STATE OF COLORADO

DEPARTMENT OF TRANSPORTATION

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DATE: January 9, 2009

TO: Judy DeHaven

FROM: Steven M. Wallace SMWallace

SUBJECT: Paleontological assessment for project NH 0242-040, US 24 West: Manitou Springs to I-25

Attached is a copy of the paleontological assessment report, "Paleontological Technical Report: CDOT Project NH 0242-040, US Highway 24 West Corridor, Manitou Springs to Interstate 25, El Paso County, Colorado", submitted December 31, 2008 by Dr. Paul Murphey and David Daitch for Centennial Archaeology, Inc.. I have read the report and found it acceptable. In their report, Murphey and Daitch recommended paleontological clearance for the US 24 West Environmental Assessment [EA] corridor, with the stipulation that "[w]hen the project design plans are finalized, the CDOT Staff Paleontologist should examine them and determine the extent of impact to the bedrock units in the southwest quadrant of US 24 and 31st Street, and the scope of paleontological monitoring, if any, which is required." I concur with their recommendation.

The paleontological impacts mitigation plan for the US 24 West EA corridor should include paleontological monitoring during construction if and wherever final design plans for any future construction project(s) permitted by approval of this EA indicate there will be significant impacts to paleontological sensitivity Class 3, 4, and 5 bedrock outcrop at the existing high road cuts in the southwest quadrant of US 24 and 31st Street. If my examination of final plan, profile, and cross-section sheets and any subsurface geologic data that might be part of any final plans set(s) for any future construction project(s) permitted by approval of this EA indicates that there will be significant impacts to Class 3, 4, and 5 bedrock outcrop at the above location, I will write a revision of Subsection 107.23 of the Standard Specifications (Archaeological and Paleontological Discoveries) identifying the paleontological monitoring corridor(s) for attachment to the construction project specifications.

Based on the Region's agreement with the above-described mitigation stipulation, I am recommending paleontological clearance for the proposed US 24 West: Manitou Springs to I-25 EA corridor. If previously unrecorded paleontological resources are uncovered during project construction in any corridor not identified in any revision to Subsection 107.23 of the Standard Specifications or in the corridor identified in any revision but not being actively monitored at the time of fossil discovery, I should be notified immediately.

SMW:smw
cc: CF, Wallace

PALEONTOLOGICAL TECHNICAL REPORT: CDOT PROJECT *NH 0242-040*, US HIGHWAY 24 WEST CORRIDOR, MANITOU SPRINGS TO INTERSTATE 25, EL PASO COUNTY, COLORADO

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Prepared under State of Colorado Paleontological Permit 2008-36

December 31, 2008

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1.0 SUMMARY

The Colorado Department of Transportation is proposing improvements to a 4.8-mile segment of US Highway 24 between I-25 and Manitou Springs (approximate highway mileposts 299.1-303.8) in order to address local and regional transportation needs. This paleontological resources assessment is an evaluation of potential impacts on non-renewable scientifically significant paleontological resources which could result from ground disturbance within the Area of Potential Effect for the US Highway 24 Project (CDOT Project NH 0242-040). The project is located on the USGS Colorado Springs and Manitou Springs 7.5' topographic quadrangles within the S½ of sections 3 and 4, the NE¼ of Section 10, the NW¼ and S½ of Section 11, the NE¼ of sections 13 and 14, and the NE¼ of Section 24, T. 14 S., R. 67 W. (Sixth Principal Meridian), in El Paso County, Colorado (see Figure 1). The proposed action includes the widening of US 24 to six lanes from 31st Street to west of 8th Street, to eight lanes from west of 8th Street to I-25, and construction of interchanges at 21st Street, 8th Street and I-25. Work will include modifications to intersecting city streets and replacement of several bridges over Fountain Creek. The proposed construction will require excavation and benching of bedrock in the southwest quadrant of US 24 and 31st Street. At the base of the bluff at this location it is estimated that the cut will be 20 to 40 feet tapering at the top of the bluff to about 5 feet. The lateral extent of this cut is estimated to be about 300 feet.

The paleontological sensitivity of the geologic units within the study area was evaluated by reviewing scientific literature, geologic mapping and museum records. Based on the geologic mapping of Carroll and Crawford (2000) and Keller et al. (2005), the study area contains eight bedrock geologic units that are mantled by eight types of surficial deposits. Bedrock units include, from oldest to youngest and in approximate ascending stratigraphic order, Middle Pennsylvanian to Lower Permian Fountain Formation; Middle and Upper Permian Lyons Sandstone; Upper Permian and Lower Triassic Lykins Formation; Upper Jurassic undifferentiated Morrison and Ralston Creek formations; Upper Cretaceous undifferentiated Carlile Shale, Greenhorn Limestone, and Graneros Shale; Upper Cretaceous Niobrara Formation; and Upper Cretaceous Pierre Shale. Surficial units include a variety of deposits of Holocene and Pleistocene age including alluvium, sheetwash, landslides, flood-plain deposits, and artificial fill. All of the bedrock units have produced fossils of varying abundance, taxonomic affinity, quality of preservation, and scientific significance. The paleontological sensitivity of these bedrock units ranges from moderate (PFYC Class 3) to very high (PFYC Class 5), with undifferentiated Morrison and Ralston Creek Formation being the most sensitive. Pleistocene-age surficial deposits are known to contain fossils in Colorado, but because fossils are uncommon in these sediments, they are generally considered to have low to moderate paleontological sensitivity (PFYC Class 3a). Holocene-age surficial deposits are too young to contain in-situ fossils, and have low paleontological sensitivity (PFYC Class 2) (see Table 2).

No fossils were observed within the study area during the field survey, no reports of fossils from within the study area were found in the literature reviewed for this study, and no records of fossils from within the study area were found during the museum record searches conducted for this study. However, there are numerous reports of fossils in the same geologic units from the Colorado Springs area and elsewhere in Colorado. Based on the project description combined with the geology of the study area, it is anticipated that potential impacts to fossils are most likely to occur in the area of the large cut planned for the southwest quadrant of Highway 24 and 31st Street where numerous upturned and faulted fossiliferous rock formations including the highly sensitive Morrison Formation are exposed in close proximity. To the west of this location, it is likely that rocks of the Fountain Formation will be locally disturbed by construction, but because this unit is sparsely fossiliferous, the likelihood of adverse impacts to scientifically significant fossils in this unit as the result of construction is low. When the project design plans are finalized, the CDOT Staff Paleontologist should examine them and determine the extent of impact to the bedrock units in the southwest quadrant of US 24 and 31st Street, and the scope of paleontological monitoring, if any, which is required. If any sub-surface bones or other potential fossils are found anywhere within the study area during ground disturbance, the CDOT Staff Paleontologist should be notified immediately to assess their significance and make further recommendations.

2.0 INTRODUCTION

The Colorado Department of Transportation (CDOT) is proposing improvements to a 4.8-mile segment of US Highway 24 (US 24) between I-25 and Manitou Springs (approximate highway mileposts 299.1-303.8) in order to address local and regional transportation needs. This paleontological resources assessment is an evaluation of potential impacts on non-renewable scientifically significant paleontological resources which could result from ground disturbance within the Area of Potential Effect for the US Highway 24 Project (CDOT Project NH 0242-040) (Figure 1). The proposed action includes the widening of US 24 to six lanes from 31st Street to west of 8th Street, to eight lanes from west of 8th Street to I-25, and construction of interchanges at 21st Street, 8th Street and I-25. Work will include modifications to intersecting city streets and replacement of several bridges over Fountain Creek. Geologically, the study area is underlain by eight mapped bedrock geologic units of Pennsylvanian to Cretaceous age which are mantled by eight mapped types of surficial deposits of Quaternary (Pleistocene and Holocene) age. Each of the bedrock geologic units within the study area is known to produce scientifically significant fossil remains of varying preservation, taxonomic affinity, abundance, and scientific significance.

2.1 DEFINITION AND SIGNIFICANCE OF PALEONTOLOGICAL RESOURCES

Paleontology is a multidisciplinary science that combines elements of geology, biology, chemistry and physics in an effort to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints or traces of once-living organisms preserved in rocks and sediments. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. In accordance with CDOT policy, paleontological resources include not only fossils themselves but also the associated rocks or organic matter and the physical characteristics of the fossils' associated sedimentary matrix.

The fossil record is the only evidence that life on earth has existed for more than 3.6 billion years. Fossils are considered non-renewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced (Murphey and Daitch, 2007). Fossils are important scientific and educational resources because they are used to:

- Study the phylogenetic relationships among extinct organisms, as well as their relationships to modern groups.
- Elucidate the taphonomic, behavioral, temporal and diagenetic pathways responsible for fossil preservation, including the biases inherent in the fossil record.
- Reconstruct ancient environments, climate change, and paleoecological relationships.
- Provide a measure of relative geologic dating which forms the basis for biochronology and biostratigraphy, and which is an independent and corroborating line of evidence for isotopic dating.
- Study the geographic distribution of organisms and tectonic movements of land masses and ocean basins through time.
- Study patterns and processes of evolution, extinction and speciation.
- Identify past and potential future human-caused effects to global environments and climates (Murphey and Daitch, 2007).

