Attachment J

Assessment of Existing Paleontologic Data Along with Field Survey Results for the Jonah Field

ASSESSMENT OF EXISTING PALEONTOLOGIC DATA ALONG WITH FIELD SURVEY RESULTS

FOR THE JONAH FIELD

ENCANA OIL & GAS (USA) INC., BP, AND ULTRA RESOURCES INC.

TOWNSHIP 28, 29, & 30 NORTH, RANGES 107, 108, & 109 WEST

SUBLETTE COUNTY, WYOMING

ON BUREAU OF LAND MANAGEMENT LANDS

UINTA PALEO

June 12, 2007

PREPARED BY

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ABSTRACT

This is compilation of a technical analysis of existing paleontological data and a limited, selective paleontological field survey of the geologic bedrock formations that will be impacted on Federal lands by construction associated with energy development in the Jonah Field, Sublette County, Wyoming. The field survey was done on approximately 20% of the field, primarily where good bedrock was exposed or where there were existing, debris piles from recent construction. Some potentially rich areas were inaccessible due to biological restrictions. Heavily vegetated areas were not examined. All locality data are compiled in the separate confidential appendix D. Uinta Paleontological Associates Inc. was contracted to do this work through EnCana Oil & Gas Inc. In addition BP and Ultra Resources are partners in this project as they also have holdings in the Jonah Field.

For this project, we reviewed a variety of geologic maps for the area (approximately 47 sections); none of maps have a scale better than 1:100,000. The Wyoming 1:500,000 geology map (Love and Christiansen, 1985) reveals two Eocene geologic formations with four members mapped within or near the Jonah Field (Wasatch – Alkali Creek and Main Body; Green River – Laney and Wilkins Peak members). In addition, Winterfeld's 1997 paleontology report for the proposed Jonah Field II Project was reviewed carefully. After considerable review of the literature and museum data, it became obvious that the portion of the mapped Alkali Creek Member in the Jonah Field is probably misinterpreted. Instead, this unit appears to be equivalent to the Cathedral Bluffs Member of the Wasatch Formation. There are three Quaternary informal units (aeolian, alluvium, and terrace deposits).

As part of our field survey, we identified five informal mapping units in the Jonah Field north to Highway 351:

- (Unit 351 – Alkali Creek beds near Highway 351,
- Blue Rim unit – distinctive blue horizon in the upper Alkali Creek,
- Section 31 bed – Green River Wilkins Peak Member,
- Burma Road unit – Wasatch beds (probably Cathedral Bluffs Member) in the Jonah Field, and
- Yellow Rim bed – Green River Laney Member.

These units are used because correlations with the better-exposed formal units to the north and east are difficult due to substantial vegetative cover in the area.

Before this project began, there was only one known fossil locality in the Jonah Field—fish found on the Yellow Point Rim during pipeline construction last year. This spring, we surveyed approximately 20% of the field. Including the known fish locality, there are now 24 formal localities (29 Trimble GPS paleontology points)—eleven with only plants/wood with some invertebrates, the rest have fossil bone of some kind (crocodile>turtle>fish>mammal). This suggests that vertebrate fossils can be found anywhere in the field.

Statistically, the interface between the Wasatch and Green River formations around the Yellow Point Rim (about 10 m or 30 ft below the contact) is the most productive zone. However, this perception probably is skewed due to heavy vegetative and soil cover throughout much of the field and due to our inability to access the Wasatch channel sandstone units in the northern parts of the field because of biological restrictions. Nonetheless, all of the Eocene units in the Jonah Field meet the BLM Condition 1 criteria. The interface between the Wasatch and the Laney Member of the Green River Formation just below the Yellow Point Rim can be categorized as PFYC 5, the Wasatch below this zone as PFYC 4 to 5, and the Laney Member above is classed as PFYC 3 to 4. The PFYC classifications are based upon the abundance of vertebrate fossils found in the units. Quaternary units were not surveyed and are classed as PFYC 2 or BLM Condition 3.

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INTRODUCTION

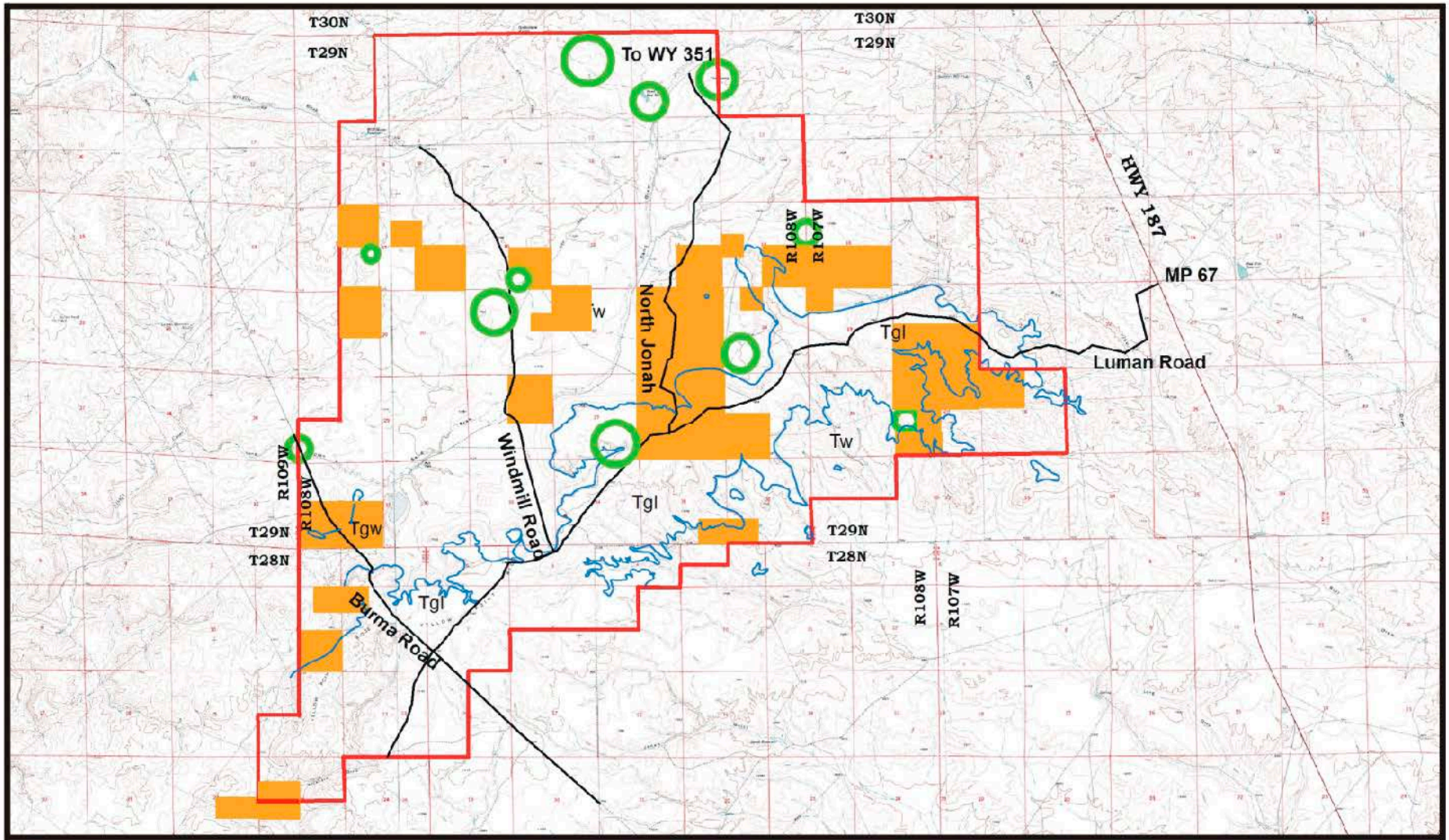
Sue Ann Bilbey, Ph.D. of Uinta Paleontological Associates Inc. (Uinta Paleo) was contacted by Paul Ulrich and Gregory Schamber of EnCana Oil & Gas (USA) Inc. to do an evaluation of existing paleontological data for the Jonah Field in Sublette County, Wyoming. Partners in the project include EnCana, BP (British Petroleum), and Ultra Resources. The area included in the Jonah Field includes most of the Stud Horse Butte Quadrangle as well as portions of Olsen Ranch, Gobblers Knob, Bull Draw, Teakettle Butte, Sugarloaf and Sugarloaf NE quadrangles—Townships 28, 29 and 30 North, Ranges 107, 108, and 109 West (Figures 1 & 2). The Bureau of Land Management out of Pinedale, Wyoming administers most of this land. However, there are Wyoming State Land Sections 16 and 36 and one private section—32 within current outline of the Jonah Field.

METHODS FOR THE ANALYSIS OF EXISTING DATA

Dr. Peter Robinson has collected fossil locality information from this area for the Wyoming Bureau of Land Management from data reposited at the University of Colorado Museum, the University of California Museum of Paleontology in Berkeley, the University of Michigan Museum of Paleontology, and the Chicago Field Museum of Natural History. Dr. Patricia Holroyd and Dr. Peter Robinson compiled the Wasatch and Bridger formational faunal lists for Sublette County from references included in the Selected Bibliography. Dr. Bilbey compiled the Green River Formation faunal and floral lists from similar listings in the Selected Bibliography, particularly Grande, 1985 and MacGinitie, 1969. Dr. Robinson has previously compiled extensive fossil locality maps and Excel files on the Greater Green River Basin. Institutions and researchers contacted for these data are included in Table 1. These locality documents and maps for Sublette County are on file with the BLM Wyoming State Office as well as the Pinedale BLM Field Office. Figure 3 shows the distribution by quadrangle of known vertebrate fossil localities within the Jonah area.

Dr. Gustaf Winterfeld (February 1997) prepared a similar survey of the known fossil resources in this general area (Proposed Jonah Field II Project). This document was carefully reviewed as part of our process. Winterfeld's lithologic descriptions of the formations in the area are consistent with Roehler (1990-1993). In addition, his compilations of known fossil localities were current for that time. He recommended that

> "specific measures should be proposed to mitigate adverse impacts to fossil resources at the surface, or within a few ft of the surface, in the Green River or Wasatch Formations, where specific paleontologic resources have been identified as the result of the field survey."



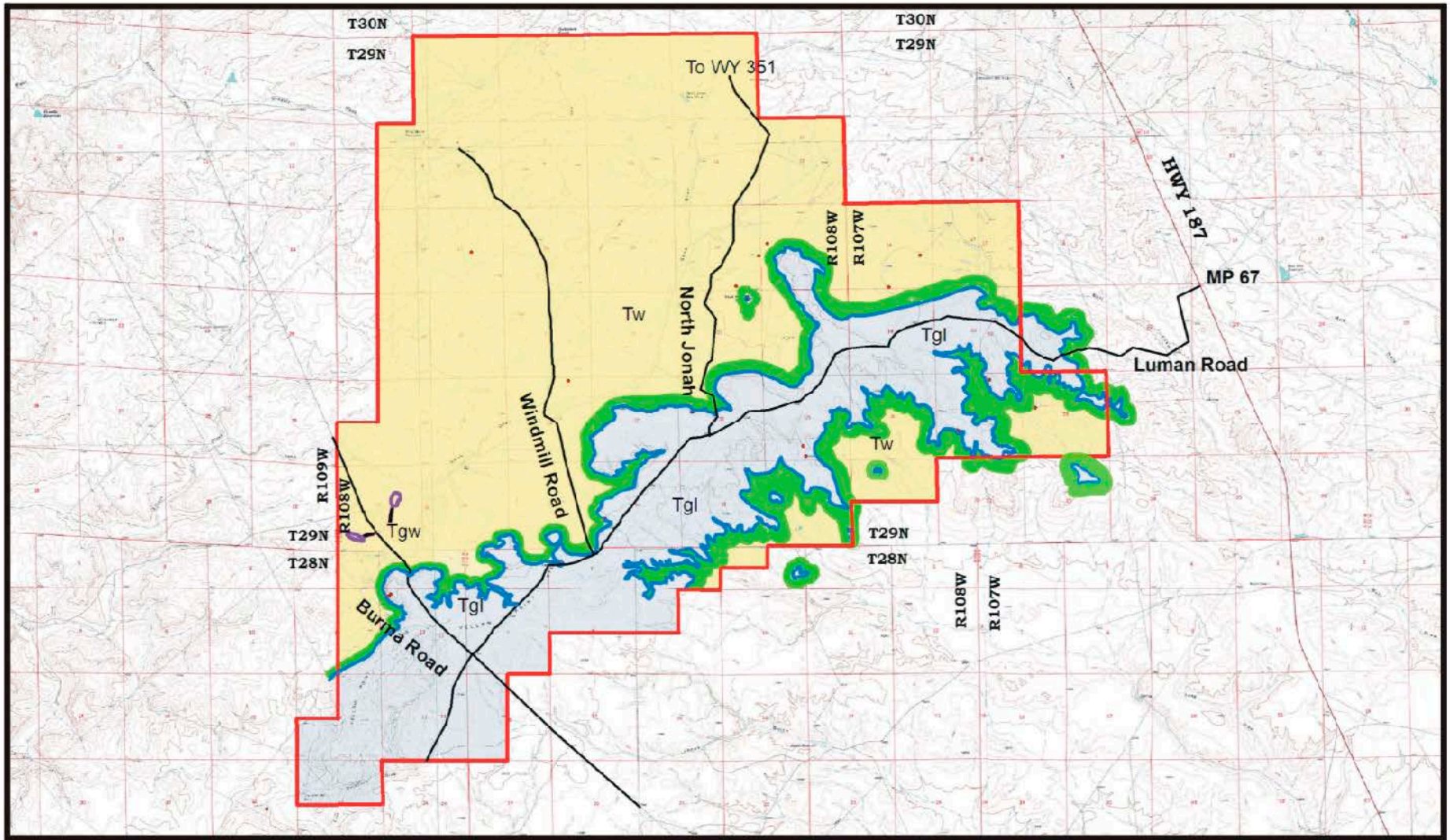
JONAH FIELD PALEONTOLOGICAL OVERVIEW
TOWNSHIPS 28 & 29 NORTH, RANGES 107 TO 109 WEST
SUBLETTE COUNTY, WY
SURVEY BLOCKS APPROXIMATE Tgl/Tw CONTACT
BIOLOGICALLY RESTRICTED AREAS

5 miles

N

Figure 1

Uinta Paleontological Associates, Inc.



JONAH FIELD PALEONTOLOGICAL OVERVIEW - BEDROCK GEOLOGY MAP
TOWNSHIPS 28 & 29 NORTH, RANGES 107 TO 109 WEST
SUBLETTE COUNTY, WY
APPROXIMATE Tgl/Tw INTERFACE Tw - Wasatch Formation - Cathedral Bluffs Member
Green River Formation Tgw - Wilkins Peak Member, Tgl - Laney Member

5 miles

N

Figure 2

Uinta Paleontological Associates, Inc.

