GROUND
ENGINEERING

February 8, 2013

Subject: Initial Geologic Hazard Evaluation, Minturn Segment, **Eagle Valley Trail**, Eagle County, Colorado

Job No. 15-6013

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Inter-Mountain Engineering
P.O. Box 978
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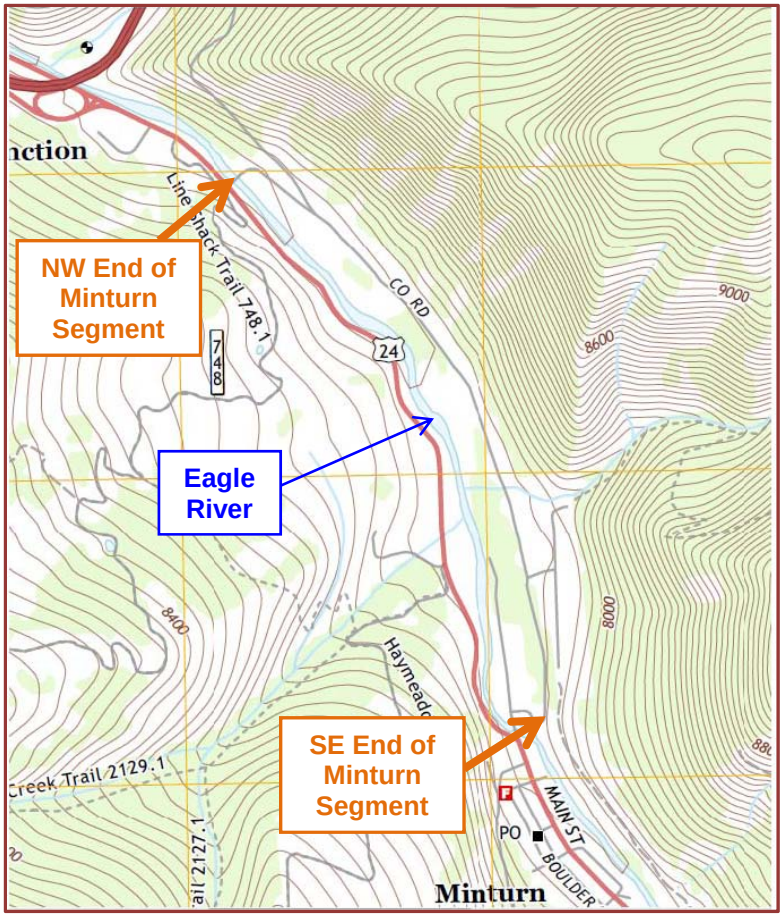
Dear Mr. Spanel:

At your request, GROUND Engineering Consultants, Inc. (GROUND) has made a geologic hazard evaluation of the alignment of the proposed Minturn Segment of the Eagle Valley Trail (EVT) extending northwestward from the town of Minturn. GROUND's services were provided in general accordance with GROUND's Proposal No. 1510-2107, dated November 5, 2015. Our findings and conclusions are summarized below.



Introduction

We understand that the subject reach of trail will extend from about the intersection of County Road 14 (Minturn Road) and Main Street in the northern part of the town to the bridge that carries Minturn Road over the Eagle River to intersect U.S. Highway 24. The segment will lie along the right (eastern) bank of the Eagle River for approximately 1⅓ miles. The general

position of the Minturn Segment is shown on a portion of a topographic map[1] reproduced above. A preferred alignment, we understand, is closer to the river, between the river and the Union Pacific rail line parallel to it. An alternative alignment under consideration is along the west side of County Road 14 (Minturn Road) about 300 feet farther northeast.

GROUND reviewed readily available geologic and topographic maps of the alignment as well as Google Earth® aerial photographs of the area. On January 28, 2016, a GROUND geologist performed a geologic reconnaissance of the alignment. Our findings and conclusions are summarized herein.

Findings

Topography In the project area, steep, southwest-facing slopes descend into the Eagle River Valley from the eastern side commonly exposing outcrops of the supporting rocks. Vegetated talus slopes cover the outcrops on the lower portion of the northeastern valley wall.

