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August 2, 2017

River Dance RV Park
Attn: Bill Smith
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Project No. 17-7-587

Subject: Geologic Hazards Review for Proposed Additions and Improvements to River Dance RV Park, Parcels 1 and 2, Mosher Parcels, 6700 Highway 6, Eagle County, Colorado

Gentlemen:

As requested, we have performed a geologic hazards review of Parcels 1 and 2 of the Mosher Parcels, 6700 Highway 6, Eagle County, Colorado, to evaluate if there are geologic conditions that could present constraints or risks to the proposed additions and improvements to the River Dance RV Park. The project site is located between Highway 6 and the Eagle River to the west of Gypsum, as shown on Figure 1. A field reconnaissance of the project site was made on August 1, 2017 to observe the geology. In addition, we reviewed published regional geologic studies, looked at aerial photographs, and reviewed our previous studies in the area. Based on this information, an assessment of the potential influence of the geology on the proposed development was made. This report summarizes our findings and presents our conclusions and recommendations. The study was performed in accordance with our agreement for professional services to River Dance RV Park dated August 1, 2017.

PROPOSED DEVELOPMENT

It is our understanding that the proposed RV park improvements will include around 200 RV spaces, an office with a community room and restrooms, deck, pool, fire pit, pavilion, playground, volleyball and pickleball courts, outdoor leisure areas including picnic tables and BBQs along the Eagle River, a maintenance garage, a manager's residence, a pedestrian path, and a sewer treatment plant, see Figure 2. The development also includes a boat ramp on the east side of the property that potentially could be dedicated as Open Space to the Town of Gypsum. We assume that the structures will be single-story buildings with slab-on-grade floors and with cut depths ranging from nil to 5 feet.

SITE CONDITIONS

Parcels 1 and 2 cover about 70 acres and are located south of Highway 6, north of the Eagle River between Dotsero and Gypsum, see Figures 1 and 2. The site is on two large debris fans that have pushed the Eagle River southward. The debris fan heads are north of Interstate 70 along the south-facing Eagle River Valley side. The slope across both of the fans is gentle down to the south, gradually grading from the pedestrian path south of Highway 6 down to the Eagle River. A Holy Cross Electric easement runs along the north side of the property before turning southward on the western-most side. There are two small drainage easements on the north side of the property, see Figure 2b. Vegetation on the fans consists of sage brush and juniper with native grasses and phreatophytes along the river. The existing River Dance RV Park currently occupies the eastern fan.

GEOLOGIC SETTING

The main geologic features in the project area are shown on Figure 3. This map is based on the published regional map by Streufert and Others (2008).

The project area is just to the north of the axis of the east- to west- trending Eagle River Anticline. This regional geologic structure was formed due to salt tectonism in the late Cenozoic, consisting of the migration of Eagle Valley Evaporite (Pee) into areas of lower vertical stress, i.e. river valley bottoms. Near surface formation rock below the surficial deposits in the area is the Eagle Valley Evaporite. The site is bordered on the north and the south by the steep Eagle River Valley sides. The eagle River Valley sides typically consist of Eagle Valley Evaporite near the base overlain with Eagle Valley Formation (Pe) and capped with the Maroon Formation (PPm). The bedding on the north side of the Eagle River Valley typically dips to the north between 10 and 30 degrees and on the south side to the south between 30 and 60 degrees. The Eagle Valley Evaporite is mainly gypsum, anhydrite, and halite with interbedded siltstones and sandstones. It is subject to erosion and dissolution and can form dissolution cavities and eventually sinkholes. Surficial deposits derived from the Evaporite can be hydrocompressive and corrosive. The Eagle Valley Formation consists of interbedded sandstone, siltstone, and shale as well as gypsum and carbonate rocks. The color can range from reddish-brown, to reddish-gray, to gray, to tan. It can intertongue with both the underlying Eagle Valley Evaporite and the overlying Maroon Formation. The Maroon Formation is made up of red beds consisting of arkosic claystone, mudstone, siltstone, sandstone, conglomerate, and occasional gray

limestone. The closest geologically young faults that are less than 15,000 years old and may be capable of generating large earthquakes are located in the Rio Grande rift to the east of the project area, see Figure 4. The southern section of the Sawatch Fault zone (Fault Q56b) is located about 67 miles to the southeast and the northern section of the Williams Fork Mountains fault (Fault Q50) is located about 46 miles to the northeast. At these distances, large earthquakes on the two faults should not result in unusually strong ground shaking at the project site.

