Northwest Corridor
A TRANSPORTATION ENVIRONMENTAL STUDY

TABLE OF CONTENTS

Page

4.14 PALEONTOLOGICAL RESOURCES 4.14-1
4.14.1 Affected Environment 4.14-1
4.14.1.1 Fossiliferous Geologic Units and Paleontological Sensitivity 4.14-3
4.14.1.2 Fossil Localities 4.14-6
4.14.2 Environmental Consequences 4.14-6
4.14.2.1 Impacts Common to All Build Alternatives 4.14-7
4.14.2.2 No Action Alternative 4.14-7
4.14.2.3 Freeway Alternative 4.14-8
4.14.2.4 Tollway Alternative 4.14-9
4.14.2.5 Regional Arterial Alternative 4.14-9
4.14.2.6 Combined Alternative (Recommended Alternative) 4.14-10
4.14.3 Suggeted Mitigation 4.14-11
4.14.3.1 Supplemental Preliminary Survey and Impact Assessment 4.14-11
4.14.3.2 Preconstruction Fossil Collection 4.14-11
4.14.3.3 Construction Monitoring 4.14-11
4.14.3.4 Suggested Project-Specific Mitigation Measures 4.14-12
4.14.4 Summary 4.14-13

LIST OF FIGURES

Page

Figure 4.14-1 Leaf Fossil and Dinosaur Tracks Located in the Project Vicinity 4.14-2
Figure 4.14-2 Paleontological Sensitivities of Geologic Units in the Northwest Corridor APE..... 4.14-4

LIST OF TABLES

Page

Table 4.14-1 Paleontological Sensitivity of Geologic Units in the Northwest Corridor APE 4.14-5
Table 4.14-2 Previously Recorded Fossil Localities Within the Northwest Corridor APE..... 4.14-6

4.14 PALEONTOLOGICAL RESOURCES

INTRODUCTION

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. 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.

Fossils are considered non-renewable scientific resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced. Fossils are protected by various laws, ordinances, regulations, and standards (LORS) across the country. The federal LORS that could apply to this project include:

- The National Environmental Policy Act of 1969.
- Archaeological and Historic Preservation Act of 1974.

More information about these LORS is available (see **Northwest Corridor Supporting Technical Document-Paleontology Assessment**). Federal protection for scientifically important paleontological resources could apply 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.

The state LORS that could apply to this project are contained in the Colorado Historical, Prehistorical, and Archaeological Resources Act of 1973.

There are no local (city or county) LORS, nor do any LORS apply to privately owned lands in the State of Colorado. No public concerns were expressed through the public involvement process.

