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September 25, 2024

Mr. Blake Carlson
Carlson Land Development
14570 Clay Street
Broomfield, Colorado 80023
c/o Highline Engineering and Surveying Co., Inc.

blake@carlsonld.com

Subject: Rockfall Hazard Assessment, Proposed Founders Vista Subdivision, Vicinity of North Ridge Road, South of State Highway 86, Castle Rock, Colorado.

Project No. 24-2-174

Dear Mr. Carlson:

As requested, we have performed a geologic site assessment for the proposed development to evaluate the potential rockfall conditions that could present constraints or risks to the development and the surrounding properties. A field reconnaissance of the project site was made on June 10 and June 11, 2024.

Proposed Construction: We understand that the Founders Vista Subdivision is proposed as an approximately 180.5-acre single-family neighborhood, with overlot grading and utility installation occurring across the plateau top, extending toward the perimeter ridgeline. New residential roadways are planned across the site, with a variety of proposed detention basins across the development.

Site Conditions: The subject site is generally located to the west and southwest of the intersection of North Ridge Road and Mountain Sun Drive in Castle Rock, Colorado. The site is within the west half of Section 7 in Township 8 south, Range 66 West and the east half of Section 12 in Township 8 south, Range 67 west, Sixth Meridian of the Public Land Survey System. The property is bound to the northeast by Ridge Road and low-density single-family residences. Vacant land is located to the southeast, south, and north of the site, with the St. Francis of Assisi Church located north-northwest of the site. Single-family residences border the subject site to the west. With an area of approximately just over 180 acres, the site is located mostly atop a geographic plateau with steep cliff faces around much of the perimeter of the proposed development. Gentle to undulating slopes to rolling hills encompass the plateau top, which is generally vegetated with native grasses and weeds and pockets of scrub oak. The borders of the site are generally steeply sloping to near vertical cliffs, sloping down away from the site. Scrub oak and native grasses and weeds are dense around the slopes beneath the cliffs. Though cliffs are found along much of the perimeter of the proposed development, an Area of Interest has been

identified by the developer along the west border of the site, particularly along cliff faces situated above residential properties, due to concern from residents below the proposed development. The Area of Interest encompasses approximately just over 2,000 linear feet of cliff face with residential properties located below. This Area of Interest has been further subdivided into 8 areas to group similar geologic conditions across the Area of Interest. Area 1 is located at the south end of the Area of Interest, with Area 8 at the north end, as seen in Figure 2. Within the Area of Interest, two drainages flow westward towards the cliff face, both located within Area 7. Along the Area of Interest, the cliff is generally well defined, although there are locations where the cliff recedes into steep, less than vertical slopes, particularly in Area 4. Across the rest of the cliff face, elevation change ranges from approximately 5 feet to up to 25 feet in locations.

Geologic Setting: The subject site is located within the Colorado Piedmont of the Great Plains physiographic province. The region consists of the Denver Basin, which is a geological structural depression situated east of the Front Range, and covers a large portion of eastern Colorado. The site is located within the Plum Creek drainage basin, which is tributary to the South Platte River. The various lithologies of the Castle Rock region are best described as a series of erosion and deposition. Geologic lithologies at the subject site include the Castle Rock Conglomerate, as well as alluvial deposits.

The Castle Rock Conglomerate, dating to the late Eocene epoch, is the youngest bedrock unit in the region. It is a pebble, cobble, and boulder sized arkosic conglomerate composed mainly of granite and quartz parent material, with lesser amounts of gneissic metamorphic rocks, quartzite, sandstone, and chert in a sandy matrix. Larger grains are found to be rounded to subrounded in a coarse to very coarse matrix. Similar in appearance to the conglomerate of Larkspur Butte, the Castle Rock Conglomerate is distinguished by the presence of up to boulder size fragments of the Wall Mountain Tuff. This unit was deposited as a sheet across the eroded surface of previous lithologies at various elevations trending north-northwest, which may indicate that it occurred as a valley filling deposit following the path of the present-day Plum Creek valley. Permeability of the Castle Rock Conglomerate varies, being well drained in some areas, and less so in others. It has good foundation characteristic, but excavation may be difficult. Rock falls from cliffs at the edges of plateaus pose slope stability risks, particularly where the less competent and easily eroded sandstone and claystone beds of the Dawson Formation supports the unit.

In addition to Castle Rock Conglomerate, the subject site contains Older alluvial deposits, particularly in the center area of the site, east of the Area of Interest. This alluvium is composed of sand, silt, gravel, and clay that was transported and deposited by flowing water, and is generally sourced from the Castle Rock Conglomerate and the Dawson Formation, although other parent sources such as the Wall Mountain Tuff have been observed. This alluvium may have a thickness of 45 to 60 feet in the region.

