5.17 Geology and Soils

This section discusses the geologic and soil resources in the study area. The impacts of the project alternatives on these resources also are evaluated and proposed mitigation measures are discussed to offset any potential adverse effects.

> Since the Supplemental Draft EIS was published in August 2014, additional analyses and content review have been performed for many of the resources discussed in this document. These updates, along with changes resulting from the comments received on the Supplemental Draft EIS, have been incorporated into this Final EIS. In this section, no content-related updates were made.

5.17.1 What are geology and soil resources and why are they important to this project?

Geology includes complex and varied soil and ground conditions in the study area. Soil considerations and potential hazards include slope stability, expansive soils, differential settlement, erosion, presence of bedrock, high groundwater levels, and flooding. These resources are important to consider during the planning of projects since they can influence the project design.

5.17.2 What study area and process were used to analyze impacts to geology and soil resources?

The study area for geology and soil resources is shown in **Exhibit 5.17-1**. Existing information and documents available from public agencies were reviewed to establish the existing geological conditions. State and federal agencies—including the U.S. Geological Survey, Colorado Geological Survey, and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS)—were contacted to obtain relevant reports and maps.

A determination of the depth to bedrock and groundwater was completed through a preliminary subsurface investigation. The investigation was performed during the months of March to June 2014, between Brighton Boulevard and Dahlia Street, and December 2014 to March 2015, between Dahlia Street and I-270. Geotechnical laboratory tests on soil and bedrock samples were completed and results of the investigation are summarized later in this section. Section 5.18, Hazardous Materials, describes the

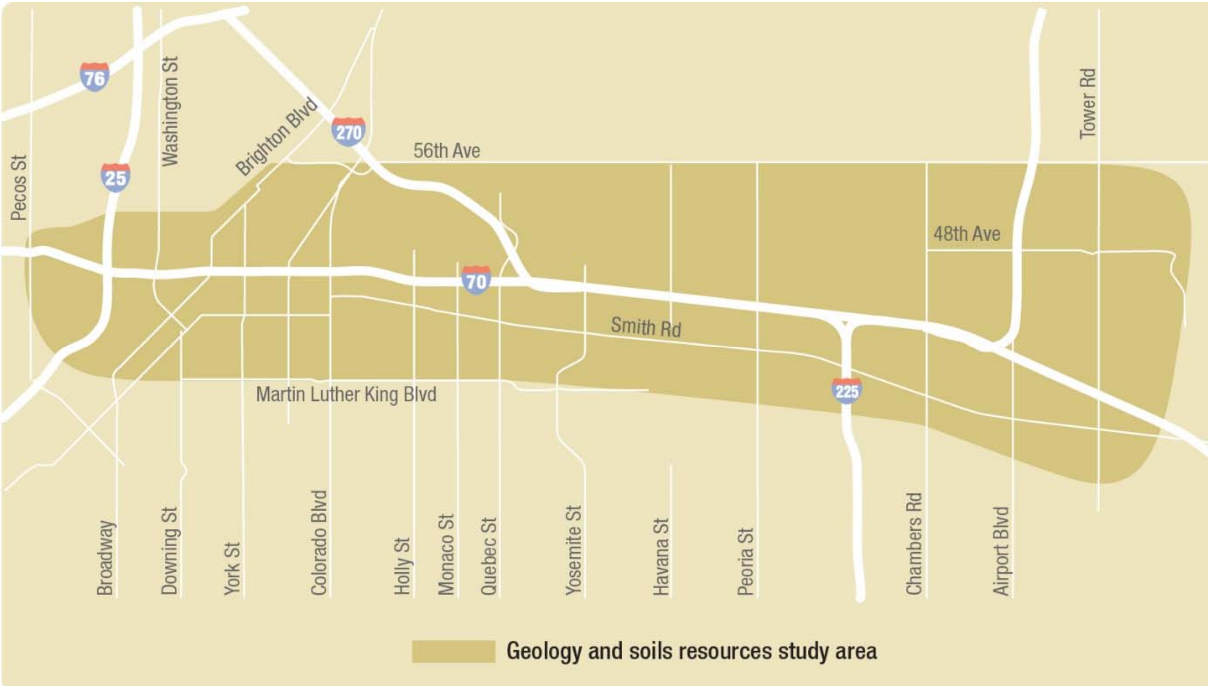
Why are geology and soil resources evaluated in this document?

