FES 08-32

Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement

Volume 1: Chapters 1, 2, 3, & 4

September 2008

BLM

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Washington D.C. 20240
http://www.blm.gov

TAKE PRIDE® IN AMERICA

July 31, 2008

In reply refer to: 1610-5.G.1.4

Dear Reader:

In August 2005, the U.S. Congress enacted the Energy Policy Act of 2005, Public Law (P.L.) 109-58. In Section 369 of this Act, titled the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005", Congress declared that oil shale and tar sands (and other unconventional fuels) are strategically important domestic energy resources that should be developed to reduce the nation's growing dependence on oil from politically and economically unstable foreign sources. To support this policy, Congress directed the Secretary of the Interior (the Secretary) to undertake a series of steps to establish a commercial leasing program for oil shale and tar sands. A principle provision mandated the Secretary to "...Complete a programmatic environmental impact statement for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming."

Enclosed are the Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement (PRMP/FPEIS). The Bureau of Land Management (BLM) prepared the PRMP/FPEIS in consultation with cooperating agencies, taking into account public comments received during this planning effort and examines alternatives for making the BLM administered lands available for application for future commercial leasing of both oil shale and tar sands resources.

This PRMP/FPEIS has been developed in accordance with the National Environmental Policy Act of 1969 (NEPA) and the Federal Land Policy and Management Act of 1976. The PRMP/ FPEIS is largely based on Alternative B, the preferred alternative in the Draft Resource Management Plan/Environmental Impact Statement (DRMP/DEIS), which was released on December 21, 2007. The PRMP/FPEIS contains the Proposed Plan Amendments, predictable impacts of the Proposed Plan Amendments, a Compact Disc (CD) of copies of all the written comments received during the public review period of the DRMP/DPEIS, and responses to these comments.

Because developing this and other alternative energy resources is of strategic importance in enhancing our Nation's domestic energy supplies, the Assistant Secretary, Land and Minerals Management, in the Department of the Interior is the responsible official for these proposed plan amendments. The Federal Land Policy and Management Act and its implementing regulations provide land use planning authority to the Secretary, as delegated to this Assistant Secretary. Because this decision is being made by the Assistant Secretary, Land and Minerals Management, it is the final decision for the Department of the Interior. This decision is not subject to administrative review (protest) under the BLM or Departmental regulations (43 CFR 1610.5-2).

As required by the NEPA, the Environmental Protection Agency (EPA) will publish a Notice in the *Federal Register* announcing the availability of the FPEIS. The BLM will wait at least 60 days after the publication of the EPA Notice before signing and issuing the Record of Decision (ROD) approving the plan amendments.

The ROD and approved plan amendments will be mailed or made available electronically to all who participated in the planning process and will be available to all parties through the "Energy" page of the BLM national website (http://www.blm.gov/wo/st/en/prog/energy.1.html), or by mail upon request.

Sincerely,

Michael D. Nedd
Assistant Director,
Minerals and Realty Management

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U.S. Department of the Interior
Bureau of Land Management

September 2008

MISSION STATEMENT

It is the mission of the Bureau of Land Management (BLM), an agency of the Department of the Interior, to manage BLM-administered lands and resources in a manner that best serves the needs of the American people. Management is based upon the principles of multiple use and sustained yield taking into account the long-term needs of future generations for renewable and nonrenewable resources.

BLM-WO-GI-08-005-3900-REV08

DOI No. FES 08-32

Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement

Lead Agency: U.S. Department of the Interior, Bureau of Land Management

Type of Action: Final, Administrative

Jurisdiction: Northwestern Colorado, Eastern Utah, and Southwestern Wyoming

Abstract: In August 2005, the U.S. Congress enacted the Energy Policy Act of 2005, Public Law (P.L.) 109-58. In Section 369 of this Act, titled the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005," Congress declared that oil shale and tar sands (and other unconventional fuels) are strategically important domestic energy resources that should be developed to reduce the nation's growing dependence on oil from politically and economically unstable foreign sources. To support this policy, Congress directed the Secretary of the Interior (the Secretary) to undertake a series of steps to establish a commercial leasing program for oil shale and tar sands.

The proposed resource management plan amendments would amend 12 land use plans to describe the most geologically prospective areas administered by the Bureau of Land Management (BLM) where oil shale and tar sands resources are present, and designate which of these areas will be open for application for commercial leasing, exploration, and development. There are approximately 2.3 million acres of BLM-administered lands within this area that are the subject of this programmatic environmental impact statement (PEIS).

Three alternatives were considered in the PEIS, and the BLM has selected Alternative B as the Proposed Plan Amendment. This alternative was selected on the basis of consistency with the requirements of the Energy Policy Act of 2005, balanced use and protection of resources, the analysis of environmental impacts, and consideration of comments and recommendations from cooperating agencies and the public. The Proposed Plan Amendment is designed to ensure that oil shale and tar sands technologies can operate at environmentally acceptable levels before commercial development is authorized. The Proposed Plan Amendment would make 1,991,222 acres of lands containing oil shale resources available for application for commercial leasing and 431,224 acres of lands containing tar sands resources available for application for commercial leasing.

On the basis of the analysis in this PEIS, the BLM has determined that there is no environmental impact associated with amending land use plans to make lands available for application for commercial leasing but there may be impacts on land values. While the BLM has determined that there are no environmental impacts associated with the amendment of land use plans, it is intending to establish a commercial leasing program and has included a programmatic-level analysis of the potential impact of commercial oil shale and tar sand technologies as they are currently known.

Contacts: For further information about this PEIS, you may contact Sherri Thompson, Project Manager, BLM Colorado State Office, 2850 Youngfield St., Lakewood, CO 80215-7093; (303) 239-3758.

Responsible Official:

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NOTATION

The following is a list of acronyms and abbreviations, chemical names, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

GENERAL ACRONYMS AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
AGFD	Arizona Game and Fish Department
AGR	aboveground retort
ANFO	ammonium nitrate and fuel oil
API	American Petroleum Institute
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
AQRV	air quality related value
ARCO	Atlantic Richfield Company
ATP	Alberta Taciuk Process
ATSDR	Agency for Toxic Substances and Disease Registry
AWEA	American Wind Energy Association
BA	biological assessment
BCD	barrels per calendar day
BLM	Bureau of Land Management
BMP	best management practice
BO	biological opinion
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
BSD	barrels per stream day
CAA	Clean Air Act
CAPP	Canadian Association of Petroleum Producers
CARB	California Air Resources Board
CASTNET	Clean Air Status and Trends NETwork
CBOSC	Cathedral Bluffs Oil Shale Company
CCW	coal combustion waste
CDC	Centers for Disease Control and Prevention
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDW	Colorado Division of Wildlife
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CHL	combined hydrocarbon lease

CIRA	Cooperative Institute for Research in the Atmosphere
CPC	Center for Plant Conservation
CRBSCF	Colorado River Basin Salinity Control Forum
CRSCP	Colorado River Salinity Control Program
CSS	cyclic steam stimulation
CSU	Controlled Surface Use
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
EA	environmental assessment
EGL	EGL Resources, Inc.
EIA	Energy Information Administration
E-ICP	bare electrode in situ conversion process
EIS	environmental impact statement
EMF	electric and magnetic field
E.O.	Executive Order
EOR	enhanced oil recovery
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act of 1973
EUB	Alberta Energy and Utilities Board
FLPMA	Federal Land Policy and Management Act of 1976
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
GCR	gas combustion retort
GHG	greenhouse gas
GIS	geographic information system
GSENM	Grand Staircase–Escalante National Monument
HAP	hazardous air pollutant
HAZCOM	hazard communication
HMA	Herd Management Area
HMMH	Harris Miller Miller & Hanson, Inc.
I-70	Interstate 70

IARC	International Agency for Research on Cancer
ICP	in situ conversion process
IEC	International Electrochemical Commission
IPPC	Intergovernmental Panel on Climate Change
ISA	Instant Study Area
ISWS	Illinois State Water Survey
IUCNNR	International Union for Conservation of Nature and Natural Resources
JMH CAP	Jack Morrow Hills Coordinated Activity Plan
KOP	key observation point
KSLA	Known Sodium Leasing Area
LAU	Lynx Analysis Unit
LETC	Laramie Energy Technology Center
LPG	liquefied petroleum gas
L_{dn}	day-night average sound level
L_{eq}	equivalent sound pressure level
M&I	municipal and industrial
MFP	Management Framework Plan
MIS	modified in situ recovery
MLA	Mineral Leasing Act
MMC	Multi Minerals Corporation
MMTA	Mechanically Mineable Trona Area
MOU	Memorandum of Understanding
MPCA	Minnesota Pollution Control Agency
MSHA	Mine Safety and Health Administration
MSL	mean sea level
MTR	military training route
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAGPRA	Native American Graves Protection and Repatriation Act
NCA	National Conservation Area
NCDC	National Climate Data Center
NEC	National Electric Code
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NLCS	National Landscape Conservation System
NMFS	National Marine Fisheries Service
NNHP	Nevada Natural Heritage Program
NOI	Notice of Intent
NORM	naturally occurring radioactive materials
NOSR	Naval Oil Shale Reserves
NPDES	National Pollutant Discharge Elimination System

NPS	National Park Service
NRA	National Recreation Area
NRHP	*National Register of Historic Places*
NSC	National Safety Council
NSO	No Surface Occupancy
NWCC	National Wind Coordinating Committee
OHV	off-highway vehicle
OOSI	Occidental Oil Shale, Inc.
OPEC	Organization of Petroleum Exporting Countries
OSEC	Oil Shale Exploration Company
OSEW/SPP	Oil Sands Expert Workgroup/Security and Prosperity Partnership
OSHA	Occupational Safety and Health Administration
OTA	Office of Technology Assessment
PA	Programmatic Agreement
PADD	Petroleum Administration for Defense District
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
PFYC	Potential Fossil Yield Classification
P.L.	Public Law
PM	particulate matter
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 μm or less
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 μm or less
PPE	personal protective equipment
PRLA	preference right lease area
PSD	Prevention of Significant Deterioration
R&I	relevance and importance
RBOSC	Rio Blanco Oil Shale Company
RCRA	Resource Conservation and Recovery Act of 1976
RD&D	research, development, and demonstration
RF	radio frequency
RFDS	reasonably foreseeable development scenario
RMP	Resource Management Plan
ROD	Record of Decision
ROI	region of influence
ROS	Recreation Opportunity Spectrum
ROW	right-of-way
SAGD	steam-assisted gravity drainage
SAMHSA	Substance Abuse and Mental Health Services Administration
SDWA	Safe Drinking Water Act of 1974
SFC	Synthetic Fuels Corporation
SHPO	State Historic Preservation Office(r)

SIP	State Implementation Plan
SMA	Special Management Area
SMP	suggested management practice
SPR	Strategic Petroleum Reserve
SRMA	Special Recreation Management Area
SSI	self-supplied industry
STSA	Special Tar Sand Area
SWCA	SWCA, Inc., Environmental Consultants
SWPPP	Stormwater Pollution Prevention Plan
SWWRC	Sates West Water Resources Corporation
TDS	total dissolved solids
THAI	toe to head air injection
TIS	true in situ recovery
TMDL	Total Maximum Daily Load
TOSCO	The Oil Shale Corporation
TSCA	Toxic Substances Control Act of 1976
TSDF	treatment, storage, and disposal facility
UDEQ	Utah Department of Environmental Quality
UDNR	Utah Department of Natural Resources
UDWR	Utah Division of Wildlife Resources
UIC	underground injection control
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VCRS	Visual Contrast Rating System
VOC	volatile organic compound
VRI	visual resource inventory
VRM	Visual Resource Management
WCA	areas recognized as having wilderness characteristics
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WRAP	Western Regional Air Partnership
WRCC	Western Regional Climate Center
WRSOC	White River Shale Oil Corporation
WSA	Wilderness Study Area
WSR	Wild and Scenic River
WTGS	wind turbine generator system
WYCRO	Wyoming Cultural Records Office

CHEMICALS

CH_4	methane	NO_x	nitrogen oxides
CO	carbon monoxide	O_3	ozone
CO_2	carbon dioxide	Pb	lead
H_2S	hydrogen sulfide	SO_2	sulfur dioxide
NH_3	ammonia	SO_x	sulfur oxides
NO_2	nitrogen dioxide		

UNITS OF MEASURE

ac-ft	acre foot (feet)	km	kilometer(s)
		kPa	kilopascal(s)
bbl	barrel(s)	kV	kilovolt(s)
Btu	British thermal unit(s)	kWh	kilowatt-hour(s)
°C	degree(s) Celsius	L	liter(s)
cfs	cubic foot (feet) per second	lb	pound(s)
cm	centimeter(s)		
		m	meter(s)
dB	decibel(s)	m^2	square meter(s)
dBA	A-weighted decibel(s)	m^3	cubic meter(s)
		mg	milligram(s)
°F	degree(s) Fahrenheit	mi	mile(s)
ft	foot (feet)	mi^2	square mile(s)
ft^3	cubic foot (feet)	mm	millimeter(s)
		MMBtu	thousand Btu
g	gram(s)	mph	mile(s) per hour
gal	gallon(s)	MW	megawatt(s)
GJ	gigajoule(s)		
gpd	gallon(s) per day	ppm	part(s) per million
gpm	gallon(s) per minute	psi	pound(s) per square inch
GW	gigawatt(s)		
GWh	gigawatt hour(s)	rpm	rotation(s) per minute
h	hour(s)	s	second(s)
ha	hectare(s)	scf	standard cubic foot (feet)
Hz	hertz		
		yd^2	square yard(s)
in.	inch(es)	yd^3	cubic yard(s)
		yr	year(s)
K	degree(s) Kelvin		
kcal	kilocalorie(s)	µm	micrometer(s)
kg	kilogram(s)		

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS[a]

The following table lists the appropriate equivalents for English and metric units.

Multiply	By	To Obtain
English/Metric Equivalents		
acres	*0.4047*	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) –32	0.5555	degrees Celsius (°C)
Feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
miles per hour (mph)	1.609	kilometers per hour (kph)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) +17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
kilometers per hour (kph)	0.6214	miles per hour (mph)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

a In general in this PEIS, only English units are presented. However, where reference sources provided both English and metric units, both values are presented in the order in which they are given in the source.

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EXECUTIVE SUMMARY

ES.1 BACKGROUND TO THE PEIS

In August 2005, the U.S. Congress enacted the Energy Policy Act of 2005, Public Law (P.L.) 109-58. In Section 369 of this Act, titled the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005," Congress declared that oil shale and tar sands (and other unconventional fuels) are strategically important domestic energy resources that should be developed to reduce the nation's growing dependence on oil from politically and economically unstable foreign sources. To support this policy, Congress directed the Secretary of the Interior (the Secretary) to undertake a series of steps to establish a commercial leasing program for oil shale and tar sands. A principle provision mandated the Secretary to "…Complete a programmatic environmental impact statement for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming."

In furtherance of this direction, the U.S. Bureau of Land Management (BLM) is amending 12 land use plans in the 3 states to describe the most geologically prospective areas administered by the BLM in these states where oil shale and tar sands resources are present, and to identify which portions of those areas will be open for application for commercial leasing, exploration, and development. Both the Draft Programmatic Environmental Impact Statement (PEIS) and this Final PEIS contain analyses of the direct, indirect, and cumulative environmental, cultural, and socioeconomic impacts of the proposed action and alternatives. Preparation of this PEIS complies with the requirements of the Federal Land Policy and Management Act; the National Environmental Policy Act of 1969 (NEPA); the President's Council on Environmental Quality's (CEQ's) NEPA implementing regulations; the BLM's land use planning regulations contained in Part 1600 of Title 43 of the *Code of Federal Regulations* (43 CFR Part 1600); the BLM's *Land Use Planning Handbook* (H-1601-1) (BLM 2005); and the BLM's *NEPA Handbook* (H-1790-1) (BLM 2008).

ES.2 DESCRIPTION OF THE PLANNING AREA

The study area for the oil shale resources includes the most geologically prospective area of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins. The BLM identified the most geologically prospective areas for oil shale development on the basis of the grade and thickness of the deposits within the Green River Formation. There are approximately 2.3 million acres of BLM-managed lands within this area that are the subject of this PEIS. For the tar sands resources, the study area, which coincides with the area considered to be the most geologically prospective for tar sands development, includes those locations in Utah previously designated as Special Tar Sand Areas (STSAs) in the geologic reports (minutes) prepared by the U.S. Geological Survey in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78). The STSAs contain approximately 656,000 acres of BLM-managed lands. The PEIS study areas for both oil shale and tar sands include public lands administered by the BLM where the federal government owns both the surface estate and subsurface mineral rights and where the federal government owns the subsurface mineral rights but the surface estate is owned by Tribes, states, or private parties (i.e., split estate lands).

ES.3 SCOPING PROCESS

The BLM published the Notice of Intent (NOI) to prepare the *Oil Shale and Tar Sands Resources Leasing PEIS* in the *Federal Register* (70 FR 73791–73792) on December 13, 2005 (the name was subsequently changed to the *Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Programmatic Environmental Impact Statement*). The NOI identified planning criteria, initiated the public scoping process, and invited interested members of the public to provide comments on the scope and objectives of the PEIS and to identify issues to be addressed in the planning process. The BLM conducted scoping from December 13, 2005, through January 31, 2006. During that period, the BLM invited the public and interested groups to provide information on resource use, land allocations, and development and protection opportunities for consideration in preparation of the PEIS. Comments were received in the broad categories of environmental concerns, socioeconomics, resource and technology concerns, stakeholder involvement, alternatives, land use planning, cumulative impacts, mitigation and reclamation, and BLM policy. It is estimated that approximately 5,000 people participated in the scoping process by attending public meetings, providing comments, requesting information, or visiting the project Web site.

The BLM published a scoping report (BLM 2006) that summarizes and categorizes the major themes, issues, concerns, and comments expressed by private citizens, government agencies, private firms, and nongovernmental organizations. These comments were considered in developing the alternatives in this PEIS, and the significant issues identified were analyzed. Copies of the scoping report, individual letters, electronic comments, and other written comments received during scoping are available on the Oil Shale and Tar Sands Programmatic EIS Web site (http://ostseis.anl.gov).

ES.4 PUBLIC REVIEW OF THE DRAFT PEIS

The Notice of Availability (NOA) of the Draft PEIS was published on December 21, 2007 (72 FR 72751–72753), beginning a 90-day comment period which ended on March 20, 2008. The comment period was reopened on March 21, 2008, and closed the second time on April 21, 2008 (73 FR 17375–17376). During both times, the BLM invited the public to provide substantive comments on the content of the Draft PEIS.

In February 2008, the BLM held a series of 12 informal, open-house style public meetings to allow the public to talk with BLM officials about the content of the PEIS. Open houses were held in Salt Lake City, Price, and Vernal, Utah; Rock Springs and Cheyenne, Wyoming; and, Rifle, Meeker, and Denver, Colorado.

The Draft PEIS was posted on the official Oil Shale and Tar Sands Programmatic EIS Web site at http://ostseis.anl.gov. Printed copies of the document and compact disks (CDs) containing electronic files of the document were mailed upon request. More than 102,000 people and organizations participated in the comment process by providing comments to the Web site or via surface mail. The comments were all posted on the project Web site. The BLM reviewed and responded to all comments and made changes to the PEIS, as appropriate.

Most of the cooperating agencies provided written comments on the Draft PEIS. Their comments, along with BLM's responses, are included in Chapter 7 of the PEIS. Both the comments of the cooperating agencies and those of the public can be found on the project Web site and in Volume 4 of the Final PEIS. Volume 4 is not printed but is provided on a CD that is included in a pocket on the back cover of printed Volume 3. A complete set of the four volumes of the Final PEIS is available on CD or in printed form in limited quantities.

ES.5 COOPERATING AGENCIES

This PEIS has been prepared in cooperation with 14 federal, state, and local governmental organizations. The BLM provided numerous opportunities for coordination. These included coordination during the scoping period, providing briefings on the proposed action and formulation of the alternatives, and providing opportunities to review and comment on preliminary and internal drafts of the PEIS. The BLM held many informal meetings and discussions with the cooperating agencies. In addition, the BLM consulted with the U.S. Environmental Protection Agency (EPA) on the PEIS.

The BLM worked collaboratively with its cooperating agencies throughout the process to create a balanced commercial leasing program, consistent with the intent of Congress. The BLM originally intended the PEIS to support the amendment of land use plans to allocate areas open to commercial leasing and development of oil shale and tar sands, as well as to support the issuance of such leases. However, in consultation with the cooperating agencies, it was determined that the analysis to support immediate leasing decisions would require making many speculative assumptions regarding potential, unproven technologies, and, consequently, the decision to offer specific parcels for lease was dropped from consideration in the PEIS.

Therefore, the PEIS analyzes an allocation decision, (i.e., making lands available or open for the potential leasing of these resources). The BLM anticipates that the eventual development of the oil shale and tar sands resources would proceed in a phased approach—proceeding from this allocation decision to a leasing decision and then to an operational permit approval. The allocation decision essentially removes an administrative barrier preventing the BLM from accepting and considering applications to lease oil shale or tar sands, while prior to the leasing and development phases additional NEPA analysis will be required. This measured approach, where each step builds upon a prior step, ensures that state and local communities have the opportunity to be involved and are fully informed of the activities associated with the program. The allocation decisions would open the areas in question for leasing. The phrase "available for application for leasing" is used above, and throughout the PEIS, rather than "available for leasing" to highlight that, unlike BLM's practice with respect to oil and gas leasing, discussed in Section 1.1.1, additional NEPA analysis would be required prior to the issuance of any lease of oil shale or tar sands resources.

ES.6 FACTORS COMMON TO BOTH OIL SHALE AND TAR SANDS

Prior to issuance of any commercial oil shale or tar sands lease on lands designated as available for application, an additional NEPA analysis will be conducted. While the term "commercial lease" is used throughout the PEIS, as discussed at Section 1.4.1, the BLM may consider issuing commercial leases or research, development, and demonstration (RD&D) leases, or both, in the areas designated as available for application. The subsequent NEPA analysis would identify certain areas to be offered for lease and the constraints to which that leasing would be subject. Another similar NEPA review would also be undertaken before approval of a plan of development on a lease and would include approval of particular activities at the specific location where development would occur. Appropriate stipulations and mitigation measures would be identified as part of both of these additional NEPA analyses.

In general, applicants would be required to identify key information regarding aspects of the proposed development needed to support the NEPA review (e.g., technologies to be employed, level of planned development, anticipated off-site impacts, and strategies to comply with regulatory requirements). During that NEPA review, the BLM would identify and establish appropriate lease stipulations to mitigate anticipated impacts. In addition, the subsequent approval of project-specific plans of development also would require NEPA review to (1) consider site-specific and project-specific factors and (2) identify and require appropriate mitigation measures as needed to control impacts beyond those established in the lease stipulations. The NEPA review for the plan of development may be incorporated into the NEPA review conducted for the lease application, at BLM's discretion, and if adequate operational data are provided by the applicant(s).

The BLM would require that the lessee conduct any commercial development in compliance with existing federal, state, and local regulatory requirements and established BLM policies, as generally described in Section 2.2 and Appendix D of the PEIS. This compliance would include, as appropriate, obtaining and complying with all permits (e.g., air, water, and waste management) required by regulatory agencies; operating within the permit constraints; completing consultation with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act; completing consultation with State Historic Preservation Officers, Tribal Historic Preservation Officers, and other consulting parties under Section 106 of the National Historic Preservation Act (P.L. 89-665); and compliance with any other relevant and applicable requirements. Compliance-related conditions would be developed on a project-by-project basis during site-specific analyses.

ES.7 ALTERNATIVES

ES.7.1 No Action Alternative, Oil Shale

Alternative A for oil shale is the no action alternative. Under this alternative, no amendments to existing land use plans to identify lands available for application for commercial oil shale leasing would be completed. Existing land use plans would continue to provide direction for management of public lands. Under this alternative for oil shale, there are approximately 294,680 acres currently classified in the White River Resource Management Plan (RMP) (BLM 1997) in Colorado as available for oil shale leasing, and there are approximately 58,100 acres classified as available for leasing in the Book Cliffs RMP (BLM 1985) in Utah.

ES.7.2 No Action Alternative, Tar Sands

Under Alternative A for tar sands, the BLM has assumed that there would be no commercial leasing or development of tar sands on public lands. On the basis of the lack of active interest in developing the resource, the BLM has determined that it is unlikely that commercial tar sands development would occur under the existing Combined Hydrocarbon Lease (CHL) Program. Under Alternative A, land use plans would not be amended to allow for leasing for commercial tar sands development under any program other than the CHL Program.

ES.7.3 Alternative B, Oil Shale

Under Alternative B, the BLM proposes to designate a total of 1,991,222 acres available for application for commercial oil shale leasing by amending 9 land use plans. Specifically, the lands that would be available for application include all lands within the most geologically prospective oil shale areas that are BLM-administered public lands, including split estate lands where the federal government owns the mineral rights, but excluding those lands that are exempted by statute, regulation, or Executive Order.

ES.7.4 Alternative B, Tar Sands

Under Alternative B, the BLM proposes to designate a total of 431,224 acres available for commercial tar sands leasing by amending 6 land use plans. Specifically, the lands that would be available for application include all BLM-administered public lands within the STSAs, including split estate lands where the federal government owns the mineral rights, but excluding those lands that are exempted by statute, regulation, or Executive Order.

ES.7.5 Alternative C, Oil Shale

Alternative C is similar to Alternative B except that additional lands are excluded from the area identified as available for application for commercial leasing. Under Alternative C, the BLM proposes to designate a total of 830,296 acres available for application for commercial oil shale leasing. The lands that would be available for application under Alternative C include some of the lands that are available under Alternative B, but exclude lands that are identified as requiring special management or resource protection in existing land use plans.

ES.7.6 Alternative C, Tar Sands

Alternative C is similar to Alternative B except that additional lands are excluded from the area made available for application for commercial leasing. Under Alternative C, the BLM proposes to identify a total of 229,038 acres available for application for commercial tar sands leasing. The lands that would be available for application under Alternative C include some of the lands that are available under Alternative B, but exclude lands that are identified as requiring special management or resource protection in existing land use plans.

ES.8 SELECTION OF THE PROPOSED PLAN AMENDMENT

Alternative B for oil shale and tar sands was selected as the Proposed Plan Amendment on the basis of the following factors, consistent with the requirements of the Energy Policy Act of 2005, a balanced use and protection of resources, the analysis of potential environmental impacts, and consideration of formal comments and recommendations from cooperating agencies and the public. The alternative was designed to ensure that oil shale and tar sands technologies can operate at environmentally acceptable levels before the authorization of oil shale or tar sands development. Tables ES-1 and ES-2 summarize the main components of the proposed plan amendment for oil shale and tar sands, respectively.

ES.9 ANALYSIS OF THE IMPACTS OF THE PROPOSED PLAN AMENDMENT FOR OIL SHALE AND TAR SANDS

The action evaluated in the PEIS is to amend existing land use plans to designate lands that would be open for application for commercial oil shale or tar sands leasing. Chapter 6 of the PEIS contains the analysis of the impacts of each of the alternatives considered, compares the alternatives, and places them in the context of other ongoing developments within the study area. Chapter 6 also presents a preliminary, qualitative, analysis of the impacts of leasing and development of these resources in order to assist in informing the land use planning decision.

The PEIS discloses, under the Proposed Plan Amendment (Alternative B), that the allocation decisions opening areas to future leasing do nothing more than to remove the administrative barrier to BLM considering any application to lease. The amendment of the land use plans does not authorize any ground-disturbing activities and is not an irreversible or irretrievable commitment of resources under NEPA. Therefore, with the exception noted in the socioeconomic analysis regarding potential impacts on land values that may result from these allocation decisions, the action alternatives presented would not result in any impacts on the environment or socioeconomic setting of the area under consideration. The decisions analyzed in the PEIS serve as the first step in the process to establish a commercial oil shale and tar sands program that meets the intent of Congress while taking advantage of the best available

TABLE ES-1 Summary of the Proposed Plan Amendment for Oil Shale: Colorado, Utah, and Wyoming[a]

Condition	Proposed Plan Amendment
Land use plans amended	Amend 9 existing land use plans.
Potential area made available for application for leasing (RD&D and commercial leasing)	1,991,222 acres would be available for application for commercial leasing: Colorado, 359,798 acres Utah, 630,971 acres Wyoming, 1,000,453 acres
Technologies considered	– In situ processes – Underground mining with surface retort – Surface mining with surface retort (only in Utah and Wyoming in areas where the overburden is 0 to 500 ft thick)
Lands excluded from commercial leasing	– Wilderness Areas, WSAs, and other areas that are part of the NLCS. – Existing ACECs that are currently closed to mineral development. – The MMTA in Wyoming. – Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. – Historic trails. – Monument Valley Management Area in Wyoming. – Management Area 3, Jack Morrow Hills Planning Area in Wyoming. – Incorporated town and city limits.
Regulatory and operational constraints	All commercial development would be conducted in compliance with federal, state, and local regulatory requirements, BLM land use plans, and established BLM policies.

a Abbreviations: ACEC = Area of Critical Environmental Concern; MMTA = Mechanically Mineable Trona Area; NLCS = National Landscape Conservation System; WSR = Wild and Scenic River; WSA = Wilderness Study Area.

information and practices to minimize impacts and ensure that states, local communities, and the public have the opportunity to be involved.

An analysis of potential direct, indirect, and cumulative impacts associated with oil shale and tar sands development based on currently known technologies is provided in Chapter 6. However, the level and degree of the potential impacts could not be quantified because this would require making many speculative assumptions regarding potential, unproven technologies,

TABLE ES-2 Summary of the Proposed Plan Amendment for Tar Sands: Utah

Condition	Proposed Plan Amendment
Land use plans amended	Amend 6 existing land use plans.
Potential area made available for application for leasing (RD&D and commercial leasing)	431,224 acres would be made available for application for commercial leasing.
Technologies considered	– Surface mining with surface retort – Surface mining with solvent extraction – In situ steam injection – In situ combustion
Lands excluded from commercial leasing	– Wilderness Areas, WSAs, other areas that are part of the NLCS. – All existing ACECs. – The Circle Cliffs STSA. – Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. – Incorporated town and city limits.

project size, or production levels. This analysis, nevertheless, discloses potential effects associated with leasing and development to provide the decision maker available information to assist in informing the allocation decision.

ES.10 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed.

BLM (Bureau of Land Management), 1985, *Record of Decision and Rangeland Program Summary for the Book Cliffs Resource Management Plan*, Vernal District Office, Utah, May.

BLM, 1997, *White River Record of Decision and Approved Resource Management Plan*, White River Resource Area, Craig District, Meeker, Colo., July.

BLM, 2005, *Land Use Planning Handbook*, BLM Handbook H-1601-1, Washington, D.C., March.

BLM, 2006, *Summary of Public Scoping Comments for the Oil Shale and Tar Sands Resources Leasing Programmatic Environmental Impact Statement*, prepared by Argonne National Laboratory, Argonne, Ill., for Bureau of Land Management, Solid Minerals Group, Washington, D.C., Jan.

BLM, 2008, *National Environmental Policy Act Handbook*, BLM Handbook H-1790-1, Washington, D.C., January.

USGS (U.S. Geological Survey), 1980a, *Argyle Canyon–Willow Creek, Utah Tar Sand Leasing Minutes No. 9*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980b, *Asphalt Ridge–Whiterocks and Vicinity, Utah Tar Sand Leasing Minutes No. 3*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980c, *Circle Cliffs East and West Flanks, Utah Tar Sand Leasing Minutes No. 5*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980d, *Hill Creek, Utah Tar Sand Leasing Minutes No. 6*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980e, *Pariette, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980f, *P.R. Spring, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980g, *Raven Ridge–Rim Rock and Vicinity, Utah Tar Sand Leasing Minutes No. 8*, Minutes of the Mineral Land Evaluation Committee, Nov. 10

USGS, 1980h, *San Rafael Swell, Utah Tar Sand Leasing Minutes No. 7*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980i, *Sunnyside and Vicinity, Utah Tar Sand Leasing Minutes No. 4*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980j, *Tar Sand Triangle, Utah Tar Sand Leasing Minutes No. 2*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980k, *White Canyon, Utah Tar Sand Leasing Minutes No. 11*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

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1 INTRODUCTION

The U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), proposes to amend 12 land use plans in Colorado, Utah, and Wyoming to designate public lands managed by the BLM as available for application for commercial leasing for oil shale or tar sands development. This action is a land allocation decision. This programmatic environmental impact statement (PEIS), prepared pursuant to Section 102 of the National Environmental Policy Act of 1969 (NEPA) (*United States Code*, Title 42, Section 4321 et seq. [42 USC 4321 et seq.]), evaluates the impacts of amending these land use plans to make these land allocation decisions. Prior to issuance of any commercial leases on lands that may be designated as available for application, additional NEPA analysis will be required to analyze the direct, indirect, and cumulative environmental, cultural, and socioeconomic impacts of the proposed lease for development of oil shale or tar sands resources. Another similar NEPA review would also be undertaken before approval of a plan of development on a lease and would include approval of particular activities at the specific location where development would occur. Appropriate stipulations and mitigation measures would be identified as part of both of these additional NEPA analyses.

The BLM administers approximately 258 million acres of public lands and 700 million acres of subsurface mineral estate in the United States. Management of these public lands must be conducted in accordance with the requirements of the Federal Land Policy and Management Act of 1976 (FLPMA) (43 USC 1701 et seq.) and many other public laws. FLPMA requires the BLM to develop land use plans, also called resource management plans (RMPs), to guide the management of the public lands it administers. In order for a commercial leasing program to occur on the public lands, the land use plans for the areas where leasing could occur must be amended to provide for such leasing. This PEIS has been developed to analyze the effects of the amendment of 12 land use plans to allow for the application for commercial leasing for oil shale and tar sands development.

In August 2005, the U.S. Congress enacted the Energy Policy Act of 2005, Public Law (P.L.) 109-58. In Section 369 of this Act, also known as the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005," Congress declared that oil shale and tar sands (and other unconventional fuels) are strategically important domestic energy resources that should be developed to reduce the nation's growing dependence on oil from politically and economically unstable foreign sources. In addition, Congress declared that both research- and commercial-scale development of oil shale and tar sands should (1) be conducted in an environmentally sound manner using management practices that will minimize potential impacts, (2) occur with an emphasis on sustainability, and (3) benefit the United States while taking into account concerns of the affected states and communities. To support this declaration of policy, Congress directed the Secretary of the Interior (the "Secretary") to undertake a series of steps, several of which are directly related to the development of a commercial leasing program for oil shale and tar sands. Those steps, contained in paragraphs (d), (e), and (n) of the Act, directed that the Secretary shall:

- "…Complete a programmatic environmental impact statement for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming";
- "…Not later than 6 months after completion of the programmatic environmental impact statement…the Secretary shall publish a final regulation establishing such program";
- "…Consult with the Governors of States with significant oil shale and tar sands resources on public lands, representatives of local governments in such States, interested Indian Tribes, and other interested persons, to determine the level of support and interest in the States in the development of tar sands and oil shale resources"; and
- "If the Secretary finds sufficient support and interest exists in a State, the Secretary may conduct a lease sale in that State under the commercial leasing program."
- Land Exchanges – (1)"… To facilitate the recovery of oil shale and tar sands, especially in areas where Federal, State, and private lands are intermingled, the Secretary shall consider the use of land exchanges where appropriate and feasible to consolidate land ownership and mineral interests into manageable areas"; (2) "…identify public lands containing deposits of oil shale or tar sands within the Green River, Piceance Creek, Uintah, and Washakie geologic basins, and shall give priority to implementing land exchanges in those basins."; and, "a land exchange…shall be implemented in accordance with Section 206 of FLPMA."

1.1 PURPOSE AND NEED

The BLM proposes to amend 12 land use plans in Colorado, Utah, and Wyoming to describe the most geologically prospective areas managed by the BLM in these states where oil shale and tar sands resources are present, and to decide which portions of those areas will be open to application for commercial leasing, exploration, and development. The BLM proposes to amend these land use plans to provide for the opportunity for application for leasing. The analyses in this PEIS have been developed to evaluate the effects of this proposed action and its alternatives. With the exception of the White River and Book Cliffs RMPs in Colorado and Utah, respectively, the current land use plans in the study area do not address development of oil shale resources. In Utah, the current land use plans do not address the development of tar sands separate and apart from combined hydrocarbon leases (CHLs). Therefore, plan amendments are required to identify those areas that will be available for application for leasing and that can be considered for future exploration and development of these resources. The plan amendments would open the areas in question for leasing. The phrase "available for application for leasing" is used above, and throughout the PEIS, rather than simply "available for leasing" to highlight that, unlike the BLM's practice with respect to oil and gas leasing, additional NEPA analysis would be required prior to the issuance of any lease of oil shale or tar sands resources.

This *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final PEIS* has been prepared to meet the requirements established by Congress in Section 369 of the Energy Policy Act of 2005. Preparation of this PEIS will comply with the requirements of FLPMA; NEPA; the President's Council on Environmental Quality's (CEQ's) NEPA implementing regulations; the BLM's land use planning regulations contained in Part 1600 of Title 43 of the *Code of Federal Regulations* (43 CFR Part 1600); the BLM's Land Use Planning Handbook (H-1601-1) (BLM 2005); and the BLM's NEPA Handbook (H-1790-1) (BLM 1988a, as revised 2008).

Section 369 of the Energy Policy Act of 2005 also requires that the BLM publish regulations establishing an oil shale and tar sands commercial leasing program. The BLM considered including an analysis of the potential environmental effects of the establishment of the leasing regulations in this PEIS but determined not to do so because development of the regulations involved different issues, was proceeding according to a different schedule, and would be better served by an environmental analysis prepared specifically to consider the rulemaking itself.

1.1.1 Evolution of the Purpose and Need of the PEIS since Publication of the Notice of Intent (NOI)

As described in the December 2005 NOI to prepare this PEIS, the BLM originally intended the PEIS to provide the NEPA analysis and documentation for both the amendment of land use plans and for issuance of commercial leases for the development of oil shale and tar sands resources. As part of the development of the PEIS, the BLM circulated an internal draft of the PEIS to its cooperating agencies for review and comment that included a commercial lease development scenario. Most of the cooperating agencies commented that the BLM's analysis did not contain enough information on the specific environmental, cultural, and socioeconomic effects of such development, and that it would be too speculative at this point to support a decision to issue any commercial leases. Therefore, consideration was given whether specific information was lacking on the effects of oil shale and tar sands leasing and development relevant to making an allocation decision.

Using comparable data, as a result of BLM's experience with surface-disturbing activities from other types of mineral development, the BLM determined that sufficient information on the nature of the effects for an allocation decision was known, but not the extent of the effect necessary to make a leasing decision. Therefore, the BLM decided to limit the scope of the PEIS to an allocation decision and to provide an analysis of potential impacts associated with oil shale and tar sands development in Chapters 4, 5, and 6 to disclose the potential impacts from future leasing and development to the extent currently possible. This analysis discloses potential effects associated with leasing and development to provide the decision maker the available, essential information for making the allocation decision. Because of the limited scope, the PEIS fulfills the requirement to take a "hard look" at the consequences of the allocation alternatives.

Consideration was also given to the possibility of future research, development, and demonstration (RD&D) leases. Section 369(c) of the Energy Policy Act of 2005 authorized the Secretary to make lands available to conduct R&D activities. Evaluating the analysis and potential impacts disclosed in Chapters 4, 5, and 6, the BLM determined that impacts from new RD&D projects are expected to be qualitatively similar to those of commercial oil shale projects, but smaller in scale until an RD&D lease is converted to a commercial lease and expanded to preference right acreage. Accordingly, while, in general, the PEIS refers to lands as being "available for application for commercial leasing," this means that land that will be open for commercial oil shale leasing will also be open for RD&D leasing. This PEIS does not provide the NEPA analysis for new RD&D leasing or for conversion of RD&D leases to commercial leases.

The BLM also concluded that subsequent NEPA analysis at the leasing stage (whether oil shale, tar sands, or RD&D) will be required to determine the extent of the effect of oil shale and tar sands development when more specific information is known about the technology and associated environmental consequences.

The BLM anticipates that oil shale development would proceed in a three-step decision-making process similar to that used for federal onshore oil and gas: (1) land use planning (i.e., amending RMPs), (2) leasing, and (3) approval of a drilling permit or a plan of development. In the present experimental stage of the oil shale and tar sands industries, however, the BLM believes that the stages of NEPA compliance will be different from those used in oil and gas.

As a result of the maturity of the oil and gas industry, the BLM is usually able to include sufficient site-specific analysis in its NEPA documentation for amendments to RMPs so that an additional NEPA document is not required for issuing an oil and gas lease in conformance with the RMP. Nonetheless, the BLM also prepares a NEPA analysis before approving a plan of development or a drilling permit that would authorize significant disturbance of the leased area. The NEPA analysis for both decision levels includes cumulative affects analysis. Analysis of each oil and gas decision is based on technical information associated with the particular proposed action, as well as information about other reasonably foreseeable future actions in and near the area of the proposal.

In contrast, the present experimental state of the oil shale and tar sands industries does not allow this PEIS for land use plan amendments to include sufficient site-specific information or cumulative impact analysis to support issuance of a lease. Accordingly, prior to any actual oil shale leasing, additional NEPA analysis will be required. That NEPA analysis could result in decisions not to lease in specific areas or to lease in particular areas with stipulations, such as a stipulation precluding disturbance of the surface.

Therefore, the BLM determined to not offer specific parcels for lease on the basis of this PEIS. The BLM believes that this multistep decision-making process would create a balanced leasing program, consistent with the intent of Congress and address the concerns of the cooperating agencies.

As explained above, the BLM will not issue leases for commercial development on the basis of this PEIS. Rather, as explained above, the PEIS is analyzing an allocation decision, the amendment of 12 existing land use plans to designate certain public lands as open for application for future oil shale and tar sands leasing. Under both programmatic oil shale and tar sands alternatives, land use plans would be amended to (1) identify the most geologically prospective oil shale or tar sands resources within each planning unit, (2) designate lands within these most geologically prospective areas as available for application for leasing, (3) identify any technology restrictions, (4) establish requirements for future NEPA analyses and consultation activities, and (5) specify that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005.

If and when applications to lease are received and accepted, the BLM will conduct additional NEPA analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as what level of development may be anticipated. On the basis of that NEPA analysis of future lease application(s), the BLM will establish general lease stipulations and best management practices (BMPs) and amend those plans, if necessary. After a lease is authorized, actual development will require additional NEPA analysis to address the site-specific conditions of the proposed development and to develop mitigating measures.

1.2 SCOPE OF THE ANALYSIS

The NOI to prepare the *Oil Shale and Tar Sands Resources Leasing PEIS* was published in the *Federal Register* (70 FR 73791–73792) on December 13, 2005 (the title was subsequently changed to the *Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and PEIS*). The NOI contained information regarding the need for the project, opportunities for public involvement, supplementary information regarding the project, planning criteria that would underlie the PEIS, and invited the public to comment on the proposed PEIS. Planning criteria are the standards, rules, and other factors used in formulating judgments about data collection, analysis, and decision making associated with preparation of the PEIS. These criteria establish parameters and help focus preparation of the PEIS. The following are the planning criteria that were considered during the preparation of the PEIS and that were included in the NOI for the project:

A. The PEIS and plan amendments will be completed in compliance with FLPMA and all applicable laws.

B. The BLM will work collaboratively with the states of Colorado, Utah, and Wyoming; Tribal governments; county and municipal governments; other federal agencies; and all other interested groups, agencies, and individuals. Public participation will be encouraged throughout the process.

C. The PEIS will amend the appropriate individual land use plans to address leasing of oil shale and tar sands resources on BLM-managed lands.

D. A strategy to mitigate socioeconomic impacts, including the infrastructure, to accommodate the required workforce, will be addressed in the PEIS and plan amendments.

E. Preparation of the PEIS and plan amendments will involve coordination with Native American Tribal governments and will provide strategies for the protection of recognized traditional uses.

F. The BLM will coordinate with local, state, and federal agencies in the PEIS and plan amendments to strive for consistency with their existing plans and policies, to the extent practicable.

G. The PEIS will comply with the legislative directives set forth in the Energy Policy Act of 2005.

As stated in the NOI, this PEIS evaluates the potential impacts of designating lands as available for commercial leasing of oil shale and tar sands resources that are located on public lands in Colorado, Utah, and Wyoming (Figures 1.2-1 and 1.2-2).

Specifically, the study area for the oil shale resources includes the most geologically prospective resources of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins.[1] The BLM has identified the most geologically prospective areas for oil shale development on the basis of the grade and thickness of the deposits. For the purposes of this PEIS, the most geologically prospective oil shale resources in Colorado and Utah are those deposits that yield 25 gal of shale oil per ton of rock (gal/ton) or more and are 25 ft thick or greater. In Wyoming, where the oil shale resource is not of as high a quality as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of shale oil and are 15 ft thick or greater. Figure 1.2-1 shows the oil shale basins, which were mapped on the basis of the extent of the Green River Formation, and the most geologically prospective oil shale resources within those basins.[2]

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1 The Piceance Basin is not referred to or described consistently in published literature. Some publications describe the Piceance Basin as an area encompassing more than 7,000 mi^2 and consisting of a northern province and a southern province, which are roughly separated by the Colorado River and Interstate 70 (I-70). Other publications refer to the southern province as the Grand Mesa Basin. Oil shale is present in both provinces, with the richest oil shale deposits in the north, and smaller, isolated deposits in the south. Various authors have used the terms "Piceance Basin" and "Piceance Creek Basin" to refer to either the overall basin or the northern area. In this PEIS, the focus is on the northern province, where the richest and thickest reserves are located, and the study area will be referred to as the "Piceance Basin."

2 Numerous sources of information were used to define the boundaries of the Green River Formation basins and the most geologically prospective oil shale resources. The basin boundaries were defined by digital data provided by the U.S. Geological Survey (USGS) taken from Green (1992), Green and Drouillard (1994), and Hintze et al. (2000). The most geologically prospective oil shale resources in the Piceance Basin were defined on the basis of digital data provided by the USGS taken from Pitman and Johnson (1978), Pitman (1979), and Pitman et al. (1989). In Wyoming, the most geologically prospective oil shale resources were defined on the basis of detailed analyses of available oil shale assay data (Wiig 2006a,b). In Utah, the most geologically prospective oil shale resources were defined by digital data provided by the BLM Utah State Office.

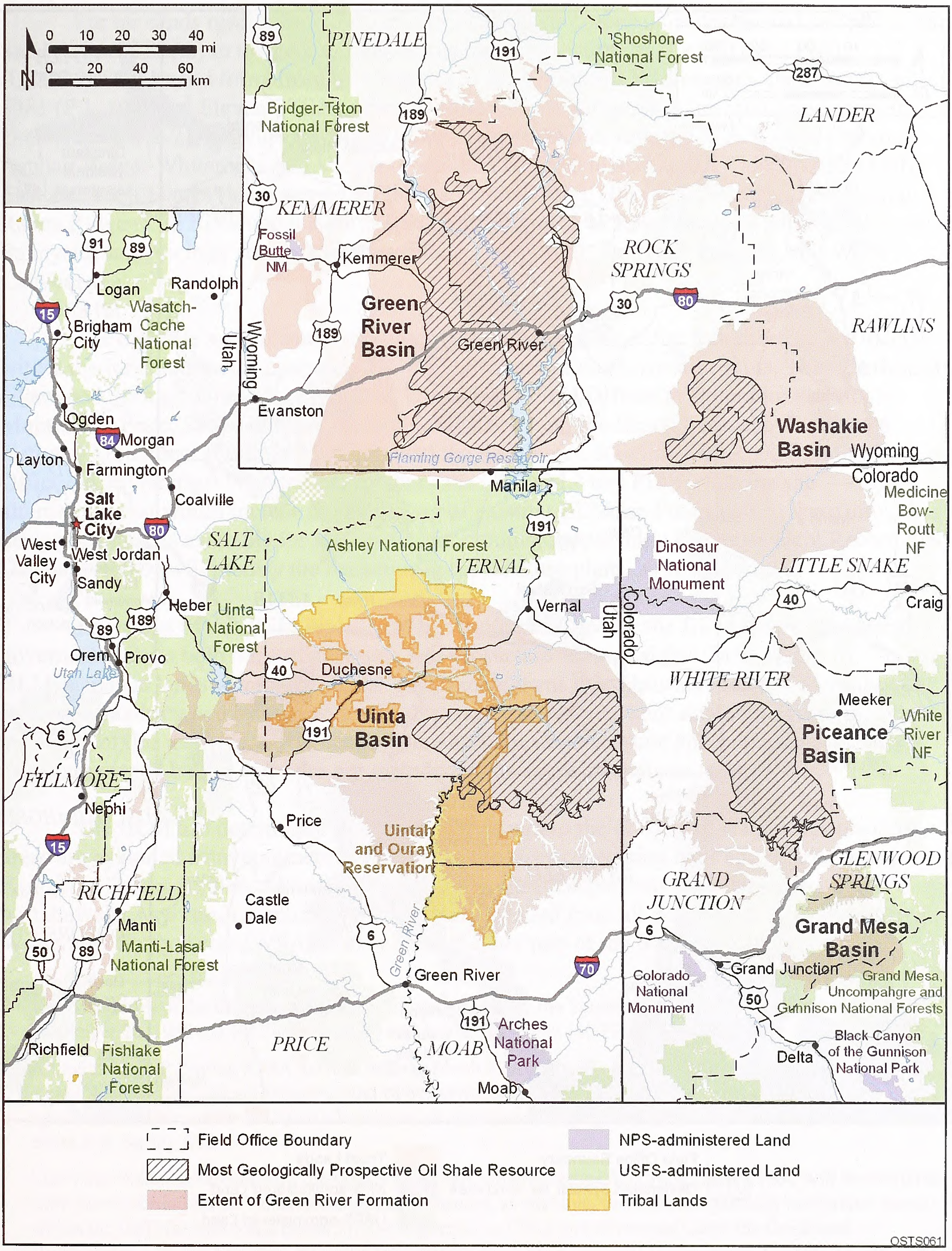

FIGURE 1.2-1 Most Geologically Prospective Oil Shale Resources within the Green River Formation Basins in Colorado, Utah, and Wyoming

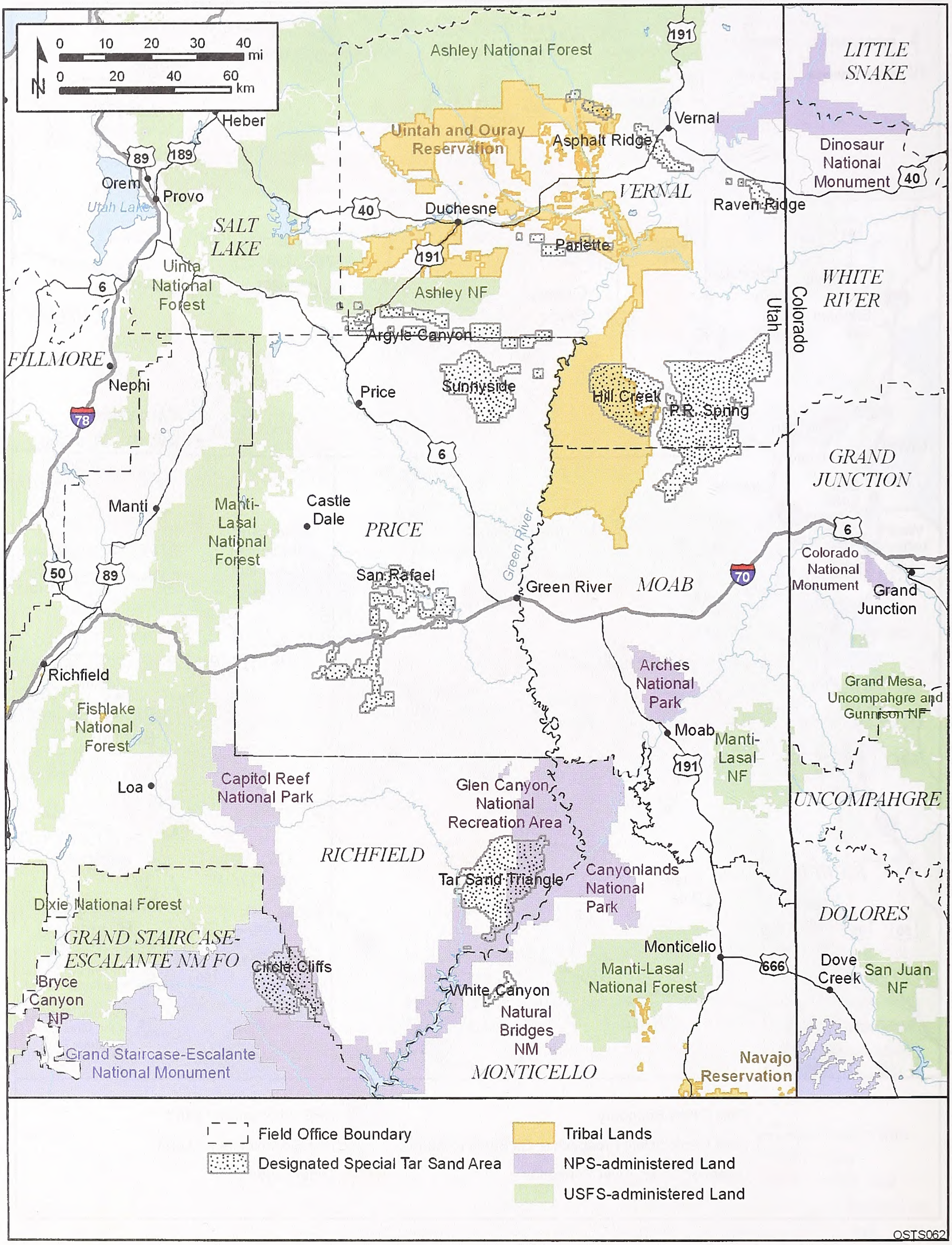

FIGURE 1.2-2 Special Tar Sand Areas in Utah

For tar sands resources, the study area includes those locations designated as Special Tar Sand Areas (STSAs) in the geologic reports (minutes) prepared by the USGS in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78).[3] Eleven STSAs were identified across different sedimentary provinces in Utah (Figure 1.2-2): Argyle Canyon–Willow Creek (hereafter referred to as Argyle Canyon), Asphalt Ridge–Whiterocks and Vicinity (hereafter referred to as Asphalt Ridge), Circle Cliffs East and West Flanks (hereafter referred to as Circle Cliffs), Hill Creek, Pariette, P.R. Spring, Raven Ridge–Rim Rock and Vicinity (hereafter referred to as Raven Ridge), San Rafael Swell, Sunnyside and Vicinity (hereafter referred to as Sunnyside), Tar Sand Triangle, and White Canyon.

The oil shale and tar sands resources that fall within the defined study areas are located within the jurisdiction of 12 separate BLM field offices or administrative units. These include the Glenwood Springs, Grand Junction, and White River Field Offices in Colorado; the Moab, Monticello, Price, Richfield, and Vernal Field Offices and the Grand Staircase–Escalante National Monument (GSENM) in Utah; and the Kemmerer, Rawlins, and Rock Springs Field Offices in Wyoming.[4] With the exception of the GSENM,[5] this PEIS evaluates the alternatives that would include the amending of existing BLM land use plans in these units to designate lands as available for application for commercial leasing. The subsequent Record of Decision (ROD) will modify the decisions in the land use plans, as appropriate.

The scope of this PEIS includes public lands managed by the BLM where the federal government owns both the surface estate and subsurface mineral rights. In addition, BLM-managed lands where the federal government owns the subsurface mineral rights but the surface estate is owned by Tribes, states, or private parties (i.e., split estate lands) are included in the scope of this analysis. Tribal lands where both the surface estate and subsurface mineral estate are owned by the Tribe are not included in the scope of analysis of this PEIS.

The BLM has determined that certain lands within the oil shale and tar sands resource areas are excluded from commercial leasing on the basis of existing laws and regulations, Executive Orders (E.O.s), administrative land use plan designations as noted below, or withdrawals. As a result, commercial leasing is excluded from all designated Wilderness Areas, Wilderness Study Areas (WSAs), other areas that are part of the National Landscape

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3 The boundaries of the designated STSAs were determined by the Secretary of the Interior's orders of November 20, 1980 (45 FR 76800–76801) and January 21, 1981 (46 FR 6077–6078).

4 Although the P.R. Spring STSA extends into the Moab Field Office boundary, this area is administered by the Vernal Field Office under a Memorandum of Understanding (MOU) with the Moab Field Office. Under this agreement, the Vernal Field Office administers all resources and programs, including land use planning, for the entire P.R. Spring STSA.

5 Like other National Monuments, the GSENM in Utah, which overlies the Circle Cliffs STSA, will be excluded from future leasing for tar sands development. However, at this time, there are two pending conversion leases within the GSENM that could potentially be converted to CHLs and developed under the Combined Hydrocarbon Leasing Program. For more information about the Combined Hydrocarbon Leasing Program and pending conversion leases for tar sands development, see Section 1.4.2. Because there will be no future tar sands leasing within the GSENM, the impacts of commercial tar sands leasing and development in the Circle Cliffs STSA are not evaluated in this PEIS.

Conservation System (NLCS) managed by the BLM (e.g., National Monuments, National Conservation Areas [NCAs], Wild and Scenic Rivers [WSRs], and National Historic and Scenic Trails), and existing Areas of Critical Environmental Concern (ACECs) that are currently closed to mineral development. As discussed in Chapter 2, additional areas are closed and will not be available for the future opportunity to lease for oil shale and tar sands on the basis of local planning decisions.

This PEIS is being prepared to meet the requirements established by Congress in Section 369 of the Energy Policy Act of 2005 and to meet the requirements of NEPA. It will amend 12 RMPs to designate lands as available for application for commercial leasing for oil shale and tar sands development on public lands in Colorado, Utah, and Wyoming managed by the BLM. Nine land use plans will be amended to designate lands available for commercial oil shale leasing, and six land use plans will be amended to designate lands available for commercial tar sands leasing. Three of the plans that are to be amended contain both oil shale and tar sands resources.

The oil shale and tar sands alternatives are described in Chapter 2 of the PEIS, including summary tables comparing the potential impact of the alternatives. For information purposes, the tables also include information on potential impacts that could accompany future commercial development of oil shale and tar sands resources. Chapter 3 describes the affected environment of the study area. The potential impacts of commercial oil shale and tar sands development are described in Chapters 4 and 5, respectively. Chapter 6 assesses the impacts of the different alternatives evaluated in this PEIS, provides a comparison of the alternatives, and provides an assessment of cumulative impacts. Chapter 7 contains a summary of the consultation and coordination associated with the PEIS and the comments from the BLM's cooperators on the Draft PEIS, along with the BLM's responses to those comments. Chapter 8 contains the list of preparers of the PEIS, and Chapter 9 is the Glossary. Appendices A and B provide overviews of the oil shale and tar sands technologies that might be used over the next 20 years. Appendix C details the proposed land use plan amendments associated with the proposed alternatives. Appendix D summarizes the potentially applicable federal, state, and county regulatory requirements for oil shale and tar sands development. Appendices E and F contain relevant biological data for the three-state study area and the proposed conservation measures for the preferred alternative. Appendix G details the methodology used for the socioeconomics assessment. Appendix H describes the approach used for interviewing selected residents of the oil shale and tar sands project area, and Appendix I provides the instream flow water rights in the Piceance Basin, Colorado.

The scope of the analysis for this PEIS does not include review of the decisions by the Secretary to issue the RD&D leases described in Section 1.4.1. Those leases authorize activities on six 160-acre parcels located in Colorado and Utah (see Figure 2.3-2) and also identify conditions under which commercial development could occur on 4,970 acres of preference right lease areas (PRLAs) included in the leases. A total of 30,720 acres may be developed under the terms of these leases. The RD&D leases are prior existing rights and are not the subject of decisions within this PEIS, with the exception that both Alternatives B and C address the subsequent availability of the lands contained in the leases should the initial leaseholder relinquish the existing leases.

In accordance with Section 369(n) of the Energy Policy Act of 2005, the BLM will consider and give priority to the use of land exchanges, where appropriate and feasible, to consolidate land ownership and mineral interests within the oil shale basins and STSAs. If the current BLM land use plan does not allow for exchanges, it may be amended to include specific language allowing land exchanges to facilitate commercial oil shale or tar sands development. However, because the possible locations for such future exchanges are unknown at this time, the scope of this PEIS does not include evaluations of potential impacts of such exchanges, and leasing for commercial development on these lands would be subject to additional NEPA review.

1.2.1 Direct, Indirect, and Cumulative Impact Analysis

The PEIS contains information on the impacts (effects) of the proposed amendment of land use plans to allow for application for commercial oil shale and tar sands leasing. It also contains information on the potential impact of future oil shale and tar sands development activities on resources and resource uses on BLM-managed public lands. Impacts that are discussed include those classified as direct, indirect, and cumulative. The CEQ regulations (40 CFR Part 1508) define these as:

(a) Direct effects, which are caused by the action and occur at the same time and place.

(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

(c) Cumulative effects are impacts on the environment which result from the incremental impact of [a proposed] action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

Effects and impacts as used in the CEQ regulations are synonymous. "Impact" is the term used in this PEIS. Impacts include ecological (such as the impacts on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Impacts may also include those resulting from actions that may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

The direct, indirect, and cumulative analysis conducted in preparation of this PEIS was based on available and credible scientific data. As a programmatic evaluation, conducted in support of land use plan amendments, this PEIS does not address site-specific issues associated with individual oil shale or tar sands development projects. A variety of location-specific factors (e.g., soil type, watershed, habitat, vegetation, viewshed, public sentiment, the presence of threatened or endangered species, and the presence of cultural resources) will vary considerably from site to site. In addition, the variations in extraction and processing technologies and project size will greatly affect the type and magnitude of the impacts from given projects. The combined effects of these location-specific and project-specific factors cannot be fully anticipated or addressed in this programmatic analysis because industry has not yet developed proven, commercially viable technologies. As a result, additional, site-specific NEPA analyses will be conducted prior to the issuance of commercial leases and the approval of specific plans of development. The BLM will invite other federal, state, local, and Tribal agencies to participate as cooperating agencies on these site-specific project-level NEPA documents.

Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." In the case of this PEIS, the proposed action is to amend land use plans to allow certain lands to be considered further for commercial leasing. The scope and scale of the potential environmental consequences of amending the land use plans are key to an effective cumulative effects analysis at the programmatic level. The information necessary for analysis in this PEIS where land use plans are to be amended will differ from the information necessary to do effective cumulative effects analysis at the leasing level and at the project level. PEISs have been considered adequate without site-specific analysis when the federal action, as here, does not contain a site-specific or critical decision. Even where the land use plans have been amended to allow for consideration of applications for lease, development cannot occur until a leasing decision has been made and implemented (i.e., leases are issued). After leases are issued, additional permits and environmental analysis are required before operations can begin.

A reasonably foreseeable development scenario (RFDS) is an analytical tool, often used in the planning process, which can inform analyses prepared pursuant to NEPA. An RFDS is a reasonable projection of the most likely anticipated oil shale and tar sands activity supported by a clear level of assumptions. At this programmatic level, an RFDS was not developed, because information regarding possible development of these resources remains highly speculative. Analysis of the effects of development at the programmatic level will be qualitative in keeping with the limited scope of the planning decisions to be made, as well as to reflect the limited and/or highly speculative nature of the information available.

If and when applications to lease oil shale and tar sands resources for commercial development are received and accepted by the BLM, and where information is less speculative, it will be possible to develop an RFDS. That RFDS will be the critical component for performing a thorough cumulative effects analysis of oil shale and tar sands activities that could occur as a result of leasing. An RFDS for an area of proposed oil shale and tar sands leasing provides information for evaluating the type and extent of potential effects from oil shale and tar sands development that *could* occur. Effects analysis (direct, indirect, and cumulative) for leasing is broad and generalized because it is necessarily based on a *hypothetical* scenario of exploration and development.

