PALEONTOLOGY REPORT
FOR THE
VALLEY HIGHWAY EIS
DENVER, COLORADO

Prepared for:

Federal Highway Administration
Colorado Department of Transportation

Prepared by:
Rocky Mountain Paleontology
Felsburg Holt & Ullevig

October 28, 2003

TABLE OF CONTENTS

Page

1.0 SUMMARY 1-1

2.0 RESOURCE DEFINITION AND REGULATORY PROTECTION 2-1

3.0 RESOURCE ASSESSMENT GUIDELINES 3-1

4.0 SURVEY PROCEDURES 4-1

4.1 Paleontological Literature and Museum Records Review 4-1

4.2 Field Survey 4-1

5.0 GEOLOGY AND PALEONTOLOGY 5-1

5.1 Denver Formation 5-1

5.2 Broadway Alluvium 5-1

5.3 Eolian Sand 5-2

5.4 Colluvium 5-2

5.5 Piney Creek and Post-Piney Creek Alluvium 5-2

5.6 Artificial Fill 5-2

6.0 SURVEY RESULTS 6-1

7.0 RECOMMENDATIONS 7-1

LIST OF FIGURES

Page

Figure 1 Boundaries of the Paleontological Study for the Valley Highway EIS 4-2
Figure 2 Geologic Map of the Valley Highway EIS Study Area..... 6-3

LIST OF TABLES

Page

Table 1 Fossil Localities within the Search Area* for the EIS 6-1
Table 2 Geologic Units within the Study Area and Their Paleontologic Sensitivities..... 6-2

1.0 SUMMARY

Paleontologic field surveys for the I-25 Valley Highway (Logan to 6th Avenue) Environmental Impact Study (EIS) were conducted on April 28 and July 10, 2003. Located in the city of Denver, Colorado, the study area extends along the Valley Highway (Interstate 25) from Logan Street approximately three miles northwest to 6th Avenue, and lies within Sections 4, 5, 8, 9, 10, 15 and 16, T. 4 S., R. 68 W. The field surveys consisted of a combination of drive-by and pedestrian inspections of the study area for 1) surface fossils, 2) exposures of potentially fossiliferous rocks, and 3) areas in which fossiliferous rocks or younger potentially fossiliferous surficial deposits could be exposed or otherwise impacted during ground disturbing activities. Prior to the field survey, literature and museum record searches were conducted in order to assess the paleontologic sensitivity of the study area and the geologic units present within it. The recommendations made in this study are designed to mitigate adverse impacts to significant non-renewable paleontological resources resulting from ground disturbance within the study area. The study area includes seven mapped geologic units (Lindvall 1978, Shroba 1980). Surficial deposits include Broadway Alluvium, eolian sand, colluvium, Piney Creek Alluvium, Post-Piney Creek Alluvium, and artificial fill, from roughly oldest to youngest. These units all have low paleontological sensitivity (Type 3 of Raup 1987; Class 2 of Probable Fossil Yield Classification [PFYC], see Resource Assessment Guidelines). The only bedrock geologic unit within the study area is the Denver Formation, which contains locally abundant and scientifically significant plant fossils and less common vertebrate fossils, and has moderate to high paleontological sensitivity (Type 2 of Raup 1987; Class 3 of PFYC).

No fossils were found during the field survey for this study; however, previously documented scientifically significant fossils have been reported from surficial deposits of late Pleistocene age and rocks of the Denver Formation within and near the study area, and are known to occur within the same geologic units elsewhere in Colorado. This indicates the potential for ground disturbing activities to adversely impact paleontological resources within the study area, but the potential varies with the sensitivity of each geologic unit. Monitoring of areas where Denver Formation rocks may be disturbed is recommended, although this should be evaluated on a project-specific basis. As project design plans are finalized, the Colorado Department of Transportation (CDOT) paleontologist should examine them to determine the extent of impact to the Denver Formation, and the scope of monitoring work, if any, which is required. Although the paleontologic sensitivity of the surficial deposits (primarily alluvium) within the study area is low because they typically contain few fossils, construction personnel should be made aware of the potential to encounter fossils while excavating. If any sub-surface bones, leaf impressions, or other potential fossils are found during construction, the CDOT paleontologist should be notified immediately to assess their significance and make further recommendations.