TABLE 1. INSTITUTIONS AND RESEARCHERS CONTACTED FOR LOCALITY INFORMATION IN THE JONAH FIELD AREA

1997 COMPILATIONS DONE BY DR. GUSTAF F. WINTERFELD (Erathem-Vanir Geological Consultants)

AFFILIATION / PROJECT	CONTACT	RESOURCE AVAILABLE
Geology Museum, University of Wyoming	J. P. Cavigelli	Museum records
Museum of Paleontology, University of California - Berkeley	Dr. Pat Holroyd	Museum records
Museum of Paleontology, University of Michigan	Dr. Gregg Gunnell	Museum records
University Museum, University of Colorado - Boulder	Dr. Peter Robinson	Museum records
Denver Museum of Natural History	Dr. Logan Ivy	Museum records

2001-2002 COMPILATIONS DONE BY DR. PETER ROBINSON FOR THE BLM - SOUTHWESTERN WYOMING

Geology Museum, University of Wyoming	Dr. M. Cassiliano	Museum Records
Museum of Paleontology, University of California	Dr. Patricia Holroyd	Museum Records
Museum of Paleontology, University of Michigan	Dr. Gregg Gunnell	Museum Records
University of Colorado Museum, Boulder	Dr. Peter Robinson, Dr. Paul Murphey	Museum Records
Denver Museum of Nature and Science	Dr. Logan Ivy	Museum Records
BLM offices, Cheyenne, Rock Springs, Kemmerer, Pinedale	G.McNaughton,D.Valenzuela,D. Hanson	office files
National Museum of Natural History	Dr. R. Purdy	Museum Records
Carnegie Museum of Natural History	Ms. Elizabeth Hill, Collections Manager	Museum Records
American Museum of Natural History	Mr. J. Alexander, Collections Manager	Museum Records

2007 UPDATES OF LOCALITIES FROM SUBLETTE COUNTY, WY FOR THE JONAH PROJECT

Department of Geology & Geophysics, University of Wyoming	Dr. Kelli Trujillo, Dr. M. Cassiliano	Museum records search
Bureau of Land Management - Wyoming State Office	Dale Hanson, Regional Paleontologist	BLM permit records
Bureau of Land Management - Kemmerer and Pinedale Field Offices	Sam Drucker, G. McNaughton	BLM permit records
Museum of Paleontology, University of California - Berkeley	Dr. Pat Holroyd	Museum records
Museum of Paleontology, University of Michigan	Dr. Gregg Gunnell	Museum records
Geology Museum, University of Colorado - Boulder	Toni Culver, Collections Manager	Museum records

Figure 3. Topographic Maps in the Pinedale area Compiled to May 2007
Numbers of known fossil localities indicated in parentheses. New localities are added (+)
Block with heavy borders includes the Jonah Infill Drill Project Area.

Onion Springs (1)	Daniel	Mount Airy (1)	Pinedale	Boulder Lake	Scab Creek	Raid Lake	Mount Bonneville
Budd Reservoir (1)	Ball Island (19) - Tw	Mesa Spring (2)	Two Buttes Reservoir (7)	Boulder (29)	Fremont Butte	Pocket Creek Lake	Big Sandy Opening
Big Piney West	Big Piney East (6)	Ross Butte (3)	**Olsen Ranch (6)**	**Gobblers Knob (18 + 1)**	Square Top (3)	Leckie SW (13)	Leckie
Chimney Butte (10)	Milleson Draw (29)	Sugarloaf NW (3)	**Sugarloaf NE (1 + 1)**	**Stud Horse Butte (4 + 20)**	**Bull Draw (1 + 1)**	Tabernacle Butte (6)	Leckie Reservoir (13)
La Barge (21 B)	La Barge SE (9 B)	Oasis Well	Sugarloaf	Teakettle Butte	Juel Spring	Big Sandy Reservoir	Big Sandy Reservoir SE (1)

Numbers of Localities highlighted

None recorded
<5
6 to 10
11 to 20
>20

In fact, he emphasized the need for a paleontological field survey based upon the results of his technical analysis of the existing data. However, Winterfeld did not subsequently conduct a field survey in the proposed areas of impact, although he realized and reported that all members of the Green River and Wasatch formations in the Jonah area have high fossil potential—BLM Condition 1 (PFYC Class 4 or 5).

FEDERAL AND STATE REQUIREMENTS FOR PALEONTOLOGY

The BLM requested the evaluation of the paleontological sensitivity of all geological formations along proposed access roads and at proposed well sites pursuant to its authority and obligations, and consistent with its internal policies and procedures, under the following:

1) The National Environmental Policy Act of 1969 (NEPA)(U.S.C. 4321-4327; P.L. 91-190; 31 Stat. 852, 42);
2) The Federal Land Policy and Management Act of 1976 (U.S.C. 1701-1782; P.L. 94-579; 90 Stat. 2743,);
3) BLM Paleontology Resources Management Manual and Handbook H-8270-1 (revised 1998).

Similar guidelines also are outlined by Wyoming State laws and regulations regarding paleontological resource protection in Wyoming Title 36-1-114 through 36-1-116 (as of 2003).

Resource assessment guidelines based on the BLM Paleontological Resources Management Manual and Handbook H-8270-1 (revised in 1998 and currently being updated) are given in detail in a proposed monitoring and mitigation plan in Appendix A.

REGIONAL GEOLOGY AND EOCENE GEOLOGIC FORMATIONS OF SUBLETTE COUNTY, WYOMING

Much of Sublette County, as part of the northern portion of the Greater Green River Basin, was formed between the Wyoming Overthrust on the west and the Wind River Mountains of the northeast. The Jonah field is defined as a wedge-shaped structural block associated with two sub-vertical shear fault zones (DuBois, et al., 2005) in the southeastern section of the Hoback basin, an extension of the Greater Green River Basin (as defined by Dorr, et al., 1977 and Roehler, 1991). These fault zones trend north-south on the western edge of the field and nearly east-west on the southern extension of the field. The wedge widens to the northeast and is bounded by the synclinal axis of the Hoback Structural basin. There is no obvious surface expression of these faults, implying their formation as Late Cretaceous or Early Tertiary, probably part of the Laramide Orogeny and associated with

regional overthrusting in western Wyoming. In fact the near surface geologic formations in the Jonah Field dip shallowly ~2° SW.

Tertiary strata identified in the subsurface as well as in surface exposures of the Jonah field are: from oldest to youngest--unnamed basal Tertiary beds (probably equivalent with the Evanston or Hoback formations), Fort Union, Wasatch (Main Body, Alkali Creek Tongue, and Cathedral Bluffs Tongue), and interfingering Green River (Tipton Shale, Wilkins Peak, and Laney members). Table 2 lists the formations in the Jonah Field with descriptions of the rocks, depositional environments, and fossil potentials. Small exposures of the Bridger Formation are mapped east of US Highway 191 near Big Sandy Reservoir. These Tertiary units generally meet paleontological criteria as BLM Condition 1 units (PFYC Class 3 or 5 depending upon the proximity to known vertebrate fossil localities).

Quaternary beds of alluvium and aeolian deposits occur sporadically, frequently filling low topographic areas. These younger beds do not produce significant fossil resources (BLM Condition 3 or PFYC Class 1 or 2), although vertebrate fossils could be found in Pleistocene deposits, particularly near waterways (e.g., Jonah Infill Drilling Project FEIS—possible Pleistocene horse bones). Anything younger than 10,000 years bp are generally considered not to be fossiliferous and may fall under the auspices of archaeological studies.

EOCENE SERIES STRATA

There are three formations of the Eocene Series in Sublette County. They are from the oldest to youngest: the Wasatch Formation, mostly fluviatile; the Green River Formation, mostly lacustrine; and the Bridger Formation, mostly fluviatile. The formations have a complex relationship to each other as the climatic conditions of the early and middle Eocene varied. The expansion or contraction of the Green River lake system led to various phases of lacustrine or non-lacustrine sedimentation resulting in interfingering members of the Wasatch and Green River formations as expressed in the Jonah Field (Figure 3 after Roehler 1991). Proximity to the source area also modifies local sedimentation.

The Wasatch Formation represents tropical or subtropical river deposits, often red or variegated in color, although the younger units frequently are greenish gray. The Green River Formation is a thick pile of lacustrine sediments, many of them evaporitic, and is usually gray, brown or yellow in color. Some oil shales and the trona deposits mined in the area are from this formation—generally from the saline lake beds of the Wilkins Peak Member. The Laney Member of the Green River Formation

TABLE 2. SUMMARY OF SURFACE GEOLOGIC DEPOSITS, PALEONTOLOGICAL RESOURCES AND FIELD SURVEY RESULTS
JONAH FIELD OVERVIEW - 2007

Geologic Deposit	Geologic Age	Type of Deposit/ Environment of Deposition	Thickness	Known Fossil Resources	Paleontologic Potential (BLM Condition 1, 2, or 3)	PFYC (1 - 5)	Known (+ New) localities in Jonah	Field Survey Results (Recommendations)
Alluvial sediments	Holocene	Unconsolidated tan silts, sands, soil development - terrestrial	< 5 m	None	3	1	0	None needed
Eolian sediments	Holocene	Wind blown silts and sands, tan, terrestrial	< 5 m	None	3	1	0	None needed
Terrace deposits	Holocene	Older cobbles, gravels, sand, silt that are probably contemporary with regional glaciation - terrestrial	<15 m	Pleistocene horse?	3	2	1 mammal	Spot check if near streams
Green River Fm - Laney Shale - LaClede	Middle Eocene - Br-1	Sandstone, limestone, shale and oil shale, yellowish to brown - lacustrine - regional	<30 m	Vertebrates, invertebrates, trace fossils	1	3 to 4	2 (+ 2) fish, plants	(Monitor during bedrock disturbance)
Wasatch Fm - Cathedral Bluffs Tongue = "New Fork"	Early to Middle Eocene - Wa-7 to Br-1	Primarily greenish gray mudstone and sandstone, some variegated and bluish gray beds - Terrestrial, fluvial, overbank, soils, interfinger with lake deposits of Lake Gosiute	<150 m	Vertebrates, invertebrates, plants, trace fossils	1	4 to 5	3 (+ 17) crocodiles, petrified wood	Monitor the Tgl/Twc interface (about 20 m below contact), Main Twc - Monitor one well per section unless vertebrate fossils are found - otherwise spot check)
Green River Fm - Wilkins Peak Member	Early to Middle Eocene - Wa-7	Tan to yellow sandstone, limestone, shale and oil shale, brown to black - saline lacustrine - regional	<50 m	Plants, invertebrates, fish	2	4	(1) wood	(Spot check during bedrock disturbance)
Wasatch Fm - Alkali Creek Tongue	Early Eocene - Wa-7	Interbedded brown, gray, green sandstone, mudstone, siltstone, shale with minor conglomerate - terrestrial - fluvial, floodplain, soils, some lacustrine units, volcanic ash?	<30 m	Vertebrates, invertebrates, plants, trace fossils	1	5	Not identified in Jonah	(Monitor during bedrock disturbance)

Table 3. Evolution of Eocene terminology in the northern part of the Greater Green River Basin, generalized lithology is diagrammed in Roehler, 1991.

Donavan (1950) Sublette & Lincoln Cos.	Oriel (1961) Fort Hill area	Lawrence (1963) Cumberland Gap	Sullivan (1980) SW Wyo	Roehler (1991) GGRB	Lillegraven, 1993 Northern GGRB	Love, Christiansen, & Ver Ploeg, 1993 Northern GGRB
Laney Member Green River Fm	Upper Tongue Green River Fm	Upper Tongue Green River Fm	Laney Member Green River Fm	Laney Member Green River Fm LaClede	Laney Member Green River Fm	Laney Member Green River Fm LaClede
				unconformity		
New Fork Tongue Wasatch Fm	Upper Tongue Wasatch Fm	Upper Tongue Wasatch Fm	Desertion Point Tongue Wasatch Fm	Cathedral Bluffs Tongue Wasatch Fm	Desertion Point Tongue Wasatch Fm	Cathedral Bluffs Tongue Wasatch Fm
					interfingering	interfingering
Fontenelle Tongue Green River Fm	Middle Tongue Green River Fm	Middle Tongue Green River Fm	Wilkins Peak Member Green River Fm	Wilkins Peak Member Green River Fm	Wilkins Peak Member Green River Fm	Wilkins Peak
	New Fork Tongue	New Fork Tongue Wasatch Fm	New Fork Tongue Wasatch Fm	Alkali Creek Tongue Wasatch Fm	New Fork Tongue Wasatch Fm	Alkali Creek / Farson SS
		Fontenelle Tongue Green River Fm	Tipton Shale Member Green River Fm	Farson Sandstone Member Green River Fm	Fontenelle Tongue Green River Fm	Farson Ss
						interfingering
	Fontenelle Tongue Green River Fm			Scheggs Bed of Tipton Sh Green River Fm	LaBarge Member Wasatch Fm	Tipton - south & east
					unconformity	
Knight Member Wasatch Fm	Main Body Wasatch Fm	Main Body Wasatch Fm	Main Body Wasatch Fm	Main Body Wasatch Fm	Chappo Member Wasatch Fm	Main Body Wasatch Fm

caps many of the exposures in the Jonah Field. Its upper LaClede Bed is identified as the last of the large fresh water lacustrine units in area, having filled as much as 75% of the Greater Green River Basin (Roehler, 1993). However, the Laney Member is less thick here than to the southeast. The Bridger Formation is mostly fluviatile, with a very large component of reworked volcanic deposits, probably derived in the most part from the Absaroka volcanic field. It is usually gray to white in color with some notable beds colored with the blue-green mineral, celadonite. There are numerous thin lacustrine units in the Bridger that have been used as marker beds. These lacustrine units are the last remnants of the once more important Green River Lakes.

The terminology of the stratigraphic units of the western Green River Basin is confusing (Table 3). The sedimentary basin in which they occur is a large intermountain basin, mostly in southwestern Wyoming but with parts in eastern Utah and northwestern Colorado. The basin is roughly divided in two by the Rock Springs Uplift, with the western part usually called the Green River Basin and the eastern parts called, from north to south, the Great Divide, Washakie and Sand Wash basins. The sum of these units makes up the "Greater Green River Basin" of Roehler (USGS PP 1506-A-F). This overview is important because people working in the western part had one set of terminologies and people working in the eastern part another. Roehler has tried to synthesize these viewpoints. However many of the older papers reflect the older terminologies and this even shows up in the 2006 EIS for the Jonah Field which still has the older terminologies cited. It is important to realize that the terms "Fontenelle Tongue" and "New Fork Tongue" have been dropped from the stratigraphic nomenclature in the Greater Green River Basin (Figure 3, revised from Roehler, 1991).

All three units are fossiliferous, having plant, invertebrate, and especially vertebrate remains. The temporal units of the Eocene present here are the Early Eocene Wasatchian Land Mammal Age and the lower Middle Eocene Bridgerian Land Mammal Age. That the temporal terminology mimics the formational terminology is regrettable but is a historic reality. The Wasatchian has been subdivided, with greater or lesser success, into 8 units, from the bottom up Wasatchian 0 to Wasatchian 7. The Bridgerian rocks have also been subdivided into Bridgerian 0 to Bridgerian 3. These subdivisions are based upon the fossil species occurring in them.

The lower part of the Wasatch Formation in the Jonah Field area of the Green River Basin (the western part of what Roehler (USGS PP 1506A-F) calls the Greater Green River Basin) is a sequence of flood plain deposits and the member is termed the Main Body. The lowest members of the intertonguing Green River Formation in this area are the Tipton Tongue and the immediately

overlying Farson Sandstone of Wasatchian-7 (or Wa-7) age. The Tipton Tongue extends well southeastward and can be traced to the Great Divide and Washakie basins (the type locality is at Tipton Butte). Above the first Green River tongue lies the Alkali Creek Tongue of the Wasatch Formation which is not present further east (Roehler, PP 1506B, fig.3). The Alkali Creek Tongue is also Wa-7 in age. The Alkali Creek Tongue is in turn overlain by the Wilkins Peak Member of the Green River Formation, which thickens noticeably southward and eastward and cuts off the Alkali Creek Tongue (Roehler, PP 1506B, fig. 10). A bright bluish-green unit caps the Alkali Creek Tongue along Wyoming Highway 351, trending northwesterly toward Pinedale.

Above the Wilkins Peak Member of the Green River Formation is the Cathedral Bluffs Member of the Wasatch Formation. The lower part of the Cathedral Bluffs Member is Wa-07 in age and the upper part is Bridgerian, Br-0 and Br-1. Without mammalian fossil evidence, it is difficult to ascertain the age of the Cathedral Bluffs Member in the Jonah Field. However, stratigraphic evidence suggests that the beds preserved are probably part of the lowest strata of the unit. The Cathedral Bluffs Member of the Wasatch Formation is overlain by the Laney Member of the Green River Formation, probably unconformably. Roehler points out that there is a local hiatus present near LaBarge where the Laney Member of the Green River Formations cuts down into older units (PP1506-A, Map; PP 1506-B, figure 3; also page B-6). Winterfeld (2006) cites the Laney as resting upon the Alkali Creek Member of the Wasatch Formation at Ross Butte. This unconformity may be present in the Jonah Field area, with exposures of the Cathedral Bluffs Member of the Wasatch Formation thinning toward the southwestern section of the field.