At the project level, the plan of development provides the specific technical information necessary for the analysis of environmental consequences of these operations, including analysis of cumulative effects of the proposed action. An exploration or development permit is definitive for activities that will involve ground disturbance, unlike the speculative RFDS used to analyze effects related to a leasing decision. Consequently, the nature and extent of effects from the proposed exploration or development action can be determined with a higher degree of accuracy and confidence than that associated with a planning/leasing level RFDS.

1.3 COOPERATING AGENCIES

The scope of the *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final PEIS* is of interest to numerous federal, Tribal, state, and local governments. The BLM invited 50 agencies to participate in the preparation of the PEIS as cooperating agencies. Fourteen agencies expressed an interest in participating as cooperating agencies, and MOUs between these agencies and the BLM were established. The following agencies are participating as cooperating agencies in the preparation of this PEIS:

- National Park Service (NPS);
- Bureau of Reclamation (BOR);
- U.S. Forest Service (USFS);
- U.S. Fish and Wildlife Service (USFWS);
- State of Colorado, Department of Natural Resources and Department of Public Health and the Environment;
- State of Utah;
- State of Wyoming;
- Garfield County, Colorado;
- Mesa County, Colorado;
- Rio Blanco County, Colorado;
- Duchesne County, Utah;
- Uintah County, Utah;
- City of Rifle, Colorado; and
- Town of Rangely, Colorado.

The roles and responsibilities of these cooperating agencies, and the extent of interactions between them and the BLM, are discussed in Chapter 7.

1.4 RELATIONSHIP OF THE PROPOSED ACTION TO OTHER BLM AND COOPERATING AGENCY PROGRAMS, POLICIES, AND PLANS

1.4.1 BLM's Oil Shale Research, Development, and Demonstration Program

On June 9, 2005, pursuant to its authority under Section 21 of the Mineral Leasing Act (MLA) (30 USC 241), the BLM initiated an oil shale RD&D program under which small tracts of land could be leased in support of activities to demonstrate the technical and economic feasibility of oil shale extractive technologies (70 FR 33753–33759). The BLM solicited the nomination of parcels, not to exceed 160 acres, to be used for oil shale RD&D activities. Applicants also were allowed to identify an additional contiguous 4,960 acres of land to be reserved as a PRLA for future commercial development, to be awarded subject to the following terms:

(a) Upon documenting to the satisfaction of the authorized officer that it has produced commercial quantities of shale oil from the lease, the Lessee has the exclusive right to convert the research and development lease acreage to a commercial lease and acquire any or all portions of the remaining preference lease area up to a total of 5,120 contiguous acres upon:

(1) Payment of a bonus based on the Fair Market Value of the lease, to be determined by the Lessor utilizing criteria to be developed through the rulemaking described in subsection (b) or other process for obtaining public input;

(2) Documentation of the Lessee's consultation with State and local officials to develop a plan for mitigating the socio-economic impacts of commercial development on communities and infrastructure;

(3) Provision of adequate bond to cover all costs associated with reclamation and abandonment of the expanded lease area; and

(4) BLM's determination, following analysis pursuant to the National Environmental Policy Act (NEPA), that commercial scale operations can be conducted, subject to mitigation measures to be specified in stipulations or regulations, without unacceptable environmental consequences.

(b) Such commercial lease shall contain terms consistent with regulations to be developed by the Secretary pursuant to section 21 of the Act and stipulations developed through appropriate NEPA analysis.

(c) Such commercial lease may be issued for a term of 20 years and so long thereafter as shale oil is produced from the Leased Lands in commercial quantities. Such commercial lease shall be subject to payment of rents and royalties to the Lessor at the established rates at the time of lease conversion,

> or at such reduced rate that the Lessee demonstrates is necessary to permit the economic development of the oil shale resource. The royalty shall be subject to the readjustment of lease terms at the end of the 20th lease year and each 20 year period thereafter.

The 160-acre RD&D leases were issued for 10-year terms with an option to extend them up to another 5 years. Prior to beginning RD&D activities, the lessees also must obtain permits from the BLM and other governmental agencies (e.g., state-issued air quality permits). These RD&D leases and the conversion right to commercial operations on preference acreage represent a prior existing right that may be exercised upon compliance with the terms of the lease.

The BLM received and reviewed a total of 20 nomination packages. Ultimately, six projects were selected for further consideration, including preparation of environmental assessments (EAs) under NEPA. The projects that were selected included five projects in the Piceance Basin, Colorado (one each submitted by Chevron Shale Oil Company and EGL Resources, Inc. [EGL],[6] and three submitted by Shell Frontier Oil & Gas), and one project in the Uinta Basin, Utah (submitted by Oil Shale Exploration Company [OSEC]). The RD&D leases for the five Colorado projects were issued January 1, 2007; the lease for the Utah project was issued in June 2007. The RD&D leases are part of the baseline activities under all alternatives considered in the PEIS. More information about these RD&D projects is provided in Section 2.3 and Appendix A.

Several commentors on the Draft PEIS urged the BLM to conduct additional RD&D leasing. In Section 369(c) of the Energy Policy Act of 2005, Congress expressly authorized the Secretary to make land available for leasing to conduct R&D activities with respect to technologies for the recovery of liquid fuels from oil shale. The Draft PEIS did not assume that there would be future rounds of RD&D leasing. The BLM finds that those comments have substantial merit. Additional RD&D leasing could promote development of new technologies to develop fuels from oil shale in ways that are both commercially viable and environmentally sound.

Under the authority of the Energy Policy Act, the BLM could publish in the *Federal Register* one or more additional requests for expressions of interest in RD&D leasing within one or more of the states of Colorado, Utah, and Wyoming. Any new RD&D lease would have to be consistent with the applicable BLM land use plans. Two BLM land use plans, Book Cliffs and White River, presently allow some oil shale RD&D leasing in certain areas. The impacts of new RD&D leasing are anticipated to be qualitatively similar to those of commercial oil shale leasing as analyzed in this PEIS.

The RD&D impacts, however, are anticipated to be smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial oil shale lease and expanded to include preference right acreage. Therefore, the analysis in this PEIS for commercial oil shale projects also provides sufficient analysis of RD&D projects for purposes of amending land use plans. New RD&D leases would be issued, if at all, only after site-specific

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6 Since the preparation of this PEIS, EGL Resources, Inc., is now American Shale Oil, LLC.

analysis under NEPA. Conversion to commercial leases would also require an individualized NEPA document.

1.4.2 Combined Hydrocarbon Leasing Program and the Interim Final Rule for Leasing in STSAs Issued under the Revised MLA

The Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78) amended the MLA to authorize the Secretary to issue CHLs in areas containing substantial deposits of tar sands, which were to be designated as STSAs. This Act further specified that a CHL was the only type of lease that could be offered in these STSAs, provided for the conversion of existing oil and gas leases or tar sands claims in these areas to CHLs, and established the maximum lease size as 5,120 acres. The CHL Act defined oil as all nongaseous hydrocarbons except coal, oil shale, gilsonite and other vein-type solid hydrocarbons. Eleven STSAs were designated in 1980 and 1981. The BLM published regulations implementing the leasing provisions of this Act in February 1983 at 43 CFR Part 3140. Subsequently, the BLM prepared the *Utah Combined Hydrocarbon Leasing EIS* (BLM 1984). Tar sands resources located outside of these STSAs were not subject to the requirements of 43 CFR Part 3140 and are available for development under oil and gas leases.

Under the authority of the Combined Hydrocarbon Leasing Act, six CHLs were issued in the mid-1980s within the Pariette and P.R. Spring STSAs in the Vernal Field Office; these leases remain in existence. Also in the mid-1980s, a number of operators holding oil and gas leases or tar sands claims within the designated STSAs applied to convert their leases to CHLs. In most instances, the conversion of these leases has not been completed; thus a number of pending conversion applications remain within the study area, specifically within the Circle Cliffs, Tar Sand Triangle, and P.R. Spring STSAs. The BLM is currently engaged in adjudication of these applications. Decisions in the ROD resulting from this PEIS regarding the availability of lands within the STSAs for future commercial leasing will not affect or be affected by the requirements established for tar sands leasing in the interim final rule.

On October 7, 2005, in response to Section 350 of the Energy Policy Act of 2005, which amended the MLA to allow separate oil and gas leases and tar sands leases in designated STSAs, the BLM issued an interim final rule on leasing in STSAs (70 FR 58610–58516). The interim final rule authorizes the BLM to issue separate leases for exploration for and extraction of tar sands, separate leases for exploration for and development of oil and gas, and separate leases for CHLs within designated STSAs. Under the proposed rule, all three types of leases would have primary terms of 10 years; CHLs and oil and gas leases would remain in effect as long thereafter as oil or gas is produced in commercial quantities; tar sands leases would remain in effect after the 10-year term as long as tar sands are produced in commercial quantities. The interim final rule increases the maximum acreage of CHLs or tar sands leases in a STSA from 5,120 to 5,760 acres, establishes the minimum acceptable bid for tar sands leases at $2.00 per acre, and requires that tar sands leases be issued by competitive processes only. In addition, under the interim final rule, leasing STSAs in NPS units is allowed only where mineral leasing is permitted by law and where the lands are open to mineral resource disposition in accordance with any applicable Minerals Management Plan. The NPS Regional Director also must find that leasing within an NPS unit would not result in any significant adverse impacts on the NPS unit or any contiguous unit.

1.4.3 Existing BLM Land Use Plans, Ongoing Planning Activities, and Resource Management Plan Revisions

The BLM develops land use plans to guide activities, establish management goals and approaches, establish land use allocations within a planning area, and provide management prescriptions for public lands. Current generation land use plans are called resource management plans (RMPs); in the past, such plans were called management framework plans (MFPs), and some MFPs are still in use. Decisions in existing BLM land use plans were incorporated into the analyses conducted in preparation of this PEIS and are discussed in Section 3.1.1. Of the existing land use plans within the study area, the BLM is currently engaged in planning efforts to revise, amend, or prepare new versions of nine of the plans. The existing plans within the PEIS study area include the following:

- Colorado
  - Glenwood Springs RMP (BLM 1988b, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006a, 2007, 2008])
  - Grand Junction RMP (BLM 1987)
  - White River RMP (BLM 1997a, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006a, 2007, 2008])[7]

- Utah
  - Book Cliffs RMP (BLM 1985)[7]
  - Diamond Mountain RMP (BLM 1994)[7]
  - Grand Staircase–Escalante National Monument (GSENM) RMP (BLM 1999)[8]
  - Henry Mountain MFP (1982)[7]
  - Price River Resource Area MFP, as amended (BLM 1989)[7]
  - San Rafael Resource Area RMP (BLM 1991a)[7]
  - San Juan Resource Area RMP (BLM 1991b)[7]

- Wyoming
  - Great Divide RMP (BLM 1990)[7]
  - Green River RMP (BLM 1997b, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006b])
  - Kemmerer RMP (BLM 1986)[7]

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7 These plans are currently undergoing revision, amendment, or replacement.

8 As noted in Section 1.2, lands within National Monuments, including the GSENM, will be excluded from future leasing for tar sands development. However, because one of the STSAs is located underneath the GSENM, the existing RMP is listed here and discussed in Section 3.1.

With the exception of the RMP for the GSENM, these existing BLM land use plans will be amended by decisions contained in the ROD for the PEIS. The proposed land use plan amendments are discussed in Chapter 2 and are shown in Appendix C.

When the amendments/revisions/replacements of eight of the nine RMPs were initiated, there was no reasonably foreseeable development projected for tar sands or oil shale over the life of these plans and for that reason, identification of areas available for potential oil shale or tar sands leasing has not been considered as part of those planning processes. The mineral reports prepared to accompany the eight RMPs did identify oil shale and tar sands resources, but did not project any leasing or development due to prevailing and anticipated economic factors. The ninth RMP effort, the amendment of the White River RMP, is being conducted specifically to consider the amendment of that RMP to allow additional oil and gas leasing activity. It was recognized at the time, that this PEIS would consider the issue of oil shale management for the White River RMP area.

Since the start of the RMP amendments/revisions by the field offices, Congress enacted the Energy Policy Act of 2005 and the Secretary of Interior is required to carry out various actions referenced above, including the preparation of this PEIS. On December 13, 2005, the BLM published a NOI in the *Federal Register* initiating a PEIS to support a commercial oil shale and tar sands leasing program on federal lands in these three states. Since that time, the scope of the PEIS has been revised. The BLM is no longer using the PEIS as the document that supports the NEPA requirements for leasing. Given that the development technologies for in situ production of oil shale are just emerging, there is a lack of information regarding resource use and associated impacts. Consequently, the BLM has changed this document to support only resource allocation decision making that identifies the BLM-managed lands for which applications to lease oil shale and tar sands resources would be accepted in the future. Although applications would be accepted, additional NEPA analysis would be performed before any leasing of the area would be considered.

The ROD for the Final PEIS will amend the land use plans existing at the time the ROD is implemented, identifying those areas designated as open for application for future oil shale and tar sands leasing.

As part of the site-specific NEPA analysis to be carried out prior to issuance of any oil shale or tar sands leases, the environmental consequences to specific resource values and uses within the areas and any alternative actions would be analyzed. At that time, at the site-specific level, the competing resource values will be analyzed and weighed as required by FLPMA and NEPA, and a decision will be made regarding management of the specific parcel of land. If, pursuant to this NEPA and land use planning process, the BLM determines that leasing and subsequent development of the oil shale or tar sands resources would cause significant impacts, the BLM can require the applicant to (1) mitigate the impact so that it is no longer significant, (2) move the proposed lease location, or, if neither of these options resolves the anticipated conflicts, (3) the BLM can decide either that the importance of development of the oil shale and tar sands resources outweighs protection of the competing resource value and approve the application, or vice versa.

This preleasing NEPA analysis would include the same opportunities for public involvement and comment that are part of this PEIS process and every other planning and NEPA process the BLM undertakes. The decisions associated with the PEIS will be incorporated into the ongoing RMPs as they are finalized or will amend the existing RMPs, depending on the order in which the documents are completed with respect to the completion of the PEIS.

Although the BLM's handbooks provide for stipulations for oil and gas leases to be made part of the land use plans, that guidance is not applicable to the present analysis to amend land use plans for development of oil shale or tar sands. Oil and gas is a mature industry where there is long experience with leasing stipulations to conserve and to protect affected resources. The present experimental stage of the oil shale and tar sands industries, however, weighs against emplacing lease stipulations in the RMPs at this time. Instead, the BLM will develop appropriate lease stipulations and either (1) include them in appropriate RMPs as part of future amendments, or (2) include them in commercial lease sale announcements. That will allow the BLM to refine lease stipulations over time based on the latest information regarding oil shale or tar sands technologies and their impacts, without unnecessary rounds of amendments to the land use plans. This PEIS does discuss various mitigation requirements, methods, and objectives that will inform both (1) the lease stipulations developed for particular lease sales or for future amendments to RMPs, and (2) the conditions of approval for plans of development.

1.4.4 Cooperating Agency Plans and Programs

As discussed in Section 1.3, this PEIS has been prepared in cooperation with 14 federal, state, and local governmental organizations. Management plans and programs established by these cooperating agencies have been considered in the preparation of this PEIS on the basis of information provided by the agencies. In consultation with the cooperating agencies, the nature and scope of the PEIS were modified from a leasing decision to an allocation decision. The allocation decision, by opening lands to leasing, only permits the BLM to consider applications to lease and does not grant any property right. It does not authorize any ground-disturbing activities nor is it an irreversible or irretrievable commitment of resources under NEPA. Therefore, the allocation decision does not conflict with any state, local, or Tribal plans. The BLM will, however, cooperate with state, local, and Tribal governments to promote consistency with their land use plans. Congress has authorized the Secretary to lease federal oil shale and tar sands resources and has declared them to be "strategically important domestic resources that should be developed" … "to benefit the United States while taking into account affected States and communities" [Energy Policy Act of 2005, Section 369(b)(1),(3)]. As the BLM is bound by this and other federal law, however, it may be possible that oil shale or tar sands projects would occur that would not be completely consistent with all aspects of state and local plans. It remains too speculative at this time, though, to assess the consistency of any number, locations, or technologies of development projects that might become commercially viable in the future.

1.4.5 BLM and USFS Energy Corridor Designation

In accordance with Section 368 of the Energy Policy Act of 2005, the BLM and USFS are working with the U.S. Department of Energy (DOE) and U.S. Department of Defense (DoD) to prepare a PEIS to evaluate issues associated with the designation of energy corridors on federal lands in 11 Western states, including Colorado, Utah, and Wyoming. On the basis of this Draft West-wide Energy Corridors PEIS (DOE 2008), the BLM and USFS may amend their respective land use plans to designate a series of energy corridors across the western states. These potential amendments may include the planning areas that are included within the scope of this *Proposed Oil Shale and Tar Sands Resources Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final PEIS*. In addition, the potential designation of energy corridors is likely to impact energy development throughout the western United States, including commercial oil shale and tar sands development, because the location of energy corridors may facilitate development by removing administrative and planning barriers for potential pipelines, electric transmission lines, and associated infrastructure. Development of the Draft West-wide Energy Corridors PEIS is underway at this time; information regarding the PEIS, including its scope and schedule, is available at http://corridoreis.anl.gov.

1.5 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed.

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2 DESCRIPTIONS OF ALTERNATIVES

2.1 INTRODUCTION

This PEIS examines alternatives for making BLM-administered lands available for application for future commercial leasing of both oil shale and tar sands resources. The plan amendments would open the areas in question for leasing. The phrase "available for application for leasing" is used above, and throughout the PEIS, rather than "available for leasing" to highlight that, unlike the BLM's practice with respect to oil and gas leasing, additional NEPA analysis would be required prior to the issuance of any lease of oil shale or tar sands resources. For oil shale and tar sands, there are three alternatives each. Alternative A (the no action alternative) does not amend plans. Management prescriptions in existing plans are not modified. Alternatives B and C describe different management approaches to amending RMPs to designate certain lands as being available for application for future commercial leasing and development. The BLM's approach is designed to ensure that oil shale technologies can operate at economic and environmentally acceptable levels before the agency authorizes full-scale commercial leasing on public lands. Future oil shale and tar sands commercial development on public lands in Colorado, Utah, and Wyoming would be conducted pursuant to regulations to be promulgated by the BLM.

This chapter presents information on each of the oil shale and tar sands alternatives examined in this PEIS. Specifically, the following sections describe the existing requirements and BLM policies potentially applicable to oil shale and tar sands development, the oil shale and tar sands resources, the suite of technologies included in the scope of this PEIS, the constraints evaluated in each alternative, and the comparison of alternatives. In addition, this chapter discusses the alternatives and issues considered by the BLM in preparing this PEIS that were eliminated from detailed analysis or from further consideration at this time.

2.2 EXISTING STATUTORY REQUIREMENTS AND BLM POLICIES POTENTIALLY APPLICABLE TO OIL SHALE AND TAR SANDS DEVELOPMENT

Commercial development of oil shale or tar sands resources on public lands will be subject to existing federal, state, and local laws and regulatory requirements as well as established BLM policies. The purpose of including the following information is to convey that management of public lands is subject to a wide array of requirements that are over and above decisions that will be made in the ROD for this PEIS. These requirements are not subject to decisions in the ROD but serve as sideboards for those decisions. The standard operating procedures that have been developed by the BLM and other governmental agencies for implementing these requirements are not necessarily reproduced in this document unless there is a particular reason to do so.

2.2.1 Existing Relevant Statutory Requirements

This section discusses, in very general terms, the major laws, E.O.s, and policies that may provide environmental protection and compliance requirements for oil shale or tar sands development projects on public lands in Colorado, Utah, and Wyoming. Because these projects would vary on the basis of design, size, specific activities, and location, the requirements described here may not apply to all projects. Lists of specific E.O.s and federal and state laws are provided in Appendix D.

The BLM conducts its operations in accordance with FLPMA and with numerous statutes, regulations, and standards regarding environmental protection. In addition, E.O. 12088, "Federal Compliance with Pollution Control Standards" (U.S. President 1978), as amended by E.O. 13148, "Greening of Government through Leadership in Environmental Management" (U.S. President 2000), requires federal agencies (including the BLM) to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Resource Conservation and Recovery Act of 1976 (RCRA), Toxic Substances Control Act of 1976 (TSCA), Clean Air Act of 1990 (CAA), Noise Control Act of 1972 (NCA), Clean Water Act of 1987 (CWA), and Safe Drinking Water Act of 1974 (SDWA). Other compliance requirements may include the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), hazardous material transportation laws, ecological resources requirements (e.g., Endangered Species Act of 1973 [ESA]), and cultural and paleontological resources requirements.

In the Energy Policy Act of 2005, among many energy-related provisions, Section 369 titled the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act," provided direction to the Secretary of the Interior to complete a PEIS for a commercial leasing program for oil shale and tar sands resources on public lands; publish a final regulation establishing a commercial leasing program; consult with the Governors of States with significant oil shale and tar sands resources on public lands, representatives of local governments in such states, interested Indian Tribes, and other interested persons, to determine the level of support and interest in the states in the development of tar sands and oil shale resources; and, if sufficient support and interest exists in a state, the Secretary may conduct a lease sale in that state under the commercial leasing program. This PEIS is the result of direction in this legislation.

The MLA authorizes the Secretary of the Interior to lease deposits of oil shale and the surface of public lands containing the deposits, or lands adjacent thereto, as may be required for the extraction and reduction of leased minerals. It also authorizes the issuance of ROW grants for oil and gas, synthetic fuels, and refined products gathering and distribution pipelines and related facilities not already authorized through a lease. Under the MLA, the lease may not exceed 5,760[1] acres and may be of an indeterminate period. The Secretary of the Interior may impose conditions on the lease, including requirements relative to methods of mining, prevention of waste, and productive development.

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[1] The acreage limit was increased from 5,120 acres by amendment of the MLA in Section 369 (i)(1) of the Energy Policy Act of 2005.

The BLM also conducts its operations in compliance with applicable land use laws, including the Wild and Scenic Rivers Act of 1968, the National Trails System Act of 1968, and the Wilderness Act of 1964. In addition, any leasing of public lands for oil shale or tar sands development that may impinge on NPS lands would require the BLM to analyze potential impacts on the park lands, including the potential to impair park resources addressed in the National Park Service Organic Act of 1916. Under current regulations, issuance of combined hydrocarbon leases within units of the NPS shall be allowed only where mineral leasing is permitted by law, where the lands are open to mineral resource disposition in accordance with any applicable Minerals Management Plan, and the Regional Director of the NPS finds that there will be no resulting significant adverse impacts on the resources and administration of the unit or other contiguous units of the NPS.

Several other land use laws may guide development of a leasing plan for commercial oil shale or tar sands development. As discussed in Chapter 1, the BLM has authority pursuant to FLPMA, the Federal Land Exchange Facilitation Act of 1994, and the Federal Land Transaction Facilitation Act of 2000 to exchange public land or interests in it for nonfederal land or interests when the exchange serves the public good.

Oil shale and tar sands development projects may require rights-of-ways (ROWs) on or across public land for project facilities. A ROW grant is the authorization to use a particular parcel of public land for specific facilities for a definite time period. FLPMA authorizes the BLM to issue ROW grants for uses such as roads and electrical power generation, transmission, and distribution systems. The MLA authorizes the agency to issue ROW grants for oil and gas gathering and distribution pipelines and related facilities not already authorized through a lease, and oil and natural gas transmission pipelines and related facilities. ROW grants carry conditions that require compliance with applicable environmental protection standards.

State and county laws and regulations also are applicable to oil shale or tar sands development projects to the extent consistent with federal law. In some cases, states have federally approved regulatory programs that meet or exceed the environmental protections provided by statutes and regulations (such as those under the CWA). States and counties also have developed laws to address concerns specific to their locations and resources with which federally approved projects must generally comply.

The potentially applicable laws have been divided into general categories, as described alphabetically below. Although the following descriptions often cite federal laws, state and county laws can also fall into these categories. Appendix D provides a list of federal, state, and county laws and E.O.s by category.

- *Air quality.* Air emissions from a development project are subject to the CAA, as amended. The CAA provides that each state must develop and submit for approval to the U.S. Environmental Protection Agency (EPA) a State Implementation Plan (SIP) for controlling air pollution and air quality in that state, and that each state must develop its own regulations to monitor, permit, and control air emissions within its boundaries. Under Section 112(r) of the CAA, owners and operators of facilities that produce, process, handle, or store specific hazardous substances above threshold quantities must meet certain requirements for planning and reporting and risk management planning requirements. The EPA has retained primacy over air quality within the boundaries of the Uintah and Ouray Reservation.

- *Cultural resources.* Cultural resources that may be affected by federal undertakings are subject to various requirements for identification and consideration in consultation with Tribal, state, and/or federal entities, and mitigation actions may be required. Under the auspices of the 1997 national Programmatic Agreement (PA) and individual state protocols, the BLM has an agency-specific process for complying with Section 106 of the National Historic Preservation Act of 1966 (NHPA).

- *Energy projects.* Project operations and facilities may require construction of facilities such as pipelines, gathering lines, transmission lines, or generation facilities. Depending on the nature of these facilities, siting will be subject to all applicable legal requirements.

- *Floodplains and wetlands.* The locations of project facilities will be subject to statutory requirements and regulations for protection of wetlands or floodplains, such as Section 404 of the CWA.

- *Groundwater, drinking water, and water rights.* The provision of drinking water from wells or surface water to a nontransient noncommunity water system at project facilities would require compliance with the SDWA. In addition, the withdrawal of surface or groundwater for industrial or drinking water purposes may require state and/or local approvals or permits.

- *Hazardous materials.* Hazardous materials may be used in the construction and operation of a project. Storage and use of fuels, petroleum, oils, lubricants, and other hazardous materials at approved project facilities are subject to numerous federal and state regulations.

- *Hazardous waste and polychlorinated biphenyls (PCBs).* Hazardous wastes (e.g., used solvents and paints) generated by a project must be accumulated, collected, transported, and disposed of in accordance with RCRA. If PCBs are used during the construction and operation of a project, they would have to be managed in accordance with the TSCA.

- *Noise.* The EPA issued guidelines for outdoor noise levels that are consistent with the protection of human health and welfare against hearing loss, annoyance, and activity interference (EPA 1974). Such guidelines state that annoyance and undue interference with activity will not occur if outdoor levels of noise are maintained at an energy equivalent of 55 decibels (dB). However, these levels are not to be construed as legally enforceable standards at this time.

- *Pesticides and noxious weeds*. Pesticide application during the construction and operation of a project must comply with the Federal Insecticide, Fungicide, and Rodenticide Act of 1974 and equivalent state requirements. In addition, sites will be subject to federal provisions to control noxious weeds and invasive species and may be subject to regulations governing state-established control areas.

- *Solid wastes*. Solid wastes generated during the construction, operation, and decommissioning of a project must be managed in accordance with the Solid Waste Disposal Act of 1976 and state and local requirements for solid waste accumulation, collection, transportation, and disposal.

- *Source water protection*. Under Part C of the SDWA, Protection of Underground Sources of Drinking Water, each state is to establish a wellhead protection program to delineate wellhead protection areas, identify potential sources of contamination, and establish control measures to prevent contamination of drinking water sources. If hazardous chemicals or materials are used during the construction or operation of a project that is located within a wellhead protection area, reporting or control measures may apply.

- *Water bodies and wastewater*. The discharge of wastewater (e.g., sanitary wastewater treatment systems or rinse/test waters) or the discharge of spent shale leachate into waters of the United States or waters of a state will require a National Pollutant Discharge Elimination System (NPDES) permit or the state equivalent. According to administrative and judicial interpretation, the scope of the federal CWA jurisdiction over waters of the United States depends on technical, site-specific factors. Regulated bodies of water could include, but are not limited to, interstate and intrastate lakes, rivers, and streams, and certain wetlands, playa lakes, prairie potholes, mudflats, intermittent streams, and wet meadows. In addition, the CWA requires an NPDES permit or the state equivalent for certain stormwater discharges. Spill prevention, control, and countermeasure plans may also be required to prevent oil spills from reaching regulated waters, adjoining shorelines, intermittent streams, or wet meadows, but only if these are hydrologically connected to the navigable waters of the United States. States may have their own planning requirements for other waters. Discharges of dredged or fill material into waters of the United States or any work in, over, or under regulated waters will require a Section 404 or Section 410 permit, respectively, from the U.S. Army Corps of Engineers (USACE).

- *Water quality*. The EPA enacted a regulation in December 1974 that set forth a basinwide salinity control policy for the Colorado River Basin. In 1975, the Colorado River Basin Salinity Control Forum (CRBSCF) proposed, the Basin States adopted, and the EPA approved water quality standards to control salinity increases in the Colorado River. These standards, including the numeric criteria and plan of implementation, are to be reviewed every 3 years. Federal, state, and Tribal water quality standards may also be applicable.

- *Ecological resources.* Among the BLM's land management objectives are protection and improvement of habitat for all federally listed species, BLM-designated sensitive species (i.e., the list published by the BLM state office of species occurring on public lands whose populations or habitats are rare or in significant decline), state-listed species, and wild horse and burro herds. The BLM evaluates all projects and activities occurring on public lands to ensure that they will not contribute to the need to list species as threatened or endangered.

In addition to these categories, the construction and operation of an oil shale or tar sands development project on public land that has valid existing mining claims in place must not materially interfere with the mining claimants' rights to mine, remove, or sell the minerals from the claim (30 USC 26). Projects may also be subject to the health and safety standards of the Federal Mine Safety and Health Act of 1977 and the Occupational Safety and Health Act of 1970.

Requirements to consider impacts of leasing public land for oil shale or tar sands development on local populations, including E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (U.S. President 1994), and E.O. 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (U.S. President 1997) may arise, depending on the activities, location, and other circumstances of the lease.

2.2.2 Existing Relevant BLM Policies and Mitigation Guidance

The BLM has developed many program-specific policies and guidance documents that establish requirements that may be relevant and/or applicable to oil shale or tar sands development. For example, from 1968 to 1989, the Office of the Secretary imposed stipulations on oil and gas leases for lands in oil shale areas in Colorado, Utah, and Wyoming (DOI 1968). These policies and guidance documents exist in a variety of forms, including BLM plans, manuals, handbooks, instruction memoranda, technical references, BMPs, standards, directives, and other such documents. The applicability of specific policies and guidance documents is discussed to varying degrees in this PEIS but is best assessed at the project-specific level.

While none of the existing BLM policies directly address commercial oil shale or tar sands development, many elements establish requirements that are relevant and applicable to these types of development projects. Examples of policies that will be applicable to oil shale or tar sands development include BLM policies regarding the management of sensitive species and visual, cultural, and paleontological resources.

Similarly, while the existing BLM guidance documents are not specific to oil shale or tar sands development, many of them address environmental issues that are relevant to such development and may provide appropriate mitigation measures. Examples of those topics include land use planning, NEPA, oil and gas development, pipeline construction and waterway crossings, road construction and maintenance, wildlife management, wild horse and burro herd management, ACECs, hazardous materials and waste management, pesticide use and integrated pest management, cultural resource management, Tribal consultations, visual resource management, and occupational health and safety. A comprehensive review of these BLM program-specific mitigation documents is beyond the scope of this PEIS, although discussion of many of these documents is included in the impact analyses sections. Readers are advised to obtain the complete guidance documents if they seek more information. Electronic copies of some of the BLM directives, manuals, and handbooks are available at http://www.blm.gov/nhp/efoia/.

2.2.3 Management of BLM-Administered Lands

The BLM manages public lands within the affected field offices for a variety of land uses, including recreation, mining, oil and gas development, livestock grazing, wild horse and burro herd management, communication sites, and ROW corridors (e.g., roads, pipelines, and transmission lines). These BLM-administered lands are managed within a framework of numerous laws, the most comprehensive of which is FLPMA (43 USC 1701 et seq.). Under FLPMA, the BLM manages the public lands by using principles of multiple use and sustained yield to provide for the protection and the use of myriad resources found on the public lands. In accordance with the requirements of FLPMA, the BLM prepares RMPs to identify the resources within each planning area and to establish land use allocations, management goals, and prescriptions for the planning area.[2] The RMPs are prepared to be consistent with the plans of state and local governments to the maximum extent feasible and consistent with federal law. These plans are developed with significant public involvement and are reviewed by the governors of each state for consistency with state and local planning objectives. Under FLPMA, the BLM is required to maintain, amend, and revise its RMPs to ensure that they reflect the current conditions and management goals within the planning area.

FLPMA, and in many cases specific authorizing legislation or proclamations, guides the BLM in its management of lands included in the NLCS. The NLCS lands include NCAs, National Monuments, Wilderness Areas, WSAs, WSRs, and National Historic and Scenic Trails. Other conservation designations within the NLCS are Instant Study Areas (ISAs), Forest Reserves, National Recreation Areas (NRAs), Research Natural Areas, and Outstanding Natural Areas.

FLPMA directs the BLM to give priority to the designation of ACECs. Designated ACECs include public lands where special management attention and direction are needed to protect and prevent irreparable damage to important historic, cultural, and scenic values, fish, or wildlife resources or other natural systems or processes; or to protect human life and safety from natural hazards. The BLM designates ACECs through land use plans that outline management

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2 Current land use plans are called resource management plans (RMPs); however, in the past such plans were called management framework plans (MFPs), and some MFPs are still in use.

objectives and prescriptions for each ACEC. Table 2.2.3-1 identifies all of the existing ACECs that intersect oil shale and tar sands areas.

Wilderness Areas are designated by Congress as part of the National Wilderness Preservation System to ensure preservation and protection of their natural conditions. They are generally 5,000 acres or more in size (or of sufficient size to make administration as wilderness practicable); offer outstanding opportunities for solitude or primitive and unconfined types of recreation; and may contain ecological, geological, or other features that have scientific, scenic, or historical value. WSAs are areas identified by a federal land management agency (i.e., the BLM, USFS, NPS, or USFWS) as having wilderness characteristics, thus making them worthy of consideration by Congress for wilderness designation. While Congress considers whether to

TABLE 2.2.3-1 Existing ACECs Intersecting Oil Shale or Tar Sands Areas

ACEC	Field Office(s)	Total ACEC Acres	ACEC Acres within Oil Shale Areas	ACEC Acres within STSAs
Colorado				
Duck Creek	White River	3,425.8	3,425.8	0.0
Dudley Bluffs	White River	1,628.2	1,628.2	0.0
East Fork Parachute Creek	Glenwood Springs	6,566.1	1,289.4	0.0
Northwater Creek	Glenwood Springs	1,961.9	1,591.9	0.0
Ryan Gulch	White River	1,436.4	1,436.4	0.0
Trapper Creek	Glenwood Springs, White River	2,844.0	1,418.1	0.0
		17,862.4	10,789.7	0.0
Utah				
Copper Globe	Price	128.6	0.0	128.6
Dark Canyon	Monticello	59,755.3	0.0	14.4
I-70 Scenic Highway	Price	45,631.3	0.0	4,369.3
Lears Canyon	Vernal	1,377.8	0.0	889.7
Lower Green River	Vernal	9,430.2	7,683.6	0.0
Nine Mile Canyon	Vernal	48,151.0	539.2	12,562.8
Pariette Wetlands	Vernal	10,635.2	6,523.1	2,254.6
San Rafael Canyon	Price	54,144.7	0.0	22,227.6
San Rafael Reef	Price	84,084.6	0.0	4,760.6
Scenic Highway Corridor	Monticello	13,554.1	0.0	1,105.5
Sid's Mountain	Price	61,430.5	0.0	215.0
Temple Mountain	Price	2,446.0	0.0	2,439.3
		1,522,274.8	199,521.1	328,938.2
Wyoming				
Greater Red Creek	Rock Springs	175,240.0	44,656.9	0.0
Greater Sand Dunes	Rock Springs	41,644.2	256.5	0.0
Pine Springs	Rock Springs	6,054.9	6,054.9	0.0
Special Status Plant Species	Rock Springs, Kemmerer	1,009.9	140.3	0.0
White Mountain Petroglyphs	Rock Springs	21.7	21.7	0.0
		223,970.6	51,130.3	0.0

designate the WSAs as permanent Wilderness Areas, the federal agency managing the WSA does so in a manner to prevent impairment of the area's suitability for wilderness designation.

Since WSAs were established in the late 1970s and 1980s, designation of wilderness lands has been extensively debated, and additional BLM lands have been identified by the public as having wilderness characteristics (WCAs). In 1996, the Secretary of the Interior directed the BLM in Utah to evaluate such lands to determine whether they possess wilderness characteristics. According to BLM policy, indicators of an area's naturalness include the extent of landscape modifications, the presence of native vegetation communities, and the connectivity of habitats. Outstanding opportunities for solitude or primitive and unconfined types of recreation may be experienced when the sights, sounds, and evidence of other people are rare or infrequent; in locations where visitors can be isolated, alone, or secluded from others; where the use of the area is through nonmotorized, nonmechanical means; and where no or minimally developed recreation facilities are encountered. A number of areas in the PEIS study area have been recognized by the BLM as having wilderness characteristics. Processes are underway in some of the BLM field offices where such lands have been identified to determine appropriate management requirements, if any, for these areas. Decisions regarding management of these areas will be made at the field office level as part of the local land use planning process, not as part of this PEIS.

A river or river section may be designated as a WSR by Congress or the Secretary of the Interior under the authority of the Wild and Scenic Rivers Act of 1968. Land management agencies conduct inventories of rivers and streams within their jurisdictions and make recommendations to Congress regarding the potential inclusion of suitable rivers into the WSR system as part of their land use planning process. These special areas are managed to protect outstanding scenic, recreational, geologic, fish and wildlife, historic, cultural, or other values, and to preserve the river or river section in its free-flowing condition. WSR boundaries are established to include a corridor of land along either side of the river as determined to be appropriate for protection of the river's values. The law recognizes three classes of rivers: wild, scenic, and recreational. It is the BLM's policy to manage potentially eligible and suitable[3] WSRs in a manner to prevent impairment of the river's suitability for WSR designation until Congress or the Secretary makes a final determination regarding the river's status. During this interim period, a corridor extending at least 0.25 mi from the "high water" mark on each bank of the river is established.

National Historic and Scenic Trails are designated by Congress under the National Trails System Act of 1968. National Historic Trails follow as closely as possible the original trails or routes of travel with national historical significance. Such designation identifies and protects historic routes and their historic remnants and artifacts for public use and enjoyment. National Scenic Trails are extended trails that offer maximum outdoor recreational potential and provide

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3 A number of land use plans are currently undergoing revision, and as part of that process WSR inventories have been undertaken. Where a river or river segment has been found to be "eligible" for inclusion in the WSR system as part of one of these inventories, the BLM Handbook directs the BLM to protect the lands along the eligible segment until a "suitability" determination has been made as part of the land use planning process. If the river or river segment is found to be "non-suitable," the lands along the river then would be available for other uses.

enjoyment of the various qualities (e.g., scenic, historical, natural, and cultural) in the areas through which they pass.

BLM-administered lands support a wide array of recreational activities important to growing numbers of local, regional, and national users. While unstructured or "dispersed" recreation uses are common on public lands, developed recreation sites, Special Recreation Management Areas (SRMAs), and off-highway vehicle (OHV) areas are all use areas found within the PEIS study area.

A significant portion of the public lands within the most geologically prospective oil shale area is undergoing mineral development, especially for oil and gas resources. Conflicts in development between resources (e.g., between oil shale or tar sands and oil and gas) may occur. Generally, the concept of prior existing rights would prevail, except in some instances when existing stipulations would take precedence; however, it is the BLM's policy to optimize recovery of natural resources in an effort to secure the maximum return to the public in revenue and energy production; prevent avoidable waste of the public's resources utilizing authority under existing statutes, regulations, and lease terms; honor the rights of lessees, subject to the terms of existing leases and sound principles of resource conservation; and protect public health and safety and mitigate environmental impacts. Conflicts among competing resource uses are generally considered and resolved when processing potential leasing actions or evaluating requests for approvals of plans of development (see also Section 4.2.1.1).

As discussed in Chapter 1, Section 369(n) of the Energy Policy Act of 2005 required the Secretary to consider and give priority to the use of land exchanges to facilitate the recovery of unconventional fuels. The Act dictates that any land exchange undertaken shall be implemented in accordance with Section 206 of FLPMA. The BLM's policy for land exchanges under Section 206 recognizes that land exchanges are a common-sense tool that enables the BLM and other landowners to improve land management and consolidate ownership. Therefore, where it can be demonstrated that the public interest will be well served, land exchanges may be considered on a case-by-case basis when the result will consolidate ownership and improve management of natural resources. Land exchanges, however, are not completed on an acre-for-acre basis, but instead are completed on an equal-value basis. One of the more challenging aspects of the land exchange process is developing an exchange proposal where the appraised values of the federal and nonfederal lands are equal. Given the complexities of achieving equal-value land exchanges, especially recognizing the difficulty in valuing a commodity like oil shale or tar sands, a viable exchange proposal may be difficult to achieve. The initial basis for considering land exchange opportunities lies within existing land use plans.

2.3 OIL SHALE

Oil shale is a term used to cover a wide range of fine-grained, organic-rich sedimentary rocks. Oil shale does not contain liquid hydrocarbons or petroleum as such but organic matter derived mainly from aquatic organisms. This organic matter, kerogen, may be converted to oil through destructive distillation or exposure to heat. The most prospective oil shale deposits in the United States are contained within sedimentary deposits of the Green River Formation in the greater Green River Basin (including Fossil Basin and Washakie Basin) in southwestern Wyoming and northwestern Colorado, the Piceance Basin in northwestern Colorado, and the Uinta Basin in northeastern Utah. As discussed in Section 1.2, the analyses in this PEIS focus on the most geologically prospective oil shale resources in these basins (i.e., the oil shale study area) shown in Figure 2.3-1. In Colorado and Utah, these are defined as those deposits that are expected to yield 25 gal/ton or more of shale oil and that are 25 ft thick or greater. In Wyoming, where the oil shale resource is not of as high a quality as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of shale oil and that are 15 ft thick or greater. Figure 2.3-1 shows the Green River Formation basins and the most geologically prospective oil shale resources within those basins. Table 2.3-1 lists the total size in acres of the Green River Formation basins and the most geologically prospective oil shale resources by state, along with the total number of acres of BLM-administered and split estate lands within the most geologically prospective area within each state.

Currently, there is no commercial production of oil from oil shale being undertaken in the United States. Considerable interest exists, however, as reflected by the numerous research and development (R&D) efforts underway, including the BLM's ongoing oil shale RD&D program. As discussed in Section 1.4.1, under the BLM's oil shale RD&D program, five RD&D leases have been issued in the Piceance Basin of Colorado (one each awarded to Chevron Shale Oil Company and EGL, and three awarded to Shell Frontier Oil & Gas), and one RD&D lease has been issued in the Uinta Basin, Utah (awarded to OSEC). The locations of the six RD&D projects are shown in Figure 2.3-1 and, in greater detail, in Figure 2.3-2. In the PEIS, these leases are recognized as prior existing rights, and development will proceed under the lease terms under all alternatives being considered. For purposes of this analysis, it was assumed that all of the sites could reach full commercial development and may utilize the full acreage available to them under their leases. The very limited decisions being considered in this PEIS regarding the areas included in the RD&D leases are described in Sections 2.3.2 and 2.3.3. Table 2.3-2 briefly describes the six RD&D projects; more detailed descriptions of these projects are contained in Appendix A.

At the time the PEIS was being prepared, there were no regulations in place that govern issuance of oil shale leases. The lack of regulations is linked to the historical lack of demand for oil shale resource development; however, the BLM, under the direction of the Energy Policy Act of 2005, began preparation of regulations that would be used to authorize commercial oil shale leasing. The BLM published a proposed rule for the management of a commercial oil shale leasing program in the *Federal Register* on July 23, 2008. However, a specific congressional limitation on expenditures prevents the preparation of final regulations until October 1, 2008, at the earliest.

2.3.1 Potential Commercial Oil Shale Development Technologies

This section briefly describes the oil shale development technologies that the BLM believes may be used commercially in the 20-year time frame assessed in this PEIS. The BLM has chosen a 20-year time frame because that is the customary time frame used in resource management planning cycles. Appendix A provides a more detailed discussion of potential

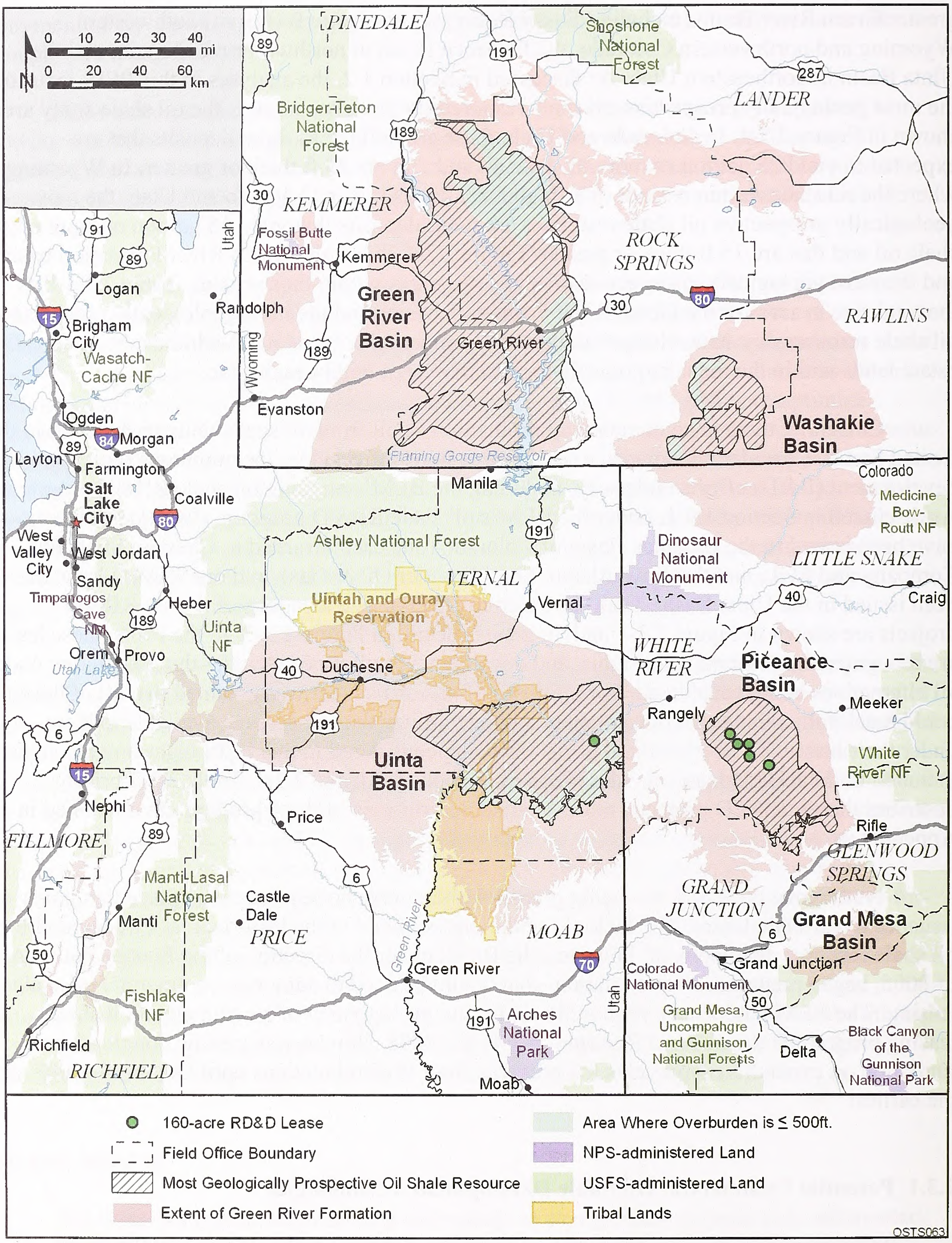

FIGURE 2.3-1 Green River Formation Basins in Colorado, Utah, and Wyoming; the Most Geologically Prospective Oil Shale Resources; the Areas Where the Overburden above the Oil Shale Resources Is ≤500 ft; and Locations of the Six RD&D Projects

TABLE 2.3-1 Total Size in Acres of the Green River Formation Basins, Most Geologically Prospective Oil Shale Areas, and Acres of BLM-Administered and Split Estate Lands within the Most Geologically Prospective Areas in Each State[a,b]

State	Total Size of Basin	Total Size of Most Geologically Prospective Area	Total BLM-Administered Lands in Most Geologically Prospective Area	Total Split Estate Lands in Most Geologically Prospective Area
Colorado				
Piceance Basin	1,185,700	503,342	319,710	41,940
Utah				
Uinta Basin[c]	2,977,900	840,213	560,972	77,220
Wyoming				
Green River and Washakie Basins	4,506,200	2,194,483	1,257,680	39,406
Total	8,669,800	3,538,038	2,138,361	158,566

[a] Totals may not be exact because of rounding. These estimates were derived from geographic information system (GIS) data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the size of the oil shale resources and the distribution of BLM-administered and split estate lands.

[b] Split estate lands include areas where the federal government owns, and the BLM administers, the subsurface mineral rights, but the surface estate is owned by Tribes, states, or private parties.

[c] The split estate lands in the Hill Creek STSA include 57,705 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

technologies that may be used over the next 20 years, along with a brief history of oil shale development. Information presented in this section and Appendix A regarding technologies that could be used is taken from the best available published data. Because commercial oil shale development technologies are still largely in an R&D phase, many details regarding the specific technologies that may be used in the future to produce oil from oil shale are unknown. In the absence of reasonably complete information about the technologies that may be deployed, a number of assumptions have been made. These assumptions are discussed in Section 4.1.

Development of oil shale resources occurs in three major steps: (1) recovery or extraction from the natural setting, (2) processing to separate organic and inorganic constituents, and (3) upgrading the organic components in anticipation of further refining into conventional fuels. The physical and chemical features of oil shale deposits and other circumstantial factors associated with their deposition dictate the most appropriate development schemes. Typical development schemes always involve each of the above major steps, although many permutations of these steps are possible and many interim steps may also be necessary. In addition, all oil shale development projects also must stabilize and properly dispose of wastes

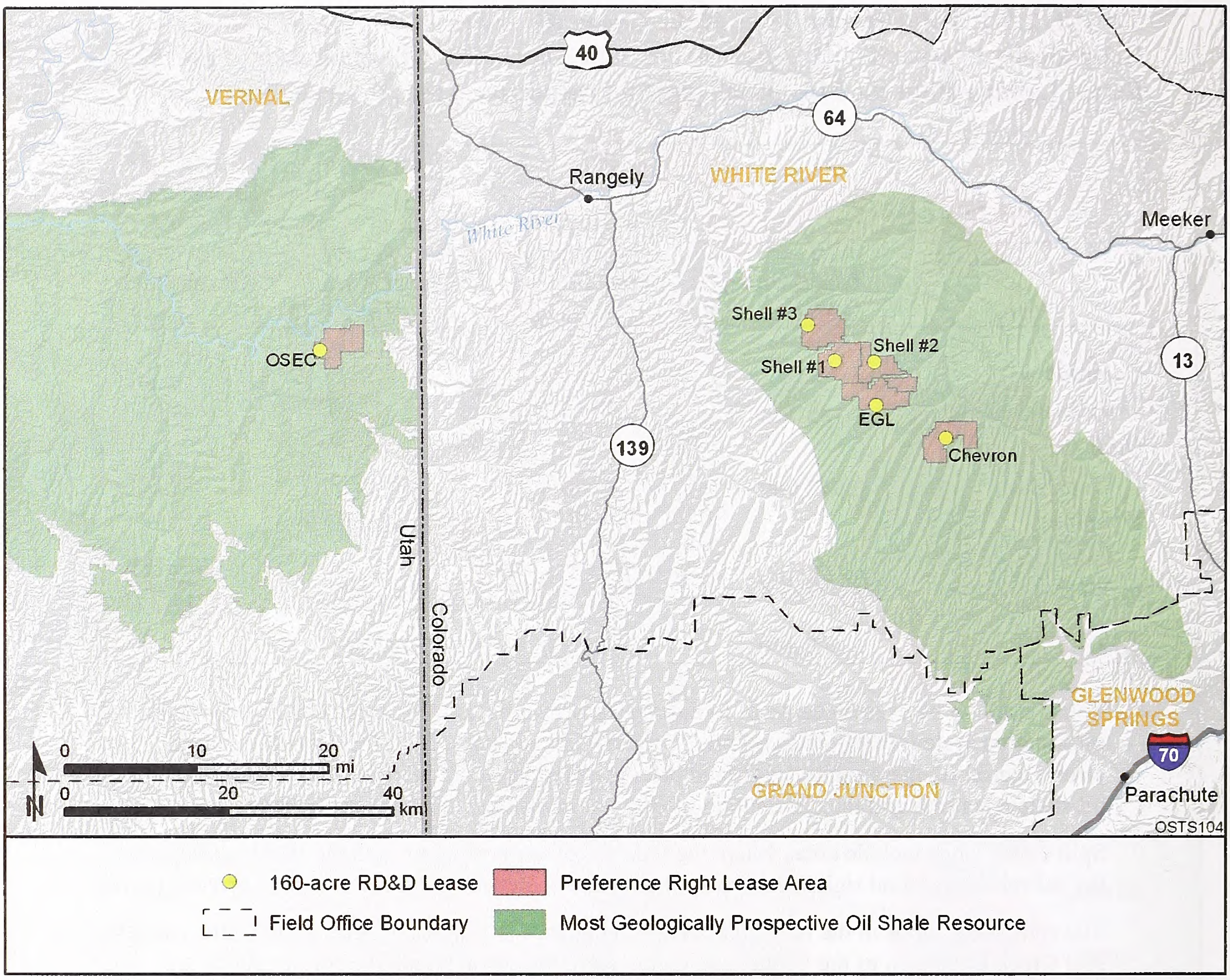

FIGURE 2.3-2 Locations of the Six RD&D Tracts and Associated PRLAs

TABLE 2.3-2 Summary Information for the Six Existing Oil Shale RD&D Projects[a]

Project[b]	Technology	Design Basis for Facility (bbl/day)	Total Annual Production (thousand bbl/yr)	Total Acreage Impacted
Shell Project 1	In situ conversion process (ICP)	500–1,500	180–550	160
Shell Project 2	Two-step ICP	500–1,500	180–550	160
Shell Project 3	Electric ICP	500–1,500	180–550	160
Chevron	In situ processes	20–50	7.3–18.25	100
EGL	In situ processes	240	87.6	90
OSEC	Underground mine with surface retort	60–3,900	23–1,400	120

a bbl = barrel; 1 bbl oil = 42 gal.

b Chevron = Chevron U.S.A., Inc; EGL = EGL Resources, Inc.; OSEC = Oil Shale Exploration Company; Shell = Shell Frontier Oil and Gas.

and by-products. For mining technologies, spent shale is a significant waste management concern.

In very simple terms, the recovery or extraction technologies can be divided into direct and indirect recovery methods. Direct recovery methods include both surface mining and underground mining technologies wherein the oil shale is removed from its physical location for processing for recovery of the hydrocarbon constituents. Indirect recovery methods recover the hydrocarbon constituents from the oil shale without requiring the excavation of the oil shale itself. Such processes can include in situ processing technologies, as well as some other enhanced oil recovery technologies developed primarily for the recovery of conventional oil and gas, in varying combinations that may be used in commercial oil shale development. Appendix A provides a detailed discussion of each of the individual technologies, some of the possible permutations, and some of the possible combinations of technologies that may be used in commercial oil shale development.

Processing technologies to separate the organic and inorganic constituents typically use retorting technologies that apply heat to the oil shale to pyrolyze the kerogen. Chemical treatment processes also may be applied. Aboveground retorting (AGR) technologies are used to process mined oil shale; the retorting processes are typically preceded by a variety of pretreatment activities, including crushing, sizing, and sorting. A number of AGR technologies have been designed in the past and are considered to be potentially applicable for future commercial oil shale development. These technologies include the Union B retort, The Oil Shale Corporation (TOSCO) II retort, Paraho retort (both direct and indirect modes), Lurgi-Ruhrgas process, Superior Oil's circular grate retort, and the Alberta Taciuk Process (ATP) technology. The indirect recovery methods mentioned above involve in situ processing to separate the organic and inorganic constituents of the oil shale. These processes typically involve the application of high temperatures to achieve pyrolysis of the kerogen and allow its in situ recovery. Information from the BLM's ongoing oil shale RD&D projects that involve in situ processes is one possible source for defining the potential in situ technologies that may be used in the future.

Irrespective of the resource recovery and retorting technologies employed, kerogen pyrolysis products are likely to require further processing or upgrading before becoming attractive to oil refineries as feedstocks for conventional fuels. Upgrading crude shale oil at commercial project sites could consist of any or all of the following steps: separation of extraneous materials from the feedstock (e.g., water, suspended solids); separation of the crude oil fractions by their boiling points in atmospheric and/or vacuum distillations; coking or cracking to thermally decompose large molecules into smaller molecules; chemical treatment (e.g., catalytic or thermal hydrocracking, hydrotreating, desulfurization, or hydrogenation); and removal of other contaminants.

This PEIS evaluates the potential impacts of commercial oil shale technologies in three primary categories:

- Surface mining projects with surface retort facilities;

- Underground mining projects with surface retort facilities; and

- In situ processing projects.

While many hypothetical development scenarios could be constructed for each of these three technology categories, it is not possible to project or analyze all of them in this PEIS. Instead, the PEIS considers the components of current technologies that could be implemented in order to analyze the range of potential impacts that could occur. It is likely that operators would consolidate a number of systems, such as power generation facilities, equipment maintenance, product storage and load-out facilities, steam and hot water production, water and wastewater treatment and recycling, and waste management, to achieve greater efficiencies and economies at a given project location.

In this PEIS, the BLM has limited its evaluation of the impacts of surface mining to those areas within the most geologically prospective oil shale areas where the overburden ranges in thickness from 0 to 500 ft. This limitation was based, in large part, on the assumption that 500 ft is about the maximum amount of overburden where surface mining can occur economically, using today's technologies. As shown in Figure 2.3-1, the areas within the most geologically prospective oil shale areas where the overburden is 0 to 500 ft thick are limited to part of the Uinta Basin in Utah and parts of the Green River and Washakie Basins in Wyoming. In Utah, about 133,194 acres of land within the most geologically prospective oil shale area have an overburden thickness of 0 to 500 ft; all of these lands fall within the Book Cliffs RMP planning area. In Wyoming, the corresponding area includes about 380,220 acres within the Green River RMP planning area. Within the most geologically prospective oil shale area defined in the Piceance Basin in Colorado, the areas where the overburden is 0 to 500 ft thick are very limited, and it would be difficult to assemble a logical mining unit.[4] The current White River RMP that includes the Piceance Basin in Colorado identifies 39,140 acres that are classified for potential open pit (surface) development, and this is part of the no action alternative in the PEIS. In Alternatives B and C, the PEIS considers making land available for lease for surface mining, only in Utah and Wyoming, in those areas shown in Figure 2.3-1.

This PEIS analyzes the amendment of nine land use plans to open certain public lands for the opportunity to allow for application for commercial oil shale development. The BLM initially intended the Final PEIS to provide the NEPA analysis and documentation not only for the amendment of the land use plans to add the development of oil shale resources to the allowable uses of the public lands in these areas, but also for the issuance of leases for commercial development. The BLM circulated a 15-project development scenario to the cooperating agencies for review and comment. The BLM developed the 15-project scenario by assuming that all 6 of the RD&D leases would convert to commercial oil shale production, and that there would be 3 additional commercial oil shale leases issued in each of the states mentioned in Section 369 of the Energy Policy Act of 2005: Colorado (two using in situ and one underground mine and surface retort); Utah (one in situ, one underground mine and surface retort, and one surface mine

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4 The areas within the most geologically prospective oil shale areas where the overburden is 0 to 500 ft thick were mapped on the basis of a variety of sources of information. In Colorado, the area was defined on the basis of data published in Donnell (1987). In Utah, the area was mapped on the basis of data provided by the Utah Geological Survey (Tabet 2007). In Wyoming, the area was mapped on the basis of data provided by Wiig (2006a,b).

and surface retort); and Wyoming (one in situ, one underground mine and surface retort, one surface mine and surface retort). The cooperating agencies commented that the BLM's analysis would be too speculative at this point to support a decision to issue any leases on the basis of this 15-project scenario.

Similarly, the BLM considered whether to present a development scenario of six projects, corresponding to the six RD&D projects currently leased, under the assumption that these RD&D projects would become viable commercial enterprises. These leases authorize research projects that will yield additional valuable insight as to the technological requirements for, and the impacts associated with commercial development of oil shale resources; however, the BLM concluded that trying to undertake this analysis at this time in order to anticipate a certain level of development would be too speculative, as well.

As a result, the BLM has elected not to attempt to issue leases for commercial development of oil shale on the basis of the NEPA analysis in this PEIS.[5] Rather, as explained in Section 2.5.1, below, this PEIS is being developed to analyze the proposed action to amend 12 existing land use plans to designate certain public lands as open for the opportunity for future oil shale and tar sands leasing. Therefore, this PEIS includes descriptions and analyses not of particular levels of development, but of the possible impacts of each type of technology currently under consideration and research, so far as this information is available to the BLM at this time. Analysis of this information will allow the BLM to determine whether or not to designate certain public lands where the resources are known to be located as open for application to lease these resources in the future.

If and when applications to lease are received and additional information becomes available, the BLM will conduct NEPA analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as what level of development may be anticipated. On the basis of that NEPA analysis to be conducted at the lease stage, the BLM will consider further amendment of one or more plans, if necessary, including, but not limited to, the establishment of general lease stipulations and BMPs.

2.3.2 Alternative A, No Action Alternative, Continuation of Current Management

Alternative A is the no action alternative. In this alternative, no amendments to existing land use plans to identify lands available for application for commercial oil shale leasing would be completed. Existing land use plans would continue to provide direction for management of public lands. Under this alternative for oil shale, there are 294,680 acres currently classified in the White River RMP (BLM 1997b) in Colorado as available for oil shale leasing, and there are 58,100 acres classified as available for leasing in the Book Cliffs RMP (BLM 1985) in Utah. These areas are shown in Figures 2.3.2-1 and 2.3.2-2, respectively.

The classified lands in Colorado are located in the Piceance Basin and include 223,860 acres classified as available for underground mining; 39,140 acres that are included as

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[5] Commercial leasing in this PEIS refers to commercial leases, future RD&D leases, or both.