2.0 RESOURCE DEFINITION AND REGULATORY PROTECTION

Paleontological resources are the mineralized (fossilized) remains of prehistoric plant and animal organisms, as well as the mineralized impressions (trace fossils) left as indirect evidence of the form and activity of such organisms. These are considered to be non-renewable resources significant to our culture under state and federal law:

- National Environmental Policy Act, 1969 (NEPA) (P.L. 91-190; 31 Stat. 852, 42 U.S.C. 4321-4327)
- State of Colorado CRS 1973 (24-80-401 through 409)

This paleontological study is designed to assess whether significant paleontological resources exist within the EIS area. Measures are proposed to mitigate potential adverse effects to these resources. This study complies with pertinent regulatory rulings and guidelines, and professional standards of paleontological resource surveys, data recovery, analysis and curation (SVP 1994). It employs the resource evaluation criteria listed under Resource Assessment Guidelines below (Section 3.0).

3.0 RESOURCE ASSESSMENT GUIDELINES

The paleontologic sensitivity of the study area was evaluated using criteria proposed by Raup (1987), and the Probable Fossil Yield Classification (PFYC) developed by the US Forest Service.

Rocky Mountain Paleontology has modified the PFYC to include fossil plants. This five-tier scheme is summarized below:

- **Class 1**: Igneous and metamorphic geologic units (excluding tuffs) that are not likely to contain recognizable fossil remains. Ground-disturbing activities will not require mitigation except in rare circumstances.
- **Class 2**: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant invertebrate (or plant) fossils. Ground-disturbing activities are not likely to require mitigation.
- **Class 3**: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Ground-disturbing activities will require sufficient mitigation to determine whether significant paleontologic resources occur in the area of a proposed action. Mitigation beyond initial findings will range from no further action necessary to full and continuous monitoring of significant localities during the action.
- **Class 4**: Class 4 geologic units are Class 5 units that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation. Proposed ground-disturbing activities will require assessment to determine whether significant paleontologic resources occur in the area of a proposed action and whether the action will impact the resources. Mitigation beyond initial findings will range from no further mitigation necessary to full and continuous monitoring of significant localities during the action. This classification will often not be applied until after on-the-ground assessments are made.
- **Class 5**: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant invertebrate (or plant) fossils, and that are at high risk of natural degradation and/or human-caused adverse impacts. These areas are likely to be poached. Mitigation of ground-disturbing activities is required and may be intense. Areas of special interest and concern should be designated and intensely managed.

Raup's (1987) criteria for the evaluation of paleontologic resources are summarized below:

- **Type 1**: Formations known to produce large numbers of vertebrate fossils are considered to have high paleontologic sensitivity.
- **Type 2**: Formations known to produce abundant numbers of invertebrate, plant, and trace fossils, and that more rarely produce vertebrate fossils, are considered to have moderate paleontologic sensitivity.
- **Type 3**: Formations that only rarely produce fossils are considered to have low paleontologic sensitivity.
  In general, invertebrate, plant, and trace fossils occur in large numbers when they are found, are not considered as significant as relatively uncommon vertebrate fossils.

In addition to the criteria proposed above, a 1978 memorandum from Griswold E. Petty (then acting director of the US Department of the Interior, Bureau of Land Management [BLM]) proposed the following guidelines to determine the significance of a paleontological resource. A paleontological resource is considered significant if any of the following are met:

- It provides important information on evolutionary trends, relating living organisms to extinct organisms.
- It provides important information pertaining to biological community development and zoological/botanical biota interaction.
- It demonstrates unusual circumstances in biotic history.
- It consists of a limited sample size, in danger of depletion or destruction by natural processes, vandalism or commercial exploitation, and is found in no other geographic location.