The Laney Member of the Green River Formation is Br-1 and Br-02 in age and may extend, in the Washakie Basin, to Br-3 (unpublished data, University of Colorado Museum). However, the LaClede Bed of the Laney Member as identified in the Jonah Field is probably no older than BR-1. The LaClede Bed is extensive, preserving evidence of one of the largest freshwater expansions of Lake Gosiute. Grande (1984) has identified four fish-bearing zones in the Laney Member, G-1 through G-4, the closest exposure to the Jonah Field area being near Farson (G-4). The fauna list for the Green River Formation includes these units, grouping them under Lake Gosiute (Appendix C). Above the Laney Member, and regionally intertonguing with it, is the Bridger Formation of Br-1 to Br-3 age. Beds near Tabernacle Butte and Elk Mountain are this young (McGrew 1959), although no Bridger Formation rocks are preserved in the Jonah Field.

To further confuse the issue, West (1973) did not distinguish the collections he made from the hillsides south of Boulder, Wyoming (in what he thought was New Fork Tongue but what Roehler has shown to be Cathedral Bluffs Tongue, 1991). West's two localities BS-1 and BS-2 are vertical, running up the side of the hill and including at least 400 feet of section. L. D. Ivy recollected this area and he was able not only to subdivide West's localities, but to show that the Wasatchian Bridgerian Boundary occurs on the hillside and distinctive Wasatchian fossils come from lower down and distinctive Bridgerian forms from higher up (material preserved in University of Colorado Collections).

To date, beds older than Wa-7 and younger than Br-3 have not been reported within the immediate area of the Jonah and Anticline fields, although they certainly occur elsewhere in the Greater Green River Basin. There is a possibility that Wa-6 beds are present.

Few fossils have been found within the confines of the Jonah Field until recently. Its southwestern boundary approaches Alkali Creek where Gazin (1962, p.17-18) cites numerous fossil vertebrates as occurring, albeit at the mouth of the drainage where it converges with the Green River. Alkali Creek heads into the west central part of the Sugarloaf NE Quadrangle, immediately west of the Jonah Field. Subsequent collecting (West 1973, UCMP field parties) have reinforced these data. As mentioned earlier, West also collected vertebrate fossils from the hills immediately south of Boulder, Wyoming in the Cathedral Bluffs equivalent and found a series of localities where the Wasatchian/Bridgerian or early/middle Eocene boundary occurs. Therefore, the most likely reason for the sparse finds from the Jonah Field area is lack of access and relatively poor exposures. Within a thirty-mile radius of the EnCana headquarters in the Jonah Field, some 36 genera and 46 species of Wasatchian and 52 genera and 65 species of Bridgerian fossil vertebrates have been found (Appendix C).

Three main units with Wasatchian Age Fossils have been the most productive:

1) The upper part of the main body of the Wasatch Formation, those beds below the Scheggs Bed/Farson Sandstone Member of the Green River Formation. This is where Gazin's principal "**LaBarge Fauna**" occurs.
2) The **Alkali Creek** Tongue of the Wasatch Formation. This occurs above the Scheggs Bed/Farson Sandstone and below the Wilkins Peak Member. It is the main fossil-bearing unit below strata locally identified as the Blue Rim. In some papers it is referred to as the New Fork Tongue.

3) The Wasatchian age part--**lower Cathedral Bluffs Tongue** of the Wasatch Formation. This is above the Wilkins Peak Member and is exposed in the base of the hillside south of Boulder, Wyoming. In some papers it is also referred to as the New Fork Tongue.

All three of these units have essentially the same uppermost Wasatchian fauna, that is, Lostcabinian or Wasatch-7. On the accompanying summary faunal list they are referred to as "LaBarge", "Alkali Creek", and "Lower Cathedral Bluffs." The famous fossil fish beds at Fossil Butte National Monument area also Wa-7 in age (and are in a different sedimentary basin).

The Bridgerian Faunas are found in the upper part of the Cathedral Bluffs Member on the hill tops south of Boulder, Wyoming, in the overlying Laney Shale Member of the Green River Formation and in the Bridger Formation near Elk Mountain and Tabernacle Butte. On the accompanying summary lists they are referred to as "Upper Cathedral Bluffs", "Green River" and "Bridger".

The Faunal Lists in Appendix C are from the earlier papers and all have the stratigraphic terminology used by the authors. In the listing from the two monographs by Gazin (1952, 1962) only those taxa reported from Sublette County are included. His papers also included material from the Fossil, Washakie and Great Divide basins. The summary lists have the suprageneric classification of mammals as used in McKenna and Bell, 1997.

HISTORY OF PALEONTOLOGICAL WORK IN SUBLETTE COUNTY, WYOMING

Historically in Sublette County, the major research efforts of paleontologists working on Eocene fossil vertebrates have been concentrated on the western side of a triangle that has its apex at Pinedale (Table 4). Paul McGrew and others worked on the Bridgerian fossils of the Tabernacle Butte area and R. M. West worked on the area south and southeast of Boulder. C. L. Gazin, with USGS parties, and especially the University of California have spent much time looking at the area from LaBarge north through Big Piney to approximately 12 miles north of Big Piney and on the area of the Blue Rim, Ross Rim and Ross Butte. These latter localities are in the upper part of the main body of the Wasatch Formation and in the Alkali Creek Tongue (aka New Fork Tongue) of the Wasatch Formation. These areas are in the Pinedale Anticline Field and in the LaBarge Field. Prior to our survey, the only Eocene vertebrate fossils known to us from the Jonah Field are the fish that were impacted during 2006 pipeline construction and collected by Sam Drucker (BLM) and newly discovered crocodilian remains from Section 26. In early 2007, crocodile, plant, and molluscan fossils have been identified on several EnCana well site construction sites. In addition, a brief visit by

TABLE 4. Institutions and researchers that have worked or are working on vertebrate fossils in southwestern Wyoming

INSTITUTIONS	RESEARCHER	YEAR	AREA
Territorial surveys	John C. Fremont	1843	Cumberland Gap (SW Wyoming)
Philadelphia Academy NS	Joseph Leidy	1869	Fort Bridger area by Carter Family
United States National Museum	F. V. Hayden	1870	SW Wyoming, Washakie Basin
Yale Peabody Museum	O. C. Marsh	1870 - 1882	Bridger Basin, Greater Green River Basin, south central Wyoming, Washakie Basin
American Museum NH	J. L. Wortman	1890's	Greater Green River Basin
American Museum NH	W. Granger	1904-1907	Green River Basin, Washakie Basin
American Museum NH	W. D. Matthew	1910-1920	Green River Basin, Washakie Basin
University of Colorado Museum	J. Henderson	1921	Along US 30 (Now I-80- U.S.30)
United States National Museum	C. L. Gazin	1930's to 1969	west-central Green River Basin, Fossil Basin
University of Wyoming	P. O. McGrew and students	1940's to 1960's	Northwest and west-central Green River Basin, southeastern WY
Univ Wyoming / USGS	H. W. Roehler	1960's	Greater Green River Basin
Field Museum NH, Amer. Museum NH, Univ. Calif.	R. M. West	1960's and 1970's	Northwest Green River Basin, Opal area
Univ. Michigan	R. M. West	late 1960's	Big Sandy WY
Univ. Calif. Museum of Paleo	H. Hutchinson	1970's to present	Green River Basin, Wind River Basin
Univ Wyoming	J. Lillegraven and students	1970's to present	Hanna Basin, S Wyoming, statewide
Field Museum NH	L. Grande	1970's to present	Fossil and Green River Basins
Univ. Colo. Museum	P. Robinson	1976, 1991 to present	Bridger Basin, Washakie Basin, west central Greater Green River Basin
Univ Wyoming	B. Breithaupt	1980's to present	overviews of WY paleo
Univ Wyoming	G. Winterfeld	1982-85, collections to present	Rock Springs Uplift, Green River Basin, Bridger Basin
Univ. Colo. Museum	L. Ivy	1983-84	Great Divide Basin; Boulder WY area
Univ. Calif. Museum of Paleo	P. Holroyd	1990's to present	Green River Basin, Wind River Basin
American Museum NH	J. Alexander	1990's to present	Green River Basin
Loma Linda University	L. Brand & Buchheim	1990's to present	Fossil and Green River Basins
Denver Museum	R. K. Stucky	1990's to present	Green River and Great Divide Basins, betweem Cedar Mtn. & I 80
Denver Museum	L. Ivy	1990's to present	Green River and Great Divide Basins
Univ. Michigan	G. Gunnell, W. Bartells, & Sonavel	1990's to present	Greater Green River Basin to Church Butte

TABLE 4. Institutions and researchers that have worked or are working on vertebrate fossils in southwestern Wyoming

INSTITUTIONS	RESEARCHER	YEAR	AREA
Univ. Colo. Museum	P. Murphey	1991 to 2003	Bridger Basin, west central Greater Green River Basin
Univ. Colo. Museum	E. Evanoff	1991 to present	Bridger Basin, west central Greater Green River Basin
collections at UCMP	S. Strait	1995 to present	NW Green River Basin
Western Wyoming College	J. D. Love	to 1990's	S. W. Wyoming
Denver Museum of Nature & Science	K. Johnson	1990's to present	Denver Basin & comparison to WY

BLM personnel to the Cabrito Unit revealed petrified wood and fragments of crocodile scutes (March 15, 2007 – Jonah 14).

There may be significant reasons for this paucity in paleontological data.

1. The geologic mapping in the area is confusing. Roehler (1991) cites the fact that the Laney Member of the Green River formation cuts out a lot of section (most, if not all, of the Cathedral Bluffs Tongue of the Wasatch) in the area near LaBarge. The Alkali Creek Tongue does not appear to be exposed in the Jonah Field, which has a much smaller footprint than either of the other two gas producing fields to the north and west. The Wasatch Formation we have seen exposed (below the caprock at Yellow Point Ridge) appears to be above the Alkali Creek Tongue. Although a member of the Wasatch (mapped as New Fork in the FEIS) is exposed in Sand Draw and below Yellow Point Ridge ("Yellow Rim Unit"), it is stratigraphically above the Blue Rim (informally identified here as "Blue Rim Bed") suggesting that it is a Cathedral Bluffs Tongue equivalent. Green River beds interfinger throughout this sequence of the Wasatch Formation, inferring complex terrestrial/overbank/lacustrine environments that need much more thorough study than this report can address. For the purposes of this study, we are identifying these intermediary strata as the "Burma Road" unit. These informal designations are included in Figure 4.
2. Badland or even good bedrock exposures are limited in the Jonah area. Paleontologists frequently choose to evaluate well-exposed strata. Vertebrate fossils found in situ within these strata help define the geologic age of units, as well as answering questions about evolutionary and paleoecological trends in the Tertiary Period. Poorly to moderately exposed areas with vegetative cover generally are not identified as priority areas to be studied unless there is a gap in the paleontological data that demands their study. Newly developed exposures of rock resulting from excavation work associated with energy extraction in the Jonah area supply access to these previously unstudied rocks.
3. Historically, access to the area has been difficult. Obviously, this is no longer a factor.

PALEONTOLOGICAL METHODOLOGIES

EVALUATION OF EXISTING DATA

The initial paleontological study of the Jonah Field involved an evaluation of existing data including an updated literature search reviewing the formations to be impacted and their paleontological

Figure 4. Cross section of stratigraphic nomenclature for the Eocene and younger beds in central and southern Sublette County, WY
Eocene Land Mammal Ages (LMA) Br - Bridgerian, Wa - Wasatchian New Fossil occurrences noted. Strata thicknesses are not to scale

EPOCH / LMA	Terrestrial		Lacustrine	Sublette Co. - Gas Fields	Jonah/Anticline Area Informal Mapping Units	Known fossils	New Localities of Fossils	Newly identified material from the Jonah Field	PFYC
QUATERNARY	eolian, alluvial, terrace deposits				*Unconformity*	**horse?**		Not surveyed	2
EOCENE									
Br-1			Green River - Laney / LaClede Bed		Yellow Rim Bed	**fish**	2	fish, plant, wood (4), algae	3 to 4
Br-0 to Br-1		upper	**Minor lake beds**		Interface (Land to Lake)	**mammals, reptiles**	3	fish, plant (3), crocodile	5
Wa/Br boundary	WASATCH	"New Fork" south of Boulder		**Jonah**	Age ? Stage		8	crocodile (3), fish (2), mammal, reptile, bone fragments	5
Wa-7	Cathedral Bluffs	lower	**Minor lake beds**		Burma Road Bed	**crocodile, wood**	10	turtle (3), crocodile (3) **(bed of numerous crocs)**, plant (5), other bone, eggshell, invertebrate (snails, clams)	4 to 5
		lowest			?				
			Green River - Wilkins Peak		Sec 31 Bed	**wood**	1	wood - probably not in situ	3
Wa-7	Wasatch - Alkali Creek	Blue Rim volcanic w/ fluvial		**Anticline**	Blue Rim (mudstone and sandstone)	**many known mammals, reptiles**	2	mammals, turtle	5
Wa-7					351 Unit = Alkali Creek	**many known mammals, reptiles**			5
Wa-7			Green River - Farson SS						
			Green River - Tipton/Scheggs Bed						
Wa-7	Wasatch - Main Body "LaBarge Fauna"								

sensitivity. Published literature and unpublished sources were reviewed as noted above. Based on those findings, we recommended that a field survey of sensitive formations be undertaken along good rock exposures (generally those with a slope of 10% or greater, or bare of vegetation) to discover the potential for impact to fossil resources. The field survey subsequently was done this spring (2007), covering approximately 20% of the Jonah Field. All new fossil localities identified during this survey are included in the confidential portion of this report (Appendix D).

When significant fossil material (vertebrate, invertebrate, plant, or trace) was encountered during the field survey, appropriate field methodologies were undertaken or recommended. These field methodologies are:

Sampling - During the field survey, fossil material was sampled to facilitate further analyses to determine significance. Frequently fossil taxa are not adequately well known to allow the determination of significance in the field.

Salvage/Mitigation - Salvage is recommended if the fossil discovery is of scientific interest and if construction would destroy the site. Obviously, salvage must be reasonably cost effective, because the cost of salvage can occasionally be very high. In addition, the time involved for such an operation, has the potential to cause delays in project construction. Rerouting may be considered the more appropriate action.

Monitoring - Where critical or significant fossil material is likely to be encountered during the construction of well sites, access roads, or pipelines in particular, monitoring is recommended. The probability of such material being encountered is determined from the evaluation of the literature and from field survey discoveries.

Rerouting or Relocation - A request for a site change is made if critical or significant fossil material is encountered during a preliminary field survey directly on the well site, access road, or pipeline corridor and the salvage cost or time factor is unacceptably high. A change may also be requested if the locality is scientifically very important and should be left undisturbed for subsequent scientific evaluation.

This report identifies and describes the formations and significant fossil-bearing localities that may be impacted by construction in the Jonah Field. In addition, recommendations are made regarding

paleontological monitoring and mitigation procedures (Appendix B). All formations to be impacted are identified in Table 2 with sensitivity levels as defined in the BLM handbook (1998). Those units partially covered by Quaternary sediments are noted if Eocene bedrock is likely to be impacted, but is not well exposed at the surface (Class 4 by the PFYC criteria).

Uinta Paleontological Associates Inc. (Sue Ann Bilbey, Ph.D.) has applied for and obtained BLM Paleontological Resource Use Permits from the BLM for Colorado BLM Permit C-56549 extended, Wyoming BLM Permits PA95-WY-008 extended (ends December 31, 2007) and PA04-WY-115 (through December 31, 2009). Affiliate Dr. Peter Robinson is also permitted in Wyoming (BLM Permit PA96-WY-022 extended). The field crews included: Sue Ann Bilbey, Peter Robinson, Evan Hall, Patricia Monaco, John Bird, and Kelly Buckley. Joshua Smith, David DeMar, and Quinn Hall were mobilized to collect significant crocodilian remains impacted during well site construction in Section 26 at SHB 42-26 in the Stud Horse Butte Quadrangle.