There are no federal or state laws that apply specifically to geologic or soil resources. However, the CDOT *NEPA Manual* (2014, Version 4) requires this analysis to:

- Ensure that geologic/soil resources are identified and that their natural and economic values and visual aesthetics are protected
- Identify potential negative impacts that the project could have on geology or soils
- Comply with CDOT's environmental stewardship policy, which ensures that the statewide transportation system is constructed and maintained in an environmentally responsible, sustainable, and compliant manner

investigation of soil and groundwater, including chemical analysis.

Exhibit 5.17-1 Geology and Soil Resources Study Area



5.17.3 What are the existing geology and soil resources in the study area?

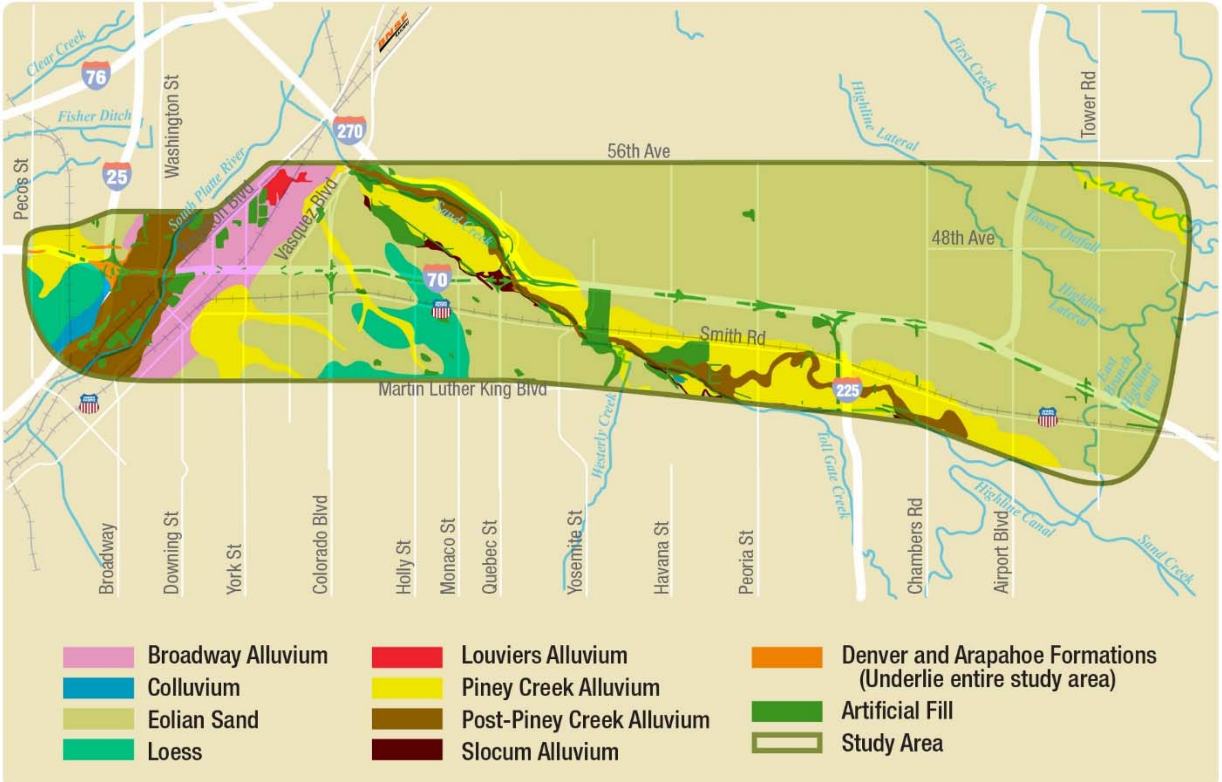
The study area is located east of the Front Range and is situated on the western margin of the Denver Basin. The Denver Basin is a north-south trending, asymmetrical basin with a relatively steep western flank and shallow eastern flank. The Denver Basin is more than 13,000 feet deep at its deepest point and contains bedrock of Paleozoic, Mesozoic, and Cenozoic age (Bilodeau & Costa, 1982). The basin extends north into Wyoming and east from the Front Range across the eastern plains to the Colorado border with Nebraska and Kansas.

The majority of the study area is paved or covered by urban development. There are some unpaved areas, especially along the South Platte River, other drainages, and right of way where soils exist and support vegetation.

Geologic units

The study area is underlain by 10 geologic units. Most of the formations in the study area are composed of alluvial sediments. The geologic units are shown in **Exhibit 5.17-2**.