4.0 SURVEY PROCEDURES

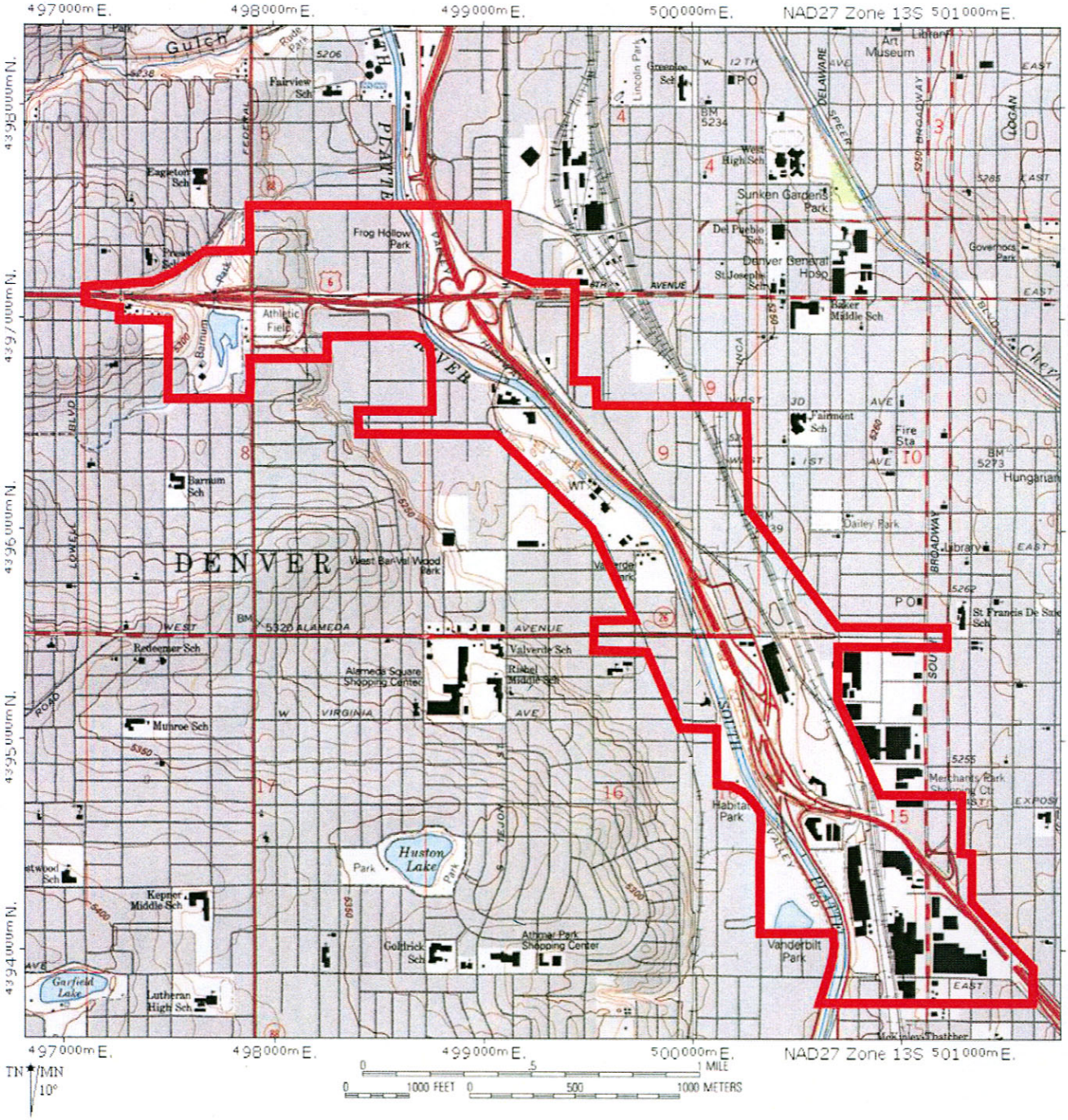
Located in the city and county of Denver, Colorado, the study area extends along the I-25 Valley Highway from Logan Street approximately three miles northwest to 6th Avenue, and along 6th Avenue from the I-25 interchange to Lowell Boulevard. It lies within Sections 4, 5, 8, 9, 10, 15, and 16, T. 4 S., R. 68 W. (Figure 1). The study was conducted under State of Colorado Paleontological Permit 2003-30.

4.1 *Paleontological Literature and Museum Records Review*

Prior to the field survey, data for this study were compiled from paleontological literature, previous geological and paleontological investigations, and museums. Data collection also included published descriptions of the geology, including geologic maps. The primary sources consulted on the geology of the study area and surrounding vicinity included geologic maps compiled by the US Geological Survey. These include the 1:24,000 scale geologic maps of the Arvada (Lindvall 1979), Commerce City (Lindvall 1980), Englewood (Shroba 1980) and Fort Logan (Lindvall 1978) 7.5' quadrangles, and the 1:100,000 scale map of the Greater Denver area, Front Range urban corridor (Trimble and Machette 1979). Museums included in the record search included the University of Colorado Museum (UCM) and the Denver Museum of Nature and Science (DMNS), the two primary paleontological repositories in the area. The purpose of the paleontological literature and records review was to 1) determine whether any known fossil localities occur within the study area; 2) assess the potential for disturbance of these localities during construction; and 3) evaluate the paleontological sensitivity of the rock formations and/or surficial deposits within the study area using existing data.

4.2 *Field Survey*

The results of the paleontological literature and museum records review assisted in a determination of the appropriate field survey coverage for the EIS. The field survey was conducted by Paul C. Murphey, Ph.D., Principle Investigator of Rocky Mountain Paleontology. It consisted of both "drive-by" and "pedestrian" inspections for 1) occurrences of surface fossils, 2) exposures of potentially fossiliferous rocks, and 3) areas in which fossiliferous rocks or younger potentially fossiliferous surficial deposits could be exposed or otherwise impacted during construction. In general, areas which were covered by existing construction were not subject to a pedestrian survey (but were located by drive-by inspection), while more open and undeveloped areas, including those in which the degree of prior disturbance was questionable, were subject to a 100% pedestrian survey. Pedestrian surveys were thus concentrated primarily along the I-25 corridor and along the South Platte River drainage, as well as adjacent presently undeveloped areas.