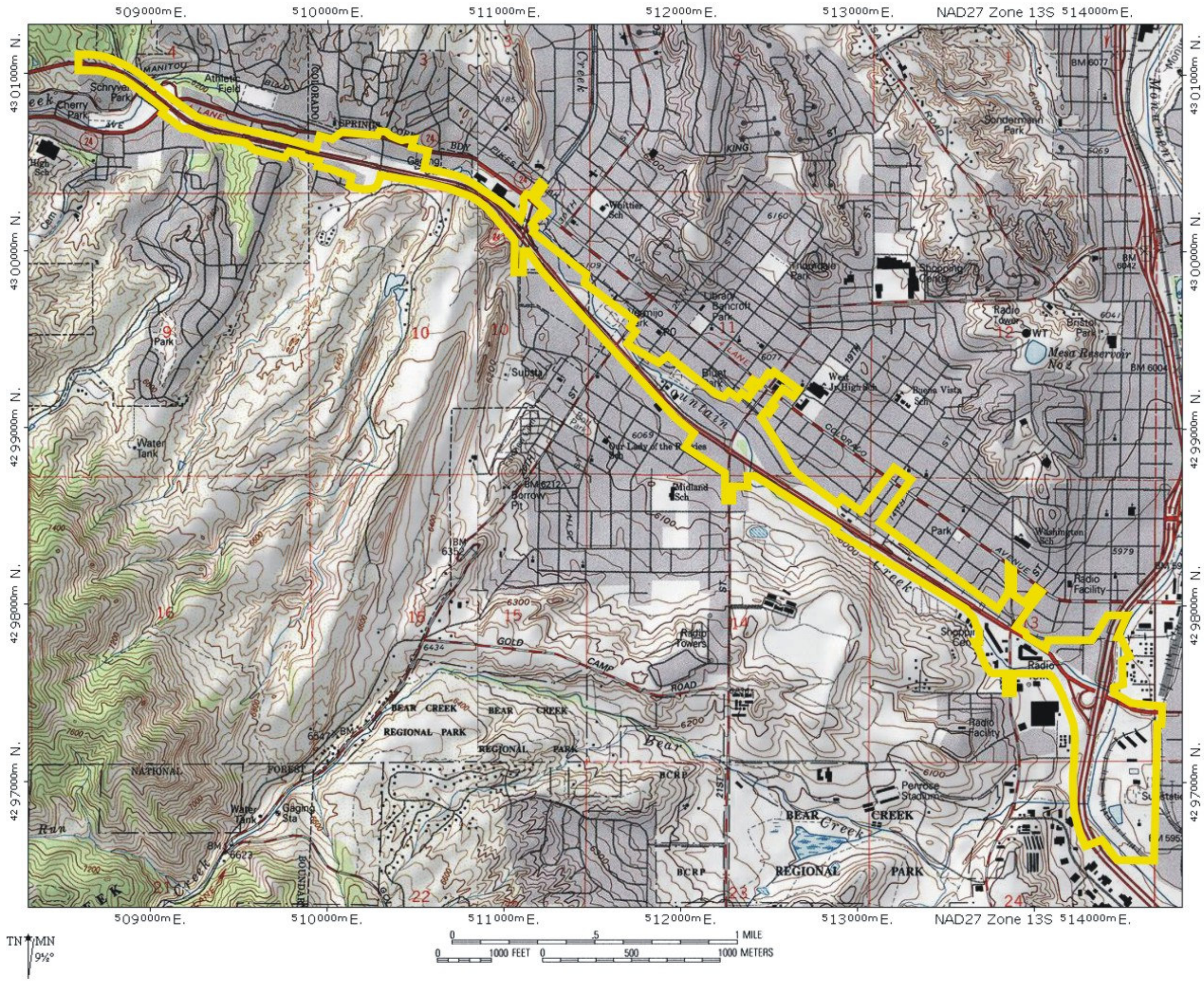


Figure 1. Location map showing the boundaries of the paleontological study area for the US 24 Project between I-25 and Manitou Springs.

3.0 METHODS

The purpose of this study is to evaluate the paleontological sensitivity of the geologic units within the study area for the US 24 Project by researching their known fossil potential and paleontological significance, and by determining the number and significance of fossil localities within the study area and elsewhere in the same geologic units. The scope of the study included a review of relevant scientific literature, geologic maps, museum records, and a field survey. The museums included in the record search are the Denver Museum of Nature and Science (DMNS) and the University of Colorado Museum of Natural History (UCM). The paleontological evaluation procedures for this study were conducted in accordance with SVP (1995) guidelines by qualified and permitted paleontologists (State of Colorado Paleontological Permit 2008-36). This study was conducted at the request of Centennial Archaeology, Fort Collins, Colorado, and CDOT.

The project is located on the USGS Colorado Springs and Manitou Springs 7.5' topographic quadrangles within the S½ of sections 3 and 4, the NE¼ of Section 10, the NW¼ and S½ of Section 11, the NE¼ of sections 13 and 14, and the NE¼ of Section 24, T. 14 S., R. 67 W. (Sixth Principal Meridian), in El Paso County, Colorado (see Figure 1).

The field survey for this study was conducted on December 28, 2008, and consisted of an inspection of the study area for 1) surface fossils; 2) exposures of potentially fossiliferous rock; and 3) areas in which fossiliferous rocks or younger potentially fossiliferous surficial deposits could be exposed or otherwise impacted during construction-related ground disturbance.

For paleontological surveys in general, areas where geologic units of moderate and high paleontological sensitivity are exposed are subject to a 100% pedestrian inspection; areas with exposures of low sensitivity deposits are spot-checked; and areas with no paleontological sensitivity are not inspected. If the geology of an area is uncertain, it is subject to a 100% pedestrian inspection. For this study, all portions of the study area that were not covered by pavement or existing construction and for which we had permission to enter were subject to a 100% pedestrian inspection. No parcels that were fenced or otherwise appeared to be private were surveyed.

4.0. LAWS, ORDINANCES, REGULATIONS AND STANDARDS

Fossils are classified as non-renewable scientific resources and are protected by various laws, ordinances, regulations and standards (LORS) across the country. Professional standards for the assessment and mitigation of adverse impacts to paleontological resources have been established by the Society of Vertebrate Paleontology (SVP) (1995, 1996). This paleontological study was conducted in accordance with the LORS which are applicable to paleontological resources within the study area for the US 24 Project (see Table 1). Pertinent federal, state, county and city LORS are summarized below:

4.1. Federal

The National Environmental Policy Act of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258 § 4(b), Sept. 13, 1982). NEPA recognizes the continuing responsibility of the Federal Government to "preserve important historic, cultural, and natural aspects of our national heritage..." (Sec. 101 [42 USC § 4321]) (#382).

The goal of the NEPA process is to make informed, publicly supported decisions regarding environmental issues. Under NEPA, the Federal government requires that:

a) all Federal agencies consider the environmental impacts of proposed actions;
b) the public be informed of the potential environmental impacts of proposed actions; and
c) that the public be involved in planning and analysis relevant to actions that impact the environment.

Federal Land Management and Policy Act of 1976 (43 U.S.C. 1712[c], 1732[b]); sec. 2, Federal Land Management and Policy Act of 1962 [30 U.S.C. 611]; Subpart 3631.0 et seq.), Federal Register Vol. 47, No. 159, 1982. The FLPMA does not refer specifically to fossils. However, "significant fossils" are understood and recognized in policy as scientific resources. Permits which authorize the collection of significant fossils for scientific purposes are issued under the authority of FLPMA.

Under FLPMA, Federal agencies are charged to:

a) manage public lands in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, archaeological, and water resources, and, where appropriate, preserve and protect certain public lands in their natural condition (Section 102 (a)(8) (11));
b) periodically inventory public lands so that the data can be used to make informed land-use decisions (Section 102(a)(2); and
c) regulate the use and development of public lands and resources through easements, licenses, and permits (Section 302(b)).

CFR Title 43

Under the Code of Federal Regulations (CFR) Title 43, Section 8365.1-5, the collection of scientific resources, including vertebrate fossils, is prohibited without a permit. Except where prohibited, individuals are also authorized to collect some fossils for their personal use. The use of fossils found on Federal lands for commercial purposes is also prohibited.