The modern landscape and surficial soil deposits in the project area are mostly the result of debris flow deposits (Qdfy) from debris flows originating in basins high up on the Eagle River Valley sides traveling in steep incised channels leading down to the Eagle River Valley bottom. These debris flow deposits consist of Holocene-age sediments deposited by sheetwash, mudflows, hyperconcentratred flows, and debris flows. This material is gravelly, sandy, clayey, silt with cobbles and boulders. The cobbles and boulders are mostly angular sandstones derived from the Maroon and Eagle Valley Formations and basalt fragments from the Dotsero Crater. These debris fans can be up to 50 feet thick and are subject to hydrocompression and future debris flows / floods (hyperconcentrated flows). Exploratory borings will be needed to evaluate the thickness and engineering properties of the debris flow deposits at the proposed site.

GEOLOGIC SITE ASSESSMENT

The project site geology should not present major constraints or unusually high risks to the proposed development. There are, however, several conditions of a geologic nature that should be considered. Geologic conditions that should be considered, their potential risks, and mitigations to reduce the potential risks are discussed below. Subsurface conditions at building sites should be evaluated by site-specific geotechnical engineering studies as project planning and design proceeds.

Potential Debris Flow / Flood (Hyperconcentrated Flow): The two main channels to the north of the project site that produced the debris fans the project site occupies should still be considered active debris fan heads. Both channels are very steep and well incised and have large basin areas above them. The debris fans at the project site should be considered potential sites of future debris flow and flood (hyperconcentrated flow) deposition triggered by extreme thunderstorms over the drainage basins. Without long term observation or detailed fan specific stratigraphic studies it is not possible to evaluate the statistical recurrence probability of major hyperconcentrated flows at the project site with a high level of confidence. In our opinion, the

statistical recurrence probability of major hyperconcentrated flows at the project site is likely long and may exceed 100 years. A major hyperconcentrated flow event has the potential to damage structures in the project site and deposition of mud and debris should be expected in the project site. The larger basins to the north of the project site appear capable of producing relatively large debris flows or floods (hyperconcentrated flows). If these risks are not acceptable to the owner or governmental regulatory agencies, then additional studies should be performed to further evaluate hyperconcentrated flow risk and mitigation. Risk mitigation would likely be direct protection of the structures by wall reinforcement or the construction of diversion channels down through the development. The construction of debris flow barriers within the channels and/or at the mouth of the channels is another possible mitigation measure depending on access and right of way constraints. There are relatively mature trees growing at the mouth of the western channel. The mature trees in the western channel indicate that it is unlikely that a very large debris flow event has occurred recently at that particular fan head, however future large debris flows at this location should not be completely ruled out. Interstate 70, Highway 6, and a pedestrian path are in between the fan heads and the project site. There are grade changes between the westbound lanes of Interstate 70, the eastbound lanes of Interstate 70, Highway 6, and the pedestrian path. In the event of a design level debris flow, it is likely that much of the material would be detained by these intervening features before reaching the project site.

Hydrocompressive Soils: The debris fan deposits that the project site sits on are derived from the Maroon Formation, the Eagle Valley Formation, and the Eagle Valley Evaporite. Sediments derived from these formations tend to be hydrocompressive and could possibly have relatively high collapse potential. The degree of compressibility and collapsibility of the subsoils on the site should be further evaluated by exploratory boring and laboratory testing for evaluation of potential settlement mitigation options.