FIELD SURVEY PROCEDURES

A. By evaluating topographic and geologic maps, we identified exposures with significant relief to allow field surveys of the strata (Figures 1 and 2).
   1. Southeastern portion of Jonah – south Cabrito Unit – carefully examine the Wasatch/Green River (Laney) interface exposures along the bluffs and on the mesas – Sections 28, 29, & 30, T29N, R107W
   2. north Cabrito Unit – north and south of the Luman Road particularly where the Wasatch channel sandstone beds are exposed, and good exposures of the Green River Formation – Laney Member. Section 18, T29N, R107W
   3. Stud Horse Butte Unit – contacts above and below the Green River (Laney) contact with the Wasatch - Sections 13, 14, 23, 25, and 26
   4. Western bluffs on Yellow Point Ridge – Wasatch/Green River (Laney) interface – Sections 1, 2, 11, and 12, T28N, R109W.
   5. Wasatch Formation exposed in well site debris (western Stud Horse Butte Unit and Corona Unit).

B. Preliminary road surveys have confirmed that the following areas need to be given more attention.
   1. Wasatch/Laney interface or contact
      - Very good exposures on top (informal unit “Yellow Rim”) and cuts below the Yellow Point Ridge (Wasatch/Laney interface)

- particularly to the southeast in Cabrito Unit
- check the northwestern exposures along the Yellow Point Ridge
- Stud Horse Butte and mesa to the east

2. Wasatch ("Burma Road" unit) – (this is the informal unit that we infer is a Cathedral Bluffs equivalent)
   - Large sandstone channel deposits on the north side of Jonah – Section 13 as well as north of Cabrito, north and south of the Luman Road
   - Evaluate sandstone channel deposits as well as associated ant hills
   - Identify and evaluate relief in the northwestern section of Jonah or debris piles and cuts into bedrock associated with existing wells
3. Wilkins Peak – Exposure mapped in Section 31 (informal unit "Section 31")
   - Tan to yellowish brown weathering sandstone caps the unit. Petrified wood was found associated with the broken sandstone. It may have weathered down onto this unit from above.
   - Underlying rocks are largely covered with vegetation/soils/Qal – look for exposures in 31

Work in these areas included full pedestrian surveys, which allowed paleontologists to evaluate the stratigraphy, sedimentology, and paleontology of the Tertiary units that are exposed in the area. As noted above, some of the area is covered with Quaternary deposits and/or vegetation. Only areas with good exposures or well site debris piles were carefully examined.

As part of the paleontological survey, the scanty anthill debris was also checked for small mammal bone and tooth fragments. In Wyoming, the prevalence of cover and the bias toward small fossil vertebrates in many of the formations makes the collection of fossils difficult without help. In the case of the Wasatch and Washakie formations, the help comes from collections made by the harvester ant, ***Pogonomyrmex occidentalis*** (Robinson and Williams, 1997). These ants place small pieces of rock on anthills as a protection against rain and wind (the gravel cover is often thicker on the western side of the hill). They often pick up small fossils as they would any other particle. From the studies of McCook (1882) it is known that the ants may tunnel as much as 3 meters (10 feet) below the surface. University of Colorado Museum experiments with colored glass beads indicate that items from as far away as 30 meters (100 feet) on the ground surface may also be picked up by the ants and placed on their hills. Therefore, the cautious use of anthills as an aid in fossil collection is feasible, if not as ideal, as finding the material in place. In many areas of Wyoming, it is the only practical way to make a useful collection. Anthills are present but sparsely distributed in the Jonah Field.

LITHOLOGIC DESCRIPTIONS OF THE EOCENE ROCKS IN THE JONAH FIELD

INTRODUCTION

The stratigraphy of the Eocene rocks in the Jonah Field has been debated throughout the years as noted in the review of existing data (Tables 3 and 4). Rather than discuss each unit of the Wasatch and the Green River formations as defined in the Roehler publications (1990-1993), it seems more appropriate to report the lithologies seen during this field survey. This is particularly important because the northwestern portion of the Greater Green River Basin has not been as extensively studied and units that are distinct elsewhere in the Basin can be difficult to identify in Sublette County. Rather than attempt tying these rocks to formal stratigraphic nomenclature, we chose to define informal mapping units that were identified in the Jonah Field and described in the previous section (Figure 4). Biostratigraphic correlations are made using time-constrained mammal fossils and some turtle fossils. Unfortunately these fossils are poorly represented in the Jonah Field. We did find mammalian bone scraps and a few turtle fragments, tantalizing but not definitive specimens.

WASATCH FORMATION – ALKALI CREEK MEMBER = "351 Unit"

The Alkali Creek Member of the Wasatch Formation (Roehler, 1991) is characterized by variegated units of fluvial and overbank deposits ranging is size from sandy claystone to mudstone to coarse sandstone and conglomerates. The colors of these units can be variegated, yellow to red to purple, to brick brown, but they are predominantly green and gray. Petrologically, the coarser grained units are arkosic with scattered biotite, preserving significant amounts of white and pink feldspar and angular quartz. Donovan (1950) suggested that the provenance for the beds seen near the confluence of the Green River and the New Fork River is the Wind River Mountains, about twenty miles to the north and east of that area. We did not perform a field survey in this area, as it does not extend into the Jonah Field. The highest identifiable unit of the Alkali Creek Member is well north of the Jonah Field along the northwestern edge of the capping Blue Rim, cutting diagonally southwest to northeast across Wyoming 351 toward Pinedale. Vertebrate fossils from this unit are definitively identified as Wasatch 7 (Appendix C).

WASATCH – "BLUE RIM"

A very brief reconnaissance of the Blue Rim bed (the uppermost member of the Alkali Creek Member of the Wasatch Formation) in Section 10, Township 30 North, Range 108 West, reveals light greenish gray mudstone and fine-grained sandstone with an underlying brownish gray mudstone. The mammalian fossils known from this area are identified as typical of Wasatch 7 beds (UCMP and

UCM fossil locality information – Appendix C). However, the overall aspect of the rock is very similar to that of the Bridger Formation, a unit known to contain significant amounts of volcanic ash. This suggests that vulcanism from the Absaroka Range may have begun before Bridgerian times, perhaps in sufficient amounts to produce a peculiar unit (Blue Rim) within the northern extent of the Wasatch Formation in the Greater Green River Basin. Unfortunately, this unit is not identifiable further south into the Jonah Field. In addition, all exposed strata south to the Jonah Field appear to be stratigraphically higher than the Blue Rim.

GREEN RIVER FORMATION – WILKINS PEAK MEMBER = "Section 31"

The Wilkins Peak Member of the Green River Formation is mapped in the western half of Section 31, Township 29 North, Range 108 West in the Jonah Field. Many more exposures are mapped west of the Burma Road, but they are not within the Jonah boundaries as defined in this document. Our field reconnaissance revealed an exposure of light orangish tan, slabby, fine-grained sandstone. The rock is generally broken on a rock soil surface with few bedrock exposures. Small, petrified wood fragments are common, but may not be in situ. They may have weathered from higher in the section. There is also light greenish gray siltstone underlying the sandstone, and weathering on the surface below the top of the hill in Section 31. Numerous chert and granite pebbles are common, perhaps part of the Quaternary glacial outwash from the mountains to the east. Tan sands, some of eolian origin, are associated with the rocky surface. There are lacustrine tongues of the Green River Formation in the north part of the Cabrito unit. These are close to the stratigraphic position of the Wilkins Peak of Sec. 31.

WASATCH FORMATION– "CATHEDRAL BLUFFS MEMBER" or UPPER ALKALI CREEK MEMBER = "Burma Road Unit"

Between the Blue Rim (Alkali Creek Member of the Wasatch Formation) and the Yellow Point Rim (Laney Member of the Green River Formation) is a unit that is predominantly greenish gray mudstones and muddy sandstone beds, with minor thinly bedded shale, as well as coarse arkosic sandstone and conglomerates.

West of the Windmill Road, green mudstones of the Wasatch predominate. The mudstones and shale units weather rapidly, forming rounded hills, lower valleys and drainages. The best exposures of the greenish gray mudstones are in the debris piles from well site and pipeline construction. On bedding planes we identified plant debris and an occasional gastropod, usually a small planorbid—perhaps an immature *Biompholaria or Gyraulus*. There is also evidence of burrowing in these mudstones, with coarser sands isolated in distinct paths about 15 mm wide. However, burrowing is not particularly common in these beds and there was no evidence of what organisms produced the burrows. The laminar structure of some beds suggests that organisms were not

actively mining the sediments during deposition. Root casts are also uncommon. The greenish gray color of many of these mudstones suggests deposition in a reducing environment, perhaps within a zone of high ground water. Some are laminar, suggesting water-laid deposition like in a lake or as a crevasse splay. Others are more massive, suggesting marshy soil development.

Thin stromatolitic zones have been impacted during well site construction in several areas near the middle of the Jonah Field as well as near the upper Wasatch interface with the Laney Tongue of the Green River Formation. Modern stromatolites form when microbial mats grow in high salinity or carbonate-rich waters. Generally they form in stable oxygenated waters with periodic influxes of fine-grained suspended matter that help build the mats. In the geologic record, these can form large mounds or flat-lying surfaces. Storms can disrupt the mats, even rolling them around other materials like logs. Huge examples are found in the Tipton Shale Member of the Green River Formation in the southern Washakie Basin. In the Jonah Field, the stromatolitic beds are rarely thicker than 10 cm, more often identified as columnar structures surrounding logs or as tubular accumulations growing on older hard grounds. Many of these stromatolitic horizons preserve casts of plants (large *Equisetum*—Figure 5) as well as surrounding petrified wood fragments.

The sandstones and conglomerates of the Wasatch are more resistant, revealing exhumed river channels that trend generally east to west (Figure 6). The coarse sandstone beds are rich in feldspar and angular quartz, apparently derived from the igneous rocks of the Wind River Mountains to the east, rather than the sedimentary rocks of the Wyoming overthrust to the west. Many of these rocky exposures were included in biologically sensitive areas, so we did not have access to them this spring. However, we identified a few outcrops that were not within the sensitive areas, so we surveyed those carefully. These beds are fairly well sorted, coarse-grained to pebbly sandstone or conglomeratic implying rapidly flowing water. Petrified wood is a common component of these rocks, or is found very nearby (Figure 7). Fossil bones found near these units are generally well-rounded, preserving little identifiable detail. Turtle shell fragments were occasionally found associated with these sandstone channel deposits, primarily Trionychids (soft-shell turtles), similar those seen today that commonly inhabit flowing water.

Sometimes the sandstone units weather differentially, preserving round cannonball concretions in isolated zones (Figure 8), suggesting a carbonate-rich ground water during the time of deposition. Although we did not find any fossils in the concretions, in similar situations the nucleus of this type of rock can preserve vertebrate fossils. Localized high pH due to bacterial decomposition of animals can precipitate calcite soaps that later crystallize into sandy calcitic rinds around a fossil.

These environmentally variable beds of the upper Wasatch Formation (Cathedral Bluffs Member equivalent?) suggest that the terrestrial/fluvial/lacustrine environments were actively changing in the northern Greater Green River Basin during the early Eocene. Petrified wood is very common, suggesting active riparian habitats with

Figure 5. A cast of a large piece of *Equisetum* surrounded with stromatolite. (Tw - Burma Road Unit)

Figure 6. Cross-bedded sandstone with graded conglomerates formed by fluvial channels in the Tertiary Wasatch Formation. (Tw) Dr. Peter Robinson for scale. Small pieces of tumbled petrified wood were found in situ.

Figure 7. Large petrified wood pieces from the Laney Member of the Green River Formation.

Figure 8. Concretionary sandstone zone in the upper Wasatch Formation.

numerous trees. Much of the wood is replaced by silica, but retains its annular rings, suggesting wet and dry seasonality.

The interface between the Wasatch Formation and the Green River Formation (Laney Member) is composed of greenish gray mudstone, brownish green paper shale beds, and mud-clast conglomerates (Figure 9). It is in this zone (approximately 10 m thick) that we found the greatest abundance of vertebrate fossil material. Crocodile remains were found within this zone, nearly everywhere we checked the interval (six localities). Ground disturbing activity at one well site (SHB 42-26) produced a muddy sandstone bed of crocodile scutes, skull fragments, vertebrae, and limb bones from more than three individuals. The bones in this bed are not articulated (Figure 10). The bones and scutes are scattered, with some evidence of linear flow, perhaps carried by a mudflow. We also found fossil egg shell at this well site, although higher stratigraphically than the crocodile bed (Figure 11). All crocodile bones found in situ or in pit debris at the well sites are dark brown to black; those weathering on the surface of hillsides are bleached to light tan (Figure 12). On a survey around Stud Horse Butte we found at least two levels with crocodile fragments weathering to the surface. A portion of a crocodile jaw with teeth was found on that hillside (Figure 13).

In the southeastern portion of the field (Jonah-21) we found mammal bone fragments along with more crocodile scutes in a good exposure of the uppermost Wasatch. Unfortunately, no mammal teeth were found to aid in the age determination of the strata. Above the fossil-bearing beds, there is a bedded chert horizon that suggests a Lake Magadi-like setting (volcanic ash deposition into a hypersaline lake) similar to those described elsewhere in the Green River Formation (Suttner, Eugster, and Mariner, 1972). Silica released during the devitrification of a volcanic ash into such as system can petrify and partially agatize wood, similar to specimens seen in the Jonah Field. For this study, we are identifying this bedded chert as an indicator for the contact between the Wasatch and Green River Formation. Further investigation may reveal a clean volcanic ash above the chert that could be radiometrically dated.

GREEN RIVER FORMATION – LANEY MEMBER = "Yellow Rim Unit"

Capping the Yellow Point Ridge in the Jonah Field is a calcareous, fine-grained sandstone unit that weathers dark brown to yellowish gray. The overall dip of the Laney – "Yellow Rim" sandstone is gradual—2° to the southwest. It is reasonably easy to trace as it occurs very near the 7200 ft contour line on the Stud Horse Butte Quadrangle, forming a resistant layer. In some areas in the southeastern portion of the field, this rock appears to be a ferricrete—sandstone cemented with iron oxide, others are yellowish brown calcareous sandstone beds. Approximately 50 cm below it is a 2 cm thick bed of a fibrous mineral—either calcite or perhaps trona; it is too hard to be gypsum. Fragments of this bed weather downhill and can be seen below the calcareous sandstone along the Yellow Point Ridge in many places.

Figure 9. Stud Horse Butte showing the Tw/Tgl fluvial to lacustrine interface.

Figure 10. Crocodile fossils in a slab from the construction at SHB 42-26.

Figure 11. Egg shell fragments from SHB 42-26. Locality Jonah 08.

Figure 12. Weathered crocodile scute and bone. Notice the difference in the color from the freshly exposed material in Figure 10.

Figure 13. Crocodile jaw fragment with teeth from Locality Jonah 10 - Stud Horse Butte.

Figure 14. *Sparganium* (?) fruit from the Tgl/Tw interval at Locality Jonah 2.

Near the western end of the field, paper shales underlie the sandstone. Light gray to tan shale units contain leaf impressions, ostracods and planorbid gastropods (Jonah-3). Lower down the slope, we found petrified wood, similar to that found near the formational interface. At YP 67-11, we found plant debris and *Sparganium* fruit (Figure 14) in a shale interbedded with a mudstone with crocodile scutes then an ostracodal shale with fish bone fragments not far from the top of the hillside. This ostracodal shale appears to be a correlative unit with the fish-bearing beds discovered last year during pipeline construction for Teppco in Section 26, Townshi9 29 North, Range 108West. This suggests that any construction that penetrates the Laney – "Yellow Rim Unit" could impact more fossil fish.