LEGEND

= EIS Valley Corridor Study Limits

North

Boundaries of the Paleontological Study for the Valley Highway EIS

Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

Figure 1

5.0 GEOLOGY AND PALEONTOLOGY

The EIS area includes seven mapped geologic units (Lindvall 1978, Shroba 1980). The only bedrock geologic unit within it is the Denver Formation. Surficial deposits include Broadway Alluvium, Piney Creek Alluvium, Post-Piney Creek Alluvium, eolian sand, colluvium, and artificial fill, from oldest to youngest.

5.1 *Denver Formation*

The Denver Formation within the EIS area is latest Cretaceous (Maastrichtian) in age. Lithologically, it consists of dark brown, yellowish-brown, and grayish-olive tuffaceous claystones, mudstones, and sandstones interbedded with scattered conglomerates (Bryant et al. 1981, Soister 1978, Trimble and Machette 1979). The Denver Formation is largely composed of altered andesitic (volcanic) debris. It is considered to have moderate to high paleontologic sensitivity because it contains locally abundant and scientifically significant plant fossils (Brown 1943, 1962; Ellis et al. 2003; Johnson and Ellis 2002; Knowlton 1930), and a less abundant but scientifically important fossil vertebrate fauna (Eberle 2003, Middleton 1983) (Type 2 of Raup 1987; Class 3 of PFYC). The geology and paleontology of the Denver Formation is the subject of active research by scientists and students at the Denver Museum of Nature and Science and University of Colorado Museum. This work has added considerably to our understanding of the geologic and biologic history of the Denver Basin and surrounding areas during the late Cretaceous and Paleocene (Eberle 2003, Ellis et al. 2003, Johnson and Ellis 2002, Johnson and Raynolds 1999). Future fossil finds from the Denver Formation will add to this ongoing research effort, and because it is largely covered throughout its distribution in the Denver area, excavations associated with new construction that expose Denver Formation rocks are an important data source.

5.2 *Broadway Alluvium*

The Broadway Alluvium is composed of light brown, non-calcareous, clean to slightly silty pebbly sand interbedded with sandy silt to silty sand along the South Platte River in central Denver, where it forms terraces which are approximately 18 to 30 feet thick (Shroba 1980). It is known to contain scattered fossil remains including mammoth, horse, bison, camel, and smaller mammals (Hunt 1954; unpublished UCM and DMNS locality data). Pleistocene-aged deposits, particularly alluvium, may contain mineralized or partially mineralized animal bones, invertebrates, and plant remains of paleontologic significance. In Colorado, the most common Pleistocene fossils include the bones of mammoth, bison, deer, and small mammals (Cook 1930, 1931; Emslie 1986; Hunt 1954; Lewis 1970; Scott 1963; unpublished UCM and DMNS collections data). Because these fossils are typically scarce and poorly preserved in Pleistocene alluvium in Colorado, including the Broadway Alluvium, this unit is considered to have low paleontologic sensitivity (Type 3 of Raup 1987; Class 2 of PFYC).

5.3 *Eolian Sand*

Eolian sand deposits within the study area are reported to be Upper Holocene and Upper Pleistocene in age (Shroba 1980), and consist of windblown light yellowish-brown to yellowish-brown, silty very fine to very coarse sand. These deposits cover large areas on the eastern side of major stream drainages, and are typically less than 10 feet but locally more than 30 feet thick (Lindvall 1980, Shroba 1978). Although windblown loess deposits of Upper Pleistocene age in eastern Colorado have produced a relatively diverse fossil mammal fauna (Scott 1963; Steven Wallace [CDOT], written communication 2000), fossils are rare in eolian sand, and it is considered to have low paleontologic sensitivity (Type 3 of Raup 1987; Class 2 of PFYC).

5.4 *Colluvium*

The colluvium within the study area is reported to be Holocene to Pleistocene in age, and consists of light brown to yellowish-brown, slightly calcareous, pebbly to cobbly clayey sandy silt to silty sand. It is frequently less than 5 feet thick (Lindvall 1978, Shroba 1980). Although they can occur in Pleistocene-aged colluvium, fossils are typically scattered and uncommon in both colluvium and landslide deposits, and these units are considered to have low paleontologic sensitivity (Type 3 of Raup 1987; Class 2 of PFYC).