Subsidence Potential: Bedrock of the Pennsylvanian age Eagle Valley Evaporite underlies the project site. These rocks are a sequence of gypsiferous shale, fine-grained sandstone and siltstone with some massive beds of gypsum and limestone. There is a possibility that massive gypsum deposits associated with the Eagle Valley Evaporite underlie portions of the site. Dissolution of the gypsum under certain conditions can cause sinkholes to develop and can produce areas of localized subsidence. During previous work in the area, several sinkholes were observed scattered throughout the Interstate 70 corridor between Gypsum and Dotsero. These sinkholes appear similar to others associated with the Eagle Valley Evaporite in areas of the Eagle River Valley.

Sinkholes were not observed in the immediate area of the subject site. No evidence of surface expression of cavities was encountered at the site; however, exploratory borings were not conducted. Based on our present knowledge of the conditions at the site, it cannot be said for certain that sinkholes will not develop. The risk of future ground subsidence on the project site throughout the service life of the proposed development, in our opinion, is low; however, the owner should be made aware of the potential for sinkhole development. If further investigation of possible cavities in the bedrock below the site is desired, we should be contacted.

Probable Shallow Groundwater and Stream Erosion Potential: The project site is located on debris fan deposits next to the Eagle River, that have changed the course of the river, and are only a relatively small distance above the current river water elevation. The portions of the fans closest to the Eagle River are thickly vegetated with phreatophyte plants and the soil in these areas appeared to be moist on the surface. The area of the site near the proposed boat ramp to the east of the main fan is nearly completely vegetated with phreatophytes, nearly the same elevation of the water elevation in the river, and is opposite a meander in the river that appears to be being cut off (through the boat ramp area). Pavement sections in these areas may need structural support and erosion control, and bank protection may be needed in areas adjacent to the Eagle River.

Earthquake Considerations: Historic earthquakes within 150 miles of the project site have typically been moderately strong with magnitudes less than 5.5 and maximum Modified Mercalli Intensities less than VI, see Figure 4. The largest historic earthquake in the project region occurred in 1882. It was located in the northern Front Range and had an estimated magnitude of about M6.2 ± 0.3 and a maximum intensity of VII. Historic ground shaking at the project site associated with the 1882 earthquake and the other larger historic earthquakes in the region does not appear to have exceeded Modified Mercalli Intensity VI (Kirkham and Rogers, 1985). Modified Mercalli Intensity VI ground shaking should be expected during a reasonable exposure time for the residence, but the probability of stronger ground shaking is low. Intensity VI ground shaking is felt by most people and caused general alarm, but results in negligible damage to structures of good design and construction. For *firm rock sites* with shear wave velocities of 2,500 fps in the upper 100 feet, the U. S. Geological Survey 2014 National Seismic Hazard Maps indicates that a peak ground acceleration of 0.07g has a 10% exceedance probability for a 50-year exposure time and a peak ground acceleration of 0.20g has a 2% exceedance probability for a 50-year exposure time at the project site (Peterson and Others, 2014). This corresponds to a statistical recurrence time of about 500 years and 2,500 years, respectively. The soil profiles at

the project site should be evaluated or site-specific shear wave evaluation should be conducted to determine the Seismic Soil Class as described in the 2015 International Building Code.

LIMITATIONS

This study was conducted according to generally accepted engineering geology principles and practices in this area at this time. We make no warranty either express or implied. The conclusions and recommendations submitted in this report are based on our field observations, aerial photograph interpretations, published regional geology information, the currently proposed development plan, and our experience in the area. This report has been prepared exclusively for our client and is an evaluation of the geologic constraints and their potential influence on the proposed development. We are not responsible for technical interpretations by others of our information.

If you have any questions or need further assistance, please call our office.

Sincerely,

H-P≋KUMAR

Robert L. Duran, E.I

Reviewed by:

Steven L. Pawlak, P.E.