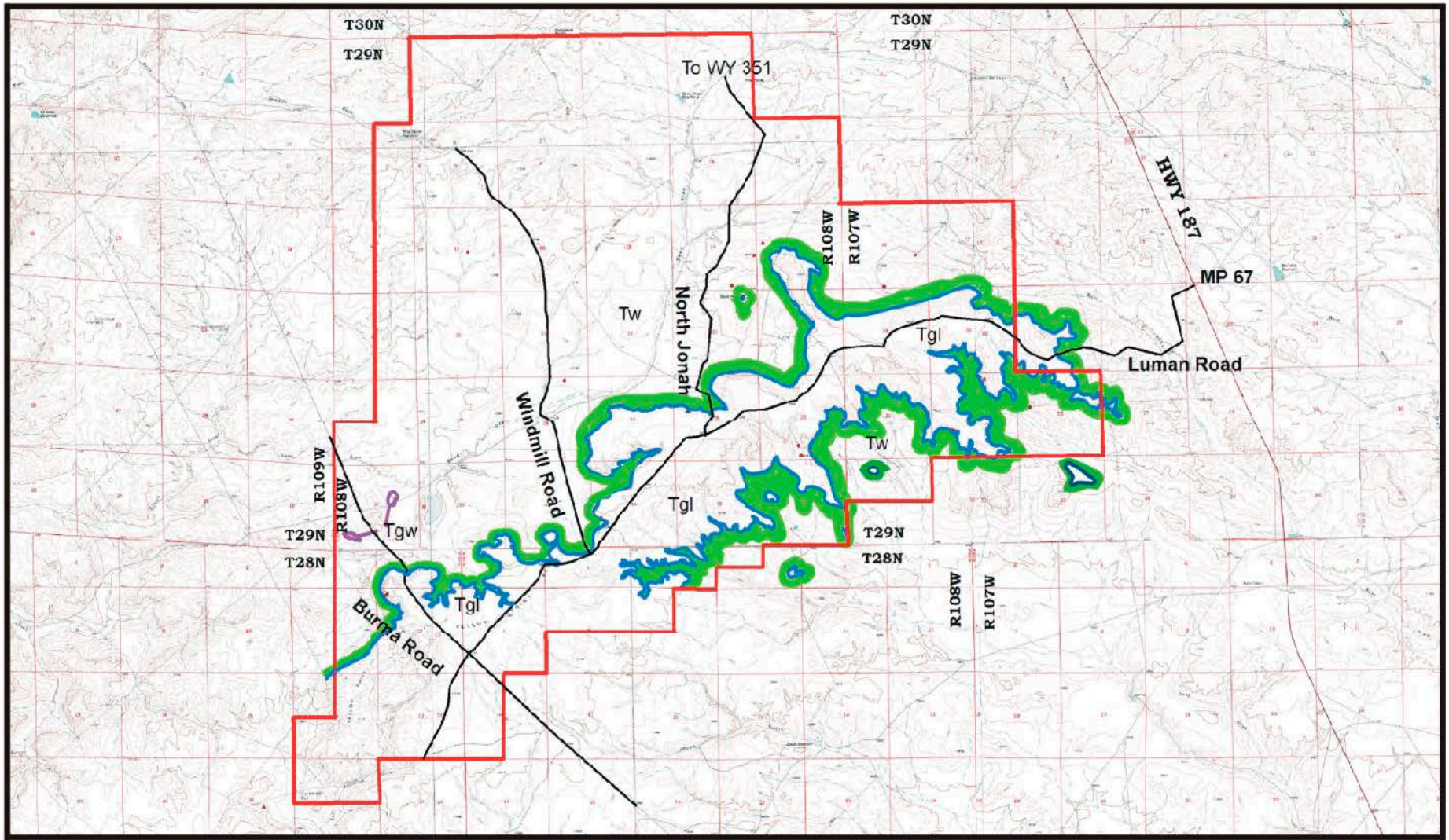
RECOMMENDATIONS FOR PALEONTOLOGICAL MONITORING AND MITIGATION

Significant vertebrate fossil occurrences identified during this paleontological field survey are mapped and locality forms and tables are included in the confidential Appendix D. The majority of the discoveries are in the formational interface between the Wasatch and Green River formations. Crocodilian scutes and bones with a few mammal bones predominate in the greenish gray mudstone and sandstone of this interval. Fish are found higher in the Laney Member ("Yellow Rim" unit) and turtles are more common lower in the "Burma Road" unit, particularly associated with the fluvial, channel sandstone deposits. Petrified wood seems ubiquitous below the "Yellow Rim"; probably weathering from high in the Wasatch Formation. Plant debris is common in the "Burma Road" unit, particularly in the light reddish gray mudstone, less so in the greenish gray units.

Much of the bedrock in the northwestern portion of the Jonah Field is covered with Quaternary alluvium and eolian deposits. **Bedrock in that area is only revealed by well site or pipeline construction**. Although we carefully checked a variety of debris piles, relatively little fossil material was found in the exposed strata. Stromatolitic layers are common among the mudstone deposits, suggesting a high ground water table with pond development during the Eocene.

Therefore, we have developed a zone of concern for paleontological resources on the Yellow Point Ridge and below the rim of at least 20 meters (Figure 15). Well site, access road, and particularly pipeline construction should be carefully monitored during all ground disturbance in these areas.

Any areas with channel sandstone exposures in the Wasatch Formation should be carefully examined **before** any ground disturbing activity (these are also archaeologically sensitive areas). Rip-up conglomerates in the basal portion of these units can preserve significant vertebrate fossils as well as petrified wood. Underlying mudstones in contact with the channel sandstone beds can also produce fossil organisms that were caught in the depositional change. Any ground disturbing activity should be monitored throughout construction in these channel sandstone areas.



JONAH FIELD PALEONTOLOGICAL OVERVIEW
TOWNSHIPS 28 & 29 NORTH, RANGES 107 TO 109 WEST
SUBLETTE COUNTY, WY
APPROXIMATE Tgl/Twc CONTACT
INTERFACING TERRESTRIAL AND LACUSTRINE BEDS BELOW THE Tgl/Twc CONTACT

5 miles

N

Figure 15

Uinta Paleontological Associates, Inc.

The Wasatch Formation, "Burma Road beds" above the Blue Rim, does not appear to be particularly productive for vertebrate fossil resources, similar to its counterpart further south, i.e., the Cathedral Bluffs Member. However, this may be only a sampling bias, due to our seeing only a minor part of potentially impacted strata. Therefore we suggest that a paleontological monitor should evaluate the entire ground disturbing process on at least one randomly selected well site per section (Sections 2 thru 22, 28, 29, 32, and 33, T29N, R108W) in the Jonah Field. Others can be spot checked. If significant vertebrate fossils are encountered, monitoring programs for that area may need to be revised.

Any large pipeline project in the area should be carefully monitored by a paleontologist, producing trench logs of the stratigraphic and lithologic changes; smaller ones should be spot checked unless they are in the sensitive Tgl/Tw interface. In that case, all pipelines should be monitored. This type of evaluation is primary to our understanding of the geology and paleontology of the Eocene rocks in Sublette County.

If vertebrate fossil resources are impacted anywhere in the field, the project paleontologist, the company environmental coordinator, and the BLM agent should be notified immediately to evaluate the discovery. A proposed monitoring and mitigation plan is enclosed with this document (Appendix B). Following this plan should minimize the loss of significant paleontologic specimens and data. Cooperation between agencies, energy companies, construction workers, and paleontologists is paramount. Together we can protect the fossil resources while allowing further energy development in the Jonah Field.

CONCLUSIONS

Energy development in the Jonah Field may impact significant fossils in Eocene bedrock in various members of the Green River and Wasatch formations. The Yellow Point Rim is an extended mesa that exposes the interfingering interval between the Twc – Cathedral Bluffs ("Burma Road Unit") and the Tgl – Laney Member ("Yellow Rim Unit"). This interval is particularly rich with crocodilian fossils. Twenty-three new fossil occurrences were identified across approximately 20% of the Jonah Field; ten were plant or petrified wood, the rest contain vertebrate or multiple types of fossils.

The bedrock in northwestern portion of the Jonah Field has been impacted by recent soil-forming processes or eolian (wind-blown) deposition. So it was not thoroughly surveyed except where there are recent debris piles associated with well site or pipeline construction. Although the bedrock is not exposed in this area, it is frequently impacted during excavation work. When bulldozers or backhoes are used in any of these areas, rock debris can be large enough to allow a monitor to identify fossils close to the original context. Scapers gather rocks and dump them elsewhere. This looses fossil

context, but rock debris can be examined more closely in the dump area in relative safety between loads.

Monitoring during all ground disturbance should be done in the area of the Wasatch/Green River interface shown on Figure 15. This zone is very productive for vertebrate fossils. It qualifies as a BLM Condition 1 / PFYC 5 unit. The Wasatch (Burma Road unit) qualifies as well, but surface expression of vertebrate fossils is not common except in areas of resistant fluvial sandstone beds. Other Green River units are less productive (Condition 2/PFYC 3 or 4). Our recommendations for monitoring of these units are variable, but generally spot checking is all that is necessary. However, if vertebrate fossils are encountered during construction, local areas should be upgraded to full monitoring as it meets the PFYC 5 unit criteria. **Any large pipeline work done in the Jonah Field should be monitored to identify fossils, changes in rock types, and clarify the boundaries of individual units**. Smaller pipelines can be spot checked unless they are in the sensitive Tgl/Tw interface. In that case, they should be monitored during construction.

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APPENDIX A

Probable Fossil Yield Classification - PFYC

Originally developed by the Paleontology Center of Excellence and the Region 2 (USFS) Paleo Initiative, 1996. Some modification by Dale Hanson, Regional Paleontologist, Wyoming BLM, 2002.

Introduction

This is a planning tool whereby geological units, usually at the formation or member level, are classified according to the probability of yielding paleontological resources that are of concern to land managers. Existing statutes and policies regulate the collection and disposition of vertebrate fossils, but not non-vertebrate fossils except in special circumstances. Therefore, this classification is based largely on how likely a geologic unit is to produce vertebrate fossils. The classes are described below, with some examples of corresponding management considerations or actions.

NOTE: This system is based on **probabilities**, not certainties or special circumstances. There will be exceptions to each criterion used as the basis for classification. These are expected and should be handled as unique cases.

Paleontology Classes

Class 1

Description: Igneous and metamorphic (tuffs are excluded from this category) geologic units or units representing heavily disturbed preservational environments that are not likely to contain recognizable fossil remains.

Basis:

- Fossils of any kind known not to occur except in the rarest of circumstances.
- Igneous or metamorphic origin.
- Landslides and glacial deposits.

Example: Sherman Granite, Laramie Mountains

Comments: The land manager's concern for paleoresources on Class 1 acres is negligible. Ground-disturbing activities will not require mitigation except in rare circumstances.

Class 2

Description: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

Basis:

- Vertebrate fossils known to occur very rarely or not at all.
- Age greater than Devonian.
- Age younger than 10,000 years before present.

- Deep marine origin.
- Aeolian origin.
- Diagenetic alteration.

Example: Tensleep Sandstone, Bighorn Mountains

Comments: The land manager's concern for paleoresources on Class 2 acres is low. Ground-disturbing activities are not likely to require mitigation.

Class 3

Description: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Also sedimentary units of unknown fossil potential.

Basis:

- Units with sporadic known occurrences of vertebrate fossils.
- Vertebrate fossils and significant nonvertebrate fossils known to occur inconsistently; predictability known to be low.
- Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Example: Chugwater Formation, central Wyoming.

Comments: The land manager's concern for paleoresources on Class 3 acres may extend across the entire range of management. Ground-disturbing activities will require sufficient mitigation to determine whether significant paleoresources occur in the area of a proposed action. Mitigation beyond initial findings will range from no further mitigation necessary to full and continuous monitoring of significant localities during the action.

Class 4

Description: Class 4 geologic units are Class 5 units (see below) that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation.

Basis:

- Significant soil/vegetative cover; outcrop is not likely to be impacted.
- Areas of any exposed outcrop are smaller than 2 contiguous acres.
- Outcrop forms cliffs of sufficient height and slope that most is out of reach by normal means.
- Other characteristics that lower the vulnerability of both known and unidentified fossil sites.

Example: Covered acres of Morrison Formation, Wyoming.

Comments: The land manager's concern for paleoresources on Class 4 acres is toward management and away from unregulated access. Proposed ground-disturbing activities will require assessment to determine whether significant paleoresources occur in the area of a proposed action and whether the action will impact the paleoresources. Mitigation beyond initial findings will range from no further mitigation necessary to full and continuous monitoring of significant localities during the action.

Class 5

Description: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant nonvertebrate fossils, and that are at risk of natural degradation and/or human-caused adverse impacts.

Basis:

- Vertebrate fossils and/or scientifically significant nonvertebrate fossils are known and documented to occur consistently, predictably, and/or abundantly.
- Unit is exposed; little or no soil/vegetative cover.
- Outcrop areas are extensive; discontinuous areas are larger than 2 contiguous acres.
- Outcrop erodes readily, may form badlands.
- Easy access to extensive outcrop in remote areas.
- Other characteristics that increase the sensitivity of both known and unidentified fossil sites.

Example: Exposed bedrock of Morrison Formation, Wyoming.

Comments: The land manager's highest concern for paleoresources should focus on Class 5 acres. 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.

Table 3 provides an historical perspective of the development of the classifications of formations and fossil localities.

APPENDIX B

PROPOSED MONITORING AND MITIGATION PLANS

PROPOSED MONITORING AND MITIGATION PROCEDURES
PALEONTOLOGICAL RESOURCES
JONAH FIELD

INTRODUCTION

The Bureau of Land Management (BLM) must approve recommendations for monitoring or mitigation of paleontological resources. The majority of the formal geologic formations or groups along within the Jonah Field are from the Cenozoic Era (two formations/four members), with three informal Quaternary units (Table 2). The final paleontological sensitivity determination of these geologic units is made after reports are submitted to the agencies, and a formal evaluation of existing paleontological data and the results of pedestrian field surveys are completed. If a geologic unit or fossil locality is deemed to be of high sensitivity for containing significant paleontologic resources, monitoring and mitigation measures will be recommended by the Federal and state agencies to protect those resources.

FEDERAL AND STATE REQUIREMENTS

The United States Department of the Interior/Bureau of Land Management (BLM) has requested the evaluation of the paleontological sensitivity of all geological formations within the Jonah Field pursuant to its authority and obligations, and consistent with its internal policies and procedures, under the following:

1) The National Environmental Policy Act of 1969 (NEPA)(P.L. 91-190; 31 Stat. 852, 42 U.S.C. 4321-4327);
2) The Federal Land Policy and Management Act of 1976 (P.L. 94-579; 90 Stat. 2743, U.S.C. 1701-1782)
3) BLM Paleontology Resources Management Manual and Handbook H-8270-1 (revised 1998).

In addition, there are Wyoming State laws and regulations regarding paleontological resource protection that have established similar guidelines: Wyoming Section 36-1-114 through 36-1-116 (current to 2003).

RESOURCE ASSESSMENT GUIDELINES

The BLM has released the BLM Paleontology Resources Management Manual and Handbook H-8270-1 (revised 1998) that established a classification system:

> "for ranking of paleontological areas according to their potential for noteworthy occurrences of fossils. . . . Public lands may be classified based on their likelihood to contain fossils, using the following criteria:
>
> a. *Condition 1* - Areas that are known to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. Consideration of paleontological

resources will be necessary if the Field Office review of available information indicates that such fossils are present in the area.

b. *Condition 2* - Areas with exposures of geological units or settings that have high potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. The presence of geologic units from which fossils have been recovered elsewhere may require further assessment of these same units where they are exposed in the area of consideration.

c. *Condition 3* – Areas that are very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils based on their surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium, or aeolian deposits or the presence of deep soils. However, if possible it should be noted at what depth bedrock may be expected in order to determine if fossiliferous deposits may be uncovered during surface disturbing activities.

