfall Mitigation Feasibility Study* (Colorado Department of Transportation [CDOT], 2005). The characterization of geologic hazards included examining active and inactive limits of landslide features. The characterization of geologic hazards was conducted between 2001 and 2005. Because no new construction has occurred since this time and geologic conditions are very slow to change, the data remain a valid representation of existing conditions.

The lead agencies characterized the severity of disturbance to an area using ratings for the existing geologic hazards. Rating criteria include the influence of climate, proximity to the I-70 highway, history of occurrence, and impact on transportation and mobility. Based on these criteria, the lead agencies developed five categories for geologic hazard severity:

- Severe
- High
- Moderate
- Low
- Slight

Each alternative is characterized according to the severity categories for each type of hazard.

3.5.3 What agencies have CDOT and FHWA coordinated with and what are their relevant issues?

The Natural Resources Conservation Service and the United States Forest Service provided maps and reports on the soil erosion potential in the Corridor. The Natural Resources Conservation Service provided soil descriptions, characteristics, and modeling factors. The United States Forest Service provided erodibility descriptions and management considerations. Both agencies characterize soil types as slightly, moderately, or severely susceptible to erosion.

The Town of Silver Plume expressed concern with rockfall on Georgetown/Silver Plume Hill. The Colorado Geological Survey considers two potential rockfall areas in Silver Plume to be "perilous."

3.5.4 What are the areas of geologic hazard interest identified in the Corridor?

The western segment of the Corridor includes the Continental Divide, with Straight Creek on the west side of the Eisenhower-Johnson Memorial Tunnels and Clear Creek on the east side of the Eisenhower-Johnson Memorial Tunnels. The primary rock type on the western side of the Continental Divide is hard granite, which is relatively intact with minimal fracturing and/or faulting. Rock types on the eastern side consist of granites and granite/migmatite mixtures. The major fault system in the vicinity is the Loveland Shear Zone, consisting of numerous faults and smaller shear zones of diverse orientation and generally trending northeast to southwest. The *I-70 Mountain Corridor PEIS Geologic Hazards Technical Report* (CDOT, March 2011) details the geologic conditions and hazards in the Corridor.

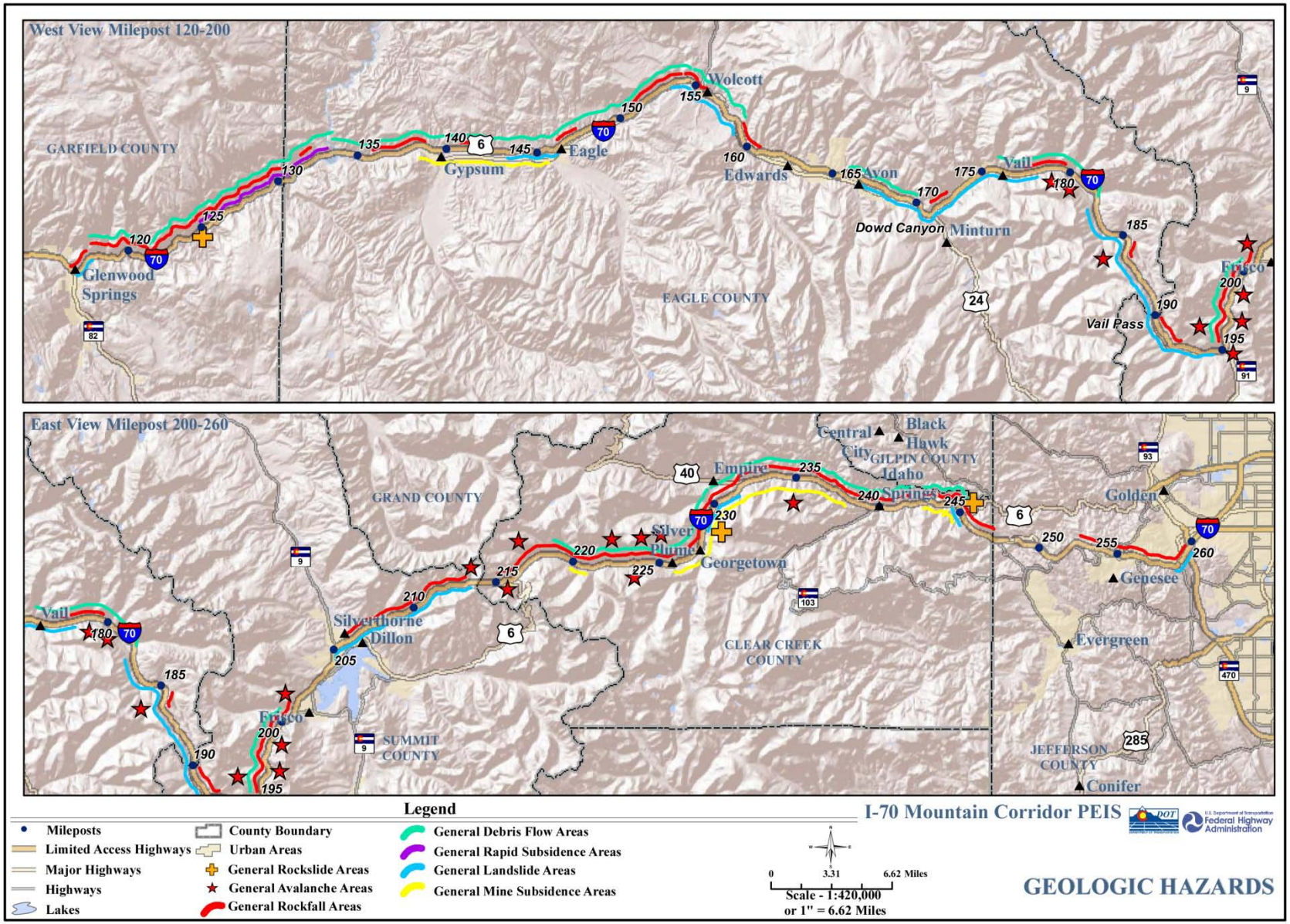
Geologic hazards of some type are present throughout the Corridor, as shown in **Figure 3.5-1**. The greatest hazards are landslides, rockfall, avalanches, and debris flow/mudflow. To a lesser degree, the potential effects of collapsible soils and rapid subsidence impact existing facilities. These hazards have the potential to cause roadway closures, and managing hazards requires ongoing highway maintenance.