RLD/kac

Attachments: Figure 1- Project Site Location
Figure 2- Conceptual Plan VII, River Dance RV Resort
Figure 2b- Mosher Parcels Land Survey Plat
Figure 3- Project Area Geology Map
Figure 4- Geologically Young Faults and Larger Historic Earthquakes

cc: Zancanella & Associates Inc. - Ben Elmore (Belmore@za-engineering.com)

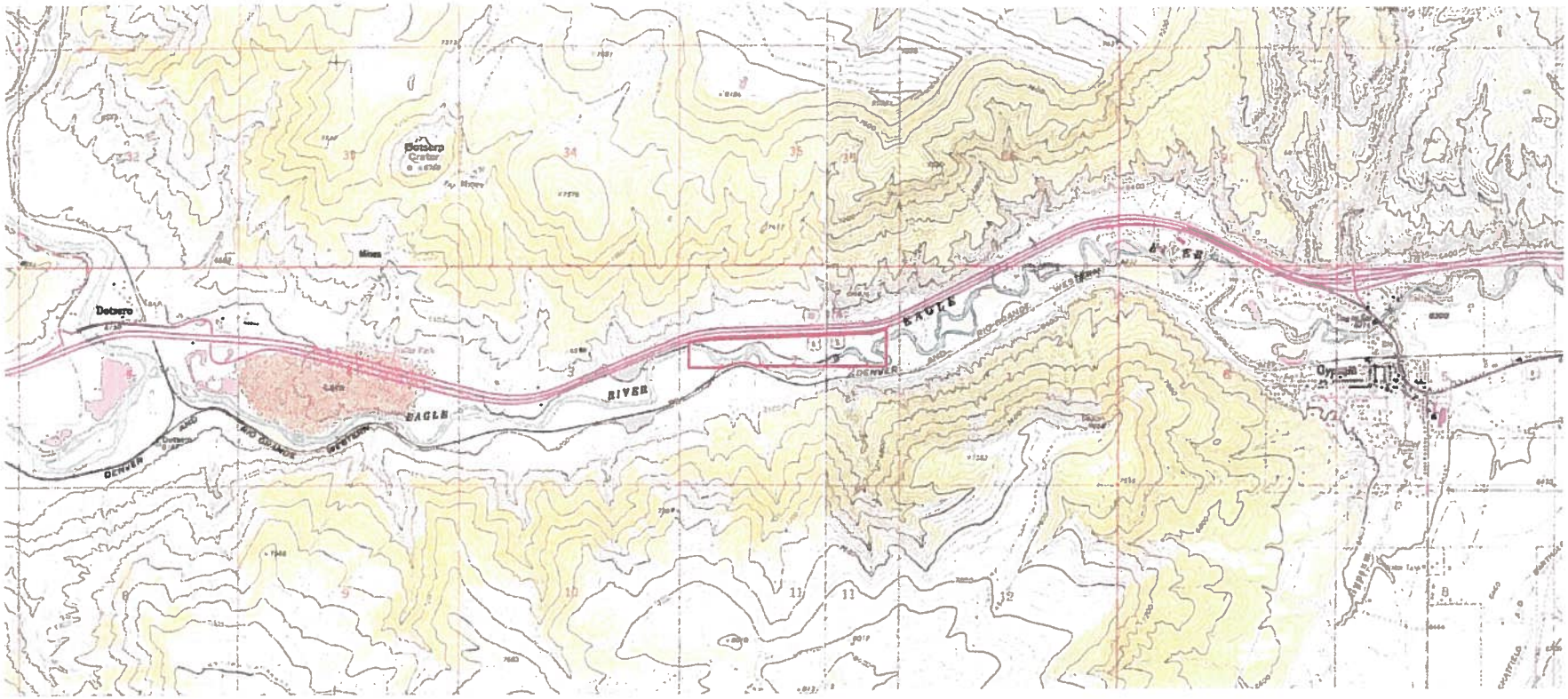
REFERENCES

Kirkham, R. M. and Rogers, W. P., 1985, *Colorado Earthquake Data and Interpretations 1867 to 1985*: Colorado Geological Survey Bulletin 46.