Either Condition 1 or Condition 2 may trigger the initiation of a formal analysis of existing data prior to authorizing land-use actions involving surface disturbance or transfer of title. Condition 3 suggests that further paleontological consideration is generally unnecessary."

The BLM in Wyoming may choose to adopt a second paleontological classification scheme for the management of paleontological resources—**Probable Fossil Yield Classification (PFYC).** The USDA Forest Service originally developed this scheme. Table 1 presents all formations within the Jonah Field, classifying them using both the BLM scheme described above and the PFYC standard.

There are several other classification systems for ranking the sensitivity of formations for containing fossils resources. Table 5 lists six systems that have been used by various Federal and state agencies over the past twenty years. This comparison will allow land managers to use older resource management plan data to determine the sensitivity of the units and localities.

Those formations known to contain vertebrate fossils (Condition 1, PFYC Class 4 and 5) tend to be considered the most sensitive and, hence, suffer the highest impacts from ground disturbance. Vertebrate fossils tend to be rare and fragmentary (portions of skeletons) when found, so even disarticulated remains are considered significant. Invertebrate and plant fossils, by contrast, are relatively common but are very important to paleoecology studies like those regarding the study of the Tertiary deposits in the northern Greater Green River Basin. Of the invertebrate and plant fossil-producing localities, the "type" sites (i.e., locations that have produced fossils that paleontologists have used to define extinct species) are considered among the most significant scientific resources.

Uinta Paleontological Associates Inc. (Uinta Paleo), as authorized by EnCana Oil and Gas (USA) Inc. as well as their partners Ultra Resources and BP, reviewed geologic maps as well as geologic and paleontological publications for known fossil occurrences in or near the

Table 5. The evolution of sensitivity designations for formations and localities containing fossil resources is presented chronologically from 1985 to 2003. The last two (BLM-1998 and USFS-2002) are the criteria used on this project.

BLM "Proposed paleontology collecting regulation" - Document 8270, dated 9/1/85	**Armstrong and Wolny, 1989, Paleontological resources of Northwest Colorado**	**Society of Vertebrate Paleontology, 1995, Formation designation**	**BLM Paleontological Document IM-96-67-Formation designation (1996)**	**BLM Paleontology Resources Management Manual and Handbook H-8270-1 (revised 1999)**	**Potential Fossil Yield Classification (PFYC)(USFS Paleo Initiative, 1996) Some modification in 2002 by Dale Hanson, Regional Paleontologist BLM Wyoming**
Class I - Documented paleontological localities that are known to contain or have produced fossils of scientific value.	**Class Ia** - Fossils of scientific significance are known to be abundant in the formation within a particular district.	**I. High Potential**. Rock units from which vertebrate or significant invertebrate fossils or significant suites of plant fossils have been recovered are consider to have a high potential for containing significant non-renewable fossiliferous resources.	**Condition 1** - Areas that are known to contain fossil localities.	***Condition 1*** - Areas that are known to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. Consideration of paleontological resources will be necessary if the Field Office review of the available information indicates that such fossils are present in the area.	**Class 5 Description**: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant nonvertebrate fossils, and that area at risk of natural degradation and/or human-caused adverse impacts.
	Class I - Fossils of scientific significance are frequently found in the formation within that district.				**Class 4 Description:** Class 4 geologic units are Class 5 units (see above) that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation.
Class II - Geologic formation or parts of formations that have produced fossils of scientific value elsewhere, thus indicating potential for discovery of fossil of scientific value.	**Class II** - Fossils of scientific significance are occasionally found in the formation within the Craig District	**II. Undetermined Potential.** Specific areas underlain by sedimentary rock units for which little information is available and are considered to have undetermined fossiliferous potential.	**Condition 2 -** Areas with exposures of geological units or settings that are likely to contain fossils. Geologic units where fossils have been found elsewhere.	***Condition 2.*** Areas with exposures of geological units or settings that have high potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. The presence of geologic units from which fossils have been recovered elsewhere, that may require further assessment of these same units where they are exposed in the area of consideration.	**Class 3 Description:** Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Also sedimentary units of unknown fossil potential.

Table 5. The evolution of sensitivity designations for formations and localities containing fossil resources is presented chronologically from 1985 to 2003. The last two (BLM-1998 and USFS-2002) are the criteria used on this project.

BLM "Proposed paleontology collecting regulation" - Document 8270, dated 9/1/85	Armstrong and Wolny, 1989, Paleontological resources of Northwest Colorado	Society of Vertebrate Paleontology, 1995, Formation designation	BLM Paleontological Document IM-96-67-Formation designation (1996)	BLM Paleontology Resources Management Manual and Handbook H-8270-1 (revised 1999)	Potential Fossil Yield Classification (PFYC)(USFS Paleo Initiative, 1996) Some modification in 2002 by Dale Hanson, Regional Paleontologist BLM Wyoming
Class III - Formations or areas of low potential for the discovery of fossils of scientific value or where fossils of scientific vare are not expected.	**Class III** - Fossils of some significance (usually due to fragmentary or poor preservation) are found in the formation or fossils of scientific significance are found in the formation elsewhere; or fossils are not reported from this formation, but there is a likelihood of fossils based on sediment description and/or environment of deposition.				**Class 2 Description**: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.
Class IV - Areas with little or no potential for the discovery of fossils.	**Class IV** - Fossils are not known from this geologic unit and there is little likelihood of their occurrence.	**III. Low Potential.** Reports in the paleontological literature or field surveys by a qualified vertebrate paleontologist may allow determination that some areas or units have low potentials for yielding significant fossils.	**Condition 3** - Areas that are very unlikely to produce fossils based on their surficial geology, e.g., igneous or metamorphic rocks, extremely young alluvium, colluvium, or aeolian deposits.	***Condition 3*** - Areas that area very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils based on their surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium, or aeolian deposits or the presence of deep soils. However, if possible it should be noted at what depth bedrock may be expected in order to determine if fossilferous deposits may be uncovered during surface disturbing activities.	**Class 1 Description**: Igneous and metamorphic (tuffs are excluded from this category) geologic units or units representing heavily disturbed preservation environments that are not likely to contain recognizable fossil remains.

Jonah Field (see Selected Bibliography). Paleontological locality information for the field was gathered from the institutions and individual researchers listed in Table 1. All fossil locality information gleaned from the analysis of existing data and the field surveys that are within one quadrangle of the Jonah Field are included in the confidential Appendix D.

CONSTRUCTION MITIGATION

Whenever fossil material (vertebrate, invertebrate, plant, or trace) is likely to be encountered during ground disturbance during construction of access roads, well sites, pits, and pipelines, the following mitigation will be implemented:

Monitoring - If critical or significant fossil material in a Condition 1 (or PFYC Class 4 or 5) unit is likely to be encountered during the ground disturbance, full paleontological monitoring is recommended. The probability of such material being encountered is determined from the evaluation of known data and from field survey discoveries.

Sampling - During construction, fossil material will be sampled to facilitate further analyses to determine significance. Frequently fossil taxa are not sufficiently well known to allow the determination of significance in the field.

Salvage - Salvage is requested when the fossil discovery is of scientific interest and if the construction will destroy or has destroyed the site. A written report with mitigation recommendations should be submitted quickly to the lead federal or state agency, as well as to the energy company's Environmental Coordinator.

Rerouting - A request for a reroute or relocation may be made if critical or significant fossil material is identified directly on a proposed pipeline corridor, access road, or well site during the field survey. This recommendation considers the fact that salvage costs or delays can be unacceptably high.

MONITORING PROGRAM

The purpose of the monitoring program is to protect scientifically significant paleontologic resources by documenting and collecting those fossils of scientific significance that are found within the pipeline corridors, on access roads, or on well sites. This includes monitoring of clearance and grading as well as excavation work (for example, pipeline trenching or pit excavation). During ground disturbing activity there should be adequate paleontological monitoring of significant units as defined by the analysis of existing data and the field survey. In sedimentary units established as highly paleontologically significant (Condition 1 or PFYC 4 or 5), a qualified paleontological monitor should be present during 100 percent of the ground-disturbing activity, unless it is subsequently determined by the project paleontologists and the BLM (or lead agency) that reduced monitoring or spot checking is appropriate. In geologic units classified as moderately significant (Condition 2, PFYC 3) a paleontological monitor should perform spot checks during construction (e.g., before final

leveling in the pit) based on the lithology of the unit. Lists of the paleontologically sensitive units in the Jonah Field are included in table 1.

The monitoring program will include the following:

1. Qualified paleontological monitors will be present during 100 percent of ground disturbing activity within the Condition 1 (PFYC 4 or 5) units and perform spot checks in area defined as Condition 2 (PFYC 3) units. Geologic maps with specific areas to be monitored along each construction spread will be provided to the paleontological monitor and the environmental coordinator prior to construction. Based on circumstances in the field, the Senior Paleontologist (PI) may downgrade portions of the field, if it is determined that reduced monitoring is appropriate. Follow up with the appropriate land managing agency office would include a written report with attached rational for the changed work plan.

2. The paleontologic monitors are experienced in paleontologic salvage and equipped with tools and supplies to allow rapid removal of specimens. Paleontological team leaders are experienced in paleontologic resource evaluation, fossil identification, fossil prospecting, and salvage. A paleontological monitor follows the earth-moving equipment and examines excavated material and pit and pipeline ditch side walls for evidence of fossil resources (without entering the pipeline ditch). Although the request to work after dark is uncommon, we have determined that paleontological monitors cannot adequately evaluate impacted rock in sensitive areas under those circumstances. A follow-up survey, a week or two later, may be conducted in sensitive areas to reaffirm the lack or presence of fossil material (wind and rain frequently expose fossil materials that may have been covered with dust during the initial evaluation).

If significant fossil material is found, the paleontological monitor will notify the senior project paleontologist immediately. The company's Environmental Coordinator must be contacted immediately to request that construction at that particular site be temporarily halted within the immediate vicinity to allow further evaluation of exposed fossil resources. If a small fossil is discovered, the paleontological monitor will immediately excavate and examine it with no delays in construction. If a complex fossil is discovered, the area will be marked for avoidance. The supervising paleontologist, in cooperation with the Bureau of Land Management personnel (or relevant land manager), company's Environmental Coordinator and paleontological monitor, will arrange for sampling and/or immediate removal of the fossil, and verify when construction at that site may continue.

3. Backup monitors will be available to assist in the removal of relatively large, complete, or abundant fossils so that delays to continued construction are minimized. These monitors will report to the site as soon as possible, but no later than 48 hours after the find is reported.

4. Some significant vertebrate fossil resources are small to microscopic in size and may not be readily apparent during construction activity. When the potential for microfossil occurrences exists, matrix samples will be collected to test for their presence during monitoring while the rock is exposed on the debris pile. If the rocks are fossiliferous, samples will be collected for further fossil recovery off site. An adequate sample size is determined by the senior project paleontologist. The sampling and testing of rock debris will be done expeditiously during construction, to avoid delays, and in a safe manner that does not impede work or traffic.

5. Under no circumstances will fossils be removed from private lands for any reason, including curation, without the written consent of the landowners.

MITIGATION PROGRAM

The purpose of the mitigation program is to protect all scientifically significant paleontologic resources that are discovered within the Jonah Field during ground disturbing activities. This includes those fossils which are found during monitoring phases of the project, as well as unanticipated discoveries made anywhere within the field by any project personnel. All phases of the mitigation are to be supervised by a qualified paleontologist and will include the following procedures:

1. To prevent damage to known paleontologically sensitive resources and to prevent construction delays, avoidance, salvage, or rerouting recommendations will be made well before the beginning of construction.

2. Specific boundaries of sensitive formations or known fossil localities (Conditions 1 and 2, PFYC 3, 4, and 5) will be delineated on construction maps so the company personnel, environmental coordinators, and/or contractors are aware of areas requiring continuous monitoring or spot checking.

3. A fossil identification pamphlet will be prepared before construction begins for the environmental coordinators, construction foremen, and for crew orientation. Responsibility for the protection of resources will be outlined as well as the definition and description of the fossils commonly found along the route. Environmental coordinators and construction personnel will attend pre-construction orientation meetings that include a paleontologic resource orientation/training class presented by a project paleontologist. Prior to the commencement of construction, all construction and company personnel will be made aware that scientifically significant fossils occur in the area, and will be instructed not to remove or touch them. In addition, the same group will be made aware that they must **immediately** contact the environmental coordinator, the land manager, and the senior project paleontologist if any subsurface fossil bones are exhumed during construction anywhere within the Jonah Field. If no paleontological personnel are in the vicinity, they will be given adequate time to reach the site.

4. Procedures to be followed in the event of fossil discoveries will be clearly defined in the pamphlet. Procedures for buried, modern bone discoveries, including human remains, are identified in the Unanticipated Cultural Resource Discovery Plan. Particularly, telephone/cell phone numbers of the paleontologist-in-charge and nearby paleontological personnel will be provided. These pamphlets will be distributed to appropriate company and construction personnel at the orientation meeting. In addition, copies will be provided to the environmental coordinator for distribution to others not attending the meetings.

5. Indirect impacts to fossil resources outside the defined workspace are possible. All workers will be advised that access to adjacent lands is restricted and that fossil resources may be found nearby. Unauthorized collection by workers or the general public may occur due to the increased access to the area. **All workers will be advised that unauthorized collection of vertebrate fossils is illegal.** This is a law enforcement issue and will be handled accordingly.

   Inadvertent discovery of significant fossils: Inadvertent discoveries are defined as fossils or fossil concentrations that were not anticipated in the monitoring and mitigation plan because their occurrence was considered to be unlikely. **Monitors, contractors and construction workers will be made aware that the environmental coordinator and the paleontological supervisor must be contacted immediately if vertebrate or significant fossil material is unearthed during construction, even in areas where monitoring is not being required.** Construction temporarily will be halted in the immediate area of the fossil discovery until it can be evaluated. Work will be allowed to continue within 50 feet of the area of discovery without interruption unless further vertebrate fossil material is encountered.

6. The project paleontologists will be given adequate time to reach the site on an inadvertent discovery of significant fossils; the project paleontologists will respond to such finds as soon as possible, but no later than 48 hours after the find is reported. In addition, any vertebrate fossil discovery on Federal or state lands will be reported immediately to the appropriate land managers as well as the environmental coordinators. They will be involved directly in the decisions regarding recovery of fossils and determining when construction may proceed at a significant fossil discovery site. Salvaging and removal of fossil specimens will be conducted as efficiently as possible to avoid delays to construction, while taking appropriate measures to avoid damaging the fossils.

7. All significant fossils found in the Jonah Field will be documented in field notebooks as well as on specimen tags. The UTM or Latitude/Longitude coordinates of each fossil locality will be recorded with a GPS. The types/taxa/numbers of fossils observed and/or collected will be recorded in field notes as well as on individual specimen identification tags / field labels. The lithology and any other pertinent sedimentological information will be included in the locality description, as well as the geologic unit from which it was collected, the collector, date, and milepost/well

site. All fossils collected will be stabilized as necessary prior to their removal from the site.

POST-CONSTRUCTION WORK

PREPARATION AND IDENTIFICATION OF FOSSIL COLLECTIONS

After removal from the construction area, all fossils collected during the monitoring and mitigation phases of the project will require preparation and identification. The primary investigators will prepare small to medium-sized vertebrate fossil material. Special arrangements will be made for preparation of large specimens, like a Uintathere. In addition, plant or invertebrate fossils also will be collected if scientifically important. Under no circumstances will fossils be removed from private lands for any reason, including curation, without the written consent of the landowners.

Preparation of fossils involves cleaning (including rock removal) and stabilizing (treating with appropriate preservatives and assembly). Identification of fossils involves their assignment to a known (or possibly new) taxon. This may involve comparisons with specimens in museum collections and literature review. Numbering, boxing, and storage will be done as prescribed by the designated curation facilities. Fossil localities on or near proposed well sites, access road or pipeline corridors encountered during the field survey as well as during construction will be plotted on United States Geological Survey 7.5 minute quadrangle sheets. A set of field and laboratory records as well as photographs with an itemized specimen inventory will be compiled and filed at the curation facilities.