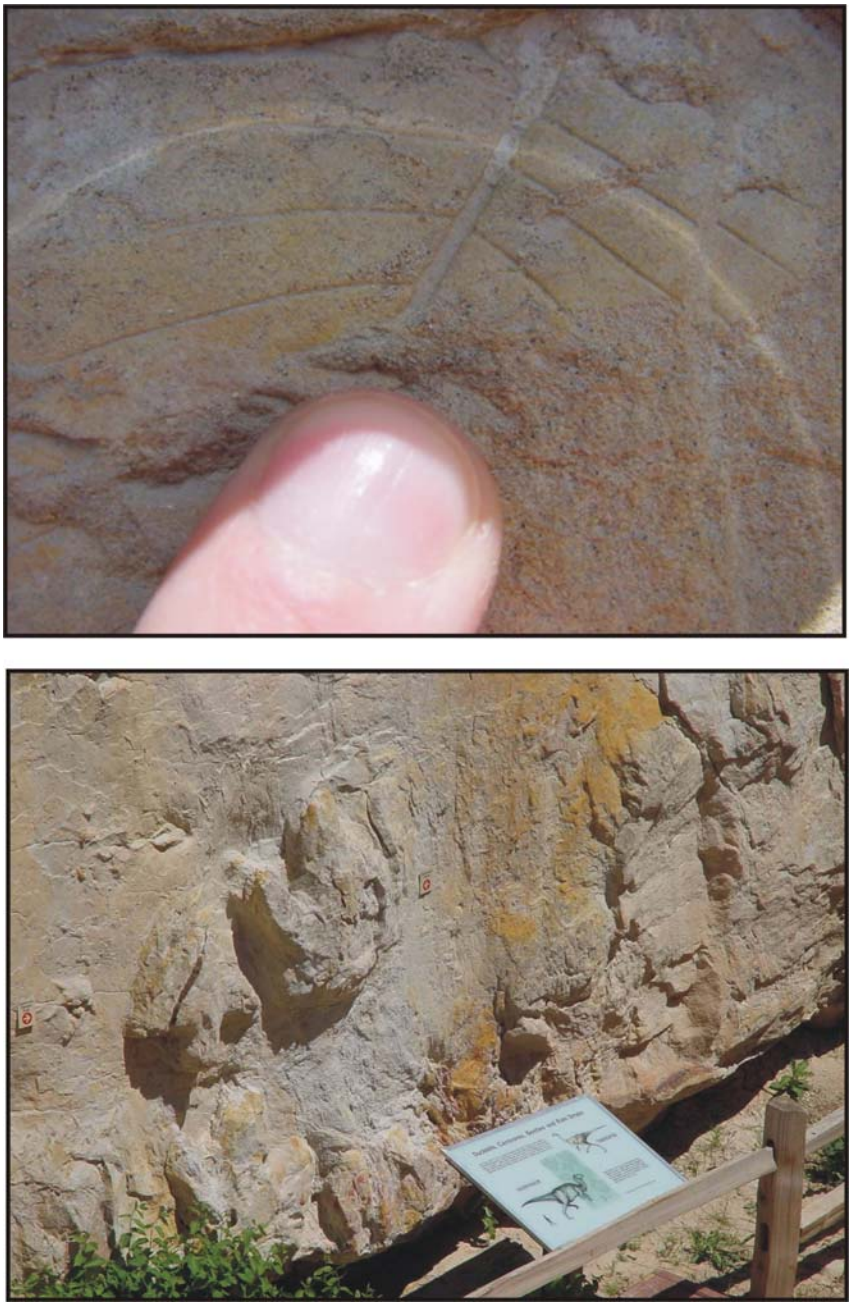
4.14.1 AFFECTED ENVIRONMENT

The Front Range foothills and adjacent plains region of Colorado is well known for its geologic history and paleontologic importance. Many important fossil specimens, including numerous holotypes, have been collected here. These include 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 are now housed in museums in Colorado and around the world.

The geology and paleontology of the region is scientifically important because it records the erosion of the ancestral Rocky Mountains, development of a vast interior seaway that covered much of central North America, extinction of the dinosaurs at the end of the Cretaceous Period, development of tropical rainforest ecosystems, and the evolutionary radiation of mammals during the Paleocene, as well as the environments and animals that lived in the region during the Pleistocene ice ages.

Today, these events in earth's history, together with evidence of the diverse organisms that inhabited ancient Colorado, can be viewed at well-known locations, many of which are adjacent to, and several that are within, the Northwest Corridor APE. These locations include, but are not limited to, Red Rocks Park, the Dakota Hogback and I-70 Roadcut, Dinosaur Ridge, North and South Table Mountains, and Fossil Trace Golf Course (Parfet Prehistoric Preserve Triceratops Trail), as well as area museums including the Denver Museum of Nature and Science, the University of Colorado Museum, and the Morrison Natural History Museum. Examples of types of fossils expected in the study area are included in this section (see **Figure 4.14-1**).

Figure 4.14-1 Leaf Fossil and Dinosaur Tracks Located in the Project Vicinity



Notes: Top: Leaf fossil at locality DD051705-01.
Bottom: Dinosaur tracks at Fossil Trace Golf Course (Parfet Prehistoric Preserve Triceratops Trail).
Locality #1: Both are Laramie Formation localities within the Northwest Corridor APE in the City of Golden, CO.