DOI Report – Fossils on Federal & Indian Lands

In 2000, the Secretary of the Interior submitted a report to Congress entitled "Assessment of Fossil Management on Federal and Indian Lands." This report was prepared with the assistance of nine federal agencies including the Bureau of Indian Affairs, the Bureau of Land Management, the Bureau of Reclamation, the United States Fish and Wildlife Service, the United States Forest Service, the National Park Service, the U.S. Geological Survey, and the Smithsonian Institution. The consulting agencies concluded that administrative and Congressional actions with respect to fossils should be governed by these seven basic principles:

a) Fossils on federal land are a part of America's heritage.
b) Most vertebrate fossils are rare.
c) Some invertebrate and plant fossils are rare.
d) Penalties for fossil theft should be strengthened.
e) Effective stewardship requires accurate information.
f) Federal fossil collections should be preserved and available for research and public education.
g) Federal fossil management should emphasize opportunities for public involvement.

Federal protection for scientifically significant paleontological resources applies to projects if any construction or other related project impacts occur on federally owned or managed lands, involve the crossing of state lines, or are federally funded. Because this project includes partial Federal funding, Federal protections under NEPA apply to paleontological resources within the study area for the US 24 Project.

4.2. State

Colorado Historical, Prehistorical and Archaeological Resources Act of 1973 (CRS 24-80-401 to 411, and 24-80-1301 to 1305). Defines permitting requirements and procedures for the collection of prehistoric resources, including paleontological resources, on state lands, and actions that should be taken in the even that resources are discovered in the course of state-funded projects and on state-owned/administered lands. Based on this legislation, the Colorado Department of Transportation (CDOT) requests assessments on state owned and/or administered lands which have the potential to contain significant paleontological resources, and mitigation monitoring during ground disturbance in these areas. This study will be reviewed by CDOT, and CDOT must fulfill FHWA's NEPA requirements under the CHPA.

4.3. County

There are no El Paso County LORS that specifically address potential adverse impacts on paleontological resources. Therefore, no county-level protections of paleontological resources pertain to the US 24 Project.

4.4. City

There are no City of Aurora LORS that specifically address potential adverse impacts on paleontological resources. Therefore, no city-level protections of paleontological resources pertain to the US 24 Project.

4.5 Private Lands

There are no LORS applicable to paleontological resources which occur on privately owned lands in the state of Colorado.

Table 1. Summary of paleontological laws, ordinances, regulations and standards applicable to the US 24 Project.

Agency/Owner	Pertinent Paleontological LORS
Federal	Assessment required by FHWA under NEPA
State	Assessment required by CDOT under CHPA
County	None
City	None
Private	None

4.6 Permits and Approvals

A State of Colorado Paleontological Permit is required to collect fossils on state owned or administered lands in Colorado. If paleontological mitigation is requested by the CDOT or other state agency, the Project Paleontologist and other paleontological personnel would be required to possess a State of Colorado paleontological permit. The paleontological mitigation program would need approval by the CDOT Staff Paleontologist or other state agency, including review and approval the final mitigation report. All fossils collected during mitigation would be required to be housed in an approved repository such as the DMNS or UCM, where they would be curated and permanently stored. This would ensure their availability for future scientific research, education and display.

5.0 RESOURCE ASSESSMENT CRITERIA

The paleontological sensitivity of each geologic unit within the study area for the US 24 Project was evaluated using the Potential Fossil Yield Classification system. This PFYC system was originally developed by the Forest Service's Paleontology Center of Excellence and the Region 2 Paleontology Initiative in 1996. Modifications have been made by the BLM's Paleontological Resources staff in subsequent years. The PFYC version used for this analysis was recently approved as policy by the BLM (IM 2008-009). This classification system is summarized below:

5.1 Potential Fossil Yield Classification

Occurrences of paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

Using the Potential Fossil Yield Classification (PFYC) system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential. This classification is applied to the geologic formation, member, or other distinguishable unit, preferably at the most detailed mappable level. It is not intended to be applied to specific paleontological localities or small areas within units. Although significant localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment.

The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered at an intermediate point in the analysis, and should be used to assist in determining the need for further mitigation assessment or actions.

The descriptions for the classes below are written to serve as guidelines rather than as strict definitions. Knowledge of the geology and the paleontological potential for individual units or preservational conditions should be considered when determining the appropriate class assignment. Assignments are best made by collaboration between land managers and knowledgeable researchers.

Class 1 **– Very Low**. Geologic units that are not likely to contain recognizable fossil remains.

- Units that are igneous or metamorphic, excluding reworked volcanic ash units.
- Units that are Precambrian in age or older.

(1) Management concern for paleontological resources in Class 1 units is usually negligible or not applicable.

(2) Assessment or mitigation is usually unnecessary except in very rare or isolated circumstances.

The probability for impacting any fossils is negligible. Assessment or mitigation of paleontological resources is usually unnecessary. The occurrence of significant fossils is non-existent or extremely rare.

Class 2 **– Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

- Vertebrate or significant invertebrate or plant fossils not present or very rare.

- Units that are generally younger than 10,000 years before present.
- Recent aeolian deposits.
- Sediments that exhibit significant physical and chemical changes (i.e., diagenetic alteration).

(1) Management concern for paleontological resources is generally low.

(2) Assessment or mitigation is usually unnecessary except in rare or isolated circumstances.

The probability for impacting vertebrate fossils or scientifically significant invertebrate or plant fossils is low. Assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist, but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

Class 3 **– Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.

- Often marine in origin with sporadic known occurrences of vertebrate fossils.
- Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low.

  (or)
- Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Class 3a – **Moderate Potential.** Units that are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for hobby collecting. The potential for a project to be sited on or impact a significant fossil locality is low, but is somewhat higher for common fossils.

Class 3b **– Unknown Potential.** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this Class may eventually be placed in another Class when sufficient survey and research is performed. The unknown potential of the units in this Class should be carefully considered when developing any mitigation or management actions.

(1) Management concern for paleontological resources is moderate; or cannot be determined from existing data.

(2) Surface-disturbing activities may require field assessment to determine appropriate course of action.

This classification includes a broad range of paleontological potential. It includes geologic units of unknown potential, as well as units of moderate or infrequent occurrence of significant fossils. Management considerations cover a broad range of options as well, and could include pre-disturbance surveys, monitoring, or avoidance. Surface-disturbing activities will require sufficient assessment to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources. These units may contain areas that would be appropriate to designate as hobby collection areas due to the higher occurrence of common fossils and a lower concern about affecting significant paleontological resources.

Class 4 **– High**. Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface disturbing activities may adversely affect paleontological resources in many cases.

Class 4a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres. Paleontological resources may be susceptible to adverse impacts from surface disturbing actions. Illegal collecting activities may impact some areas.

Class 4b – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

• Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.

• Areas of exposed outcrop are smaller than two contiguous acres.

• Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.

• Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action.

(2) A field survey by a qualified paleontologist is often needed to assess local conditions.

(3) Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered.

(4) Class 4 and Class 5 units may be combined as Class 5 for broad applications, such as planning efforts or preliminary assessments, when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation, and other management considerations are similar at this level of analysis, and impacts and alternatives can be addressed at a level appropriate to the application.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation considerations must include assessment of the disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access resulting in greater looting potential. If impacts to significant fossils can be anticipated, on-the-ground surveys prior to authorizing the surface disturbing action will usually be necessary. On-site monitoring or spot-checking may be necessary during construction activities.

***Class 5* – Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface disturbing actions. Unit is frequently the focus of illegal collecting activities.

Class 5b – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

• Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.

• Areas of exposed outcrop are smaller than two contiguous acres.

• Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.

• Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 5 areas is high to very high.

(2) A field survey by a qualified paleontologist is usually necessary prior to surface disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions.

(3) Official designation of areas of avoidance, special interest, and concern may be appropriate.

The probability for impacting significant fossils is high. Vertebrate fossils or scientifically significant invertebrate fossils are known or can reasonably be expected to occur in the impacted area. On-the-ground surveys prior to authorizing any surface disturbing activities will usually be necessary. On-site monitoring may be necessary during construction activities.

6.0 PALEONTOLOGICAL RESOURCE ASSESSMENT

According to the geologic mapping of Carroll and Crawford (2002) and Keller et al. (2005), ground disturbance associated with construction within the study area for the US 24 Project has the potential to impact eight mapped bedrock geologic units and eight mapped surficial deposits. Bedrock units include, from approximately oldest to youngest, and in approximate ascending stratigraphic order, Middle Pennsylvanian to Lower Permian Fountain Formation; Middle and Upper Permian Lyons Sandstone; Upper Permian and Lower Triassic Lykins Formation; Upper Jurassic undifferentiated Morrison and Ralston Creek Formations; Upper Cretaceous undifferentiated Carlile Shale, Greenhorn Limestone, and Graneros Shale; Upper Cretaceous Niobrara Formation; and Upper Cretaceous Pierre Shale. Surficial units include a variety of deposits of Holocene and Pleistocene age including alluvium, sheetwash, landslides, flood-plain deposits, and artificial fill.