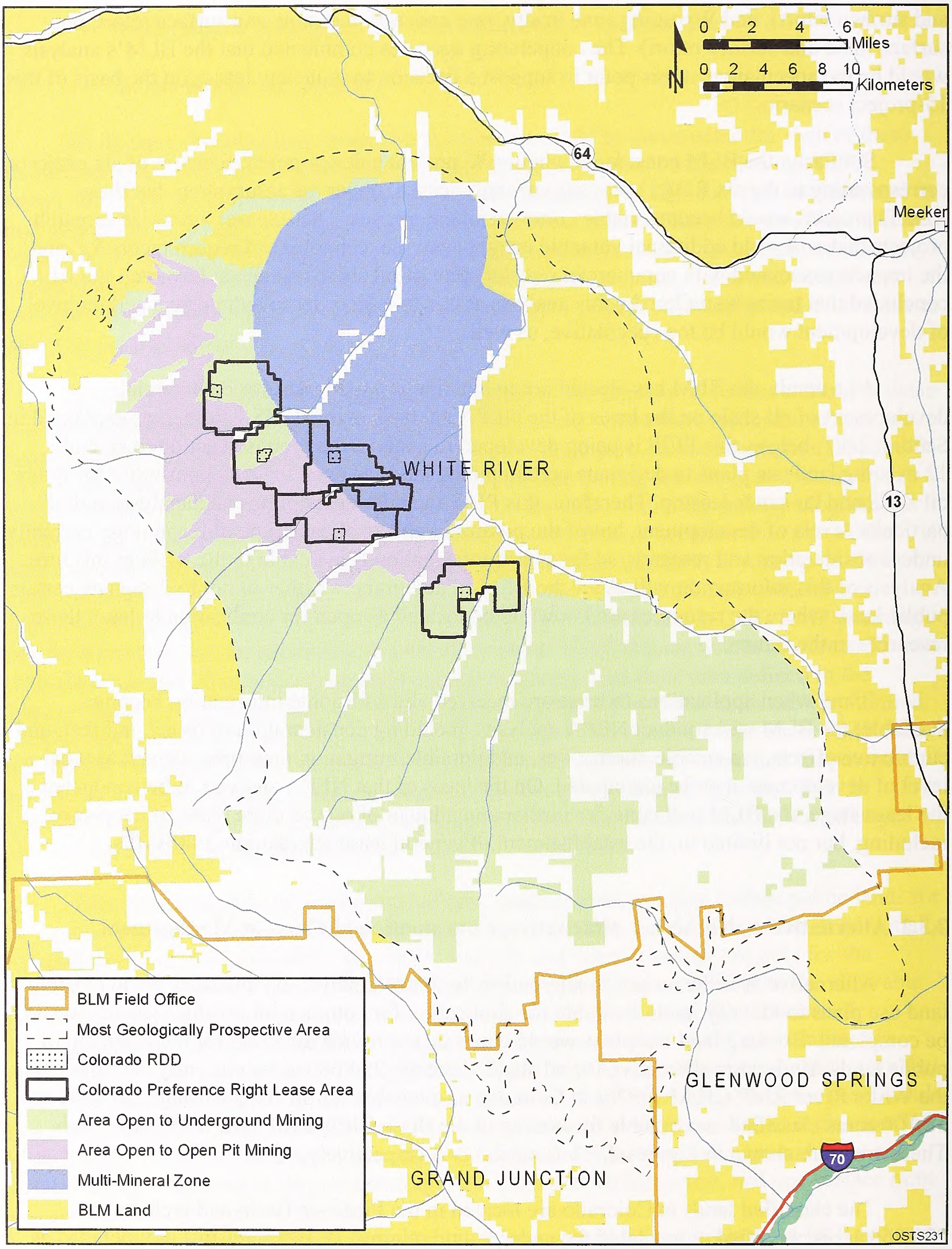

FIGURE 2.3.2-1 Lands Available for Oil Shale Leasing under Alternative A in Colorado

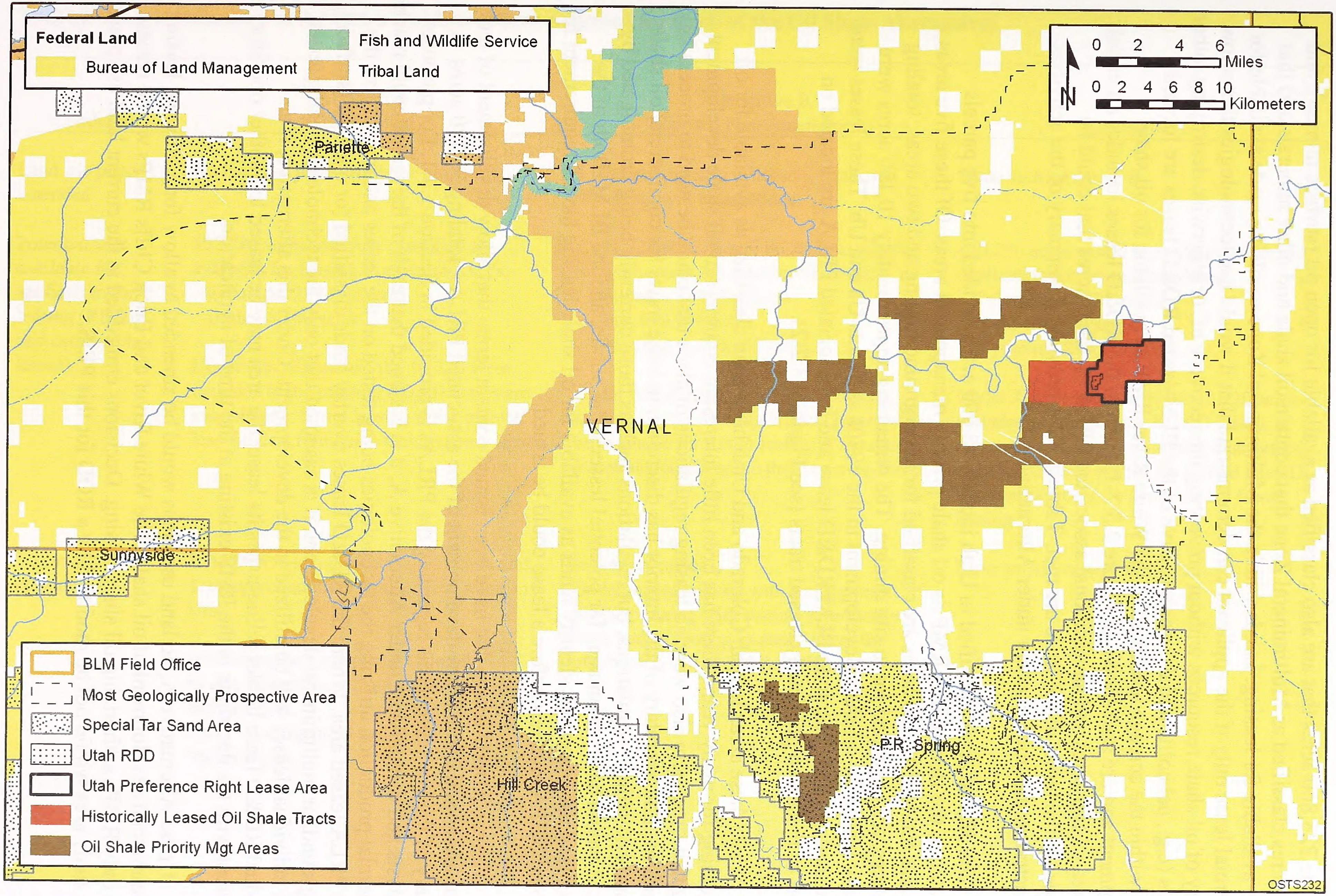

FIGURE 2.3.2-2 Lands Available for Oil Shale Leasing under Alternative A in Utah

part of the 223,860 acres that are also classified as available for open pit (surface mining); and 70,820 acres classified as Multimineral Zone that contain oil shale and other minerals and that are also available for leasing. Lands within the Multimineral Zone would be made available for commercial lease only if the applicant can demonstrate that it would use technologies that allow recovery of oil shale resources without preventing the recovery of, or otherwise destroying, other minerals (e.g., nahcolite and dawsonite). Five of the BLM-issued RD&D leases are located largely within the acreage identified in the White River RMP as available for oil shale development and are also shown in Figure 2.3.2-1. Each of the RD&D leases includes an initial lease area of 160 acres and an additional associated PRLA of 4,960 acres that could be developed if the terms of the lease are met. Table 2.3.2-1 provides a summary of the activities and constraints assumed to occur under Alternative A.

The 58,100 acres identified in Utah include 48,000 acres divided into five parcels designated in the Book Cliffs RMP as oil shale priority management areas. Of these five areas, three areas totaling 42,000 acres are classified for underground mining and two areas, totaling 6,000 acres, are classified for in situ mining. The remaining approximately 10,100 acres were originally leased for oil shale development in the 1970s as Tracts Ua and Ub. These leases were relinquished in 1985. The sixth BLM RD&D lease and its associated PRLA are located on portions of these two previously leased tracts (see Figure 2.3.2-2).

While these areas in both Colorado and Utah have been classified as available for oil shale leasing for many years, there has been little interest in commercial oil shale development. During that time there also were no leasing regulations in place that could be used to process any applications. The Secretary of the Interior has discretion to lease tracts for commercial oil shale development without regulations, but regulations such as those currently being promulgated by the BLM would have advantages for potential lessees, the public, and the BLM. Both of the existing land use plans that identify lands as available for oil shale leasing have a requirement for additional NEPA analysis before a lease could be issued.

The six RD&D leases that have been issued contain terms that allow development of the original leases and could allow development of the associated PRLAs, totaling 30,720 acres. A summary of the key lease terms regarding the PRLAs is provided in Section 1.4.1. For purposes of analysis and comparison, under Alternative A, it is assumed that each of the leases could reach commercial production utilizing the technologies being tested on the leases and may utilize the whole PRLA leased area. Where the RD&D leases overlay lands classified for open pit (surface), underground, or multimineral development, it is assumed that only the technologies being tested on the individual leases will be utilized in the development. Under this alternative, if an individual RD&D lease holder relinquishes its lease, the area may be leased to another operator consistent with the decisions in the RMP existing at the time of application.

Under Alternative A, no land use plans would be amended to allow for additional leasing for commercial development of oil shale. The White River and Book Cliffs RMPs would remain as the only RMPs authorizing oil shale leasing. Decisions embedded in the current land use plans in the study area would not be modified by a ROD for this PEIS.

TABLE 2.3.2-1 Summary of Activities and Conditions Assumed for Each of the Oil Shale Alternatives

Condition	Alternative A (No Action)	Alternative B (Proposed Plan Amendment)	Alternative C
Land use plans amended	No land use plans would be amended.	9 land use plans in Colorado, Utah, and Wyoming will be amended.	Same as Alternative B.
Potential area available for application for leasing (RD&D and commercial leases)	352,780 acres currently classified as available for leasing in existing RMPs: Colorado, 294,680 acres Utah, 58,100 acres Under this alternative, the 30,720 acres included in the existing RD&D leases are available for future leasing if the current leaseholders relinquish their existing leases.	1,991,222 acres would be made available for application for commercial lease: Colorado, 359,798 acres Utah, 630,971 acres Wyoming, 1,000,453 acres Under this alternative, the 30,720 acres included in the existing RD&D leases will be available for future leasing if the current leaseholders relinquish their existing leases.	830,296 acres would be made available for application for commercial lease: Colorado, 40,325 acres Utah, 490,460 acres Wyoming, 299,511 acres Under this alternative, of the 30,720 acres included in the existing RD&D leases, if current leaseholders relinquish their leases, only 8,205 acres within the current RD&D lease areas would be available for future leasing.
Technologies considered	RD&D: 5 in situ projects in Colorado and 1 underground mine with surface retort in Utah. In existing land use plans: Colorado – in situ, underground, and surface mining technologies. Utah – underground and in situ technologies.	In situ processes Underground mining with surface retort Surface mining with surface retort (only in Utah and Wyoming in areas where the overburden is 0 to 500 ft thick)	Same as Alternative B.

TABLE 2.3.2-1 (Cont.)

Condition	Alternative A (No Action)	Alternative B (Proposed Plan Amendment)	Alternative C
Lands excluded from commercial leasing	Only lands identified in the White River and Book Cliffs RMPs are available for leasing.	– Wilderness Areas, WSAs, and other areas that are part of the NLCS. – Existing ACECs that are currently closed to mineral development. – The MMTA in Wyoming. – Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. – Historic trails. – Monument Valley Management Area in Wyoming. – Management Area 3, Jack Morrow Hills Planning Area in Wyoming. – Incorporated town and city limits.	Same as Alternative B plus: – All existing ACECs would be excluded from application for commercial leasing. – All lands where surface-disturbance restrictions or seasonal limitations are in place in existing land use plans in order to protect known sensitive resources would be excluded from application for commercial leasing (see Section 2.3.3.2).
Regulatory and operational constraints	All commercial development would be conducted in compliance with existing federal, state, and local regulatory requirements and established BLM policies. Leases would be subject to constraints in the existing RMPs.	All commercial development would be conducted in compliance with existing federal, state, and local regulatory requirements and established BLM policies.	Same as Alternative B.
Additional NEPA requirements	Additional NEPA analysis would be required before any leases for commercial development can be issued. Site-specific NEPA analyses also would be conducted during the review and approval of project plans of development.	Same as Alternative A.	Same as Alternative A.

2.3.3 Commercial Oil Shale Program Alternatives[6]

The BLM has developed two programmatic allocation alternatives. Under both programmatic alternatives, nine land use plans would be amended to (1) identify the most geologically prospective oil shale resources within each planning unit, (2) designate lands within these most geologically prospective areas available for application for leasing, (3) identify any technology restrictions, (4) establish requirements for future NEPA analyses and consultation activities, and (5) specify that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005. The contents of the two alternatives are summarized in Table 2.3.2-1. The plans that would be amended include the following:

- Colorado
  - Glenwood Springs RMP (BLM 1988, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006b, 2007a, 2008])
  - Grand Junction RMP (BLM 1987)
  - White River RMP (BLM 1997b, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006b, 2007a, 2008])

- Utah
  - Book Cliffs RMP (BLM 1985)
  - Diamond Mountain RMP (BLM 1994)
  - Price River Resource Area MFP, as amended (BLM 1989)

- Wyoming
  - Great Divide RMP (BLM 1990)
  - Green River RMP (BLM 1997a, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006a])
  - Kemmerer RMP (BLM 1986).

The potential impacts from oil shale development and the possible mitigation measures discussed in the Chapter 4 impact analyses could be considered, as appropriate, during the site-specific NEPA analyses identified in program element (4) above.

In both programmatic alternatives, it is recognized that the six existing RD&D leases contain terms and conditions that could allow commercial development of the original leases and the associated PRLAs totaling 30,720 acres to occur. A summary of the key lease terms and conditions regarding the PRLAs is provided in Section 1.4.1. For purposes of analysis and comparison, under both programmatic alternatives, it is assumed that each of the leases could reach commercial production utilizing the technologies being tested on the leases and may utilize the whole leased area. If an initial RD&D lease holder relinquishes its lease, the different acreages within the existing RD&D and PRLA lease areas that then would be available for future leasing under each alternative are defined.

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6 The title of this section and subsections has been modified from that of the Draft PEIS. The two alternatives remain the same.

Also, in both programmatic alternatives, new RD&D leases could be issued in any areas opened to commercial oil shale leasing. Both programmatic alternatives would alter the boundaries of areas presently open to RD&D leasing as specified in the White River and Book Cliffs RMPs (BLM 1997b, 1985). New RD&D projects might precede commercial oil shale leasing, or might be conducted contemporaneously with commercial leasing and operations. Impacts from new RD&D projects are anticipated to be qualitatively similar but smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial oil shale lease and expanded to include preference right acreage. Additional NEPA analysis would be required prior to issuance of any RD&D lease, and prior to conversion of an RD&D lease to a commercial oil shale lease and expansion into a PRLA.

As discussed in Section 1.2, the BLM has determined that certain lands within the most geologically prospective oil shale resource areas are excluded from commercial leasing, under all alternatives, on the basis of existing laws and regulations, E.O.s, land use plan designations, and other administrative designations or withdrawals. As a result, commercial leasing is excluded from all designated Wilderness Areas, WSAs, and other areas that are part of the NLCS administered by the BLM (e.g., National Monuments, NCAs, WSRs, and National Historic and Scenic Trails), existing ACECs that are currently closed to mineral development, and lands within incorporated town and city limits. The BLM has also determined that additional areas would be closed and would not be available for future opportunity to lease for commercial development of oil shale resources under both programmatic alternatives. These additional areas include:

- *Mechanically Mineable Trona Area (MMTA).* This area, which is located in the Green River Basin in Wyoming, falls within a portion of the Known Sodium Leasing Area (KSLA) that encompasses the world's largest known trona deposits.[7] Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has determined that the MMTA would be excluded from oil shale leasing until technology or other factors exist to allow development of the oil shale resource without jeopardizing the safe operation of underground trona mines.

- *Segments of rivers that the BLM has determined to be potentially eligible for WSR status by virtue of a WSR inventory.* These river segments and a corridor extending at least 0.25 mi from the high water mark on either side of these segments would be excluded from commercial leasing (see footnote 3 on p. 2-9 for a discussion of this restriction.

- *Historic trails.* Historic trails identified by the BLM Wyoming State Office and a corridor extending at least 0.25 mi on either side of the trail would be excluded from commercial leasing.[8]

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7 Trona is a hydrous sodium carbonate mineral that is refined into soda ash, sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and chemical caustic soda.

8 For the purposes of analysis in this PEIS, the centerline of trails mapped in the GIS was used to define the 0.25 mi buffer.

- *Monument Valley Management Area.* Oil shale development within this management area, which is located in the Rock Springs Field Office area, is prohibited in the Green River RMP (BLM 1997a). Specifically, the RMP directs that these lands remain withdrawn from oil shale development until a comprehensive study of the area has been conducted, including an assessment of the potential designation of this area as an ACEC on the basis of the need to protect cultural and paleontological resources.

- *Management Area 3, Jack Morrow Hills Planning Area.* In accordance with the Jack Morrow Hills Coordinated Activity Plan (BLM 2006a), extensive restrictions on surface-disturbing activities have been established for Area 3 within the Jack Morrow Hills Planning Area because of the presence of sensitive natural and cultural resources. The portion of Area 3 that overlaps with the most geologically prospective oil shale resources in the Green River Basin is restricted to No Surface Occupancy (NSO) and has been excluded from future leasing on the basis of input from the field office.

- *Expansion Areas around Rock Springs and Green River, Wyoming.* The BLM has determined that it will not issue leases within the "expansion areas" agreed upon with the cities of Rock Springs and Green River, Wyoming.

Public lands outside of the most geologically prospective area are not being excluded from consideration for leasing for any environmental or other specific reason and could be considered for application for leasing at a later time but would require consideration in a new NEPA analysis and a land use plan amendment before leasing could be authorized. Areas within the most prospectively valuable area that are excluded from consideration for application for leasing in the current PEIS, or environmentally and economically sound proposals employing different technologies, could also be considered in the future.

Leasing would occur pursuant to regulations that are not yet final. This PEIS is not dependent upon the provisions of the final regulations. It does anticipate that decisions regarding leasing and approval of plans of development will be informed by appropriate analysis documents as required by NEPA.

For information purposes, however, under the proposed regulations, the BLM would issue a call for applications for commercial leases that may be restricted to certain areas. In response, companies would be required to identify the specific lands that they are interested in as part of their lease application package. It is also possible that the BLM would identify specific tracts to be leased in the call for applications. The proposed process would require that NEPA analyses be conducted prior to lease issuance. Information collected as part of the lease application process would be incorporated into the NEPA analysis. Applicants would be required to identify key information regarding aspects of the proposed development needed to support a complete NEPA review (e.g., technologies to be employed, level of planned development, anticipated off-site impacts, strategies to comply with regulatory requirements, etc.). During that NEPA review, the BLM would identify and establish appropriate lease stipulations to mitigate anticipated impacts. In addition, the subsequent approval of project-specific plans of development would require NEPA review to (1) consider site-specific and project-specific factors and (2) identify and require appropriate mitigation measures as needed to control impacts beyond those established in the lease stipulations. The NEPA review for the plan of development may be incorporated into the NEPA review conducted for the lease application, at BLM's discretion, and if adequate operational data are provided by the applicant(s).

Under both programmatic alternatives (i.e., Alternatives B and C), the BLM would require that the operator conduct commercial development in compliance with existing federal, state, and local regulatory requirements and established BLM policies, as generally described in Section 2.2 and Appendix D. This compliance would include, as appropriate, obtaining and complying with all required permits (e.g., air, water, and waste management) as required by regulatory agencies; operating within the permit constraints; completing consultation with the USFWS under Section 7 of the ESA; completing consultation with State Historic Preservation Officers (SHPOs), Tribal Historic Preservation Officers, and other consulting parties under Section 106 of the NHPA (P.L. 89-665); and compliance with any other relevant and applicable requirements. Compliance-related conditions would be developed on a project-by-project basis during site-specific analyses.

Under both programmatic oil shale alternatives, in Colorado, lands within the Multimineral Zone identified in the White River RMP (BLM 1997b) would be made available for application for commercial lease only if the applicant can demonstrate that it would use technologies that allow recovery of oil shale resources without preventing the recovery of or otherwise destroying other minerals (i.e., nahcolite and dawsonite). This is consistent with existing provisions in the White River RMP. However, the BLM has determined that other decisions in the White River RMP relevant to oil shale leasing would be modified under both programmatic alternatives. The decisions that would be modified include the (1) designation of specific areas as available for commercial oil shale leasing, (2) designation of a subset of this area as available for commercial development by surface mining (e.g., open pit), and (3) prohibition of oil shale leasing with the Piceance Creek Dome area. Specific information about the White River RMP decisions relevant to oil shale is discussed in greater detail in Section 3.1.1.3 and shown in Figure 3.1.1-3.

In Utah, the BLM has determined that the decisions in the Book Cliffs RMP identifying lands as available for oil shale leasing would be modified under both programmatic alternatives. The decisions that would be modified include the (1) designation of specific areas available for commercial oil shale leasing, and (2) identification of specific areas as suitable for development using underground or in situ methods. Specific information about the Book Cliffs RMP decisions relevant to oil shale is discussed in greater detail in Section 3.1.1.8 and shown in Figure 3.1.1-13.

2.3.3.1 Alternative B for a Commercial Oil Shale Program, the Proposed Plan Amendment

Under Alternative B, the BLM proposes to designate a total of 1,991,222 acres[9] available for application for commercial oil shale leasing by amending nine land use plans. Specifically, the lands that would be available for application include all lands within the most geologically

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9 This amount includes the total potential RD&D lease acreage of 30,720 acres.

prospective oil shale areas that are BLM-administered public lands, including split estate lands where the federal government owns the mineral rights, but excluding those lands described in Section 2.3.3. The public lands that would be available for application for lease Alternative B are shown in Figures 2.3.3-1, 2.3.3-2, and 2.3.3-3 for Colorado, Utah, and Wyoming, respectively. Table 2.3.3-1 lists the approximate number of acres of BLM-administered lands available for application for commercial leasing under Alternative B by state.[10]

As shown in Figure 2.3.3-2, split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation are included in the lands proposed to be available for leasing under Alternative B. These lands total 57,657 acres.

Also, as discussed in Section 2.3.1, commercial leases for surface mining projects would be allowed only on those lands in Utah and Wyoming where the overburden is 0 to 500 ft thick. In Utah, under Alternative B, lands available for application for leasing for surface mining projects total about 85,640 acres in the Book Cliffs RMP planning area. In Wyoming, under Alternative B, these lands total about 248,000 acres in the Green River RMP planning area.

In Alternative B, the PRLAs for the five RD&D projects in Colorado coincide entirely with the area proposed to be available for application for commercial leasing. For the OSEC RD&D project in Utah, however, a portion of the PRLA is not identified as available for application for commercial leasing under Alternative B because of the presence of a potentially eligible WSR, Evacuation Creek (see Section 2.3.3).[11] Under the terms of the existing RD&D leases, the federal government has a commitment to grant the RD&D lessees leases for commercial development within the PRLAs, provided that all terms and conditions of the leases are met (see Section 1.4.1). As a result, all lands within the PRLAs would be available for issuance of commercial leases to the current RD&D lessees, subject to lease requirements. For commercial oil shale development to occur on lands excluded from Alternative B along Evacuation Creek, the Book Cliffs RMP (or successor RMP) would need to be amended to consider the excluded area for potential leasing.

The federal government is not under an obligation to grant leases for commercial development within the existing RD&D lease areas to any other applicants; however, under this alternative, if an existing RD&D leaseholder relinquishes its lease, the area would be available for consideration for future leasing.

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[10] The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available geographic information system (GIS) datasets available to the BLM. These maps and acreage estimates may contain errors and should be considered to be only representative of the proposed leasing area for this alternative. As specific areas are considered for commercial leasing, a detailed evaluation of land status would be required.

[11] Although a power line will cross Evacuation Creek at two locations as part of the RD&D project development, OSEC will not be able to locate other surface facilities within 0.25 mi of the creek during commercial operations if the creek has been determined to be suitable for designation as a WSR at the time the commercial lease is issued. The Vernal Field Office is in the process of amending the land use plan for this area and will make a final determination on whether the river segment will be recommended to Congress for designation.

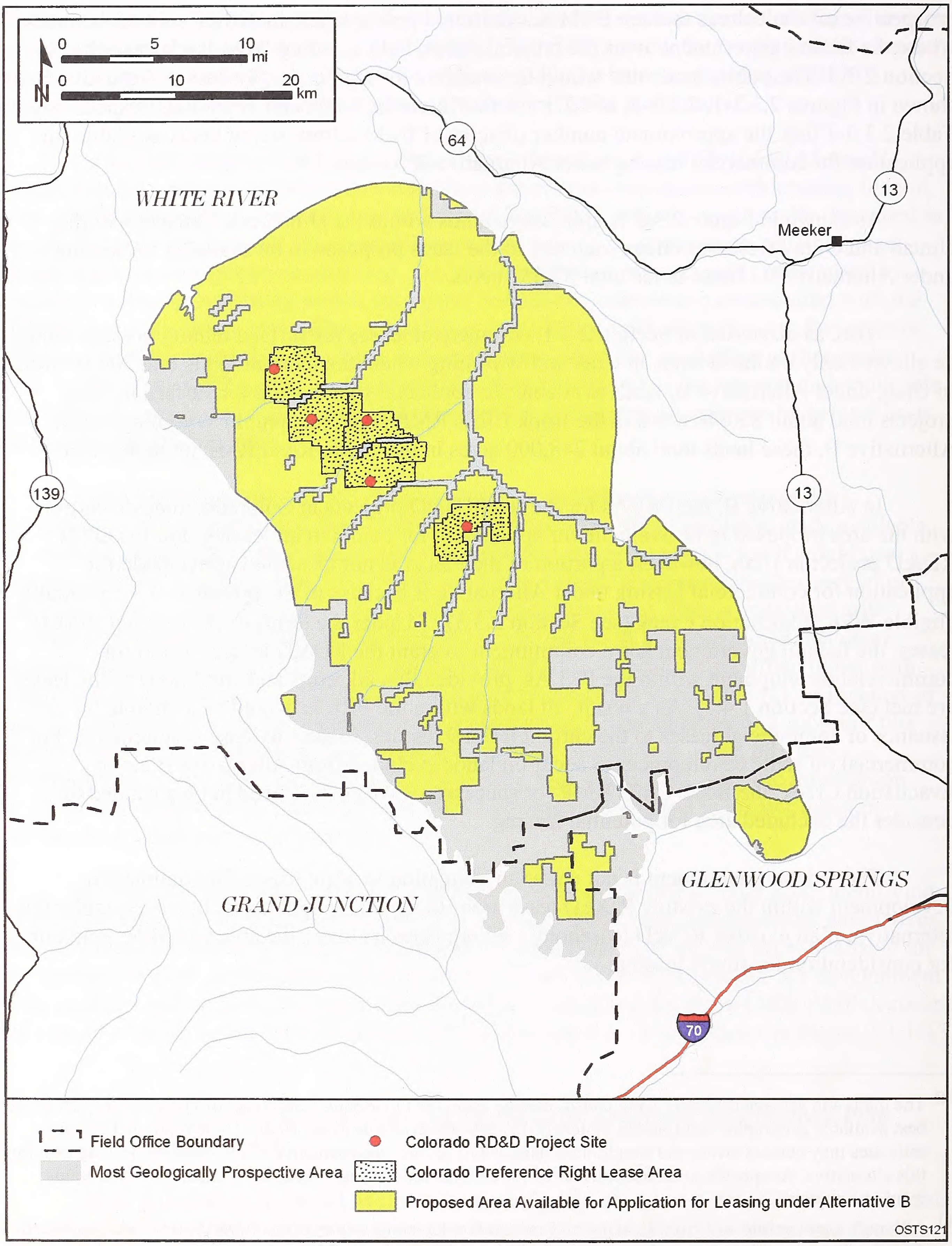

FIGURE 2.3.3-1 Lands Available for Application for Leasing under Alternative B for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Colorado

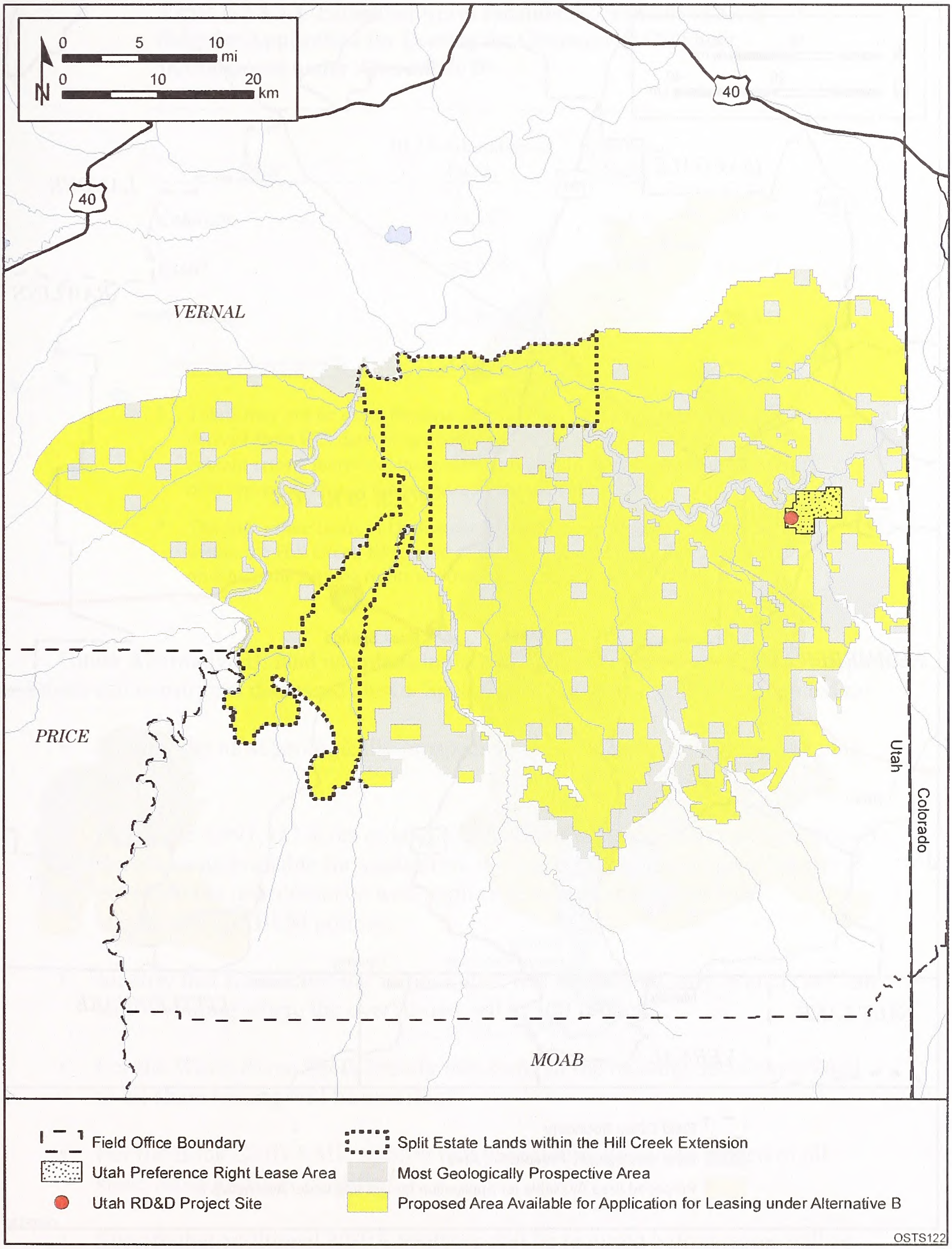

FIGURE 2.3.3-2 Lands Available for Application for Leasing under Alternative B for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Utah

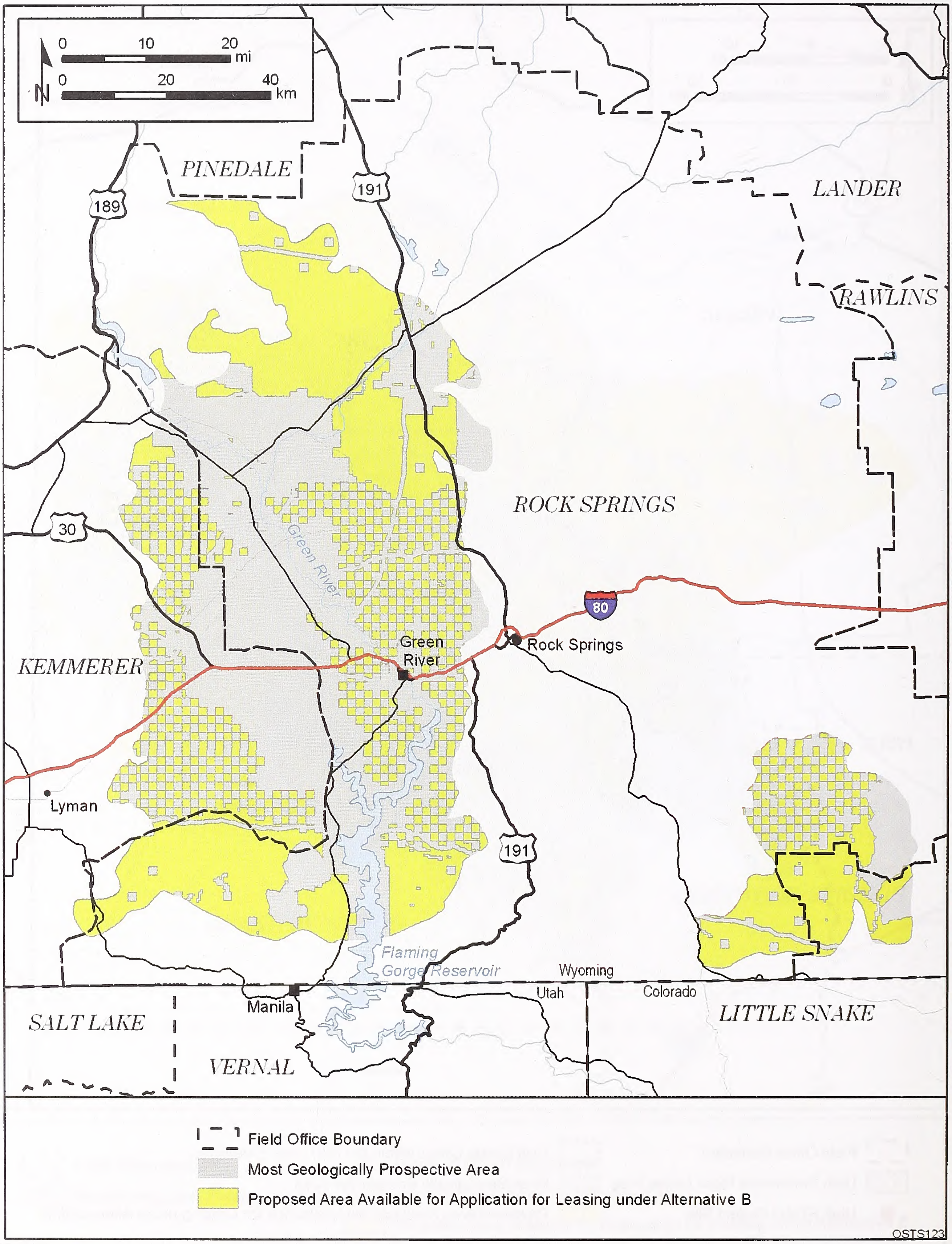

FIGURE 2.3.3-3 Lands Available for Application for Leasing under Alternative B for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Wyoming

TABLE 2.3.3-1 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative B[a]

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado	317,882	41,916	359,798
Utah[b]	554,977	75,995	630,971
Wyoming	992,682	7,771	1,000,453
Total for Alternative B	1,865,542	125,681	1,991,222

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

[b] The split estate lands in Utah include 57,657 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

Under Alternative B, land use plans in the study area would be amended to adopt the conditions and constraints discussed above. Specifically, the plans would be amended to:

- Identify the most geologically prospective oil shale areas within the planning unit;
- Designate 1,991,222 acres of land within the most geologically prospective oil shale area as available for application for leasing for commercial oil shale development in accordance with applicable federal, state, and local regulations and BLM policies;
- Identify that surface mining technologies will be allowed only in areas in Utah and Wyoming where the overburden is 0 to 500 ft thick;
- For the White River RMP, specify that some of the existing decisions related to oil shale leasing will be modified;
- For the Book Cliffs RMP, specify that the existing decisions related to oil shale leasing will be modified.
- Specify that additional NEPA analyses will be required before leases will be issued for commercial development;

- Specify that approval of project-specific plans of development will require additional NEPA review to consider site-specific and project-specific factors; and

- Specify that the BLM will consider and give priority to the use of land exchanges, where appropriate and feasible, to consolidate land ownership and mineral interests within the oil shale basins.

The proposed land use plan amendments are included in Appendix C.

2.3.3.2 Alternative C for a Commercial Oil Shale Program

Alternative C is similar to Alternative B except that additional lands are excluded from the area identified as available for application for commercial leasing. Under Alternative C, the BLM proposes to designate a total of 830,296 acres[12] available for application for commercial oil shale leasing. The lands that would be available for application under Alternative C include some of the lands that are available under Alternative B, but exclude lands that are identified as requiring special management or resource protection in existing land use plans.

To identify those lands that would be excluded on the basis of existing land use plan decisions, the BLM considered the possible impacts associated with commercial oil shale development. On the basis of these impact analyses, described in Chapter 4, it was determined that commercial oil shale development could be in conflict with existing land use plan decisions that require surface-disturbance restrictions or seasonal limitations on activities in order to adequately protect a specific resource. Alternative C excludes from application for leasing all lands where such surface-disturbance and seasonal limitations are in place to protect known sensitive resources. The BLM made the determination that the most effective means of identifying lands that should be excluded was to exclude those lands within each field office where stipulations for no surface disturbance or seasonal limitations are in place for oil and gas leasing. Under this alternative, the BLM would place a priority on protecting known sensitive resources within each field office by excluding these lands from application for leasing.

The lands that would be available for application for leasing under Alternative C are shown in Figures 2.3.3-4, 2.3.3-5, and 2.3.3-6 for Colorado, Utah, and Wyoming, respectively. Table 2.3.3-2 lists, by state, the approximate number of acres of BLM-administered lands available for application for commercial leasing under Alternative C.[13] Table 2.3.3-3 identifies the types of stipulations and restrictions in place for oil and gas leasing in each state that are being used to identify those lands that would not be available for application for leasing for commercial oil shale development under Alternative C.

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[12] This amount includes the total potential RD&D lease acreage of 30,720 areas.

[13] The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available GIS datasets available to the BLM. These maps and acreage estimates may contain errors and should be considered to be only representative of the proposed leasing area for this alternative. As specific areas are considered for commercial leasing, a detailed evaluation of land status would be required.

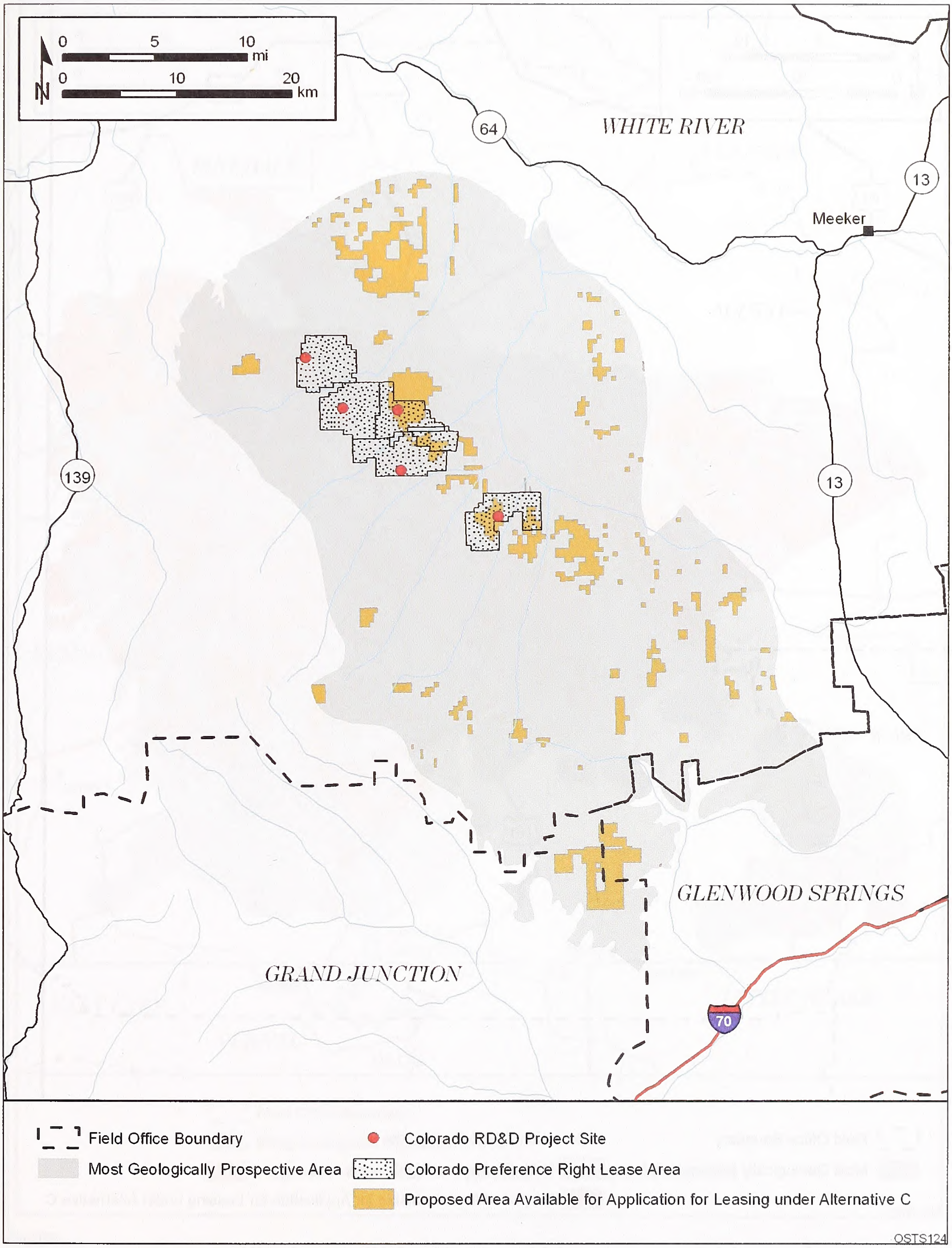

FIGURE 2.3.3-4 Lands Available for Application for Leasing under Alternative C for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Colorado

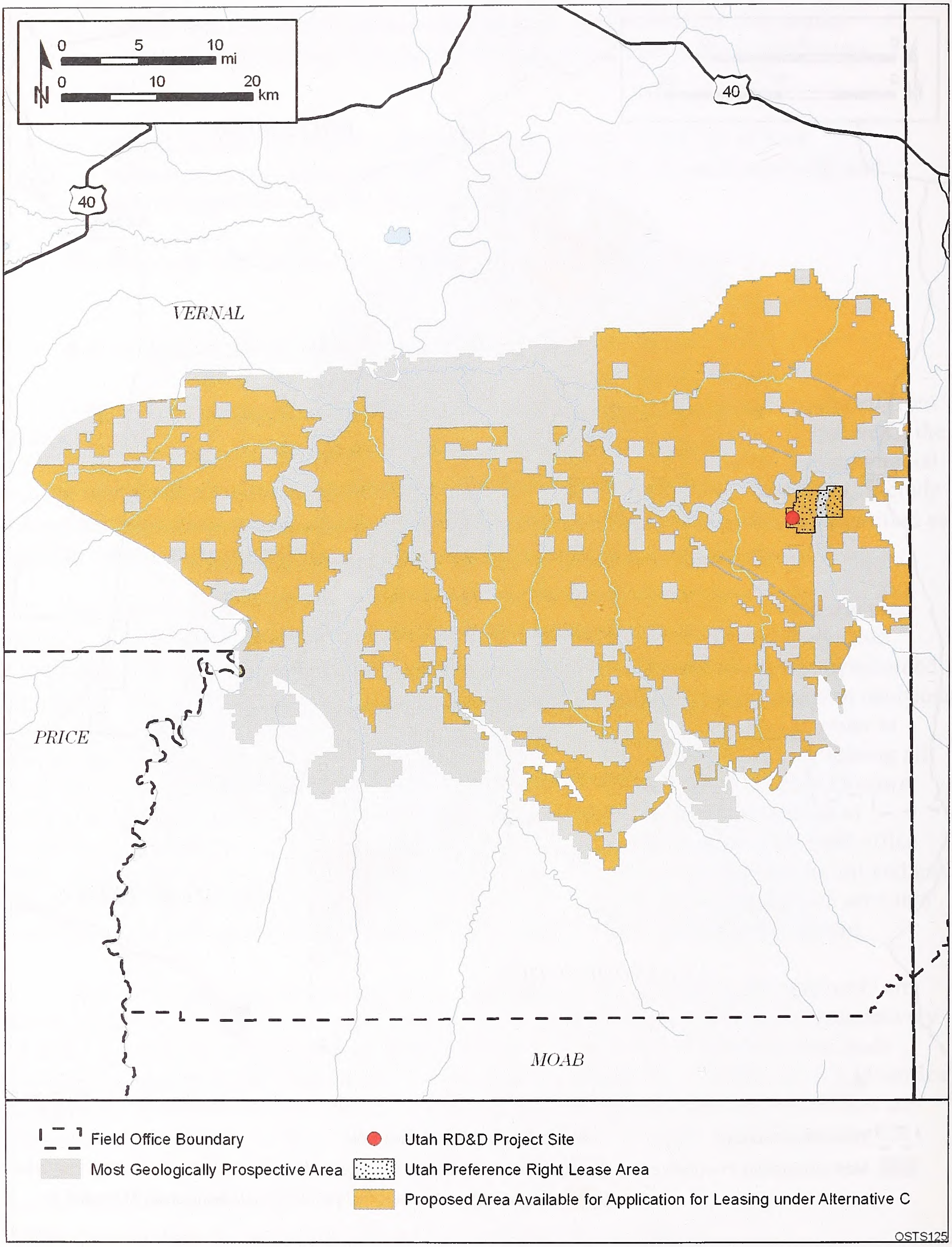

FIGURE 2.3.3-5 Lands Available for Application for Leasing under Alternative C for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Utah

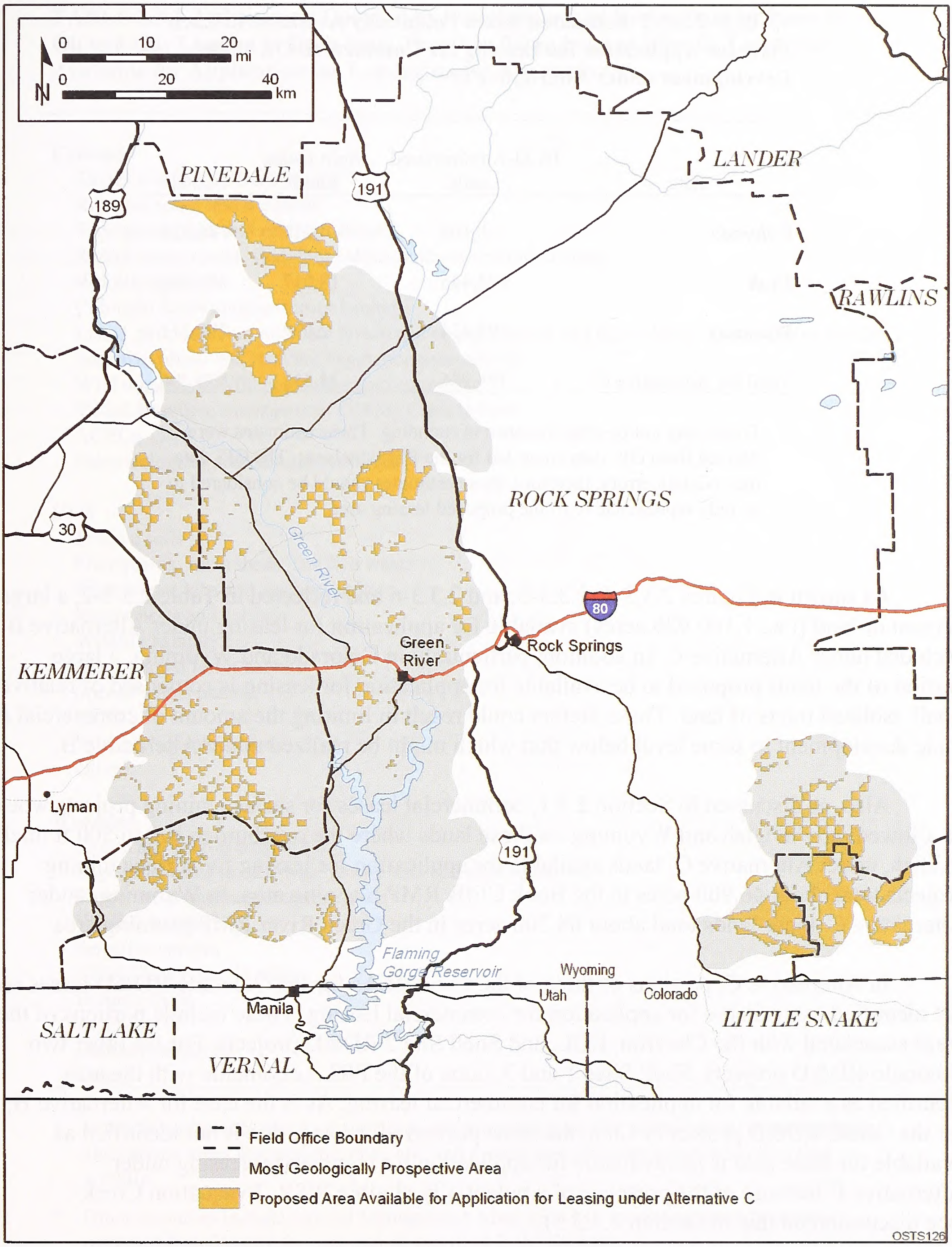

FIGURE 2.3.3-6 Lands Available for Application for Leasing under Alternative C for Commercial Oil Shale Development within the Most Geologically Prospective Areas in Wyoming

TABLE 2.3.3-2 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative C[a]

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado	26,109	14,217	40,325
Utah	472,443	18,017	490,460
Wyoming	297,434	2,077	299,511
Total for Alternative C	795,986	34,311	830,296

a Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

As shown in Figures 2.3.3-4, 2.3.3-5, and 2.3.3-6 and reflected in Table 2.3.3-2, a large amount of land (i.e., 1,160,926 acres) available for application for leasing under Alternative B is excluded under Alternative C. In addition, particularly in Colorado and Wyoming, a large portion of the lands proposed to be available for application for leasing is composed of relatively small, isolated tracts of land. These factors could result in limiting the amount of commercial oil shale development to some level below that which might be realized under Alternative B.

Also, as discussed in Section 2.3.1, commercial leases for surface mining projects would be allowed only in Utah and Wyoming on those lands where the overburden is 0 to 500 ft thick. In Utah, under Alternative C, lands available for application for leasing for surface mining projects total about 46,900 acres in the Book Cliffs RMP planning area. In Wyoming, under Alternative C, these lands total about 68,200 acres in the Green River RMP planning area.

In Alternative C, portions of three of the five PRLAs for the Colorado RD&D leases are not identified as available for application for commercial leasing. These include portions of the areas associated with the Chevron, EGL, and Shell Site 2 RD&D projects. For the other two Colorado RD&D projects, Shell Sites 1 and 3, none of the PRLAs coincide with the area identified as available for application for commercial leasing. As is the case for Alternative B, for the OSEC RD&D project in Utah, the same portion of the area that is not identified as available for lease also is not available for application for commercial leasing under Alternative C because of the presence of a potentially eligible WSR, Evacuation Creek (see discussion on this in Section 2.3.3.1).

Under the terms of the RD&D program, the federal government has a commitment to grant the RD&D companies leases for commercial development within the PRLAs, provided that all terms and conditions of the leases are met (see Section 1.4.1). As a result, all lands within the

TABLE 2.3.3-3 Resources Covered by Stipulations and Restrictions in Place for Oil and Gas Leasing in Each State That Are Being Used to Identify Lands Not Available for Application for Leasing under Alternative C

Colorado
- Slopes and fragile/erosive soils
- Riparian zones and wetlands
- Sage grouse leks and nesting habitat
- Raptor nests, roosts, fledgling habitat, and concentration areas
- Wildlife habitat[a]
- Colorado River cutthroat trout habitat
- Listed, proposed, or candidate threatened or endangered and BLM-designated sensitive species
- Sensitive plants and remnant vegetation associations
- Wild horses and wild horse management areas
- Visual Resource Management (VRM) Class II areas
- ACECs
- Paleontological and cultural resources

Utah
- Erosive soils
- Floodplains, watersheds, and live water
- Sage grouse leks and nesting habitat
- Raptor nests and habitat
- Wildlife habitat[a]
- Black-footed ferret habitat
- Special status plants
- ACECs
- Paleontological resources
- Other[b]

Wyoming
- Slopes and fragile/erosive soil
- Sage grouse and greater sage grouse leks and nesting habitat
- Raptor nests and concentration areas
- Wildlife habitat[a]
- Sensitive species
- VRM Class I and II areas
- Historic trails
- ACECs
- Cultural resources
- Other[b]

[a] Wildlife habitat includes a combination of winter range, crucial winter range, summer range, and calving areas for antelope, deer, elk, and moose, as well as seclusion areas for other wildlife.

[b] Other resources include Special Management Areas (SMAs), recreation areas, and areas restricted from leasing for reasons not specified in the GIS data.

PRLAs would be available for issuance of commercial leases to the current RD&D lessees, subject to their lease requirements. For commercial oil shale development to occur on lands excluded by Alternative C, the specific land use plans would need to be amended to consider the excluded area for potential leasing.

The federal government is not under an obligation to grant leases for commercial development within the currently leased RD&D areas to any other applicants. Under this alternative, if existing RD&D lessees relinquish their leases, only 8,205 acres of the 30,720 acres included in the current RD&D leases would be available for application for future leasing. The areas that would be available for lease are shown in Figures 2.3.3-4 and 2.3.3-5.

Under Alternative C, land use plans in the study area would be amended to:

- Identify the most geologically prospective oil shale areas within the planning unit;
- Designate 830,296 acres of land within the most geologically prospective oil shale area as available for application for leasing for commercial oil shale development in accordance with applicable federal and state regulations and BLM policies;
- Identify that surface mining technologies will be allowed only in areas in Utah and Wyoming where the overburden is 0 to 500 ft thick;
- For the White River RMP, specify that some of the existing decisions related to oil shale leasing will be modified;
- For the Book Cliffs RMP, specify that the existing decisions related to oil shale leasing will be modified.
- Specify that additional NEPA analyses will be required before leases will be issued for commercial development;
- Specify that approval of project-specific plans of development will require additional NEPA review to consider site-specific and project-specific factors; and
- Specify that the BLM will consider and give priority to the use of land exchanges, where appropriate and feasible, to consolidate land ownership and mineral interests within the oil shale basins.

The proposed land use plan amendments are included in Appendix C.

2.4 TAR SANDS

Tar sands are sedimentary rocks containing bitumen, a heavy hydrocarbon complex. Lighter, more volatile hydrocarbons once present in these rocks have escaped to the environment, leaving the heavier, less volatile bitumen in place. Because of the very viscous nature of the bitumen, tar sands cannot be processed by normal petroleum production techniques.

More than 50 tar sands deposits occur in Utah. Limited data are available on many of these deposits, and most of the known bitumen occurs in just a few of the deposits. The deposits that are being evaluated in this PEIS are those classified in the 11 sets of geologic reports (minutes) prepared by the USGS in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78).[14] The 11 STSAs, which define the tar sands study area, are shown in Figure 2.4-1 and listed in Table 2.4-1, along with their total size in acres and the number of acres of BLM-administered and split estate lands within each STSA. These STSAs are considered to be the most geologically prospective areas for tar sands development.

Although no tar sands development is currently taking place on public lands in Utah, in the mid-1980s, a number of CHLs were issued in the Pariette and P.R. Spring STSAs under the authority of the Combined Hydrocarbon Leasing Act (P.L. 97-78). These include four leases in the Pariette STSA and two leases in the P.R. Spring STSA; these leases remain in existence. Also in the mid-1980s, a number of operators holding oil and gas leases or tar sands claims within designated STSAs applied to convert their leases to CHLs. In most instances, the conversion of these leases has not been completed; thus, a number of pending conversion applications remain within the study area, specifically within the Circle Cliffs, Tar Sand Triangle, and P.R. Spring STSAs.[15] The BLM is currently engaged in adjudication of these leases.[16] Tar sands deposits outside the areas designated by the Secretary of the Interior in the 11 sets of minutes are not available for leasing under the CHL Program, but are available for development under a conventional oil and gas lease.

Potential tar sands development could occur on the existing CHLs or on pending conversion leases should they be converted to CHLs. However, because there has been no tar sands development to date on any of the CHLs and no project proposals have been submitted, the BLM cannot reasonably foresee any development of tar sands on public lands within the STSAs over the next 20 years under the CHL Program.

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[14] The boundaries of the designated STSAs were determined by the Secretary of the Interior's orders of November 20, 1980 (45 FR 76800–76801), and January 21, 1981 (46 FR 6077–6078).

[15] While the Circle Cliffs STSA is a designated STSA, the BLM-administered portion of it falls entirely within the GSENM and has been excluded from consideration for being designated as open to application for leasing in this PEIS.

[16] Decisions in this PEIS and its accompanying ROD regarding the availability of lands within the STSAs for future commercial leasing and the constraints under which such future leases would be issued would not affect the existing CHLs or any of the pending applications that are converted to CHLs.

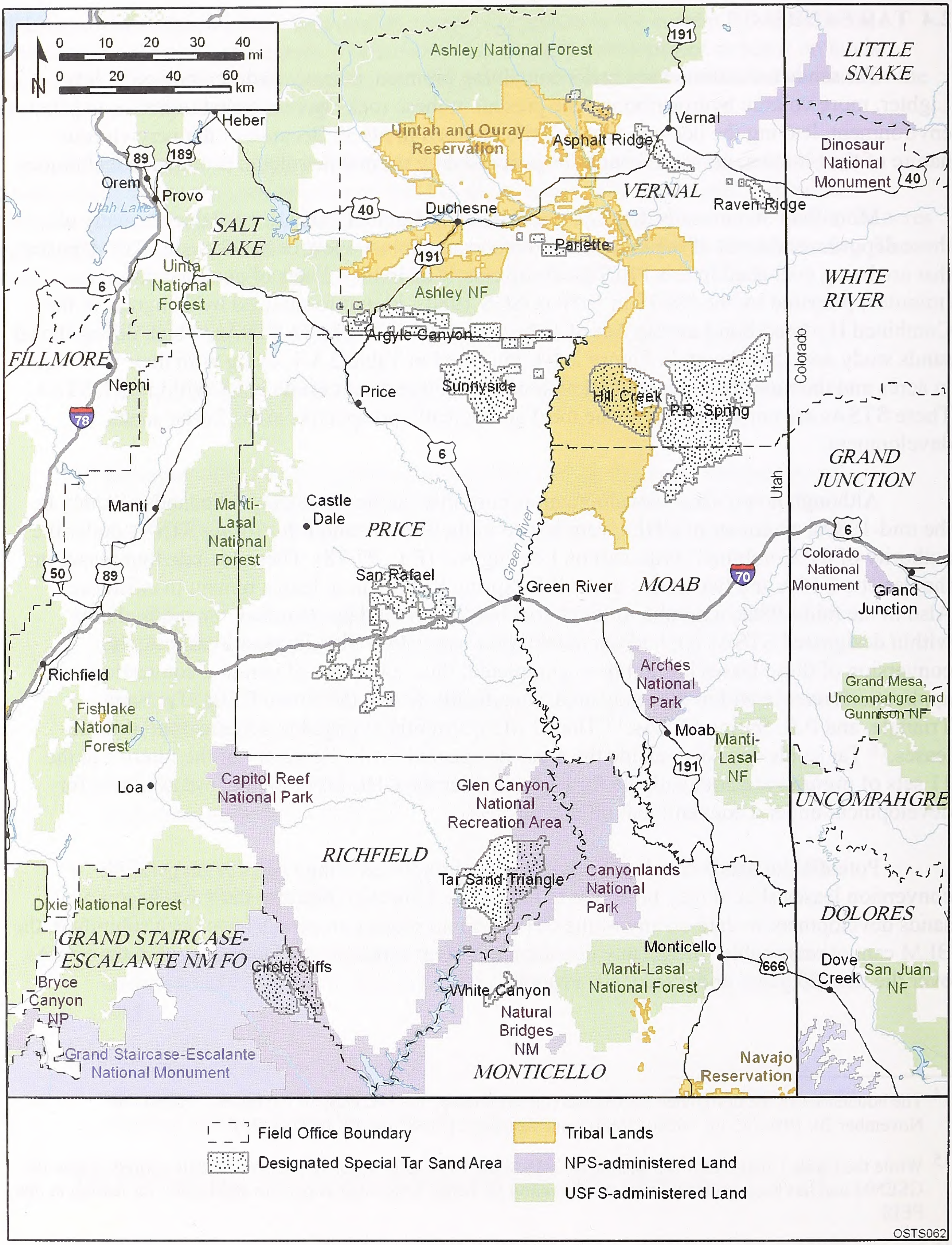

FIGURE 2.4-1 Special Tar Sand Areas in Utah

TABLE 2.4-1 Total Size in Acres of the 11 STSAs and Acres of BLM-Administered and Split Estate Lands within Each STSA[a,b]

STSA	Total Size	Total BLM-Administered Lands within STSA	Total Split Estate Lands within STSA
Argyle Canyon	22,259	1,224	11,869
Asphalt Ridge	39,151	5,323	128
Circle Cliffs[c]	91,303	51,226	6,707
Hill Creek[d]	106,795	19,923	36,583
Pariette	22,622	12,337	78
P.R. Spring	273,922	184,558	8,192
Raven Ridge	16,533	14,352	16
San Rafael Swell	130,737	115,667	0
Sunnyside	157,406	78,657	18,575
Tar Sand Triangle	155,049	83,040	0
White Canyon	10,490	8,050	0
Total	1,026,266	574,357	82,148

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the size of the STSAs and the distribution of BLM-administered and split estate lands.

[b] Split estate lands include areas where the federal government owns, and the BLM administers, the subsurface mineral rights, but the surface estate is owned by Tribes, states, or private parties.

[c] The Circle Cliffs STSA is included for information purposes only; it has been excluded from consideration for being designated as open to application for leasing in this PEIS. The BLM-administered lands fall entirely within the GSENM.

[d] The split estate lands in the Hill Creek STSA include 35,472 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

2.4.1 Potential Commercial Tar Sands Development Technologies

This section briefly describes the tar sands development technologies that have been considered in the scope of the PEIS analyses. Appendix B provides a more detailed discussion of potential technologies that may be used over the next 20 years and includes a discussion of oil sands development in Canada. Information presented in this section and Appendix B on technologies that might be used is taken from the best available published data. Because commercial tar sands development is still evolving, many details regarding the specific technologies that will be used in the future to produce oil from tar sands are unknown. In the absence of complete and definitive information about the technologies that may be deployed, a number of assumptions have been made. These assumptions are discussed in Section 5.1.

Commercial development of a tar sands resource occurs in three major steps: (1) recovery of the bitumen in its natural setting, (2) processing of the bitumen to extract it from the inorganic matrix (largely sand and silt) in which it occurs, and (3) upgrading of the bitumen to produce a synthetic crude oil suitable as a feedstock for a conventional refinery. The physical and chemical features of the tar sands deposits and other circumstantial factors associated with their deposition dictate the most appropriate development schemes. Typical development schemes always involve each of the above major steps, although many permutations of these steps are possible and many interim steps may also be necessary.