Source: *Rocky Mountain Paleontology, 2005.*

4.14.1.1 FOSSILIFEROUS GEOLOGIC UNITS AND PALEONTOLOGICAL SENSITIVITY

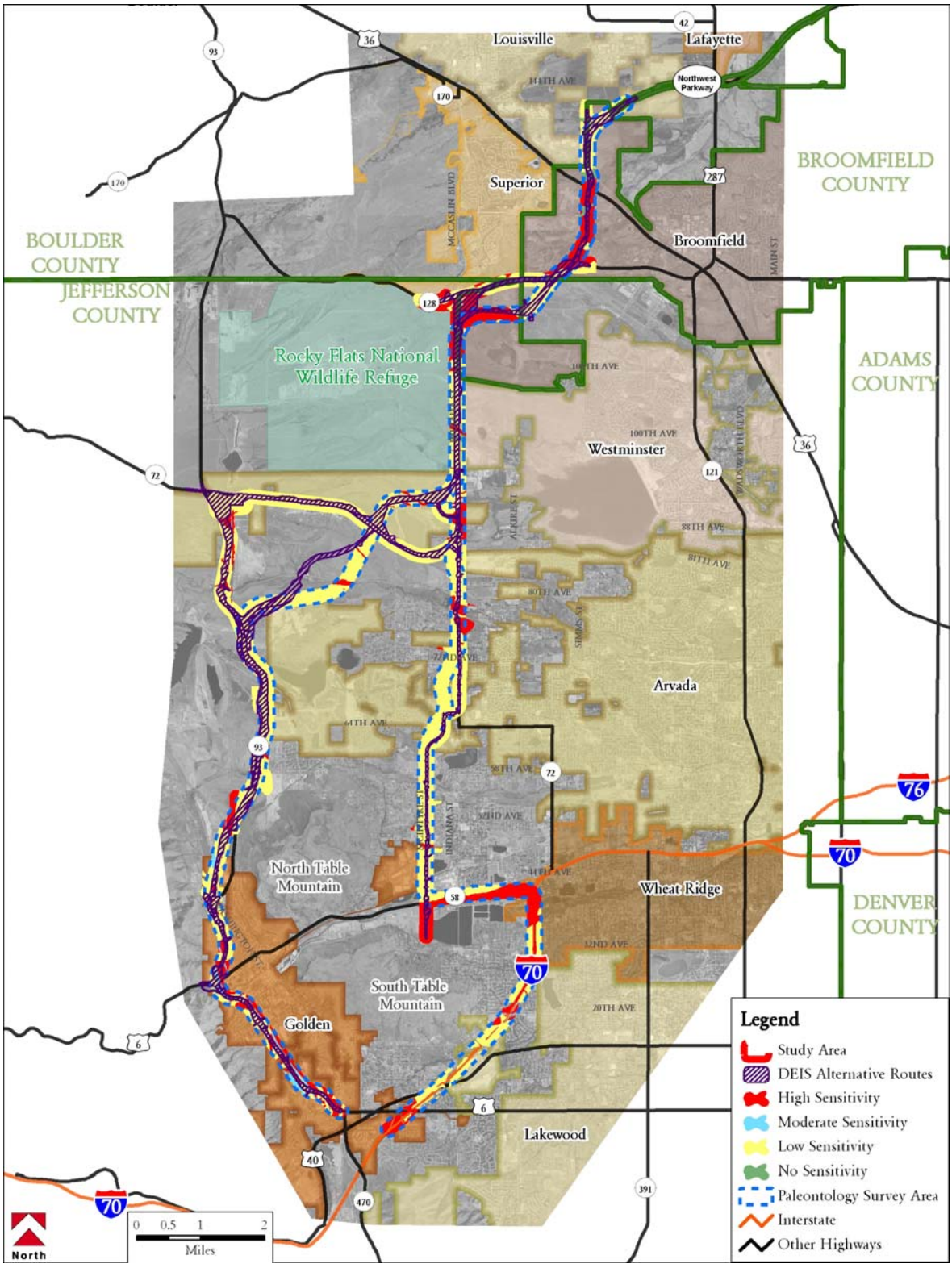
A detailed assessment of the paleontological resources of the study area and a paleontological field survey of 600-foot wide corridors around the alternatives were completed in 2005 (Murphey and Daitch, 2005). This study included a review of the scientific literature, geologic mapping, and museum records to identify and determine the geological contexts of known fossil localities. This information was also used to evaluate the paleontological sensitivities of the various geologic units within the Northwest Corridor APE. Portions of the alternatives were field surveyed for fossils and exposures of fossiliferous rock. Due to the design changes made during the alternatives screening process, some areas may require supplemental survey and assessment for paleontological resources.

Twenty-two mapped geologic units underlie the alternative alignments within the study area. These range in age from late Paleozoic to Holocene and 19 of them are known to contain scientifically important fossils of varying taxonomic affinities, importance, and abundance across their distribution.

The paleontological sensitivities of each geologic unit within the Northwest Corridor APE were evaluated using widely accepted and utilized paleontological resource assessment criteria developed by the Society of Vertebrate Paleontology, the U.S. Forest Service, the Bureau of Land Management, and the National Academy of Sciences (see Murphey and Daitch, 2005).

Paleontological sensitivity of the geologic units is ranked: high, moderate, low, and no sensitivity (see **Figure 4.14-2**). Two units have high paleontological sensitivity, six have moderate sensitivity, 11 have low sensitivity, and three have no sensitivity (see **Table 4.14-1**). Detailed information about geologic units in the study area is provided (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

Figure 4.14-2 Paleontological Sensitivities of Geologic Units in the Northwest Corridor APE



Source: Compiled by FHU, 2006.

Table 4.14-1 Paleontological Sensitivity of Geologic Units in the Northwest Corridor APE

Geologic Unit	Typical Map Abbreviation[1]	Age	Typical Fossils	Sensitivity
Artificial Fill	Qaf	Modern	None	No
Post-Piney Creek Alluvium	Qpp	Upper Holocene	None	No
Piney Creek Alluvium	Qp	Holocene	None	No
Colluvium	Qco, Qc	Holocene, Pleistocene	Vertebrates	Low
Loess	Ql	Holocene, Pleistocene	Vertebrates	Low
Broadway Alluvium	Qb	Pleistocene	Vertebrates	Low
Louviers Alluvium	Qlo	Pleistocene	Vertebrates	Low
Slocum Alluvium	Qs	Pleistocene	Vertebrates, invertebrates	Low
Verdos Alluvium	Qv	Pleistocene	Vertebrates	Low
Rocky Flats Alluvium	Qrf	Pleistocene	Vertebrates	Low
Transported Mantle (older alluvium)	Qre	Pleistocene	Unknown	Low
Younger Alluvial Fan	Qyf	Pleistocene	Vertebrates	Low
Older Alluvial Fan	Qof	Pleistocene	Vertebrates	Low
Arapahoe Formation	Ka	Cretaceous	Vertebrates, plants	Low
Fountain Formation	PPf	Permian and Pennsylvanian	Vertebrates, trace fossils	Moderate
Dakota Sandstone	Kd	Cretaceous	Vertebrates, invertebrates, plants, trace fossils	Moderate
Fox Hills Sandstone	Kf/Kfh	Cretaceous	Invertebrates, trace fossils	Moderate
Pierre Shale	Kp	Cretaceous	Vertebrates, invertebrates, plants, trace fossils	Moderate
Niobrara Formation	Kn	Cretaceous	Vertebrates, invertebrates, trace fossils	Moderate
Benton Shale	Kb	Cretaceous	Vertebrates, invertebrates, trace fossils	Moderate
Laramie Formation	Kl[2]	Cretaceous	Vertebrates, invertebrates, plants	Moderate or high[2]
Denver Formation	TKd/Tkda	Cretaceous, Paleocene	Vertebrates, plants, invertebrates	High