5.5 *Piney Creek and Post-Piney Creek Alluvium*

The Piney Creek Alluvium consists of light gray to dark grayish-brown, humic, slightly calcareous, sandy silt and clay overlying noncalcareous, clean to silty pebbly sand interbedded with sandy silt with a thickness of approximately 18 to 25 feet along the South Platte River in central Denver (Lindvall 1978, Shroba 1980). The Post-Piney Creek Alluvium consists of light gray to light brown, non-calcareous, clean to slightly silty pebbly sand interbedded with sandy silt and with a thickness of approximately 3 to 10 feet (Lindvall 1978, Shroba 1980). Both the Piney Creek and Post-Piney Creek Alluvium are Upper Holocene in age, and are thus considered to be “recent” deposits. Holocene-aged deposits contain the unfossilized remains of modern species of plants and animals, as well as possible charcoal hearths and stone artifacts of human origin (Hunt 1954). These units are considered to have low paleontologic sensitivity (Type 3 of Raup 1987; Class 2 of PFYC).

5.6 *Artificial Fill*

The artificial fill within the study area is composed of imported clay, silt, sand, gravel, and a variety of debris including concrete, brick, wood, metal, plastic, glass, vegetation, and other trash. It is generally 5 to 15 feet thick, but locally up to 40 feet thick, and it is used for highways, buildings, bridge abutments, canal and railway embankments, and stream channelization dikes (Shroba 1980). It has low paleontologic sensitivity (Type 3 of Raup 1987; Class 2 of PFYC).

6.0 SURVEY RESULTS

No fossils were found during the field survey for this study. Previously documented fossil localities have, however, been reported from within and near the EIS area. These reports come from the scientific literature, previous technical reports, and unpublished UCM and DMNS paleontological specimen and locality data. Those localities occurring within the EIS museum record search area are listed in Table 1, and other pertinent localities are discussed below.

Table 1 Fossil Localities within the Search Area* for the EIS

Repository or Data Source	Locality # or Name	Formation or age	Location	Fossils found
DMNS	224	Pleistocene	SW SW NE Sec. 9, T. 4 S., R. 67 W.	Mammoth tooth
DMNS	1086	Pleistocene	SW SW W Sec. 22, T. 4 S., R. 67 W.	Mammoth teeth and tusk, horse tooth
DMNS	1089	Pleistocene	NW SW NE Sec. 23, T. 4 S., R. 67 W.	Camel vertebrae
DMNS	1091	Pleistocene	Sec. 16 and 22, T. 4 S., R. 67 W.	Mammoth tooth
DMNS	1096	Pleistocene	S 1/2 Section 15, T. 4 S., R. 67 W.	Mammoth tooth
DMNS	1285	Cretaceous	NW SW NW W Sec. 22,T. 4 S., R. 67 W.	Plants
DMNS	2029	Cretaceous	NW SE Sec. 21, T. 4 S., R. 67 W.	Plants
Monitoring project in progress, report not yet prepared	DD040602-01 (R Mtn. Paleo. field #)	Cretaceous	UTM 13S 500873 mE, 4393887 mN	Plants
* (Sections 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 21, 22, and 23, T. 4 S., R. 68 W)				

Prior paleontological technical reports from within or near the study area that were available for inspection include Murphey (1999a, 1999b, 2000, 2001, 2002), but these list no localities not included in this report. Within the EIS area, one locality that has not yet been reported occurs at UTM 13S, 500873 mE, 4393887 mN (see Table 1). Here, in March 2002, Denver Formation bedrock was exposed at a depth of 3 feet in an excavation adjacent to Santa Fe Drive and Washington Street associated with the ongoing TREX (widening of I-25) project in an area mapped as Piney Creek Alluvium, and significant Cretaceous plant fossils were collected. The fossils were transferred to the DMNS where they will be curated along with other Denver Formation plant fossils collected during the TREX project. Monitoring for this project is ongoing and so a final report has not yet been prepared.

In addition to the localities listed in Table 1, numerous other reports of fossils from the area exist. Cannon (1893) mentions a mammoth tooth from a cellar excavation at 16th and Larimer, just north of the study area. In a 1906 publication, Cannon reports that mammoth molars were found near the corners of 14th and Lawrence streets and at 17th and California Streets in downtown Denver. He mentions other occurrences as well, but the locality data are too vague to permit precise relocation. C.B. Hunt reports that more than 100 “collections” of Pleistocene and recent mammal remains were made during the field work for his 1954 study, with an additional 32 from the Denver Museum of Natural History (now DMNS). These were mostly collected from alluvium (Hunt 1954, p. 118), and he notes that practically all consisted of “single bones, and a

large proportion of them are fragmentary." Hunt's report attests to the mostly isolated nature of Pleistocene skeletal remains in the Denver area.