CURATION FACILITIES

Curation facilities are chosen by their proximity to the fossil site, by the professional curation staff, by the landowner, or by the federal or state agency that has authority over the locality. Curation agreements with potential repositories for fossils found in the Jonah Field must be in place prior to construction in accordance with BLM paleontology permit regulations—in this case, the University of Colorado Museum in Boulder. No federal repository for this type of collection is available in Wyoming at this time (2007).

FINAL REPORT

Upon completion of construction of individual well sites, access roads, and pipelines, and upon completion of preparation and evaluation of fossil samples collected within the Jonah Field, final reports will be compiled and submitted to the agencies. Specifically regarding completion of the field survey, a schedule to complete the final report will be negotiated. Included in these reports will be:

1) Description of fieldwork, including pre-construction and monitoring and mitigation plan;

2) Geologic history and stratigraphy of the formations in the area, with locality related logs;

3) Survey results and evaluation of the formations impacted, with a description of fossil localities by formation;

4) Significance of recovered paleontological resources with regard to other known localities;

5) Bibliography of formations and paleontological resources;

6) Appendix of BLM paleontology locality forms with maps and photographs. A confidential fossil locality appendix will be bound separately from the main report and will be distributed only to the BLM Field Office Paleontology Coordinators, the BLM Regional Paleontologists, and the curation facilities. This requirement is for the protection of sensitive paleontological resources in the Jonah Field;

7) Appendix of an itemized specimen inventory of collected samples with the curatorial facility accession numbers if applicable; and

8) Appendix of collection permits, curation agreements, and other appropriate communications.

Copies of the final report will be submitted for review and approval to the BLM as well as any other involved Federal and State agencies at the state office level. Additional copies will be provided to all agencies after the final report has been approved by appropriate Federal and State officials.

APPENDIX C

FOSSIL FAUNAL LISTS FROM THE EOCENE UNITS OF SUBLETTE COUNTY, WYOMING

WASATCH FORMATION FAUNA

GREEN RIVER FORMATION FAUNA

BRIDGER FORMATION FAUNA

COMPILED BY PETER ROBINSON, Ph.D.,

PATRICIA HOLROYD, Ph.D., and SUE ANN BILBEY, Ph.D.

APP. C - Table 1. Summary of the Wasatchian Fauna from Sublette County, Wyoming as of 2006				Compiled by Peter Robinson and Pat Holroyd				
Class	**Order**	**Family**	**Genus**	**Species**	**type**	**Reference**	**locality**	**beds**
Mammalian Taxa	Marsupicarnivora	Didelphidae	*Peratherium*	*edwardi*	HT	Gazin, 1952	12 mi N BP	LaBarge
Mammalia	Marsupicarnivora	Didelphidae	*Peratherium*	*chesteri*	HT	Gazin, 1952	12 mi N BP	LaBarge
Mammalia	Leptictida	Leptictidae	*Palaeictops*	*pineyensis*	HT	Gazin, 1962	12 mi N BP	LaBarge
Mammalia	Cimolesta, Pantolesta	Pantolestidae	*Palaeosinopa*	*didelphodes (cf.)*		Gazin, 1962		Alkali Ck
Mammalia	Cimolesta, Apatotheria	Apatemyidae	*Apatemys*	*hürzeleri*	HT	Gazin, 1962	12 mi.N BP	LaBarge
Mammalia	Cimolesta, Apatotheria	Apatemyidae	*Apatemys*	*sp.*		Smith/Holroyd 2003	12 mi.N BP	LaBarge
Mammalia	Cimolesta, Tillodontia	Esthonychidae	*Esthonyx*	*acutidens (cf)*		Gazin 1952	12 mi N BP	LaBarge
Mammalia	Cimolesta, Taeniodonta	Stylinodontidae	*indeterminate*			Gazin 1952	12 mi N BP	LaBarge
Mammalia	Cimolesta, Pholidota	Epoicotheriidae	*Pentapassalus*	*pearcei*	GHT	Gazin 1952	SE of BP	LaBarge
Mammalia	Cimolesta, Pantodonta	Coryphodontidae	*Coryphodon*	*radians (cf)*		Gazin 1952	Dry Piney	LaBarge
	Insectivora	Nyctitheriidae	2 undetermined genera			UCMP collection	12 mi N BP	LaBarge
Mammalia	Primates, sensu lato	Microsyopidae	*Microsyops*	*knightensis*	HT	Gazin 52; Gunnell 89	12 mi N BP	LaBarge
	Primates, sensu lato	Paromomyidae	*Phenacolemur*			UCMP collection	12 mi N BP	LaBarge
	Primates, sensu lato	Paromomyidae	small undetermined genus			UCMP collection	12 mi N BP	LaBarge
Mammalia	Primates	Omomyidae	*Absarokius*	*abbotti*	Gazin 1952; Smith/Holroyd 2003			LaBarge
Mammalia	Primates	Omomyidae	*Anemorhysis*	*sublettensis*	GHT	Gazin 52, 62	12 mi N BP	LaBarge
	Primates	Omomyidae	*Chlororhysis*	*knightensis*	HT	Gazin 1958	Millison Draw	LaBarge
	Primates	Omomyidae	*Loveina*	*sheai*	HT	Gazin, 1962	12 mi N BP	LaBarge
Mammalia	Primates	Omomyidae	*Loveina*	*sheai*		West 1973	NF 1	Alkali Ck
	Primates	Omomyidae	*Loveina*	*wapitiensis*		UCMP collection		LaBarge
	Primates	Omomyidae	*Strigorhysis*	*bridgerensis*		UCMP collection	12 mi N BP	LaBarge
Mammalia	Primates	Adapidae	*Notharctus*	*nunienus*		West 1973	NF 2	Alkali Ck
Mammalia	Primates	Adapidae	*Notharctus*	*limosus*		Gazin 1962		Alkali Ck
	Primates	Adapidae	*Cantius*	*frugivorus*	Gazin 1952, Godinot 1988, Gunnell 1992			LaBarge
Mammalia	Rodentia	Ishchyromyidae	*Paramys*	*copei (?)*		Gazin 1952		LaBarge
Mammalia	Rodentia	Sciuravidae	*Sciuravus*	*depressus (?)*		Gazin 1952	12 mi N BP	LaBarge
Mammalia	Rodentia	Sciuravidae	*Knightomys*	*senior*	GHT	Gazin 1952	12 mi N BP	LaBarge
Mammalia	Mesonychia	Mesonychidae	*Pachyaena*	*sp.*		Gazin 1952		Alkali Ck
Mammalia	Mesonychia	Mesonychidae	*Ambloctonus*	*major (?)*		Gazin 1952	2 mi SE LB	LaBarge
Mammalia	Creodonta	Hyaenodontidae	*Prolimnocyon*	*elizabethae*	HT	Gazin 1952	Red Hill	LaBarge
Mammalia	Creodonta	Hyaenodontidae	*Gazinocyon*	*vulpecula*		Gazin 1952, Polly, 1996		LaBarge
	Creodonta	Hyaenodontidae	*Wyolestes*	*dioctes*	HT	Gingerich, 1982	12 mi N BP	LaBarge
Mammalia	Carnivora	Viverravidae	*Didymictis*	*altidens*		Gazin 1952	12 mi N BP	LaBarge
Mammalia	Carnivora	Viverravidae	*Didymictis*	*altidens*		West 1973	NF4,5	Alkali Ck
Mammalia	Carnivora	Viverravidae	*Viverravus*	*lutosus*	HT	Gazin 1952	12 mi N BP	LaBarge
Mammalia	Carnivora	Miacidae	*Uintacyon*	*asodes*	HT	Gazin 1952	12 mi N BP	LaBarge
Mammalia	Carnivora	Miacidae	*Miacis*	*latidens (?)*		Gazin 1952	12 mi N BP	LaBarge
Mammalia	Carnivora	Miacidae	*Miacis*	*latidens (?)*		West 1973	NF 2	Alkali Ck
Mammalia	Carnivora	Miacidae	*Vulpavus*	*asius*	HT	Gazin 1952	12 mi N BP	LaBarge
Mammalia	Condylarthra	Hyopsodontidae	*Hyopsodus*	*wortmani*		Gazin 1952		LaBarge
Mammalia	Condylarthra	Hyopsodontidae	*Hyopsodus*	*mentalis*		Gazin 1952		LaBarge
Mammalia	Condylarthra	Phenacodontidae	*Meniscotherium*	*chamense (?)*		Gazin 1952	Alkali Ck	Alkali Ck
Mammalia	Condylarthra	Phenacodontidae	*Meniscotherium*	*chamense*		West 1973, W&L 92	NF	Alkali Ck
Mammalia	Condylarthra	Phenacodontidae	*Meniscotherium*	*sp.*		UCM Collection	BS	Lwr CB

Class	Order	Family	Genus	Species	type	Reference	locality	beds
Mammalia	Condylarthra	Phenacodontidae	*Phenacodus*	*vortmani*		West 1973	NF	Alkali Ck
	Condylarthra	Phenacodontidae	*Phenacodus*	*vortmani*		UCMP collection	12 mi N BP	
Mammalia	Condylarthra	Phenacodontidae	*Phenacodus*	*primaevus*		West 1973	NF 5	Alkali Ck
Mammalia	Dinocerata	Uintatheriiidae	*Bathyopsis*	*fissidens*		Gazin 1952	Alkali Ck	Alkali Ck
Mammalia	Perissodactyla	Equidae	*Hyracotherium*	*index*		Gazin 1952		LaBarge
Mammalia	Perissodactyla	Equidae	*Hyracotherium*	*vassacciense*		Gazin 1952		LaBarge
Mammalia	Perissodactyla	Equidae	*Hyracotherium*	*vassacciense*		West 1973	NF	Alkali Ck
Mammalia	Perissodactyla	Equidae	*Hyracotherium*	*venticolum*		Smith/Holroyd 2003	12 mi N BP	LaBarge
Mammalia	Perissodactyla	Equidae	*Hyracotherium*	*craspedotum*		West 1973	NF	Alkali Ck
Mammalia	Perissodactyla	Equidae	*Orohippus*	*proteros*		Smith/Holroyd 2003	12 mi N BP	LaBarge
Mammalia	Perissodactyla	Brontotheriidae	*Lambdotherium*	*popoagicum*		Gazin 1952		LaBarge
Mammalia	Perissodactyla	Brontotheriidae	*Lambdotherium*	*popoagicum*		West 1973	NF	Alkali Ck
Mammalia	Perissodactyla	Brontotheriidae	*Lambdotherium*	*popoagicum*		UCM Collection	BS	Lwr CB
Mammalia	Perissodactyla	Brontotheriidae	*Eotitanops*	*borealis*		Smith/Holroyd 2003	12 mi N BP	LaBarge
Mammalia	Perissodactyla	Helaletidae	*Heptodon*	*ventorum (cf)*		Gazin 1952		LaBarge
Mammalia	Perissodactyla	Helaletidae	*Heptodon*	*sp.*		Gazin 1952		Alkali Ck
Mammalia	Perissodactyla	Helaletidae	*Heptodon*	*calciculus*		Smith/Holroyd 2003	12 mi N BP	LaBarge
Mammalia	Artiodactyla	Dichobunidae	*Diacodexis*	*secans (near)*		Gazin 1952		LaBarge
Mammalia	Artiodactyla	Dichobunidae	*Hexacodus*	*pelodes*	GHT	Gazin 1952	12 mi N BP	LaBarge
Mammalia	Artiodactyla	Dichobunidae	*Bunophorus*	*macropternus*		Smith/Holroyd 2003	12 mi N BP	LaBarge
Non-Mammalian Taxa								
Aves	Phoenicopteriformes	Juncitarsidae	*Juncitarsus*			UCMP collection	12 mi N BP	LaBarge
Aves	Galliformes	Gallinuloididae				UCMP collection	13 mi N BP	LaBarge
Reptilia	Crocodylia	Alligatoridae	*Borealosuchus*	*sternbergi*		Brochu, 1999		LaBarge
Reptilia	Crocodylia	Alligatoridae	*Diplocynodon*			UCMP collection		LaBarge
Reptilia	Crocodylia	Crocodylidae				UCMP collection		LaBarge
Reptilia	Sauria	Anguidae	*Eoglyptosaurus*	*donohoei*		Sullivan, 1979	12 mi N BP	LaBarge
Reptilia	Sauria	Anguidae	*Glyptosaurus*			UCMP collection		LaBarge
Reptilia	Serpentes					UCMP collection		LaBarge
Reptilia	Testudines	Baenidae	*Baena*	*arenosa*		UCMP collection		LaBarge
Reptilia	Testudines	Bataguridae	*Echmatemys*	*testudinea*		UCMP collection		LaBarge
Reptilia	Testudines	Bataguridae	*Echmatemys*	*testudinea*		UCMP collection		Alkali Ck
Reptilia	Testudines	Dermatemydidae	*Baptemys*	*garmanii*		UCMP collection		LaBarge
Reptilia	Testudines	Emydidae	*Planetochelys*	*dithyros*		UCMP collection		Alkali Ck
Reptilia	Testudines	Emydidae	*Planetochelys*	*dithyros*		UCMP collection		LaBarge
Reptilia	Testudines	Kinosternidae	*Xenochelys*	*lostcabinensis*		Hutchison, 1991		LaBarge
Reptilia	Testudines	Kinosternidae	*Baltemys*	*staurogastros*		UCMP collection		LaBarge
Reptilia	Testudines	Testudinidae	*Hadrianus*	*majusculus*		UCMP collection		LaBarge
Reptilia	Testudines	Trionychidae	*Axestemys*			UCMP collection		LaBarge
Reptilia	Testudines	Trionychidae	*Trionyx*			UCMP collection		LaBarge
Reptilia	Testudines	Trionychidae	*Aspideretes*			UCMP collection		LaBarge
Reptilia	Testudines	Trionychidae	*Apalone*			UCMP collection		LaBarge
Reptilia	Testudines	Trionychidae	*Plastomenus*			UCMP collection		LaBarge
Osteichthyes	Amiiformes	Amiidae	*Amia*			UCMP collection		LaBarge
Osteichthyes	Lepisosteiformes	Lepisosteidae	*Lepisosteus*			UCMP collection		LaBarge

APP. C - TABLE 2. TERTIARY GREEN RIVER FORMATION - VERTEBRATE FOSSILS
Taken from Grande, 1984; MacGinitie, 1969; Krishtalka and Stucky, 1984; Gunnell and Bartels, 1999
Occurrences: F - Fossil Lake, G - Lake Gosiute, U - Lake Uinta, U-P Powder Wash

	Fossil Lake	Lake Gosiute	Lake Uinta
Class Pisces			
Heliobatis (stingray)	F		
Crossopholis (paddle fish)	F		
Lepisosteus (gar)	F	G - Laney	U
Amia (bowfin)	F	G - Laney	
Knightia (herring)	F	G - Luman	U
Gosiutichthys (herring)		G	
Diplomystus (herring)	F	G	U
Eohiodon (Mooneye)	F		
Phareodus (osteoglossid)	F	G	
Notogoneus (gonorynchid)	F		
Amyzon (sucker)		G	
Astephus antiquus (catfish)	F	G - Laney	U
Hypsidoris (catfish)	F	G	
Erismatopterus (trout perch)	F		
Amphiplaga (trout perch)	F		
Asineops (uncertain)	F	G	U
Mioplosus (perch-like)	F		
Priscacara (percoid)	F	G	U
new percoid	F	G?	
Class Amphibia			
Eopelobates (frog)	F	G	U
salamanders	F	G	U
Class Reptilia			
Order Testudines	F	G	U
Trionychidae	F	G - Laney	U-P
Emydidae			
Echmatemys		G - Laney	U-P
Baenid turtle			
Chelydridid turtle			
Testudinidae			
Hadrianus sp.	F?	G?	U-P
Order Lacertilia			
Iguanidae			
Parasauromalus olseni			U-P
Parasauromalus sp.			U-P
Agamidae			
Tinosaurus stenodon		G?	U-P
Xantusiidae			
Paleoxantusia sp.			U-P
Anguidae			
Glyptosaurus sylvestris			U-P
Xestops vagans			U-P
Eodiploglossus borealis			U-P
Varanidae			