Notes: [1]Map abbreviations are from published USGS geologic maps (Machette, 1977; Scott, 1972; Spencer, 1961; Trimble and Machette, 1979; Van Horn, 1957; 1972).

[2]Laramie Foundation is considered to have high sensitivity in the City of Golden because of the presence of existing fossil localities and scientifically important fossils along US 6/SH 93.

Source: Northwest Corridor Supporting Technical Document-Paleontological Assessment.

4.14.1.2 FOSSIL LOCALITIES

Due to the risk of unauthorized collection and the loss of paleontological data, specific fossil locality information is considered sensitive and is kept confidential. General information is provided.

As confirmed by the field survey, and as recorded in the databases of the University of Colorado Museum (UCM), Denver Museum of Nature and Science (DMNS), Colorado Historical Society (CHS), and other sources, four previously documented fossil localities occur within the Northwest Corridor APE and at least 146 additional localities occur within five miles of it (Murphey and Daitch, 2005) (see **Table 4.14-2**).

Five previously unrecorded fossil localities were discovered during the field survey for this study. These localities are all in Cretaceous-aged rock units, and include the only fossils observed during the field survey (Murphey and Daitch, 2005).

Table 4.14-2 Previously Recorded Fossil Localities Within the Northwest Corridor APE

Locality #	Institution	Locality Name	Formation	Age	Fossils
No number*	CSM	Mines Geology Trail Stop 2	Laramie	Cretaceous?	Triceratops footprints, wood and plant impressions
5JF.768	CHS	uncertain	Not recorded, probably Laramie	Cretaceous?	Dinosaur/bird tracks
No number*	none	Fossil Trace Golf Course: Parfet Prehistoric Preserve Triceratops Trail #1	Laramie	Cretaceous	Trace fossils (dinosaur, bird, and mammal tracks; invertebrate tracks and burrows; plant impressions)
No number*	none	Fossil Trace Golf Course: Parfet Prehistoric Preserve Triceratops Trail #2	Laramie	Cretaceous	Trace fossils (dinosaur and insect tracks)

Note: *Coordinates provided by CDOT staff Paleontologist Steve Wallace and verified during field survey.

Source: Northwest Corridor Supporting Technical Document-Paleontological Assessment

4.14.2 ENVIRONMENTAL CONSEQUENCES

The loss of any identifiable fossil that could yield information important to prehistory, or that embodies the distinctive characteristics of a type of organism, environment, period of time, or geographic region, would be an adverse environmental impact. This impact analysis provides an assessment of the direct, indirect, and cumulative impacts on paleontological resources for the proposed alternatives for the study. Direct impacts primarily concern the potential destruction of paleontological resources and the loss of information associated with these resources. As a result of any of the proposed build alternatives, project excavations may result in the destruction of paleontological resources and subsequent loss of information (adverse impact). However, construction impacts also result in the exposure of fossils that may never have been unearthed by natural means. If suggested mitigation measures are implemented, these newly exposed fossils become available for salvage, data recovery, scientific analysis, and preservation into perpetuity at a public museum (beneficial impact). Adverse direct impacts can be decreased to below the level of importance through the proper implementation of a paleontological monitoring and mitigation program (see **Section 4.14.3**).

Grading, excavation, and removal of potentially fossiliferous bedrock or Pleistocene-aged surficial deposits within the Northwest Corridor APE, as well as the unlawful collection of fossil remains by construction personnel, could result in the loss of previously unrecorded fossil sites and scientifically important fossil remains. There would be no adverse impacts in areas where grading, excavating, and removal disturb artificial fill or Holocene-aged surficial deposits, because these materials are unfossiliferous. Thus, no suggested mitigation measures are necessary in these areas.

The potential for direct adverse impacts on scientifically important sub-surface fossils in geologic units known to contain them is controlled by two factors. These include the depth and lateral extent of disturbance of fossiliferous bedrock and/or surficial sediments and the depth and lateral extent of occurrence of fossiliferous bedrock and/or surficial sediments beneath the surface. Where the depth of disturbance exceeds the depth of occurrence, potential adverse impacts may occur due to breakage and crushing of fossils during ground disturbance associated with construction. At the time of this analysis, precise information regarding the depth of proposed excavations or the thickness and depth of underlying fossiliferous bedrock and/or surficial sediments within the Northwest Corridor APE was unavailable. Therefore, potential adverse impacts on paleontological resources for each of the build alternatives were analyzed and estimated using the best available information. General information about anticipated impacts to paleontological resources under each of the alternatives is provided below. Sensitive-specific fossil locality information is omitted but is available (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

4.14.2.1 Impacts Common to All Build Alternatives

Direct Impacts

Direct impacts would result primarily from construction excavations within the build alternative footprint. Construction excavations will disturb known (surface) occurrences of paleontological resources, and these excavations also have the potential to disturb an unknown quantity of paleontological resources that may occur beneath the surface in areas containing paleontologically sensitive geologic units. Without mitigation, these non-renewable resources, as well as the paleontological data they could provide if properly salvaged and documented, could be destroyed, rendering them permanently unavailable for future scientific investigation.