UCM locality 92121 ("Sheep Thrill"), from the Pleistocene Louviers Alluvium, is located in Section 28, T. 3 S., R. 68 W., several miles northeast of the study area. During the construction of Coors Baseball Field approximately 2 miles to the north, dinosaur rib fragments and a palm frond were collected from the NW NW NE Section 27, T. 3 S., R. 68 W. A fossil camel tooth was collected from NE NE SW SE Section 34, T. 3 S., 68 W., approximately 1.5 miles northeast of the study area. These latter two are DMNS localities.

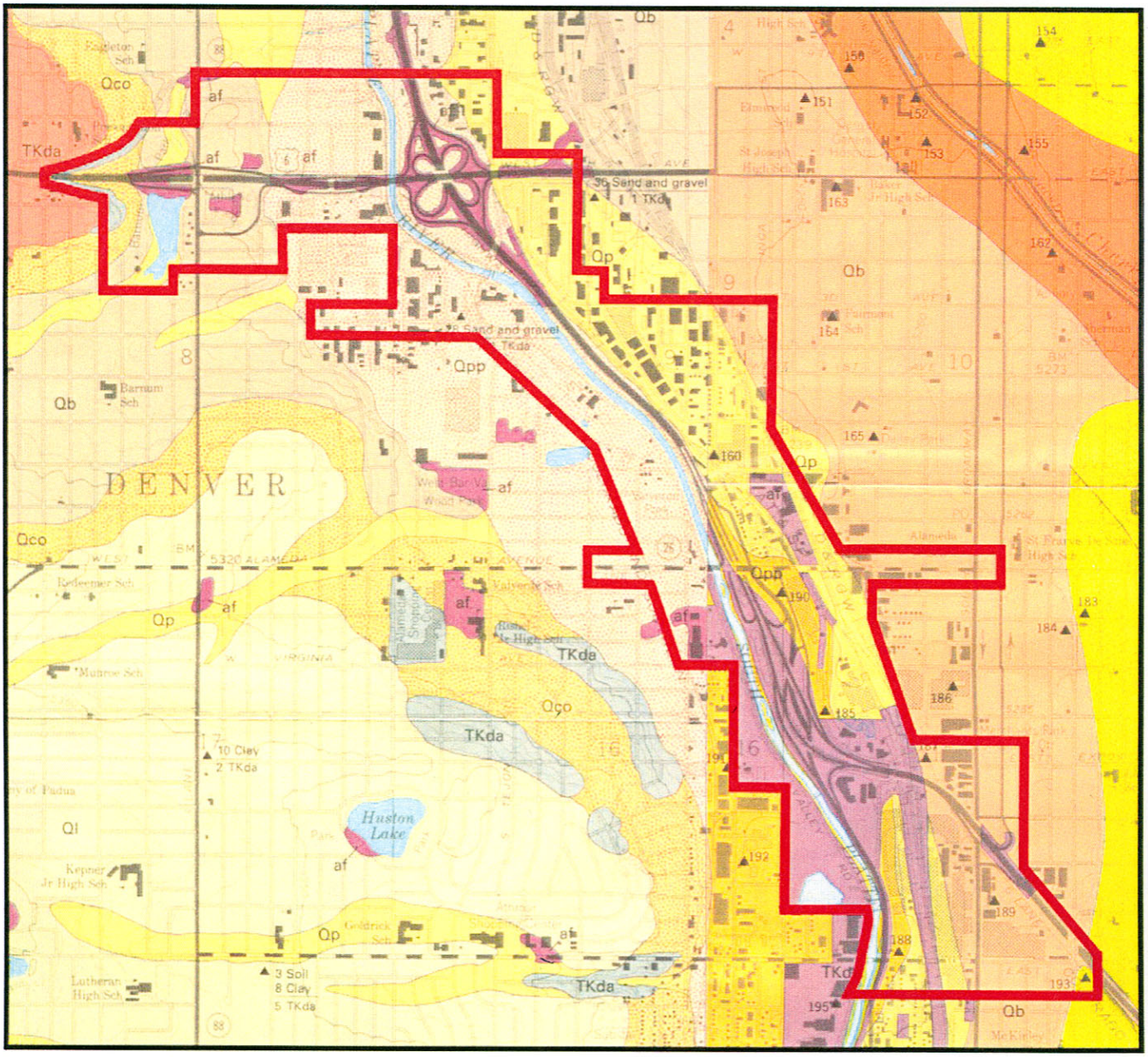
Attesting to the paleontologic sensitivity of the Denver Formation, the UCM has over 600 vertebrate fossils from 59 localities in the Denver Formation from around the Denver Basin. The DMNS has fewer vertebrates but maintains a large and growing collection of Denver Formation fossil plants and an active stratigraphic and paleobotanical research program (see Section 5.1).