The steep slopes flattened downward to form an irregular valley floor sloping gently to moderately southwestward toward the river. Along a trend about 200 to 400 feet east of the river, an abrupt slope descended for 10 to 20 feet onto the nearly flat-lying terrace that lay just above the active river channel. The terrace below the abrupt slope is shown in the photograph at right. (The slope descending to the river terrace was less abrupt near the northern and southern ends of the trail segment.)

Geology Published geologic maps, e.g., Tweto and Lovering (1977)[2] depict the proposed trail alignments as underlain by Pleistocene and Holocene Alluvium (stream-laid deposits) associated with the Eagle River, underlain in turn by the middle Pennsylvanian Belden and Minturn Formations. The Belden Formation is described as consisting of gray to black shales

[1] U.S. Geological Survey, 2013, *Minturn Quadrangle, Colorado*, 7.5-minute Quadrangle Series (Topographic), 1:24,000.

[2] Tweto, O.L., and T.S. Lovering, 1977, *Geology of the Minturn 15-minute Quadrangle, Eagle and Summit counties, Colorado*, U.S. Geological Survey Professional Paper 956.

with thin beds of limestone. The Minturn Formation consists of gray to locally red sandstones, conglomerates and shales, with beds of limestone and dolomite within the other deposits. Exposures of the Minturn Formation above the subject trail segment are shown in the photograph at right. The beds of the Minturn Formation dip (are tilted) to the northeast at 10 to 15 degrees below the horizontal. The alluvial deposits consist of boulders, cobbles, gravel and sand.

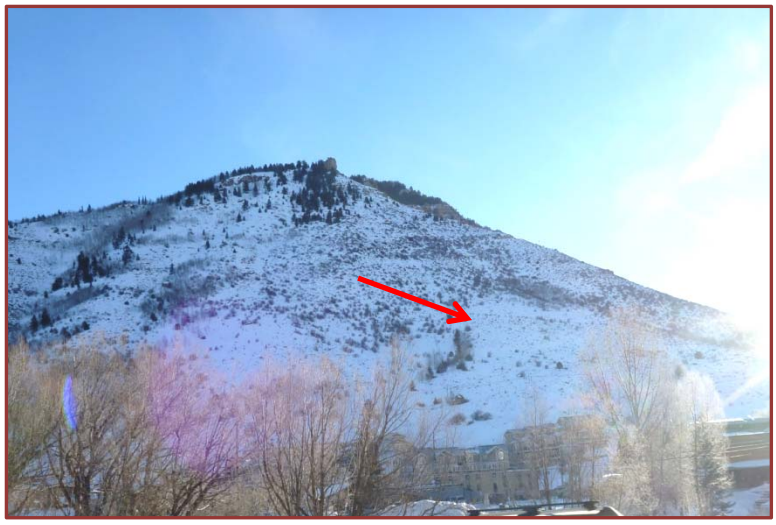
Debris flow fans not mapped by Tweto and Lovering (1977) occupied much of the area between the talus slopes. Although largely covered by snow at the time of our reconnaissance, the fan deposits appeared to consist of sand, gravel, cobbles and boulders derived from the overlying slopes.

Scattered individual boulders were noted on the ground surface along and above the trail alignments, particularly in the northern half of the segment. Observed boulders ranged up to more than 10 feet in maximum dimension.

Geologic Hazard Evaluation

Debris Flows A series of debris flow fans occupied the area between the steep slopes and the stream terrace on which the rail line and the preferred trail alignment lay. Minturn Road and the alternative trail alignment traversed the lower, distal portions of these fans. The snow-covered surface of a debris flow fan is shown in the foreground of the photograph at right, composed of material derived from the gullies in the overlying slopes.

The debris flow fan deposits were formed by accumulation of material from episodic debris flows bringing sand, gravel, cobbles and boulders off the heights to the northeast. The 'toes' of the debris fans were truncated by erosion on the southwest forming the 'abrupt slope' descending to the river terrace. This suggests that the fans are relatively inactive and that the risk of debris flows affecting either trail alignment is relatively low, although we consider some risk of debris flows to remain. The debris flow risk to the lower, preferred alignment appears significantly lower than the alternative alignment.