Indirect Impacts

Indirect impacts are those resulting from the post-construction normal operations of the improved transportation corridor and associated infrastructure within each build alternative. No indirect impacts on paleontological resources would be expected to occur from the continuing operation of roadways or any associated infrastructure and related facilities within the study area.

Cumulative Impacts

If known scientifically important paleontological resources within any of the build alternative footprints are salvaged during or prior to construction-related ground disturbance, potential cumulative impacts would be low. If previously unknown scientifically important paleontological resources are discovered within any of the build alternative footprints during construction, the potential cumulative impacts would also be low, so long as mitigation measures were implemented to salvage the resources. The suggested mitigation measures proposed in **Section 4.14.3** would effectively recover the value to science of fossils that would otherwise have been destroyed by construction-related ground disturbance.

4.14.2.2 No Action Alternative

Adverse impacts on paleontological resources may be caused as a result of implementing the numerous individual projects associated with the No Action Alternative. Impacts to paleontological resources for each of these individual projects should be determined on a project specific basis.

4.14.2.3 FREEWAY ALTERNATIVE

Adverse impacts on paleontological resources may be caused as a result of a variety of ground-disturbing construction activities that are common to the northern, central, and southern portions of the Freeway Alternative. These include, but are not limited to; grading and re-grading for roadways including freeway lanes, frontage roads, underpasses, on-ramps and off-ramps, and pedestrian and bicycle paths; drilling for piles, traffic signal poles, and light standards; excavations for bridge abutments and column footings; trenching for storm drains and electrical conduits; and foundation excavations for retaining walls and other highway infrastructure facilities. More details on specific impacts expected for the Freeway Alternative are available (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

NORTHERN PORTION

Bedrock units that have mostly high or moderate paleontological sensitivity (primarily the Laramie Formation, and Denver/Arapahoe Formation) underlie the northern portion of the Freeway Alternative. Relatively thin coverings of surficial deposits of either Holocene age with no paleontological sensitivity or Pleistocene age with low paleontological sensitivity mantle these bedrock units. Information regarding the depth of proposed construction excavations is not available. However, excavations near existing grade throughout the northern portion of this alternative could disturb fossil-bearing rocks and destroy scientifically important fossils. Until geotechnical studies and construction design plans for this alternative have been completed, it will not be possible to determine the extent of potential adverse impacts on paleontological resources in bedrock because, with the obvious exception of areas of surface outcrop, the precise depth of bedrock is unknown.

CENTRAL PORTION

Bedrock units that have mostly high or moderate paleontological sensitivity (primarily the Laramie Formation and Denver Formation) underlie the central portion of the Freeway Alternative. Relatively thin coverings of surficial deposits of either Holocene age with no paleontological sensitivity or Pleistocene age with low paleontological sensitivity mantle these bedrock units. Information regarding the depth of proposed construction excavations is not available. However, excavations near existing grade throughout the central portion of this alternative could disturb fossil-bearing rocks and destroy scientifically important fossils. Until suggested geotechnical studies and construction design plans for this alternative are completed, it will not be possible to determine the extent of potential adverse impacts on paleontological resources in bedrock because, with the obvious exception of areas of surface outcrop, the precise depth of bedrock is unknown.

SOUTHERN PORTION

The following direct impacts to paleontological resources are anticipated to occur under the Freeway Alternative in the southern portion:

- Bedrock units that have mostly high or moderate paleontological sensitivity (primarily the Pierre Shale, Laramie Formation, and Denver Formation) underlie the entire southern portion of the Freeway Alternative. Relatively thin coverings of surficial deposits of either Holocene age with no paleontological sensitivity or Pleistocene age with low paleontological sensitivity mantle these bedrock units. Information regarding the depth of proposed construction excavations was not available for this analysis. However, excavations near existing grade throughout the southern portion of this alternative could disturb fossil-bearing rocks and destroy scientifically important fossils. Until suggested geotechnical studies and construction design plans for this alternative are completed, it will not be possible to determine the extent of potential adverse impacts on paleontological resources in bedrock because, with the obvious exception of areas of surface outcrop, the precise depth of bedrock is unknown.

- The most paleontologically sensitive segment within all build alternatives occurs within the southern portion of the Freeway Alternative. Nine recorded fossil localities preserving fossilized plants, invertebrate burrows, and other trace fossils, and a variety of dinosaur, bird, and mammal tracks of Cretaceous age occur within the Laramie Formation and the Dakota Sandstone area in the southern portion of the Freeway Alternative. The likelihood that these fossils would be adversely impacted by grading for widening and associated highway improvements is high.