The paleontological sensitivity of all geologic units within the study area was evaluated using the recently revised PFYC, which was presented in Section 5.1. The results are summarized in Table 2. The geology and paleontology of the potentially affected geologic units is discussed in Section 7.0. All of the bedrock units have yielded fossils of varying abundance, taxonomic affinity, quality of preservation, and scientific significance. The paleontological sensitivity of the bedrock units ranges from moderate (PFYC Class 3) to very high (PFYC Class 5), with undifferentiated Morrison and Ralston Creek Formation being the most sensitive. Pleistocene-age surficial deposits are known to contain fossils in Colorado, but because fossils are uncommon in these sediments, they are generally considered to have low to moderate paleontological sensitivity (PFYC Class 3a). Holocene-age surficial deposits are too young to contain in-situ fossils, and have low paleontological sensitivity (PFYC Class 2).

Table 2. Summarized paleontological sensitivities of geologic units within the study area for the US Highway 24 Project using the Potential Fossil Yield Classification System (map abbreviations and ages of units are from Carroll and Crawford (2000) and Keller et al. (2005).

Geologic Unit	Map Abbreviation	Age	Typical Fossils	PFYC
Artificial Fill	af	Latest Holocene	No in-situ fossils	*Class* 2
Alluvium one	Qa1	late Holocene	Contains unfossilized remains of modern species of animals and plants; no in-situ fossils	*Class* 2
Alluvium two	Qa2	late to early Holocene	Contains unfossilized remains of modern species of animals and plants; no in-situ fossils	*Class* 2
Stream channel, flood-plain, and terrace alluvium, undivided	Qa	Holocene to late Pleistocene	Generally scattered and uncommon occurrences of vertebrates, invertebrates, and plants. No in-situ fossils in Holocene deposits	*Class* 3a
Landslide deposits	Qls	Holocene and Pleistocene	Rare fossils in Pleistocene deposits. No in-situ fossils in Holocene deposits	*Class* 2

Table 2. Continued.

Sheetwash Deposits	Qsw	Holocene and late Pleistocene	Rare fossils in Pleistocene deposits. No in-situ fossils in Holocene deposits	*Class* 2
Terrace Alluvium two	Qt2	Late Pleistocene	Generally scattered and uncommon occurrences of vertebrates, invertebrates, and plants.	*Class* 3a
Terrace Alluvium three	Qt3	Late-middle Pleistocene	Generally scattered and uncommon occurrences of vertebrates, invertebrates, and plants	*Class* 3a
Pierre Shale	Kp	Upper Cretaceous	Locally abundant marine invertebrates (mostly mollusks) and trace fossils, less common vertebrates and plants	*Class* 4
Niobrara Formation	Kn	Upper Cretaceous	Locally abundant marine invertebrates (mostly mollusks), less common vertebrates	*Class* 4
Carlile Shale, Greenhorn Limestone, and Graneros Shale, undifferentiated	Kcgg	Upper Cretaceous	Locally common marine invertebrates (mostly mollusks), foraminifera, palynomorphs, less common vertebrates (fishes, reptiles)	*Class* 3
Dakota Sandstone and Purgatoire formations, undifferentiated	Kdp	Lower Cretaceous	Locally common marine invertebrates, terrestrial plants, and trace fossils, scarce vertebrates	*Class* 4
Morrison and Ralston Creek formations, undifferentiated	Jmr	Upper Jurassic	Locally common terrestrial vertebrates (especially dinosaurs), invertebrates, plants, and trace fossils	*Class* 5
Lykins Formation	Ply	Upper Permian and Lower Triassic?	Stromatolites	*Class* 2
Lyons Sandstone	TrPl	Middle? And Upper Permian	Trace fossils (trackways)	*Class* 3
Fountain Formation	PPf	Middle Pennsylvanian to Lower Permian	Localized occurrences of marine invertebrates; uncommon vertebrates (fish bones) and trace fossils (including rare fossil vertebrate trackways)	*Class* 3

7.0 AFFECTED ENVIRONMENT

7.1 Paleontological Significance of Eastern Colorado

The Front Range foothills and adjacent eastern plains region of Colorado is well known for its geologic history and paleontologic importance. Scientists working in this area have conducted numerous studies in geology and paleontology, some of which are now considered classic works, and others that are on the leading edge of modern paleontological and paleoenvironmental research. Many important fossil specimens, including numerous holotypes, have been collected in this region. These include the type specimens of the dinosaurs *Stegosaurus armatus, Diplodocus, Allosaurus,* and *Apatosaurus ajax*, which were collected during the late nineteenth century from historic quarries near the town of Morrison. These and many other fossils from the Front Range and eastern plains region of Colorado are now housed in museums across in Colorado and across the United States.

The geology and paleontology of Colorado is scientifically important because, to cite several examples, it records some of the earliest known vertebrate fossils: small armored fish from the Harding Formation of middle Ordovician age; the uplift and erosion of the ancestral Rocky Mountains, early tetrapod trackways, and the marine fauna of adjacent shallow seas during the late Paleozoic Era; the development of a shallow epeiric seaway which covered much of central North America during the late Cretaceous Period; the uplift of the Rocky Mountains and extinction of the dinosaurs at the end of the Cretaceous Period; the development of tropical rainforest ecosystems and rapid evolutionary radiation of mammals during the Paleocene Epoch; the development of grassland savannah ecosystems during the Oligocene and Miocene; and the glacial and interglacial climates, environments and megafaunas of the Pleistocene "ice ages."

Today, these and many other events in the history of ancient Colorado, which are recorded both by both the diversity of fossils and associated well-exposed sedimentary rocks in this area, can be studied at many locations. In central and eastern Colorado, a few representative examples the Kremmling Giant Ammonite Site in Middle Park; the Picketwire Dinosaur Tracksite in Comanche National Grassland; the Garden Park Dinosaur Area north of Cañon City; Florissant Fossil Beds National Monument; Red Rocks Park, the Dakota Hogback, and Dinosaur Ridge just to the west of Denver; and museums including the Dinosaur Depot Museum, Denver Museum of Nature and Science, University of Colorado Museum of Natural History in Boulder, and the Morrison Natural History Museum. Immediately adjacent to the US 24 study area, a number of fossil occurrences have recently been documented in Red Rock Canyon Open Space in Colorado Springs (Milito, 2008).

7.2 Geology and Paleontology

Because of the complex structural geology and large number of closely spaced rock formations within a small geographic area within and immediately adjacent to the US 24 project, especially in the area just to the southwest of US 24 and 31st Street, it was difficult to precisely determine which geologic units will be impacted by construction-related ground disturbance. It was also difficult given the scale of available maps to determine the extent of disturbance to each of these units based on the project information provided to us. Therefore, we were liberal in our inclusion of the number of formations that we included in this report, but believe that all could be impacted by construction.

According to Carroll and Crawford (2002) and Keller et al. (2005), the study area for the US 24 Project contains eight mapped bedrock geologic units and eight mapped surficial deposits. Bedrock units include, from oldest to youngest, Middle Pennsylvanian to Lower Permian Fountain Formation; Middle and Upper Permian Lyons Sandstone; Upper Permian and Lower Triassic Lykins Formation; Upper Jurassic undifferentiated Morrison and Ralston Creek Formations; Upper Cretaceous undifferentiated Carlile Shale, Greenhorn Limestone, and Graneros Shale; Upper Cretaceous Niobrara Formation; and Upper Cretaceous Pierre Shale. Surficial units include a variety of deposits of Holocene and Pleistocene age including alluvium, sheetwash, landslides, flood-plain deposits, and artificial fill. The following are generalized summaries of the geology and paleontologic content of these units based mostly on published scientific literature.

7.2.1 Fountain Formation

The Middle Pennsylvanian to Lower Permian Fountain Formation consists of arkosic thick-bedded coarse-grained sandstone and conglomerate containing thin layers of dark maroon micaceous silty fine-grained sandstone that are more abundant in the lower part of the unit. The coarse clastic facies are characterized by well-developed crossbedding and poor sorting (Scott, 1972; Trimble and Machette, 1979; Van Horn, 1972). Interbeds of locally fossiliferous limestone also occur. Color is generally reddish with local variations of white, green, and gray. The Fountain Formation is 4,050 feet thick at its type locality along Fountain Creek in the Manitou Springs quadrangle (Keller et al., 2005). It was deposited mostly in alluvial fans and braided streams during the uplift of the ancestral Rocky Mountains. Fine-grained facies (limestone and siltstone) locally contain a diverse invertebrate fauna, including gastropods, crinoids, echinoderms, brachiopods, and echinoids. Fossil amphibian footprints and rare fish bone fragments also occur along the Front Range (unpublished UCM paleontological data). The distribution of the Fountain Formation within the US 24 study area is shown in Figure 2 (PPf). Although the Fountain Formation is sparsely fossiliferous, it is considered to have moderate paleontological sensitivity (PFYC Class 3) because any additional fossils discovered within it, especially vertebrates and vertebrate trace fossils, would be very important scientifically.