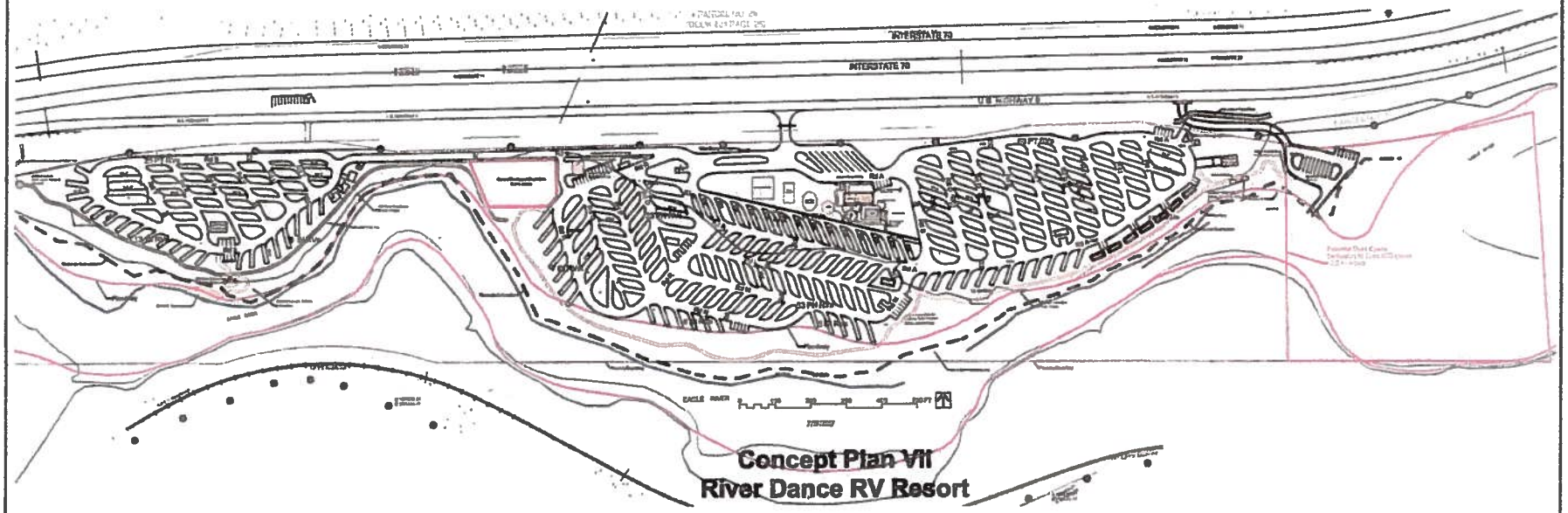
Peterson, M. D. and Others, 2014, *Documentation for the 2014 Update of the National Seismic Hazard Maps*: U. S. Geological Survey Open-File Report 2014–1091.

Streufert, R. K., Kirkham, R. M., Schroeder II, J. T., and Widmann, B. L., 2008, *Geologic Map of the Dotsero Quadrangle, Eagle and Garfield Counties, Colorado*: Colorado Geological Survey Open File Report OF-08-14.