Recovery methods can be categorized as either mining activities or in situ processes, although some techniques involve a combination of recovery methods. Mining consists of using surface or subsurface mining techniques to excavate the tar sands with subsequent recovery of the bitumen by washing, flotation, or retorting.[17] True in situ methods generally involve either heating the tar sands (referred to as in situ combustion) or injecting materials (e.g., steam, hot water, gas, or solvents) into them to mobilize the bitumen for recovery. Depending on production costs and the price of the synthetic crude produced, surface mining operations are generally cost-effective only where the overburden is no more than about 45 m (150 ft) (Meyer 1995). In situ processes requiring high pressures are generally considered to require a thick overburden of about 150 m (500 ft) to contain the pressure. Between these depths, bitumen must be recovered by other means.

The choice of recovery method affects which extraction and processing operations are used. In mining operations, the mined bitumen must be processed to recover or separate it from the inorganic matrix (largely sand, silt, and clay) in which it occurs. Nonmining recovery methods produce bitumen mixed with water, steam, other gases, or solvent from which it must be separated. If combustion recovery is used, the viscosity of the recovered bitumen may need to be reduced prior to further processing. In all cases, the viscosity of the bitumen might need to be changed prior to further processing and upgrading (BLM 1984). Depending on the recovery method, mining operations may also need to perform similar separations. The recovery processes evaluated in this PEIS include those discussed in Appendix B: the hot water process, cold water process, solvent extraction process, and thermal recovery processes, including retorting.

Irrespective of the recovery and processing technologies employed, it is assumed that at most commercial projects the recovered bitumen would need to be upgraded in order for it to be accepted by oil refineries as feedstocks for conventional fuels. Although there are variations among different production operations, four main processes are used to upgrade bitumen: coking (thermal conversion), catalytic conversion, distillation (fractionation), and hydrotreating.

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[17] The PEIS does not evaluate the application of underground mining technologies for the commercial development of tar sands because, at this time, underground mining to develop tar sands does not appear to be commercially viable.

Four technology combinations are evaluated in this PEIS for commercial tar sands development:

- Surface mining projects with surface retorting,
- Surface mining projects with solvent extraction,
- In situ steam injection projects, and
- In situ combustion projects.

While many hypothetical development scenarios could be constructed for various technology combinations, it is not possible to project or analyze all of them in this PEIS.

For the same reasons the BLM has elected not to attempt to issue leases on the basis of the NEPA analysis in this PEIS (see Section 2.5.1, below), this PEIS does not include analysis of a particular development scenario. Because the tar sands industry in the United States still lacks a commercially viable technology, the BLM concluded that trying to anticipate a certain level of development would be too speculative.

Therefore, this PEIS includes description and analysis not of a particular level of development, but of the possible impacts of each type of technology that has been considered and researched, so far as this information is available to the BLM at this time.

In both programmatic alternatives, RD&D leases could be issued in any areas opened to commercial tar sands leasing. RD&D projects might precede commercial tar sands leasing or might be conducted contemporaneously with commercial leasing and operations. Impacts from RD&D projects are anticipated to be qualitatively similar but smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial tar sands lease and expanded to include preference right acreage. Additional NEPA analysis would be required prior to issuance of any RD&D lease and prior to conversion of an RD&D lease to a commercial tar sands lease and expansion into a PRLA.

If and when applications to lease are received and additional information becomes available, the BLM will conduct NEPA analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as what level of development may be anticipated. On the basis of that NEPA analysis to be conducted at the lease stage, the BLM will consider the establishment of general lease stipulations and BMPs, either by further plan amendment, if necessary, or by other means.

This PEIS considers the components of current technologies that could be implemented in order to analyze the range of potential impacts that could occur. The scope of the PEIS analyses is intended to be broad enough to include the potential array of technologies that might be used to commercially develop tar sands resources on public lands. It is possible, however, that additional technologies may be identified as viable in the next 20 years. The application of such technologies on public lands may be allowed by the BLM; however, these technologies would need to be evaluated on a case-by-case basis.

2.4.2 Alternative A, No Action Alternative, Continuation of Current Management

Under this alternative for tar sands, the BLM has assumed that there would be no commercial leasing or development of tar sands on public lands. As discussed in Section 2.4, although a number of CHLs were issued in the mid-1980s (and there are additional pending applications to convert oil and gas leases or tar sands claims to CHLs), there has been no tar sands development on public lands in the last 20 years or more. Furthermore, at the time this PEIS was prepared, no commercial tar sands project proposals had been submitted to the BLM. Based on this history, the BLM has determined that it is unlikely that commercial tar sands development would occur under the existing CHL Program. Under Alternative A, land use plans would not be amended to allow for leasing for commercial tar sands development under any program other than the CHL Program. Table 2.4.2-1 provides a summary of the activities and conditions assumed to occur under Alternative A.

2.4.3 Commercial Tar Sands Program Alternatives[18]

The two separate alternatives that the BLM has developed for establishing a commercial tar sands program are summarized in Table 2.4.2-1. These programmatic alternatives, labeled Alternatives B and C, consist of different management approaches to future commercial tar sands leasing. Under each programmatic alternative, the BLM proposes to make certain lands within the STSAs available for application for commercial leases. Under both alternatives, additional NEPA analyses would be conducted prior to the issuance of commercial leases. In addition, site-specific NEPA analyses would be conducted during evaluation and approval of plans of development during the project development phase. These site-specific analyses, which potentially could be combined into a single NEPA evaluation, would identify potential project-specific impacts and define appropriate lease stipulations and required mitigation measures. The potentially applicable mitigation measures discussed in the Chapter 5 impact analyses would be applied during the site-specific analyses, as appropriate.

As discussed in Section 1.2, the BLM has determined that certain lands within the STSAs are excluded from commercial leasing under all alternatives, on the basis of existing laws and regulations, E.O.s, land use plan designations, and other administrative designations or withdrawals. As a result, commercial leasing is excluded from all designated Wilderness Areas, WSAs, and other areas that are part of the NLCS administered by the BLM (e.g., National Monuments, NCAs, WSRs, and National Historic and Scenic Trails). Leasing also would be excluded from all existing ACECs and lands within incorporated town and city limits. The BLM has also determined that additional areas would be closed and would not be available for future

[18] The title of this section and subsections has been modified from that of the Draft PEIS. The two alternatives remain the same.

TABLE 2.4.2-1 Summary of Activities and Conditions Assumed for Each of the Tar Sands Alternatives

Condition	Alternative A (No Action)	Alternative B (Proposed Plan Amendment)	Alternative C
Land use plans amended	No plans would be amended.	Six plans would be amended.	Same as Alternative B.
Potential area made available for application for leasing (RD&D and commercial leases)	STSAs consistent with existing land use plans	431,224 acres would be made available for application for commercial lease. Argyle Canyon: 11,226 acres Asphalt Ridge: 5,435 acres Circle Cliffs: 0 acres Hill Creek: 56,506 acres Pariette: 10,161 acres P.R. Spring: 153,003 acres Raven Ridge: 14,364 acres San Rafael: 70,475 acres Sunnyside: 78,116 acres Tar Sand Triangle: 24,938 acres White Canyon: 7,001 acres	229,038 acres would be made available for application for commercial lease. Argyle Canyon: 0 acres Asphalt Ridge: 1,464 acres Circle Cliffs: 0 acres Hill Creek: 19,934 acres Pariette: 830 acres P.R. Spring: 56,728 acres Raven Ridge: 9,950 acres San Rafael: 54,492 acres Sunnyside: 62,741 acres Tar Sand Triangle: 22,511 acres White Canyon: 386 acres
Technologies considered	None	Surface mining with surface retort Surface mining with solvent extraction In situ steam injection In situ combustion	Same as Alternative B.
Lands excluded from commercial leasing	Wilderness Areas, WSAs, other areas that are part of the NLCS. Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. Any leasing would be consistent with existing land use plan decisions.	– Wilderness Areas, WSAs, other areas that are part of the NLCS. – All existing ACECs. – The Circle Cliffs STSA. – Historic trails. – Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. – Incorporated town and city limits.	Same as Alternative B, plus all lands where surface-disturbance restrictions or seasonal limitations are in place in existing land use plans in order to protect known sensitive resources would be excluded from application for commercial leasing (see Section 2.4.3.2).

TABLE 2.4.2-1 (Cont.)

	Alternative A (No Action)	Alternative B (Proposed Plan Amendment)	Alternative C
Regulatory and operational constraints	All commercial development would be conducted in compliance with existing federal, state, and local regulatory requirements and established BLM policies.	Same as Alternative A.	Same as Alternative A.
Additional NEPA requirements	Additional NEPA analyses would be required before any leases for commercial development could be issued. Site-specific NEPA analyses also would be conducted during the review and approval of project plans of development.	Same as Alternative A.	Same as Alternative A.
Applicable leasing regulations	Leasing would be conducted pursuant to the CHL regulations contained in 43 CFR Part 3140.	Leasing would be conducted pursuant to the interim final rules for tar sands leasing in STSAs published in 70 FR 58610–58516, and CHLs could be considered as provided in 43 CFR Part 3140.	Same as Alternative B.

opportunity to lease for commercial development of tar sands resources under both programmatic alternatives. These additional areas include:

- *Circle Cliffs STSA*. Most of the Circle Cliffs STSA falls entirely within the GSENM and Capitol Reef National Park. The issuance of new leases for mineral development within each of these units is prohibited. Also, a small portion of the Circle Cliffs STSA underlies the Glen Canyon NRA; this area is part of the "Natural Zone" within which mineral leasing and development are prohibited.

- *Segments of rivers that have been determined to be potentially eligible for WSR status by virtue of a WSR inventory*. These river segments and a corridor extending at least 0.25 mi on either side of these segments would be excluded from commercial leasing.

Leasing would occur as set forth in 43 CFR Part 3140. For information purposes, the process could be summarized as follows. The BLM would hold a competitive lease sale as provided in 43 CFR 3141.1. A potential lessee could submit a request or expression of interest in one or more tracts for competitive lease offering as provided in 43 CFR 3141.6-1. The BLM anticipates that it will need additional information about potential technologies for, and impacts from, commercial production of tar sands in order to complete an analysis under NEPA for issuing leases or approving plans of developments. That information does not presently exist and would likely need to come from the industry before the BLM would proceed with leasing or approval of operations.

Under both programmatic alternatives, the BLM would ensure that the operator conducts commercial development in compliance with existing federal, state, and local regulatory requirements and established BLM policies, as generally described in Section 2.2 and Appendix D. That compliance would include, as appropriate, obtaining all permits (e.g., air, water, and waste management) as required by regulatory agencies; operating within the permit constraints; completing consultation with the USFWS under Section 7 of the ESA; completing consultation with SHPOs, Tribal Historic Preservation Officers, and other consulting parties under Section 106 of the NHPA; and compliance with any other relevant and applicable requirements. Compliance-related conditions would be developed on a project-by-project basis during site-specific analyses.

Under both programmatic tar sands alternatives, six land use plans in Utah would be amended to (1) designate lands within the STSAs available for application to lease, (2) stipulate requirements for future NEPA analyses and consultation activities, and (3) specify that the BLM will consider and give priority to the use of land exchanges to facilitate commercial tar sands development pursuant to Section 369(n) of the Energy Policy Act of 2005. The plans that would be amended to address commercial tar sands leasing and development include the following:

- Book Cliffs RMP (BLM 1985);

- Diamond Mountain RMP (BLM 1994);

- Henry Mountain MFP (BLM 1982);
- Price River Resource Area MFP, as amended (BLM 1989);
- San Rafael Resource Area RMP (BLM 1991a); and
- San Juan Resource Area RMP (BLM 1991b).

Public lands outside of the STSAs are not being excluded from consideration for leasing for any environmental or other specific reason and could be considered for application for leasing at a later time but would require consideration in a new NEPA analysis and a land use plan amendment before leasing could be authorized. Areas within the STSAs that are excluded from consideration for application for leasing in the current PEIS, or environmentally and economically sound proposals employing different technologies, could also be considered in the future.

The following sections describe the programmatic alternatives evaluated in this PEIS. The sections identify the additional leasing exclusions that the BLM has identified for each alternative and the proposed land use plan amendments. The specific land use plan amendments are discussed in greater detail in Appendix C.

2.4.3.1 Alternative B for a Commercial Tar Sands Program, the Proposed Plan Amendment

Under Alternative B, the BLM proposes to designate a total of 431,224 acres available for commercial tar sands leasing by amending six land use plans. Specifically, the lands that would be available for application include all BLM-administered public lands within the STSAs, including split estate lands where the federal government owns the mineral rights, except those lands described in Section 2.4.3. The lands that would be available for application for lease are shown in Figure 2.4.3-1. Table 2.4.3-1 lists the approximate number of acres available for application for commercial leasing under Alternative B by STSA.[19]

As indicated in Table 2.4.3-1, split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation where the surface estate is owned by the Tribes and the minerals are owned by the federal government, are included in the lands proposed to be available for leasing under Alternative B. These lands encompass 35,472 acres.

Under Alternative B, land use plans in the study area would be amended to adopt the conditions and constraints discussed above. Specifically, the plans would be amended to:

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[19] The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available GIS datasets available to the BLM. These maps and acreage estimates may contain errors and should be considered to be only representative of the proposed leasing area for this alternative. As specific areas are considered for commercial leasing, a detailed evaluation of land status would be required.

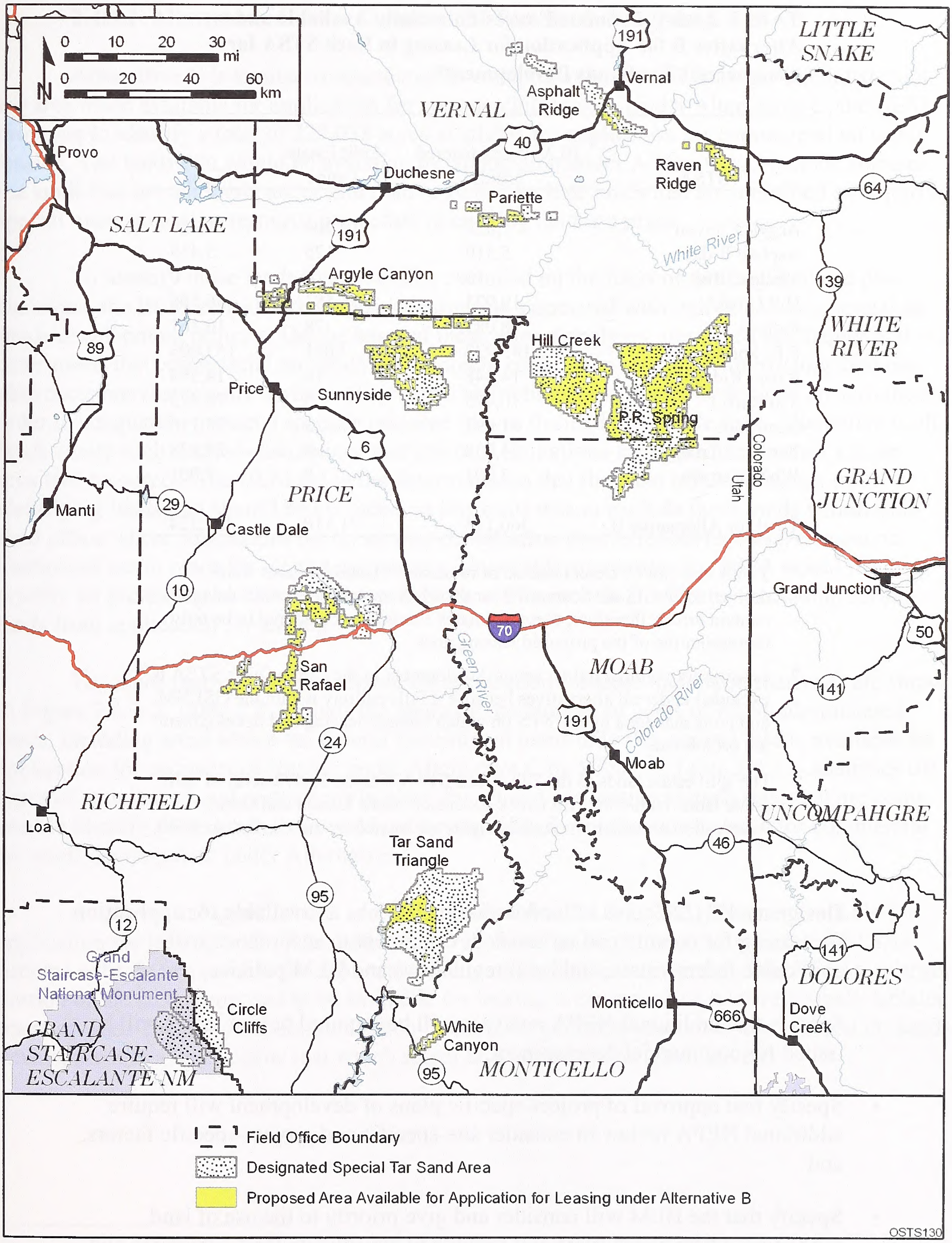

FIGURE 2.4.3-1 Lands Available for Application for Leasing under Alternative B for Commercial Tar Sands Development within the STSAs in Utah

TABLE 2.4.3-1 Estimated Acres Potentially Available under Alternative B for Application for Leasing in Each STSA for Commercial Tar Sands Development[a]

STSA	BLM-Administered Lands	Split Estate Lands	Total
Argyle Canyon	1,022	10,204	11,226
Asphalt Ridge	5,310	125	5,435
Circle Cliffs[b]	0	0	0
Hill Creek[c]	19,923	36,583	56,506
Pariette	10,083	78	10,161
P.R. Spring	145,922	7,081	153,003
Raven Ridge	14,348	16	14,364
San Rafael	70,475	0	70,475
Sunnyside	61,093	17,023	78,116
Tar Sand Triangle	24,938	0	24,938
White Canyon	7,001	0	7,001
Total for Alternative B	360,115	71,110	431,224

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

[b] Leasing for commercial tar sands development in the Circle Cliffs STSA is excluded under all alternatives because it falls entirely within the GSENM and units managed by the NPS on which mineral leasing and development are prohibited.

[c] The split estate lands in the Hill Creek STSA include 35,472 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

- Designate 431,224 acres of land within the STSAs as available for application for leasing for commercial tar sands development in accordance with applicable federal, state, and local regulations and BLM policies;
- Specify that additional NEPA analyses will be required before leases will be issued for commercial development;
- Specify that approval of project-specific plans of development will require additional NEPA review to consider site-specific and project-specific factors; and
- Specify that the BLM will consider and give priority to the use of land exchanges where appropriate and feasible to consolidate land ownership and mineral interests within the STSAs.

2.4.3.2 Alternative C for a Commercial Tar Sands Program

Alternative C is similar to Alternative B except that additional lands are excluded from the area made available for application for commercial leasing. Under Alternative C, the BLM proposes to identify a total of 229,038 acres available for application for commercial tar sands leasing. The lands that would be available for application under Alternative C include some of the lands that are available under Alternative B, but exclude lands that are identified as requiring special management or resource protection in existing land use plans.

To identify those lands that would be excluded on the basis of existing land use plan decisions, the BLM considered the possible impacts associated with individual commercial tar sands development projects. On the basis of these impact analyses, described in Chapter 5, it was determined that commercial tar sands development could be in conflict with existing land use plan decisions that require surface-disturbance restrictions or seasonal limitations on activities in order to adequately protect a specific resource. It was decided to exclude from Alternative C all lands where such surface-disturbance and seasonal limitations are in place to protect known sensitive resources. The BLM made the determination that the most effective means of identifying lands that should be excluded on this basis was to exclude those lands within each field office where stipulations for no surface disturbance, controlled surface use, or seasonal limitations are in place for oil and gas leasing. Under this alternative, the BLM would place a priority on protecting known sensitive resources within each field office by excluding certain lands from application for leasing.

The lands that would be available for application for lease under Alternative C are shown in Figure 2.4.3-2. Table 2.4.3-2 lists the approximate number of acres of BLM-administered lands, including areas where the federal government owns only the mineral estate, available for application for commercial leasing under Alternative C by STSA.[20] Table 2.4.3-3 identifies the types of stipulations and restrictions in place for oil and gas leasing in each state that are being used to identify those lands that would not be available for application to lease for commercial tar sands development under Alternative C.

As shown in Figure 2.4.3-2 and reflected in Table 2.4.3-2, 202,186 acres available for application for leasing under Alternative B are excluded under Alternative C; several STSAs become entirely unavailable for application for lease. In addition, in some of the STSAs, a large portion of the lands proposed to be available for leasing is composed of relatively small, isolated tracts of land. These factors could result in limiting the potential amount of commercial tar sands development to a level below that which might be realized under Alternative B.

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20 The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available GIS datasets available to the BLM. These maps and acreage estimates may contain errors and should be considered to be only representative of the proposed leasing area for this alternative. As specific areas are considered for commercial leasing, a detailed evaluation of land status would be required.

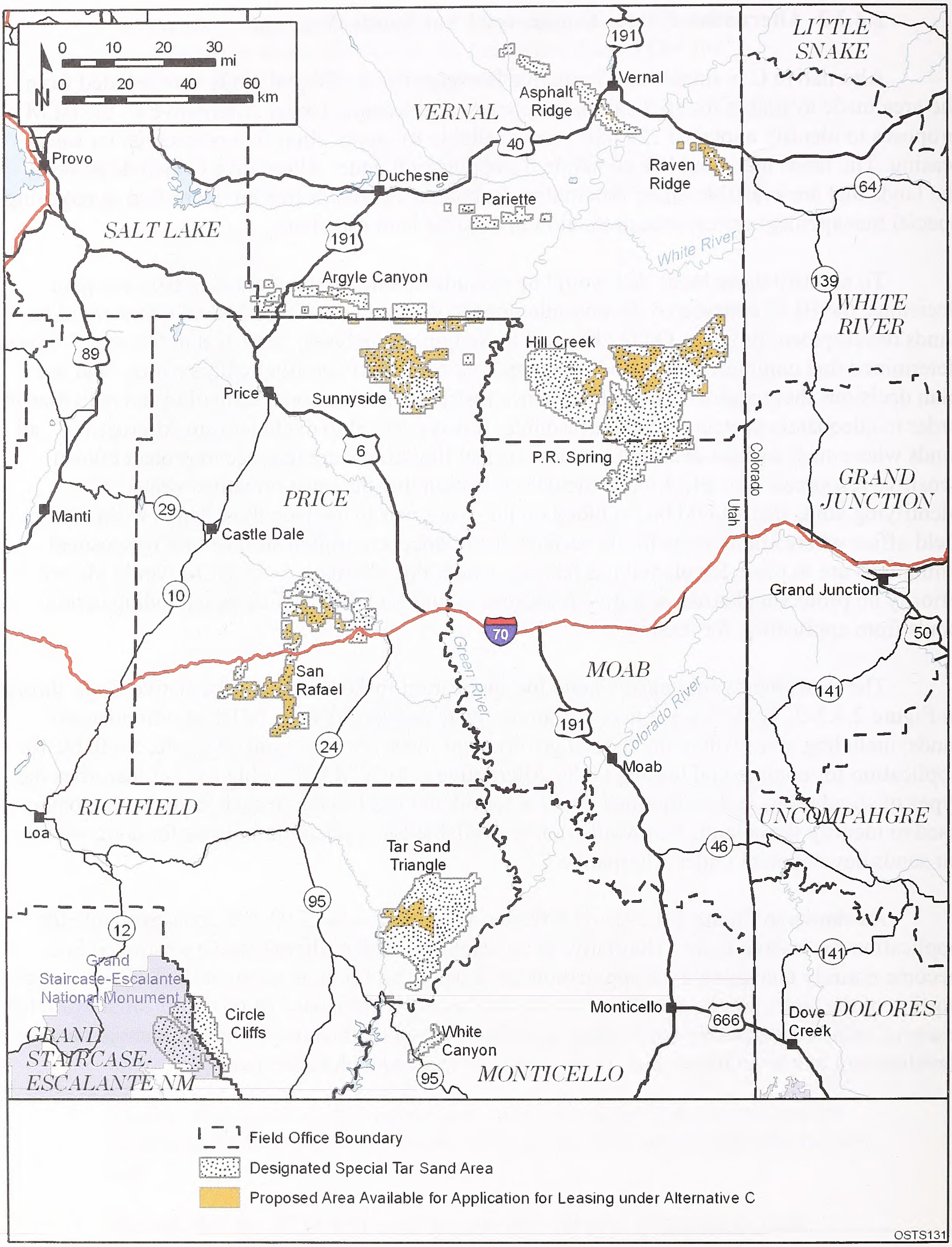

FIGURE 2.4.3-2 Lands Available for Application for Leasing under Alternative C for Commercial Tar Sands Development within the STSAs in Utah

TABLE 2.4.3-2 Estimated Acres Potentially Available under Alternative C for Application for Leasing in Each STSA for Commercial Tar Sands Development[a]

STSA	BLM-Administered Lands	Split Estate Lands	Total
Argyle Canyon	0	0	0
Asphalt Ridge	1,372	93	1,464
Circle Cliffs[b]	0	0	0
Hill Creek	19,455	480	19,934
Pariette	830	0	830
P.R. Spring	50,727	6,001	56,728
Raven Ridge	9,935	16	9,950
San Rafael	54,492	0	54,492
Sunnyside	48,731	14,010	62,741
Tar Sand Triangle	22,511	0	22,511
White Canyon	386	0	386
Total for Alternative C	208,438	20,600	229,038

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

[b] Leasing for commercial tar sands development in the Circle Cliffs STSA is excluded under all alternatives because it falls entirely within the GSENM and units managed by the NPS on which mineral leasing and development are prohibited.

Under Alternative C, land use plans in the study area would be amended to adopt the conditions and constraints discussed above. Specifically, the plans would be amended to:

- Designate 229,038 acres of land within the STSAs as available for application for leasing for commercial tar sands development in accordance with applicable federal, state, and local regulations and BLM policies,
- Specify that additional NEPA analyses will be required before leases will be issued for commercial development,
- Specify that approval of project-specific plans of development will require additional NEPA review to consider site-specific and project-specific factors, and
- Specify that the BLM will consider and give priority to the use of land exchanges where appropriate and feasible to consolidate land ownership and mineral interests within the STSAs.

TABLE 2.4.3-3 Resources Covered by Stipulations and Restrictions in Place for Oil and Gas Leasing in the STSAs That Are Being Used to Identify Lands That Would Not Be Available for Application for Commercial Tar Sands Development Leasing under Alternative C

Slopes and erosive/critical soils
Floodplains, watersheds, and live water
Sage grouse leks and nesting habitat
Raptor nests and habitat
Wildlife habitat[a]
Special status plants and relict vegetation
VRM Class II areas and other high-quality visual resources
ACECs
Paleontological resources
Other[b]

[a] Wildlife habitat includes a combination of winter range, crucial winter range, summer range, and calving areas for antelope, bighorn sheep, deer, and elk, as well as seclusion areas for other wildlife.

[b] Other resources include SMA, recreation areas, and areas restricted from leasing for reasons not specified in the GIS data.

2.5 ALTERNATIVES AND ISSUES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

During the initial public comment period regarding the scope of the PEIS (see Section 7.1), a number of comments were submitted regarding the analysis of specific alternatives or issues. A number of the suggestions for specific alternatives were incorporated into alternatives assessed in the PEIS. These include suggestions regarding the development of (1) a credible no action alternative against which leasing alternatives could be assessed, (2) alternatives that would consider delaying decisions regarding leasing until definitive information is available describing what commercial development will entail, (3) alternatives that would consider the full range of alternate uses of public lands and the total impacts of proposed RMP amendments, and (4) an alternative that avoids impacts on wetlands or other waters of the United States. The BLM believes that one or more of the alternatives assessed for oil shale or tar sands leasing incorporate these concerns.

As discussed below, some of the suggested alternatives and key issues were determined to be either outside the scope of the PEIS, inconsistent with the requirements established for the BLM by the Energy Policy Act of 2005, or inappropriate to incorporate as recommended in the comment. As a result, these alternatives and issues were eliminated from detailed analysis in the PEIS. In addition, the BLM, during initial stages of the PEIS process, formulated several alternatives that ultimately were not analyzed in the Draft PEIS in detail. The following sections discuss these alternatives and issues, why they were eliminated, and, where applicable, how parts of the PEIS process address the general points raised by commentors.

2.5.1 Alternatives Approving Issuance of Commercial Leases

The BLM initially considered alternatives that would approve the issuance of commercial leases on the basis of analyses included in the PEIS. This intent was presented to the cooperating agencies and public stakeholders during the initial discussions and scoping meetings. A number of leasing alternatives were considered but, ultimately, the BLM concluded that critical information on the basis of which to assess potential impacts, define required mitigation measures, and issue commercial leases, is not available at this time. Specifically, the BLM determined that it does not have, at this time, adequate information on the (1) magnitude of commercial development and pace of that development, (2) potential locations for commercial leases, (3) technologies that will be employed, (4) size or production level of individual commercial projects, and (5) development time lines for individual projects to support decisions about lease issuance.

Because there are no commercial operations extracting fuel from oil shale or tar sands in the United States, the published information, though informative, cannot be relied on to accurately describe future commercial technologies. Although the BLM potentially could construct scenarios for commercial oil shale development on the basis of the information available for the six RD&D projects underway, conversations with the companies holding the RD&D leases provided little definitive information about future commercial development beyond the locations of the PRLAs. For example, the companies are uncertain exactly what processes commercial development will involve, what the power requirements are for individual components of their technologies, whether there are ways to generate needed power on-site via the commercial process itself, how much water will be required per barrel of shale oil produced, how many employees will be required during the construction and operations phases, and how much land will be disturbed during different phases of development. Without this information, it is not possible to define what related impacts will be, such as how power needs will be met, where water resources will come from, and where employees will be housed.

The BLM considered constructing development scenarios for both oil shale and tar sands by developing assumptions in the absence of available information. It concluded, however, that the amount of information that was available was too meager, that analyses would have to be based on an unacceptably large number of assumptions, and that such analyses would be unreliable and possibly misleading. Initial analyses indicated that, on the basis of certain conservative assumptions, potential impacts on many resources, especially air, water, and socioeconomic conditions, could be significant depending upon the location and number of commercial projects and the pace of development. The uncertainty associated with the preliminary analyses indicated that the BLM should defer approving the issuance of commercial leases until adequate information is available to define what the development will entail. This PEIS only analyzes the impacts of amending RMPs to make public lands available for application for leasing, whether that be for additional RD&D projects or commercial development or both. Unlike the BLM's practice with respect to oil and gas leasing, additional

NEPA analysis would be required prior to the issuance of any lease of oil shale or tar sands resources. Therefore, the BLM must defer more detailed and site-specific analyses until the time of leasing and/or review and approval of a project-specific plan of development.

2.5.2 Alternatives That Preclude Oil Shale and Tar Sands Leasing or Development

Several comments were received during the public scoping process that suggested that the BLM should not move forward to establish commercial leasing programs for oil shale or tar sands development on public lands. A variety of concerns were cited as reasons for not establishing commercial programs, including concerns regarding (1) the sensitivity of specific resources within the three-state study area, such as lands with wilderness characteristics, visual resources, ecological resources, and cultural resources; (2) the lack of definitive information about the technologies that will be employed in commercial operations; (3) the need for the nation to focus on alternative sources of energy, such as renewable resources; and (4) in the case of oil shale, the potential recurrence of adverse socioeconomic impacts resulting from a possible boom/bust cycle of development. Nonetheless, Section 369 of the Energy Policy Act of 2005 requires the BLM to evaluate establishment of commercial leasing programs for oil shale and tar sands development, and any alternatives in the PEIS other than the no action alternative that did not evaluate initiating a program for opening public lands for commercial leasing would not be consistent with the Energy Policy Act of 2005 or with the Purpose and Need for the PEIS.

2.5.3 Alternatives Considering Alternate Energy Sources and Carbon Sequestration

Several comments were received during public scoping that suggested that the BLM should evaluate the development of alternate energy sources, including renewable energy (e.g., wind and solar power systems), nuclear energy, and conventional oil and gas resources instead of or in comparison with the development of oil shale or tar sands. In addition, several comments suggested that the BLM should evaluate ways to displace the nation's dependence on oil through conservation and market- and innovation-based strategies. The BLM has determined that such evaluations, although worthwhile with respect to national energy policy development, do not fulfill the purpose of this PEIS, which is to evaluate opening public lands for commercial oil shale and tar sands development.

In addition, several comments suggested that the BLM should evaluate oil shale and tar sands technologies that incorporate carbon sequestration. The BLM believes this is an issue that would be best examined in detail at the time of site-specific NEPA analyses of a specific plan of development.

2.5.4 Alternatives That Prohibit Leasing in Specific Areas

A number of scoping comments requested that the BLM develop alternatives prohibiting commercial leasing in specific areas, including all NPS units, the GSENM, existing WSAs, and wilderness-quality lands in Utah. Since the scoping meetings were conducted, the BLM has determined that the scope of this PEIS will be limited to BLM-administered lands only and will not evaluate commercial leasing on USFS- and NPS-administered lands.

As discussed in Sections 2.3.3 and 2.4.3, Wilderness Areas, WSAs, other lands within the NLCS (including National Monuments), and existing ACECs currently closed to mineral development are excluded from consideration for leasing under all alternatives in the PEIS.

The BLM has not explicitly excluded leasing within lands it believes may have one or more characteristics of wilderness under any of the alternatives. Processes are underway in each of the field offices where such lands have been identified to determine appropriate management requirements for these areas. The PEIS identifies the location of such lands in Chapter 3 (see Section 3.1) and, in general terms, assesses the impacts of development on these lands in Chapters 4 and 5. When future site-specific NEPA analyses are conducted on the issuance of commercial leases, the presence of any lands with wilderness characteristics will be considered at that time. The presence of wilderness characteristics on lands otherwise available for multiple use, however, does not necessarily preclude mineral development.

2.5.5 Off-Site Processing of Oil Shale

At least one comment suggested that the BLM develop an alternative that examines off-site processing of oil shale in locations where environmental impacts may be mitigated by site-specific factors. The BLM has concluded that it does not have the authority to require that such steps be taken by lessees. In addition, constructing adequate scenarios that could evaluate all the possible locations and site-specific factors contributing to the magnitude (or mitigation) of impacts would be speculative and, potentially, misleading. Such considerations might be appropriate at the site-specific level when more information is known about the project location, specific technologies, and other factors. Potential mitigation opportunities could be incorporated into the project plan of development at that time.

2.5.6 Establishment of Federal Subsidies

Several comments suggested that the BLM evaluate the potential for federal subsidies and the level of subsidy required to facilitate leasing and development. This suggestion was considered to be outside the scope of the PEIS and BLM's authority, and beyond the mandate established by the Energy Policy Act of 2005.

2.5.7 Carrying-Capacity Thresholds

A number of commentors suggested that the BLM consider the potential impacts of oil shale development within the context of the carrying capacity of the regional and local environment and economies. The carrying capacity of a system is the maximum level of activity that can be sustained within a specific area without significant, detrimental impact. The White River RMP (BLM 1997b) established carrying-capacity thresholds specific to oil shale development and potential impacts on air quality, socioeconomic impacts, big game habitat, and water quality. Carrying-capacity thresholds have not been established elsewhere within the three-state study area. Although the programmatic alternatives do not explicitly consider carrying-capacity thresholds nor propose that commercial leasing levels be constrained in the future by these thresholds, they do require that additional site-specific NEPA analyses be conducted prior to the issuance of commercial leases. At that time, when complete information is available defining the location of the commercial development, technologies to be employed, scale of operations, and time line for development, analyses can more reliably define appropriate carrying-capacity thresholds and evaluate potential impacts.

2.5.8 Establishment of Trust Funds

Several commentors requested that the PEIS consider the establishment of a trust fund to provide financial support to local communities early in the development process. While the PEIS socioeconomic impact analyses consider the potential benefits of a trust fund in terms of impact mitigation, requiring lessees to establish such a fund is beyond the jurisdiction of the BLM and, therefore, is not included in any of the alternatives. If an applicant proposes such a fund as part of its plan of development, perhaps as potential mitigation for socioeconomic impacts, the BLM would analyze it in site-specific NEPA analyses of the plan of development.

2.6 COMPARISON OF ALTERNATIVES

The alternatives presented in this PEIS were evaluated for potential environmental impacts associated with the amendment of land use plans to identify BLM-administered lands in Colorado, Utah, and Wyoming that would be made available for application for leasing for commercial oil shale or tar sands development. The PEIS also identifies the types of environmental impacts that could accompany commercial oil shale and tar sands development. More quantitative and detailed impact analysis, including the identification of the magnitude and extent of potential impacts on specific social, cultural, economic, and natural resources, will be conducted at the leasing and project levels. Table 2.6-1 summarizes the impacts of oil shale alternatives, and Table 2.6-2 summarizes the impacts of the tar sands alternatives that are more fully described in Chapter 6 of the PEIS.

TABLE 2.6-1 Summary Comparison of Potential Environmental Impacts of Amending Land Use Plans to Identify Lands Available for Application for Leasing for the Commercial Development of Oil Shale, Including RD&D, in Colorado, Utah, and Wyoming, and Environmental Impacts of Future Construction and Operation of Commercial Projects under the Three Alternatives

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Impacts Common To All	The six existing 160-acre RD&D projects are valid existing rights and the impacts are the same for each of the alternatives. Each of the existing RD&D projects may be expanded to include a total of 5,120 acres if the terms and conditions of their existing leases are met. Commercial development could occur on a total acreage of 30,720 acres based on these existing leases. Impacts identified under Alternative A for the RD&D leases will be the same in Alternatives B and C. On the basis of the analysis in this PEIS, the BLM has determined that, with the exception noted in the socioeconomic analysis regarding potential impacts on property values, land use plan amendments would not result in any impacts on the environment or socioeconomic setting. However, the future development of commercial oil shale projects that could be approved after subsequent NEPA analysis identified in both of these alternatives would have impacts on these resources. The types of impacts that could be associated with future commercial oil shale development are described in Chapter 4 of the PEIS. The magnitude of these potential impacts cannot be quantified at this time because key information about the location of commercial projects, the technologies that may be employed, the project size or production level, development time lines, and mitigation measures that would be applied, are unknown.		

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Land Use	RD&D project development and operations are not expected to affect land use on adjacent parcels except where vehicular traffic, noise, and construction and operations activities could alter the quality of recreational activities.	Same as Alternative A.	Same as Alternative A.
	Current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction would be affected at locations where commercial oil shale projects (and supporting infrastructure) would be located within the 352,780 acres designated as available for commercial leasing. These lands include 3 ACECs totaling 4,853 acres, approximately 26,732 acres of potential ACECs, and 6,973 acres of lands with wilderness characteristics. Potential impacts on these areas are subject to decisions in the existing RMPs	Current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction would be affected at locations where commercial oil shale projects (and supporting infrastructure) would be located within the 1,991,222-acre proposed lease area. These lands include 10 ACECs totaling 23,000 acres, approximately 185,000 acres of potential ACECs, and 170,000 acres of lands with wilderness characteristics.	Potential impacts of commercial development would be similar to the impacts identified for commercial development under Alternative B, but excludes 23,000 acres of existing ACECs; would have less impact on oil and gas activities, especially in the Piceance Basin; and would include 110,000 acres of lands with wilderness characteristics and 137,000 acres of lands with potential for designation as ACECs.
	Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.	Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.	

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Soil and Geologic Resources	Geologic resources could be affected by construction and operation activities at the six 160-acre RD&D locations and at areas where support infrastructure (e.g., utility ROWs and access roads) would be located.	Same as Alternative A.	Same as Alternative A.
	Impacts on soil and geologic resources at the RD&D locations would be associated with soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Same as Alternative A	Same as Alternative A
	Future commercial oil shale development could affect soil and geologic resources in the Alternative A potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts would be associated with the construction and operation of project facilities and related infrastructure and would include soil disturbance, soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Future commercial oil shale development could affect soil and geologic resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts would be associated with the construction and operation of project facilities and related infrastructure and would include soil disturbance, soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Potential project impacts from future project development would be similar to those identified for Alternative B but could occur at fewer locations and in less geologically sensitive locations.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Paleontological Resources	The construction and operation of the RD&D projects is not expected to significantly impact paleontological resources in the six project areas.	Same as Alternative A.	Same as Alternative A.
	Within the 352,780 acres available for oil shale development under existing RMPs, including the lands in the PRLAs for the RD&D projects, approximately 97% of the area in Colorado and 99% of the area in Utah are considered as having high potential for containing significant paleontological resources (i.e., conditional Potential Fossil Yield Classification 4/5).	About 1.8 million acres (90%) of the proposed lease areas have the potential to contain important paleontological resources, and future commercial oil shale development could affect paleontological resources in these areas. Project-related impacts would be associated with construction and mining activities and could result in the damage or destruction of resources in or near the development areas.	Potential impacts of commercial project development on paleontological resources in these areas would be similar to those identified for Alternative B but could occur in fewer locations. About 750,000 acres (90%) of the Alternative C lease areas have the potential to contain important paleontological resources.
	Commercial oil shale development could impact paleontological resources at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located.	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Water Resources	Water resources could incur localized impacts as a result of construction and operation activities of the six RD&D projects. Surface disturbance at the sites could lead to increased erosion and subsequent runoff and sedimentation to local streams, while groundwater could be affected by dewatering or contamination from accidental releases of hazardous materials (e.g., fuels and industrial solvents).	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Water Resources (Cont.)	Commercial oil shale development could impact water resources in the Alternative A potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. About 152 mi of perennial streams (or about 76% of the total perennial streams in the basin) are within the geologically prospective oil shale area, plus a 2-mi buffer zone in the Piceance Basin. In Utah, about 57 mi of perennial streams (or about 22% of the total streams in the Uinta Basin) are within areas available for lease. Seventeen acres of protected floodplains, wetlands, and riparian areas occur within the lease areas in Colorado and Utah.	Commercial oil shale development could impact water resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. The Alternative B potential lease areas include about 248 mi of perennial streams and 45,000 acres of lands with sensitive hydrologic features, which could be affected by the future construction and operation of commercial oil shale facilities in the potential lease areas. Potential project-related impacts may include reduced water quality due to erosion and sedimentation, dewatering of local aquifers, modification of surface and groundwater flow, and contamination of surface water or groundwater by accidental releases of hazardous materials.	Potential impacts from future construction and operation of commercial oil shale projects would be similar to those identified for Alternative B. Alternative C includes only 65 mi of perennial streams that could be affected by commercial project development. In addition, Alternative C excludes lands that are currently identified in BLM land use plans as having steep slopes and/or fragile or highly erosive soils included in Alternative B. Thus, there is a reduced potential for erosion-related impacts with commercial oil shale development under this alternative.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Air Quality	Air quality is not expected to be adversely affected by the construction and operation of the six RD&D projects. Minor, localized impacts could result from vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and oil shale processing emissions.	Same as Alternative A.	Same as Alternative A.
	Commercial oil shale development could impact air quality in the Alternative A potential lease areas and at locations on nonfederal lands where project-related infrastructure would be located. The construction and operation of future commercial oil shale projects could result in local and regional impacts on air quality. Local impacts could result from vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and oil shale processing emissions.	Commercial oil shale development could impact air quality in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure would be located. The construction and operation of future commercial oil shale projects could result in local and regional impacts on air quality. Local impacts could result from vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and oil shale processing emissions.	Potential impacts on air quality would be similar to those identified for Alternative B. However, Alternative C has approximately 1.2 million fewer acres of land than Alternative B where future commercial oil shale development could occur and affect local or regional air quality.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Noise	Localized noise impacts (i.e., increased noise levels) could occur at each of the RD&D project locations as a result of construction activities, mining, operating machinery (e.g., crushers and conveyors) and other equipment (generators and compressors), and vehicular traffic.	Same as Alternative A.	Same as Alternative A.
	Commercial oil shale development could affect noise levels in the Alternative A potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located.	Potential noise impacts would be similar to those identified for Alternative A. However, Alternative B has approximately 1.6 million more acres of land than Alternative A where future commercial oil shale development could occur and affect local noise levels.	Potential noise impacts would be similar to those identified for Alternative A. However, Alternative C has approximately 480,000 more acres of land than Alternative A where future commercial oil shale development could occur and affect local noise levels.
	Local noise levels could be affected by operating construction, mining and processing equipment, pipeline compressor stations, and vehicle traffic. Such impacts could occur within the Alternative A potential lease areas wherever a project would be developed.		

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Ecological Resources (resource subgroups summarized below)	Ecological resources could be affected at each of the six RD&D locations. RD&D project-related impacts may include wildlife disturbance, habitat loss, exposure to accidental releases of hazardous materials, the spread or establishment of invasive species, and the loss or injury of biota within physically disturbed areas related to the projects (e.g., utility ROWs and access roads).	Same as Alternative A.	Same as Alternative A.
	Commercial oil shale development could impact ecological resources in the Alternative A potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located.	Commercial oil shale development could impact ecological resources in Alternative B potential lease areas in the same manner as Alternative A but on 1.6 million more acres.	Commercial oil shale development within the Alternative C potential lease areas could adversely affect ecological resources in these areas in the same manner as in Alternative A but would occur on 480,000 more acres of land, some of which has been excluded because of the presence of sensitive ecological resources.
	Indirect impacts such as those related to surface and groundwater withdrawals could occur in more distant, but hydrologically connected, areas.	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Aquatic Resources	The Alternative A lease areas overlap portions of 19 perennial streams totaling about 209 mi of stream habitat. Aquatic resources could be affected by changes in water quality due to erosion and runoff and accidental releases of hazardous materials from project areas. Surface water depletion resulting from groundwater and surface water use could negatively affect aquatic resources. Some aquatic biota could be impacted as a result of the physical disturbance of aquatic habitats during construction and by utility and ROW crossings. Project-related ROWs could also increase public access to aquatic habitats.	The Alternative B potential lease areas include 50 perennial streams totaling 680 mi, and the construction and operation of commercial oil shale projects within the lease areas could adversely affect aquatic resources in these streams. Potential types of impacts would be similar to those identified for Alternative A and could result in habitat loss or degradation, which could affect the abundance and distribution of aquatic biota in the affected habitats.	The Alternative C potential lease areas include 41 perennial streams totaling 426 mi, and aquatic resources in these streams could be impacted by commercial oil shale development. Potential impacts would be similar in nature to those identified for Alternative B but could occur in fewer locations.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Plant Communities and Habitats	The construction and operation of commercial oil shale projects in areas available for leasing under Alternative A could affect plant communities and habitats, including oil shale endemics on or near project sites and in areas where associated infrastructure would be located. Impacts could include direct loss of vegetation from site clearing and grading; reduced habitat quality due to soil compaction, dewatering, water quality reduction, erosion, sedimentation, or accidental releases of hazardous materials; and the introduction or spread of invasive species. Utility and access road ROWs could also result in the fragmentation of some habitats. The areas available for lease application include about 17 acres that have been identified for the protection of wetlands, riparian habitat, and floodplains. Direct impacts on the six RD&D project sites would include the loss of about 700 acres of habitat.	The construction and operation of commercial oil shale projects could impact plant communities and habitats that are present in the Alternative B potential lease areas. These potential lease areas include about 41,000 acres that have been identified for the protection of wetlands, riparian habitats, and floodplains. Potential impacts would be similar in nature to those identified for Alternative A but could occur in many more locations.	The construction and operation of commercial oil shale projects could impact plant communities and habitats that occur in the Alternative C potential lease areas. These potential lease areas do not include the 41,000 acres of land currently identified for the protection of wetlands, riparian habitats, and floodplains. Potential impacts would be similar in nature to those identified for Alternative B but could occur in fewer locations.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Wildlife	The construction and operation of commercial oil shale projects could disturb wildlife and their habitats where individual projects are located within the 352,780 acres that have already been allocated for leasing application. Wildlife habitats identified for protection in BLM land use plans that would be present in the lease application areas include nearly 40,000 acres of sage grouse nesting habitat, about 11,500 acres of raptor nests, more than 46,000 acres of big game severe winter range, more than 155,000 acres of deer and elk summer range, and nearly 56,000 acres of wild horse Herd Management Areas (HMAs).	The construction and operation of commercial oil shale projects could disturb wildlife and their habitats where individual projects are located within the 1,991,222 acres identified as available for leasing application. Wildlife habitats identified for protection in BLM land use plans that would be present in the lease application areas include more than 400,000 acres of greater sage-grouse nesting habitat, more than 100,000 acres of raptor nests, about 89,000 acres of big game severe winter range, more than 163,000 acres of deer and elk summer range, and more than 65,000 acres of wild horse HMAs. Potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative A but could occur in more locations.	The construction and operation of commercial oil shale projects could disturb wildlife and their habitats where individual projects are located within the 830,296 acres identified as available for leasing application. Those lease areas do not include the acres of land currently identified for the protection of wildlife habitats and wild horse HMAs. Potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative B but could occur in fewer locations.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Wildlife (Cont.)	Potential impacts on these habitats and their wildlife would be associated with site clearing and grading, operational noise and activities, accidental releases of hazardous materials, and increased human access to some habitats, and could result in reduced abundance and distribution of affected species. The construction and operation of the six RD&D projects would eliminate about 666 acres of wildlife habitat as a result of clearing activities at each of the six sites. Construction and operation activities could also disturb wildlife in nearby locations and also fragment habitats along the RD&D project-related ROWs.	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Threatened and Endangered Species	Sixty-eight federal candidate, BLM-designated sensitive, and state-listed species, and 14 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative A. Of these, 31 federal candidate, BLM-designated sensitive, and state-listed species, and 8 federally listed threatened or endangered species could occur in RD&D areas. Approximately 61,000 acres of land with existing lease stipulations for the protection of listed species would be available for leasing under Alternative A. Impacts on threatened and endangered species would be similar to or the same as those described for impacts on aquatic resources, plant communities and habitats, and wildlife. Specific impacts associated with development would depend on the locations of projects relative to species populations and the details of project development.	One hundred and seventy federal candidate, BLM-designated sensitive, and state-listed species, and 14 federally listed threatened or endangered species could occur in areas that are available for leasing application under Alternative B. Approximately 382,000 acres of land with existing lease stipulations for the protection of listed species would be available for leasing under Alternative B. Potential types of impacts would be similar to those for Alternative A.	One hundred and seventy federal candidate, BLM-designated sensitive, and state-listed species, and 14 federally listed threatened or endangered species could occur in areas that are available for leasing application under Alternative C. Lands with existing lease stipulations for the protection of listed species would not be available for leasing under Alternative C. Potential types of impacts would be similar to those for Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Visual Resources	The construction and operation of the six RD&D projects and projects elsewhere in the potential lease areas would have visual impacts at each project location. Short- and long-term visual impacts may result with the construction and operation of the projects and would be associated with construction activities at each site and along associated ROWs. Additional visual impacts may be associated with the presence of site facilities within viewsheds and with lighting pollution. Construction impacts would be short-term, while impacts associated with facility presence and site lighting would continue through the life of each project.	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Visual Resources (Cont.)	Commercial oil shale development could impact visual resources on the Alternative A lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts from project construction and operation would be similar to those identified for Alternative A. Visually sensitive areas within the potential lease areas include 2 ACECs, 2 potential ACECs, and 2 river segments eligible for WSR designation. Sensitive areas occurring within 5 mi of the potential lease areas include 1 WSA, 6 ACECs, 4 potential ACECs, and 4 WSR-eligible river segments. These visually sensitive areas could be affected by future commercial oil shale development within the Alternative A lease areas.	Commercial oil shale development could impact visual resources on the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts from project construction and operation would be similar to those identified for Alternative A. Visually sensitive areas within the potential lease areas include 10 ACECs, 10 potential ACECs, and 2 river segments eligible for WSR designation. Sensitive areas occurring within 5 mi of the proposed lease areas include 7 WSAs, 11 ACECs, 13 potential ACECs, 9 WSR-eligible river segments, 1 National Scenic Highway, and 9 National Historic Trails. These visually sensitive areas could be affected by future commercial oil shale development within the Alternative B lease areas.	Potential impacts from project construction and operation would be similar to those identified for Alternative B. Visual impacts from commercial project development could occur, depending on individual project location, within the 830,296 acres made available for leasing under Alternative C. Visually sensitive areas within the potential lease areas include 10 potential ACECs, while sensitive areas within 5 mi of the lease areas include 7 WSAs, 12 ACECs, 13 potential ACECs, 9 WSR-eligible river segments, 1 National Scenic Highway, and 9 National Historic Trails.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Cultural Resources	The six RD&D sites have been surveyed for cultural resources, and two of the sites contain cultural resources. Because mitigation is required for these sites, the construction and operation of the six projects are not expected to significantly impact cultural resources. However, approximately 298,000 acres of the available area have the potential to contain important cultural resources. Some of these resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or destruction, and increased potential for vandalism or theft due to increased human access.	Commercial oil shale development could impact cultural resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Approximately 1.6 million acres that would be available for leasing application have the potential to contain important cultural resources. Some of these resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or destruction, and increased potential for vandalism or theft due to increased human access.	Approximately 719,000 acres have the potential to contain important cultural resources. Potential impacts on these resources from commercial oil shale development within the Alternative C lease areas would be similar to those identified for Alternative B but could occur in fewer locations.
Socioeconomics	Construction and operation associated with individual oil shale technologies, including the RD&D facilities would have small to moderate impacts on employment, income, population, housing, public finances, and public service employment in the ROI in each state. Small to moderate impacts on property.	Same as Alternative A.	Same as Alternative A.
		Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur.	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Environmental Justice	Environmental and human health impacts on the general population are expected to be low. Construction and operation of the six RD&D projects could have minor disproportionate impacts on minority and low-income populations, depending on their location, primarily associated with changes in quality of life and social disruption. Property value and visual impacts would depend on the location of land parcels impacted by oil shale projects, their importance for subsistence, their cultural and religious significance, and possible alternate economic uses.	Same as Alternative A.	Same as Alternative A.
	Larger scale oil shale project construction and operation could disproportionately impact minority and low-income populations depending on their location. Changes in quality of life and social disruption caused by rapid in-migration of population into rural communities would likely occur,	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

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Environmental Justice (Cont.)	thereby undermining local community social structures and requiring a transition to more urban life styles. The impacts of facility operations on air and water quality and on the demand for water for agriculture in the region could also cause environmental justice impacts. Land use and visual impacts would depend on the location of land parcels impacted by oil shale projects, their importance for subsistence, their cultural and religious significance, and possible alternate economic uses.	Minority or low-income populations within the study area would not incur any impacts from amending land use plans.	Minority or low-income populations within the study area would not incur any impacts from amending land use plans.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Hazardous Materials and Waste Management	The six RD&D projects would use and generate similar types of hazardous materials and wastes. Hazardous materials would include fuels for equipment and heating, lubricating oils, solvents, and other industrial chemicals, as well as materials produced during oil shale processing. Herbicides may also be used to clear and/or control vegetation at project locations and along utility ROWs. Waste materials would also be similar among the six RD&D projects; these would include solids such as construction debris. Liquid wastes would include both sanitary and industrial wastewater.	The use and generation of hazardous materials and wastes from the six RD&D projects would be the same as those identified for Alternative A.	The use and generation of hazardous materials and wastes from the six RD&D projects would be the same as those identified for Alternative A.
	Future commercial oil shale development within the potential lease areas would use and generate similar types of hazardous materials and wastes as would be generated for the RD&D projects. Spent shale may also be generated in large quantities if development by mining occurs; the shale would require management as a waste. The specific types and amounts and their handling and treatment would depend on the specific design of each commercial project.	Same as Alternative A.	Same as Alternative A.

TABLE 2.6-1 (Cont.)

Resource	Alternative A: No Action. 352,780 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended to allow for Additional Oil Shale Development[a]	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 1,991,222 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]	Alternative C: Amend Land Use Plans to Identify 830,296 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Commercial Oil Shale Development[b]
Health and Safety	The construction and operation of the six RD&D projects could result in health and safety impacts on workers. These impacts would be associated with accidents causing injuries and fatalities, possible hearing loss from high noise levels, and inhalation of particulates and/or volatiles emitted from the facilities. Injuries from all RD&D projects are estimated at about 75 per year during construction and 40 per year during operations; less than 1 fatality per year is estimated for both construction and operations.	Potential health and safety impacts from the six RD&D projects would be the same as those identified for Alternative A.	Potential health and safety impacts from the six RD&D projects would be the same as those identified for Alternative A.
	The commercial development of oil shale projects in the potential lease areas would have the same types of health and safety impacts as would occur in association with the RD&D projects, but the potential incidence of those impacts would be greater.	Same as Alternative A.	Same as Alternative A.

[a] The adverse impacts of the RD&D projects will be addressed through mitigation measures described in the environmental assessments (EAs) for those projects. All the EAs resulted in Findings of No Significant Impact (BLM 2006c-j; 2007b,c).

[b] Under both Alternatives B and C, the nature, magnitude, and extent of project-related impacts of commercial development on all resource areas would depend on the type, location, and design of the individual projects.

TABLE 2.6-2 Summary Comparison of Potential Environmental Impacts of Amending Land Use Plans to Identify Lands Available for Application for Leasing for the Commercial Development of Tar Sands, Including RD&D, in Colorado, Utah, and Wyoming, and Environmental Impacts of Future Construction and Operation of Commercial Projects under the Three Alternatives

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Impacts Common to Alternatives B and C	NA[a]	On the basis of the analysis in the PEIS, the BLM has determined that, with the exception noted in the socioeconomic analysis regarding potential impacts on property values, land use plan amendments would not result in any impacts on the environment or socioeconomic setting. However, the future development of commercial oil shale projects that could be approved after subsequent NEPA analysis identified of these alternatives would have impacts on these resources. The types of impacts that could be associated with future tar sands development are described in Chapter 5 of the PEIS. The magnitude of these potential impacts cannot be quantified at this time because key information about the location of commercial projects, the technologies that may be employed, the project size or production level, development time lines, and mitigation measures that would be applied, are unknown.	

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Land Use	NA	Future commercial tar sands development could affect current land use in the Alternative B proposed lease areas. Current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction would be affected at locations where commercial tar sands projects (and supporting infrastructure) would be located. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., employer-provided housing) would be constructed. The areas available for application for lease include approximately 180,000 acres of potential ACECs and 100,000 acres of lands with wilderness characteristics.	Potential impacts on land use from commercial development would be similar to those identified for Alternative B but would be restricted to about 200,000 fewer acres of federal land. The lands available for lease application under Alternative C include approximately 85,000 acres of potential ACECs and approximately 68,000 acres identified as having wilderness characteristics.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Soil and Geologic Resources	NA	Future commercial tar sands development could affect soil and geologic resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential impacts would be associated with the construction and operation of project facilities and related infrastructure and would include soil disturbance, soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Potential impacts on soil and geologic resources from commercial tar sands development would be similar to those identified for Alternative B, but under Alternative C impacts could occur at fewer locations and in less geologically sensitive locations.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Paleontological Resources	NA	About 335,000 acres of the proposed lease areas have the potential to contain important paleontological resources, and future commercial tar sands development could affect paleontological resources in these areas. Project-related impacts would be associated with construction and mining activities and could result in the damage or destruction of resources in or near the development areas. Commercial tar sands development could impact paleontological resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located.	Potential impacts on paleontological resources from commercial project development in these areas would be similar to those identified for Alternative B but could occur in significantly fewer locations. About 148,000 acres of the Alternative C potential lease areas have the potential to contain important paleontological resources.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Water Resources	NA	Commercial tar sands development could impact water resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential project-related impacts may include reduced water quality due to erosion and sedimentation, dewatering of local aquifers, and contamination of surface water or groundwater by accidental releases of hazardous materials. The Alternative B potential lease areas include about 28 mi of perennial streams that could be affected by commercial project development.	Potential impacts on water resources from future construction and operation of commercial tar sands projects in the Alternative C potential lease areas would be similar to those identified for Alternative B. Alternative C excludes from lease application about 200,000 acres of land that is currently identified in BLM land use plans as having steep slopes and/or fragile or highly erosive soils and included under Alternative B. Thus, there is a reduced potential for erosion-related impacts with commercial tar sands development under Alternative C. Alternative C potential lease areas include about 19 mi of perennial streams that could be affected by commercial project development.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Air Quality	NA	Commercial tar sands development could impact air quality in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. The construction and operation of future commercial tar sands projects could result in local and regional impacts on air quality. Local impacts could result from vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and tar sands processing emissions. Because of the need for project- and site-specific information, it is not possible to identify the nature and magnitude of regional air quality impacts from commercial development within the Alternative B potential lease areas.	Potential impacts on air quality from the construction and operation of commercial tar sands projects would be similar to those identified for Alternative B. However, Alternative C has approximately 202,000 fewer acres of land than Alternative B where future commercial tar sands development could occur and affect local or regional air quality.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Noise	NA	Commercial tar sands development could affect noise levels in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Local noise levels could be affected by operating construction, mining and processing equipment, pipeline compressor stations, and vehicle traffic. Such impacts could occur within the Alternative B potential lease areas wherever a project would be developed.	Potential noise impacts from commercial tar sands development would be similar to those identified for Alternative B. However, Alternative C has approximately 202,000 fewer acres of land than Alternative B where future commercial tar sands development could occur and affect local noise levels.
Ecological Resources (resource subgroups summarized below)	NA	Commercial tar sands development could impact ecological resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Indirect impacts such as those related to surface and groundwater withdrawals could occur in more distant, but hydrologically connected, areas.	Commercial tar sands development impacts would be similar to those identified for Alternative B but would occur on 202,000 fewer acres of land, some of which has been excluded because of the presence of sensitive ecological resources. Indirect impacts, such as those related to surface and groundwater withdrawals, could occur in more distant, but hydrologically connected areas.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Aquatic Resources	NA	The Alternative B allocation areas include 9 perennial streams totaling about 29 mi of aquatic habitat. The construction and operation of commercial tar sands projects within the potential leases areas could adversely affect aquatic resources in these streams. Surface water depletions resulting from groundwater and surface water use could adversely affect aquatic resources. Potential impacts could result in habitat loss or degradation, affecting the abundance and distribution of aquatic biota in the affected habitats.	The Alternative C allocation areas include 8 perennial streams totaling about 20 mi of aquatic habitat. Aquatic resources in these streams could be impacted by the commercial tar sands development. When aquatic habitat within 2 mi of the allocation areas is considered, Alternative C has the potential to affect less aquatic habitat than Alternative B.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Plant Communities and Habitats	NA	The construction and operation of commercial tar sands projects could impact plant communities and habitats that are present in the Alternative B potential lease areas. The potential lease areas include about 1,599 acres that have been identified for the protection of floodplains. Impacts could include direct loss of vegetation from site clearing and grading; reduced habitat quality due to soil compaction, dewatering, water quality reduction, erosion, sedimentation, or accidental releases of hazardous materials; and the introduction or spread of invasive species. Utility and access road ROWs could also result in the fragmentation of some habitats.	The construction and operation of commercial tar sands projects could impact plant communities and habitats that occur in Alternative C potential lease areas. The areas where commercial development could occur do not include land currently identified for protection of floodplains. Potential impacts would be similar in nature to those identified for Alternative B but could occur in fewer locations.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Wildlife	NA	The construction and operation of commercial tar sands projects could disturb wildlife and their habitats where individual projects are located within the 431,224 acres identified as available for leasing. Wildlife habitats identified for protection in BLM land use plans that would be present in the lease application areas include more than 2,500 acres of greater sage-grouse lek sites, 7 acres of raptor nests, about 18,000 acres of deer fawning and elk calving crucial habitat, more than 3,800 acres of desert bighorn sheep crucial habitat, more than 12,000 acres of elk crucial winter habitat, and nearly 5,900 acres of pronghorn crucial kidding habitat. Potential impacts on these habitats and their wildlife would be associated with site clearing and grading, operational noise and activities, accidental releases of hazardous materials, and increased human access to some habitats, and could result in reduced abundance and distribution of affected species.	The construction and operation of commercial tar sands projects could disturb wildlife and their habitats where individual projects are located within the 229,038 acres identified as available for leasing. Potential impacts would be similar to those identified for Alternative B but could occur in fewer locations. However, lands with existing lease stipulations for the protection of wildlife would not be available for application for leasing under Alternative C.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Threatened and Endangered Species	NA	Ninety-five federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for leasing under Alternative B. Approximately 15,450 acres of land with existing lease stipulations for the protection of listed species would be available for application for leasing under Alternative B. Impacts on threatened and endangered species would be similar to or the same as those described for impacts on aquatic resources, plant communities and habitats, and wildlife. Specific impacts associated with development would depend on the locations of projects relative to species populations and the details of project development.	Ninety-five federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative C. Lands with existing lease stipulations for the protection of listed species would not be available for leasing under Alternative C. Potential types of impacts on these species, which are the same identified for Alternative B, would be similar to those for Alternative B.
Visual Resources	NA	Commercial tar sands development could impact visual resources in the Alternative B lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Short- and long-term visual impacts may result with	Visually sensitive areas within the proposed lease areas include 11 ACECs and 1 WSR-eligible river segment. Sensitive areas within 5 mi of the lease areas include 18 WSAs, 13 ACECs, 18 potential ACECs, 18 WSR-eligible river segments, 1 National Park, 1 NRA, and 2 scenic highways. Because of

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Visual Resources (Cont.)		the construction and operation of the projects and would be associated with construction activities at each site and along associated ROWs. Additional visual impacts may be associated with the presence of site facilities within viewsheds and lighting pollution. Visually sensitive areas within the proposed lease areas include 11 potential ACECs, 1 river segment eligible for WSR designation, and 1 national scenic highway. Sensitive areas occurring within 5 mi of the proposed lease areas may include as many as 19 WSAs, 11 ACECs, 18 potential ACECs, 18 WSR-eligible river segments, 1 National Park, 1 NRA, and 2 national scenic highways. These visually sensitive areas could be affected by future commercial tar sands development within the Alternative B lease areas.	the similarity in sensitive visual resource areas within and near each proposed lease area, potential impacts from commercial project development would be similar to those identified for Alternative B.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Cultural Resources	NA	Commercial tar sands development could impact cultural resources in the Alternative B potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Approximately 221,000 acres of the land that would be available for leasing application have the potential to contain important cultural resources. Some of these resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or destruction and increased potential for vandalism or theft due to increased human access.	Approximately 97,000 acres that would be available for lease application have the potential to contain important cultural resources. Potential impacts on these resources from commercial tar sands development within the Alternative C potential lease areas would be similar to those identified for Alternative B but could occur in fewer locations.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Socioeconomics	NA	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur. Construction and operation associated with individual tar sands technologies would have small to moderate impacts on employment, income, population, housing, public finances, and public service employment in the ROI. Small to moderate impacts on property values and recreation would also occur, and water diversions would also affect agriculture. Rapid increases in population in-migration in the ROI could impact quality of life, in particular requiring a transition from traditional rural, to more urban lifestyles, and potentially cause large social disruption impacts.	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur. Potential project impacts would be similar to those identified for Alternative B.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Environmental Justice	NA	Tar sands project construction and operation would disproportionately impact minority and low-income populations depending on their location. Changes in quality of life caused by rapid in-migration of population into rural communities would likely occur, thereby undermining local community social structures and requiring a transition to more urban life styles. Social disruption would also occur. The impacts of facility operations on air and water quality and on the demand for water for agriculture in the region could also cause environmental justice impacts. Land use and visual impacts would depend on the location of land parcels impacted by tar sands projects, their importance for subsistence, their cultural and religious significance, and possible alternate economic uses.	Potential project impacts would be similar to those identified for Alternative B.