Rockfall: Map 8.1 from the Douglas County 2040 Master Plan shows a western portion of the site to contain areas of Class 3 Hazards, specifically potential rockfall-rockslide/debris avalanche areas. Rockfalls and slides occur on steep slopes where a source of rock exists above the slope. Rockfalls are considered a Class 3 hazard as falling, rolling, and/or bouncing rocks and boulders can cause significant property damage and may threaten injury or loss of life. Rockfalls generally originate on slopes greater than 70 percent, although they can occur on less-steep slopes.

Rockfalls are caused by a range of variables, which include, but are not limited to: rainfall and changes in groundwater conditions, weathering and erosion, root growth, and freeze/thaw processes. The subject Area of Interest has a rockfall source material consisting of rock from the Castle Rock Conglomerate caprock, and has slopes greater than 70 percent, up to vertical, with sections of unsupported overhanging rock. As the geologic/topographic conditions required for a rockfall hazard are present, the potential for rockfall events at the subject site should be considered.

Rock Mass Rating: The Rock Mass Rating (RMR) system was created by Bieniawski in 1976 and was updated by Bieniawski in 1989. This rating system was created to investigate the quality of intact rock by examining the mechanical properties of the rock and the orientation and geometry present within the rock mass. The Rock Mass Rating system factors in 6 separate parameters that includes: uniaxial compressive strength, rock quality designation, spacing of discontinuities, condition of discontinuities, groundwater conditions, and the orientation of discontinuities. The rating system varies from Very Good Rock to Good Rock to Fair Rock to Poor Rock to Very Poor Rock. The 8 separate sub-areas of the Area of Interest were rated using the Rock Mass Rating system with ratings of Fair Rock to Poor Rock. Areas 1, 3, 4, 6, and 8 were rated as Fair Rock, while Areas 2, 5, and 7 were rated as Poor Rock.

Rockfall Assessment: Using the Rock Mass Rating along with the existing geologic and geographic conditions, the rockfall hazard of each sub-area within the Area of Interest has been investigated. The assessment included factors such as lithology, Rock Mass Rating, discontinuities, slope, undercutting/overhanging geometries, groundwater, runout zones, history of rockfall, etc. Using these properties, the rockfall hazard of the sub-areas were categorized as either Lower Risk or Higher Risk. Areas 1, 4, 6, and 8 were assessed to be Lower Risk areas, while Areas 2, 3, 5, and 7 were assessed as Higher Risk areas.

Conclusions: Areas 2, 3, 5, and 7 were assessed as Higher Risk areas. A rockfall hazard should be considered in these areas during the design and construction phases of the subject development. The potential for rockfall hazards in the other areas still exists, but Areas 2, 3, 5, and 7 are Higher Risk areas. Areas 2, 3, 5, & 7 all have areas of undercutting and overhanging geometries in spots. Areas 2, 3 and 7 have potential runout zones that are in proximity to private residences. Historic rockfall events have occurred in these areas as well, and the potential for future rockfall events exists. The potential for future rockfall events may be increased due to construction activities during the development of the subject site, including site grading, which may involve blasting activities. Areas 3 and 5 were found to have a Rock Mass Rating of Fair Rock, but due to the runout zone and rock mass geometries, have been assessed as Higher Risk. Area 2 has a Poor Rock rating and a Higher Risk assessment due to overhanging/undercut geometry with a runout zone situated above private property. Area 7 has a Poor Rock rating and has a Higher Risk assessment due to runoff locations, previous rockfall history, hydrologic properties of the area, and geologic geometries, including large overhanging shelves and separated joints.

It is our understanding that development for the subject site will mainly be focused on the northern half of the Area of Interest. As such, construction activities may have a larger impact on Area 7 and Area 5. As construction activities, which may include blasting, have the potential to impact

rockfall hazards within the Area of Interest, continued observation is recommended during the construction of the development. Mitigation measures may be required, particularly during blasting and site grading. Setbacks, rock bolting, and temporary and/or permanent mesh netting are examples of mitigation methods that may be incorporated at the subject site to mitigate rockfall potential. Test blasting including frequency monitoring should be conducted to ensure proper setback distances from rockfall hazard areas during subsequent blasting. We should be contacted to provide additional specific rockfall mitigation measures following test blasting and to review setback recommendations.