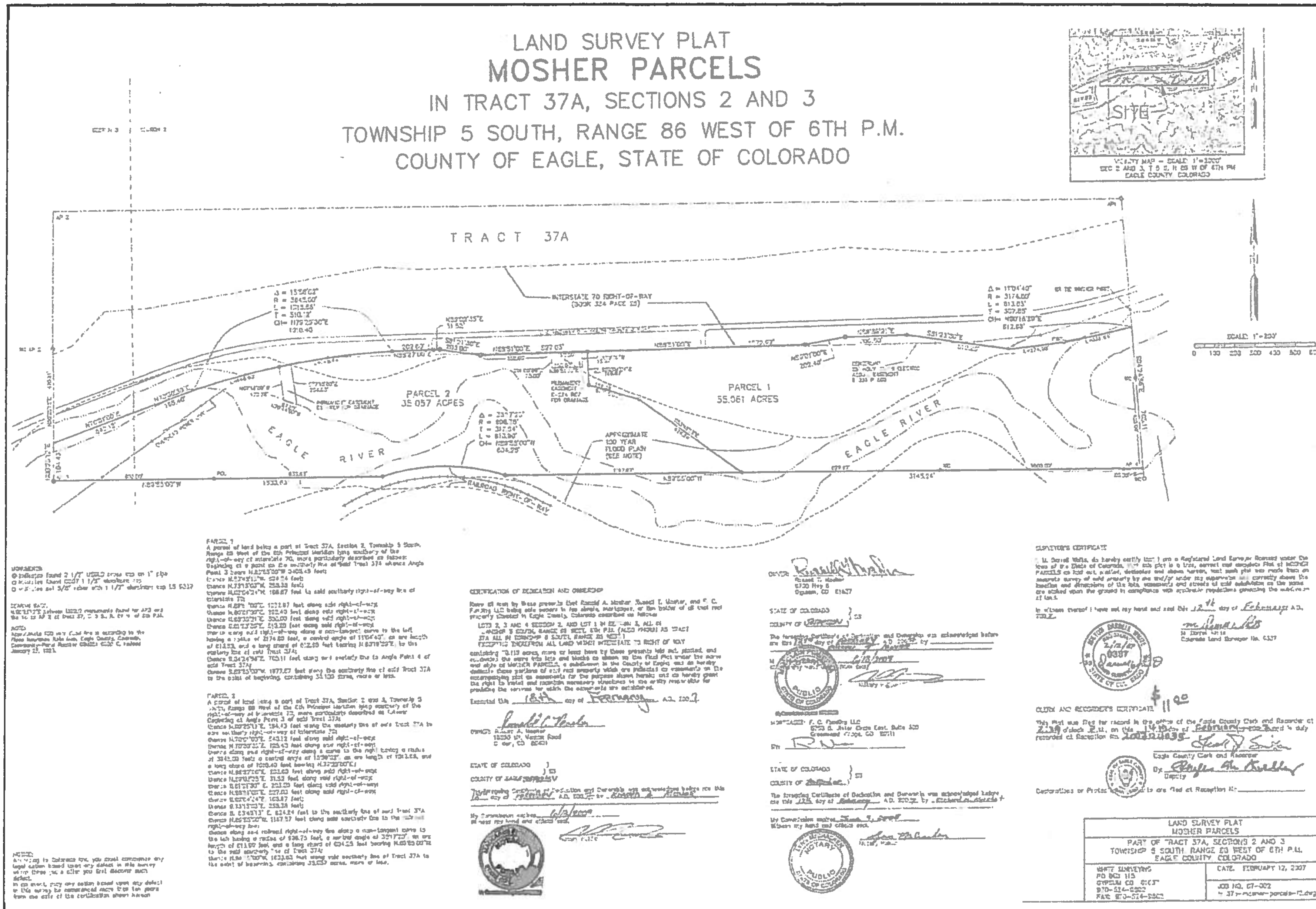
Widmann B. L. and Others, 1998, *Preliminary Quaternary Fault and Fold Map and Data Base of Colorado*: Colorado Geological Survey Open-File Report 98-8.