TABLE 2.6-2 (Cont.)

Resource	Alternative A: No Action	Alternative B: the Proposed Plan Amendment. Amend Land Use Plans to Identify 431,224 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]	Alternative C: Amend Land Use Plans to Identify 229,038 Acres of Federal Land in Utah as Available for Application for Commercial Tar Sands Development[b]
Hazardous Materials and Waste Management	NA	Future commercial tar sands development within the Alternative B potential lease areas would use and generate similar types of hazardous materials and wastes. Spent tar sands may also be generated in large quantities if development by mining occurs; the shale would require management as a waste. The specific types and amounts and their handling and treatment would depend on the specific design of each commercial project.	For individual projects, the types and amounts of hazardous materials and wastes that could be used and generated during commercial tar sands development would be the same as those identified for Alternative B.
Health and Safety	NA	Commercial tar sands project development may result in worker injuries or fatalities from accidents, possible hearing loss from high noise levels, and inhalation of particulates and/or volatile compounds.	Potential health and safety impacts from project construction and operation would be similar to those identified for Alternative B and identical for projects with identical plans of development and located in common lease areas.

a NA = not applicable.

b Under both Alternatives B and C, the nature, magnitude, and extent of project-related impacts of commercial development on all resource areas would depend on the type, location, and design of the individual projects.

2.7 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed.

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USGS, 1980k, *White Canyon, Utah Tar Sand Leasing Minutes No. 11*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

Wiig, S., 2006a, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to P. Perlewitz (BLM Wyoming State Office, Cheyenne, Wyo.), June 13.

Wiig, S., 2006b, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to K.P. Smith (Argonne National Laboratory, Lakewood, Colo.), June 27.

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3 AFFECTED ENVIRONMENT

This PEIS provides an assessment of environmental, social, and economic issues at a programmatic level and not at the site-specific level. The descriptions of the affected environment presented in this chapter do not provide detailed information about conditions at specific project locations. These descriptions provide the level of detail needed to assess the range of possible impacts that may occur because of potential oil shale or tar sands resource leasing and development on BLM-administered lands.

3.1 LAND USE

This section describes the wide range of land uses that occur on BLM-administered lands and other lands within the study area. General information about the management of BLM-administered lands is presented in the context of each BLM field office and administrative unit that has jurisdiction over the oil shale and tar sands resources evaluated in this PEIS. Additional information is presented about other federal lands that coincide with oil shale and tar sands resources, and general information is presented about the use of other federal and state lands in the area. A description of the management of BLM-administered lands is presented in Section 2.2.3.

Decisions within this PEIS apply only to lands administered by the BLM. Tables 2.3-1 and 2.4-1 in Chapter 2 identify the total acreage included within the study area for the PEIS. The total acreage included in the most geologically prospective areas for oil shale and tar sands (the STSAs) is approximately 4.5 million surface acres. The BLM administers approximately 2.7 million surface acres of this total, or approximately 60%. The remaining 40% of acres are owned by states, Tribes, local governments, and private individuals and corporations, or are administered by other federal agencies (e.g., the USFWS and NPS). These lands are interspersed throughout the study areas, and activities on all of these lands have the potential to affect lands owned or managed by others. Figures 2.3.3-1, 2.3.3-2, and 2.3.3-3 in Chapter 2 illustrate how these lands are interspersed. Privately owned lands within the study areas total approximately 870,000 acres or 19%. Much of the privately owned land derived from the operation of the many and varied federal public land laws that were designed and intended to facilitate settlement of the West. The pattern of private ownership tends to concentrate along rivers, streams, and other sources of perennial water; at the intersections of historical travel routes; and in areas of more fertile farm and ranch lands. Both historically and today, private lands and communities have had strong economic, cultural, and social ties to the federally managed lands which surround them. Uses on these federal lands are of extremely high interest to local communities and also, increasingly, to populations that are far removed from them.

3.1.1 BLM Land Use Plans within the Study Area

Table 3.1.1-1 lists the BLM field offices and administrative units with jurisdiction over areas containing the oil shale and tar sands resources evaluated in this PEIS. The table includes the names of the existing land use plans and estimates of the total acreage of BLM-administered and split estate lands that coincide with the most geologically prospective oil shale areas and STSAs being evaluated in this PEIS. As discussed in Section 1.4.3, management decisions contained in these existing BLM land use plans have been incorporated into the analyses conducted in this PEIS. In turn, the ROD resulting from the final PEIS will amend these land use plans to incorporate management decisions related to making land available for application for commercial leasing and development of oil shale and tar sands resources. Figure 3.1.1-1 shows the distribution of public lands administered by the BLM within the region where the oil shale and tar sands resources are located.

The following sections provide an overview of each administrative unit and corresponding land use plan that falls within the PEIS study area. Information about ongoing planning activities and the status of each land use plan is presented. In addition, information about specially designated areas and land uses (e.g., energy and mineral development activities, grazing, recreational use, and ROW authorizations) is presented for those areas that coincide with the oil shale or tar sands resources or could be impacted by their commercial leasing and development. Some of these activities, such as grazing and recreational use, are widespread and dispersed across any given planning area. Similarly, ROW authorizations are extensive in some planning areas. The information presented in these sections is not exhaustive; individual land use plans provide more complete descriptions of land use.

3.1.1.1 Glenwood Springs Field Office, Colorado

The Glenwood Springs RMP (BLM 1988) was first issued in 1984, revised in 1988, and has been amended numerous times. The BLM administers approximately 566,000 acres within the planning area encompassed by this RMP (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin; no tar sands resources are located within the jurisdiction of this field office.

In 2001, the Glenwood Springs RMP was amended to revoke previous decisions to withdraw deposits of oil shale and public lands containing such deposits from leasing or other disposal, in order to protect the oil shale resource pending further study and classification (BLM 2001a). The withdrawals were no longer considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

Other energy and mineral development on lands managed by the Glenwood Springs Field Office includes oil and gas and coal. In the 1988 version of the RMP, most of the lands in the field office region were designated as open to mineral leasing and development. Of these, only oil and gas resources overlap the oil shale resources being evaluated in this PEIS. In 1991 and again in 1999, in response to increased oil and gas development activities, the RMP was amended to facilitate orderly, economic, and environmentally sound exploration and

TABLE 3.1.1-1 BLM Field Offices and Administrative Units, Existing Land Use Plans, and Estimated Surface Acreages Overlying the Most Geologically Prospective Oil Shale Resources and STSAs

		Estimated Surface Overlying the Resources (acres)[a]			
		Oil Shale		Tar Sands	
Field Office	Existing Land Use Plan	BLM	Split Estate	BLM	Split Estate
Colorado					
Glenwood Springs	Glenwood Springs RMP (BLM 1988, as amended by the Roan Plateau Plan Amendment [BLM 2007a, 2008])	10,442	3,715	0	0
Grand Junction	Grand Junction RMP (BLM 1987a)	181	3,843	0	0
White River	White River RMP (BLM 1997a, as amended by the Roan Plateau Plan Amendment [BLM 2007a, 2008])	309,086	34,382	0	0
Colorado total		319,710	41,940	0	0
Utah					
Grand Staircase–Escalante National Monument[b]	Grand Staircase–Escalante National Monument Management Plan (BLM 1999a)	0	0	51,226	6,707
Monticello[c]	San Juan Resource Area RMP (BLM 1991b)	0	0	8,050	0
Price[c]	Price River Resource Area MFP (BLM 1989) San Rafael Resource Area RMP (BLM 1991a)	107	0	194,324	18,575
Richfield[c]	Henry Mountain MFP, issued 1982	0	0	83,040	0
Vernal[c,d,e]	Book Cliffs RMP (BLM 1985a) Diamond Mountain RMP (BLM 1994a)	560,864	77,220	237,717	56,866
Utah total		560,972	77,220	574,357	82,148
Wyoming					
Kemmerer[c]	Kemmerer RMP (BLM 1986c)	221,358	2,313	0	0
Rawlins[c]	Great Divide RMP (BLM 1990)	80,492	0	0	0
Rock Springs	Green River RMP (BLM 1997b, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006b])	955,829	37,093	0	0
Wyoming total		1,257,680	39,046	0	0

Footnotes on following page.

TABLE 3.1.1-1 (Cont.)

a Estimated acreages were calculated from GIS data compiled to support the PEIS analyses.

b Although lands within the GSENM would be excluded from future leasing for tar sands development, they are included in this table because they overlie the Circle Cliffs STSA. Potential commercial tar sands leasing and development in the GSENM, however, is not assessed in the PEIS.

c Planning efforts are underway to revise or replace the plan(s) in this field office.

d A portion of the P.R. Spring STSA extends south from the Vernal Field Office boundary into the Moab Field Office boundary; however, this area is administered by the Vernal Field Office under an MOU with the Moab Field Office. Under this agreement, the Vernal Field Office administers all resources and programs, including land use planning, for the entire P.R. Spring STSA. Therefore, the Moab Field Office plan is not impacted by this PEIS.

e Split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation coincide with oil shale and tar sands resources in the Vernal Field Office. The split estate acreage estimate for oil shale in the Vernal Field Office includes approximately 57,705 acres of lands within the Hill Creek Extension. The split estate acreage estimate for tar sands in the Vernal Field Office includes approximately 35,472 acres of lands within the Hill Creek Extension.

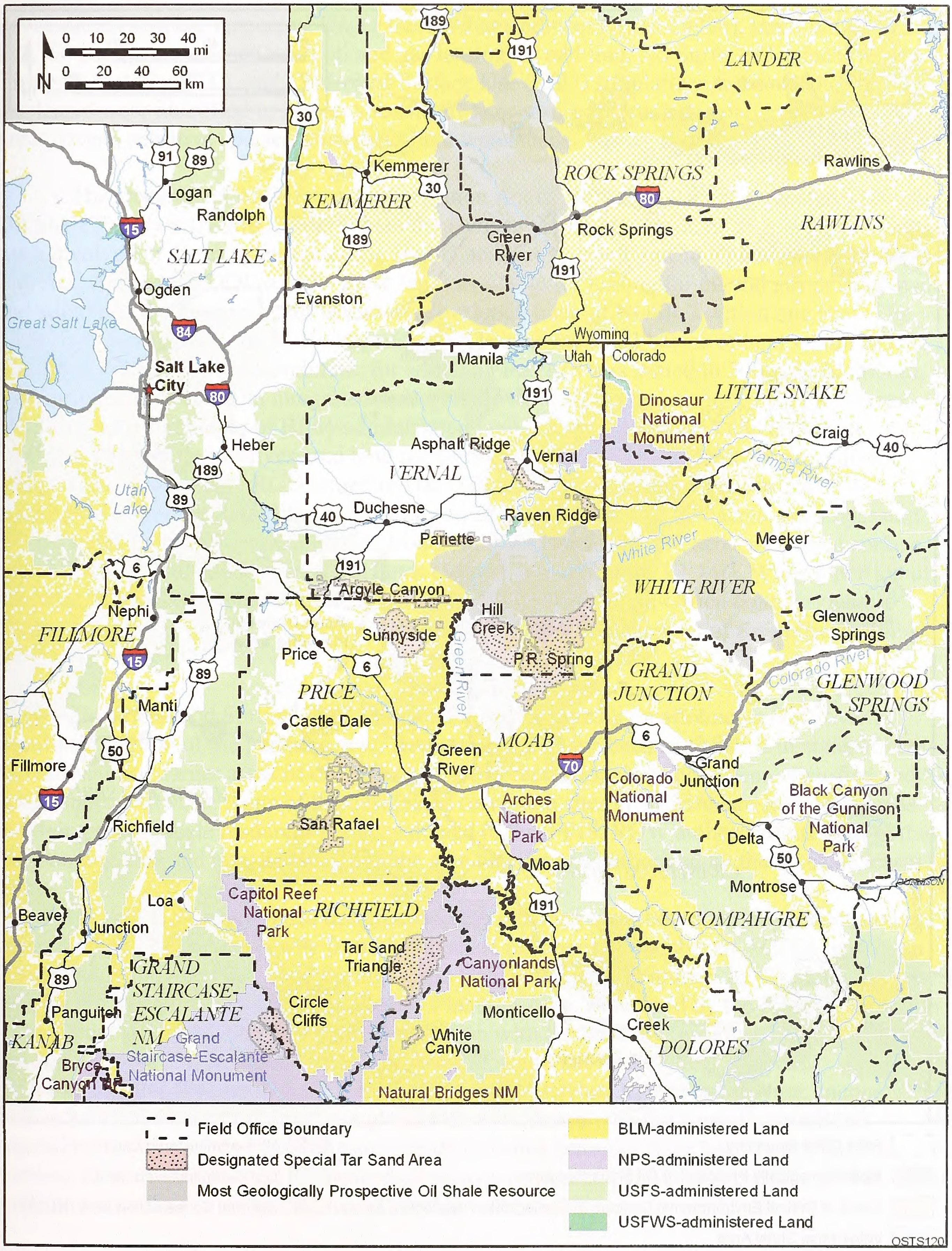

FIGURE 3.1.1-1 Distribution of BLM-, NPS-, USFS-, and USFWS-Administered Lands with Respect to Oil Shale and Tar Sands Resources

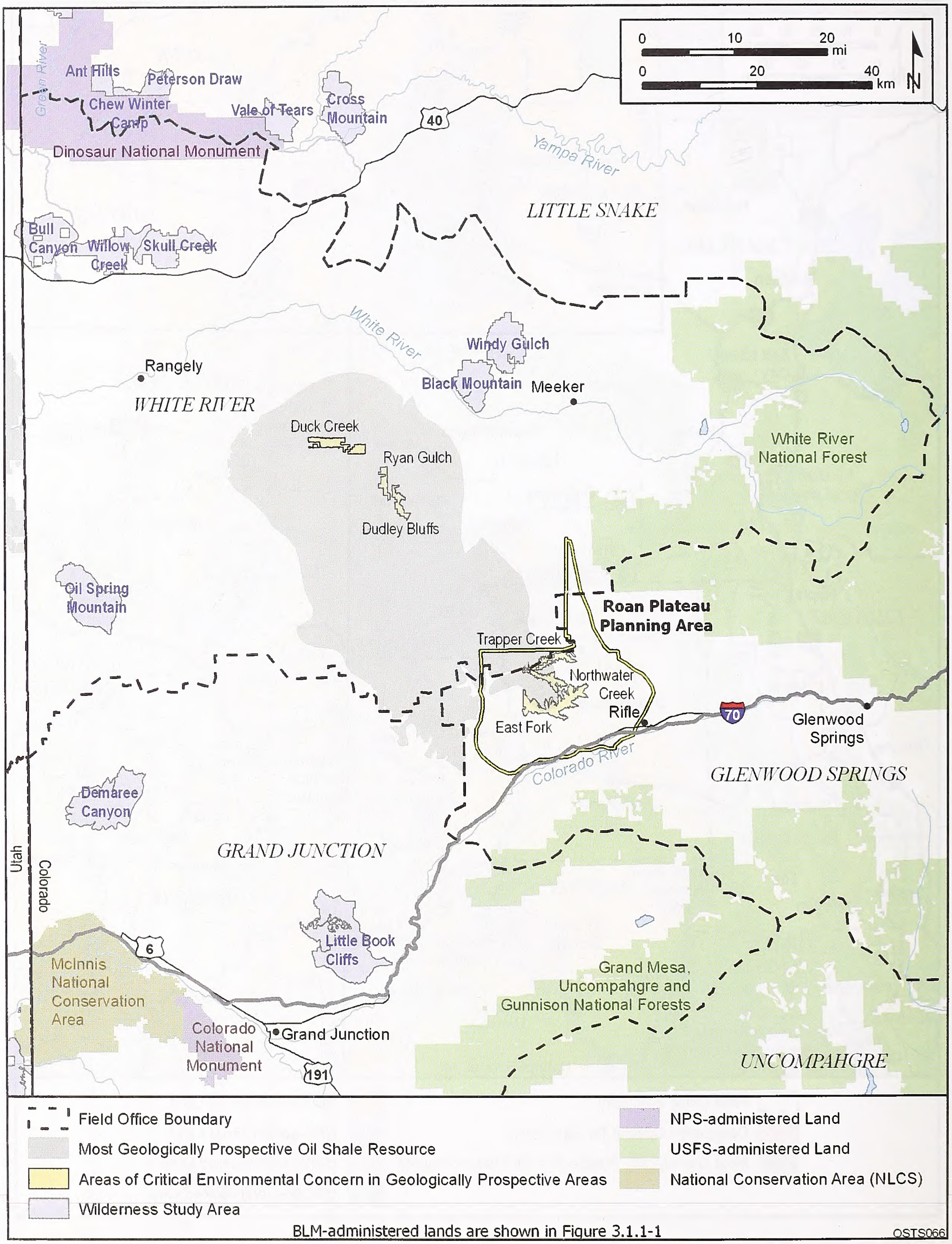

FIGURE 3.1.1-2 BLM Planning Areas in Colorado Where Oil Shale Resources Are Located

development of these resources. Under the 1999 amendment (BLM 1999b), lands within WSAs (27,760 acres) were closed to all oil and gas leasing. In addition, No Surface Occupancy (NSO), Timing Limitation (TL), and Controlled Surface Use (CSU) stipulations to be attached to oil and gas leases were identified to protect specific areas or resources, such as riparian and wetlands areas, rivers, sensitive species, viewsheds, and watersheds.

The Department of Defense Authorization Act of 1998 (P.L. 105-85) transferred Naval Oil Shale Reserves (NOSR) 1 and 3 from the DOE to the BLM. A total of 55,354 acres of land were involved in the transfer, including 36,362 acres in NOSR 1 and 18,992 acres in NOSR 3. The Act required the DOI to make these lands available for leasing for oil and gas development, and stipulated that leasing occur within the developed track of NOSR 3 within one year. The 1999 RMP amendment (BLM 1999b) addressed leasing on 12,029 acres of land within NOSR 3. The Roan Plateau RMP Amendment, for which a Final EIS was issued in 2006 (BLM 2006a), was prepared to develop an integrated management strategy that incorporates the transferred NOSR into the remainder of BLM-administered land in the planning area and establishes a unified set of goals, objectives, and land use or management actions. The RMP amendment, which was approved by a ROD issued in 2007 (BLM 2007b) and one issued in 2008 (BLM 2008), establishes the Roan Plateau Planning Area as an area of 127,007 acres, encompassing NOSR 1 and 3 (55,354 acres), other BLM-administered lands (18,248 acres of federal surface and split estate lands), and nonfederal lands (53,405 acres) (Figure 3.1.1-2). While a portion of the Roan Plateau Planning Area extends into the White River Field Office boundary, the Glenwood Springs Field Office will have jurisdiction over management of the entire planning area.

The Glenwood Springs Field Office administers grazing on allotments that cover a significant portion of the planning area. Recreation sites have been established in areas of heavy recreational use; larger areas of dispersed but heavy recreational use have been identified and designated as SRMAs. None of the designated recreation sites or SRMAs are located in areas overlying the oil shale resources being evaluated in this PEIS. ROW authorizations exist within the planning area and may be located in the area that may be authorized by the oil shale leases.

Several WSAs have been designated in the planning area; however, they are located in the eastern part of the area, away from the oil shale resources. A number of ACECs have been designated within the Glenwood Springs Field Office boundary (Figure 3.1.1-2). Four of these ACECs are located within the Roan Plateau Planning Area, as defined by the Roan Plateau Plan Amendment (BLM 2006a).[1] Two of them overlap with the oil shale resources being evaluated in this PEIS (Table 3.1.1-2). In addition, the Roan Plateau Plan Amendment and ROD (BLM 2006a, 2007b) establish the Parachute Creek Watershed Management Area, encompassing an area of 33,575 acres, on top of the plateau. In accordance with the Roan Plateau RMP Amendment, stipulations restricting surface-disturbance activities have been established for portions of these ACECs and the watershed management area (BLM 2006a, 2007a, 2008). Other ACECs within the planning area do not overlap with oil shale resources.

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1 The Roan Plateau ROD issued in 2007 only approved portions of the proposed plan amendments in BLM 2006a. A second ROD finalizing establishment of these ACECs is still pending.

TABLE 3.1.1-2 Glenwood Springs Field Office ACECs That Overlap with Oil Shale Resources

ACEC	R&I Criteria[a]	Acreage[b]
East Fork Parachute Creek	Scenic values, fisheries, and plant resources	6,571
Trapper/Northwater Creek	Fisheries and plant resources	4,810

a R&I = relevance and importance.

b Acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from the Roan Plateau RMP Amendment (BLM 2008).

The BLM has identified rivers and corridors within the Roan Plateau Planning Area as being eligible for designation as WSRs (BLM 2006a). Portions of the eligible Trapper Creek, Northwater Creek, and East Fork Parachute Creek, shown in Figure 3.1.1-2, overlie the oil shale study area.

3.1.1.2 Grand Junction Field Office, Colorado

The Grand Junction RMP (BLM 1987a) was first issued in 1987 and has been amended numerous times. The BLM administers approximately 1.2 million acres within the planning area encompassed by this RMP; however, only a small portion of the planning area overlaps with the oil shale resources evaluated in this PEIS (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin; no known tar sands resources are located within the boundaries of this field office.

In 2001, the Grand Junction RMP was amended to revoke previous decisions to withdraw deposits of oil shale and public lands containing such deposits from leasing or other disposal, in order to protect the oil shale resource, pending further study and classification (BLM 2001a). The withdrawals were no longer considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

Oil and gas and mineral development activities occur within the Grand Junction RMP boundary on both public and nonfederal lands. About 8% of the planning area is closed to oil and gas leasing; of the remaining area, almost 43% is open to leasing with standard lease terms, 9% has NSO stipulations, and the remaining 38% has other stipulations attached to leasing. Approximately 390,000 acres of the Book Cliffs potential coal development area are considered acceptable for further coal leasing consideration. The Palisade municipal watershed and the Colorado River corridor through DeBeque Canyon are closed to coal development.

Other principal uses of public land within the boundary of the field office include grazing and recreation. Recreational use is varied and dispersed throughout the planning area. A number of areas are managed as SRMAs; however, none of them coincide with the oil shale resources evaluated in this PEIS. ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Several WSAs and ACECs are located within the planning area; however, none of these areas overlap with the oil shale resources. The McInnis Canyons NCA, managed by the BLM, and Colorado National Monument, managed by the NPS, are located within the Grand Junction Field Office boundary, but both are more than 35 mi from the oil shale resources being evaluated in this PEIS.

3.1.1.3 White River Field Office, Colorado

The White River RMP was first issued in 1997 (BLM 1997a) and has been amended several times. The BLM administers approximately 1.46 million acres of surface estate and an additional 365,000 acres of split estate lands within the planning area encompassed by this RMP (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin; no tar sands resources are located within the boundary of this field office.

In 2001, the White River RMP was amended to revoke previous decisions to withdraw deposits of oil shale and public lands containing such deposits from leasing or other disposal, in order to protect the oil shale resource, pending further study and classification (BLM 2001a). The withdrawals were no longer considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

As discussed in Section 3.1.1.1, the Roan Plateau RMP Amendment and ROD (BLM 2006a, 2007b, 2008) establish the Roan Plateau Planning Area as an area incorporating NOSR 1 and 3, other BLM-administered lands, and nonfederal lands. A small portion of this new planning area overlaps with the White River Field Office. The amendment defines an integrated management strategy for the entire area, although management decisions are applicable only to the BLM-administered lands. While a portion of the Roan Plateau Planning Area extends into the White River Field Office boundary, the Glenwood Springs Field Office will have jurisdiction over management of the entire planning area.

The White River RMP contains a number of decisions related to oil shale development in the Piceance Basin that were carried forward from the 1985 Piceance Basin RMP (BLM 1985b) that it replaced. Accordingly, under the existing RMP, lands within the "Piceance dome area" are currently closed to leasing for oil shale because of conflicts with oil and gas development and an "unfavorable geologic setting." A total of 294,680 acres of land are available for oil shale leases, of which 39,140 acres are available for surface mining (e.g., open pit) development. An additional 70,820 acres are available for leasing for multimineral development (i.e., development of oil shale, nahcolite, and dawsonite) inside the identified Multimineral Zone (Figure 3.1.1-3). Per the RMP, multimineral development will be allowed only if recovery technologies are implemented to ensure that each of these minerals can be recovered without preventing recovery of the others. The White River RMP also allows for the issuance of leases for oil shale research activities. Five RD&D leases have been issued in the White River Field Office for the purpose of demonstrating the application of potential oil shale recovery technologies (see Section 2.3 and

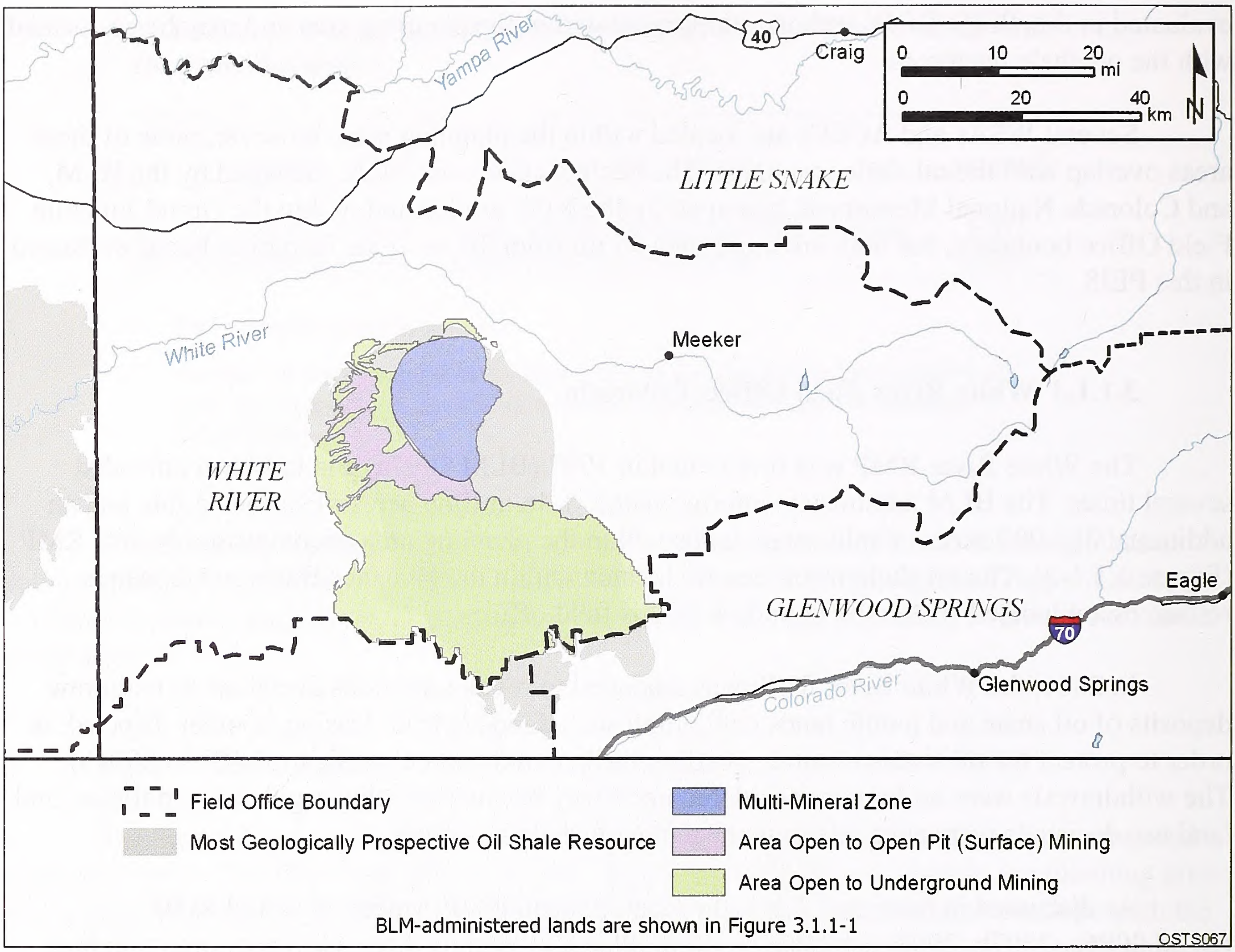

FIGURE 3.1.1-3 White River RMP Decisions Related to Oil Shale Leasing and Development

Figure 2.3-2). Additional NEPA analysis is also required for oil shale leasing according to the 1997 RMP.[2]

Oil and gas and other mineral development are intensive within the White River Field Office boundary on both public and nonfederal lands, and much of this development is coincident with the oil shale resources. More than 1.5 million acres of land are available for oil and gas leasing with special stipulations, and an additional 168,486 acres are available for leasing under standard lease terms. Oil and gas transport and feeder pipelines cross the oil shale resources evaluated in this PEIS.

Oil and gas development is projected to increase significantly on the lands managed by the White River Field Office. A number of projects are currently under consideration to expand existing development and the associated infrastructure. In June 2006, the BLM initiated

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2 This PEIS will not satisfy the requirement for additional analysis identified in the White River RMP.

preparation of an EIS to evaluate the proposed amendment of the existing RMP to address the potential impacts of significant increases in oil and gas development in the area. In the last plan revision in 1997, the BLM anticipated the potential development of 1,100 oil and gas wells (at a rate of about 55 wells/yr), most of which were to be drilled south of Rangely, Colorado. The oil and gas industry is now projecting that more than 21,000 wells could be drilled in the planning area over the next 20 years (Hollowed 2007).

The White River RMP states that 172,700 acres of land within the planning area are underlain by recoverable coal reserves; 11,470 acres were found to be unsuitable for coal mining; 43,380 acres were found to be suitable for underground mining only; and 117,850 acres were found to be suitable for both surface and underground mining. Approximately 610,000 acres are available for mining of locatable minerals.

The White River Field Office administers grazing on allotments that cover a significant portion of the planning area, including the area where the oil shale resources are located. The entire field office area has been designated as the White River Extensive Recreation Management Area; no SRMAs have been designated. The Piceance-East Douglas Creek Wild Horse Herd Management Area (HMA) overlaps with the oil shale resources (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Several WSAs have been designated within the White River Field Office region; however, they are all located to the northeast and northwest of the oil shale resources being evaluated in this PEIS. A number of ACECs have been designated within the White River Field Office boundary. Figure 3.1.1-2 shows those located within the geologically prospective area for oil shale. The ACECs that overlap with the oil shale resources being evaluated in this PEIS are listed in Table 3.1.1-3. One of these ACECs, the Trapper/Northwater Creek ACEC, is located within the Roan Plateau Planning Area.

A portion of Dinosaur National Monument, which is managed by the NPS, falls within the White River Field Office boundary; however, it does not overlie any of the oil shale

TABLE 3.1.1-3 White River Field Office ACECs That Overlap with Oil Shale Resources

ACEC	R&I Criteria	Acreage[a]
Duck Creek	Threatened and endangered plant and cultural resources	3,430
Ryan Gulch	Threatened and endangered plant resources	1,440
Dudley Bluffs	Threatened and endangered and sensitive plant resources	1,630
Trapper/Northwater Creek	Fisheries and plant resources	4,810[b]

a Acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from the White River RMP (BLM 1997a) unless otherwise noted.

b Acreage estimates were derived from the Roan Plateau RMP Amendment (BLM 2006a).

resources within the Piceance Basin being evaluated in this PEIS (Figure 3.1.1-2). At its closest point, the Monument is more than 25 mi from the oil shale resources being evaluated within the Piceance Basin.

An underground nuclear test site, the Rio Blanco site, is also located in the Piceance Basin, White River Field Office area. The 360-acre site on DOE land, approximately 30 mi southwest of Meeker, was the location of nuclear testing in 1973. Three 30-kiloton nuclear devices were detonated simultaneously at the bottom of more than 1-mi deep shafts. This site is not included as part of the study area because the area is not on BLM-administered land.

Because the detonations took place in low-permeability, low-transmissivity shale and claystone formations with sandstone lenses, test-related radionuclides are not expected to travel far from the source area. Ongoing monitoring conducted at this DOE Legacy site shows no surface contamination, and there are no surface use restrictions at the site. However, subsurface disturbance is not allowed within a 600-ft radius of the test area without U.S. government permission. Groundwater and surface water monitoring have shown no radiological contamination.

The Green River Formation lies about 3,000 ft above the depth where the detonations occurred. If the BLM were to lease its bordering property for oil shale development in the future, stipulations would be included to confirm that no radioactive contaminants would be mobilized.

3.1.1.4 Grand Staircase–Escalante National Monument, Utah

The GSENM was established by Presidential Proclamation in September 1996. The GSENM Management Plan, published in 1999, became effective in February 2000 (BLM 1999a). The GSENM encompasses about 1.87 million acres of federal lands and is surrounded primarily by federal lands, including the Dixie National Forest, Capitol Reef National Park, Glen Canyon NRA, Bryce Canyon National Park, and other BLM-administered lands (Figure 3.1.1-4). The GSENM overlies the western portion of the Circle Cliffs STSA. The eastern portion of this STSA extends into Capitol Reef National Park. According to available maps, a small portion of the Circle Cliffs STSA extends to the south into the Glen Canyon NRA. No oil shale resources are located within the Monument.

Currently, 8,921.36 acres within the Circle Cliffs STSA are held under two pending conversion leases for tar sands development (see Section 1.4.2). When the GSENM was established, all federal lands and interests within the Monument were withdrawn from additional entry, location, selection, sale, leasing, or other disposition, including mineral leasing. No new federal mineral leases can be issued, nor can new mining claims be located within the Monument. However, a number of oil and gas leases, mineral leases, and mining claims were in place at the time the Monument was established. While there are 68 federal mining claims covering about 2,700 acres, 85 federal oil and gas leases covering more than 136,000 acres, and 18 federal coal leases on about 52,800 acres, the BLM will verify whether "valid existing rights" are present on a case-by-case basis (BLM 1999a). This adjudication process to determine the

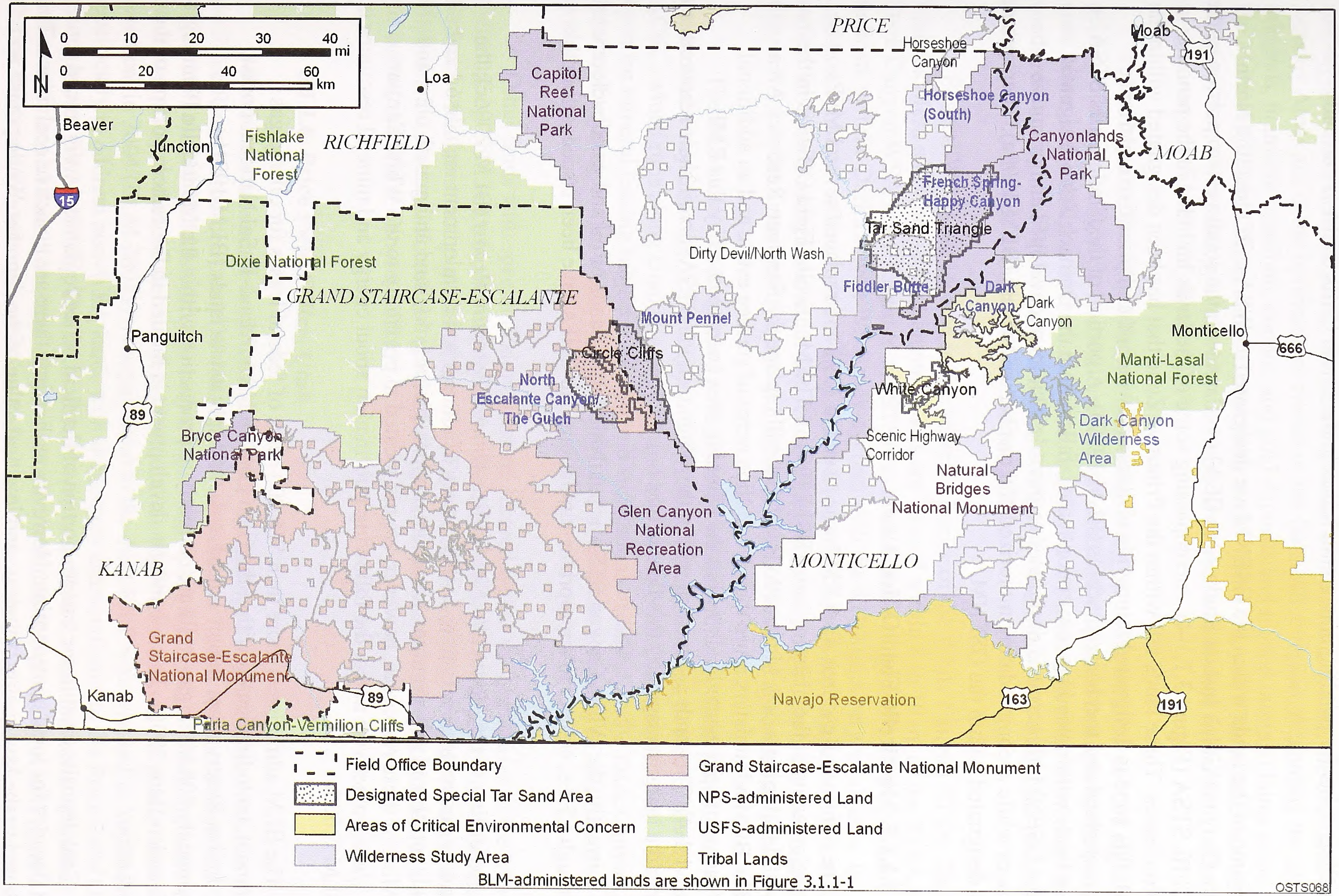

FIGURE 3.1.1-4 Portions of the Grand Staircase–Escalante National Monument and the Monticello and Richfield Field Offices Where Tar Sands Resources Are Located

valid existing rights for pending conversion leases in the Circle Cliffs STSA is currently underway.

Some of the lands within the GSENM are designated as WSAs. Of these, the North Escalante Canyons/Gulch Instant Study Area (ISA) overlaps with the southwestern portion of the Circle Cliffs STSA (Figure 3.1.1-4), encompassing some of the lands included in the pending conversion leases. These lands fall within the Primitive Zone that has been designated within the GSENM; this zone is designated to provide visitors undeveloped and primitive experiences without motorized and mechanized access (BLM 1999a). A portion of the Circle Cliffs STSA, including lands within pending conversion leases, falls within the Outback Zone designated within the GSENM; this zone is designated to provide visitors undeveloped and primitive experiences while accommodating motorized and mechanized access (BLM 1999a). There are no ACECs designated within the GSENM.

3.1.1.5 Monticello Field Office, Utah

The San Juan Resource Area RMP was issued in 1991 and replaced several MFPs addressing subunits of the planning area (BLM 1991a). The Monticello Field Office is in the process of developing a new Monticello RMP that will replace the San Juan Resource Area RMP. The BLM administers more than 1.7 million acres of surface estate and an additional 763,000 acres of split estate lands within the planning area encompassed by this RMP (Figure 3.1.1-4). Tar sands are located within the White Canyon STSA; no oil shale resources are located in the lands managed by this field office.

Currently, the White Canyon STSA is available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. No CHLs have been issued within this STSA.

According to the *Monticello Field Office Mineral Potential Report* (BLM 2006c), the other energy and mineral resources with a history of interest and development include oil and gas, coal, potash and salt, uranium-vanadium, copper, placer gold, sand and gravel, clay, and stone. Most of these resources, however, are not located in proximity to the White Canyon STSA. Unless otherwise noted, the following information about energy and mineral resources is from BLM (2006c).

The BLM administers more than 576,000 acres of federal leases for oil and gas development, including leases within the Glen Canyon NRA, Manti-LaSal National Forest, Navajo Indian Reservation, Indian Trust Lands, and split estate lands (BLM 1991b). Approximately 508 oil or gas wells are currently in production within the Monticello Planning Area (Vanden Berg 2005). This oil and gas development is located in the eastern portion of the planning area.

Coal deposits exist in the eastern portion of the field office region and were mined for several decades for local consumption. However, at this time there are no active coal mines. This is attributed to the low quality, thinness, and low heat value of the deposits. While potash and salt deposits are extensive across the eastern portion of the planning area, the only Known Potash Leasing Areas are in the northeastern corner of the field office region. Regarding the locatable minerals, uranium-vanadium, copper, and gold deposits and related mining claims occur within the Monticello Field Office, some in proximity to the White Canyon STSA. Salable Mineral Disposal Areas (for sand, gravel, clay, etc.) also have been established in the field office but not in proximity to the White Canyon STSA.

The Monticello Field Office administers grazing on allotments that cover a significant portion of the planning area. Recreational use is varied and dispersed throughout the planning area. None of the designated recreation sites or SRMAs are located in areas overlying the tar sands resources in the White Canyon STSA. ROW authorizations exist within the planning area and may be co-located with the White Canyon STSA.

Several WSAs are located in the general vicinity of the White Canyon STSA. The Mancos Mesa and Cheesebox Canyon WSAs are located within 8 to 10 mi of the STSA, and the Dark Canyon WSA lies adjacent to the STSA to the northeast (Figure 3.1.1-5). Available maps indicate that the Dark Canyon WSA may overlap with the STSA in a very small area. In addition, a number of areas that overlap White Canyon STSA, or are located within a 10-mi radius, have been recognized as having wilderness characteristics. These areas are shown in Figure 3.1.1-5; the areas that overlap with White Canyon STSA are described in Table 3.1.1-4.

The BLM also has designated a number of ACECs within the field office, most of which are located away from the White Canyon STSA. One exception is the Scenic Highway Corridor ACEC, which runs along Utah Highway 95 and bisects the STSA (Figure 3.1.1-4). This ACEC is open for mineral leasing subject to review and stipulations. In addition, the Dark Canyon ACEC is located adjacent to the White Canyon STSA and overlaps in a small area, according to available maps.

Other lands with special designations are located within the boundaries of the Monticello Field Office. NPS lands in the vicinity of the White Canyon STSA include Natural Bridges National Monument and portions of the Glen Canyon NRA and Canyonlands National Park. The Manti-La Sal National Forest and the Dark Canyon Wilderness Area are located about 8 mi to the east of the White Canyon STSA.

3.1.1.6 Price Field Office, Utah

Resources present in the Price Field Office are managed in accordance with two plans: the Price River Resource Area MFP (BLM 1989) and the San Rafael Resource Area RMP (BLM 1991a). The BLM is currently preparing a single plan for the field office that will replace these two plans. A draft of the new Price Field Office RMP was released for public review and comment in 2004 (BLM 2004a). A supplement to the draft RMP was released in September 2007 specifically to address non-WSA lands with wilderness characteristics in the Price Field Office planning area (BLM 2007b). The BLM administers more than 2.5 million acres of surface estate and an additional 2.8 million acres of split estate lands within this planning area (Figure 3.1.1-6). The tar sands are located within the San Rafael and Sunnyside STSAs; only a small portion of

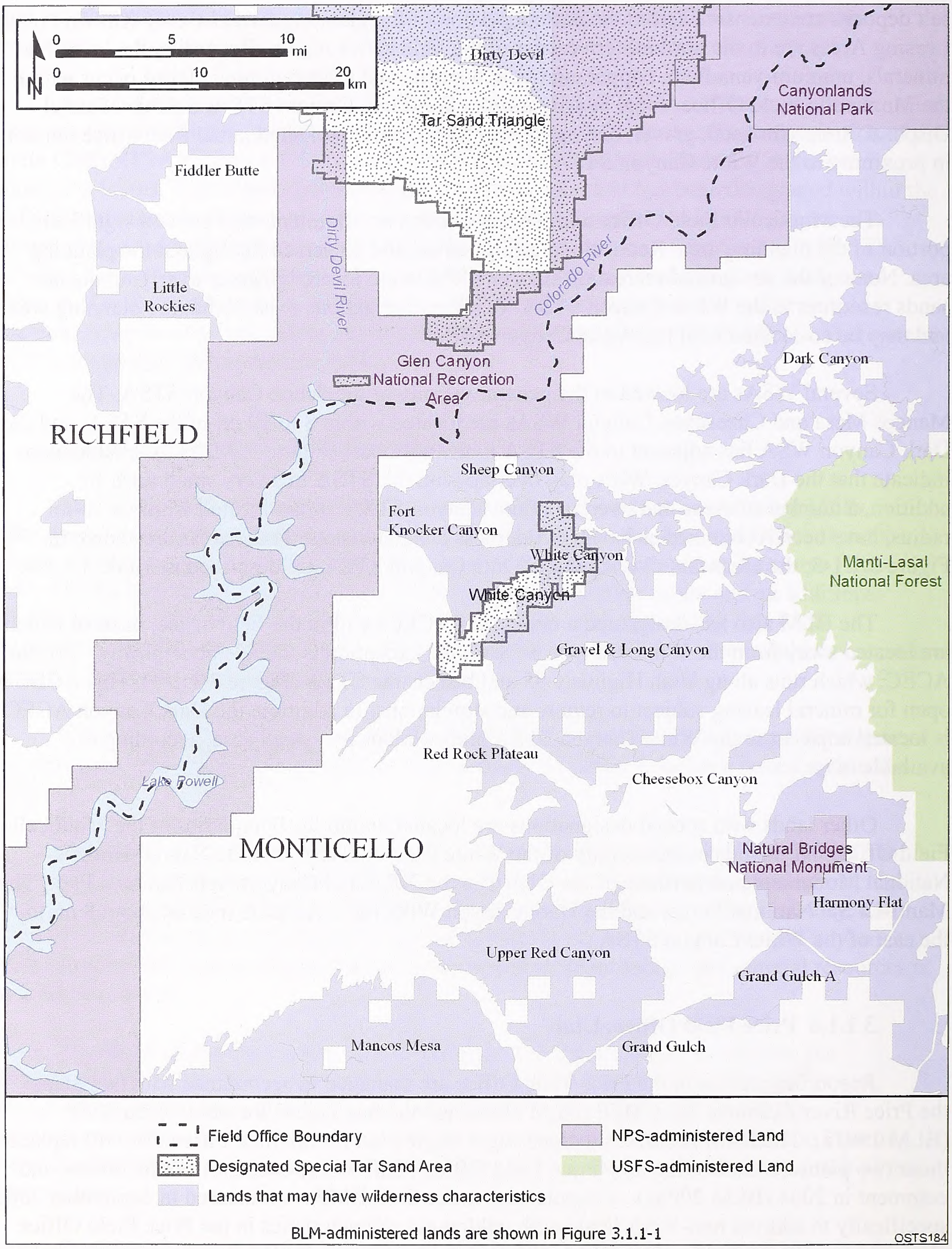

FIGURE 3.1.1-5 Areas with Wilderness Characteristics in the Monticello Field Office in the Vicinity of the White Canyon STSA

TABLE 3.1.1-4 Areas Recognized as Having Wilderness Characteristics in the Monticello Field Office That Overlap with the White Canyon STSA[a,b]

Name of Area with Wilderness Characteristics	Total Size of Area (acres)	Amount of Overlap (acres)
Dark Canyon	66,374	227
Fort Knocker Canyon	12,418	243
Gravel and Long Canyon	36,910	2,240
Red Rocks Plateau A	17,023	69
White Canyon	9,086	2,750

a The key characteristics of wilderness that may be considered in land use planning include an area's appearance of naturalness and the existence of outstanding opportunities for solitude or primitive and unconfined types of recreation.

b Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

the oil shale resources included in the study area falls within this field office. An oil shale withdrawal is currently in place under E.O. 5327 (U.S. President 1930), which would need to be modified or revoked before oil shale leasing could occur.

Currently, the San Rafael and Sunnyside STSAs are available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. No CHLs have been issued within these STSAs.

According to the *Mineral Potential Report for Price Field Office, Carbon and Emery Counties, Utah* (BLM 2002a), the other energy and mineral resources that have been developed within the field office's region include oil and gas, coal, uranium, gypsum, potash and salt, sand and gravel, clay, and stone. Some of these resources are located in close proximity to the STSAs.

Unless otherwise noted, the following information about energy and mineral resources is from BLM (2002a).

Approximately 489,125 acres of land are included in about 895 active (or recently active) oil and gas leases. There are no active leases in the vicinity of the San Rafael STSA and, while some portions of these lands are open to leasing under standard lease terms, other portions are closed to leasing for oil and gas development because they fall within WSA boundaries. The potential for future oil and gas development in the vicinity of the San Rafael STSA is considered to be low. A considerable number of active leases exist adjacent to the Sunnyside STSA, and this area is projected to have a high potential for development. Most of the lands around the Sunnyside STSA are leased, with seasonal or other minor constraints. Although currently there is no coalbed natural gas production in the vicinity of the Sunnyside STSA, the area is considered

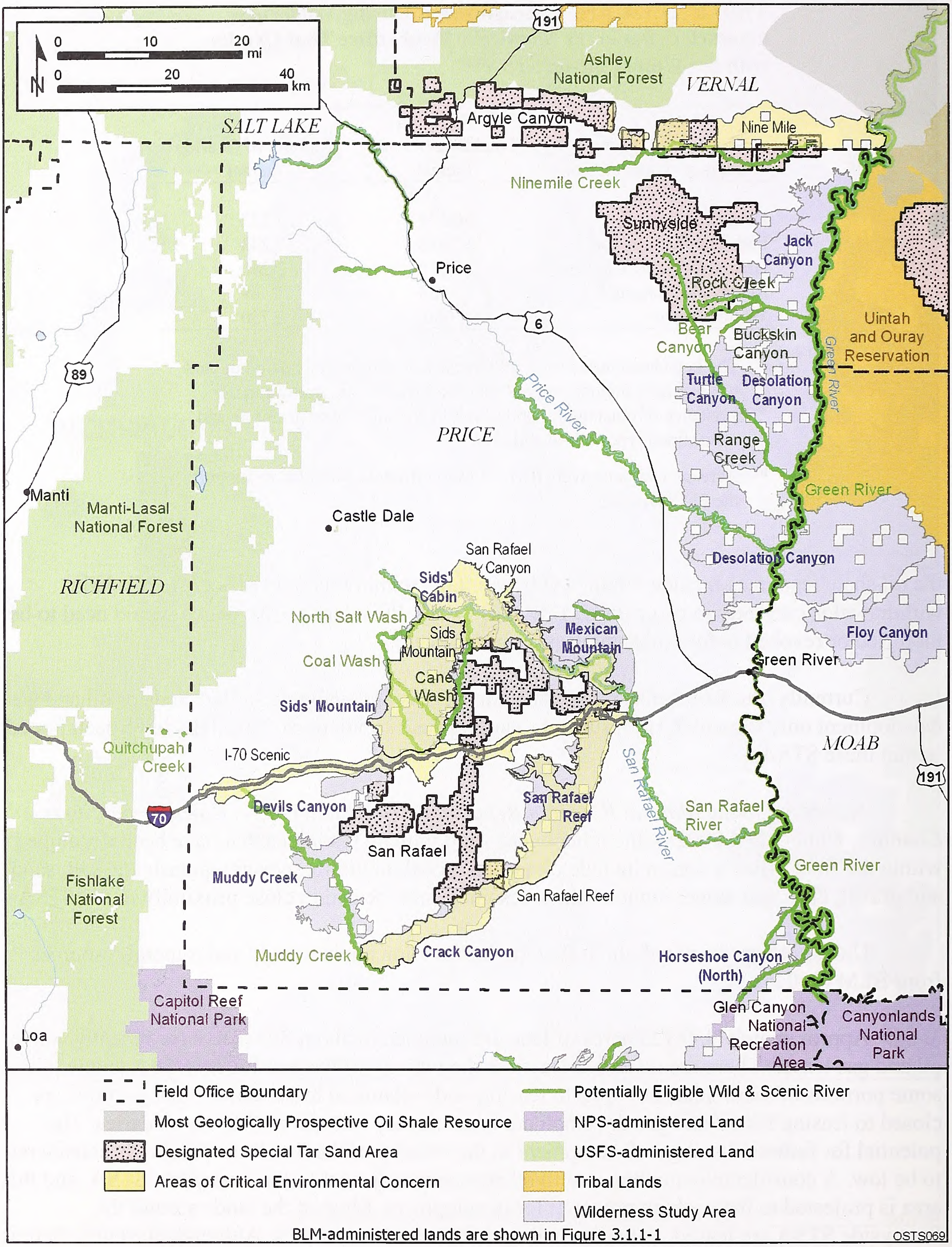

FIGURE 3.1.1-6 Price Field Office RMP Planning Area

to have potential for future coalbed natural gas production within the Book Cliffs Coalbed Methane Play.

Currently, there are about 673,389 acres of land included in 106 coal leases on lands managed by the field office. None of these leases are located near the San Rafael STSA. Only a few areas are leased to the west of the Sunnyside STSA within the Book Cliffs coal field.

Mining claims involve about 32,000 acres of land in the field office's region. Historic production of uranium has occurred in the vicinity of the San Rafael Swell in areas adjacent to the San Rafael STSA. Although continued development of this resource is considered in the existing land use plans as unlikely over the next 15 years, there has recently been a very high interest in the development of uranium, as the price of this resource has increased. The prospects for other metal mining are relatively low throughout the field office area and in the vicinity of the STSAs. Production of gypsum, clay, sand and gravel, and stone has occurred in the vicinity of the San Rafael STSA or has the potential to occur in the future.

The Price Field Office administers grazing allotments on the basis of historical use and the availability of forage and water. These allotments cover the majority of the planning area and are categorized on the basis of their resource production potential and resource use conflicts. Most of the STSAs within the planning area coincide with grazing allotments. Several SRMAs have been established within the planning area, some of which are co-located with the STSAs, including the Desolation Canyon, San Rafael Swell, Nine Mile Canyon, and Range Creek SRMAs. The Muddy Creek, Sinbad, and Range Creek Wild Horse HMAs overlap with some of the tar sands resources, as does the Sinbad Wild Burro HMA (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the tar sands resources.

Several WSAs and ACECs have been designated in the Price Field Office. The WSAs and ACECs that overlap with an STSA and/or the most geologically prospective oil shale area are shown in Figure 3.1.1-6 and are listed in Table 3.1.1-5. In addition, portions of several rivers have been determined to be eligible for potential designation as a WSR (see Appendix 3 of BLM 2004a). Those portions that overlie oil shale and/or tar sands deposits are shown in Figure 3.1.1-7 and include portions of the Green River, San Rafael River, Cane Wash, Range Creek, Rock Creek, and Bear Canyon.

A number of areas that overlie both the San Rafael STSA and the Sunnyside STSA, and the most geologically prospective oil shale area, have been recognized as having wilderness characteristics. These areas are shown in Figure 3.1.1-7; the areas that overlap with the STSAs are described in Table 3.1.1-6. These areas are discussed in greater detail in the supplement to the draft RMP (BLM 2007b).

As part of the ongoing effort to develop the new Price Field Office RMP, the BLM has conducted a review of a number of potential ACECs (BLM 2006d). Table 3.1.1-7 lists the potential ACECs that have been determined to meet relevance and importance (R&I) criteria; this list includes the existing ACECs, some of which have changed in size per submitted proposals. Figure 3.1.1-8 shows the locations of the potential ACECs.

TABLE 3.1.1-5 Price Field Office WSAs and ACECs That Overlap with Tar Sands Resources

Area	R&I Criteria	Acreage[a]
Desolation Canyon WSA	NA[b]	229,860
Jack Canyon WSA	NA[b]	7,735
Mexican Mountain WSA	NA[b]	59,930
San Rafael Reef WSA	NA[b]	63,007
Sid's Mountain WSA	NA[b]	78,718
Devil's Canyon WSA	NA[b]	9,111
Crack Canyon WSA	NA[b]	26,640
Link Flats ISA	NA[b]	855
I-70 Scenic ACEC	Scenic resources	45,463
San Rafael Canyon ACEC	Scenic resources	54,102
San Rafael Reef ACEC	Scenic resources and relict vegetation	84,018
Sid's Mountain ACEC	Scenic resources	61,380
Temple Mountain ACEC	Historic resources	2,444
Copper Globe ACEC	Historic resources	128

a Acreage estimates represent the entire unit (not just the portion overlying the tar sands resources) and were derived from GIS data compiled to support the PEIS analysis.

b NA = not applicable.

3.1.1.7 Richfield Field Office, Utah

The Henry Mountain MFP covers public lands within the Richfield Field Office boundary that contain tar sands resources. This MFP was first issued in 1982 and has been amended multiple times. The Richfield Field Office is in the process of developing a new Richfield RMP that will replace the Henry Mountain MFP, along with several other land use plans that fall within the field office boundary. The field office region includes the Tar Sand Triangle STSA, portions of which extend into the Glen Canyon NRA and Canyonlands National Park (Figure 3.1.1-4). The eastern portion of the Circle Cliffs STSA also falls within the field office boundary, with the western portion extending into the GSENM (see Section 3.1.1.4).

Where the Circle Cliffs STSA is located within the Richfield Field Office boundary, it lies inside Capitol Reef National Park. No oil shale resources are located under lands managed by this field office.

Currently, the Tar Sand Triangle STSA is available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. At this time, there are no CHLs in this STSA; there are, however, seven pending conversion leases, totaling 41,254.16 acres. Four of these pending conversion leases, totaling 20,442.20 acres, fall within the Glen Canyon NRA. The BLM is engaged in an adjudication process to determine the status of these pending conversion leases and whether or not to convert them to CHLs.

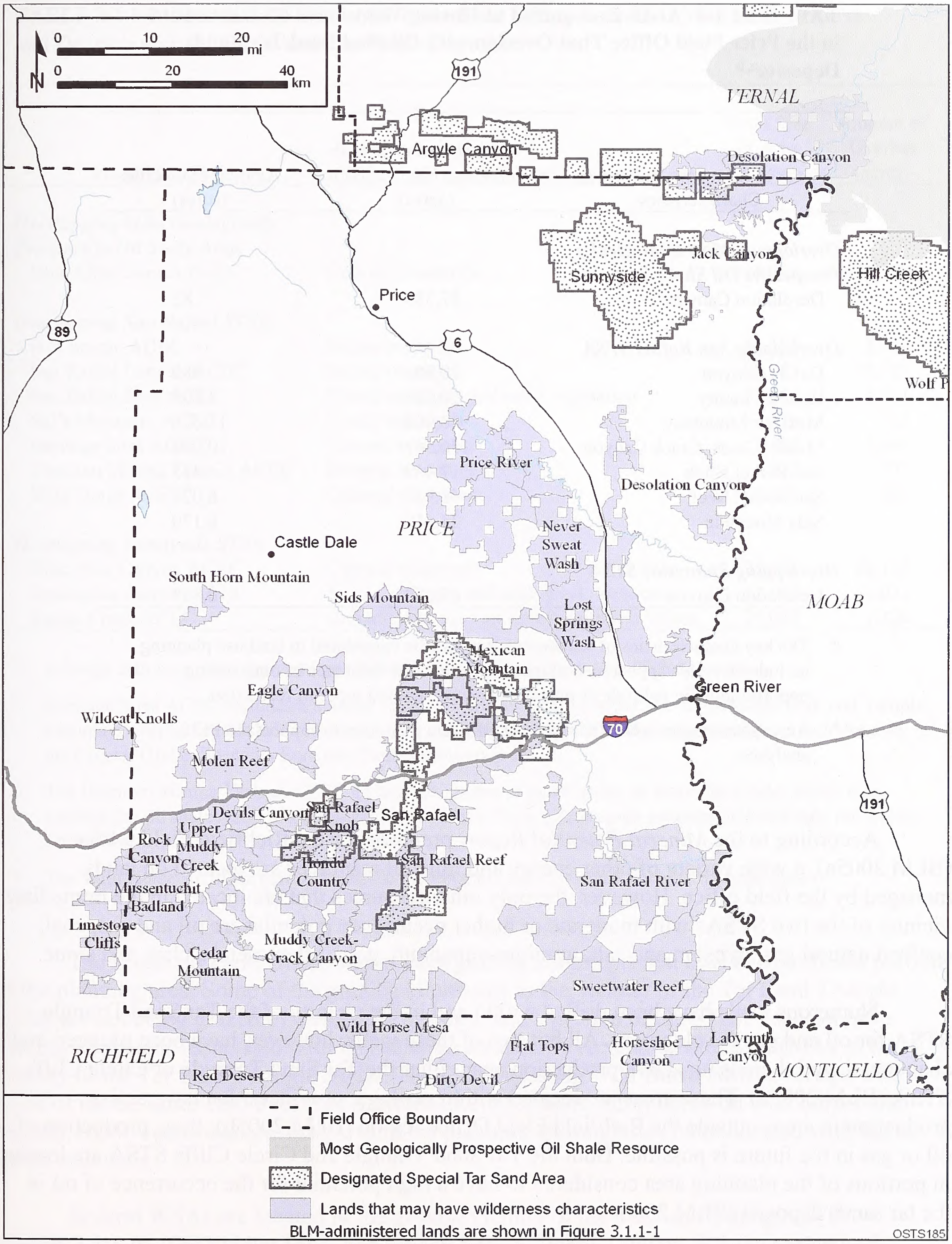

FIGURE 3.1.1-7 Areas with Wilderness Characteristics in the Price Field Office That Overlap with Oil Shale and/or Tar Sands Deposits

TABLE 3.1.1-6 Areas Recognized as Having Wilderness Characteristics in the Price Field Office That Overlap with Oil Shale and Tar Sands Deposits[a,b]

Name of Area with Wilderness Characteristics	Total Size of Area with Wilderness Characteristics (acres)	Amount of Overlap (acres)
Overlapping Most Geologically Prospective Oil Shale Area		
Desolation Canyon	87,359	85
Overlapping San Rafael STSA		
Devils Canyon	10,904	989
Hondu Country	20,121	4,209
Mexican Mountain	40,968	15,676
Muddy Creek–Crack Canyon	176,567	10,904
San Rafael Knob	17,449	5,415
San Rafael Reef	45,953	6,025
Sids Mountain	34,619	6,170
Overlapping Sunnyside STSA		
Desolation Canyon	87,359	6,883

a The key characteristics of wilderness that may be considered in land use planning include an area's appearance of naturalness and the existence of outstanding opportunities for solitude or primitive and unconfined types of recreation.

b Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

According to the *Mineral Potential Report* prepared for the Richfield Field Office (BLM 2005a), a wide variety of other energy and mineral resources are located on lands managed by the field office. However, the only other resources that are located in the immediate vicinity of the two STSAs with moderate or higher occurrence potential are oil and gas, coal, coalbed natural gas, gypsum and salt, uranium-vanadium, gold, other metals, clay, and stone.