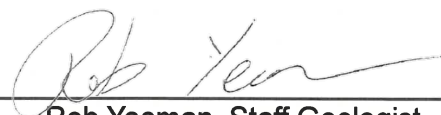
Blast induced ground vibrations should be evaluated prior to construction in order to determine a setback range based on the blasting frequency and the rock characteristics. The criteria of blast frequency include particle acceleration, displacement, and velocity. Blast frequency for construction is typically found within a 2 Hz to 200 Hz window, although frequency above 200 Hz can occur in rare cases. The Colorado State Division of Oil and Public Safety requires that the nearest dwelling or occupied building be monitored during blasting, in order to ensure the Maximum Allowable Particle Velocity (MAPV) is not exceeded. The Colorado State Division of Oil and Public safety indicates that a frequency range of 2 to 250 Hz must be monitored, and a velocity range of 0.02 to 5.0 inches per second must be monitored. Within 300 feet of blasting, the Maximum Allowable Particle Velocity is listed as 2.00 inches per second in any direction. Distances of 301 to 5,000 feet have a MAPV of 1.55 inches per second, and distances greater than 5,001 feet have a MAPV of 1.00 inches per second. Rock characteristics, blasting apparatus, and distance from blast source are three of the variables that determine the vibration frequency and particle velocity. As rock characteristics are unalterable at each location, the blasting apparatus and distance from blasting are variables that may be altered to maintain safe vibration frequencies and particle velocity. If these variables cannot be altered to maintain safe vibration frequencies and particle velocity, rockfall mitigation, whether temporary or permanent, will be required. The pre-blasting survey and test blasting should determine a setback distance for blasting, and if it is determined that construction activities, particularly blasting, need to occur within that setback distance, additional specific rockfall mitigation measures will be required. The most effective method of mitigation will involve increasing separation from the blasting source to the potential rockfall risk areas. A Blasting Management and Safety Plan should be developed for the site and all local and federal regulations regarding explosives should be followed. Kumar & Associates, Inc. should be contacted to cooperate with the pre-blasting survey and test blasting to review setback distances and specific mitigation measures required based on the circumstances.

Sub-Area	Rock Mass Rating	Rockfall Assessment
Area 1	Fair Rock	Lower Risk
Area 2	Poor Rock	Higher Risk
Area 3	Fair Rock	Higher Risk
Area 4	Fair Rock	Lower Risk
Area 5	Poor Rock	Higher Risk
Area 6	Fair Rock	Lower Risk
Area 7	Poor Rock	Higher Risk
Area 8	Fair Rock	Lower Risk

Please contact us if you have any questions or require additional information.

Sincerely,

Kumar & Associates, Inc.

By 
Rob Yeoman, Staff Geologist

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Reviewed by:
Robert L. Duran, P.E.



References:

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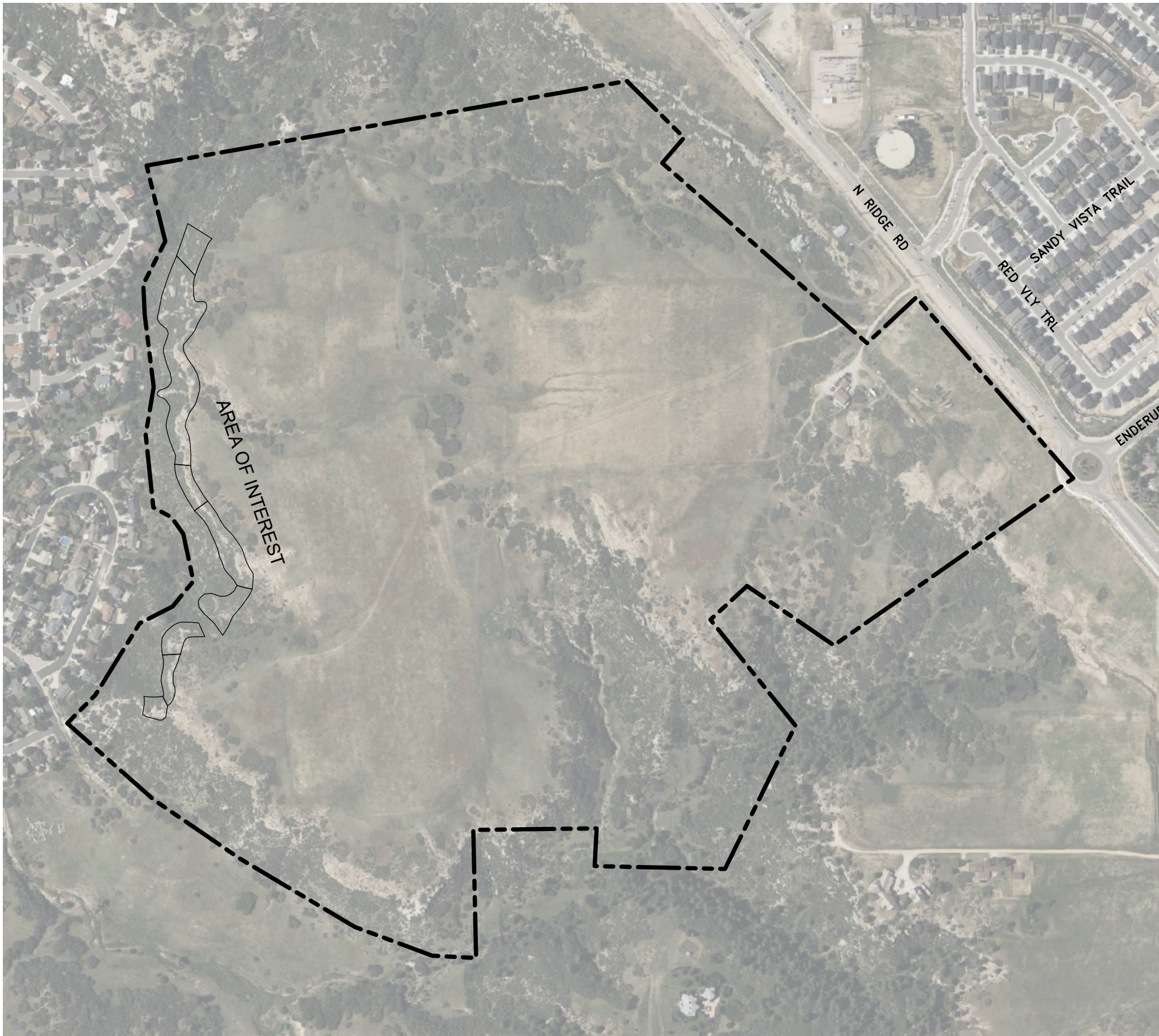
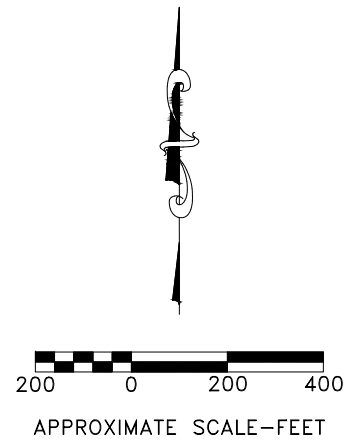
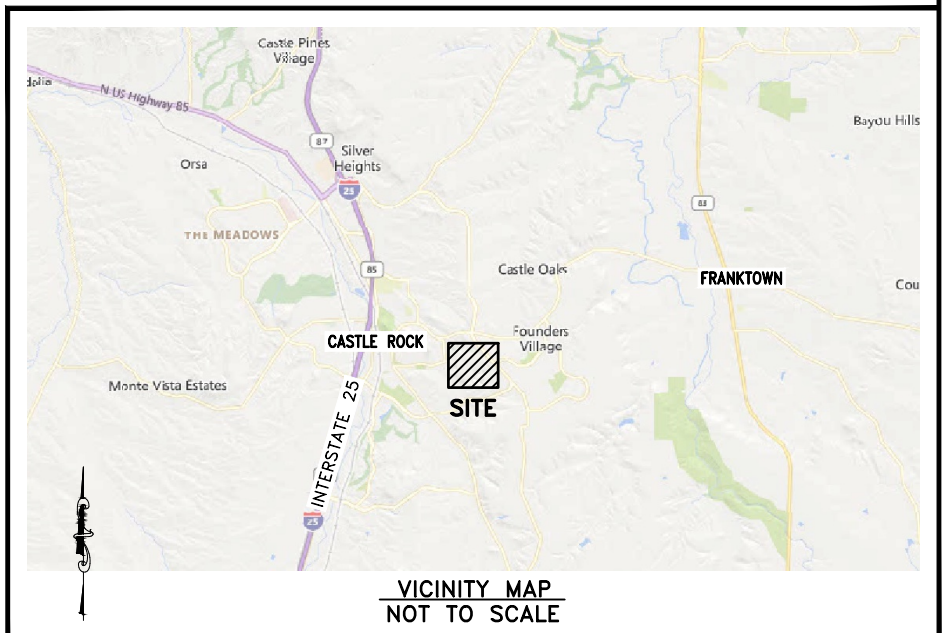
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