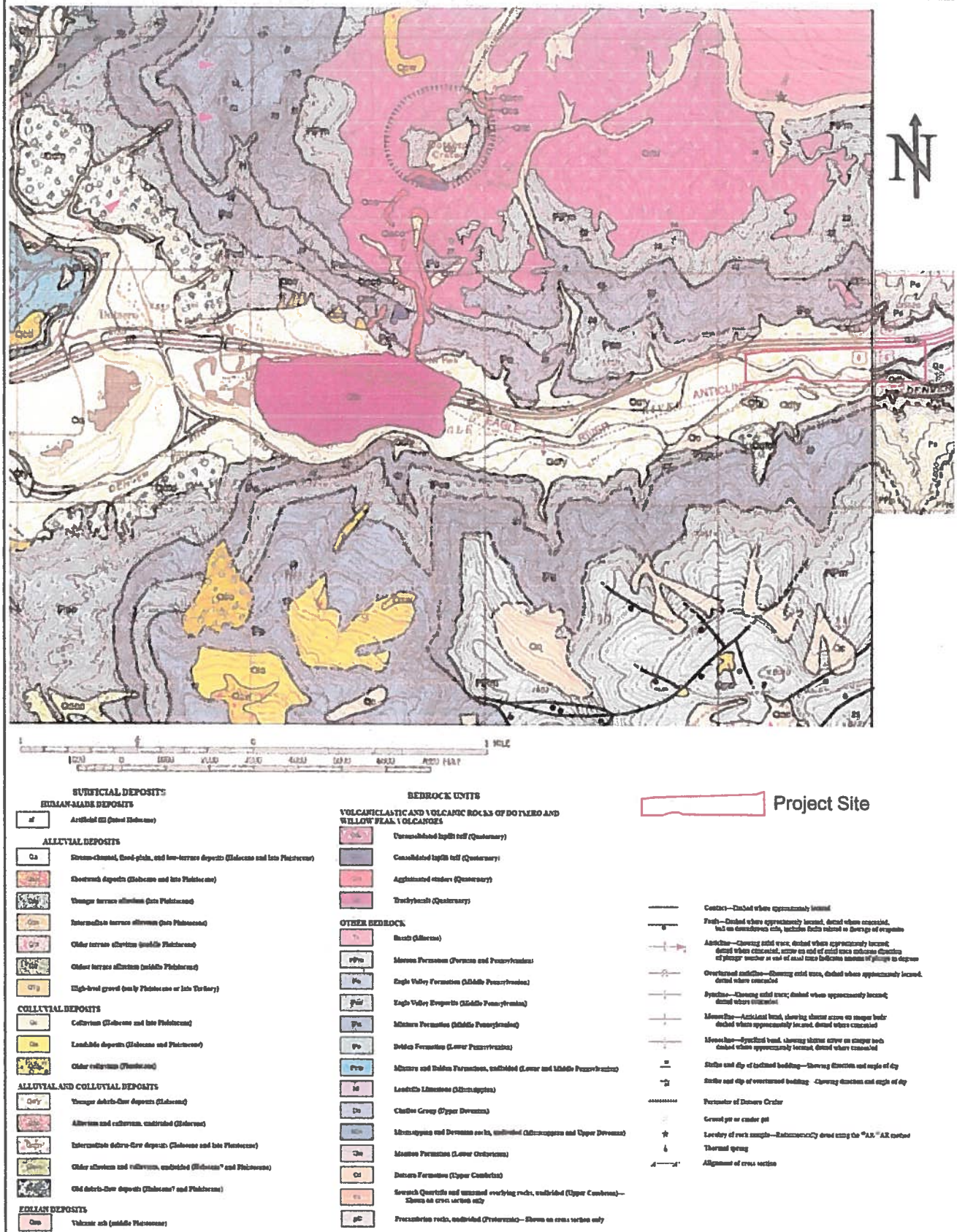
17-7-587	H-P≋KUMAR	River Dance RV Park, 6700 Highway 6, Eagle County, Colorado - Project Site Location	Figure 1