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	Fossil Lake	Lake Gosiute	Lake Uinta
Saniwa sp.	F?	G?	U-P
Varanidae? lizard	F	G	U
trackways			U
Order Serpentes			
Booidea			U-P
Boavus idelmani boa	F		
Order Crocodylia			
Crocodylidae			
Leidyosuchus		G	
Gen. & Sp. indet.			U-P
Alligatoridae			
Alligator	F	G	
Procaimanoidea kayi			U-P
cf. Allognathosuchus sp.			U-P
Pristichampsidae			
Pristichampsus vorax			U-P
Caimanidae			
Diplocynodon sp.			U-P
numerous partial skeletons,		G	
bone, teeth, and scute fragments		G	
as well as coprolites.			
Numerous tracks of birds, mammals, and reptiles.			U
Class Aves:			
Order Pelecaniformes			
Limnofregata azygosternon	F		
Order Aegialornithidae - undescribed		G (Tipton)	
Order Cuculiformes			
Foro panarium	F		
Order Gallinuloididae			
Gallinuloides wyomingensis	F	G	
Order Gruiformes - undescribed	F		
Order Anseriformes			
Presbyornis pervetus		G	U
Order Coraciiformes - undescribed	F		
Primobucco mcgrewi			
P. olsoni			
Neanis schucherti			
N. kistneri			
Numerous downy feathers	F	G	U
Bird tracks			U
Class Mammalia			
Order Marsupialia			
Peratherium knighti		G	
P. innominatum		G	U
P. marsupium			U-P

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	Fossil Lake	Lake Gosiute	Lake Uinta
P. innominatum			U-P
Peradectes chesteri			U-P
Armintodelphys dawsoni			U-P
Order Proteutheria			
Apatemyidae			
Apatemys sp., cf. A. rodens			U-P
Apatemys sp., cf. A. bellus		G - Laney	U-P
Apatemys sp., cf. A. bellulus			U-P
Pantolestidae			
Pantolestes sp., cf. P. longicaudus			U-P
Leptictidae			
Palaeictops bridgeri			U-P
Order Insectivora			
Sespedectidae			
Scenopagus edenensis			U-P
S. priscus		G - Laney	U-P
Talpavus nitidus		G	U-P
Talpavus sp., cf. T. nitidus			U-P
Crypholestes sp.			U-P
Nyctitheriidae			
Nyctitherium sp.			U-P
N. serotinum			U-P
Geolabididae			
Centetodon pulcher			U-P
C. bembicophagus			U-P
Family Uncertain			
"Eoryctes" sp.			U-P
Aethomylus simplicidens			U-P
Order Creodonta			
Oxyaenidae			
Patriofelix sp.			U-P
Hyaenodontidae			
Sinopa grangeri			U-P
S. minor			U, U-P
Tritemnodon sp., cf. *T. gracilis*			U-P
Tritemnodon sp., cf. *T. whitiae*			U-P
Limnocyon sp., cf. *L. verus*			U-P
?Proviverroides sp.			U-P
Order Carnivora			
Viverravidae			
Viverravus minutus			U-P
V. gracilis			U-P
V. sicarius			U-P
V. eucristadens			U-P
Vulpavus profectus		G	
V. australis			U

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	Fossil Lake	Lake Gosiute	Lake Uinta
Miacidae			
Miacus gracillis			U
Miacus sp. cf. *M. parvivorus*			U-P
Uintacyon sp., cf. U. major			U-P
?Oodectes sp.			U-P
Order Condylarthra			
Hyopsodontidae		G - Laney	
Hyopsodus minisculus		G	U, U-P
H. vicarius			U
H. paulus			U-P
H. sp.		G - Laney	
Order Tillodonta			
Esthonychidae			
Trogosus sp.			U-P
Tellotherium?			U
Order Rodentia			
Paramyidae			
Paramys sp.			U
P. cf P. delicatus			U, U-P
Pseudotomus cf. P. robustus			U, U-P
Microparamys minutus			U, U-P
Thisbemys sp.		G - Laney	
Sciuravidae			
Sciuravus sp.			U, U-P
S. eucristadens			U, U-P
Sciuravid sp.			U
Pauromys sp.			U, U-P
Order Chiroptera			
Icaronycteris index	F		U
Cf. Ageina sp.			U-P
Order Primates?			
Microsyopidae			
Uintasorex parvulus		G	U
U. sp. cf. U. parvulus			U-P
Microsyops elegans		G	
Microsyops sp., cf. M. elegans			U-P
Cynodontomys		G - Tipton	
Order Primates			
Omomyidae			
Utahia kayi			U, U-P
Anaptomorphus aemulus			U-P
Omomys pucillus			U
O. lloydi			U, U-P
O. carteri		G - Laney	U-P
Uintanius ameghini			U-P
Hemiacodon gracilis		G - Laney	

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	Fossil Lake	Lake Gosiute	Lake Uinta
Washakius insignis		G	
Uintalacus nettingi			U-P
"Tetonius" sp.			U
Notharctidae			
Notharctus sp.		G	
N. matthewi			U
Notharctus sp., cf. *N. tenebrosus*			U-P
Smilodectes sp., cf. *S. gracilis*		G - Laney	U-P
Order Perissodactyla			
Equidae			
Hyracotherium vassaciense			U-P
Hyracotherium sp.		G - Tipton	
Orohippus			U
Hyrachyus		G - Laney	U
Palaeothere			
Lambdotherium		G - Tipton	U
Isectolophidae			
Isectolophus sp., cf. *I. latidens*			U-P
Helaletidae			
Helaletes nanus			U-P
Hyrachyus modestus		G - Laney	U-P
Brontotheriidae			
Palaeosyops?		G - Laney	
Mesartirhinus			U
unidentified perissodactyl (BYU)			U
Order Artiodactyla			
Homocodontidae			
Antiacodon pygmaeus			U, U-P
Order Mesonychia			
Mesonychidae			
Mesonyx sp.			U-P
Order Dinocerata			
Uintatheriidae			
Uintatherium		G - Laney	

APP C - Table 3. Summary of the Bridgerian Fauna from Sublette County, Wyoming as of 2006				Compiled by Peter Robinson and Pat Holroyd				
Class	**Order**	**Family**	**Genus**	**Species**	**type**	**Reference**	**Locality**	**Beds**
Amphibia	Anura	Rhinophrynidae	Eorhinophrinus	septentrionalis	GHT	Hecht in McGrew 1959	5	Bridger
Amphibia	Anura	Rhinophrynidae	Eorhinophrynus	septentrionalis		Henrici 1998		
Amphibia	Anura	Pelobatidae	indet	sp.		Hecht in McGrew 1959	5	Bridger
Amphibia	Anura	Pelobatidae	Eopelobates			UCMP collection		
Reptilia	Crocodylia	indet.				Hecht in McGrew 1959	9,10	Green R
Reptilia	Crocodylia	Crocodylidae	Pristichampsus			UCMP collection		
Reptilia	Squamata, Lacertilia	Anguidae	Xestops	sp.		Hecht in McGrew 1959	5, 15	Bridger
Reptilia	Squamata, Lacertilia	Anguidae	Dimetopisaurus	wyomingensis	GHT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Anguidae	Peltosaurus	sp.		Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Anguidae	Melanosaurus	sp.		Hecht in McGrew 1959	10	Green R
Reptilia	Squamata, Lacertilia	Varanidae	Parasaniwa	sp.		Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Varanidae	Saniwa	grandis		Hecht in McGrew 1959	13	Bridger
Reptilia	Squamata, Lacertilia	Varanidae	Saniwa	sp.		Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Xantusiidae	Palaeoxantusia	fera	GHT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Agamidae	Thinosaurus	stenodon		Hecht in McGrew 1959	5, 22	Bridger
Reptilia	Squamata, Lacertilia	Teiidae	indet			Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Lacertilia	Amphisbaenidae	Lestophis	sp.		Hecht in McGrew 1959		Bridger
Reptilia	Squamata, Lacertilia	Amphisbaenidae	Rhineura	sp.		Hecht in McGrew 1959	5,15	Bridger
Reptilia	Squamata, Serpentes	Aniliidae	Coniophis	carinatus	HT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Serpentes	Aniliidae	Coniophis	platycarinatus	HT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Serpentes	Boidae	Calamagrus	primus	HT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Serpentes	Boidae	Boavus	sp.		Hecht in McGrew 1959	several	Bridger
Reptilia	Squamata, Serpentes	Boidae	Paraepicrates	brevispondylus	GHT	Hecht in McGrew 1959	5	Bridger
Reptilia	Squamata, Serpentes	Incertae sedis	Dunnophis	michroechinus	GHT	Hecht in McGrew 1959	5	Bridger
Reptilia	Testudines	Dermatemydidae	Baptemys	wyomingensis		Meylan and Gaffney 1989		
Reptilia	Testudines	Trionychidae				UCMP collection		
Mammalia	Didelphimorpha	Didelphidae	Peratherium	innominatum (cf)		McGrew 59, West 73	15	Bridger
Mammalia	Didelphimorpha	Didelphidae	Peratherium	sp.		McGrew 1959	5	Bridger
Mammalia	Didelphimorpha	Didelphidae	Peratherium	knighti	HT	McGrew 1959	5	Bridger
Mammalia	Didelphimorpha	Didelphidae	Peratherium	marsupium (cf)		West 1973	B1,3,5	Bridger
Mammalia	Insectivora	Amphilemuridae	Scenopagus	edenensis	HT	McGrew 1959	10	Green R
Mammalia	Insectivora	Amphilemuridae	Scenopagus	priscus		West 1973		Bridger
Mammalia	Insectivora	Nyctitherridae	Nyctitherium	bacchanalis	HT	McGrew 1959	5	Bridger
Mammalia	Insectivora	Nyctitheriidae	Nyctitherium	velox		McGrew 1959	5	Bridger
Mammalia	Insectivora	Geolabididae	Centetodon	pulcher		West, 1973	B4	Bridger
Mammalia	Cimolesta, Apatotheria	Apatemyidae	Apatemys	bellulus		West, 1973	B 1	Bridger
Mammalia	Cimolesta, Didelphodonta	Cimolestidae	Didelphodus	altidens		West 1973	B1	Bridger
Mammalia	Primates, sensu lato	Microsyopidae	Microsyops	elegans		West, 1973	B1, 13	Bridger
Mammalia	Primates, sensu lato	Microsyopidae	Uintasorex	parvulus		Simpson in McGrew 59	5	Bridger
Mammalia	Primates	Adapidae	Smilodectes	gracilis		Gazin, 1958	10	Green R
Mammalia	Primates	Adapidae	Smilodectes	gracilis		Simpson in McGrew 59	10	Green R
Mammalia	Primates	Adapidae	Notharctus	tenebrosus		West, 1973		Bridger

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Class	**Order**	**Family**	**Genus**	**Species**	**type**	**Reference**	**Locality**	**Beds**
Mammalia	Primates	Omomyidae	Anaptomorphus	westi	HT	West 73, Szalay, 76	B1-5	Bridger
Mammalia	Primates	Omomyidae	Omomys	carteri		Simpson in McGrew 59	10	Green R
Mammalia	Primates	Omomyidae	Omomys	carteri		West 1973	B1-5, 13	Bridger
Mammalia	Primates	Omomyidae	Washakius	insignis		Szalay, 1976	10	Green R
Mammalia	Primates	Omomyidae	Washakius	insignis		Simpson in McGrew 59	5,13,15	Bridger
Mammalia	Rodentia	Paramyidae	Paramys	delicatus		Wood in McGrew, 1959	10	Green R
Mammalia	Rodentia	Paramyidae	Paramys	delicatior		Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Paramyidae	Paramys	excavatus (near)		Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Paramyidae	Leptotomus	parvus		Wood in McGrew, 1959	9	Green R
Mammalia	Rodentia	Paramyidae	Leptotomus	sp.		Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Paramyidae	Microparamys	wyomingensis	HT	Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Paramyidae	Microparamys	minutus		West 1973	B1, 4	Bridger
Mammalia	Rodentia	Paramyidae	Thisbemys	sp.		Wood in McGrew, 1959	10	Green R
Mammalia	Rodentia	Paramyidae	Reithroparamys	delicatissimus		Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Paramyidae	Reithroparamys	huerfanensis		West 1973	B1,	Bridger
Mammalia	Rodentia	Sciuravidae	Sciuravus	nitidus		Wood in McGrew, 1959	several	Bridger/GR
Mammalia	Rodentia	Sciuravidae	Sciuravus	nitidus		West 1973	B1-13	Bridger
Mammalia	Rodentia	Sciuravidae	Taxymys	lucaris		Wood in McGrew, 1959	5	Bridger
Mammalia	Rodentia	Sciuravidae	Taxymys	lucaris		West 1973	B1, 13	Bridger
Mammalia	Rodentia	Sciuravidae	Tillomys	senex		Wood in McGrew, 1959	13	Bridger
Mammalia	Creodonta	Hyaenodontidae	Thinocyon	sp.		McGrew 1959	7	Bridger
Mammalia	Creodonta	Hyaenodontidae	Proviverra (?)	sp		West 1973	B1	Bridger
Mammalia	Carnivora	Viverravidae	Viverravus	gracilis		West 1973	B1,13	Bridger
Mammalia	Dinocerata	Uintatheriidae	Uintatherium	sp.		McGrew 1959	2a, 2b	Bridger
Mammalia	Condylarthra	Hyopsodontidae	Hyopsodus	lepidus		McGrew 1959	several	Bridger/GR
Mammalia	Condylarthra	Hyopsodontidae	Hyopsodus	paulus		West, 1973	B1,5	Bridger
Mammalia	Condylarthra	Hyopsodontidae	Hyopsodus	minusculus		West, 1973	B1, 7	Bridger
Mammalia	Perissodactyla	Equidae	Orohippus	sp. (small)		McGrew 1959	5,13,15	Bridger
Mammalia	Perissodactyla	Equidae	Orohippus	sp. (large)		McGrew 1959	5	Bridger
Mammalia	Perissodactyla	Equidae	Orohippus	pumilis		West 1973	B1,4	Bridger
Mammalia	Perissodactyla	Brontotheriidae	Telmatherium	cultridens		McGrew 1959	2	Bridger
Mammalia	Perissodactyla	Brontotheriidae	Manteoceras	manteoceras		McGrew 1959	3,5	Bridger
Mammalia	Perissodactyla	Brontotheriidae	Palaeosyops	fontinalis		West 1973	B1, 3	Bridger
Mammalia	Perissodactyla	Brontotheriidae	Palaeosyops	fontinalis (cf)		UCM Collection	BS	Upr CB
Mammalia	Perissodactyla	Hyracodontidae	Hyrachyus	eximius (cf)		McGrew 1959	5,6	Bridger
Mammalia	Perissodactyla	Hyracodontidae	Hyrachyus	modestus		UCM Collection	BS	Upr CB
Mammalia	Perissodactyla	Hyracodontidae	Hyrachyus	modestus		West 1973		Bridger
Mammalia	Perissodactyla	Hyracodontidae	Hyrachyus	sp.		Gazin 1952	NF	Upr CB
Mammalia	Artiodactyla	Helohyidae	Helohyus	validus		McGrew 1959	1	Bridger
Mammalia	Artiodactyla	Helohyidae	Helohyus	plicodon (cf)		West 1973	B1,2	Bridger
Mammalia	Artiodactyla	Dichobunidae	Microsus	sp.		West 1973	B1	Bridger
Mammalia	Artiodactyla	Dichobunidae	Antiacodon	pygmaeus		West 1973	B1-3	Bridger