Slope Stability A quantitative analysis of the stability of the slopes overlooking the subject trail segment was beyond the scope of this initial evaluation. However, the dip of the bedrock to the northeast, i.e., back into the slope, tends to enhance gross stability of those slopes, however. Observation of the slopes suggested only one area near the southern end of the alignment that may be a feature resulting from past, relatively large scale slope failure. This area is indicated by the arrow the photograph above. The feature is relatively subdued suggesting that if it is the result of a past slope failure, that event likely happened centuries ago. The risk of large scale landsliding affecting the Minturn Segment of the trail is considered low. Mitigating such risk, in any case, likely is beyond the scope of trail construction. Construction of either alignment of the trail does not appear to result in a significant decrease in large scale slope stability. Locally, of course, grading for the trail may result in local slopes that will require stability analysis. Retaining walls along either alignment may require evaluation for global stability.

Erosion has resulted in over-steepened slopes locally along the margins of the active river channel and presumably will continue to do so. Adequate erosion protection of the trail where it will lie close to the river channel using rip-rap or other measures, and periodic maintenance likely will be sufficient to address this risk.

Rock Fall Large boulders were noted on the ground surface both above and below the trail alignments that we interpret to have resulted from rock falls from the overlying slopes. Smaller boulders and cobbles presumably were present beneath the snow cover.

Relatively few boulders were noted south of the valley in which 6th Avenue ascends to the higher ground east of the town. The rock fall risk to the trail is considered low in that area, both because the overlying slopes are less steep and farther from the trail, but also because the homes and other buildings above Taylor Street and Lions Lane screen the trail alignments significantly in that area.

Farther north, however, scattered boulders were observed, more commonly above and just below the upper, alternative alignment, but also on the river terrace close to the preferred, lower alignment. The number of large boulders observed and the frequency of boulders near the lower trail alignment generally increased farther north, and were most common in the northern ⅓ ± of the trail. We consider the risk of rockfall to be moderate for the central portion of the trail and relatively high for the northern portion. The rock fall risk for the upper, alternative trail is somewhat higher than for the lower preferred alignment. This must be understood as relative to other areas where there is little or no risk of rock falls at all, however. The risk will be elevated during periods of heavy rainfall and snow melt, but in drier periods, the likelihood of a dangerous rock fall on a given day, for example, is low, even for the northern end of the alignment.

Avalanche Chutes In addition, a number of possible avalanche chutes were noted in the steep slopes overlooking the trail alignments. Examples can be seen in the photograph at right. These may represent an elevated risk of avalanches to at least portions of the trails, presumably to the upper, alternative alignment in particular. If avalanches are a design consideration, a specialist should be consulted in that regard.

Dissolution and Sinkholes Unlike other areas farther west, the relatively shallow bedrock formations underlying the trail alignments do not include beds of significant thickness of halite, gypsum or other evaporate minerals that are highly vulnerable to dissolution with resultant development of sinkholes through the overlying materials. The limestone and dolomite beds in the Belden and Minturn Formations are relatively thin and have not resulted in widespread karst development in the project area. Therefore, the risk to the trail of the development of dissolution-related sinkholes is considered low.

However, piping – the transport of fines through the pore volume of a granular soil – can result in local settlements or sinkholes in the debris fan materials on which the upper, alternative trail alignment generally will lie. The latter generally can be addressed through effective drainage design and routine maintenance, however. In that regard, water should not be applied to or allowed to pond on debris fan deposits.

Mining-Related Subsidence Review of available maps did not reveal indications of mining in the vicinity of the trail segment except local aggregate surface mining in the alluvial deposits near the northern end of Minturn. No features of prior mining activities were noted during alignment reconnaissance. Therefore, the risk to the trail of mining-related subsidence also is considered low.