7.2.2 Lyons Sandstone

The Middle (?) and Upper Permian Lyons Sandstone consists of white, yellowish-gray to reddish-brown, massive, well-sorted, fine- to medium-grained, cross-bedded quartzose and hematitic sandstone composed of well rounded clasts (Carroll and Crawford, 2000). It has a maximum thickness of about 700 feet in the Colorado Springs area (Keller et al., 2005). The Lyons Sandstone is best known for its fossilized insect and amphibian footprints (unpublished UCM paleontological data), and its laminated rock slabs have been widely used as flagstone in urban construction in Colorado. Well preserved fossil sand dune ripple marks and mud cracks are preserved in this unit in Red Rock Canyon Open Space to the south of the US 24 study area (Milito, 2008). The distribution of the Lyons Sandstone within the study area is shown in Figure 2 (Pll. Plu) and Figure 3 (TrPl). The Lyons Sandstone has moderate paleontological sensitivity (PFYC Class 3).

7.2.3 Lykins Formation

The Upper Permian and Lower Triassic (?) Lykins Formation is at least partially equivalent with the Chugwater, Dinwoody, Thanes, Spearfish, Jelm, Ankareh, Woodside, Lykins, Chinle, and Dolores formations, and the Glen Canyon and Dockum groups. In the vicinity of the study area, it is composed of reddish-brown and light tan sandy siltstone and shale that contains two prominent beds of light gray to tan dolostone, and is approximately 120 feet thick (Keller et al., 2005). The Lykins Formation has been subdivided into four members: the Forelle Limestone, Bergen Shale, Falcon Limestone, and Harriman Shale. The Lykins contains few fossils, and is best known for its algal stromatolites. Carbonate beds within the Lykins exhibit a laminated texture indicative of algal mats in a shallow marine environment (Keller et al., 2005), and stromatolitic structures have been reported to occur in the US 24 roadcut at the north end of Red Rock Canyon Open Space (presumably within the study area). Rare fossil bones have also been discovered in the Lykins Formation (unpublished UCM paleontological data). The distribution of this unit within the survey corridor is shown on Figure 2 (TrPl) and Figure 3 (Ply). Because of its scarce fossils, the Lykins Formation is considered to have low paleontological sensitivity (PFYC Class 2).

7.2.4 Morrison and Ralston Creek Formations, Undifferentiated

The Upper Jurassic Morrison Formation is composed of variegated reddish-brown, maroon, green, white to brown claystone, white to brown sandstone, and brown siltstone with dark gray gypsiferous shale (Carroll and Crawford, 2000). It is interpreted to contain numerous unconformities. In much of its distribution in Colorado, the Morrison Formation has been locally subdivided into members including the Brushy Basin, Westwater Canyon, Recapture Creek, Salt Wash, and Bluff Sandstone. The underlying Ralston Creek Formation is composed of light reddish-brown to tan, interbedded sandstone, shale, limestone and gypsum (Keller et al., 2005). The combined thickness of both formations is approximately 220 feet (Carroll and Crawford, 2000). The widely distributed and highly fossiliferous Upper Jurassic Morrison Formation was deposited in a combination of fluvial and lacustrine environments in warm, humid climatic conditions after the regression of an inland sea (Peterson, 1972), while the Ralston Creek Formation was deposited in more near shore shallow marine environments (Berman et al., 1980).

The Morrison Formation is well known for the large number of dinosaur remains that are preserved within it, including many historically important specimens on display in museums around the world. Historically important fossil localities within the Morrison Formation are numerous, and include Como Bluff in Wyoming, Dinosaur National Monument in Utah, and localities near Morrison (the type locality of the Morrison Formation) and Canon City, Colorado, among others. Although dinosaur bones, teeth and fragments of fossilized wood are perhaps the most common Morrison Formation fossils, an extremely diverse fish, non-dinosaur reptilian, mammalian, plant, and trace fossil assemblage has also been documented. In addition to its rich dinosaur bone beds with articulated and disarticulated remains that are often very well preserved, the Morrison Formation has produced a diverse assemblage of small mammals and non-dinosaurian reptiles, dinosaur eggs, trackways, and plants. The geology and paleontology of the Morrison Formation has been studied extensively (Armstrong and Kihm, 1980; Armstrong et al., 1987; Bilbey, 1992; Carpenter, 1979; Dodson et al., 1980, Peterson, 1988; Tidwell, 1990; and numerous other references), and it has produced the greatest diversity of Jurassic-age fossils of any rock unit in the world (Breithaupt, 1994). Although no fossils were observed within the Morrison or Ralston Creek formations within the US 24 study area, fragments of dinosaur bone have been reported to be exposed in a channel sandstone deposit to the south of Red Rock Canyon Open Space (Milito, 2008). The distribution of undifferentiated Morrison and Ralston Creek formations within the study area is shown in Figure 3 (Jmr). For the purpose of this study, undifferentiated Morrison and Ralston Creek formations are considered to have very high paleontological sensitivity (PFYC Class 5).

7.2.5 Dakota Sandstone and Purgatoire Formations, Undifferentiated

The Lower Cretaceous Dakota Sandstone is composed of white and yellowish-brown quartz sandstone interbedded with gray shale, and is approximately 160 feet thick (Keller et al., 2005). The Purgatoire Formation consists of massive white sandstone and gray claystone (Keller et al., 2005). It has been divided into the basal Lytle Sandstone Member and overlying Glencairn Shale Member. The total thickness of the Dakota-Purgatoire sequence is approximately 300 feet (Carroll and Crawford, 2000). The widely distributed Dakota Sandstone and its associated formations/members have locally been elevated to group status (Martin et al., 2004).

Deposited during the first major transgression of the Cretaceous Interior Seaway in beach, estuarine, and other proximal shoreline depositional environments, rocks of the Dakota Sandstone contain a moderately diverse fossil fauna and flora. The unit is well known for its fossil footprints and other trace fossils, and also contains scattered bones and locally well-preserved plant remains. Dinosaur track sites from near the top of the Dakota Group have been reported from numerous localities in Colorado. Lockley et al. (1992) described several dozen dinosaur track sites along the Front Range of Colorado and the southern high plains of Colorado, Oklahoma, and New Mexico. According to these authors, all of these track sites occur in a stratigraphic interval that is less than 30 feet thick.

This interval is referred to as a "megatracksite" and it is estimated that this track-bearing complex, which includes dinosaur, crocodile and bird tracks, covers an area of 80,000 square kilometers. Waage (1955) cited plesiosaur vertebrae in the Dakota Group in northern Colorado, and Dakota Sandstone fossils have been the subject of numerous paleontologic studies (Chamberlain, 1976; Elliot and Nations, 1998; Lockley, 1987, 1990, 1992; Mehl, 1931; Snow, 1887; Rushforth, 1971; Waage and Eicher, 1960; Young, 1960). Immediately to the south of the US 24 study area in Red Rock Canyon Open Space, the Dakota-Purgatoire sequence has yielded a number of fossils including burrows and tracks, dinosaur tracks, several varieties of leaves, and wood (Milito, 2008). In 1878, a partial dinosaur skull was discovered in the Lytle Member of the Purgatoire Formation to the north of the US 24 study area in the Garden of the Gods area. This specimen was later identified as a new genus and species of iguanodont, *Theiophytalia Kerri*, and was formally described by Carpenter and Brill (2006). The distribution of the Dakota Sandstone and Purgatoire Formation within the US 24 study area is shown in Figure 3 (Kdp). The undifferentiated Dakota Sandstone and Purgatoire Formation sequence is considered to have high paleontological sensitivity within the study area (PFYC Class 4) because of the many fossil occurrences that have been recorded nearby.

7.2.6 Carlile Shale, Greenhorn Limestone, and Graneros Shale, Undifferentiated

The stratigraphic nomenclature associated with these widely distributed Upper Cretaceous units, their various members, and their stratigraphic equivalents is complex. These units, listed above in descending stratigraphic order, were formerly known as the Benton Group and are now known as the Colorado Group (Carroll and Crawford, 2000). The Carlile Shale is composed of dark gray shale interbedded with thin beds of dark brown sandstone, yellowish-brown siltstone, and gray limestone. The Greenhorn Limestone consists of dark to light gray limestone with lesser amount of shale and siltstone. The Graneros Shale consists of black marine shale with thin interbedded bentonite beds. The combined thickness of these three units is approximately 350 feet.