4.14.2.4 TOLLWAY ALTERNATIVE

Adverse impacts on paleontological resources may be caused as a result of a variety of ground-disturbing construction activities that are common to the northern, central, and southern portions of the Tollway Alternative. These include, but are not limited to; grading and re-grading for roadways including tollway lanes, frontage roads, underpasses, on-ramps and off-ramps, and pedestrian and bicycle paths; drilling for piles, traffic signal poles, and light standards; excavations for bridge abutments and column footings; trenching for storm drains and electrical conduits; and foundation excavations for retaining walls and other highway infrastructure facilities. The precise locations of toll plazas were not available for this analysis. More details on specific impacts expected for the Tollway Alternative are available (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

NORTHERN PORTION

Impacts within the northern portion of the Tollway Alternative are expected to be identical to those within the northern portion of the Freeway Alternative.

CENTRAL PORTION

Impacts within the central portion of the Tollway Alternative are expected to be identical to those within the central portion of the Freeway Alternative.

SOUTHERN PORTION

Impacts within the southern portion of the Tollway Alternative are expected to be identical to those within the southern portion of the Freeway Alternative.

4.14.2.5 REGIONAL ARTERIAL ALTERNATIVE

Adverse impacts on paleontological resources may be caused as a result of a variety of ground-disturbing construction activities that are common to the northern, central, and southern portions of the Regional Arterial Alternative. These include, but are not limited to; grading and re-grading for roadways including regional arterial lanes, frontage roads, underpasses, on-ramps and off-ramps, and pedestrian and bicycle paths; drilling for piles, traffic signal poles, and light standards; excavations for bridge abutments and column footings; trenching for storm drains and electrical conduits; and foundation excavations for retaining walls and other highway infrastructure facilities. More details on specific impacts expected for the Regional Arterial Alternative are available (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

NORTHERN PORTION

Construction activities have the potential to adversely impact sub-surface paleontological resources at ten locations in the northern portion including seven intersections/interchanges, ramps, and connections to existing transportation facilities. Potential adverse impacts may also occur at three creek crossings in the northern portion of the Regional Arterial Alternative. All are underlain at unknown depths by moderate sensitivity Laramie Formation. Low sensitivity alluvium and/or loess are also present at four of these locations.

CENTRAL PORTION

Bedrock units that have mostly high or moderate paleontological sensitivity (primarily the Laramie Formation and Denver Formation) underlie the central portion of the Regional Arterial Alternative. Relatively thin coverings of surficial deposits of either Holocene age with no paleontological sensitivity or Pleistocene age with low paleontological sensitivity mantle these bedrock units. Information regarding the depth of proposed construction excavations is not available. However, excavations near existing grade throughout the central portion of this alternative could disturb fossil-bearing rocks and destroy scientifically important fossils. Until suggested geotechnical studies and construction design plans for this alternative are completed, it will not be possible to determine the extent of potential adverse impacts on paleontological resources in bedrock because, with the obvious exception of areas of surface outcrop, the precise depth of bedrock is unknown.

Potential adverse impacts to subsurface paleontological resources could occur at numerous locations requiring excavations, including eight intersections/interchanges, the SH 72 Frontage Road, and four creek crossings.

SOUTHERN PORTION

With the exception of the addition of the Ralston Creek crossing, impacts within the southern portion of the Regional Arterial Alternative are expected to be identical to those within the southern portion of the Freeway Alternative. No sensitivity artificial fill and Piney Creek Alluvium, low sensitivity Broadway Alluvium, and moderate sensitivity Pierre Shale underlie the Ralston Creek crossing. Construction excavations in this area have the potential to adversely impact sub-surface paleontological resources.

4.14.2.6 COMBINED ALTERNATIVE (RECOMMENDED ALTERNATIVE)

Adverse impacts on paleontological resources may be caused as a result of a variety of ground-disturbing construction activities that are common to the northern, central, and southern portions of the Combined Alternative (Recommended Alternative). These include, but are not limited to; grading and re-grading for roadways including tollway lanes, regional arterial lanes, principal arterial lanes, frontage roads, underpasses, on-ramps and off-ramps, and pedestrian and bicycle paths; drilling for piles, traffic signal poles, and light standards; excavations for bridge abutments and column footings; trenching for storm drains and electrical conduits; and foundation excavations for retaining walls and other highway infrastructure facilities. The precise locations of toll plazas were not available for this analysis. More details on specific impacts expected for the Combined Alternative (Recommended Alternative) are available (see **Northwest Corridor Supporting Technical Document-Paleontological Assessment**).

NORTHERN PORTION

Impacts within the northern portion of the Combined Alternative (Recommended Alternative) are expected to be similar to those within the northern portion of the Regional Arterial Alternative.

CENTRAL PORTION

Impacts within the central portion of the Combined Alternative (Recommended Alternative) are expected to be identical to those within the central portion of the Freeway Alternative.