The paleontological sensitivities of the geologic units within the study area are summarized in Table 2, and their approximate locations shown in Figure 2. With moderate to high paleontologic sensitivity, the Denver Formation underlies the surficial deposits within the survey corridor at various and largely unpredictable depths because of the varying thickness of surficial alluvial, eolian and colluvial deposits. Isolated and relatively small surface exposures of the Denver Formation are mapped by Lindvall (1978) and Shroba (1980), but none were observed during the field survey.

Table 2 Geologic Units within the Study Area and Their Paleontologic Sensitivities

Rock Unit	Reported Thickness	Age	Sensitivity
Denver Formation	N/A (bedrock)	Cretaceous	Moderate to high; Class 3 of PFYC
Broadway Alluvium	~ 18–30 feet	Pleistocene	Low; Class 2 of PFYC
Eolian sand	~ 10–30 feet	Holocene to Pleistocene	Low; Class 2 of PFYC
Colluvium	< 5 feet	Holocene to Pleistocene	Low; Class 2 of PFYC
Piney Creek Alluvium	~ 18–25 feet	Holocene	Low; Class 2 of PFYC
Post-Piney Creek Alluvium	~ 3–10 feet	Holocene	Low; Class 2 of PFYC
Artificial Fill	~ 5–15 feet	Recent	Low; Class 2 of PFYC

Notes: Thicknesses and ages from Lindvall (1978) and Shroba (1980).
See Resource Assessment Guidelines for sensitivity definitions.



1 MILE

LEGEND

=	EIS Valley Corridor Study Limits	Qpp =	Post-Piney Creek Alluvium
af =	Artificial Fill	Qp =	Piney Creek Alluvium
Qc =	Colluvium	Qb =	Broadway Alluvium
Qes =	Eolian Sand	TKd &TKda =	Denver Formation

North

Geologic Map of the Valley Highway EIS Study Area

Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

Figure 2

7.0 RECOMMENDATIONS

Based on the results of this study, the following recommendations are made:

1. Monitoring of areas within the EIS where Denver Formation rocks may be impacted is recommended, but this should be evaluated on a project-specific basis because of the varying and unpredictable thickness of the Pleistocene and Holocene sediments which mantle Denver Formation bedrock in most places. As project design plans are finalized, the CDOT or other qualified paleontologist should examine them to determine the extent of impact to the Denver Formation, and the scope of monitoring and mitigation work, if any, which is required. Where monitoring or other mitigation efforts are recommended, these should be supervised by a qualified professional paleontologist using standards set forth by the Society of Vertebrate Paleontology (SVP 1994).

2. Although the paleontologic sensitivity of the surficial deposits (primarily alluvium) within the study area is considered low because the fossils they contain are typically isolated and poorly preserved, this report has clearly demonstrated that numerous such fossils of Pleistocene age have been recovered from the central Denver area. During worker environmental awareness training, construction personnel should be made aware of the potential to encounter such fossils while excavating. If any sub-surface bones, leaf impressions, or other potential fossils are found during construction, the CDOT paleontologist should be notified immediately to assess their significance and make further recommendations.

REFERENCES

Brown, R.W., 1943, Cretaceous-Tertiary boundary in the Denver Basin, Colorado: *Geological Society of America Bulletin*, v. 54, p. 65-86.

Brown, R.W., 1962, Paleocene flora of the Rocky Mountains and the Great Plains: *U.S. Geological Survey Professional Paper* 375, 119 p.

Bryant, B., McGrew, L., and Wobus, R.A., 1981, Geologic map of the Denver 1° X 2° Quadrangle, north-central Colorado: *U.S. Geological Survey Miscellaneous Investigations Map*, I-1163, 2 sheets (scale 1:250,000).

Cannon, G.L., 1893, The geology of Denver and vicinity: *Proceedings of the Colorado Scientific Society*, v. 4, p. 235-270.

Cannon, G.L., 1906, notes on some fossils recently discovered near Denver, Colorado: *Proceedings of the Colorado Scientific Society*, v. 8, p. 194-198.

Cook, H.J., 1930, Occurrence of mammoth and giant bison in Glacial moraines in the high mountains of Colorado: *Science*, v. 72, no. 1855, p. 68.

Cook, H.J., 1931, More evidence of mammoths in the high mountains of Colorado: *Science*, v. 73, no. 1889, p. 283-284.

Denver Museum of Nature and Science, unpublished *paleontological specimen and locality data*.

Eberle, J.J., 2003, Puercan mammalian systematics and biostratigraphy in the Denver Formation, Denver Basin, Colorado: *Rocky Mountain Geology*, vol. 38, no. 1, p. 143-169.

Emslie, S.D., 1986, Late Pleistocene vertebrates from Gunnison County, Colorado: *Journal of Paleontology*, v. 60, no. 1, p. 170-176.