Fossils are locally common and diverse in these units. They include trace fossils, fossil wood and plant debris, foraminifera, barnacles, brachiopods, bivalves, gastropods, ammonites, radiolarians, fish scales and other fish remains including sharks, and marine reptiles including plesiosaurs and ichthyosaurs (Cobban and Kennedy, 1989; Cicimurri, 2001; Hanson and Connely, 2006; Knechtel and Patterson, 1962; Massare and Dain, 1989; Merewether, 1996; Romer, 1968; Stewart et al., 1994; Stewart and Hakel, 2006; Yacobucci, 2004). Foraminifera and palynomorphs are also abundant and varied in this formation (Courtinat, 1993; Fox, 1954; Merewether, 1996; Okumura, 1994). Just to the south of the US 24 study area, the uppermost Codell Sandstone Member of the Carlile Shale has produced burrows and feeding trails of marine invertebrates and sharks teeth (Milito, 2008). Although fossil invertebrates are locally abundant in the Carlile Shale, Greenhorn Limestone, and Graneros Shale, fossil vertebrates are uncommon. Therefore, the undifferentiated Carlile Shale, Greenhorn Limestone, and Graneros Shale is considered to have moderate paleontological sensitivity (PFYC Class 3). The distribution of this undifferentiated unit within the US 24 study area is shown in Figure 3 (Kcgg).

7.2.7 Niobrara Formation

Like the Dakota and Benton groups, the Upper Cretaceous Niobrara Formation is a stratigraphically complex geologic unit. It has been subdivided into the Fort Hays Limestone Member and the conformably overlying Smoky Hill Shale Member, and is stratigraphically equivalent with the Mancos Shale which occurs further to the northwest. The Smoky Hill Shale Member consists of yellowish-orange to brown shale interbedded with thin gray and white chalk beds, and thin rare limestone beds. The Fort Hayes Limestone Member is composed primarily of gray limestone with lesser amount of chalky limestone and shale. The combined thickness of both members is approximately 450 feet (Carroll and Crawford, 2000; Keller et al., 2005). The Niobrara Formation is widely distributed, and was deposited mostly in nearshore marine settings during the second late Cretaceous transgressive-regressive cycle.

Most fossil vertebrates known from the Niobrara Formation have been discovered in the Smoky Hill Shale Member in Kansas, although other geographic areas have produced less abundant and less well-preserved vertebrate remains. Among the most well known Niobrara Formation fossils from Kansas are articulated skeletons of pterosaurs, fishes (including rare sharks), birds, and numerous plesiosaurs, mosasaurs and turtles. Free swimming crinoids (sea lilies) have also been reported (Cobban, 1995). Mosasaurs, plesiosaurs, and fishes have been discovered within the Smoky Hill Shale Member of the Niobrara Formation in Larimer County, Colorado (Anthony and Smith, 1992; Martz, 1996). Fossil marine mollusks, cephalopods and foraminifers are also locally abundant within the Niobrara Formation throughout its distribution. Niobrara Formation fossils have been the subject of numerous paleontological studies (Anthony and Smith, 1992; Cobban, 1995; Feager and Smidt, 1992; Martz, 1996; Russell, 1993; and many others). Just to the south of the US 24 study area in Red Rock Canyon Open Space, the Fort Hays Limestone Member of the Niobrara Formation has produced trace fossils including invertebrate burrows and trackways, and shells of oysters and clams. The Smoky Hill Shale Member produced partial tail rays of an ichthyodectid fish (Milito, 2008). Although fossil invertebrates are locally common, the Niobrara Formation contains less abundant fossil vertebrates throughout most of its distribution. Nevertheless, several vertebrate specimens were documented within neighboring Red Rock Canyon Open Space. Therefore, the Niobrara Formation is considered to have high paleontological sensitivity (PFYC Class 4). The distribution of the Niobrara Formation within the study area is shown in Figure 3 (Kn).

7.2.8 Pierre Shale

The Upper Cretaceous (Campanian-Maastrichtian) Pierre Shale occurs in Montana, North Dakota, South Dakota, Wyoming, and Colorado. Until recently the Pierre Shale was always given a formation-level designation; however recent stratigraphic research has prompted some workers to elevate the Pierre Shale to group status in Nebraska, North Dakota, South Dakota and eastern-Wyoming, thereby elevating the subdivisions of the Pierre Shale in western Kansas, North Dakota, central and western South Dakota and southeastern Wyoming to the formation level (Martin et al., 2004). Generally, lithologies of the Pierre Shale include hard, platy to flaky gray, dark gray, brownish-gray, grayish-black, tan shale and silty shale, light olive gray silty bentonitic shale, limestone, and ironstone concretions (Haymes, 1989; Gill and Cobban, 1966; Scott and Wobus, 1973). The Pierre Shale underlies and is gradational with the Fox Hills Formation and conformably and unconformably lies on the Niobrara Formation. Contact with the underlying Niobrara Formation is gradational and conformable, and the unit has a thickness of about 4,500 feet in the Colorado Springs quadrangle (Carroll and Crawford, 2000).

The invertebrate and vertebrate fossil faunas of the Pierre Shale in Colorado, Wyoming, South Dakota, North Dakota, Montana, Kansas, and New Mexico have been the subject of far more studies than can be cited here (Bergstresser, 1981; Bishop, 1985; Carpenter, 1996; Cobban et al., 1993; Gill and Cobban, 1966; Kauffman and Kesling, 1960; Lammons, 1969; Martz et al., 1999; Scott and Cobban, 1986; and many others). The invertebrate fauna includes a diverse assemblage of mollusks (primarily ammonites and inoceramids), as well as other bivalves, bryozoans, and gastropods. The ichnofauna consists primarily of trails, burrows, tubes, fecal pellets, and raspings on shells (Gill and Cobban, 1966), and gastroliths. Plant fossils are more rare, consisting of logs and wood fragments. The vertebrate fauna is diverse but geographically constrained, containing a variety of fish, turtles, mosasaurs, plesiosaurs, and more rare dinosaurs, pterosaurs, and birds (Carpenter, 1996; Carpenter, 2006). Most vertebrate fossils have been discovered in the Sharon Springs Member of the Pierre Shale in Wyoming, South Dakota and Kansas. However, additional vertebrate fossils including mosasaurs have been discovered in the Pierre Shale in the Walsenburg area, southern Colorado. The distribution of the Pierre Shale within the US 24 study area is shown in Figure 3 (Kp). Because it contains a diverse invertebrate fauna and locally produces well preserved vertebrate fossils in southern Colorado, the Pierre Shale is considered to have high paleontological sensitivity (PFYC Class 4).

7.2.9 Quaternary Surficial Deposits

Eight mapped surficial deposits of Quaternary (Pleistocene or Holocene) age occur within the US 24 study area. These include a combination of stream channel, floodplain, sheetwash, landslide, and terrace alluvium deposits (see Table 2), many of which are associated with the Fountain Creek stream drainage. For the purpose of this report, these surficial deposits are combined into two categories: those of Pleistocene and those of Holocene age. This is because, whereas deposits of the former age are too young to contain fossils, deposits of the latter age may be fossiliferous. The distribution of these deposits within the US 24 study area is shown on Figure 2 (Qa, Qa2, Qa1, af) and Figure 3 (Qt3, Qt2, Qsw, Qls).

Holocene-age alluvium is composed primarily of poorly consolidated silt, sand, and cobbles derived from eroded bedrock and older alluvial and colluvial deposits. These sediments are deposited by rivers and streams in stream channels and on active alluvial floodplains. Pleistocene-age alluvium consists of gravel, sand, silt, mud, and clay that forms alluvial terraces and isolated remnants on dissected benches along stream drainages. Sheetwash deposits include sediments that are transported by sheetflow and deposited on the sides of valleys with ephemeral and intermittent streams, on gentle hillslopes below landslides and alluvial fans, and within depositional basins. Landslide deposits consist of rock material that has moved under the influence of gravity. Lithologies of these units vary and are dependent upon the type of source rock. They form on unstable slopes and on older landslides and colluvial deposits. In general, colluvium and landslide deposits are much less likely to contain well-preserved animal and plant remains than intact native sediments. Landslide material is often subjected to increased groundwater percolation, which tends to have a negative effect on the preservation of organic material. Gravitationally induced movement of sediment can also destroy animal and plant remains through abrasion and breakage. Additionally, when the original stratigraphic position of the sediments is disturbed, there are varying degrees of information loss with the severity of changes to the slide mass. Artificial fill consists of clay, silt, sand, gravel, and a variety of man-made debris including concrete, brick, wood, metal, plastic, glass, vegetation, and other trash. It includes engineered and compacted fill for highways, buildings, and bridge abutments; engineered and semi-engineered fill for dams, canal and railway embankments; stream channelization dikes, and some landfills.