Exhibit 5.17-2 Geologic Units



Sources: Lindvall 1979, 1980, 1983

The primary geologic units underlying the project area are the Piney Creek Alluvium, Post-Piney Creek Alluvium, artificial fill, loess, Broadway Alluvium, and eolian sand (Lindvall, 1979, 1980, 1983; Machette & Trimble, 1979). Eolian sand is the most extensive geologic unit underlying the area. There are small, isolated areas of Louviers Alluvium and Slocum Alluvium in the western portion of the study area and isolated segments of the Denver and Arapahoe Formations are exposed beneath the I-70/I-25 interchange, east of Quebec Street, and south of I-70 along the western bank of Sand Creek.

The preliminary subsurface investigation identified that bedrock is present at depths ranging from 31 feet to 79 feet below existing grade—an approximate elevation of 5,142 feet to 5,165 feet— between Brighton Boulevard and Colorado Boulevard except near Columbine Street, where bedrock was encountered at an elevation of 5,113 feet. The lower bedrock elevation appears to be associated with a paleo-channel created by the historic South Platte River. The bedrock consists of hard to very hard claystone that contains interbedded, hard to very hard sandstone.

Bedrock and groundwater excavation issues

Although excavating into bedrock and below groundwater depths is not impossible, the excavation at these depths is more complicated and costly.

To minimize the construction cost and time, it is desirable for the highway to be designed and constructed with minimal groundwater and bedrock disturbance.

There are scattered mineral deposits in the study area. Most of which consist of sand, gravel, and clay pits with some processing plants in the study area. These mines and mining claims are located in the western portion of the study area.

Geologic hazards

Colorado is in a region that has minimal earthquake activity. The only major earthquake recorded in Colorado occurred in 1882. Since the 1882 earthquake, there has been little seismic activity within the 200-mile radius around Denver. Tremors were felt in Denver between 1962 and 1967 in the vicinity of the Rocky Mountain Arsenal National Wildlife Refuge and a minor earthquake occurred in 1994 south of Castle Rock. The tremors at the arsenal have been attributed to the pumping of fluid into a deep injection well (Bilodeau & Costa, 1982). The U.S. Geological Survey has evaluated the stability of the geologic units during earthquakes; this information is summarized in **Exhibit 5.17-3**.

Exhibit 5.17-3 Summary of Geologic Unit Stability During an Earthquake

Geologic Unit	Stability During Earthquake
Broadway Alluvium	Poor to Fair
Piney Creek Alluvium	Poor to Fair
Post-Piney Creek Alluvium	Poor to Fair
Louviers Alluvium	Poor to Fair
Slocum Alluvium	Poor to Fair
Colluvium	Poor to Fair
Loess	Poor to Fair
Eolian Sand	Poor
Denver/Arapahoe Formation	Good to Very Good
Artificial Fill Layer	Poor

Sources: Lindvall, 1979, 1980, 1983; Machette & Trimble, 1979

Stability of the eolian sand deposits will depend, in part, on moisture content and angle of slope. The colluvium and loess units have low to moderate swelling pressures when wetted and the Denver Formation has low to very high swelling pressures when wetted (Shroba, 1980). The overall tectonic activity and seismic risk to the greater Denver metropolitan area is continually being evaluated by federal and state geophysicists. There does not appear to be any specific risk in the study area.

Soil types and associations

The soils in the study area have been grouped into associations by the NRCS. A soil association normally consists of one or more major soil types and at least one minor soil and is named for the major soils. Soil associations are useful for planning purposes. However, detailed geotechnical investigations and testing are required to determine site conditions for future facility construction.