Ellis, E., Johnson, K.R., and Dunn, R.E., 2003, Evidence for an in situ early Paleocene rainforest from Castle Rock, Colorado: *Rocky Mountain Geology*, v. 38, no. 1, p. 73-100.

Hunt, C.B., 1954, Pleistocene and Recent deposits in the Denver area, Colorado: *U.S. Geological Survey Bulletin* 996-C, pp. 91-140.

Johnson, K., and Raynolds, R.G., 1999, Field trip guide to Upper Cretaceous and Tertiary Formations and fossils plants and vertebrates of the northwestern Denver Basin: *Field Trip Guidebook for the 1999 Annual Meeting of the Society of Vertebrate Paleontology, Denver*, 13 p.

Johnson, K.R., and Ellis, E., 2002, A tropical rainforest in Colorado: 1.4 million years after the Cretaceous-Tertiary boundary: *Science*, v. 296, p. 2379-2383.

Knowlton, F.H., 1930, The flora of the Denver and associated formations in Colorado: *U.S. Geological Survey Professional Paper* 130, 175p.

Lewis, G.E., 1970, New discoveries of Pleistocene bison and peccaries in Colorado: *U.S. Geological Survey Professional Paper* 700-B, p. B137-B140.

Lindvall, R.M., 1978, Geologic map of the Fort Logan Quadrangle, Jefferson, Denver, and Arapahoe Counties: *U.S. Geological Survey Map* GQ-1427, scale 1:24,000 (1 sheet).

Lindvall, R.M., 1979, Geologic map of the Arvada Quadrangle, Adams, Denver and Jefferson counties, Colorado: *U.S. Geological Survey Map* GQ-1453, Scale 1:24,000, 1 sheet.

Lindvall, R.M., 1980, Geologic map of the Commerce City Quadrangle, Adams and Denver Counties, Colorado: *U.S. Geological Survey Map* GQ-1541, Scale 1:24,000, 1 sheet.

Middleton, M.D., 1983, Early Paleocene vertebrates of the Denver Basin, Colorado: *Doctoral Dissertation, University of Colorado, Boulder*, 402 p.

Murphey, P.C., 1999a, Paleontologic assessment of the Washington Street widening and bridge replacement project, Denver, Colorado: *Unpublished report prepared for HNTB Engineers*, 3 p.

Murphey, P.C., 1999b, Paleontologic assessment of the Interstate 25 Corridor and associated interchanges between 9th and Florida Avenues, Denver, Colorado: *Unpublished report prepared for Balloffet and Associates*, 6 p.

Murphey, P.C., 2000, Paleontologic assessment for the Adesta Ring-Closure Project, Denver City and County, Colorado: *Unpublished report prepared for SWCA Environmental Consultants, Inc.*,12 p.

Murphey, P.C., 2001, Paleontologic assessment for the proposed improvements to the Interstate 25/23rd Avenue Interchange, Denver City and County, Colorado: *Unpublished report prepared for Smith Environmental Inc.*, 8 p.

Murphey, P.C., 2002, Paleontologic sensitivity review of forty one intersections in downtown Denver, Colorado: *Unpublished report prepared for Associated Cultural Resource Experts*, 11 p.

Raup, D.M., 1987, Paleontological Collecting: *Committee on Guidelines for Paleontological Collecting, National Academy of Sciences*, National Academy Press, Washington, D.C., 243 pp.

Scott, G.R., 1963, Quaternary geology and geomorphic history of the Kassler Quadrangle, Colorado: *U.S. Geological Survey Professional Paper* 421-A, 70 p.

Society of Vertebrate Paleontology, 1994, Newsletter of the Society of Vertebrate Paleontology, p. 152.

Soister, P.E., 1978, Stratigraphy of uppermost Cretaceous and lower Tertiary rocks of the Denver Basin, in Pruit, J.D., and Coffin, P.E., eds., *Energy Resources of the Denver Basin: Rocky Mountain Association of Geologists*, p. 231-235.

Shroba, R.R., 1980, Geologic map and physical relief properties of the surficial and bedrock units of the Englewood Quadrangle, Denver, Arapahoe, and Adams Counties, Colorado: *USGS Geological Survey Map* GQ-1524, scale 1:24,000 (1 sheet).

Trimble, D.E., and Machette, M.N., 1979, Geologic map of the greater Denver area, Front Range urban corridor, Colorado: *U.S. Geological Survey Miscellaneous Geologic Map*, I-856-H, scale 1:100,000, 1 sheet.

United States Forest Service, 1996, Probable fossil yield classification (PFYC): *Developed by the Paleontology Center of Excellence and the Region 2 (USFS) Paleo Initiative*.

University of Colorado Museum, *unpublished paleontological specimen and locality data*.