Landslides causing roadway closures or maintenance issues are most prevalent in Dowd Canyon, on Vail Pass, and along the Floyd Hill rockslide. Areas of concern for rockfall hazards include rockfall excavations through Dowd Canyon between Avon and Vail and along US 40 through Mount Vernon Canyon, where rocks originating from US 40 (runs parallel to the Corridor and at a higher elevation on the north) roll onto the highway. Debris flow/mudflows have the potential to affect the highway at Watrous Gulch, Georgetown Lake, and west of Silver Plume. Both triggered and natural avalanches result in impacts on the roadway, especially at the chutes west of the Eisenhower-Johnson Memorial Tunnels and on Vail Pass. Ground subsidence from past mining has affected the highway at Hidden Valley and Idaho Springs, but the extent of this hazard is unknown at this time. **Figure 3.5-1** shows these hazard locations.

3.5.5 How do the alternatives potentially affect geologic hazards?

In general, the Action Alternatives have similar effects on geologic conditions. Excavations in rock and soil cause both temporary impacts from construction activities and long-term impacts associated with achieving and maintaining slope stability. As shown in **Figure 3.5-1**, the most prevalent geologic hazard for the alternatives throughout the Corridor is rockfall, particularly in the area between Silver Plume and Georgetown, commonly referred to as the Georgetown Incline. Proposed tunnel boring locations in the Continental Divide increase exposure to rockfall hazards and potential landslides. Alternatives disturb the highly fractured and foliated rock that make up the Floyd Hill rockslide (south of the US 6 merge), increasing rockslide hazards in this area. The greatest area of active debris flow disturbance for the capacity improvements is near Georgetown Lake. Finally, with the exception of the Minimal Action Alternative, which does not include an additional tunnel bore at the Eisenhower-Johnson Memorial Tunnels, avalanches in the Mount Bethel area north of the Eisenhower-Johnson Memorial Tunnels potentially have an impact on alternatives.

Figure 3.5-1. Geologic Hazards in the Corridor



How do the alternatives directly affect geologic hazards?

All alternatives, including the No Action Alternative, interact with geologic hazards along the Corridor. All Action Alternatives construct interchange improvements, climbing lanes, and auxiliary lanes. Climbing lanes in Dowd Canyon (milepost 170 to milepost 173) are not included in the Transit-only alternatives; in this location, the structure of geologic layers contributes to landslides and rockfall hazards, and avoiding construction in this area reduces landslide and rockfall hazards. Climbing lanes on Vail Pass (milepost 180 to milepost 190) common to all Action Alternatives are constructed in terrain affected by alpine glaciation where extensive landslides persist as a result of glacial events and poor rock quality. Widening on the cut slope side of the highway along the west approach to the Eisenhower-Johnson Memorial Tunnels (milepost 215.3 to milepost 218.3), also common to all alternatives, may trigger large slope failures. The Bus in Guideway proposed within the median impedes efforts to use the I-70 highway median as a catchment area of debris/mudflow from the highway when necessary and may lead to additional accumulation of debris on the highway.

Highway components included in the Action Alternatives encounter essentially the same geologic hazards along the Corridor with a few exceptions. The 65 miles per hour variation of the Six-Lane Highway Alternative is the only Action Alternative that includes a proposed tunnel at Dowd Canyon; this component avoids many of the geologic hazards and provides safer highway conditions, bypassing the active slide by placing the eastbound lanes in a new three-lane tunnel and lowering potential for rockslides. From Floyd Hill through the Twin Tunnels, including a bike trail and frontage roads from Idaho Springs east to Hidden Valley and Hidden Valley to US 6, all of the Action Alternatives cut through rugged terrain with areas of adverse structure and poor rock quality. Rockfall is the most prevalent hazard. Debris flow and erosion are common in the Empire Junction area (at the junction with US 40 at milepost 232) and may affect improvements at that location (included in all Action Alternatives), as the effects of glaciation terminate and the valley develops a “V” shape that directs debris materials toward the Corridor. Debris flow and potential avalanches could impact auxiliary lanes eastbound from the Eisenhower-Johnson Memorial Tunnels to Herman Gulch and westbound from Bakerville to the Eisenhower-Johnson Memorial Tunnels.