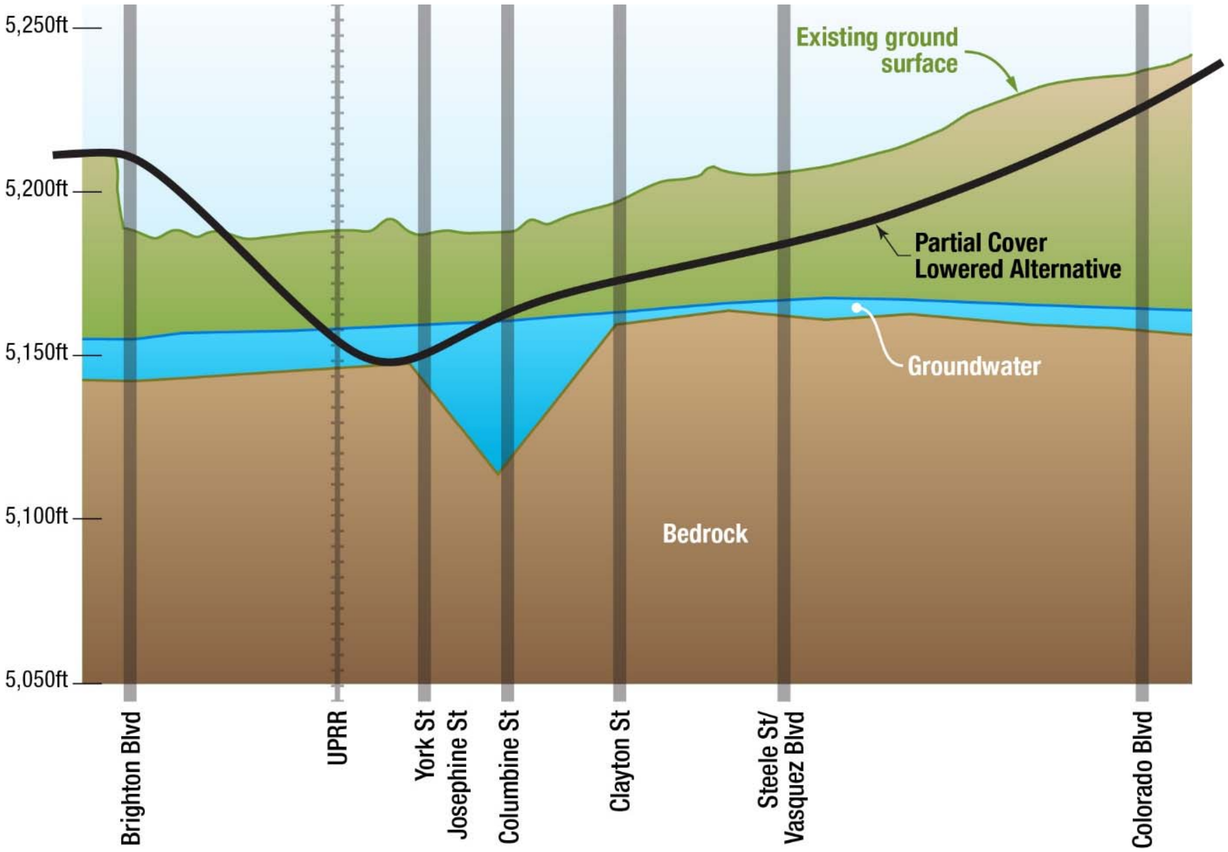
The study area is highly urbanized and most of the native soils in the area have been paved over or excavated for buildings. Because much of the area from I-25 to I-225 along I-70 consists of introduced urban fill, it has not been mapped by the NRCS. There are areas of native soils that still exist along I-70 east of I-225. The predominant soil associations in this area are Blakeland-Valent-Terry, Ascalon-Vona-Truckton, Platner-Ulm-Renohill, and Weld-Adena-Colby.

Groundwater

The preliminary subsurface investigation identified that the depth to groundwater between Brighton Boulevard and Colorado Boulevard ranges from approximately 24 feet to 76 feet below existing grade. The depth to groundwater exists at an elevation of 5,155 feet to 5,170 feet. Permanent groundwater wells were installed to monitor variations of groundwater levels over time. Variations in the groundwater levels can occur during different seasons, following precipitation events, after construction and site grading, and due to changes in surface and subsurface drainage characteristics of the surrounding area. Since the monitoring wells were installed, the variations in the groundwater levels have been found to be minimal.

Exhibit 5.17-4 compiles the results from the preliminary subsurface investigations. The graphic shows a general profile of groundwater and bedrock depths relative to existing and proposed ground surfaces. Note that the proposed ground surface represents the lowest elevation being evaluated, which is the Partial Cover Lowered Alternative.

Exhibit 5.17-4 Comparison of Surface, Groundwater, and Bedrock Elevations



Source: Preliminary Subsurface Investigation Report, Partial Cover Lowered Alternative, I-70 East EIS, CDOT Region 1, 2015

5.17.4 How do the project alternatives affect the geology and soil resources?

Effects to geologic and soil resources may occur during the construction phase of the project, but likely would not cause any geologic hazards or affect the predominant soil types identified in the study area.

Geologic and soil resource risks related to engineering in the study area are associated with the unconsolidated surficial deposits. These deposits mantle the bedrock to depths of as much as 100 feet in some areas, although they are typically less thick. Some of the engineering geology effects related to construction can be attributed to the underlying bedrock of the Denver and Arapahoe Formations. These conclusions are based on U.S. Geological Survey evaluation (Lindvall, 1980, 1983) of construction activity on deposits in the study area, including excavation, compaction, and stability, specifically in areas where structural fill would be imported for some areas of the highway.