SOUTHERN PORTION

Impacts within the southern portion of the Combined Alternative (Recommended Alternative) are expected to be identical to those within the southern portion of the Freeway Alternative, except for one additional interchange underlain by moderate sensitivity Pierre Shale, and a frontage road underlain by low sensitivity alluvium and Arapahoe Formation.

INDIANA STREET/MCINTYRE STREET PORTION

Potential adverse impacts to subsurface paleontological resources could occur along the Indiana Street/McIntyre Street alignment, which is underlain by fossiliferous geologic units including low sensitivity Arapahoe Formation, colluvium, Louviers, Broadway, and Slocum Alluvium, as well as high sensitivity Denver Formation. The Denver Formation bedrock is also present and may have potential adverse impacts at two creek crossings, one of which (Clear Creek) is underlain by high sensitivity Denver Formation.

Numerous canal crossings could require box culverts, and could cause adverse impacts to paleontological resources in the low sensitivity Arapahoe Formation, moderate sensitivity Laramie Formation, and high sensitivity Denver Formation bedrock.

4.14.3 SUGGETED MITIGATION

The following suggested mitigation measures have been developed to reduce adverse impacts of project construction on paleontological resources to a less than important level. They follow the guidelines of the Society of Vertebrate Paleontology (1995, 1996) and meet the standards of federal agencies and the State of Colorado. These suggested mitigation measures have been implemented throughout the western United States and have been demonstrated to be successful in protecting paleontological resources while preventing construction delays. Paleontological mitigation seeks to thoroughly and accurately document fossil sites and salvage as many fossils as possible prior to their destruction during construction-related ground disturbance. Programmatic and project specific mitigation measures are described below.

Adverse impacts to paleontological resources may occur if proper mitigation measures are not implemented. If proper mitigation measures are implemented, ground disturbance is generally considered beneficial to the science of paleontology. Mitigation efforts commonly result in the collection of fossils that might otherwise never be discovered and the permanent housing of these fossils in public museums where they are available for research.

4.14.3.1 SUPPLEMENTAL PRELIMINARY SURVEY AND IMPACT ASSESSMENT

Prior to construction, a supplemental paleontological field survey should be conducted for the rreferred alternative to evaluate those areas that were not surveyed as part of the initial paleontological assessment for the Northwest Corridor study (Murphey and Daitch, 2005).

4.14.3.2 PRECONSTRUCTION FOSSIL COLLECTION

Specimen collection prior to construction would be recommended at locations where construction ground disturbance will occur if important fossils are known to remain on the surface, are partially exposed, or if there is a high probability that sub-surface fossils exist within the study area. This work could include additional surface collecting or systematic excavation of a locality to salvage an important fossil or collect a statistical sample of the fossil taxa present at the locality. If important sub-surface fossils may be further impacted during ground disturbance, construction monitoring may be recommended.

4.14.3.3 CONSTRUCTION MONITORING

When the construction design plans for the project are finalized, a paleontologist should examine them and determine the extent of impact to the fossiliferous units and the scope of monitoring, if any, that is required. Paleontological construction monitoring by a qualified and permitted paleontologist should include inspection of exposed rock units and microscopic examination of matrix to determine if fossils are present. Depending upon the types and importance of potential fossils, monitoring should be scheduled to take place continuously or should consist of spot-checks of construction excavations. Paleontological monitors should follow earth-moving equipment and examine excavated sediments and excavation sidewalls for evidence of paleontological resources. The monitors should have authority to temporarily divert grading away from exposed fossils in order to professionally and efficiently recover the fossil specimens and collect associated data. All efforts should be made to avoid delays to construction.

If any subsurface bones or other potential fossils were found by construction personnel during construction, work in the immediate area should be immediately suspended and a paleontologist should be contacted immediately to evaluate the find. Once salvage or other mitigation measures (including sampling) were complete, the paleontologist should notify the construction supervisor that paleontologic clearance is granted.

Paleontological monitors should be equipped with the necessary tools for the rapid removal of fossils and retrieval of associated data in order to prevent construction delays. Specimens and samples collected should be transported to an appropriate paleontological laboratory for processing.

In the laboratory, all fossils should be prepared, identified, analyzed, and inventoried. Specimen preparation and stabilization methods should be recorded for use by the designated curation facility. All specimens should be transferred to the designated curation facility and accompanied by the final paleontological resources report with all data presented in hard and electronic format.

A final paleontological resources report should be produced and should include the results of the monitoring and mitigation program, an evaluation and analysis of the fossils collected (including an assessment of their importance, age, and geologic context), an itemized inventory of fossils collected including photographs where appropriate, an appendix of locality and specimen data with locality maps and photographs, an appendix of curation agreements and other appropriate communications, and a copy of the project-specific paleontological monitoring and mitigation plan.

4.14.3.4 SUGGESTED PROJECT-SPECIFIC MITIGATION MEASURES

Suggested mitigation prescriptions for the four classes of paleontological sensitivity represented by geologic units in the Northwest Corridor APE are presented.