Pleistocene surficial deposits, particularly alluvium, may contain mineralized or partially mineralized animal bones, invertebrates, and plant remains of paleontological significance. With the exception of some caves, hot springs, and tar deposits, these fossils typically occur in low density and usually consist of scattered and poorly preserved remains. Nevertheless, many Pleistocene fossils provide important paleobiologic, paleobiogeographic, and paleoenvironmental information and are therefore scientifically important. The most common Pleistocene vertebrate fossils include the bones of mammoth, bison, deer, and small mammals; but other taxa including horse, lion, cheetah, wolf, camel, antelope, peccary, mastodon, and giant ground sloth, have been reported from the Rocky Mountain region (Cook, 1930, 1931; Emslie, 1986; Graham and Lundelius, 1994; Gillette and Miller, 1999; Gillette et al., 1999a, 1999b; Heaton, 1999; Hunt, 1954; Lewis, 1970; Scott, 1963; Smith et al., 1999; unpublished paleontological data, Denver Museum of Nature and Science). Pleistocene-age surficial deposits have low to moderate or unknown paleontological sensitivity (PFYC Class 2, 3a, or 3b).

Holocene surficial deposits contain animal and plant remains (e.g. Hunt, 1954), but these are the unfossilized remains of modern species. Deposits of Holocene age are generally considered too young to contain in-situ fossils, and have low paleontological sensitivity (PFYC Class 2).

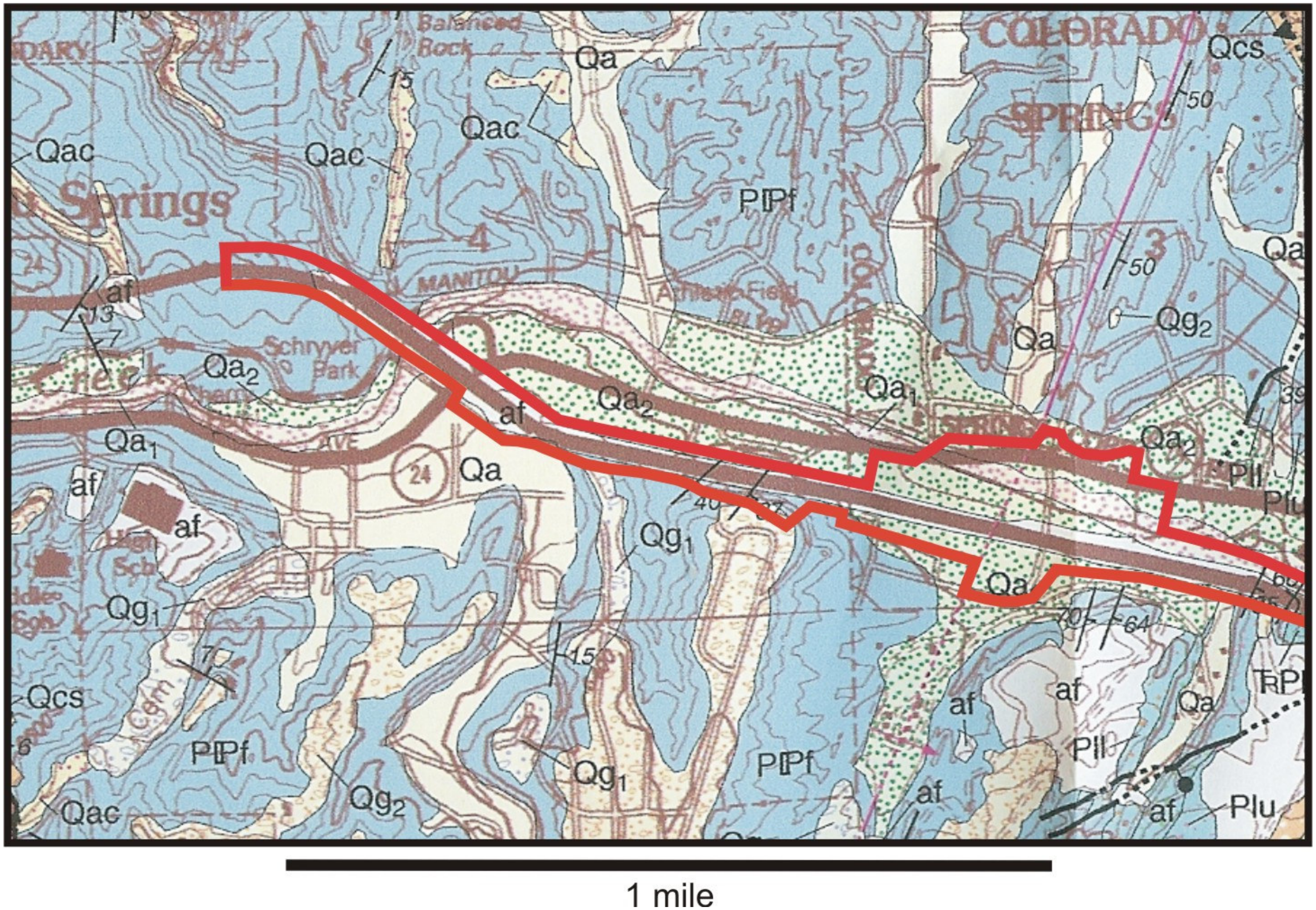


Figure 2. Geologic map of the western part of the study area for the US 24 Project (from Keller et al., 2005). The approximate location of the survey corridor is shown in red. See text sections 7.2.1 to 7.2.9 for geologic unit abbreviations.

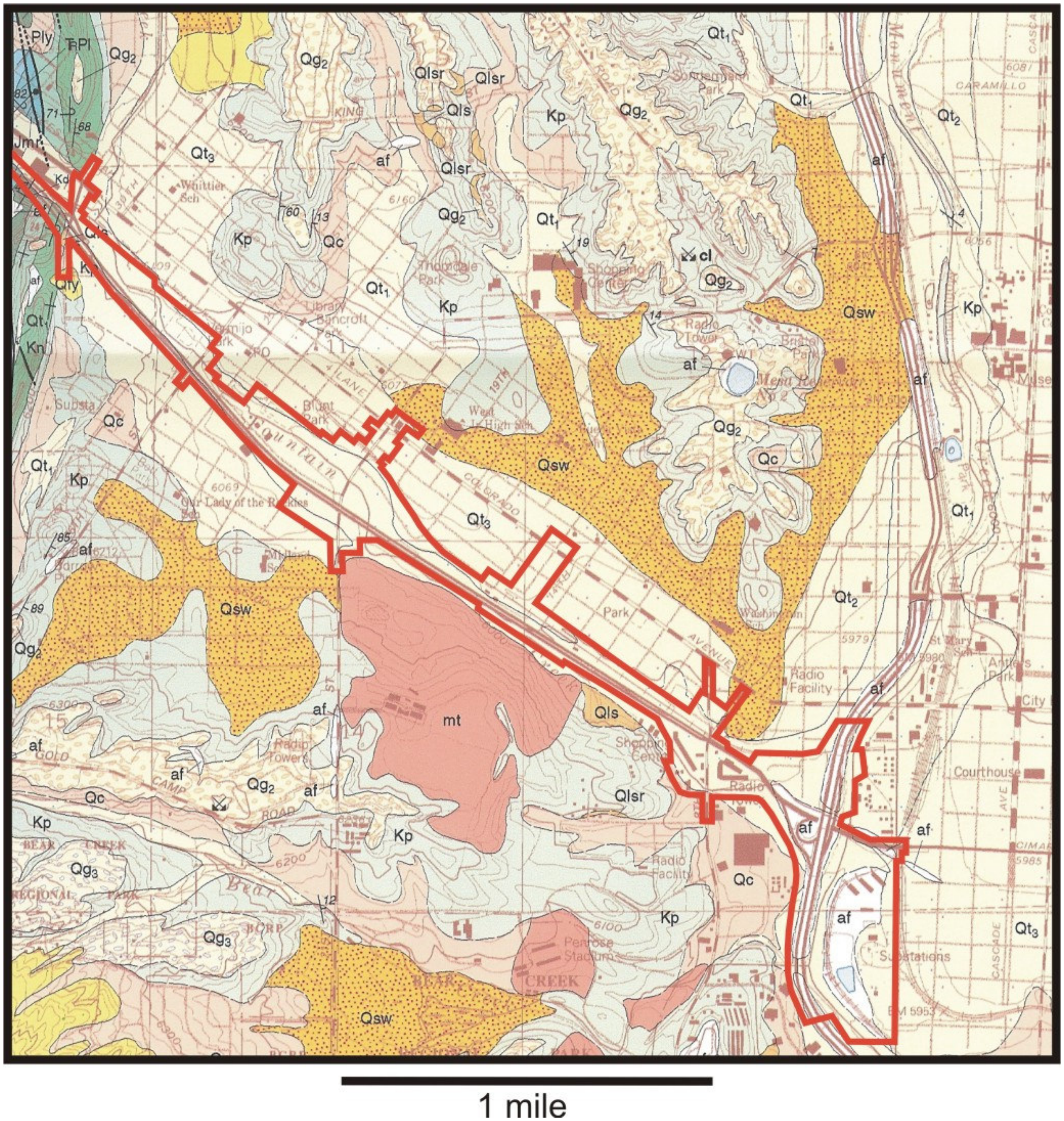


Figure 3. Geologic map of the eastern part of the study area for the US 24 Project (from Carroll and Crawford, 2000). The approximate location of the survey corridor is shown in yellow. See text sections 7.2.1 to 7.2.9 for geologic unit abbreviations.