Numerous wells have been drilled within and in the vicinity of the Tar Sand Triangle STSA for oil and gas development. All but two of these wells, however, have been plugged and abandoned, and there is no active production near either the Tar Sand Triangle or Circle Cliffs STSA (BLM 2005a). These areas are located within geologic provinces that have active production in areas outside the Richfield Field Office region (BLM 2005b); thus, production of oil or gas in the future is possible. Both the Tar Sand Triangle and Circle Cliffs STSA are located in portions of the planning area considered to have a high potential for the occurrence of oil in the tar sands deposits (BLM 2005a).

The Henry Mountains coal field is located to the east of the Circle Cliffs STSA. There are no coal resources in the vicinity of the Tar Sand Triangle STSA.

TABLE 3.1.1-7 Potential ACECs in the Price Field Office Area That Meet R&I Criteria and Overlap with Oil Shale and Tar Sands Deposits[a]

Potential ACEC	R&I Criteria	Total Size of Area (acres)	Amount of Overlap (acres)
Overlapping Most Geologically Prospective Oil Shale Area			
Nine Mile Canyon ACEC	Cultural resources	125,798	85
Overlapping San Rafael STSA			
I-70 Scenic ACEC	Scenic resources	53,193	4,296
San Rafael Canyon ACEC	Scenic resources	90,813	22,228
San Rafael Reef ACEC	Scenic resources and relict vegetation	81,352	4,761
Sid's Mountain ACEC	Scenic resources	87,429	215
Heritage Sites ACEC[b]	Historic resources	2,568	2,568
Uranium Mining District ACEC[c]	Historic resources	893	577
Wild Horse ACEC[d]	Cultural resources	3,006	670
Overlapping Sunnyside STSA			
Nine Mile Canyon ACEC	Cultural resources	125,798	28,130
Desolation Canyon ACEC	Scenic, cultural, and ecological resources	152,089	8,033
Range Creek ACEC	Cultural resources and natural process values	74,054	1,320

[a] Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

[b] Heritage Sites ACEC includes a number of small areas: of these, Copper Globe, Sheperds End, and Temple Mountain overlie the oil shale resources being evaluated in this PEIS. The acreage estimate includes only the Copper Globe, Sheperds End, and Temple Mountain areas.

[c] The Uranium Mining District ACEC includes a number of small areas; of these, the Lucky Strike area overlies the oil shale resources being evaluated in this PEIS. The acreage estimate includes only the Lucky Strike area.

[d] The Wild Horse ACEC is part of the Rock Art Potential ACEC, which includes 13 total sites.

The Richfield Field Office administers grazing allotments that cover a significant portion of the planning area. Some of the grazing allotments in the vicinity of the Tar Sand Triangle STSA are not being grazed by livestock currently, and a portion of the STSA does not have grazing allotments associated with it. There are no specific recreation sites or SRMAs in the vicinity of the Tar Sand Triangle STSA. The Canyon Lands Wild Burro HMA overlaps with some of the tar sands resources (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the tar sands resources.

Several WSAs are located in the general vicinity of the Tar Sand Triangle STSA (Figure 3.1.1-9). The Fiddler Butte and French Spring–Happy Canyon WSAs overlap with portions of the Tar Sand Triangle STSA. According to available maps, a very small portion of the Horseshoe Canyon and Dirty Devil WSAs also may overlap with this STSA. The Mount

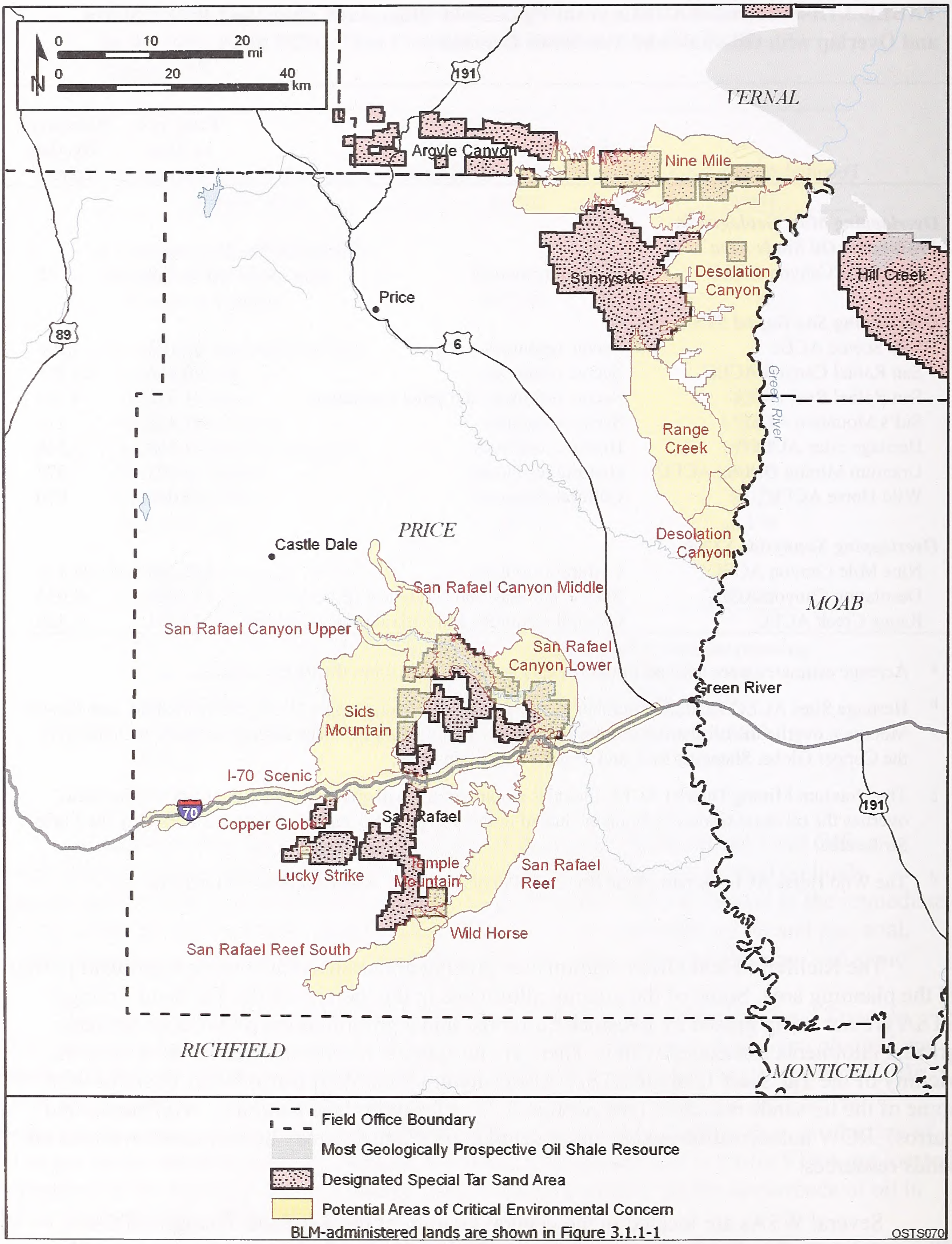

FIGURE 3.1.1-8 Potential ACECs in the Price Field Office That Overlie Oil Shale and Tar Sands Deposits

Pennel WSA is situated immediately to the east of the Circle Cliffs STSA, abutting in some places with Capitol Reef National Park. In addition, portions of several rivers have been determined to be eligible for potential designation as a WSR (BLM 2005c). Of these river segments (Figure 3.1.1-9), only a portion of one, the Dirty Devil River, coincides with the Tar Sand Triangle STSA.

None of the existing ACECs that have been designated within the Henry Mountain MFP planning area overlap with the designated STSAs. However, as part of the ongoing effort to develop the new Richfield RMP, the BLM has conducted a review of a number of potential ACECs (BLM 2005d). Two of the potential ACECs that have been determined to meet R&I criteria overlap with the Tar Sand Triangle STSA: the Horseshoe Canyon Potential ACEC (with scenic and cultural values) and the Dirty Devil–North Wash Potential ACEC (with scenic, cultural, and wildlife values) (Figure 3.1.1-9). The Horseshoe Canyon Potential ACEC is 40,935 acres in size and overlaps with the STSA by 248 acres; the Dirty Devil–North Wash Potential ACEC is 205,500 acres in size and overlaps the STSA by 57,944 acres.

A tract of land overlying the Tar Sand Triangle STSA has been recognized as having wilderness characteristics. This area, named the Dirty Devil–French South area, is shown on Figure 3.1.1-10. On the basis of GIS data compiled to support the PEIS analyses, this area has a total size of 133,202 acres; about 24,255 acres of this area overlap with the STSA.

3.1.1.8 Vernal Field Office, Utah

Resources present in the Vernal Field Office are managed in accordance with two plans: the Diamond Mountain RMP (BLM 1994a) and the Book Cliffs RMP (BLM 1985a). The BLM is currently preparing a single plan for the field office that will replace these two plans. A draft of the new Vernal Field Office RMP was released for public review and comment in 2005 (BLM 2005e). A supplement to the draft RMP was released in October 2007. The supplement identifies non-WSA lands the BLM has found to possess wilderness characteristics. A new alternative included in the supplement emphasized managing those lands to protect and preserve their wilderness characteristics. The BLM administers almost 1.7 million acres of land within this planning area (Figure 3.1.1-11). Tar sands resources are located within the Hill Creek, P.R. Spring, Raven Ridge, Asphalt Ridge, Pariette, Sunnyside, and Argyle Canyon STSAs within the field office boundary.[3] The field office is located within the Uinta Basin and also contains oil shale resources. Currently, an oil shale withdrawal is in place under E.O. 5327, which would need to be modified or revoked before oil shale leasing could occur.

Most of the Uintah and Ouray Indian Reservation falls within the area managed by the Vernal Field Office. Lands within the reservation on which the subsurface mineral estate is owned by the Northern Ute Tribe will not be opened for leasing under this PEIS and are not

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3 A portion of the P.R. Spring STSA extends south from the Vernal Field Office boundary into the Moab Field Office boundary; however, this area is administered by the Vernal Field Office under a MOU with the Moab Field Office. Under this agreement, the Vernal Field Office administers all resources and programs, including land use planning, for the entire P.R. Spring STSA.

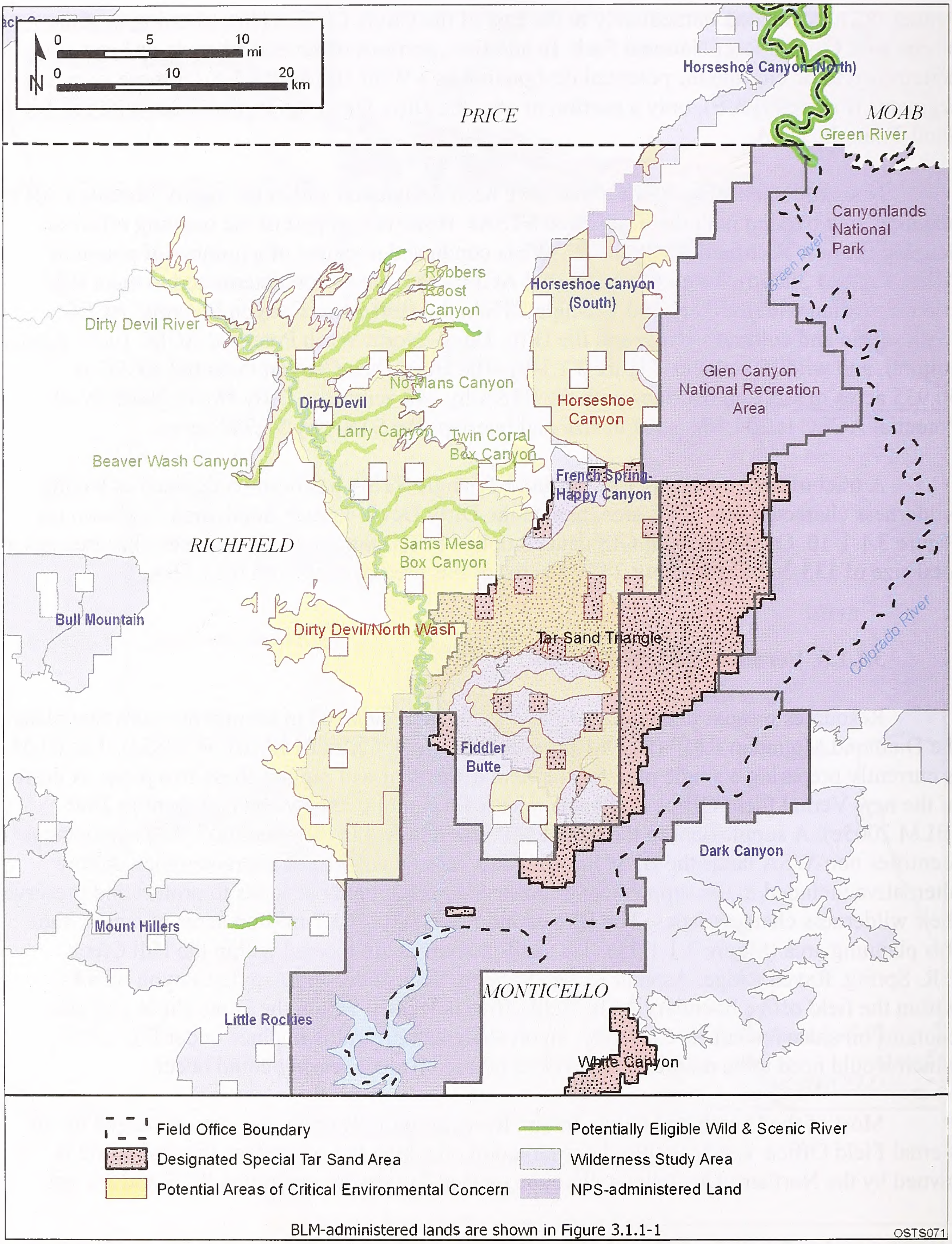

FIGURE 3.1.1-9 WSAs and Potential ACECs in the Richfield Field Office That Overlie the Tar Sand Triangle STSA

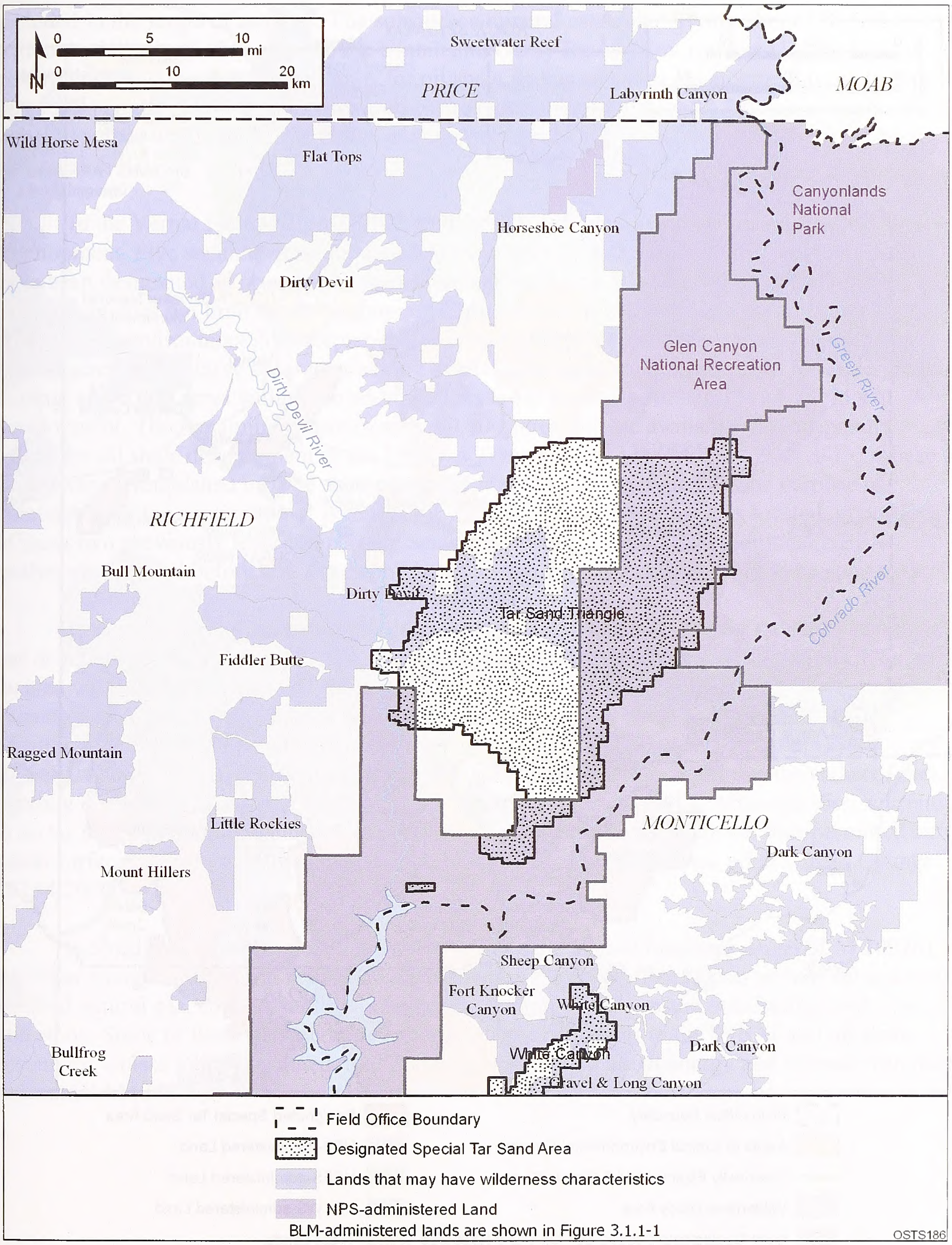

FIGURE 3.1.1-10 Areas with Wilderness Characteristics in the Richfield Field Office That Overlap with the Tar Sand Triangle STSA

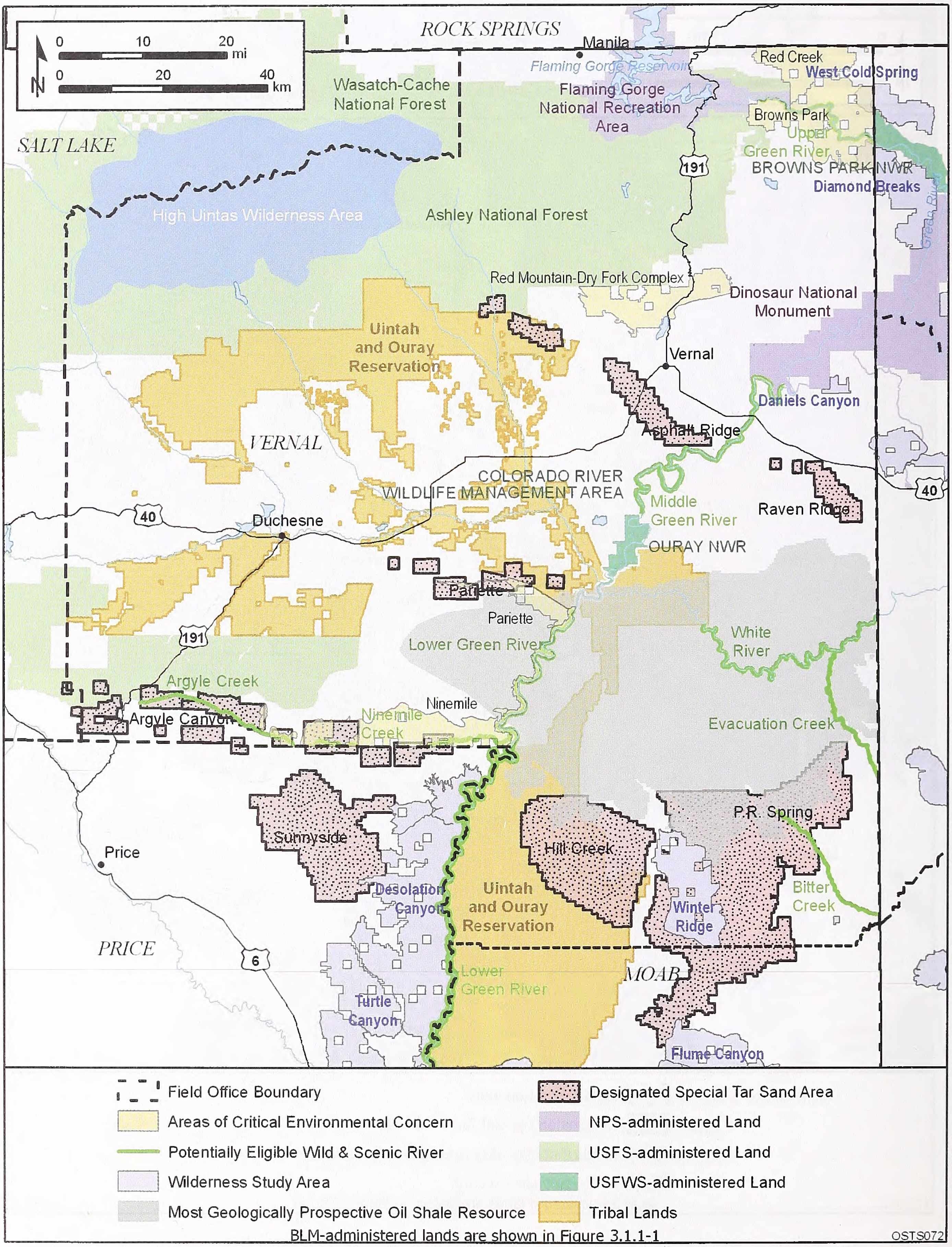

FIGURE 3.1.1-11 Vernal Field Office RMP Planning Area

included in the scope of analysis. The subsurface mineral estate underlying about 188,500 acres within the Hill Creek Extension of the Uintah and Ouray Reservation is owned by the federal government, and leasing of these lands for oil shale and/or tar sands development is evaluated in this PEIS (Figure 3.1.1-12). Of these split estate lands, approximately 57,705 acres overlie the oil shale resources within the Uinta Basin, and approximately 35,472 acres overlie the Hill Creek STSA.

In the Vernal Field Office, 58,100 acres are identified as available for oil shale development. Five separate areas totaling 48,000 acres within the Book Cliffs Resource Area have been designated as priority management areas for future oil shale leases (BLM 1985a). This designation does not limit the development of other resource values (it is not a withdrawal), but it defines an environmentally acceptable area with high-quality oil shale values. Approximately 42,000 acres within three separate areas are available for application for leasing for underground mining, and 6,000 acres within two additional areas are available for application for in situ development. The remaining approximately 10,100 acres that are available were originally leased for oil shale development in the 1970s as Tracts Ua and Ub (see Figure 3.1.1-13). These leases were relinquished in 1985; however, a BLM RD&D lease issued for the purpose of demonstrating the application of potential oil shale recovery technologies is located on portions of these two previously leased tracts (see Section 2.3 and Figure 2.3-2). Additional NEPA analysis is required before any lease application for oil shale development could be approved.

Currently, the tar sands resources within the STSAs are available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. Six existing CHLs are located within the Vernal Field Office region; 1,066.41 acres are held under four leases in the Pariette STSA, and 6,080.30 acres are held under two leases in the P.R. Spring STSA. In addition, there are eight pending conversion leases in the P.R. Spring STSA, totaling 27,668.04 acres. The BLM is engaged in an adjudication process to determine the status of these pending conversion leases and whether or not to convert them to CHLs. Although there currently is no tar sands development underway on BLM-administered lands, there are four permitted tar sands surface mining operations in the Vernal Field Office planning area, all in Uintah County (BLM 2006c).

According to the *Mineral Potential Report for the Vernal Planning Area* (BLM 2002b), the other energy and mineral resources located within the field office region include oil and gas, coalbed natural gas, coal, gilsonite,[4] phosphate, uranium, gold, gypsum, sand and gravel, clay, and stone. Some of these resources are located in close proximity to the STSAs and oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from BLM (2002b).

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4 Gilsonite is a black, homogeneous, solid hydrocarbon that is mined and used in the production of varnishes, lacquers, paints, some plastics, ink, and drilling muds.

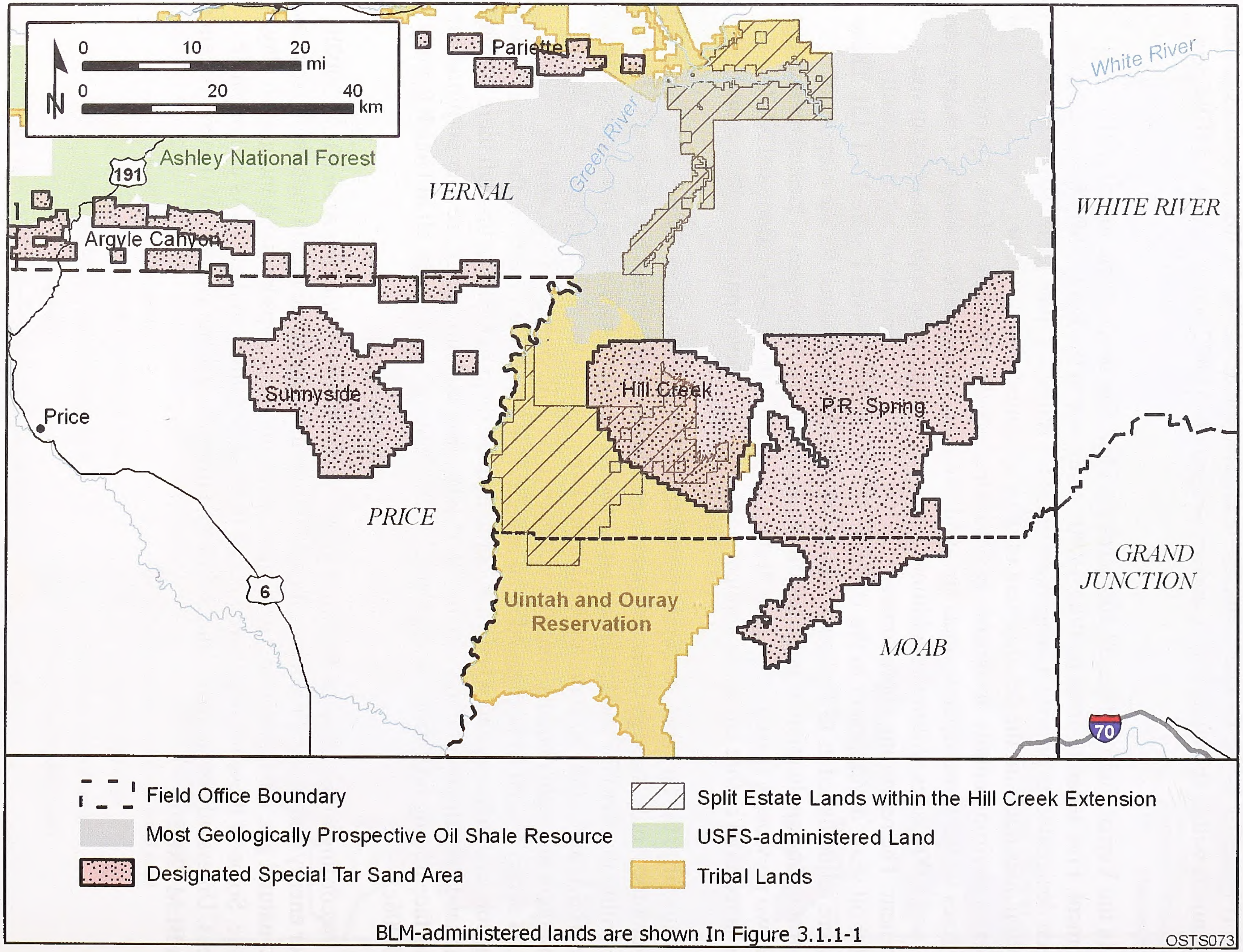

FIGURE 3.1.1-12 Split Estate Lands within the Hill Creek Extension of the Uintah and Ouray Reservation

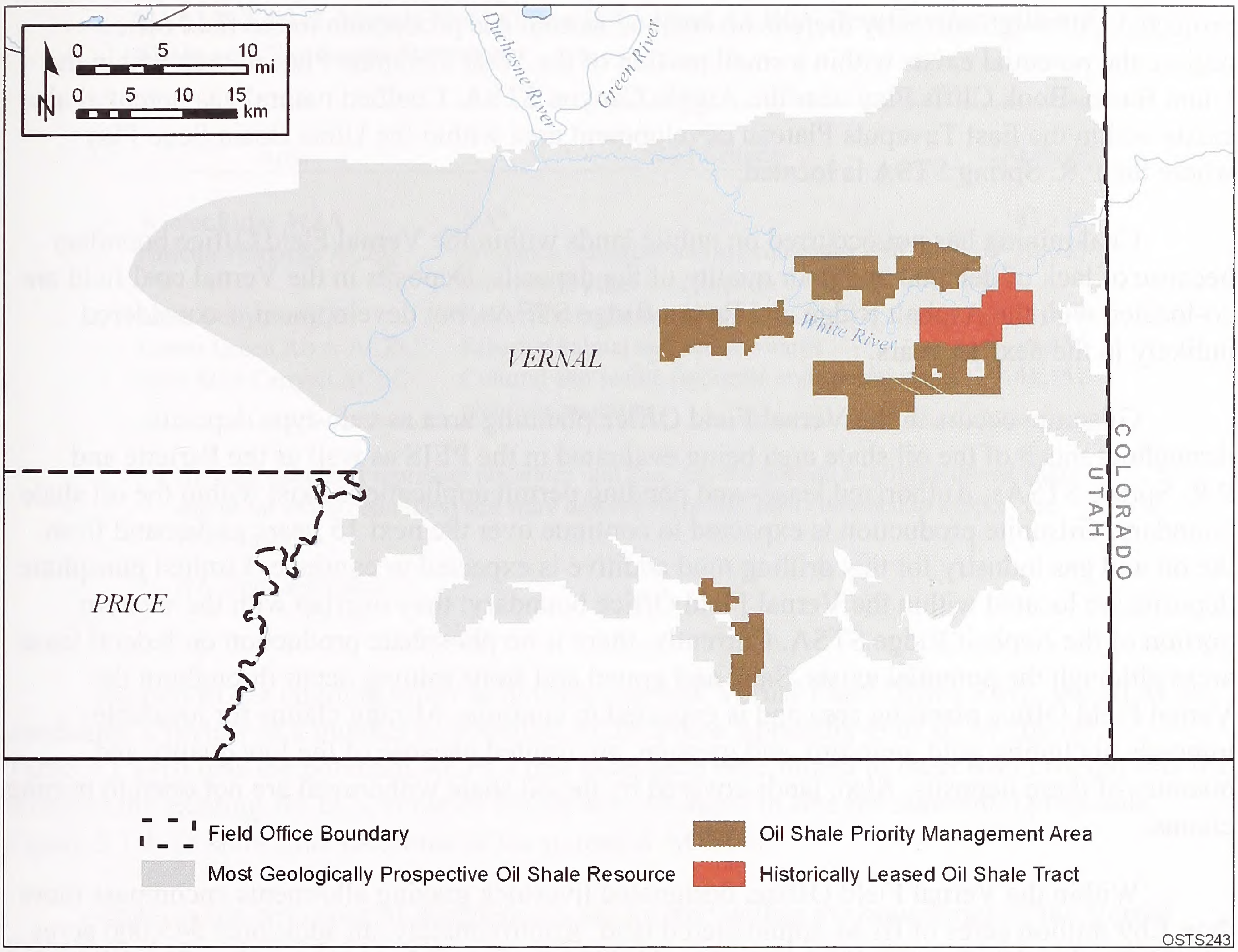

FIGURE 3.1.1-13 Book Cliffs RMP Decisions Related to Oil Shale Leasing and Development

About 2,800 active oil and gas wells are located within the Vernal Field Office planning area, and more than 1.8 million acres of land are available for leasing (for both conventional oil and gas and coalbed natural gas development), including about 188,500 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Indian Reservation (BLM 2005e). Conventional oil and gas production occurs and is projected to continue in the future within six development areas, four of which include either tar sands or oil shale resources or both. Specifically, the Tabiona-Ashley Valley development area overlaps with the Asphalt Ridge and Raven Ridge STSAs. The Monument Butte-Redwash development area overlaps with the Raven Ridge and Pariette STSAs, as well as the oil shale resources within the Uinta Basin. The West Tavaputs Plateau development area overlaps with the Sunnyside and Argyle Canyon STSAs and some of the oil shale resources. And, the East Tavaputs Plateau development area overlaps with the Hill Creek and P.R. Spring STSAs as well as some of the oil shale resources. Existing oil and gas development is relatively limited in the Tabiona-Ashley Valley development area and is expected to remain low over the next 15 years. Conversely, development is extensive in the remaining three development areas and is expected to be relatively high in the next 15 years, especially in the Monument Butte-Redwash area where 1,700 oil wells and 3,100 gas wells are projected. Although currently there is no coalbed natural gas production in the field office region, the potential exists within a small portion of the West Tavaputs Plateau area within the Uinta Basin–Book Cliffs Play near the Argyle Canyon STSA. Coalbed natural gas potential also exists within the East Tavaputs Plateau development area within the Uinta Basin Sego Play where the P.R. Spring STSA is located.

Coal mining has not occurred on public lands within the Vernal Field Office boundary because of lack of demand and poor quality of the deposits. Deposits in the Vernal coal field are co-located with the Asphalt Ridge and Raven Ridge STSAs, but development is considered unlikely in the next 15 years.

Gilsonite occurs in the Vernal Field Office planning area as vein-type deposits throughout much of the oil shale area being evaluated in the PEIS as well as the Pariette and P.R. Spring STSAs. Authorized leases and pending permit applications exist within the oil shale boundary. Gilsonite production is expected to continue over the next 15 years as demand from the oil and gas industry for this drilling mud additive is expected to continue. Limited phosphate deposits are located within the Vernal Field Office boundary; they overlap with the western portion of the Asphalt Ridge STSA. Currently, there is no phosphate production on federal lease areas although the potential exists. Sand and gravel and stone mining occur throughout the Vernal Field Office planning area and is expected to continue. Mining claims for locatable minerals, including gold, uranium, and gypsum, are limited because of the low quality and quantity of these deposits. Also, lands covered by the oil shale withdrawal are not open to mining claims.

Within the Vernal Field Office, designated livestock grazing allotments encompass more than 1.69 million acres of BLM-administered land. Approximately, an additional 545,000 acres of other lands (e.g., private, state, Tribal) are included within these allotments. These allotments cover the majority of the planning area and are categorized on the basis of their resource production potential and resource use conflicts. Several SRMAs have been established within the planning area, some of which are co-located with the tar sands and oil shale resources, including the White River, Book Cliffs, and Nine Mile Canyon SRMAs. The Hill Creek Wild Horse HMA overlaps with some of the oil shale and tar sands resources (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the tar sands or oil shale resources.

Several WSAs and ACECs have been designated in the Diamond Mountain and Book Cliffs RMPs in the vicinity of the STSAs. The WSAs and ACECs that overlap with tar sands and/or oil shale resources are shown in Figure 3.1.1-11 and are listed in Table 3.1.1-8. In addition, portions of several rivers have been determined to be eligible for potential designation as a WSR (see Appendix C of BLM 2005e). Those portions that overlie oil shale and/or tar sands deposits are shown in Figure 3.1.1-11 and include portions of the Green River, Argyle Creek, Nine Mile Creek, White River, Evacuation Creek, and Bitter Creek.

A number of areas that overlie the most geologically prospective oil shale area, as well as several STSAs, have been recognized as having wilderness characteristics. These areas are shown in Figure 3.1.1-14; the areas that overlap with the oil shale area and the STSAs are described in Table 3.1.1-9.

TABLE 3.1.1-8 Vernal Field Office WSAs and ACECs That Overlap with Oil Shale and Tar Sands Resources

Area	R&I Criteria	Acreage[a]
Winter Ridge WSA	NA[b]	43,339
Pariette Wetlands ACEC	Wetlands resources and special status bird habitat and plant communities	10,635
Lears Canyon ACEC	Relict plant communities	1,378
Lower Green River ACEC	Riparian habitat and scenic values	9,430
Nine Mile Canyon ACEC	Cultural and scenic resources and special status plant communities	48,151

[a] Acreage estimates represent the entire unit (not just the portion overlying the oil shale and/or tar sands resources) and were derived from GIS data compiled to support the PEIS analyses.

[b] NA = not applicable.

As part of the ongoing effort to develop the new Vernal Field Office RMP, the BLM has conducted a review of a number of potential ACECs (see Appendix G of BLM 2005e). Table 3.1.1-10 lists the potential ACECs that have been determined to meet R&I criteria; this list includes the existing ACECs, some of which have changed in size per submitted proposals. Figure 3.1.1-15 shows the locations of the potential ACECs.

Other lands with special designations are located within the boundaries of the Vernal Field Office (Figure 3.1.1-11). A portion of Dinosaur National Monument, which is managed by the NPS, falls within the Vernal Field Office boundary; however, it does not overlie any of the oil shale or tar sands resources being evaluated in this PEIS. At its closest point, the Monument is just under 7 mi from the Raven Ridge STSA, 8.5 mi from the Asphalt Ridge STSA, and 17 mi from the oil shale resources being evaluated within the Uinta Basin. The Ashley National Forest and Wasatch-Cache National Forest both fall within the Vernal Field Office boundary. Lands within the Ashley National Forest overlie the Asphalt Ridge, Argyle Canyon, and Sunnyside STSAs. In addition, lands within the Flaming Gorge NRA, which is administered by the Ashley National Forest, overlie oil shale resources identified in the Green River Basin in Wyoming. The BLM is not considering making allocation decisions for areas within the Ashley National Forest. The High Uintas Wilderness Area, which is located within both the Ashley and Wasatch-Cache National Forests, does not overlie the oil shale or tar sands resources being evaluated in this PEIS. This Wilderness Area is more than 13 mi from the Asphalt Ridge STSA, the closest STSA, and more than 13.5 mi from the nearest oil shale resources being evaluated within the Green River Basin in Wyoming.

3.1.1.9 Kemmerer Field Office, Wyoming

The Kemmerer Field Office is in the process of revising the Kemmerer RMP, which was completed in 1986 (BLM 1986c). The BLM administers 1.4 million acres of surface lands and

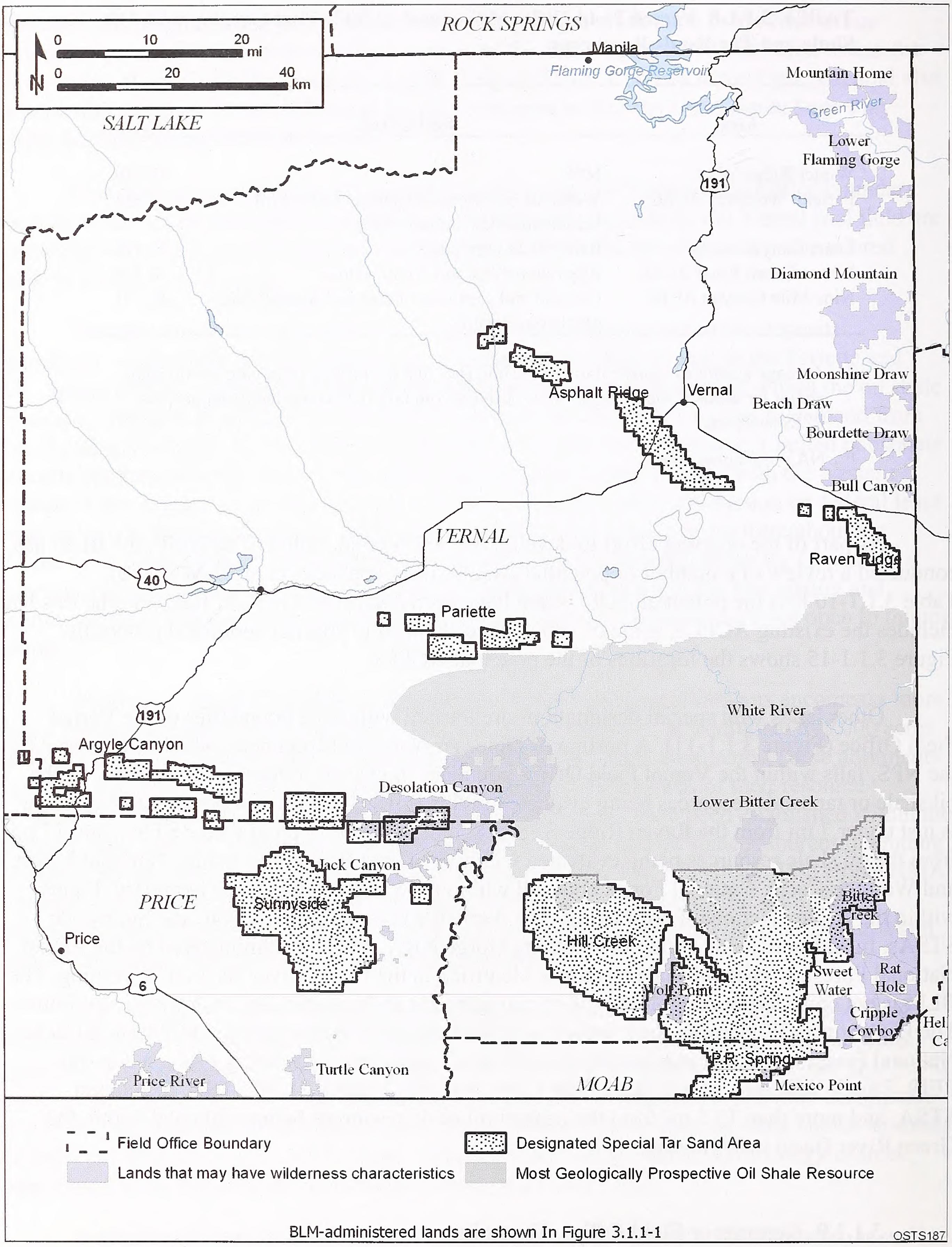

FIGURE 3.1.1-14 Wilderness Characteristics in the Vernal Field Office That Overlap with the Most Geologically Prospective Oil Shale Area and STSAs

TABLE 3.1.1-9 Areas Recognized as Having Wilderness Characteristics in the Vernal Field Office That Overlap with the Most Geologically Prospective Oil Shale Area and STSAs[a,b]

Name of Area with Wilderness Characteristics	Total Size of Area (acres)	Amount of Overlap (acres)
Overlapping Most Geologically Prospective Oil Shale Area		
Bitter Creek	33,375	1,218
Desolation Canyon	87,359	31,083
Lower Bitter Creek	11,417	11,417
White River	21,314	21,314
Overlapping Hill Creek STSA		
Wolf Point	11,807	937
Overlapping P.R. Spring STSA[c]		
Bitter Creek	33,375	12,936
Hideout Canyon	1,113	993
Lower Bitter Creek	11,421	514
Mexico Point	1,277	739
Wolf Point	11,807	5,147
Overlapping Sunnyside STSA		
Desolation Canyon	87,359	2,819

[a] The key characteristics of wilderness that may be considered in land use planning include an area's appearance of naturalness and the existence of outstanding opportunities for solitude or primitive and unconfined types of recreation.

[b] Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

[c] Lands in the Hideout Canyon and Mexico Point areas fall within the Moab Field Office.

1.6 million acres of federal mineral estate within the planning area encompassed by this RMP (Figure 3.1.1-16). The oil shale resources are located within the Green River Basin; no known tar sands resources are located within the boundaries of this field office. Currently, an oil shale withdrawal is in place under E.O. 5327, which would need to be modified or revoked before oil shale leasing could occur.

According to the *Kemmerer Field Office Planning Area Mineral Assessment Report* (BLM 2004b), the other energy and mineral resources of note located within the field office

TABLE 3.1.1-10 Potential ACECs in the Vernal Field Office Area That Meet R&I Criteria and Overlap with Oil Shale and/or Tar Sands Resources[a]

Potential ACEC	R&I Criteria	Total Size of Area (acres)	Amount of Overlap (acres)
Overlapping Most Geologically Prospective Oil Shale Area			
Bitter Creek ACEC	Significant old growth forest, cultural and historic resources, watershed, and critical ecosystem for migratory birds	72,167	7,917
Bitter Creek/P.R. Spring ACEC	Significant old growth forest, cultural and historic resources, watershed, and critical ecosystem for migratory birds	81,371	2,856
Coyote Basin–Coyote Basin ACEC	Critical ecosystem for white-tailed prairie dog	26,656	19,270
Coyote Basin–Kennedy Wash ACEC	Critical ecosystem for white-tailed prairie dog	10,148	8,692
Coyote Basin–Myton Bench ACEC	Critical ecosystem for white-tailed prairie dog	38,112	25,403
Four Mile Wash ACEC	High-value scenery, riparian system, and special status fish	50,325	32,569
Lower Green River ACEC	Riparian habitat and scenic values	11,075	9,588
Main Canyon ACEC	Cultural and historic resources and natural systems	107,612	17,134
Pariette Wetlands ACEC	Wetlands resources and special status bird habitat and plant communities	10,635	6,523
White River ACEC	Unique geologic formations, high-value scenic vistas, and riparian ecosystem	56,358	55,423
Overlapping Argyle Canyon STSA			
Nine Mile Canyon ACEC	Cultural resources	93,344	873
Overlapping Hill Creek STSA			
Main Canyon ACEC	Cultural and historic resources and natural systems	107,612	5,648
Overlapping Pariette STSA			
Coyote Basin–Myton Bench ACEC	Critical ecosystem for white-tailed prairie dog	38,112	3,612
Pariette Wetlands ACEC	Wetlands resources and special status bird habitat and plant communities	10,635	2,255
Overlapping P.R. Spring STSA			
Bitter Creek ACEC	Significant old growth forest, cultural and historic resources, watershed, and critical ecosystem for migratory birds	72,167	24,408
Bitter Creek/P.R. Spring ACEC	Significant old growth forest, cultural and historic resources, watershed, and critical ecosystem for migratory birds	81,371	48,361

TABLE 3.1.1-10 (Cont.)

Potential ACEC	R&I Criteria	Total Size of Area (acres)	Amount of Overlap (acres)
Overlapping P.R. Spring STSA (Cont.)			
Main Canyon ACEC	Cultural and historic resources and natural systems	107,612	77,669
Overlapping Raven Ridge STSA			
Coyote Basin–Snake John ACEC	Critical ecosystem for white-tailed prairie dog	30,648	6,780
Overlapping Sunnyside STSA			
Nine Mile Canyon ACEC	Cultural resources	93,344	22,508

[a] Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

include oil and gas, coalbed natural gas, coal, trona,[5] uranium, bentonite, sand, gravel, and decorative stone. Some of these resources are located in close proximity to the oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from BLM (2004b).

More than 1 million acres of land are currently leased for oil and gas development in the jurisdiction of this field office, including most of the federal subsurface mineral estate that coincides with the oil shale resources. Production in the Green River Basin is associated with gas fields located in and adjacent to the La Barge Platform–Moxa Arch trend. Coalbed natural gas wells have been drilled in the Kemmerer Field Office and, while production is currently low, more development is expected in the future.

Coal reserves in the Kemmerer Field Office area occur in two major regional coal fields: the Hams Fork Coal Field and the western portion of the Green River Coal Field. Coal production is currently occurring only in the Hams Fork Coal Field, which does not coincide with the oil shale resources located in the Green River Basin. There are no existing coal leases in the Green River Coal Field, which overlaps with the oil shale resources.

The world's largest known trona deposits exist within an area defined as the KSLA, which extends into the eastern portion of the Kemmerer Field Office region. Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has designated a portion of the KSLA as the MMTA (Figure 3.1.1-16) and determined that this area will be excluded from oil shale leasing until technology or other factors exist to allow

[5] Trona is a hydrous sodium carbonate mineral that is refined into soda ash, sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and chemical caustic soda.

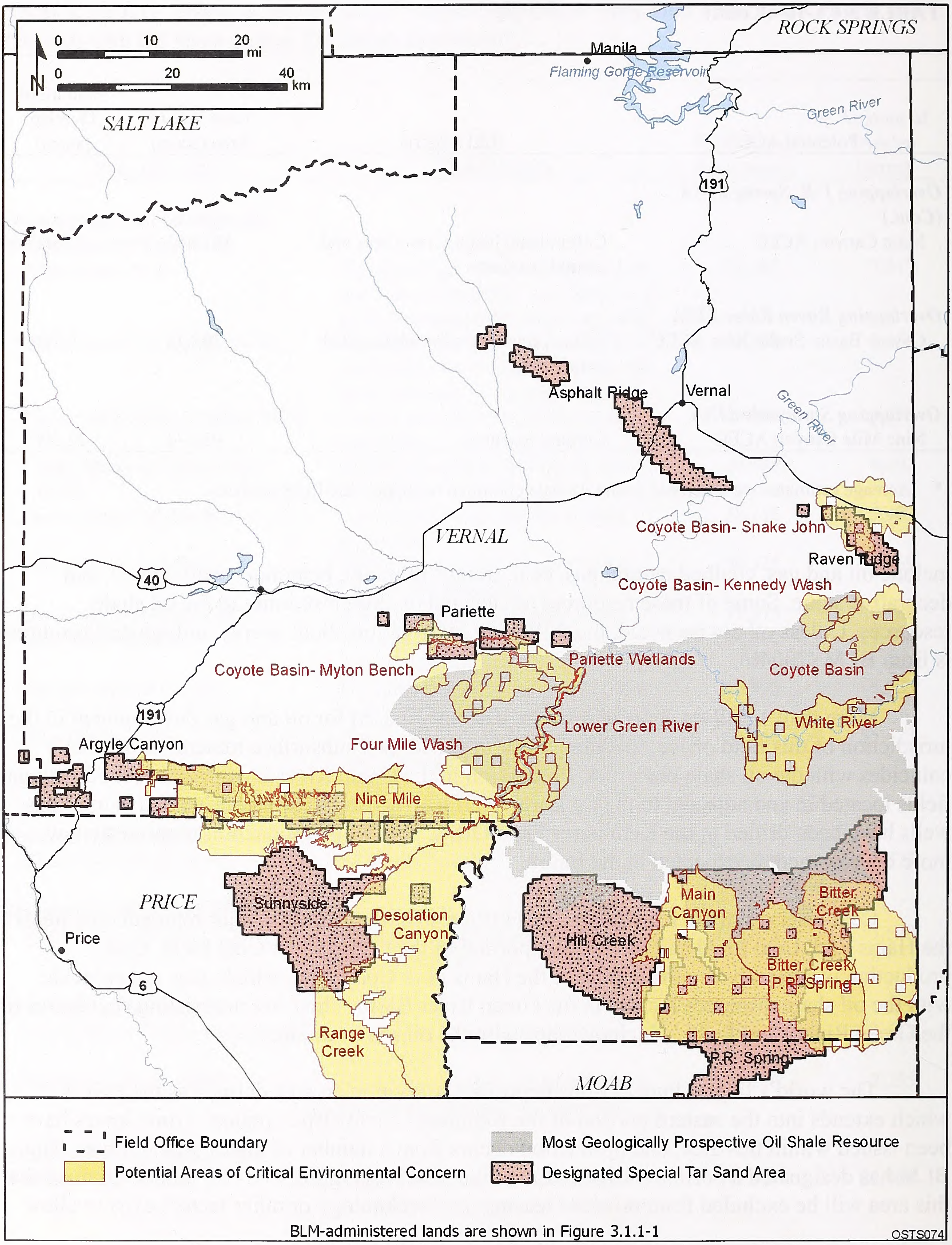

FIGURE 3.1.1-15 Potential ACECs in the Vernal Field Office

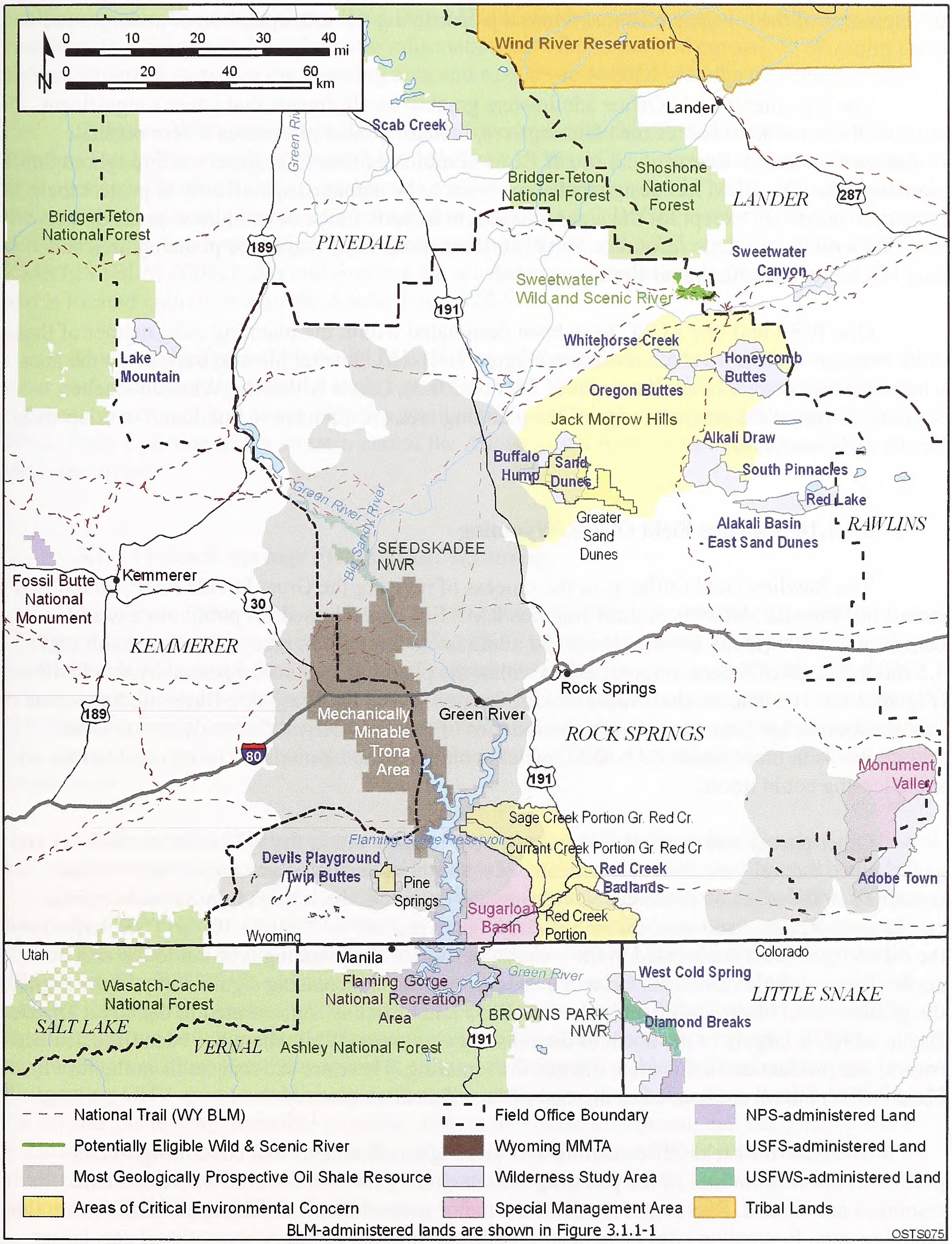

FIGURE 3.1.1-16 BLM Planning Areas in Wyoming Where Oil Shale Resources Are Located

development of the oil shale resource without jeopardizing the safe operation of underground trona mines.

The Kemmerer Field Office administers grazing on allotments that cover a significant portion of the southern half of the planning area, including most of the area where oil shale resources are located. Recreational use of BLM-administered lands is dispersed throughout the planning area. The BLM has designated some areas to be managed specifically to protect their recreation potential; except for the areas adjacent to historic trails, most of these areas do not coincide with the oil shale resources. ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

One WSA and one ACEC have been designated within the planning area; neither of these units overlap with the oil shale resources (Figure 3.1.1-16). Several historic trails cross the area where oil shale resources are located (see Section 3.9.3). Lands within the Wasatch-Cache National Forest at the southern edge of the planning area are adjacent to but do not overlap with the oil shale resources.

3.1.1.10 Rawlins Field Office, Wyoming

The Rawlins Field Office is in the process of revising the Great Divide RMP, which was issued in 1990 (BLM 1990). A draft Rawlins RMP EIS was released for public review and comment in 2004 (BLM 2004e). The BLM administers 3.5 million acres of surface lands and 4.5 million acres of federal mineral estate within the planning area encompassed by this RMP (Figure 3.1.1-16). The oil shale resources are located within the Washakie Basin; no known tar sands resources are located within the boundaries of this field office. Currently, an oil shale withdrawal is in place under E.O. 5327, which would need to be modified or revoked before oil shale leasing could occur.

Other energy and mineral resources of note located within the field office include oil and gas, coalbed natural gas, coal, and uranium. Most of these resources are not located in close proximity to the oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from the Draft Rawlins RMP EIS (BLM 2004e). The majority of the oil and gas fields are located in the western portion of the planning area but to the east or north of the oil shale resources. Oil and gas development is increasing significantly in the region; the greatest level of development in the Rawlins Field Office is concentrated in the Great Divide Basin, which is largely to the north of the oil shale resources. While there has been little coalbed natural gas production in this area, interest is increasing. There are six coal fields in the Rawlins Field Office, but all are located to the east of the oil shale resources.

The Rawlins Field Office administers grazing on allotments that cover a significant portion of the western half of the planning area, including most of the area where oil shale resources are located. Recreation is one of the major uses of BLM-administered lands within this planning area. Recreation sites have been established in areas of heavy recreational use; larger areas of dispersed but heavy recreational use also have been identified and designated as SRMAs. None of the designated recreation sites or SRMAs are located in areas overlying the oil shale resources. The Adobe Town Wild Horse HMA overlaps with some of the oil shale resources (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Only one WSA, the Adobe Town WSA, overlaps with the oil shale resources in the Rawlins Field Office region (Figure 3.1.1-15). None of the ACECs designated in the planning area overlap with the oil shale. One historic trail, the southern route of Cherokee Trail, crosses the area where oil shale resources are located (see Section 3.9.3). One river unit, the Skull Creek Waterway Unit, has been designated as potentially eligible for WSR designation in the Draft RMP EIS (BLM 2004e); this unit overlies the oil shale resources being evaluated in this PEIS and is located entirely within the Adobe Town WSA.

One area recognized by the BLM as having wilderness characteristics overlaps with the most geologically prospective oil shale resources in the Washakie Basin. This area is called the Adobe Town fringe. It is about 31,510 acres in size and is located adjacent to the Adobe Town WSA. Only a portion of the western end of the Adobe Town fringe area overlaps with the oil shale resources.

3.1.1.11 Rock Springs Field Office, Wyoming

The Green River RMP was issued in 1997 (BLM 1997b), and several maintenance changes have been implemented over time. The BLM administers about 3.6 million acres of public land surface and 3.5 million acres of federal mineral estate (Figure 3.1.1-16). Oil shale resources are located within both the Green River and Washakie Basins; no known tar sands resources are located within the boundaries of this field office. Currently, an oil shale withdrawal is in place under E.O. 5327, which would need to be modified or revoked before oil shale leasing could occur.

Other energy and mineral resources of note located within the field office include oil and gas, coalbed natural gas, coal, geothermal resources, and trona. In 2006, the Green River RMP was amended by the Jack Morrow Hills Coordinated Activity Plan (JMH CAP) (BLM 2006b). The JMH CAP projects that 205 oil and gas exploration and production wells and 50 coalbed natural gas wells will be drilled in this area, for a total reasonably foreseeable development of 255 wells. The JMH CAP addresses issues associated with increased levels of oil and gas and coalbed development in the Jack Morrow Hills area, and it amended the Green River RMP by establishing two new Special Management Areas (SMAs); expanding an existing ACEC; establishing visual resource management classes; defining allowable uses and restrictions; designating OHV areas; establishing surface use restrictions and designating availability of lands for oil and gas leasing, locatable minerals, and salable mineral disposal; and designating ROW exclusion and avoidance areas. A small portion of the Jack Morrow Hills area overlaps with oil shale resources in the Green River Basin being evaluated in this PEIS, including some areas that are now under NSO and CSU stipulations.

About 422,000 acres of lands within the Coal Occurrence and Development Potential Area are open to further consideration for coal leasing and development. This area is located to the east of the oil shale resources being evaluated in this PEIS.

As discussed in Section 3.1.1.9, the world's largest known trona deposits exist within the KSLA, which extends into the western portion of the Rock Springs Field Office region. Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has designated a portion of the KSLA as the MMTA (Figure 3.1.1-16) and determined that this area will be excluded from oil shale leasing until technology or other factors exist to allow development of the oil shale resource without jeopardizing the safe operation of underground trona mines.

The Rock Springs Field Office administers grazing on allotments that cover almost the entire planning area, including most of the areas where oil shale resources are located. Recreation sites have been established in areas that coincide with the oil shale resources in the Green River Basin, and several SRMAs and SMAs have been designated. The SMAs that overlap with the oil shale resources include the Monument Valley and Sugarloaf Basin SMAs. The Adobe Town, Little Colorado, Salt Wells Creek, and White Mountain Wild Horse HMAs overlap with some of the oil shale resources (see Section 3.7.3.4 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Several WSAs and ACECs have been designated within the planning area. A number of them overlap with the oil shale resources being evaluated in this PEIS, as shown in Figure 3.1.1-16 and listed in Table 3.1.1-11 In addition, several historic trails cross the area where oil shale resources are located (see Section 3.9.3). The BLM also has established stipulations restricting surface-disturbance activities within the two SMAs that overlap the oil shale resources being evaluated in this PEIS and in Area 3 of the Jack Morrow Hills area (BLM 2006b). These areas also are shown in Figure 3.1.1-16 and listed in Table 3.1.1-11.

Several areas recognized by the BLM as having wilderness characteristics overlap with the most geologically prospective oil shale resources. These wilderness characteristic areas (WCAs) are listed in Table 3.1.1-11.

The Flaming Gorge NRA, a unit within the Ashley National Forest, falls within the Rock Springs Field Office boundary and overlaps in part with the oil shale resources in the Green River Basin being evaluated in this PEIS. The BLM is not considering making allocation decisions for this area. The High Uintas Wilderness Area, which is located within both the Ashley and Wasatch-Cache National Forests in northern Utah, is more than 13.5 mi at its closest point from the oil shale resources being evaluated within the Green River Basin in Wyoming.