The on-grade Rail with Intermountain Connection is more susceptible to geologic hazards than the Advanced Guideway System, which is capable of being fully elevated, or the Bus in Guideway Alternatives, which generally follow the I-70 highway median and are, thus, more distant from the rockfall or avalanche hazards. As noted previously, the Bus in Guideway Alternatives could affect highway operations since the median cannot be used as a catchment area. The Advanced Guideway System elevated structure allows for debris flow or any other material to potentially pass underneath with no impact to operations, whereas debris flow could affect operations at Watrous Gulch, Silver Plume, and Georgetown Lake for the other Transit-only alternatives. The Combination alternatives combine impacts of the Transit and Highway alternatives due to the larger footprint and scope of construction.

Impacts of the Preferred Alternative are similar to those of other alternatives. All the alternatives, including the No Action Alternative, result in disturbance of geologic hazards. While the impacts of the Preferred Alternative could be as great as the Combination alternatives if the Maximum Program is fully implemented, the adaptive management approach of the Preferred Alternative allows the project components and mitigations to be phased or adapted in implementation to address geologic hazard conditions that exist at the time improvements are constructed.

How do the alternatives indirectly affect geologic hazards?

Indirect impacts from geologic hazards result from operations and maintenance activities that are required for all of the alternatives, including the No Action Alternative. Hazards persist in the Corridor, but the probability of such hazards creating impacts are no greater than the existing conditions. The Action Alternatives reduce the risks posed by geologic hazards in some cases where construction stabilizes

slopes. Regular avalanche control and rockfall mitigation continues under all alternatives. Avalanches are often controlled by triggering slides. In some cases avalanche or rockfall control work fails resulting in the roadway being covered and causing temporary road closures.

How does construction of the alternatives affect geologic hazards?

Constructing tunnels creates large quantities of waste rock, some of which is reused on-site, but some requires disposal. Construction also disturbs unstable rock formations and creates rockfalls or landslides.

What are the project effects on geologic hazards in 2050?

Geologic hazards continue in the Corridor, with and without the Action Alternatives. The effects of geologic hazards in 2050 relate to timing of the implementation of the Action Alternatives, including mitigations that could improve rockfalls, avalanches, or other hazardous conditions, as well as disturbance of unstable geologic units that could create long-term maintenance or safety issues. Some conditions may be improved, while others may worsen. The longer implementation timeframe does not change impacts in a meaningful way because some potentially adverse impacts of disturbing geologic hazards might be avoided temporarily but mitigations that may reduce hazards from geologic conditions may also be delayed.

3.5.6 What will be addressed in Tier 2 processes?

Tier 2 processes will involve a more detailed analysis of the geologic hazards present in the Corridor and identify specific mitigation measures that will be required. For alternatives requiring tunneling, Tier 2 processes will address impacts of blasting activities and the disposal of waste materials. In locations where a strong potential for rockfall or avalanches exists, Tier 2 processes will consider the options that may be used to avoid or contain debris.

During Tier 2 processes, the lead agencies will accomplish the following activities:

- Develop specific and more detailed mitigation strategies and measures
- Develop best management practices specific to each project
- Adhere to any new laws and regulations that may be in place when Tier 2 processes are underway

3.5.7 What are the approaches to programmatic mitigation planning for geologic hazards?

The lead agencies will incorporate mitigation strategies, such as those described below, that have been learned from previous projects:

- Incorporating new design features to minimize slope excavation and follow natural topography.
- Using excavation and landscaping techniques to minimize soil loss and reverse existing erosion problems.
- Using rock sculpting, which involves blasting rock by using the existing rock structure to control overbreak and blast damage, to create a more natural-looking cut.
- Using proven techniques, such as rockfall catchments, mesh, cable netting, and fences, as well as scaling and blasting, to address rockfall from cut slope areas.

- Reusing excavated material from tunnel construction onsite where possible. If materials are used on National Forest System lands, the lead agencies will follow the *Memorandum of Understanding Related to Activities Affecting the State Transportation System and Public Lands in the State of Colorado among the Federal Highway Administration, Colorado Department of Transportation, Bureau of Land Management, and United States Forest Service*.
- Adhering to the *Programmatic Agreement among the Federal Highway Administration, Advisory Council on Historic Preservation, United States Forest Service, Colorado Department of Transportation and State Historic Preservation Officer Regarding Rockfall Mitigation Projects along Interstate 70 within the Georgetown-Silver Plume National Historic Landmark District* (2009).

Mitigation strategies also are presented in **Section 3.19, Mitigation Strategies**.