7.3 Fossil Locality Searches

Because paleontological locality data are confidential and are exempt from the Freedom of Information Act, note that only general fossil locality data are provided in this report.

No specific reports of fossils from within the survey corridor for the US 24 Project were found in museum records. Two UCM localities (Loc. 90049, Loc. 90050) were recorded by the CDOT Staff Paleontologist in the Pierre Shale approximately three miles east of the eastern terminus of the US 24 study area (unpublished UCM paleontological data). These localities yielded six taxa of marine mollusks (ammonites, bivalves, gastropods). As discussed in section 7.2 of this report, numerous invertebrate, plant, trace, and vertebrate fossil occurrences have recently been documented in Red Rock Canyon Open Space which borders a portion of the US 24 study area to the south. These fossil occurrences are documented in an unpublished technical report (Milito, 2008) which includes mention of fossil stromatolites in the Lykins Formation observed in a US 24 road cut (presumably between Ridge Rd. and 31st Street). The recently named Iguanodont dinosaur *Theiophytalia Kerri* was discovered in what is now the Purgatoire Formation in the Garden of the Gods area to the north of the study area (Carpenter and Brill, 2008). In addition to these nearby localities, numerous additional fossil localities in the same eight bedrock geologic units that occur within the US 24 study area (see Table 2) have been documented elsewhere in Colorado in the scientific literature and museum records.

No record of Pleistocene fossils was found within the US 24 study area. However, UCM records include eight Pleistocene fossil localities elsewhere in the Colorado Springs area that produced remains of fossil camel, horse, marmot, and ground squirrel. Both the UCM and DMNS have numerous additional recorded fossil localities in sedimentary deposits of Pleistocene-age elsewhere in Colorado.

7.4 Field Survey

The results of the field survey for the US 24 Project are summarized in this section. The proposed construction includes the widening of US 24 to six lanes from 31st Street to west of 8th Street, to eight lanes from west of 8th Street to I-25, and construction of interchanges at 21st Street, 8th Street and I-25. Work will include modifications to intersecting city streets and replacement of several bridges over Fountain Creek. The majority of the corridor has been previously disturbed and developed, with the exception of the Red Rocks Open Space area in the southwest quadrant of US 24 and 31st Street. The proposed construction will require excavation and benching of bedrock in the southwest quadrant of US 24 and 31st Street. At the base of the bluff at this location it is estimated that the cut will be 20 to 40 feet tapering at the top of the bluff to about 5 feet. The lateral extent of this cut is estimated to be about 300 feet. This excavation will remain within CDOT's right-of-way.

Much of the study area is covered with development (commercial, industrial and residential) with no exposed bedrock (figures 4-9, Figure 11). Areas including Fountain Creek, Monument Creek and various small parks are largely vegetated. The area in the vicinity of the I-25/US 24 interchange is heavily developed (industrial/commercial and residential). Development adjacent to I-25 has encroached on Fountain Creek. From the I-25/US 24 interchange, the study area extends northwest along US 24 through a highly developed and urbanized area with no exposed bedrock. This section of highway is mapped as terrace alluvium (Qt3) (from the I-25/US 24 interchange to South 31st Street). Fountain Creek runs along the north side of US 24 and is within the survey corridor, however access to this area is limited. The creek banks are heavily vegetated and no bedrock was observed anywhere along this segment. The south side of US 24 is developed for a portion of this section, but also includes undeveloped vegetated shoulder extending to the Red Rock Canyon Open Space parking area. A sequence of well exposed upturned Mesozoic rocks is present on the south side of US 24 just west of 31st Street (figures 12 and 13). This area will be excavated for an expanded road cut as part of the proposed US 24 improvements. The western part of the study area (west of Red Rock Canyon Open Space) is undeveloped and includes numerous road cuts and cliffs with well exposed rocks of the Fountain Formation (Figure 10).

Although bedrock is locally well exposed within the study area, no fossils were observed during the field survey of the surface of the study area. However, based on the presence of nearby fossil occurrences in the same geologic units, there is the potential for subsurface fossils within excavations associated with construction. Areas underlain by the Fountain Formation and Quaternary surficial deposits have a low potential to contain fossils, and this includes most of the study area with the exception of the south side of US 24 between Ridge Road and 31st Street. Here, a sequence of upturned and faulted low to very high sensitivity rock units is present including the Lyons Sandstone, Lykins Formation, Ralston Creek and Morrison formations, Dakota Sandstone, Purgatoire Formation, Carlile Shale, Greenhorn Limestone, Graneros Shale, Niobrara Formation, and Pierre Shale. When the project design plans are finalized, the extent of disturbance to moderate and high sensitivity rock units (PFYC Class 3, 4, and 5) should be evaluated, and depending upon the amount of disturbance, paleontological monitoring should be required during construction.

Note: All UTM coordinates listed below were recorded using NAD83 Datum.

Figure 4. View looking north at a portion of the southeast quadrant of the I-25/US 24 interchange along Fountain Creek. Photo taken from UTM 13, 514288 mE, 4297157mN.

Figure 5. View looking southeast at the northeast quadrant of the I-25/US 24 interchange. Photo taken from UTM 13, 514383 mE, 4297791 mN.

Figure 6. View looking northwest on the north side of US 24 along Fountain Creek from 21st Street. Photo from UTM 13, 512269 mE, 4299206 mN.

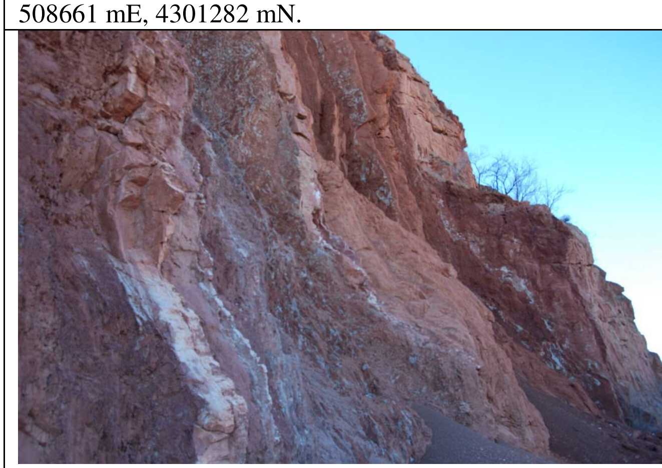
Figure 7. View looking southeast at US 24 along Fountain Creek from 21st Street. Photo from UTM 13, 512269 mE, 4299206 mN.

<u>Figure 8.</u> View looking northwest from Ridge Road on the north side of US 24 with Fountain Creek on the right side of the photograph. Photo taken from UTM 13, 510222 mE, 4300722 mN.

<u>Figure 9.</u> View looking southeast from Ridge Road on the north side of US 24 with Fountain Creek on the left of the photograph. Photo taken from UTM 13, 510222 mE, 4300722mN.

<u>Figure 10.</u> View looking northwest at road cut exposing Fountain Formation on the north side of US 24 west of the Manitou Avenue overpass. Photo taken from UTM 13, 508661 mE, 4301282 mN.

<u>Figure 11.</u> View looking southeast from the Red Rock Canyon Open Space parking entrance on the south side of US 24. Photo taken from UTM 13, 510227 mE, 4300637mN.



<u>Figure 12</u>. View looking southwest at road cut exposure of Lykins Formation on the south side of US 24 between Ridge Road and 31st Street. Photo taken from UTM 13, 510735 mE, 4300554 mN.

<u>Figure 13</u>. View looking southeast at road cut exposure of Lykins Formation (foreground) and Ralston Creek and Morrison formations (background) on the south side of US 24 between Ridge Road and 31st Street. Photo taken from UTM 13, 510735 mE, 4300554 mN.

8.0 RECOMMENDATIONS

1) Based on the results of this study, immediate paleontological clearance for the surface of the study area is recommended. However, additional analysis that may lead to construction monitoring for subsurface fossils is recommended (see #2).

2) When the project design plans are finalized, the CDOT Staff Paleontologist should examine them and determine the amount of impact to geologic units of moderate to very high paleontological sensitivity on the south side of US 24 between Ridge Road and 31st Street, and the scope of paleontological monitoring, if any, which is required.

3) If any sub-surface bones or other potential fossils are found anywhere within the study area during construction, the CDOT Staff Paleontologist should be notified immediately to assess their significance and make further mitigation recommendations.

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