3.1.2 Recreational Land Use in the Three-State Study Area

Recreational use of BLM-administered lands within the three-state study area is varied and dispersed. Specific recreational sites and use areas have been designated by the BLM

TABLE 3.1.1-11 Rock Springs Field Office, WCAs, WSAs, and ACECs That Overlap with Oil Shale Resources

Area	R&I Criteria	Acreage[a]
Devils Playground/Twin Buttes WSA	NA[b]	23,070
Buffalo Hump WSA	NA	9,480
Adobe Town WSA	NA	54,330
White Mountain Petroglyphs ACEC	Cultural values of national significance	20[c]
Greater Red Creek ACEC	Fragile soils; unique ecological features; watershed and cultural values; and sensitive species of regional, national, and international importance	131,890[c]
Pine Springs ACEC	Cultural values of national significance	6,030[c]
Greater Sand Dunes ACEC	Outstanding geologic features; prehistoric and historic values of national significance; and recreation values of regional/national importance	38,650[c]
Special Status Plant Species ACEC	Natural processes, fragile plant species	900[c]
Monument Valley Management Area	NA	98,308
Sugarloaf Basin Management Area	NA	92,962
Jack Morrow Hills Area 3	NA	233,350
Buffalo Hemp WCA	NA	11,151
Kinney Rim North WCA	NA	57,063
Kinney Rim South WCA	NA	77,392
Sand Dunes WCA	NA	2,535
Range Creek Wildlife Management Area	NA	1,590[d]
Mallard Springs Wildlife Management Area	NA	270[e]

a Acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from GIS data compiled to support the PEIS analyses, unless otherwise noted.

b NA = not applicable.

c Acreage estimate was derived from the Green River RMP (BLM 1997b).

d UDWR (undated).

e Wasatoh Audubon Society (undated).

throughout the region. To facilitate and manage OHV use, existing land use plans within the study area identify areas that are designated as either closed, open, or limited to OHV use.

Generally, the BLM provides recreational opportunities where they are compatible with other authorized land uses, while minimizing risks to public health and safety and maintaining the health and diversity of the land. The Recreation Opportunity Spectrum (ROS) is one of the means that the BLM uses to inventory, plan, and manage recreational use. Seven elements provide the basis for inventorying and delineating recreational settings: access, remoteness, naturalness, facility and site management, visitor management, social encounters, and visitor impacts. Based on these elements, the BLM (1981) utilizes six ROS classes to describe management goals:

1. *Primitive.* Large areas of about 5,000 acres (2,023 ha) or more located at least 3 mi (5 km) from the nearest point of motor vehicle access;

2. *Semiprimitive nonmotorized.* Areas of about 2,500 acres (1,012 ha) located at least 0.5 mi (0.8 km) from the nearest point of motor vehicle access;

3. *Semiprimitive motorized.* Areas of about 2,500 acres (1,012 ha) located within 0.5 mi (0.8 km) of primitive roads and two-track vehicle trails;

4. *Roaded natural.* Areas near improved and maintained roads;

5. *Rural.* Areas characterized by a substantially modified natural environment; and

6. *Urban.* Areas located near paved highways where the landscape is dominated by human modification.

The BLM also distinguishes recreational use on the basis of the level of use and management requirements. Areas designated as SRMAs require recreation activity plans and a major investment in facilities or supervision of more intensive activities. Areas designated as extensive SRMAs, however, offer mostly unstructured, dispersed, and low-intensity recreational opportunities that require a minimum amount of facilities and management. These designations are made through the land use planning process. Both SRMAs and extensive SRMAs are found within the study area.

Other federal and state agencies also manage a wide variety of recreational areas in the region, and recreational use is a significant part of the regional economy. Table 3.1.2-1 provides at least a partial listing of the many recreational areas and other areas that may provide recreation opportunities located within about a 50-mi radius of the oil shale and tar sands resources evaluated in this PEIS. This information was derived from various Internet sites and may not be all inclusive; it does not include recreation sites and areas, WSAs, or ACECs that are managed by the BLM and also occur in the area (many of these are discussed in Section 3.1.1). The intent of the table is to demonstrate the overall importance of recreational land use and the large variety of recreation areas in the region.

3.2 GEOLOGICAL RESOURCES AND SEISMIC SETTING

Extensive work has been conducted in the study area to describe the geologic setting (e.g., Cashion 1964; Culburtson and Pitman 1973; Dyni 2003; Blackett 1996). In addition, Chapter 2 and Appendices A and B provide general information regarding oil shale and tar sands resources and geology, respectively. A brief summary of the geologic setting for each major basin and STSA is presented in this section.

TABLE 3.1.2-1 Federal and State Recreation Areas within a 50-mi Radius of the Most Geologically Prospective Oil Shale Areas and STSAs

Recreation Area[a]	Managing Agency[b]
Colorado	
Black Ridge Canyons Wilderness Area	BLM
Brown's Park National Wildlife Refuge	USFWS
Canyon Pintado National Register Historic District	BLM
Colorado National Monument	NPS
Dinosaur Diamond National Scenic Byway	DOT
Dinosaur National Monument	NPS
Elkhead Reservoir	CSP
Flat Tops Wilderness Area	USFS
Grand Mesa National Forest	USFS
Grand Mesa Scenic and Historic Byway	DOT
Harvey Gap State Park	CSP
Highline Lake State Park	CSP
James M. Robb–Colorado River State Park	CSP
McInnis Canyons National Conservation Area	BLM
Maroon Bells Wilderness Area	USFS
Rabbit Valley Research Natural Area	BLM
Raggeds Wilderness Area	USFS
Routt National Forest	USFS
Horsethief Canyon State Wildlife Area	BOR
Rifle Falls State Park	CSP
Rifle Gap Reservoir and State Park	BOR and CSP
Sweitzer Lake State Park	CSP
Vega Reservoir and State Park	BOR and CSP
White River National Forest	USFS
Yampa River State Park	CSP
Utah	
Anasazi Indian State Park	USPR
Arches National Park	NPS
Ashley National Forest	USFS
Bryce Canyon National Park	NPS
Box-Death Hollow Wilderness Area	USFS
Canyonlands National Park	NPS
Capitol Reef National Park	NPS
Cleveland-Lloyd Dinosaur Quarry	BLM
Dark Canyon Wilderness Area	USFS
Dead Horse Point State Park	USPR
Dinosaur Diamond National Scenic Byway	DOT
Dinosaur National Monument	NPS
Dixie National Forest	USFS
Edge of the Cedars State Park	USPR
Escalante State Park	USPR
Fantasy Canyon	BLM
Fishlake National Forest	USFS
Flaming Gorge National Recreation Area	USFS

TABLE 3.1.2-1 (Cont.)

Recreation Area[a]	Managing Agency[b]
Utah (Cont.)	
Flaming Gorge–Uintas Scenic Byway	DOT
Glen Canyon National Recreation Area	NPS
Grand Staircase–Escalante National Monument	BLM
Green River State Park	USPR
Goblin Valley	USPR
High Uintas Wilderness Area	USFS
Huntington North Reservoir and Huntington State Park	BOR and USPR
Joes Valley Reservoir	BOR
Kodachrome Basin State Park	USPR
Manti-La Sal National Forest	USFS
Millsite State Park	USPR
Moon Lake Reservoir	BOR
Mt. Nebo Wilderness Area	USFS
Ouray National Wildlife Refuge	USFWS
Palisade State Park	USPR
Red Fleet Reservoir and State Park	BOR and USPR
Scofield Reservoir and State Park	BOR and USPR
Starvation Reservoir and State Park	BOR and USPR
Steinaker Reservoir and State Park	BOR and USPR
Uinta National Forest	USFS
Upper Stillwater Reservoir	BOR
Wasatch-Cache National Forest	USFS
Wyoming	
Bear River State Park	WSPCR
Bridger National Forest	USFS
Bridger Wilderness Area	USFS
Cokeville Meadows National Wildlife Refuge	USFWS
Fitzpatrick Wilderness Area	USFS
Flaming Gorge National Recreation Area	USFS
Fort Bridger State Park	WSPCR
Fossil Butte National Monument	NPS
Medicine Bow National Forest	USFS
Oregon, Mormon, Pioneer, California, and Pony Express Trails	BLM
Popo Agie Wilderness Area	USFS
Seedskadee National Wildlife Refuge	USFWS
Shoshone National Forest	USFS
Wasatch-Cache National Forest	USFS

[a] Includes areas that are within or partially within an approximately 50-mi radius.

[b] Abbreviations: BLM = Bureau of Land Management; BOR = Bureau of Reclamation; CSP = Colorado State Parks; DOT = U.S. Department of Transportation; NPS = National Park Service; USFS = U.S. Forest Service; USFWS = U.S. Fish and Wildlife Service; USPR = Utah State Parks and Recreation; WSPCR = Wyoming Department of State Parks and Cultural Resources.

Sources: federal recreation areas, Recreation.gov (2006); Colorado State Parks (2006a); Utah State Parks and Recreation (2006); Wyoming Division of State Parks and Historic Sites (2006).

3.2.1 Piceance Basin

3.2.1.1 Physiography

The Piceance Basin is located mainly in the Colorado Plateau physiographic province (Figure 1.2-1). The Piceance Basin is simultaneously a structural, depositional, and drainage basin. The structural basin is downwarped and surrounded by uplifts resulting from the Laramide Orogeny. This tectonic activity created a depositional basin that filled with sediments from the surrounding uplands, mainly during the Tertiary period. The Piceance Basin is not referred to or described consistently in the published literature. Some publications describe the Piceance Basin as an area encompassing more than 7,000 mi^2 and consisting of a northern province and a southern province that are separated approximately by the Colorado River and I-70. Other publications refer to the southern province as the Grand Mesa Basin. Oil shale is present in both provinces, with the richest oil shale deposits in the north, and smaller, isolated deposits in the south.

3.2.1.2 Geologic Setting

Within the Piceance Basin, the upper bedrock stratigraphy consists of a series of basin-fill sediments from the Tertiary period (Topper et al. 2003). The uppermost unit is the Uinta Formation, which consists of up to 1,400 ft of Eocene-age sandstone, siltstone, and marlstone. Below the Uinta Formation is the Eocene Green River Formation, which can be up to 5,000 ft thick and includes four members: the Parachute Creek (keragenous dolomitic marlstone and shale), the Anvil Points (shale, sandstone, and marlstone), the Garden Gulch (claystone, siltstone, clay-rich oil shale, and marlstone), and the Douglas Creek (siltstone, shale, and sandstone) members. The Eocene-Paleocene Wasatch Formation underlies the Green River Formation. The Wasatch is a shale and sandstone formation. Below the Wasatch is the Cretaceous Mesaverde Group (sandstone and shale), the Cretaceous Mancos Shale, and older sedimentary formations atop Precambrian rock.

The main oil shale members of interest in the Piceance Basin are the Parachute Creek and Garden Gulch Members. The grade of oil shale varies with location and depth, but the Parachute Creek Member has the richest material and includes the Mahogany Zone.

Quaternary alluvium of varying thickness is present in the significant drainages of the basin. The alluvium can provide sand and gravel resources for construction projects, and the alluvium aquifers are often important sources of groundwater.

3.2.1.3 Soils

Soils vary in the Piceance Basin in their thickness and character (DOI 1973). On upland areas, soils are generally rocky with shallow depth to bedrock. Slopes in these areas are typically 10 to 60%. Eolian deposits (silt) may blanket the upland surface. Deep alluvial soils are found in drainageways and in valleys, with slopes less than 10%. Locally, valleys may contain colluvium from the side slopes. Erosion occurs mainly along roads and trails and in stream valleys. Intermittent creeks show head cutting, bank cutting, and deep gullying. Summer storms may cause bridge washouts and flash floods with extensive sheet erosion.

On upland ridges and cliffs, soil formation is minimal because of steep slopes and strong winds. Erosion is mainly by wind where overgrazing has exposed thin loamy soils. Gullying is possible in small drainageways, as is mass wasting of weathered soil and rock.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

3.2.1.4 Seismology

Seismic risk in the Piceance Basin is fairly low according to the USGS, with a peak acceleration of about 5% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of 14 to 16% of gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002).

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Piceance Basin, the susceptibility of the landscape to landslides is generally high, though the incidence of landslides in the basin is low (less than 1.5% of the area involved) in most of the basin.

3.2.1.5 Mineral Resources

In addition to oil shale, the Piceance Basin contains the sodium minerals halite, dawsonite, and nahcolite, which are intermingled with the oil shale. Nahcolite is sodium bicarbonate and may be used as soda ash, to remove sulfur from industrial air emissions, and as a cattle feed supplement. It occurs in the Parachute Creek Member at proportions generally less than 5% by weight; however, in the lower oil shale zone it may average more than 30% by weight (DOI 1973). Dawsonite is dihydroxy sodium aluminum carbonate and is found in the lower portion of the northern province of the Piceance Basin. It is a source of alumina, and some intervals contain up to 3% by weight of equivalent extractable alumina (DOI 1973). Interbedded halite and oil shale are found in a sequence in the northern province of the Piceance Basin. The halite beds range from 1 to 30 ft in thickness (DOI 1973). Recoverable amounts of these minerals are estimated by the BLM (1983a) for several individual tracts of land within the basin. An area near the northern edge of the Piceance Basin that measures more than 100 mi^2 is referred to as the Multimineral Zone. Here, the BLM does not allow oil shale development without suitable recovery of sodium minerals. In a surrounding area set aside for sodium leasing, sodium mineral extraction is not allowed to damage oil shale units.

Oil, natural gas, and coal are also present in the Piceance Basin (DOI 1973). The most productive zone is at the base of the Green River Formation. Other productive sandstones are up to 6,000 ft deeper than the Green River Formation. Extensive natural gas drilling is occurring in the southern portion of the northern Piceance province. Coal underlies essentially the entire basin (DOI 1973).

3.2.2 Uinta Basin

3.2.2.1 Physiography

The overall Uinta Basin has an area of about 7,000 mi^2, bounded by the Uinta Mountains on the north, the Wasatch Range on the west, the Roan Cliffs on the south, and the Douglas Creek Arch on the east (Cashion 1967). The basin is almost entirely in Utah, with a small portion of the overall basin extending into Colorado. The Uinta Basin is a structural, depositional, and topographic/drainage basin. This description focuses on the study area located in the east-central portion of the Uinta Basin, where the expected oil shale reserves are more than 25 ft thick and can produce more than 25 gal/ton of shale oil (Figure 1.2-1). This region is primarily in Uintah County, Utah, with a small western extension into Duchesne County, Utah.

3.2.2.2 Geologic Setting

The Uinta Basin contains a thickness of up to 15,000 ft of lacustrine and fluvial sedimentary rock of Eocene age above older sedimentary formations (Cashion 1967).

The uppermost bedrock unit is the Duchesne River Formation of fluvial sandstone and shale. Below this formation is the Uinta Formation of similar lithologies. Below the Uinta is the Green River Formation, which is composed of four members. The uppermost is the Evacuation Creek Member (also commonly known as the Uinta-Green River Transition), which is composed mainly of marlstone and siltstone and which interfingers with the overlying Uinta Formation. The underlying Garden Gulch and Parachute Creek Members are of similar lithologies. The Parachute Creek Member is the main oil shale-bearing member, and it includes the rich Mahogany Zone. The Douglas Creek Member is composed of mixed lithologies, including sandstone, siltstone, and limestone, and it interfingers with the overlying Garden Gulch and Parachute Creek Members and the underlying Wasatch Formation. The Wasatch is also an Eocene-age basin-fill unit and is composed of sandstone and shale.

Quaternary alluvium is present along the Uinta Basin's major stream valleys. The alluvium can provide sand and gravel resources for construction projects, and the alluvium aquifers are often important sources of groundwater.

3.2.2.3 Soils

Soils in the Uinta Basin are in two general groupings on the basis of the geomorphological setting (DOI 1973). Most of the basin's flat areas are covered with shallow soils over weathered bedrock. These soils are typically either fine loam or silt over silty or clayey subsoils, or sandy or coarse loamy soils. Shale and/or sandstone bedrock is usually about 20 in. deep. Erosion is high during summer storms.

Along the floodplains and terraces of major rivers are deep loamy or silty soils over coarser subsoils. Erosion through stream cutting is high during high flow periods.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

Overall, the basin's erosion potential is critically high, though some areas are in the slight to moderate range, and some areas have erosion potential that is considered severe.

Biological soil crusts occur on undisturbed soils in some portions of Utah and may be found in the study area. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion of the soils, fix atmospheric nitrogen, and contribute to soil organic matter (BLM 2002c).

3.2.2.4 Seismology

Seismic risk in the Uinta Basin is fairly low according to the USGS, with a peak acceleration of about 6 to 7% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 14 to 18% of gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002).

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Uinta Basin, the susceptibility of the landscape to landslides is low, as is the incidence of landslides (less than 1.5% of the area involved).

3.2.2.5 Mineral Resources

Gilsonite, a black, brittle natural petroleum residue, is found in the Uinta Basin, numerous veins of which are found in the prospective oil shale area. It occurs as vertical veins up to 7 mi long and 18 ft wide (Cashion 1967). Along the southern portion of the study area, part of the prospective oil shale area overlaps two STSAs—Hill Creek and P.R. Spring. Oil and gas have been produced from the lower part of the Green River Formation, the Wasatch Formation, and deeper Mesozoic-age rocks.

3.2.3 Green River Basin and Washakie Basin

3.2.3.1 Physiography

The Green River and Washakie Basins are located in the Wyoming Basin Physiographic Province of the Rocky Mountain Region. The oil shale areas are surrounded by the Wasatch, Green, Uintah, and Seminoe Mountains and by the Wind River and Medicine Bow Ranges. The overall basin has an area of about 6,700 mi^2. This description focuses on the study areas located within the Green River and Washakie Basins (Figure 1.2-1).

The Green River Basin is mainly bounded by escarpments of the Green River and Wasatch Formations (Mason and Miller 2004). The Washakie Basin is a synclinal structure with faulting mainly along its southern and western edges. Its central portion has few faults (DOI 1973). The rim of the basin is formed by rock of the Green River Formation (Mason and Miller 2004).

3.2.3.2 Geologic Setting

The Green River and the Washakie Basins are separated by the Rock Springs uplift. Each contains sedimentary rock with thicknesses of more than 20,000 ft.

In the Green River Basin, the uppermost unit is the Bridger Formation of fluvial and paludal (marsh) origin. The underlying Green River Formation is mostly lacustrine basin-fill rock. The Wasatch Formation underlies the Green River Formation and is mostly fluvial and paludal material. The Green River Formation intertongues with both the overlying Bridger Formation and the underlying Wasatch Formation, and it is replaced by these formations, and, in some locations around the basin, by the fluvial Battle Spring Formation boundary (Roehler 1992).

In the Washakie Basin, the stratigraphy is similar; however, the uppermost unit is referred to as the Washakie Formation rather than the Bridger Formation (Roehler 1992). The Green River Formation here is composed of four units. The Laney Member is up to 1,300 ft thick and consists of sandstone, siltstone, and mudstone, with generally low-grade oil shale zones. The Wilkins Peak Member is about 400 ft thick. Its upper portion is mudstone, siltstone, and sandstone, with minor amounts of oolitic and algal limestone and thin beds of low-grade oil shale. The lower portion is mainly low-grade to moderate-grade oil shale with algal limestone and siltstone. The Tipton Member is about 200 ft thick and is made up of low- to moderate-grade oil shale with some algal limestone and siltstone. The Luman Tongue is about 300 ft thick and is the lowermost unit of the Green River Formation. Its upper half is mainly low-grade oil shale with some limestone. The lower half is interbedded siltstone, sandstone, mudstone, low-grade oil shale, thin units of moderate-grade oil shale, limestone, shale, and coal.

3.2.3.3 Soils

The soils of the Green River and Washakie Basins are developed on the Green River, Bridger, and Wasatch Formations (DOI 1973). The soils' textures range from sandy to loamy to clayey. The soil surfaces are mainly level or moderately sloping, though roughly 20% of the area has steep slopes. Sixty percent of the basin area has shallow soil, with the bedrock within 20 in. of the surface. Erosion rates are generally moderate to high. Because of the aridity, wind erosion is greater than water erosion.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

3.2.3.4 Seismology

Seismic risk in the Green River Basin is fairly low according to the USGS, with a peak acceleration of about 5% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 18 to 22% gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002). In the Washakie Basin, the seismic risk is also fairly low, with a peak acceleration value of about 7 to 8% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 16 to 20% of gravity, with a 2% probability of occurrence in 50 years.

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Green River Basin, the susceptibility of the landscape to landslides is low in most areas, but high along the edges of the Flaming Gorge Reservoir and in an area northeast of the City of Green River. The incidence of landslides in the basin is low (less than 1.5% of the area involved) in most areas, but moderate (1.5 to 15% of the area) in a portion of the basin near the City of Green River and in a small zone in the southwestern portion of the basin. The Washakie Basin's susceptibility to landslides is approximately evenly split between low and moderate areas. The incidence of landslides is low (less than 1.5% of the area).

3.2.3.5 Mineral Resources

According to the DOI (1973), sodium minerals have not been discovered in the Washakie Basin. The central Green River Basin, however, has economic deposits of trona and halite in the Wilkins Peak Member of the Green River Formation (Roehler 1992). Approximately 500 m^2 in the central Green River Basin are designated as the MMTA. Oil and natural gas are present in the Wasatch, Fort Union, and Mesaverde Formations and have been produced in commercial quantities at locations surrounding the Washakie Basin (DOI 1973). These formations underlie the basin at depths several thousand feet below the lowermost Green River Formation oil shales. Coal is also present below the oil shale in the Green River and Washakie Basins (DOI 1973; Mason and Miller 2004).

3.2.4 Special Tar Sand Areas

3.2.4.1 Physiography

Seven of the STSAs (Argyle Canyon, Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside) are located in the Uinta Basin (Figure 1.2-2). The physiographic setting in Section 3.2.2.1 applies to these sites.

The four STSAs in southeast-central Utah (San Rafael, Circle Cliffs, Tar Sand Triangle, and White Canyon) are in the Canyonlands section of the Colorado Plateau physiographic province (BLM 1984b) (Figure 1.2-2). San Rafael is located on the San Rafael Swell; White Canyon is on the northwest flank of the Abajo Mountains; Circle Cliffs is an upland area between the Aquarius Plateau and the Henry Mountains; and the Tar Sand Triangle is located at the southern end of the San Rafael Desert.

3.2.4.2 Geologic Setting

The seven northern STSAs (Argyle Canyon, Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside) are located in the Uinta Basin, and most are in Tertiary-age sedimentary rocks. The geologic description in Section 3.2.3.2 applies to most of these sites. The exception is Asphalt Ridge, which is partially in the Cretaceous Mesaverde Formation (BLM 1984b). The rock units containing the tar are mostly fluvial sandstones, though some are lacustrine sediments. The bitumen is usually concentrated in the coarser facies of the sediments.

The four southern STSAs (San Rafael, Circle Cliffs, Tar Sand Triangle, and White Canyon) have bedrock of Permian and Triassic ages (BLM 1984b). The Tar Sand Triangle is in the Permian White Rim Sandstone, which may be dune sand or shallow marine sand deposits. Bitumen varies at the STSA along with the variations in sand texture and permeability. The Circle Cliffs and San Rafael STSAs are located in the lower Moenkopi Formation. This unit is a large deltaic deposit of fine- to medium-grained, moderately well-sorted sandstone of Triassic age. The White Canyon STSA occurs in the Hoskininni Sandstone, a Triassic shallow marine deposit.

3.2.4.3 Soils

Soils at the 11 STSAs have a wide range of thicknesses and character because of spatially varying factors such as parent material, climate, topography, and vegetation. Data compiled by the BLM (1984b) indicate general conditions in mountainous areas (moist, dark or light) and valley or mesa areas (dry, light-colored). The soils are developed from sandstone, shale, and siltstone bedrock and have corresponding textures, (e.g., sandy soils near more resistant ridges, clayey soils near shale outcrops). Alluvial fan soils are loamy and bouldery. Slopes vary within individual STSAs and among different STSAs.

The BLM (1984b) has evaluated the erosion potential of the STSA soils in terms of sediment yield classification. Overall, the largest category of the STSA land area is that of moderate sediment yield (0.2 to 0.5 ac-ft/mi^2/yr), followed by high sediment yield (0.5 to 1.0 ac-ft/mi^2/yr).[6] The San Rafael STSA had the only significant amount of land area (18%) at a very high sediment yield (1.0 to 3.0 ac-ft/mi^2/yr).

Biological soil crusts occur on undisturbed soils in some portions of Utah and may be found in the study area. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion of the soils, fix atmospheric nitrogen, and contribute to soil organic matter (BLM 2002c).

3.2.4.4 Seismology

Seismic risk among the STSAs varies with location, with the westernmost STSAs having higher risk than the others. Argyle Canyon, San Rafael, and Circle Cliffs have peak acceleration of roughly 10% of gravity with a 10% probability of exceedance in 50 years (Frankel et al. 2002). At the other eight STSAs, the seismic risk is lower, with peak acceleration values ranging from about 4 to 7% of gravity.

Landslide risk varies among the 11 STSAs. At most of the northern STSAs (Argyle Canyon, Pariette, Sunnyside, Hill Creek, P.R. Spring, and Raven Ridge), the susceptibility to landslides is low, and the incidence of landslides is low (less than 1.5% of the area) (Radbruch-Hall et al. 1982). The other northern STSA, Asphalt Ridge, is the same, except along its northern edge, where the incidence is moderate (1.5 to 15% of the land). At the San Rafael Swell, the incidence is low, and the susceptibility is approximately half low and half moderate across the scattered parcels of land. The Circle Cliffs STSA has low incidence in most of its area, but high incidence (more than 15% of the mapped area) in narrow bands along the western and eastern edges of the STSA. Landslide susceptibility here, however, is low. The White Canyon STSA's land area is a mix of low, moderate, and high incidence, and low-to-moderate susceptibility. The Tar Sand Triangle STSA has low landslide incidence but mostly moderate landslide susceptibility.

3.2.4.5 Mineral Resources

Other mineral resources are present or possibly present at the 11 STSAs (BLM 1984b). Oil and gas are present at P.R. Spring and Pariette, and are likely at Hill Creek and Raven Ridge. Oil and gas are possible, though not highly likely, at Argyle Canyon, Asphalt Ridge, Circle Cliffs, and White Canyon.

Oil shale of significant thickness and yield overlies the tar sands deposits along the northern edge of the P.R. Spring and Hill Creek STSAs. The Mahogany Oil Shale Zone is

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6 An acre-foot is the volume of water that covers 1 acre (43,560 ft) to a depth of 1 ft (0.3 m).

present at the Pariette and Raven Ridge STSAs; however, these oil shale deposits are not included in the oil shale study area defined for this PEIS.

Coal of potential commercial thickness and quality occurs below the Sunnyside STSA; it is at a depth that would require underground rather than surface mining. Any potential coal beds in cretaceous rocks under the Hill Creek, P.R. Spring, and Asphalt Ridge STSAs would not likely be minable.

Uranium may occur locally above the Moenkopi Formation in the Shinarump Conglomerate Member of the Chinle Formation at the Circle Cliffs, Tar Sand Triangle, and White Canyon STSAs, and at the San Rafael STSA.

Copper occurs locally at the San Rafael STSA.

3.3 PALEONTOLOGICAL RESOURCES

Paleontological resources are fossilized remains, imprints, and traces of plants and animals preserved in rocks and sediments. Greater attention is often given to vertebrate fossils than to invertebrate fossils because of their rarity; however, some plant and invertebrate fossils are also rare. The rarity of such specimens and the unique information that can be gleaned from these items emphasize their scientific value and the need to protect them.

The large number of productive fossil-bearing geological landforms found on federal land in the American West has encouraged the BLM to provide guidance on protecting this resource. The 2000 report by the Secretary of the Interior on Fossils on Federal Land (DOI 2000) provides guidance on the treatment of paleontological resources. Further guidance is provided in the BLM manual, *8270—Paleontological Resource Management* (BLM 1998). Procedures for managing these resources are identified in an attachment to BLM Manual 8270, the Paleontological Resources Handbook H-8270-1—General Procedural Guidance for Paleontological Resource Management. The goal of the BLM program is to locate, evaluate, manage, and protect paleontological resources on public lands. (See Section 3.1 of this PEIS, Land Use, for a description of designated ACECs, some of which are designated specifically to protect paleontological resources.)

To date, no comprehensive inventory of fossils and no systematic inventory of fossil-bearing areas on BLM-administered lands have been conducted. Most assessments and inventories of paleontological resources on public lands are conducted on a project-by-project basis. Some BLM field offices, along with various museums, geologic surveys, and other partners, maintain records of the paleontological finds made on the lands that they manage. Often this information is held by the primary state repository for fossil finds in that area. Site-specific information regarding paleontological resources would need to be collected to define the affected environment for an individual project.

Occurrences of paleontological resources are closely related to the geological units that contain them. Therefore, the potential for finding important paleontological resources can be predicted by the presence of the relevant geological units. A paleontological overview report describing, in general, the types of resources known to be present in the oil shale and tar sands study areas has been prepared in support of this PEIS. This overview is summarized below for each of the oil shale basins and STSAs (Murphey and Daitch 2007). The BLM's former classification system for paleontological sensitivity is presented in BLM Manual 8270 (BLM 1998) and involves the ranking of areas on the basis of their potential to meet certain criteria known as Conditions 1, 2, and 3. The BLM, however, recently adopted an alternate classification system, known as the Potential Fossil Yield Classification (PFYC), developed originally by the USFS, to promote consistency among agencies (DOI 2007). (See the text boxes that follow for summaries of the two classification systems.) Table 3.3-1 provides a summary of the programmatic-level sensitivity of geologic units within each of the basins that could potentially be affected by oil shale or tar sands development. Sensitivity maps (1:500,000 scale) have been prepared for the overview; the maps show the areas with the highest potential for containing significant paleontological resources and are available in the paleontological overview report (Murphey and Daitch 2007). The BLM is developing maps with a finer scale.

3.3.1 Piceance Basin

Several geologic units dating from the Paleocene/Early Eocene to the Middle Eocene (approximately 66 to 40 million years ago) within the Piceance Basin have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. These units, as listed in Table 3.3-1, include the Uintah Formation, the Parachute Member of the Green River Formation, and the Atwell Gulch, Molina, and Shire Members of the Debeque (or Wasatch) Formation.

BLM Classification System

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.

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 such fossils have been recovered elsewhere may require further assessment of these same units where they are exposed in the area of consideration.

Condition 3: Areas that are very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils on the basis of their surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium, or eolian 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.

Source: BLM (1998).

Potential Fossil Yield Classification

Class 1: Geologic units that are not likely to contain recognizable fossil remains. This includes units that are igneous or metamorphic in origin (but excludes tuffs), as well as units that are Precambrian in age or older. Management concern for paleontological resources in Class 1 units is negligible or not applicable. No assessment or mitigation is needed except in very rare circumstances. The occurrence of significant fossils in Class 1 units is nonexistent or extremely rare.

Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils. This includes units in which vertebrate or significant nonvertebrate fossils are unknown or very rare, units that are younger than 10,000 years before present, units that are eolian in origin, and units that exhibit significant diagenetic alteration. The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is low. Management concern for paleontological resources is low, and management actions are not likely to be needed. Localities containing important resources may exist but would be rare and would not influence the classification.

Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence, or sedimentary units of unknown fossil potential. These units are often marine in origin with sporadic known occurrences of vertebrate fossils. Vertebrate fossils and uncommon nonvertebrate fossils are known to occur inconsistently, and predictability is known to be low. Class 3 includes units that are poorly studied and/or poorly documented, so that the potential yield cannot be assigned without ground reconnaissance. Management concern for paleontological resources in these units is moderate or cannot be determined from existing data. Surface-disturbing activities may require field assessment to determine a further course of action.

Class 4: Class 4 units are Class 5 geologic units (see below) that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation. They include bedrock units with extensive soil or vegetative cover, bedrock exposures that are limited or not expected to be impacted, units with areas of exposed outcrop that are smaller than two contiguous acres, units in which outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic effects, and units where other characteristics are present that lower the vulnerability of both known and unidentified fossil localities.

Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or uncommon invertebrate or plant fossils and that are at risk of human-caused adverse impacts or natural degradation. These include units in which vertebrate fossils or uncommon invertebrate or plant fossils are known and documented to occur consistently, predictably, or abundantly. Class 5 pertains to highly sensitive units that are well exposed with little or no soil or vegetative cover, units in which outcrop areas are extensive, and exposed bedrock areas that are larger than two contiguous acres.

Source: Murphey and Daitch (2007).

TABLE 3.3-1 Summary of Programmatic-Level Paleontological Sensitivities of Geologic Units within the Piceance, Uinta, and Greater Green River Basins

Geologic Unit	Age	Typical Fossils	BLM Designation	PFYC Designation
Piceance Basin				
Alluvium, colluvium, landslide deposits, and glacial drift	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, landslide deposits, and glacial drift	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Uinta Formation	Middle Eocene	Localized occurrences of vertebrates (mammals, reptiles), invertebrates (mollusks), and plants (leaves and wood)	Condition 1	Class 4/5
Green River Formation: Parachute Creek Member	Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (insects, arthropods, and mollusks), plants (leaves, flowers, and wood), and ichnofossils	Condition 1	Class 4/5
Green River Formation: Anvil Points and Garden Gulch Members	Early Eocene	Vertebrates (mostly fish), invertebrates (mollusks), and plants (leaves)	Condition 2	Class 3
DeBeque (Wasatch Formation), Atwell Gulch, Molina and Shire Members	Paleocene and Early Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks), and plants	Condition 1	Class 4/5
Uinta Basin				
Alluvium, colluvium, landslide deposits, pediment deposits, glacial outwash, and till	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, landslide deposits, pediment deposits, glacial outwash, and till	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Duchesne River Formation: Brennan Basin and Lapoint Members	Middle Eocene	Vertebrate (mammal) fossil accumulations occur locally but are uncommon	Condition 2	Class 4/5

TABLE 3.3-1 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation	PFYC Designation
Uinta Basin (Cont.)				
Duchesne River Formation: Dry Gulch Creek and Starr Flat Members	Middle Eocene	Vertebrate (mammal) fossils rare in Dry Gulch Member; no records of fossils in Starr Flat Member	Condition 2	Class 3
Uinta Formation: Wagonhound and Myton Members	Middle Eocene	Locally abundant vertebrates (mammals, reptiles), invertebrates (mollusks), and plants (leaves and wood)	Condition 1	Class 4/5
Green River Formation: Parachute Creek Member	Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (insects, arthropods, and mollusks), plants (leaves, flowers, and wood), and ichnofossils	Condition 1	Class 4/5
Green River Formation: Douglas Creek Member	Early and Middle Eocene	Scarce vertebrates (mostly fish but also reptiles and uncommon mammals), vertebrate trackways, locally common invertebrates (mollusks) and plants (leaves)	Condition 2	Class 3 (Class 4/5 at Raven Ridge and Nine Mile Canyon)
Wasatch Formation: Renegade Tongue	Middle Eocene	Scattered, poorly preserved vertebrates and plants (leaves and wood)	Condition 2	Class 3
Wasatch Formation: main body	Paleocene and Early Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks), and plants	Condition 1	Class 4/5
Mesaverde Group	Late Cretaceous (Santonian and Campanian)	Moderately abundant terrestrial and marine vertebrates (fish, amphibians, reptiles, including dinosaurs, mammals), invertebrates (mollusks), and terrestrial plants	Condition 1	Class 4/5
Greater Green River Basin				
Alluvium, colluvium, landslide deposits, sand dune deposits, pediment deposits, and alluvial fan deposits	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2

TABLE 3.3-1 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation	PFYC Designation
Greater Green River Basin (Cont.)				
Alluvium, colluvium, landslide deposits, sand dune deposits, pediment deposits, and alluvial fan deposits	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Browns Park Formation	Middle and Late Miocene	Vertebrates (mammals and turtles) rare; mammal tracks have also been reported; silicified wood is locally common	Condition 2	Class 3
Bishop Conglomerate	Late Oligocene	Rare unidentified mammal bone fragments, reworked Paleozoic invertebrates	Condition 3	Class 2
Washakie Formation: Kinney Rim and Adobe Town Members	Middle Eocene	Vertebrates (fishes, amphibians, reptiles, and mammals) locally abundant in both members; invertebrates (mollusks) and plants (wood) locally common	Condition 1	Class 4/5
Bridger Formation: Blacks Fork, Twin Buttes, Turtle Bluff Members	Middle Eocene	Vertebrates (fishes, amphibians, reptiles, birds, and mammals) locally abundant; invertebrates (mollusks) and plants (wood and leaves) locally common; insect and vertebrate ichnofossils also present	Condition 1	Class 4/5
Green River Formation: Laney and Fossil Butte Members	Early and Middle Eocene	Vertebrates (fishes, amphibians, reptiles, birds, and mammals) locally abundant; invertebrates (insects, arthropods, and mollusks), plants, ichnofossils locally abundant	Condition 1	Class 4/5
Green River Formation: Luman Tongue, Fontenelle Tongue, Tipton Shale Member, Wilkins Peak Member, Angelo Member	Early and Middle Eocene	Uncommon but locally present vertebrates (fishes, reptiles, and mammals), scattered plants, locally common invertebrates (mollusks and ostracods)	Condition 2	Class 3

TABLE 3.3-1 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation	PFYC Designation
Greater Green River Basin (Cont.)				
Wasatch Formation: LaBarge Member, New Fork Tongue, Niland Tongue, Main Body, Upper Member, Cathedral Bluffs Tongue, Hiawatha Member	Mostly Early Eocene, Cathedral Bluffs Tongue is Early and Early-Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), plants, invertebrates (mollusks), and ichnofossils	Condition 1	Class 4/5
STSAs				
Alluvium, colluvium, slope wash, and landslide deposits	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, slope wash, and landslide deposits	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Chinle Formation: Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock Members	Upper Triassic	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 4/5
Moenkopi Formation: Black Dragon and Torrey and Moody Canyon Members	Lower and Middle Triassic	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 3
Moenkopi Formation: Sinbad Limestone Member	Lower Triassic	Locally abundant marine invertebrates	Condition 3	Class 2
Kaibab Limestone	Upper Permian	Locally abundant marine invertebrates	Condition 3	Class 2
Cutler Group, Cutler Formation undivided, Halgaito Formation	Upper Pennsylvanian and Permian	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 3
Organ Rock Formation: Cutler Group, Cedar Mesa Sandstone, White Rim Sandstone, De Chelly Sandstone	Upper Pennsylvanian and Permian	Uncommon vertebrates and invertebrate ichnofossils	Condition 2	Class 2

Source: Adapted from Murphey and Daitch (2007).

3.3.2 Uinta Basin

Several geologic units dating from the Late Cretaceous to the Middle Eocene (approximately 87 to 40 million years ago) within the Uinta Basin have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. These units, as listed in Table 3.3-1, include the Brennan Basin and LaPoint members of the Duchesne River Formation, Wagonhound and Myton Members of the Uinta Formation, the Parachute Creek Member of the Green River Formation, the Douglas Creek Member of the Green River Formation at Raven Ridge and Nine Mile Canyon, the main body of the Wasatch Formation, and the Mesaverde Group.

3.3.3 Green River and Washakie Basins

Several geologic units dating to the Early and Middle Eocene (approximately 55 to 40 million years ago) within the Greater Green River Basin (including the Washakie Basin) have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. These units, as listed in Table 3.3-1, include the Kinney Rim and Adobe Town Members of the Washakie Formation; Blacks Fork, Twin Buttes, and Turtle Bluff Members of the Bridger Formation; Laney and Fossil Butte Members of the Green River Formation; and LaBarge Member, New Fork Tongue, Niland Tongue, Main Body, Upper Member, Cathedral Bluffs Tongue, and Hiawatha Member of the Wasatch Formation.

3.3.4 Special Tar Sand Areas

Several geologic units dating to the Upper Triassic (approximately 200 to 230 million years ago) within the STSAs have been classified as having the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to tar sands development. These units, as listed in Table 3.3-1, include the Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock Members of the Chinle Formation.

3.4 WATER RESOURCES

The oil shale basins and STSAs in this PEIS are located within the Upper Colorado River Basin. Specifically, the oil shale is present in the White River hydrologic basin in Colorado, the Uinta Basin in Utah, and the Green River Basin in Wyoming. The STSAs are situated in the Uinta and West Colorado River Basins in Utah. The Colorado's Piceance Basin, where the oil shale occurs, is located in the White River hydrologic basin. Similarly, the geologic Green River and Washakie Basins are in the hydrologic Green River Basin.

Water use in the Colorado River Basin is highly regulated. In describing the water resources related to oil shale and tar sands development, it is appropriate to describe the Upper Colorado River Basin as a whole, with emphasis on hydrologic basins where the oil shale and tar sands are located. This is because intra- and interbasin water transfers are common in the region, and water allocation of the Upper Colorado River Basin Compact is prescribed by state and not by hydrologic basin. In the following subsections, important aspects of the legal framework related to water resources are introduced. The existing groundwater and surface water resources, water quality, current water uses, and resource constraints within each oil shale basin or STSA are described.

3.4.1 Legal Framework of the Upper Colorado River Basin

3.4.1.1 Water Allocation

The use of the Colorado River Basin water is shared by many states and Mexico. On the basis of the Colorado River Compact of 1922, the Colorado River Basin is divided into the Upper Colorado River Basin and Lower Colorado River Basin at Lees Ferry (just below the confluence of the Paria River and the Colorado River near the Utah-Arizona boundary). The upper basin and the lower basin were each apportioned a consumptive use of 7.5 million ac-ft of water annually, based on an assumption of 17.5 million ac-ft of virgin flow for the Colorado River. The assumption was demonstrated to be an overestimate and reduced to 15 million ac-ft in a hydrologic study by the BOR (BOR 1988; CWCB 2004) by using historical data collected from 1906 and 1986. This assumes that the upper Colorado Basin states are obligated to deliver 7.5 million ac-ft to the lower basin states and 0.75 million ac-ft to Mexico. The hydrologic determination study (BOR 1988) concluded that the Upper Basin states could have 6 million ac-ft of water and rarely triggered water calls from the Lower Basin States. The 6 million ac-ft is assumed for analyses in this PEIS. In the Upper Colorado River Basin Compact of 1948, the water of the Upper Colorado River Basin was further allocated among the states of Arizona, Colorado, New Mexico, Utah, and Wyoming. Arizona has a fixed allocation of 50,000 ac-ft annually. The remainder is shared by Colorado (51.75%), New Mexico (11.25%), Utah (23%), and Wyoming (14%) (DOI 2005). If the other Upper Basin States do not use their full allocation, Colorado is entitled to use those states' unused shares in a given year.

3.4.1.2 Basin Salinity and Surface Water Quality

Salinity is a key water quality issue in the basin. The major sections of the CWA that relate to salinity control are Section 302 (Water Quality Related Effluent Limitations), Section 303 (Water Quality Standards), Section 313 (Federal Facilities Pollution Control), Section 401 (State Certification of Federal Permits), Section 402 (NPDES), and Section 404 (Permits for Dredged or Fill Material). In 1973, to support compliance with Section 303 requirements to establish water quality standards and implementation plans, the CRBSCF was formed, including the Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. In 1974, Congress enacted the Colorado River Basin Salinity Control Act

(P.L. 93-320). In addition, in 1974, the EPA enacted a regulation setting forth the basinwide salinity control policy for the Colorado River Basin. In 1975, the CRBSCF proposed, the Basin States adopted, and the EPA approved water quality standards for the Colorado River Basin, including numeric criteria, and a plan of implementation to control salinity increases in the Colorado River. In 1984, Congress amended the Colorado River Basin Salinity Control Act (P.L. 98-569) and directed the BLM to implement a comprehensive program to minimize salt loading in the Colorado River Basin.

In 1995, P.L. 104-20 authorized the BOR to implement a basinwide approach to salinity control throughout the Colorado River Basin in its Salinity Control Program. The new authorities also allow the BOR to respond quickly to time-sensitive opportunities provided by other cost-sharing partners (states and federal agencies), resulting in the implementation of more cost-effective measures for salinity control. Since 1995, the BOR has solicited proposals and awarded funds in 1996, 1997, 1998, 2001, and 2004 to various salinity control projects under its Basinwide Salinity Control Program.

The BLM coordinates salinity control activities with the CRBSCF, the Basin States, the BOR, and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). These agencies receive Congressional funding for salinity control. Other federal agencies that have a stake and participate in the CRBSCF Work Group meetings include the EPA, USFWS, and the USGS.

The BLM has conducted ongoing salinity control activities to minimize salt loading from BLM-administered lands within the Upper Colorado River Basin since 1973. Point-source controls were implemented beginning in fiscal year (FY) 1974. The BLM created a four-person salinity team to evaluate landscape processes and land management actions relevant to the Colorado River Basin salinity during the period 1975 to 1984. Non–point-source control activities began in 1980, following intensive studies of salt occurrence and salt behavior on arid rangelands (BLM 1987c). In addition, prior to 1984, the USDA conducted salinity control activities as part of the Agricultural Conservation Program administered by the Agricultural Stabilization and Conservation Service and the Soil Conservation Service. P.L. 98-569 authorized the USDA Colorado River Salinity Control Program (CRSCP) through mid-1996. The 1996 Farm Bill, P.L. 104-127, combined the CRSCP into the Environmental Quality Incentives Program (EQIP). In the 2002 Farm Bill (P.L. 107-171), EQIP was reauthorized through 2007. The goals of these programs are to minimize salt loading in the Colorado River Basin and to offset the effects of additional water development (DOI 2005).

Salinity has long been recognized as one of the major problems of the river (CRBSCF 2005). The river carries an average salt load of approximately 4.4 million tons annually past Lees Ferry, Arizona. It is estimated that the BLM-administered lands in the Upper Colorado River Basin contribute about 700,000 tons of salt a year from surface runoff. The remaining 3.7 million tons are contributed primarily by groundwater inflow and saline springs, and runoff from other federal, Tribal, state, and private lands (DOI 2005).

The sources of salinity in the basinwide Colorado River were estimated to be 47% from natural sources, 37% from irrigation, 12% from reservoir leaching, and 4% from municipal and industrial activities. In 2004, the salinity control programs for the BOR, USDA, and the BLM prevented a total of 1,072,000 tons of salts from entering the river. A goal has been set to prevent an additional 728,000 tons/yr from entering the river by 2025 basinwide (DOI 2005).

The quality of the surface water in the four oil shale basins generally declines from their headwaters in the mountain areas to the basins. As the Colorado River reaches the basins where sedimentary rocks dominate, more soluble minerals containing sodium, sulfate, and chloride become available, resulting in an increase of dissolved salt and sediment (USGS 1968). Urban development in the basins and heavy agricultural uses of surface water in areas underlain by shaley sedimentary rocks also contribute to the increase of dissolved salt and sediment content in surface water bodies (Spahr et al. 2000).

The BLM's efforts to reduce salt loading due to activities conducted on BLM-administered lands would be applicable to future oil shale and tar sands development activities. The agency has developed a strategy to be implemented through its RMPs that primarily relies on best management of the basic resource base, including identifying targeted watersheds with high salt loading, improving vegetation cover to reduce surface runoff and soil erosion on rangelands, and proper land uses. In addition, the BLM has developed a water source inventory to identify saline springs in the basin (DOI 2005).

3.4.1.3 Impaired Streams under the Clean Water Act

Under the CWA, each state is required to establish and maintain water quality standards to protect, restore, and preserve its water quality. In addition to numerical water quality standards, states also establish narrative criteria that include designated, specific chemical and biological criteria necessary for protecting designated uses, and an antidegradation policy. When a lake, river, or stream fails to meet the narrative criteria, Section 303(d) of the CWA directs the state to place the water body on the 303(d) list of "impaired" waters. Water quality criteria called Total Maximum Daily Load (TMDL) are developed for impaired waters. A TMDL establishes the maximum amount of a pollutant allowed in the water while maintaining all of its designated beneficial uses.

Table 3.4.1-1 lists the impaired water bodies located in the target oil shale basins and STSAs in 2006. In general, no impaired streams are reported in the White River, Yampa River, and Green River Basins in Colorado. Impaired streams in the oil shale and tar sands areas in Utah have problems with meeting the total dissolved solids (TDS) water quality standard; Colorado and Wyoming do not have a TDS water quality standard. Streams in the Indian Canyon Creek subbasin also have elevated levels of selenium and boron. Fecal coliform is the major impairment in the Green River Basin in Wyoming; the source remains unknown.

3.4.1.4 Water Use

Data for water use provided by the states and the BOR are generally organized by watersheds or hydrologic basins. The boundaries of these hydrologic basins do not necessarily

TABLE 3.4.1-1 Water-Impaired Streams in Oil Shale Basins and STSAs in 2006

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Oil Shale					
Colorado	No streams in the White River/Yampa River/Green River hydrologic basin requiring TMDLs.				
Utah					
Uinta Basin	Duchesne River -1	UT14060003-001	Duchesne River and tributaries	Confluence Green River to Randlett	TDS
	Duchesne River -2	UT14060003-002	Duchesne River	Randlett to Myton	TDS
	Antelope Creek	UT14060003-005	Antelope Creek and tributaries	Confluence Duchesne River to headwaters	TDS
	Indian Canyon Creek	UT14060004-002	Indian Canyon Creek and tributaries	Confluence Strawberry River to headwaters	TDS
	Pariette Draw Creek	UT14060005-002	Pariette Draw Creek and tributaries	Confluence Green River to headwaters	Selenium, boron, and TDS
	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Wyoming					
Green River Basin	Blacks Fork Subbasin	14040107	Blacks Fork	From confluence with Ham's Fork upstream to an undetermined distance above Smiths Fork	Fecal coliform
			Smiths Fork	From confluence with Blacks Fork an undetermined distance upstream	Habitat degradation, fecal coliform
	Bitter Creek Subbasin	14040105	Bitter Creek	From Green River up to Killpecker Creek	Chloride, fecal coliform

TABLE 3.4.1-1 (Cont.)

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Special Tar Sand Areas (only with impaired streams are listed)					
Utah (in Uinta Basin)					
P.R. Spring	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Hill Creek	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Pariette	Pariette Draw Creek	UT14060005-002	Pariette Draw Creek and tributaries	Confluence Green River to headwaters	Selenium, boron, and TDS
Sunnyside	Nine Mile	UT14060005-003	Nine Mile Creek and tributaries	Confluence Green River to headwaters	Temperature
Argyle Canyon	Indian Canyon Creek	UT14060004-002	Indian Canyon Creek and tributaries	Confluence Strawberry River to headwaters	TDS
	Antelope Creek	UT14060003-005	Antelope Creek and tributaries	Confluence Duchesne River to headwaters	TDS

Sources: WDEQ (2006b); CDPHE (2006b); UDEQ (2007).

coincide with the geologic basins (such as the Piceance Basin, Green River Basin, Uinta Basin, and Washakie Basin), though the same names are used. Generally, the geologic Piceance Basin is inside the hydrologic White River Basin. The oil shale Uinta Basin is within the hydrologic Uinta Basin. The hydrologic Green River Basin covers an area that includes both the geologic Green River Basin and the Washakie Basin. The STSAs are located within the hydrologic Uinta Basin and the West Colorado River Basin in Utah.

In the following discussion, the water uses in each hydrologic basin of the Upper Colorado River Basin are provided by state for the municipal and industrial (M&I), self-supplied industry (SSI), and agricultural sectors. These data are useful because the water allocation in the Upper Colorado River Compact is based on individual states. Water demand and consumptive use, as well as availability by state, can then be compared. In addition, major streamflows within the areas where the oil shale is located are also listed. The streamflow data can be used to compare with the possible water needs for oil shale or tar sands development (see Sections 4.5 and 5.5), and to demonstrate whether interbasin water transfer is likely to occur. The water use data listed in this section cover 2000 as the base year and projected water use in 2030 for Colorado and Wyoming, and in 2050 for Utah,[7] taking into account population and industrial growth and changes in the agricultural landscape, excluding potential water needs for oil shale or tar sands development.

Tables 3.4.1-2 to 3.4.1-4 display the water demand and the water consumption in Colorado, Utah, and Wyoming in the Upper Colorado River Basin. These tables do not include instream uses or water needs of ESA-listed fishes. The data for water demand from water bodies or groundwater wells are from state agencies (CWCB 2004; SWWRC 2001a,b; UDNR 1999, 2000a,b, 2001; BOR 2004).

Water diversion is the amount of water withdrawn from a water body (stream or reservoir) or a well (groundwater). The amount of water diverted in the Upper Colorado River Basin is commonly much larger than the amount of water actually consumed, since a portion of the diverted water is lost during delivery through evaporation to the air and leakage to the subsurface, and some also returns to the water body as return flow. Consumptive use is defined as the portion of the diverted water that does not return to the stream system. In general, consumptive use is assumed in the calculations for apportioning water in the Upper Colorado River Basin Compact.

The M&I sector indicates residential, commercial, institutional, and industrial uses in Colorado. M&I water demand is closely related to the size of the human population. In urban areas, diverted M&I water is used, creating wastewater, with the wastewater being treated before being discharged back to a water body. The water actually consumed is less than the water delivered. In Colorado, the ratio (consumptive use rate) for M&I is about 35% (CWCB 2004).

Industries in the SSI sector, such as power plants or mining companies, could consume a large amount of water. The SSI industries generally have their own water supplies. In some

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7 The water availability is projected to different years based on the availability of projection data from the three states.

TABLE 3.4.1-2 Colorado Water Demand and Consumptive Use in 2000 and 2030 (ac-ft/yr)

	Demand			Consumptive Use		
		2030[a]			2030[a]	
Location	2000	Low	High	2000	Low	High
Colorado Basin						
M&I and SSI[b]	73,975	100,975	145,193	25,891	35,341	50,818
Agriculture[b,c]	1,764,000	1,644,000	1,706,000	582,120	542,520	562,980
Export[d]	759,800	759,800	759,800	759,800	759,800	759,800
Dolores/San Juan/San Miguel						
M&I and SSI[b]	23,629	33,369	46,030	5,900	11,679	16,111
Agriculture[b,c]	953,000	948,000	962,000	368,200	312,840	317,460
Export[d]	–176200	–176200	–176200	–176,200	–176,200	–176,200
Gunnison Basin						
M&I and SSI[b]	20,688	29,044	38,849	7,241	10,165	13,597
Agriculture[b,c]	1,705,000	1,640,000	1,689,000	562,650	541,200	557,370
Export[d]	0	0	0	0	0	0
Yampa/White/Green						
M&I and SSI[b]	29,408	45,262	56,880	17,800	28,830	36,230
Agriculture[b,c]	642,000	627,000	852,000	194,000	206,910	281,160
Export[d]	1,800	1,800	1,800	1,800	1,800	1,800
Total reservoir evaporation[e]	389,575	389,575	389,575	389,575	389,575	389,575
Grand total	6,186,675	6,042,625	6,470,927	2,738,777	2,664,460	2,810,700
Legally available[f]				3,079,125	3,079,125	3,079,125
% of legally available allocated to sectors				88.9	86.5	91.3
Water surplus				340,348	414,665	268,425

Footnotes on following page.

TABLE 3.4.1-2 (Cont.)

a Assumes irrigated acreage change in 2030 ranges from –2,600 acres (due to urbanization of irrigated lands) to +39,000 acres (assumes a firm supply of water and funding sources provided).

b Includes delivery system loss, irrigation water requirement, incident losses, and stock pond evaporation.

c The consumptive use factors for M&I and agricultural are 0.35 and 0.33, respectively. The factors were derived from year 2000 data from BOR (2004) and CWCB (2004).

d Diversion was measured: a negative value means import, a positive value means export. Include Gunnison and the Dolores Rivers (BOR 2004). Assumes export does not change in 2030.

e Evaporation from main stem reservoirs of the Upper Colorado River Basin and the reservoirs in northwestern Colorado (using last 10 years average).

f Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin based on long-term historical data from 1906 to 1986.

Sources: CWCB (2004); BOR (1988, 2004).

TABLE 3.4.1-3 Utah Water Demand and Consumptive Use in 2000, 2020, and 2050 (ac-ft/yr)

	Demand			Consumptive Use		
Location	1996/2000[a]	2020	2050	1996/2000[a]	2020	2050
Southeastern Colorado River Basin						
M&I and SSI[b,c]	8,740	10,000	12,000	5,990	6,800	8,160
Agricultural[d]	73,000	73,000	72,000	43,255	42,295	41,095
Uinta Basin	2000	2020	2050	1995/2000	2,020	2,050
M&I and SSI[a]	15,830	20,360	30,850	8,450	10,870	16,210
Agricultural[d,e]	745,000	744000	741,000	387,400	386,880	385,320
Export	150,400	150,400	150,400	150,400	150,400	150,400
Western Colorado River Basin	1996/2000[a]	2020	2050	1996/2000[a]	2,020	2,050
M&I and SSI[b]	55,168	70,300	79,300	43,400	56,200	62,200
Agricultural[d,f]	284,000	283,000	281,000	156,200	181,120	179,000
Export/Import[c]	4,640	79,640	160,280	4,640	79,640	160,280
Groundwater Source[g]	–17,871	–17,871	–17,871	–17,871	–17,871	–17,871
Evaporation[h]				53,250	53,250	53,250
Main Stem Reservoir Evaporation[i]				137,402	137,402	137,402
Total water use (ac-ft/yr)	1,318,907	1,412,829	1,508,959	972,516	1,086,986	1,175,446
Legally available[j]				1,368,500	1,368,500	1,368,500
Projected use in % of legally available				71.1	79.4	85.9
Water surplus				395,984	281,514	193,054

a In the southeastern and western Colorado River Basin, M&I and SSI from 1996 data and agricultural water from 2000 data; in Uinta Basin, agricultural water from 1995 data, while M&I and SSI from 2000 data (Source: UDNR 2000a).

b Sources: UDNR (1999; 2000a,b).

Footnotes continued on following page.

TABLE 3.4.1-3 (Cont.)

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c Consumptive use in 2020 and 2050 was estimated by multiplying the demand by a factor of 0.68. The factor was derived from the 1996 data.

d Agricultural water use information is from UDNR (2001). Southeastern Colorado River Basin includes 24,825 ac-ft of Flaming Gorge Water Right; exports of 50,000 ac-ft from water right on the Fremont River in Wayne County and 25,000 ac-ft near Green River in Emery and Grand Counties, 5,400 ac-ft from Price River drainage to the Sevier River Basin; 70,000 ac-ft of water from Lake Powell to Washington County, and 6,000 ac-ft from Lake Powell to Kane County.

e The consumptive use was estimated by multiplying the demand by a factor of 0.52. The factor was derived from data provided in UDNR (1999).

f The consumptive uses were estimated by multiplying the demand by factors of 0.55, 0.64, and 0.64 for 2000, 2020, and 2050. The factors were derived from data provided in UDNR (2000b).

g Yield of the West Colorado River Basin is 630,000 ac-ft/yr; the Navajo Sandstone Aquifer may store several million ac-ft of groundwater.

h Based on average of 10 years evaporation for Utah in the Upper Colorado River Basin.

i 23% of the average of 10 years main stem evaporation. The main stem evaporation includes major reservoirs shared by several states.

j Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin; Utah's share is 23% of 5,950,000 ac-ft.

Sources: UDNR (1999; 2000a,b; 2001).

TABLE 3.4.1-4 Wyoming Water Consumptive Use in 2000 and 2030 (ac-ft/yr)

	Consumptive Use				Consumptive Use[b]
		2030[a]			
Location	2000	Low	Moderate	High	2000
Green River Basin					
Surface Water					
Municipal	6,542	6,628	8,059	10,068	
SSI (power generation+soda ash+others)	66,460	77,960	106,400	166,300	
Municipal and industrial					45,900
Agricultural[c]	401,000	408,000	423,000	438,000	326,700
Export[d]	17,200	22,700	22,700	22,700	17,200
Evaporation from state water bodies	32,300	32,300	32,300	32,300	32,300
Main-stem reservoir evaporation[e]	83,636	83,636	83,636	83,636	83,636
Surface Water Subtotal	607,138	631,224	676,095	753,004	505,736
Legally available[f]	833,000	833,000	833,000	833,000	833,000
Projected use in % of legally available	72.89	75.78	81.16	90.40	60.71
Water Surplus	225,862	201,776	156,905	79,996	327,264
Groundwater Use					
Municipal	811	927	1,065	1,140	
Domestic	1,940–3,880	2,100	3,600	5,080	
SSI (oil and gas, coalbed methane, mining)[g]	0	0	0	0	
Groundwater subtotal	2,751–4,691	3,027	4,665	6,220	

a Low growth scenario depends on cattle price (or foliage price), population growth, and industrial growth. Sources: BOR (2004); SWWRC (2001b).

b Source: BOR (2004).

Footnotes continued on following page.

TABLE 3.4.1-4 (Cont.)

[c] Depletion is used for agricultural consumptive use, resulting in a higher number than the BOR's estimate. Source: SWWRC (2001a).

[d] A diversion from the upper Little Snake River Basin to the City of Cheyenne. Source: SWWRC (2001b).

[e] Assumes 14% of 597,400 ac-ft (yearly average of the last 10 years of 4 major reservoirs).

[f] Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin.

[g] The groundwater pumped by these industries is returned to the subsurface, no consumptive use.

Sources: SWWRC (2001a,b), BOR (2004).

instances, SSIs may use M&I water in addition to their own primary water supply. In the oil shale basins of Colorado and Wyoming, power generating plants and soda mining are important SSI industries that contribute relatively high consumptive use rates. In power generating plants, a large amount of water is used for cooling. The amount used depends on the cooling system of the power generating plants and may vary considerably. The consumptive use rate for SSI in Moffat County in northwestern Colorado (primarily from two power generating plants and the soda mining industry) is about 76%. The rate is derived by comparing the amount of water diverted with actual water consumption data in 2000 provided by the state (CWCB 2004) and BOR (2004).

In the agricultural sector, reported consumptive use (to support the calculations apportioning water in the Upper Colorado River Compact) is calculated differently in Colorado and Utah than in Wyoming. Colorado and Utah report consumptive use as the water that does not return to surface water bodies. However, Wyoming reports irrigation depletion separately and does not consider return water, and thus may overestimate actual consumptive use due to irrigation. Irrigation depletion and consumptive use are calculated by models with input of acreages of agricultural land, types of crop, and weather data.

Generally, water demand in the Upper Colorado River Basin cannot be totally met because the availability of water is limited by physical streamflow conditions, water rights (physically and legally available water, respectively), and lack of storage facilities. In addition, infrastructure for storage (reservoirs) and delivery systems is required to send physically and legally available water to end users. In many agricultural areas, the lack of financial resources often limits the construction of infrastructure, thereby reducing potential agricultural water use. This results in a disparity between high water demand and relatively lower consumptive water use. The infrastructure also dictates water supply availability.

Both intra- and interbasin water transfers are common in Colorado and Utah. Water from the upper reaches of the Colorado River is transferred to the South Platte and Arkansas hydrologic basins (or Front Range) to support metropolitan and agricultural water needs. Similarly, water from the Uinta Basin is transferred to central Utah. Because the water is exported to outside the Upper Colorado River Basin, the total amount exported is considered to be a consumptive use.

Evaporation of water from reservoirs and other water bodies contributes a large portion of consumptive water use in the Upper Colorado River Basin. The evaporation is from four major reservoirs (Flaming Gorge, Blue Mesa, Morrow Point, and Lake Powell) along the main stem of the river, and from smaller reservoirs, stock ponds, and streams within each state.

Although groundwater is commonly used in the four basin areas, most of the groundwater is drawn from alluvium adjacent to the major streams (Repplier et al. 1981). In Colorado, water from the shallow alluvial aquifer is considered part of the surface water (tributary water). For deeper aquifers (nontributary water), withdrawal of groundwater, if it is not returned to the subsurface, is considered to be consumptive use (BOR 2004). Environmental and recreation water use to maintain instream flows are not considered consumptive water use.