MITIGATION MEASURES IN AREAS OF HIGH PALEONTOLOGICAL SENSITIVITY

Within the Northwest Corridor APE, the Cretaceous and Paleocene-age Denver Formation and the Cretaceous Laramie Formation have high paleontological sensitivity. The Laramie Formation is only considered to have high sensitivity along SH 93 in the City of Golden where vertebrate fossils localities have been recorded. Prior to the initiation of all earth-moving construction activities in rock units of high paleontological sensitivity, a preconstruction Worker Awareness Training Program with a paleontological component should be required, followed by continuous monitoring or spot-checking of excavations during all phases of construction. The scope of monitoring should be based on the extent and depth of the excavations as determined by a paleontologist and/or qualified professional paleontologist.

SUGGESTED MITIGATION MEASURES IN AREAS OF MODERATE PALEONTOLOGICAL SENSITIVITY

Within the Northwest Corridor APE, the Fountain Formation, Dakota Sandstone, Fox Hills Sandstone, Pierre Shale, Niobrara Formation, Benton Shale, and Laramie Formation have moderate paleontological sensitivity. The Laramie Formation is considered to have moderate sensitivity in all areas of the Northwest Corridor APE except along SH 93 in the City of Golden where vertebrate fossil localities have been recorded and it is considered to have high sensitivity. Prior to the initiation of all earth-moving construction activities in rock units of moderate paleontological sensitivity, a preconstruction Worker Awareness Training Program with a paleontological component should be required, followed by monitoring or spot-checking of excavations during all phases of construction. The scope of monitoring should be based on the extent and depth of the excavations as determined by a paleontologist and/or qualified professional paleontologist.

SUGGESTED MITIGATION MEASURES IN AREAS OF LOW PALEONTOLOGICAL SENSITIVITY

Within the Northwest Corridor APE, Pleistocene and Lower Holocene surficial deposits including alluvium, alluvial fans, transported mantle, colluvium, loess, and bedrock Cretaceous-age Arapahoe Formation have low paleontological sensitivity. A Worker Awareness Training Program would be conducted prior to the initiation of all construction activities. Continuous monitoring may not be required, but spot-checking may be conducted in certain areas at the discretion of a paleontologist and/or qualified professional paleontologist. This would also help to ensure that older, more deeply buried fossiliferous sediments were not being impacted.

SUGGESTED MITIGATION IN AREAS OF NO PALEONTOLOGICAL SENSITIVITY

Areas of no paleontological sensitivity within the Northwest Corridor APE may not require mitigation.

4.14.4 SUMMARY

All build alternatives and the No Action Alternative have the potential to adversely impact paleontological resources. With regard to adverse impacts on paleontological resources, no alternatives are preferred over others. This is because all alternatives involve excavation in potentially fossiliferous bedrock and thus have equal potential for adverse impacts on paleontological resources. The most paleontologically sensitive area within the Northwest Corridor APE is located within the southern portion of all of the build alternatives where nine fossil localities are recorded. With the proper implementation of the suggested paleontological mitigation measures, adverse impacts on non-renewable paleontological resources can be reduced to an insignificant level of importance. The discovery of any fossils from project excavations would be a beneficial impact because it would result in the recovery and preservation of fossils and the data they contain.

A supplemental pre-construction survey and impact assessment, pre-construction fossil collection, and construction monitoring are prescribed to reduce adverse impacts of project construction on paleontological resources to an acceptable level. Impacts will also be minimized by following the guidelines of the Society of Vertebrate Paleontology (1995, 1996) and meeting the standards of federal agencies and the State of Colorado. These suggested mitigation measures have been implemented throughout the western United States and have been demonstrated to be successful in protecting paleontological resources while limiting construction delays.

This Page Left Intentionally Blank

REFERENCES

Machette, M.N. 1977. Geologic Map of the Lafayette Quadrangle, Adams, Boulder, and Jefferson Counties, Colorado: USGS Map GQ-1392, scale 1:24,000.

Murphey, Paul C., and David Daitch. 2005. Northwest Corridor Supporting Technical Documents-Paleontology Assessment. Prepared by Rocky Mountain Paleontology for Felsburg Holt & Ullevig and CDOT (September).

Scott, G.R. 1972. Geologic Map of the Morrison Quadrangle, Jefferson County, Colorado: USGS Map I-790-A, scale 1:24,000.

Spencer, F.D. 1961. Bedrock Geology of the Louisville Quadrangle, Colorado: U.S. Geological Survey Map GQ-151, scale 1:24,000 (1 sheet).

Society of Vertebrate Paleontology 1995 Assessment and mitigation of adverse impacts to nonrenewable paleontologic resources – standard guideline. Society of Vertebrate Paleontology News Bulletin, vol. 163, p. 22-27.

———. 1996, Conditions of receivership for paleontologic salvage collections. Society of Vertebrate Paleontology News Bulletin, vol. 166, p. 31–32.

Trimble, D.E., and M.N. Machette. 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.

Van Horn, D. 1957. Bedrock Geology of the Golden Quadrangle, Colorado: U.S. Geological Survey Map GQ 103.

Van Horn, R. 1972. Geologic Map of the Golden Quadrangle, Jefferson County, Colorado: U.S. Geological Survey Map, I-761-A, scale 1:24,000 (1 sheet).

This Page Left Intentionally Blank