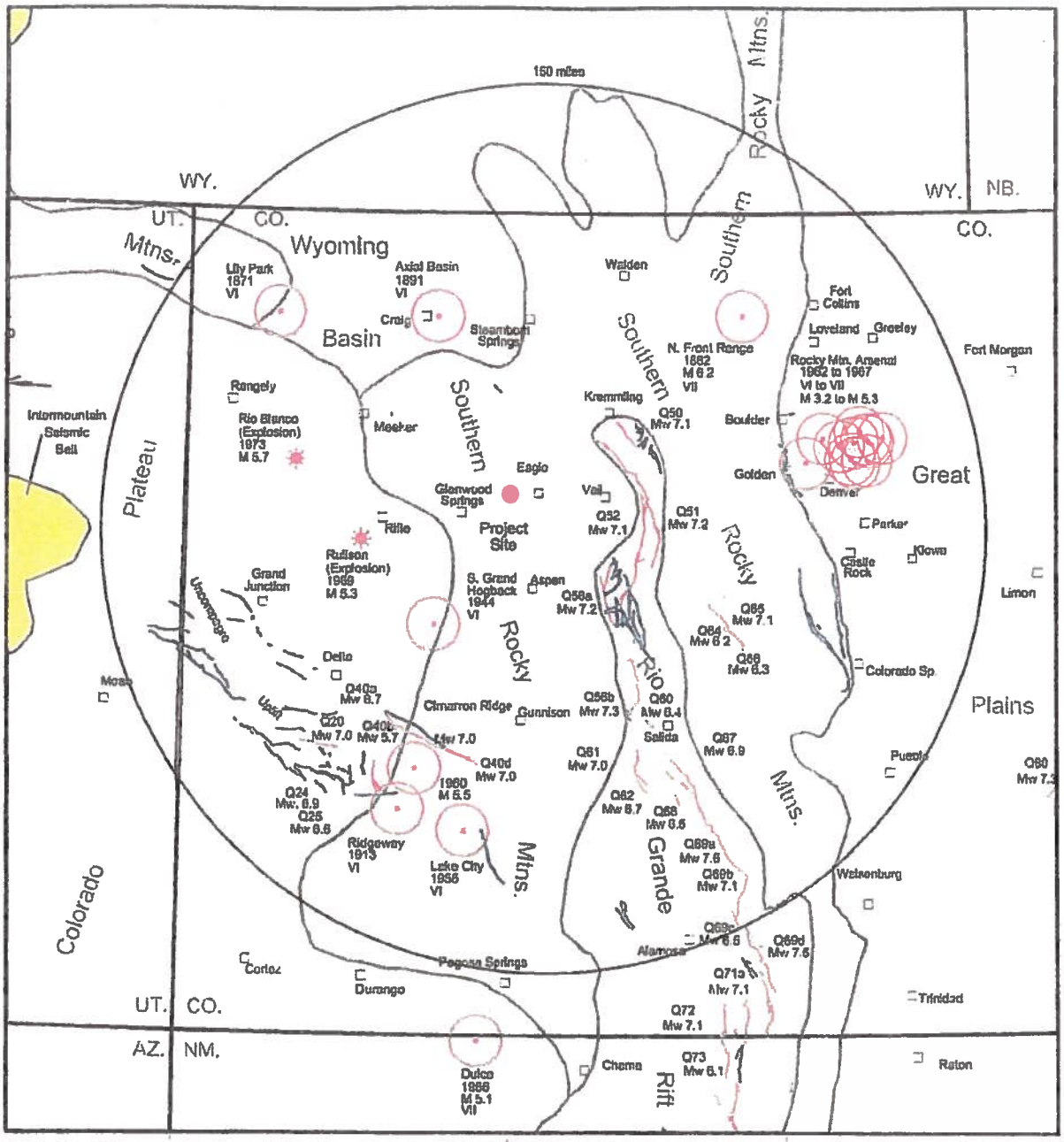
17-7-587	H-P≋KUMAR	River Dance RV Park, 6700 Highway 6, Eagle County, Colorado - Conceptual Plan VII, River Dance RV Resort	Figure 2



17-7-587 | H-P≈KUMAR | River Dance RV Park, 6700 Highway 6, Eagle County, Colorado - Mosher Parcels Land Survey Plat | **Figure 2b**



17-7-587	H-P≋KUMAR	River Dance RV Park, 6700 Highway 6, Eagle County, Colorado - Project Area Geology Map	Figure 3



Explanation:

Late Pleistocene Faults:
Fault younger than about 130,000 years excluding faults associated with evaporite tectonics. Mw moment magnitude of maximum credible earthquake

Quaternary Faults:
Faults younger than about 1.6 million years excluding faults associated with evaporite tectonics.

Larger Historic Earthquakes:
Earthquakes with maximum intensity greater than VI or magnitude greater than M 5.0 from 1867 to present

Nuclear Explosion:
Large underground nuclear explosion for natural gas reservoir enhancement.

Historic Seismic Zones:
Areas with historically high seismic activity

M Local, surface wave or body wave magnitude
Mw Moment Magnitude
VI Modified Mercalli Intensity

References:
Widmann and Others (1998)
U. S. Geological Survey Earthquake Catalogs
U. S. Geological Survey Quaternary Fault Catalogs

17-7-587	H-P≋KUMAR	River Dance RV Park, 6700 Highway 6, Eagle County, Colorado. Geologically Young Faults and Larger Historic Earthquakes	Figure 4