Expansive Soils The debris flow and alluvial deposits above the Eagle River include relatively few clayey deposits that are expansive. The shales comprising much of the Belden Formation and present locally in the Minturn Formation can be expansive, but along the alignments under consideration, they are near and under the active channel of the Eagle River. Construction of

the trail will do little to alter the established moisture-stress-volume relationships in the clay shales. Therefore, based on available data, the risk of increased distress to the proposed trail due to expansive soils heave is considered low. Ordinary maintenance measures such as local replacement of concrete trail panels (where use) likely will address any effects of soil expansion.

Collapsible Soils Certain surficial deposits, including eolian (wind-blown) materials such as loess as well as debris flow deposits, are known to be susceptible to local hydro-consolidation or "collapse." Hydro-consolidation refers to volume loss in a soil due to re-structuring of the constituent grains to a more compact arrangement upon wetting. The upper, alternative trail alignment traverses debris flow deposits for much of its length. Therefore, the risk of that alignment experiencing settlements or local sinkholes is considered moderate. Regular trail maintenance, however, should be sufficient to address the resultant distress. The risk of collapse affecting the trail can be reduced by effective drainage and avoiding irrigating those soils.

Flooding The proposed trail alignment traverses alluvial terraces associated with the Eagle River at elevations not far above river stage at the time of our site visit. Therefore, at least portions of the lower, preferred trail alignment likely are vulnerable to seasonal flooding. The higher, alternative alignment appears to be at significantly lower risk. A civil engineer should be consulted to evaluate the potential for flooding quantitatively if that is a design consideration.

Radon Radon accumulations typically are found in basements or other enclosed portions of buildings built in areas underlain at relatively shallow depths by granitic crystalline rock. The likelihood of encountering radon in concentrations exceeding applicable health standards along the outdoor trail alignment, which is underlain by relatively deep soils and sedimentary bedrock, is considered low.

Discussion

Rock fall and flooding appear to be the most significant geologic hazards that may affect the use of the trail. The lower, preferred alignment appears to be at significantly greater risk of flooding, but a risk of flooding is relatively common, we understand, for scenic trails in Colorado mountain valleys. The risk of rock fall increases northward along the subject segment as discussed above. Mitigation of rock fall hazards commonly is done with energy dissipation structures such as protective walls, berms and/or ditches, as well as preemptive scaling of rocks vulnerable to becoming dislodged and/or placement of steel mesh to limit initiation and the speed of rock falls. However, it is possible that none of these methods may be appropriate or practical for the subject segment, particularly given the generally seasonal nature of the risk. The same generally applies to mitigation of potential avalanches. Even without mitigation, the Minturn

Segment of the Eagle Valley Trail may not be at significantly more risk than other comparable reaches of trail in the central Colorado area, particularly if the trail were closed during winter months or even only when the avalanche is considered to be high.

Closure

This preliminary geologic hazard evaluation has been prepared for Inter-Mountain Engineering as it pertains to planning and alignment selection for the proposed trail segment as described herein. It may not contain sufficient information for other parties or other purposes. If any information referred to herein is not well understood, then Inter-Mountain Engineering, or anyone using this report, should contact the author or a GROUND principal immediately. We will be available to meet to discuss the risks and remedial approaches presented in this report, as well as other potential approaches, upon request.

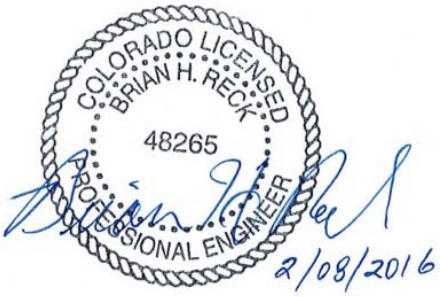
The geotechnical conclusions in this report relied upon readily available published maps and reports, and our experience in the project area. No subsurface exploration or laboratory testing was performed. The conditions exposed during design-level evaluations or construction may differ from those described herein.

This report was prepared in accordance with generally accepted soil and foundation engineering practice in the Eagle County, Colorado, area at the date of preparation. GROUND makes no warranties, either expressed or implied, as to the professional data, opinions or conclusions contained herein.

We trust that this provided the information that you needed at this time. If you have any questions, please contact this office.

Sincerely,

GROUND Engineering Consultants, Inc.



Brian H. Reck, P.G., C.E.G, P.E.