Excavation and compaction of the alluvial and loess deposits during construction generally would be easy to moderately easy, and artificial fill would be variable, depending on soil composition. Compaction of the sand deposits would be difficult, and moisture content of the sand and loess deposits must be controlled.

Stability of the Piney Creek and Post-Piney Creek alluvial deposits ranges from poor to good, while stability of the Broadway, Slocum, and Louviers alluvial deposits is good to excellent. Stability of the colluviums is poor to fair. Stability of the loess and sand units is variable, depending on moisture content. Stability of the artificial fill is variable and usually poor.

Construction activities associated with all of the alternatives would take place in an already urbanized area along an existing highway. Construction may cause either minor effects or no effects to geologic and soil resources. In general, the stability of all soil formations depends on water content. Cut slopes of the alluvial, loess, and sand deposits may stand vertically for short periods—longer periods for loess—but eventually will slump to become stable slopes of approximately 3:1 (horizontal to vertical). The colluvial deposits are not stable. Slope stability of the bedrock units ranges from good to excellent. The alluvial and loess deposits are moderately resistant to erosion, while colluvial deposits are generally erodible. The eolian sand and alluvium are moderately resistant to erosion on flat areas, but easily eroded on slopes and cut banks. Resistance to erosion in the bedrock deposits is moderate to excellent.

The Partial Cover Lowered Alternative requires the largest excavation of the alternatives, so it has the greatest potential to affect—and to be affected by—geologic conditions. The excavation is anticipated to extend below the depth of groundwater from approximately the UPRR to Columbine Street. It will be necessary to prevent the groundwater from entering the excavated trench for the lowered portion of I-70.

The lowest grade for the Partial Cover Lowered Alternative is located between the UPRR separation and York Street, where an approximate 40-foot cut is proposed. The excavation for the roadway is located just above the bedrock, so minimal bedrock excavation is anticipated. Tunneling for a drainage outfall north to the South Platte River, for other storm drain pipes, and for utilities could require bedrock excavation, but it is not expected to be significant.

Any uncontaminated excavated material from the Partial Cover Lowered Alternative could be used potentially as fill for other parts of the project.

5.17.5 How are the impacts to the geological resources minimized and mitigated?

To minimize impacts to the lowered highway from the groundwater, the contractor can construct retaining walls to the depth of bedrock. This will include cutting off groundwater infiltration into the lowered section of the highway. Storm underdrain pipes below the pavement will drain any additional groundwater that still enters the lowered section. Extensive dewatering during the construction is anticipated for the Partial Cover Lowered Alternative. For the Revised Viaduct Alternative, the construction of structure foundations also will require dewatering. Water collected from dewatering will be treated according to regulations if contaminants are discovered.

Dewatering

Dewatering is the removal or draining of groundwater or surface water from a construction area.

The proposed retaining walls could be constructed using top-down construction techniques. This involves drilling a caisson or driving a pile first, followed by excavation in phases. The wall is constructed as the excavation progresses. Within the area of large excavations and below groundwater, caisson walls are anticipated. The caisson walls provide additional wall stiffness and support in deep excavation areas. Secant or grouted injection wall types can be designed to seal the portion of the I-70 highway that will be below the groundwater table elevation.

Exhibit 5.17-5 summarizes the impacts and mitigation measures pertaining to geologic and soil resources.

Secant caisson wall

Secant caisson walls are formed by constructing a series of drilled shafts and a series of secondary overlapping shafts. These walls minimize deflection and keep groundwater from flowing into the facility.

Exhibit 5.17-5 Summary of Geology and Soils Impacts and Mitigations

<table>
<tr><th>Alternative</th><th>Impacts and/or Benefits</th><th>Mitigation Measures Specific to Alternatives</th></tr>
<tr><td>No-Action Alternative</td><td>• Excavation below groundwater for construction of the viaduct structure foundations
• Temporary impacts to groundwater during excavation</td><td rowspan="2">• Dewater structure foundations during construction</td></tr>
<tr><td>Revised Viaduct Alternative</td><td>• Excavation below groundwater for construction of the viaduct structure foundations
• Temporary impacts to groundwater during excavation</td></tr>
<tr><td>Partial Cover Lowered Alternative</td><td>• Excavation is anticipated to extend below the depth of groundwater from approximately the UPRR to Columbine Street
• Temporary impacts to groundwater during excavation</td><td>• Prevent groundwater infiltration into the lowered section of the highway; install underdrain pipes below the pavement to drain any additional groundwater that still enters the lowered section
• Dewater during the construction process</td></tr>
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