As shown in Table 3.4.1-2, the demand for water in Colorado in the Upper Colorado River Basin was more than 6,000,000 ac-ft in the year 2000. The projected demands for the year 2030 also exceed 6,000,000 ac-ft. The projected demands are based on projected population decrease or growth in the region as well as the transfer of part of the agricultural water to the M&I sector, with an assumption that water conservation practices remain at existing levels. The state used two scenarios to project future use to 2030. The low water use projection is based on an assumed 5% reduction of water use per capita, 5% reduction of population, and 10% water conservation in those counties with identified self-supplied water. The high water use projection, instead, assumes a 5% increase of water use per capita, 5% increase in population, and 10% increase of water use in those counties with identified self-supplied water use. Both the 2000 and projected future water demands well exceed the legally allocated water of 3,079,125 ac-ft specified in the Upper Colorado River Compact of 1948. On the other hand, the existing and projected consumptive uses of water in the 2000 and 2030 range from 2,664,000 to 2,810,000 ac-ft, or about 87 to 91% of the legally allocated water. The projected values do not include the water demand for oil shale and/or tar sands development.

In Utah, projected water use data provided by the state's water plan are for 2020 and 2050 rather than 2030. Table 3.4.1-3 lists existing and projected water demands and consumptive uses, not considering the water use of any oil shale and/or tar sands development. A comparison of the water demands and Utah's allocated water under the Upper Colorado River Basin Compact shows that the projected demands in 2020 and 2050 are less than the allocated water. The projected consumptive use of water potentially reaches about 79% and 86% of the allocated water in the 2020 and 2050, respectively.

In Wyoming, water data for consumptive use are provided by the state and BOR (Table 3.4.1-4). In the state estimates, the consumptive agricultural water use is defined as the total irrigated water (i.e., return flow water was not subtracted from the irrigated water, resulting in a higher amount of consumptive use water estimated by the state than by the BOR, see Table 3.4.1-4, year 2000 data). Nevertheless, the projected consumptive use water is less than 90% of the allocated water specified by the Upper Colorado River Basin Compact of 1948. The low, moderate, and high water use scenarios in Table 3.4.1-4 are based on the scenarios of cattle price, population growth, and industrial growth.

In 2005, the BOR's *Quality of Water: Colorado River Basin, Progress Report No. 22* (DOI 2005) also estimated the depletion of the water due to full basin development for the main stem of the Upper Colorado River Basin. The projections were made in consultation with individual states and the Upper Colorado River Commission. The remaining amount of water available and the percentages of state share available for development are shown in Table 3.4.1-5. The projected water consumption of each state by the BOR is much larger than that projected by the states.

Although a certain amount of water is calculated to be available in Wyoming and Utah and to a lesser extent in Colorado, this does not imply that the water is readily or physically available for development. Oil shale basins and STSAs are situated in much smaller areas, as compared to the size of the hydrologic Upper Colorado River Basin by which the water availability was calculated. In addition, hydrologic basins enriched with surplus water resources

TABLE 3.4.1-5 Upper Colorado Basin Depletion Projections (1,000 ac-ft/yr)[a]

Year	2010	2020	2030	2040
Colorado				
State share	3,079	3,079	3,079	3,079
Remaining available	204	158	109	81
Percent of state share available	7	5	4	3
Utah				
State share	1,369	1,369	1,369	1,369
Remaining available	240	194	120	72
Percent of state share available	18	14	9	5
Wyoming				
State share	833	833	833	833
Remaining available	244	225	189	145
Percent of state share available	29	27	23	17

[a] States do not necessarily concur with the projections adopted by the BOR for planning purposes.

Source: DOI (2005).

are not necessarily coincident with the oil shale basins and STSAs. Storage infrastructures and delivery systems have to be built to capture water for use. Also, water rights and water storage rights (for reservoirs) have to be transferred or purchased before the water can be used for development, as most of the water and storage rights have been claimed in the Upper Colorado River Basin. Finally, water use for the development must meet different state and federal regulations, including requirements to protect instream flows for endangered Colorado River fishes in the basin. All in all, whether enough water is available for development depends on the results of intensive negotiations between various parties, including water right owners, state and federal agencies, and municipal water providers as well as the developers.

3.4.2 Piceance Basin

3.4.2.1 Groundwater Resources

As discussed in Section 3.2.1, within the Piceance Basin, the upper bedrock stratigraphy consists of a series of basin-fill sediments from the Tertiary period. Hydrogeologically, the Tertiary units are grouped into two aquifers and two confining units (Czyzewski 2000; Topper et al. 2003; Weeks et al. 1974; Robson and Saulnier 1981). The Uinta Formation and the upper portion of the Parachute Creek Member compose the Upper Piceance Basin Aquifer. The middle of the Parachute Creek Member, however, is considered the Mahogany confining unit. This Mahogany Zone is the richest oil shale zone in the basin. The lower Parachute Creek

Member is the Lower Piceance Basin Aquifer, while the Garden Gulch, Douglas Creek, and Anvil Points Members, combined, constitute another confining unit. Local variations in lithology occur at various scales and may result in permeable zones in units that are predominantly confining units and impermeable zones in units that are predominantly aquifers. The Cretaceous Mesaverde Group composes the Mesaverde Aquifer, while the deeper Mancos Shale is a confining unit.

Permeability within the Upper Piceance Basin Aquifer is attributable to the primary porosity of the sandstone and fractured siltstone of the Uinta Formation and the fractured and dissolution-enhanced fractures of the Parachute Creek Member of the Green River Formation. The upper aquifer's hydraulic conductivity is approximately 1 ft/day. The aquifer's thickness is generally 250 to 1,000 ft in most of the basin. Well yields are 1 to 900 gpm; a yield of 100 gpm is common (Czyzewski 2000).

The Mahogany confining unit has an average thickness of 160 ft, but ranges up to 225 ft. Its horizontal hydraulic conductivity is reported as <0.01 ft/day. Fractures within the Mahogany Zone permit some vertical flow between the upper and lower aquifers (Czyzewski 2000). The vertical hydraulic conductivity is generally low but may increase locally due to natural vertical fractures. Locally, a different interval may be the primary confining unit separating the upper and lower aquifers reported in BLM (2006i).

The Lower Piceance Basin Aquifer's permeability is attributable to the fractured marlstone of the lower Parachute Creek Member. The lower aquifer's hydraulic conductivity is also approximately 1 ft/day, and its thickness is 500 to 1,000 ft in most of the basin. Well yields in the lower aquifer range from 1 to 1,000 gpm; yields of 200 to 400 gpm are typical (Czyzewski 2000).

Exploratory drilling in the basin has shown that groundwater in the Upper and Lower Piceance Basin Aquifers is typically contained in intervals 0.5 to 20 ft thick composed of fractured or vuggy marlstone, lean oil shale, or sandstone. In the basin, 90% of the water wells are completed to a depth of 300 ft or less, and the median reported well yield is 11 gpm.

The lower Green River Formation's confining unit separates the Lower Piceance Basin Aquifer from the Mesaverde Aquifer. This confining unit is 1,000 to 6,000 ft thick in the basin. The Mesaverde Aquifer has a saturated thickness of 500 to 2,000 ft. It is underlain by the Mancos Shale, which ranges up to 7,000 ft thick.

The Colorado Water Quality Control Commission established an aquifer classification system of five categories of groundwater based on chemical concentration standards and TDS. These include domestic use quality (meets state human health standards and TDS concentrations are below 10,000 mg/L), agricultural use quality (meets state agricultural health standards and TDS concentrations are below 10,000 mg/L), surface water protection quality (guards against proposed or existing activities impacting groundwater such that water quality standards for classified surface water bodies will be exceeded), potentially useable quality (TDS below 10,000 mg/L and potential future use), and limited use and quality (TDS above 10,000 mg/L)

(Topper et al. 2003). Additional details on the water classification system, including specific chemical limits, are available in CDPHE (2005).

Most recharge to the basin's aquifers takes place as winter precipitation in the surrounding areas of higher elevation (Czyzewski 2000; Topper et al. 2003). In summer, high evapotranspiration rates allow little to no infiltration (Glover et al. 1998). Recharge is estimated as 0 to 2.3 in/yr, depending on ground elevation (Glover et al. 1998). The estimated total recharge to the Piceance Basin Aquifer system north of the Colorado River is about 30,400 ac-ft/yr (Topper et al. 2003).

In the northern province, groundwater discharge from the upper and lower aquifers in the Piceance and Yellow Creek drainage basins is generally as upward flow either into alluvial valley fill along creeks or as springs in the shallow valleys. In the Roan and Parachute Creek drainage basins, discharge generally occurs as springs in deep canyon walls (Czyzewski 2000; Topper et al. 2003). In the southern province, similar discharge scenarios are assumed, dependent upon local relationships among topography, hydrogeology, and water levels.

In Colorado's Piceance Basin, the principal aquifer is alluvium along major rivers (Topper et al. 2003). However, in the counties composing the basin, water use is dominated by surface water, which accounts for approximately 97% of the water usage (Topper et al. 2003). An exception is in Rio Blanco County, where groundwater is approximately 10% of the water use. In this county, which includes most of the Piceance Basin as well as large areas outside the basin, the total average annual groundwater withdrawal from bedrock and alluvial aquifers is estimated as 15,000 ac-ft, of which 88% is used in mining activities (coal, oil, and gas). Other groundwater uses in northwestern Colorado include domestic purposes, livestock watering, industrial, and irrigation supplies.

The alluvial aquifer along the White River in Colorado is mainly used for domestic purposes and for watering livestock (Topper et al. 2003). The annual amount of water pumped from this alluvium is about 1,000 ac-ft (Hatton 2000). Well yields range from 2 to 600 gpm, with an average of 50 gpm (Topper et al. 2003).

Sparse data on the White River alluvial aquifer's water chemistry suggest fair quality, with TDS from 200 to 2,500 mg/L and hardness ranging from 160 to 1,400 mg/L (Hatton 2000; Topper et al. 2003). Water with TDS levels below 1,000 mg/L is generally suitable for domestic supply, while water with TDS values below 3,000 mg/L is generally suitable for agricultural purposes (Hranac 2000). The water chemistry is calcium bicarbonate or sodium sulfate.

The Upper Piceance Basin Aquifer north of the Colorado River increases in TDS from the recharge areas (about 500 mg/L) to the discharge areas (about 1,000 mg/L). The water chemistry varies from calcium carbonate to sodium carbonate, with large concentrations of sulfate. The Lower Piceance Basin Aquifer has TDS levels that increase from 1,000 to 10,000 mg/L along its flowpaths. The water chemistry is sodium bicarbonate. Groundwater with TDS values higher than 10,000 mg/L is considered unusable.

Surface water in the basin receives base flow from alluvial aquifers. Groundwater discharge from bedrock to alluvium, therefore, indirectly provides a portion of the water used by surface water systems (Hatton 2000).

Total groundwater storage in the northern province of the Piceance Basin is estimated as 25 million ac-ft (Czyzewski 2000). The White River alluvium between the towns of Meeker and Rangely contains an estimated 103,000 ac-ft of groundwater (Topper et al. 2003). In 1995, the total groundwater withdrawal for the five counties that compose the overall Piceance Basin amounted to nearly 46,000 ac-ft, including bedrock and alluvial aquifers. Groundwater is possibly being mined (i.e., overdrawn) in the basin, resulting in depletion of the aquifer system (Topper et al. 2003). Demand is unlikely to change (Hatton 2000).

Aquifers below the Green River Formation aquifers are generally not viable because of poor water quality and high costs associated with drilling and pumping (Czyzewski 2000).

Essentially the only groundwater users in the northern province of the Piceance Basin (apart from the White River alluvium) are ranchers. An exception during the 1970s and early 1980s was oil shale exploration; the brevity of the development period, however, left the groundwater resources essentially untouched (Czyzewski 2000). Current oil and gas development, however, may be relying on groundwater resources as allowed by water rights laws. Throughout the Piceance Basin, the Tertiary bedrock may be the only practical water resource away from rivers, significant creeks, and major alluvial aquifers.

3.4.2.2 Surface Water Resources

Two major rivers drain the Piceance Basin in the study area: the White River and its tributaries on the north and the Colorado River and its tributaries on the south (Repplier et al. 1981). The White River and Colorado River are administered by two different Water Divisions in Colorado. Each has its own authority to administer and distribute waters, promulgate rules and regulations, and collect data on water supply. The Recovery Program for Endangered Fish of the Upper Colorado River Basin is designed to protect flow conditions needed by native endangered fishes in the Basin.

Precipitation varies greatly within the Piceance Basin and is closely related to topography. Annual precipitation, in the form of rain and snow, ranges from less than 10 in. in the Colorado River valley in western Colorado to 32 in. near the top of mountains surrounding the basin (Topper et al. 2003; Andrews 1983). Streamflows fluctuate seasonally, with the highest flow occurring in the spring as a result of snowmelt from April to June, and the minimum flow occurring in early winter. Because of rugged terrain, summer storms can result in occasional flash floods in rivers. Since agricultural lands are well developed in the valley of the Colorado River, reservoirs have been constructed for better distribution of irrigation water. Therefore, the streamflows of many rivers in the Piceance Basin are regulated.

Besides the seasonal fluctuation, the annual average flows of the Colorado River also changed with wet and dry years (CWCB 2004). During the early 1920s, the region in the Upper Colorado Basin experienced wet years. The river had an annual calculated virgin flow at Lees Ferry, Arizona, as high as 24 million ac-ft. From the mid-1950s to the mid-1960s, the average virgin annual flow dropped tremendously and was reduced to as low as 7.8 million ac-ft. The lowest annual flow of about 5.5 million ac-ft was recorded in 1934. Wet years were recorded again in the early 1980s and in 1997–1998, and reached a recorded high flow of about 24 million ac-ft in 1984. The wet years were separated by dry years in the early 1990s and early 2000s. About 8.23 million ac-ft annual flow was recorded in 2002.

Computed average annual lake evapotranspiration is roughly 30 to 36 in./yr in the basin (Topper et al. 2003). The calculated water balance, determined by subtracting the average annual lake evaporation from the average annual precipitation, ranges from a loss of 12 in./yr or more in the low, western portion of Rio Blanco County to a gain of 4 in./yr or more in mountainous eastern Rio Blanco County. In most of the county and the basin, however, the water balance ranges from a loss of 12 in./yr to a loss of 4 in./yr (Topper et al. 2003).

Several tributaries of the White River, including Yellow Creek and Piceance Creek, drain the study area (Figure 3.4.2-1) between the upstream town of Meeker and the downstream town of Rangely. Two reservoirs, the Rio Blanco Lake Reservoir and the Kenny Reservoir (or Taylor Draw Reservoir), are present along this segment of the river.

The streamflow of the White River fluctuates seasonally. High flows occur between April and July. The minimum and maximum recorded flows below the town of Meeker are 78 cubic feet per second (cfs) (in 1977) and 6,950 cfs (in 1984), respectively. The average discharge based on records from 1910 to 2006 near the town of Meeker is 620 cfs (USGS 2006a). The river flows west into the Green River in Utah. The average annual flow leaving the state at the Colorado-Utah border is 590,100 ac-ft (Topper et al. 2003). During low-flow seasons, groundwater discharge contributes to part of the streamflow (Tobin 1987).

The White River Basin is sparsely populated. Management of the waters in the White River Basin is under the jurisdiction of Colorado Water Division 6. The major water use in the White River Basin is irrigation. Groundwater use is minimal. On the main stem of the White River, water has been available for appropriation. However, water rights calls occur on Piceance Creek where irrigation demands can exceed streamflows (CWCB 2002).

Several tributaries of the Colorado River drain the Piceance Basin between the towns of Rifle and Grand Junction. From the east to the west, they are Parachute Creek, Roan Creek, and Plateau Creek (Figure 3.4.2-1). A major reservoir, the Vega Reservoir, is present along Plateau Creek, which drains to the Colorado River from the south.

Snowmelt runoff dominates the streamflow of the upper Colorado River and is typically highest in the spring and lowest in the winter (Spahr et al. 2000). The mean annual streamflow (based on 1934 to 2006 data) near Cameo is about 3,818 cfs (USGS 2006b). However, the maximum peak streamflow is much higher at 39,300 cfs. During low-flow seasons, groundwater discharge contributes part of the streamflow (Tobin 1987).

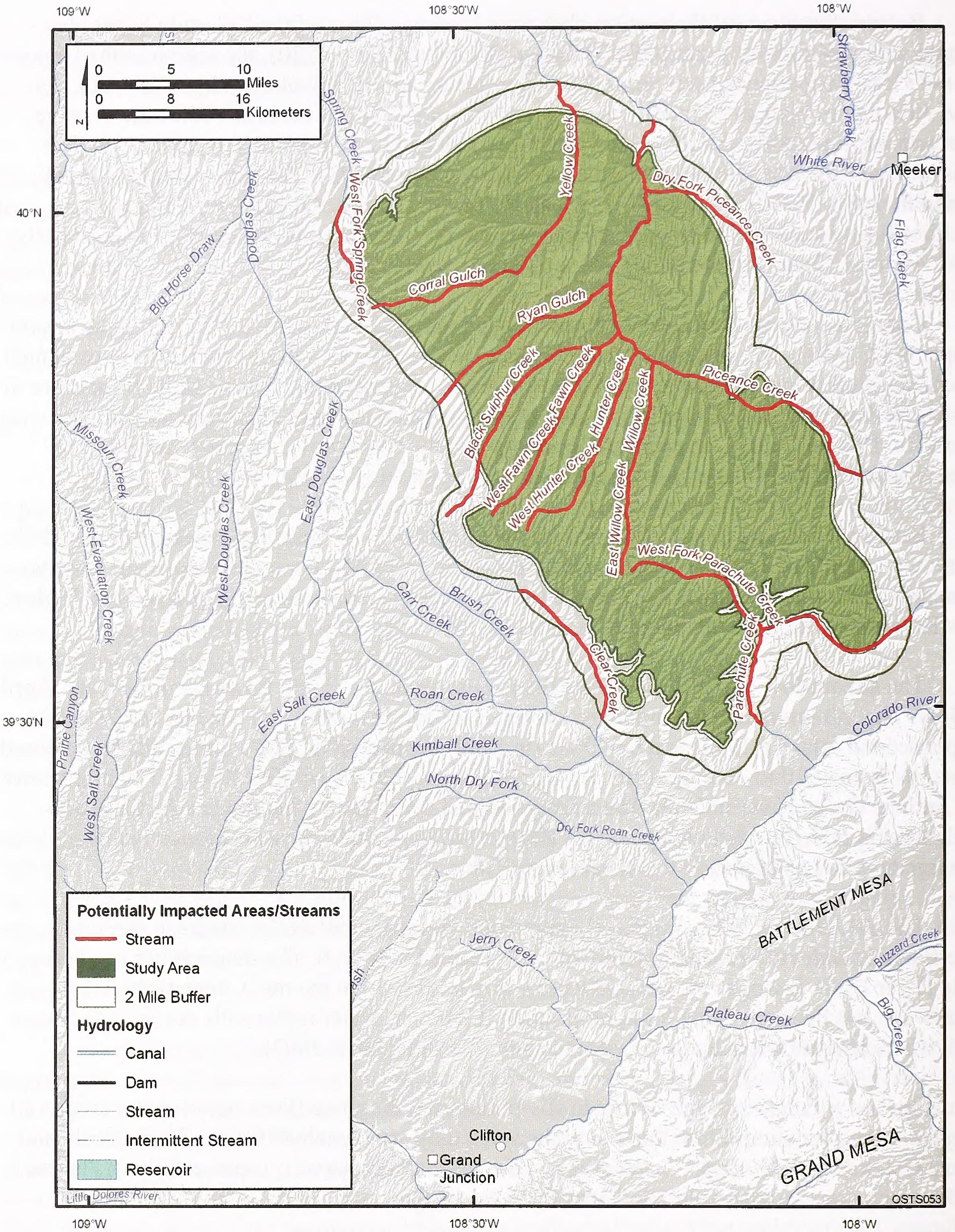

FIGURE 3.4.2-1 Yellow and Piceance Creeks and Their Tributaries in the Piceance Basin

Management of the waters in the Colorado River Basin is under the jurisdiction of Colorado Water Division 5. Irrigation accounts for 97% of the water use in the upper Colorado River; 99% of the water used is derived from surface water sources (Topper et al. 2003).

Large amounts of dissolved salts and sediment enter the Colorado River between Glenwood Springs and Cameo (USGS 1968) because local bedrock and the derived soil have relatively high contents of soluble salts. Heavy irrigation in this area also promotes the leaching process in soils, thereby releasing salts, sediments, nutrients (e.g., nitrogen and phosphorus), pesticides, and herbicides into the river (Spahr et al. 2000). Between 1914 and 1957, the Colorado River water near Cameo had flow-weighted-average concentrations of dissolved solids of 387 parts per million (ppm) and suspended sediment of 2,300 ppm (USGS 1968). Using data collected from 1970 to 1983, Bauch and Spahr (1998) found that the dissolved solids concentrations trended downward, or that no trend was indicated. Although their concentrations are typically low, pesticides are commonly detected in streams in agricultural areas (Topper et al. 2003). In the Piceance Creek subbasin of the White River Basin, Andrews (1983) claimed that 36% of the total denudation (removal of both solid particles and dissolved material) from the subbasin was as dissolved load.

3.4.3 Uinta Basin

3.4.3.1 Groundwater Resources

Section 3.2.2 describes the overall geologic framework of the Uinta Basin. Key aquifers in the basin include the alluvium, the Uinta-Duchesne Aquifer, the Parachute Creek Member of the Green River Formation (including the "Bird's Nest Aquifer"), and the Douglas Creek Aquifer of the Green River Formation.

The alluvial aquifers are recharged by infiltration of surface water and by discharge of bedrock aquifers. The average thickness of the alluvial fill in the White River and Evacuation Creek drainages is 30 ft; in the Bitter Creek drainage and elsewhere, the alluvium is about 100 ft thick. Maximum well yields are less than 1,000 gpm. Water type is typically sodium sulfate, and TDS concentrations vary from 480 to 27,800 mg/L. Most alluvial wells are along the White River, near Bonanza, where the water is used to support gilsonite mining (Holmes and Kimball 1987).

The Uinta Formation and Duchesne River Formation act as a single hydrologic unit (Glover 1996). The combined thickness of the Uinta-Duchesne Aquifer, where both units are present, is about 8,000 ft. Well yields are typically 30 to 40 gpm, but range from less than 1 gpm to as much as about 300 gpm in fractured zones. Recharge to the aquifer is mainly from infiltration of precipitation and surface water in the western extent of the formations in Duchesne and Wasatch Counties. Flow is generally to the east across the study area, with discharge to perennial streams. TDS levels range from <500 to >3,000 mg/L (Glover et al. 1998).

The Parachute Creek Aquifer is recharged by stream infiltration and leakage from the overlying Uinta Formation. It discharges to Bitter Creek and the White River. The aquifer thickness ranges from 90 to 205 ft. Water generally moves to the west from recharge areas along Evacuation Creek, and from the south and north toward the lower reaches of Bitter Creek. The "bird's nest" zone is named because in outcrops it resembles a wall of sparrows' nests. This zone contains solution cavities up to 2 ft in diameter caused by the natural removal of soluble nahcolite. Connection of the cavities has resulted in a highly permeable zone within the Parachute Creek Member. Properties of the Parachute Creek Aquifer vary greatly with location and the degree of dissolution of the nahcolite. Well yields vary also and are as high as 5,000 gpm. Water type is generally sodium sulfate to sodium bicarbonate. TDS levels range from 870 to 5,810 mg/L (Holmes and Kimball 1987).

The Douglas Creek Aquifer receives recharge mainly by infiltration of precipitation and surface water in its outcrop area, with little leakage from underlying bedrock aquifers. It discharges locally to springs in the outcrop area and to alluvium along major drainageways such as the Green and White Rivers. In the study area, flow is generally to the north and northwest. The unit is roughly 500 ft thick, although in the center of the Uinta Basin it is as thick as 1,000 ft. Maximum well yields are less than 500 gpm. Water type is typically sodium sulfate to sodium bicarbonate. TDS levels range from 640 to 6,100 mg/L (Holmes and Kimball 1987).

Groundwater in Utah is classified according to water quality and importance (State of Utah 2006). Class IA groundwater is pristine, with TDS levels less than 500 mg/L and no contaminant exceedances. Class IB groundwater is irreplaceable as a public supply source because it is a sole source of adequate quality, quantity, and economics. Class IC is ecologically important groundwater that discharges to a wildlife habitat. Class II is drinking water quality, with TDS between 500 and 3,000 mg/L and no contaminant exceedances. Class III is limited-use groundwater, with TDS between 3,000 and 10,000 mg/L and one or more contaminants exceeding groundwater quality standards. Class IV groundwater is saline, with TDS above 10,000 mg/L.

Lindskov and Kimball (1984) estimated the recoverable groundwater in storage in three main aquifers (alluvium, Parachute Creek, and Douglas Creek) in the broader southeastern Uinta Basin (an area two to three times the size of the study area) to be 18 million ac-ft. They also estimated the practical limit to groundwater withdrawal in this area as about 20,000 ac-ft/yr.

Hood and Fields (1978) provide information on water usage in the northern portion of the Uinta Basin. This area includes the northeastern part of the study area. It is assumed that their study area and the study area of this PEIS have similar water uses. They note that irrigation is the dominant water use in the region, with domestic and industrial uses being relatively small. Irrigation water for livestock and crops amounted to 575,000 ac-ft/yr from surface water and 6,000 ac-ft/yr from groundwater. Their 1974 estimates of population and water use were 28,700 persons in northern Uinta Basin counties and 12,700 ac-ft/yr of domestic use. This domestic water was almost all from wells and springs. Wells were also used to supply the industrial needs of 4,900 ac-ft/yr.

Groundwater quality in the Uinta Basin decreases with increased travel distance from recharge locations and with increasing depth. Concentrations of TDS in the basin show a range that affects the potential use of the water. In many locations, the water is marginally useful or even unsuitable for domestic use or irrigation.

3.4.3.2 Surface Water Resources

The Uinta Basin is bounded by the Uinta Mountains on the north and the Roan Plateau on the south. The basin is dissected by the deeply incised southward-flowing Green River, the largest tributary of the Colorado River. The Green River is joined by two major tributaries, the Duchesne and White Rivers, near Ouray, Utah (Figure 3.4.3-1). The combined flow of the White, Duchesne, and Green Rivers near Ouray averages about 5,900 cfs, based on records from 1965 to 1979 (Lindskov and Kimball 1982). About 4 million ac-ft of water per year enters the basin (via the Duchesne, Green, and White Rivers) and leaves (via the Green River) (Lindskov and Kimball 1984). Most of the flow is attributed to water entering the basin by the White and Green Rivers.

The Uinta Basin can be divided into the northern and southern Uinta Basin by using the Strawberry, Duchesne, and White Rivers in Utah and Colorado as a divide (Figure 3.4.3-1). The northern area includes two major drainages, the Strawberry and Duchesne, with a combined drainage area of 4,250 mi^2. The oil shale considered in the study area of this PEIS lies mostly in the southern Uinta Basin and in a small area in the southern part of the northern Uinta Basin within the Duchesne drainage.

Most of the tributaries of the Duchesne drainage begin on the south slope of the Uinta Mountains. Major tributaries to the Duchesne River include the Whiterocks River, Uinta River, Dry Gulch Creek, Lake Fork River, Rock Creek, Ashley Creek, North Fork and West Fork Duchesne Rivers, Red and Currant Creeks, and the Strawberry River. The Duchesne River flows to the east and joins the Green River near Ouray, Utah.

The average annual volume of precipitation on the northern Uinta Basin is estimated to be 4.87 million ac-ft on the basis of data from 1941 to 1970. The average annual transbasin inflow includes 3.03 million ac-ft in the Green River and 521,000 ac-ft in the White River. About 4.27 million ac-ft are consumed annually by evapotranspiration (Hood and Fields 1978), and 190,000 ac-ft/yr are exported to the southern Uinta Basin and Great Basin. The average outflow of the Green River from the northern Uinta Basin is about 3.95 million ac-ft/yr (Hood and Fields 1978).

The southern Uinta Basin lies south of the Strawberry, Duchesne, and White Rivers in Utah and Colorado, draining an area about 4,900 mi^2. Most of the major streams on the southern Uinta Basin originate from the Roan Plateau and flow northward to the Duchesne and White Rivers (Price and Miller 1975). Major perennial and intermittent streams west of the Green River include the Pariette Draw, Petes Wash, Indian and Lake Canyons, and the Avintaquin, Antelope, Sowers, and Nine Mile Creeks. Streams east of the Green River include the Willow, Bitter, and Evacuation Creeks, and the Asphalt, Sand, and Coyote Washes.

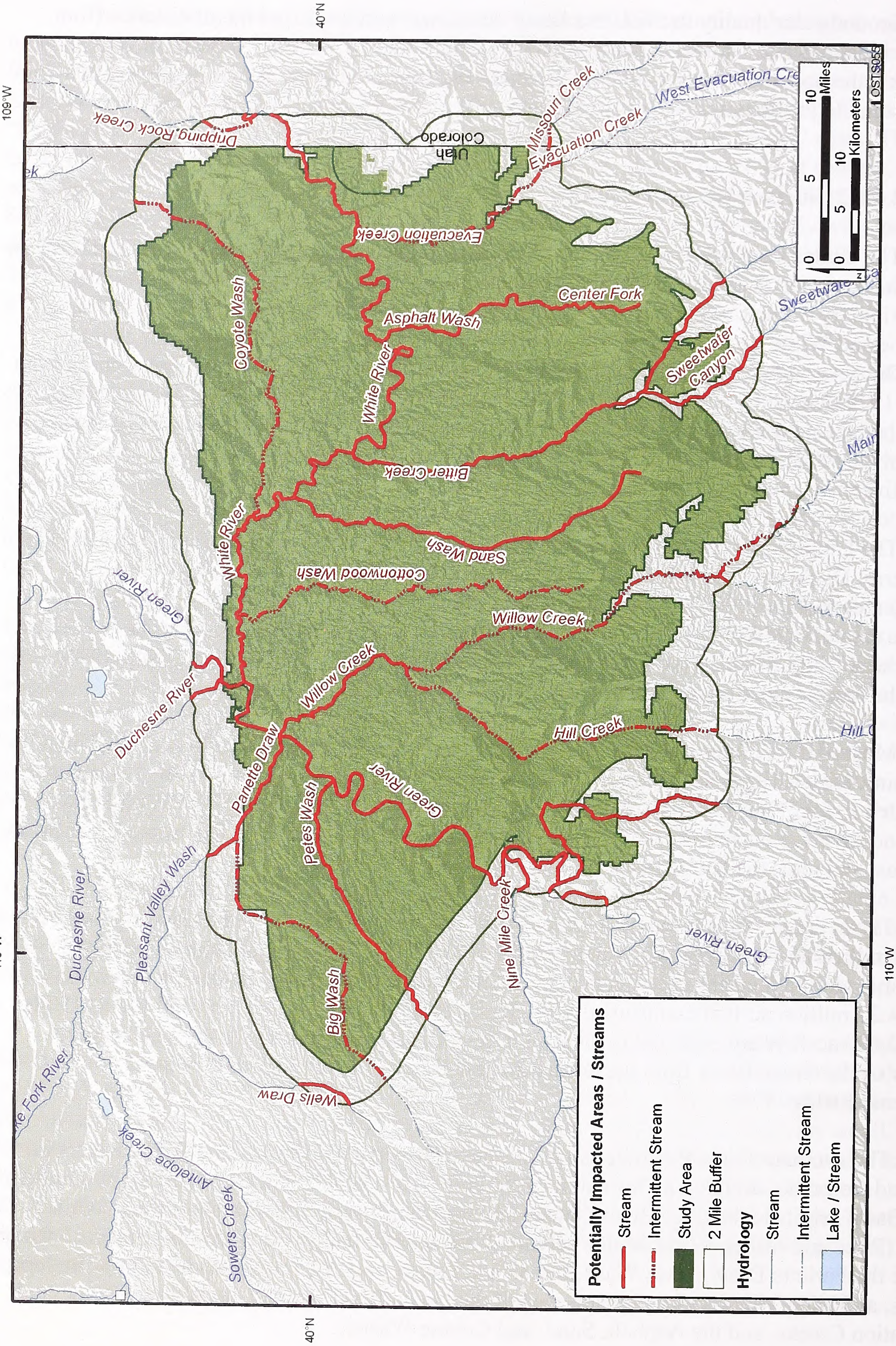

FIGURE 3.4.3-1 Major Rivers and Their Tributaries in the Uinta Basin

The average annual volume of precipitation on the southern Uinta Basin is estimated to be 3.1 million ac-ft on the basis of data from 1941 to 1970. Another 80,000 ac-ft/yr are transported into the basin from the northern Uinta Basin. The estimated annual runoff from the southern Uinta Basin is 134,000 ac-ft (Price and Miller 1975; Hood and Fields 1978). The subbasins that may be developed to provide sustainable water supply are Evacuation, Willow, Nine Mile, Range, and Avintaquin Creek, with a total estimated mean annual runoff of 55,000 ac-ft/yr (Price and Miller 1975).

The climate of most of the Uinta Basin below an elevation about 8,000 ft is arid to semiarid. Average annual precipitation ranges from less than 8 in. near the bottom of the basin at altitudes below 5,000 ft, to 26 in. in the western part of the Roan Plateau. Most of the precipitation is from snow in the winter and rainstorms in the late summer (Price and Miller 1975; Hood and Fields 1978; Lindskov and Kimball 1982).

The streamflow in the basin is extremely variable. Annual runoff varies from year to year and over periods of months, weeks, and days (Lindskov and Kimball 1984). Streams are typically perennial in the higher altitudes of the mountains and plateaus. They become intermittent and ephemeral in areas where annual precipitation is less than 10 in. and evapotranspiration is high (Lindskov and Kimball 1984). Evapotranspiration is estimated to be 94 to 98% of the precipitation in the basin (Price and Miller 1975; Lindskov and Kimball 1982). High streamflow occurs during snowmelt from March to June and during rainstorm activities in July, August, and September. The flows in the Green, Duchesne, and White Rivers are moderated by reservoirs built along the rivers.

The Duchesne River and its tributaries have been extensively affected by water development projects. Construction of a system of transbasin tunnels, canals, and reservoirs began in 1915. The Duchesne River is currently undergoing four separate federal water projects as part of the Central Utah Project (BOR 2006). Flow of the Duchesne River has been reduced, and the river channel has been substantially changed in the last 50 years. The daily average streamflow measured near Randlett is 634 cfs (USGS 2006a). The minimum and maximum daily mean flows were 13 cfs and 7,000 cfs, respectively, based on 62 years of record (USGS 2006a). The maximum recorded peak discharge was 11,500 cfs. The USFWS (Modde and Keleher 2003) recommended a minimum flow of 115 cfs in the lower river between March 1 and June 30 and 50 to 115 cfs for the remainder of the year for endangered fish needs.

Dissolved salt in the rivers is a major concern in the Uinta Basin. The salts originate from marine and lacustrine sedimentary rocks and their derived soils that have high salt content. Surface runoff, irrigation return flow, saline groundwater discharges, and evapotranspiration are the major causes of the elevated TDS concentrations in the surface water (Price and Miller 1975). The concentrations of dissolved salt in streams generally are low near headwater areas, but increase dramatically near the lower reaches of the streams. This is magnified during low-flow periods. For major rivers such as the Green, White, and Duchesne Rivers, the concentrations of dissolved salts are moderated by reservoirs. Recorded concentrations in the Green River generally are less than 1,000 mg/L throughout the year. During low flow in the White River, the TDS concentration is about 1,000 mg/L. The concentrations in the lower reach of the Duchesne River, however, commonly exceed 1,000 mg/L and occasionally exceed

2,000 mg/L during late irrigation and low-flow periods (Price and Miller 1975; Lindskov and Kimball 1984; UDEQ 2006b).

Agricultural irrigation accounts for the largest use of water in the Uinta Basin, almost all of which is obtained from streams (Price and Miller 1975; Hood and Fields 1978). Irrigation water is applied mainly to lands that support the livestock and dairy industry.

3.4.4 Green River Basin and Washakie Basin

3.4.4.1 Groundwater Resources

Section 3.2.3 contains a description of the geological setting of both the Green River and Washakie Basins. Hydrogeological data for the basins are available in Mason and Miller (2004). Unconsolidated alluvial aquifers along major drainages generally have poor water quality. Alluvial thicknesses range up to 50 ft, and some portion of the alluvium may be saturated. Mason and Miller (2004) assembled historical well-yield data from across the basins and describe yield as less than 1 gpm to about 30 gpm in alluvium. Samples collected and analyzed during their study were found to have high concentrations of at least one of the following: TDS, nitrate, chloride, fluoride, sulfate, arsenic, boron, manganese, molybdenum, selenium, and uranium. Overall, less than 25% of the sampled alluvial groundwater was suitable for domestic use, but most was suitable for livestock.

In the Bridger-Washakie Formation, data from wells or springs were sparse. Samples represented a range of water types, and many were high in one or more water quality parameters such as sulfate, TDS, manganese, pH, boron, iron, or uranium. The samples varied in their suitability for domestic, livestock, or irrigation uses. The potential for groundwater development in these formations is not well known but probably poor. Well yields were not provided. The highest spring flow value presented was only 2.25 gpm.

In the Green River Formation, the water quality varies among the various formation members, but is mainly dependent on well depth and distance from groundwater recharge areas.

Data summarized by Mason and Miller (2004) for the Laney Member in the Green River Basin suggest well yields from 1 to 75 gpm. Information for the Washakie Basin suggests that well yields in the Washakie range up to 200 gpm, with TDS concentrations from 500 to 900 mg/L. Mason and Miller (2004) summarized water quality data for wells completed in the Laney Member in both basins. Half the samples were sodium-sulfate type; the remaining ones were mixed. The water quality of the samples was generally marginal to poor because of sulfate and TDS, which ranged from 311 to 53,700 mg/L, with a median of 2,080 mg/L. TDS concentrations increased with well depth and were significantly increased for wells more than 1,000 ft deep. Spring sampling showed a median TDS concentration of 2,200 mg/L. Some water well or spring samples were high in fluoride, boron, or manganese.

A small number of samples were reviewed or collected by Miller and Mason (2004) from the Wilkins Peak Member of the Green River Formation. These were all from recharge locations within the Green River Basin. The samples were of mixed water chemistry, with high sulfate and TDS concentrations. The water was suitable for livestock watering, and some of the samples represented water acceptable for irrigation or domestic use. Miller and Mason (2004) summarized prior studies on the Wilkins Peak water quality, in which the water was of very poor quality, and suggested that the water quality worsens rapidly with distance traveled. Well yields in the Wilkins Peak were reported to be less than 30 gpm.

To address the Tipton Shale Member, Miller and Mason (2004) reviewed and collected groundwater sample data. Water chemistry was found to be either sodium bicarbonate or mixed. The samples had TDS levels that made them marginally suitable for domestic use, but they were acceptable for livestock watering. However, a few of the samples were high in boron or fluoride. These samples were from wells in the Green River Basin, which were in use for livestock watering or other purposes; they were, therefore, not of poor quality. A review of historical reports on other water samples in the Green River Basin found groundwater in the Tipton Shale to be of good quality in portions of the Green River Basin, but poorer in other parts of the basin. Yields from nine wells in the Tipton Shale ranged from 10 to 170 gpm. The potential for groundwater development in the Washakie Basin is considered to be low.

No data are available for the Luman Tongue of the Green River Formation. The aquifer can probably produce enough groundwater for livestock or domestic use, provided the well is close to a recharge area (Mason and Miller 2004).

A review of wells completed in the Wasatch showed yields from less than 1 to 1,300 gpm, with most less than 500 gpm (Mason and Miller 2004). Samples from 84 Wasatch water wells and springs were completed by Mason and Miller (2004). The water type ranged from sodium bicarbonate to sodium sulfate to mixed water types. Concentrations of TDS, sulfate, and fluoride were generally high, and boron was high in some locations. Of 84 samples from water wells and springs, many were at least marginally acceptable for domestic use; almost all were acceptable for livestock, but only half were suitable for irrigation use. Fifty produced water samples had TDS concentrations ranging from 1,050 to 130,000 mg/L, with a median of 13,000 mg/L. Most were sodium chloride type. Deeper samples had higher TDS concentrations, with wells more than 2,000 ft deep generally unsuitable for domestic, irrigation, or livestock use.

Wyoming classifies its aquifers according to standards designed to protect groundwater of a given classification from anthropogenic degradation, so that the water quality is suitable for its intended use or potential future use (WDEQ 2005). Three categories have been defined on the basis of ionic concentrations and other water quality parameters, including TDS. The Class I aquifers are those for domestic use and have TDS concentrations up to 500 mg/L. The Class II aquifers are for agricultural use and have TDS concentrations from 500 to 2,000 mg/L. The Class III aquifers are for livestock watering and have TDS concentrations from 2,000 to 5,000 mg/L. Class IV aquifers have TDS concentrations above 5,000 mg/L and may be used by industry.

Recharge to the aquifers in Sweetwater County occurs as infiltration in aquifer outcrop areas (including snowmelt infiltration at high elevations), losing streams, and even irrigation water infiltration (Mason and Miller 2004). Overall areal recharge is less than 0.5 in./yr. The bulk of groundwater discharge out of the county takes place as bedrock aquifer flow and alluvial underflow, with minor amounts of well withdrawals (Mason and Miller 2004).

The Green River and Washakie Basins are sparsely populated. In Sweetwater County, Wyoming, which contains most of the basins, the estimated mean daily water use in 2000 was 170 million gpd (Mason and Miller 2004). The largest water use is irrigation, at an estimated mean daily rate of 92 million gpd, of which 90% was surface water. Groundwater, though relied on as a resource to a much smaller degree than surface water, is the sole source of water in many areas. The second largest water use in Sweetwater County was mining (41 million gpd), for which essentially all water was saline groundwater. The predominant mining water use was for trona mining and oil and gas production (Mason and Miller 2004).

Population centers in the Wyoming basins are located in the Green River Basin, with the cities of Rock Springs and Green River composing more than 80% of the Sweetwater County population (Mason and Miller 2004). These cities, as well as the town of Granger, rely on surface water for municipal supply, with Granger along Blacks Fork, Rock Springs at the confluence of Bitter Creek and Killpecker Creek, and Green River along the Green River itself.

Groundwater use by irrigation, public supply, industry, and domestic wells is essentially negligible (Mason and Miller 2004). Mining operations have constituted the only significant use of groundwater in Sweetwater County.

Groundwater quality in the basins decreases in quality with increased travel distance from recharge locations and with increasing depth (Mason and Miller 2004). TDS concentrations are moderately saline to briny in aquifers a few thousand feet deep, but locally even shallow groundwater can have moderate salinity. In Sweetwater County, which contains most of the Green River and Washakie Basins' oil shale, shallow groundwater is available in most places (Mason and Miller 2004). However, high TDS concentrations in many locations cause the water to be marginally useful or even unsuitable for domestic use or irrigation. Water of livestock-watering quality is generally available in the county.

In addition to having high TDS concentrations, groundwater from some aquifers in Sweetwater County exceeds EPA drinking water standards for sulfate, fluoride, boron, iron, and manganese (Mason and Miller 2004).

Water quality in alluvial aquifers in Sweetwater County is generally poor because of high TDS concentrations (Mason and Miller 2004). Tertiary bedrock aquifers, although of variable quality, have the most abundant groundwater in the Sweetwater County vicinity and are the most widely used (Mason and Miller 2004).

3.4.4.2 Surface Water Resources

The Green River Basin in Wyoming is part of the Colorado River Basin. Major tributaries of the Green River in the basin include the New Fork, Hams Fork, Big Sandy, Blacks Fork, and Henry's Fork Rivers, and Bitter Creek (Figure 3.4.4-1).

Annual rainfall within the basin varies with altitude, ranging from less than 8 in. on the basin floor to more than 50 in. in the surrounding mountain ranges (Hahn and Jessen 2001). The Fontenelle and Flaming Gorge Reservoirs are two major reservoirs on the Green River. In addition, there are many smaller reservoirs constructed along the major tributaries of the Green River.

The streamflow pattern in the basin is highlighted by spring snowmelts, with high flow from April to July. The streamflow is also moderated by reservoirs built along the rivers. For the Green River below the Fontenelle Reservoir in Wyoming, the mean annual flow was 1,780 cfs for the 1965 to 1984 period. The minimum and maximum annual flows were 690 cfs and 2,780 cfs, respectively. Near the town of Green River, Wyoming, the mean, maximum, and minimum annual flows of the Green River were 1,800, 3,010, and 689 cfs, respectively (Peterson 1988).

The water quality of the streams near mountains is generally good but deteriorates as the streams flow across the basin. The degradation of the water quality is caused by both natural and man-made sources (Strohman 2000). The Green River drainage above Fontenelle Reservoir and the Green River itself above Flaming Gorge Reservoir contain less than 500 mg/L TDS. The water at the Flaming Gorge Reservoir has a median TDS concentration at or slightly above 500 mg/L. The water quality of many streams originating in the low areas is rated as fair to poor in the capacity to support nongame fish, or the water does not have the potential to support fish (Strohman 2000).

Agricultural irrigation is the largest use of surface water in the basin. The most common use of irrigation is in the growth of grass hay for harvest and pasture. The BOR reported that for the 1986 to 1990 period, irrigation depletions in Wyoming's Green River Basin averaged 399,000 ac-ft, or about 79% of total depletions. Livestock and domestic and municipal uses account for the other uses of the surface water in the basin (SWWRC 2001a).

The oil shale area in the Washakie Basin of Wyoming is drained by the tributaries of the Little Snake River. Alkali Creek and Vermillion Creek are two perennial rivers draining the basin. Most of the other creeks in the basin, such as Sand Creek, Shell Creek, and Barrow Spring Draw, are ephemeral.

Annual precipitation varies with elevation, ranging from less than 10 in. near the bottom of the basin to more than 18 in. near the summit of Pine Mountain in the southwestern part of the basin. For most streams in the basin, high flow occurs during periods of snowmelt and rainstorms, and low flow occurs during the fall and early winters. Extended periods of no flow are common for ephemeral streams. Most ephemeral streams are also losing streams (Mason and Miller 2004).

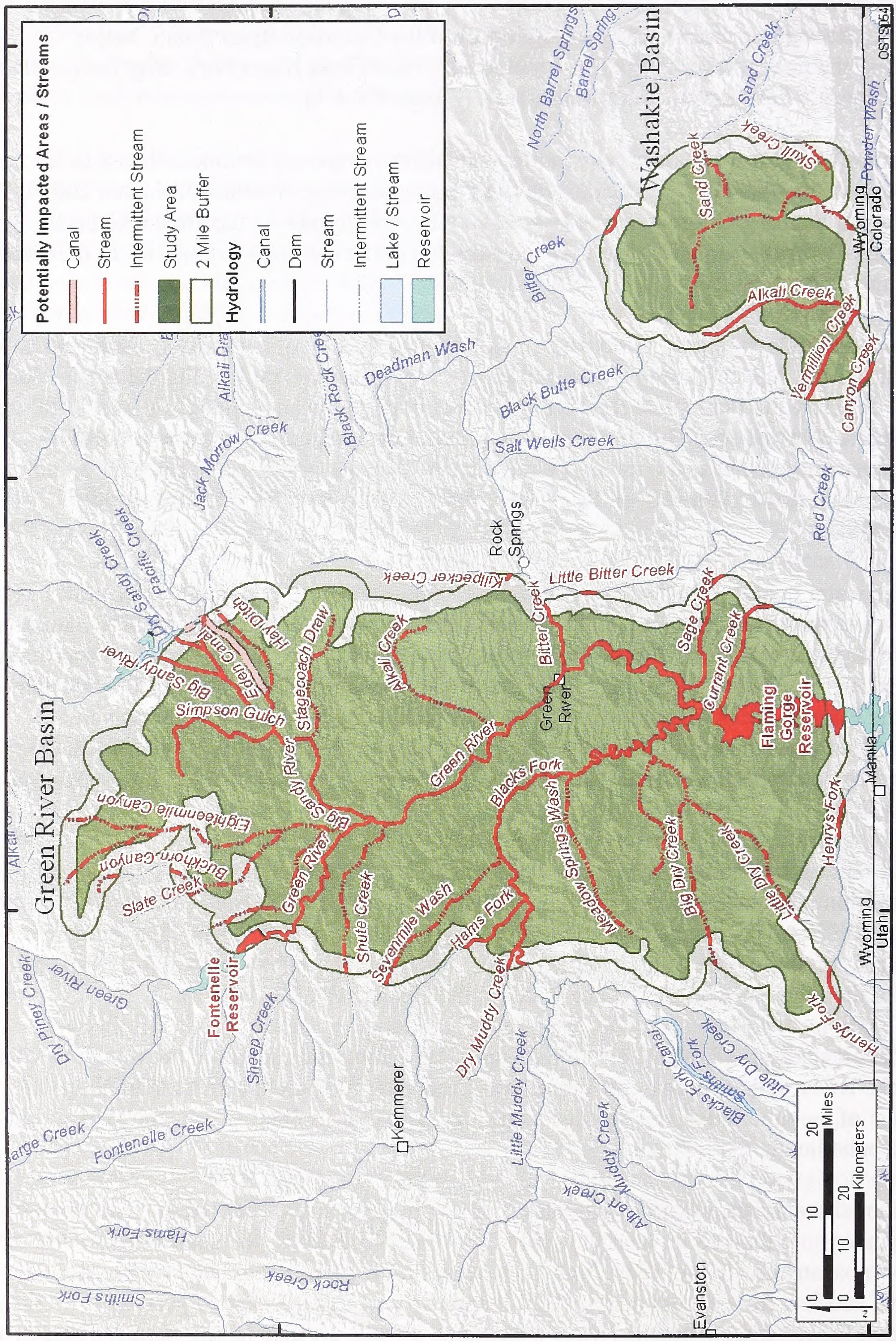

FIGURE 3.4.4-1 Major Rivers and Their Tributaries in the Green River and Washakie Basins

3.4.5 Special Tar Sand Areas

3.4.5.1 Groundwater Resources

The BLM (1984b) compiled groundwater information for each STSA, including estimates of well yields, spring flows, and ranges of TDS values (Table 3.4.5-1). In cases where sufficient data are available, wide ranges of values are noted for each parameter. Water quality is affected by the geochemistry of the unconsolidated and bedrock aquifers. Groundwater quality is typically better from shallower sources.

Groundwater at or near the 11 STSAs is likely used for a combination of mining, stock watering, irrigation, domestic, municipal, and industrial uses. Local withdrawals at each STSA are dependent upon mining activities, population density, and agricultural land use.

TABLE 3.4.5-1 Groundwater Data within or near STSAs

STSA	Water Source	Well Yield or Spring Flow (gpm)	TDS (mg/L)	Formation(s)
Argyle Canyon and Sunnyside	Wells and springs	<1–350	190–67,800	Alluvium, Green River, Uinta, and others
Asphalt Ridge	Wells	0.1–503	149–2,420	Duchesne River, and others
Asphalt Ridge	Springs	36–83,250	69–742	From Chinle Formation, possibly others
Circle Cliffs	Wells, including mine dewatering	NA[a]	188–8,510	NA
Hill Creek and P.R. Spring	Springs	Up to 50, though most are less than 10	297–6,110	Alluvium, Bird's Nest Aquifer of the Parachute Creek Member and Douglas Creek Member of the Green River Formation
Pariette	Wells	3–60	116–4,480	Uinta
Raven Ridge	Wells	0.1–200	221–118,000	Uinta, Green River, Wasatch, and others
San Rafael Swell	Wells	2.8–200	NA	Navajo, Moenkopi, and others
San Rafael Swell	Springs	<1–200	NA	Navajo, Moenkopi, and others
Tar Sand Triangle and White Canyon	Wells	Up to 70, most are <50	318–85,500	Navajo, Wingate, and Coconino
Tar Sand Triangle and White Canyon	Springs	360–450	179–6,530 (most are <2,400)	Navajo, Wingate, and Coconino

[a] NA = data not available.

Source: BLM (1984b).

3.4.5.2 Surface Water Resources

Precipitation varies across the STSAs with elevation. Higher-elevation STSAs, such as Argyle Canyon and Sunnyside, receive 30 or more in./yr of precipitation (BLM 1984b). Most of the STSAs, however, receive less than 8 in./yr. At San Rafael, annual precipitation is less than 6 in.

Except for San Rafael Swell, Tar Sand Triangle, Circle Cliffs, and White Canyon, most of the STSAs are located in the Uinta Basin. The hydrology of the Uinta Basin is described in Section 3.4.3.2. Figure 3.4.5-1 shows the streams and intermittent streams draining the STSAs.

The STSAs in the northern Uinta Basin that are drained by perennial and intermittent streams include Raven Ridge and Asphalt Ridge. The Asphalt Ridge STSA is crossed by the Twelve Mile Wash, which flows south and discharges into the Green River. The Raven Ridge STSA is crossed by the Powder Springs Wash, which flows westward into the Green River (Blackett 1996). Both the Twelve Mile Wash and the Powder Springs Wash are intermittent streams.

The STSAs in the southern Uinta Basin that are drained by perennial and intermittent streams within a distance of 0.25 mi include the P.R. Spring and Hill Creek STSAs east of the Green River, and the Pariette Draw, Sunnyside, and Argyle Canyon STSAs west of the Green River (Figure 3.4.5-1).

Pariette Draw and its tributaries drain the area near the Pariette STSA. Pariette Draw is a perennial stream, discharging to the Green River.

The P.R. Spring and Hill Creek STSAs are incised by intermittent and perennial streams, forming a dendritic drainage pattern. The P.R. Spring STSA is drained by Bitter Creek, Sand Wash, and Willow Creek and their tributaries. The Hill Creek STSA is drained by the Hill Creek and Tabyago Canyon and their tributaries (Blackett 1996). The Sunnyside STSA is dissected by tributaries of Dry Creek and Cotton Wood Canyon, and the upper reach of Range Creek. Dry Creek and Cotton Wood Canyon are two major tributaries of Nine Mile Creek. The upper reach of Range Creek is an intermittent stream. Both Nine Mile Creek and Range Creek discharge to the Green River (Blackett 1996).

The Argyle Canyon STSA is exposed along the valley of Argyle Creek that flows eastward to join Minnie Maude Creek and Nine-Mile Creek, forming the main stem of Nine-Mile Creek.

The San Rafael Swell STSA is primarily drained by the San Rafael River and its tributaries in a desert environment. The river is part of the West Colorado drainage, draining to the Green River. The main stem of the San Rafael River is a perennial river, while most of the tributaries that cross the STSA are intermittent streams. Based on 68 years of record, the annual runoff of the San Rafael River near Green River, Utah, is 374 cfs (USGS Gage 09328500), with a minimum and maximum flow of 1.2 cfs and 2,760 cfs, respectively (USGS 2006b).

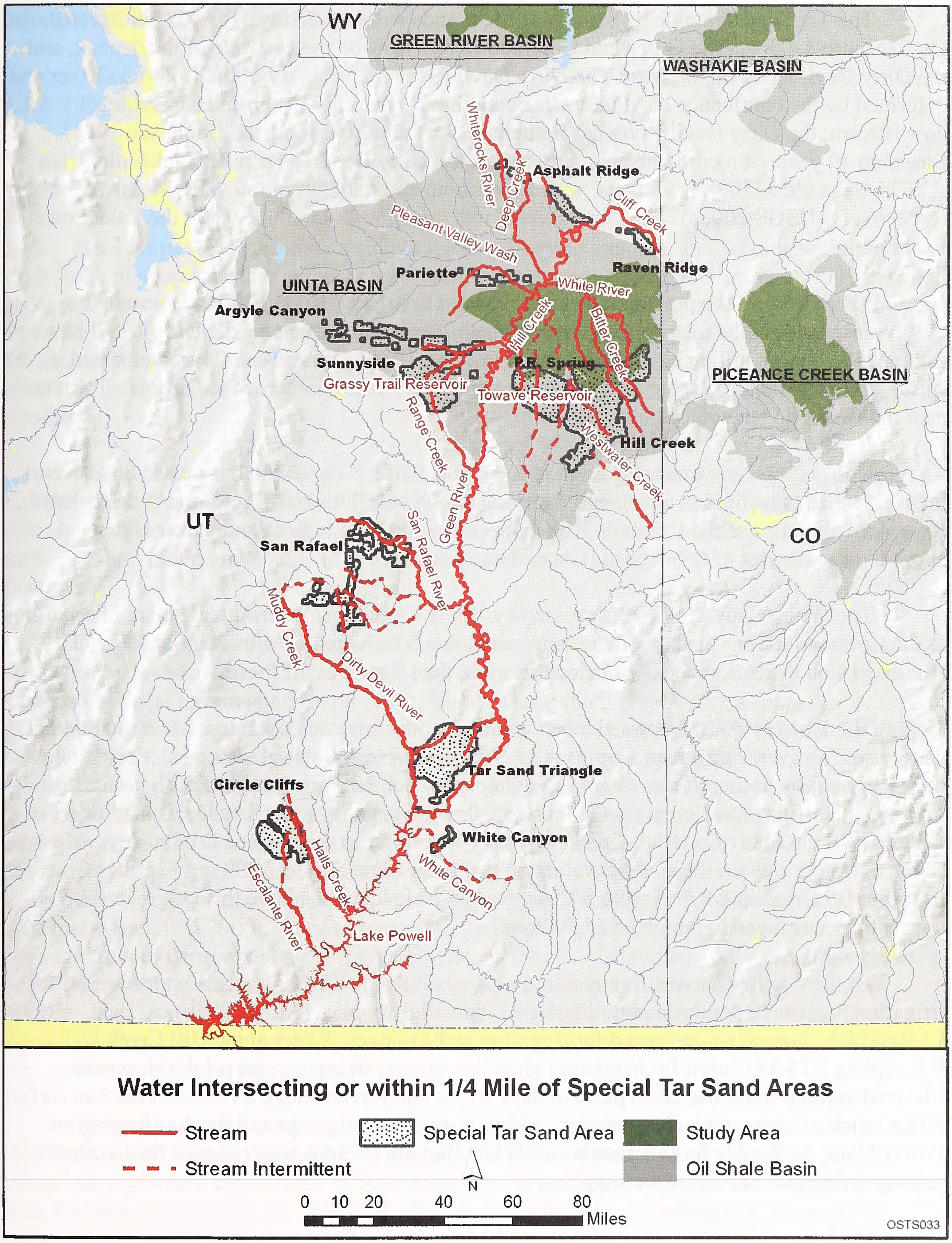

FIGURE 3.4.5-1 Green River and Dirty Devil River Basins Drainage Map

The Tar Sand Triangle STSA is in the lowlands within the lower Dirty Devil River Basin, Utah (Figure 3.4.5-1). The Green and Colorado Rivers flow on the east side of the deposit, and the Dirty Devil River on the west. The Dirty Devil River is a tributary of the Colorado River and is formed by the confluence of Muddy Creek and the Fremont River. From Hanksville downstream, the Dirty Devil River has no perennial tributaries (Hood and Danielson 1981). Based on 49 years of record, the annual runoff of the Dirty Devil River near Hanksville, Utah (USGS Gage 09333500), is 98.6 cfs, with a minimum and maximum flow of 0 cfs and 975 cfs, respectively (USGS 2006c). The Dirty Devil River joins the Colorado River at the Lake Powell Reservoir.

About 96% of the precipitation in the lower Dirty Devil River Basin is consumed by evapotranspiration. The long-term average annual inflow and outflow of the Dirty Devil River is estimated to be 1.6 million ac-ft (Hood and Danielson 1981). High streamflow is expected in spring and occasionally during summer rainstorms. The water quality of the Dirty Devil River near the Colorado River is slightly saline.

No perennial streams are present in the Circle Cliffs STSA, which is crossed by several intermittent streams of Hall Creek and the Escalante River. Both Hall Creek and the Escalante River are tributaries of the Colorado River. The main stem of the Escalante River is located about 6 mi southwest of the deposit (Glassett and Glassett 1976).

The White Canyon STSA is crossed by White Canyon, an intermittent stream discharging to the Colorado River. Surface water resources in this STSA are very limited. Lake Powell (Reservoir) on the Colorado River is located more than 7 mi west of the area.

The BLM (1984b) compiled information on surface water flow rates, water quality, and water uses for rivers and streams near the 11 STSAs. Average flows at various stations along the major rivers (Duchesne, White, Green, and Colorado) ranged from hundreds of thousands to millions of ac-ft/yr. Smaller rivers (Strawberry, Price, Escalante, and Dirty Devil) had flows in the tens of thousands of ac-ft/yr. Creeks typically had flows in the thousands of ac-ft/yr. Most TDS concentrations for the surface waters ranged from about 500 to 7,000 mg/L. Bitter Creek, near the Hill Creek and P.R. Spring STSAs, was the sole location above this range; its TDS concentrations ranged to a high of 15,500 mg/L.

At the Argyle Canyon, Sunnyside, and Asphalt Ridge STSAs, surface water is used for irrigation, livestock, domestic, municipal, and industrial supplies (BLM 1984b). At the Circle Cliffs STSA, surface water is used for irrigation and livestock. Water at the Hill Creek and P.R. Spring STSAs is used for irrigation, gilsonite mining, livestock, and oil development. Minimal surface water use takes place at the Pariette and Raven Ridge STSAs. At the San Rafael STSA, surface water, including reservoir water, is used for irrigation and for the Huntington Power Plant. At the Tar Sand Triangle and White Canyon STSAs, water is used for livestock, mining, irrigation, and domestic supplies.

3.5 AIR QUALITY AND CLIMATE

3.5.1 Climate

3.5.1.1 Meteorology

Because of wide variations in elevation, topographic features, and latitude within the study area, meteorological conditions vary considerably among specific locations. Other than a highland climate in mountainous areas, the study areas have a semiarid mid-continental climate characterized by abundant sunshine, low humidity, low precipitation, and cold, snowy winters. Strong, outgoing terrestrial radiation provides cool nights. In midwinter, air temperatures are often low, but strong solar radiation and dry air combine to provide generally pleasant conditions.

The local climate is strongly influenced by microclimatic features such as slope, aspect, and elevation. The local surface wind patterns and vertical temperature profiles are almost entirely dependent upon topography. Predominantly westerly winds provide additional moisture on the western mountain slopes, with drier conditions on the lee side (often referred to as "rain shadows").

The predominant prevailing wind direction aloft over the region is from the west and southwest as in most of the United States; however, surface air movement patterns are greatly modified by local terrain and ground cover. Wind roses (which graphically display the distribution of wind speed and direction classifications from which the winds originate) at the 33-ft level for selected meteorological stations around the study area for the 6-year period (2000–2005) are shown in Figure 3.5.1-1 (NCDC 2006a). As shown in the figure, although most locations display westerly winds, prevailing wind directions are different from site to site (most obviously for Grand Junction, Colorado, located just southwest of the Book Cliffs). Average wind speeds range from 5 to 8 mph in Colorado and Utah, with the highest speed of nearly 11 mph measured at the Rock Springs, Wyoming, airport, which is situated on a mesa at an elevation of nearly 6,700 ft. Stations located in the valleys typically experience nocturnal drainage flow of denser cold air at higher elevations into the valley floor. This condition causes poor dispersion and stagnation, which tend to trap air pollutants within the valley. A higher occurrence of low wind speeds or calm conditions is typically measured at these sites. The Vernal, Meeker, and Moab surface stations show very high occurrences of stagnant conditions (i.e., calm periods occur more than 20% of the time).

Temperatures in the region vary widely with elevation, latitude, season, and time of day. Historical annual average temperatures measured at selected meteorological stations in and around the study area range from 36°F in Big Piney, Wyoming (just east of the Wyoming Range at an elevation of 6,800 ft), to 54°F in Hanksville, Utah (in a desert setting), as presented in Table 3.5.1-1 (WRCC 2006). Typically, January is the coldest month, ranging from –5°F to 16°F, and July is the warmest month, ranging from 80°F to 99°F.

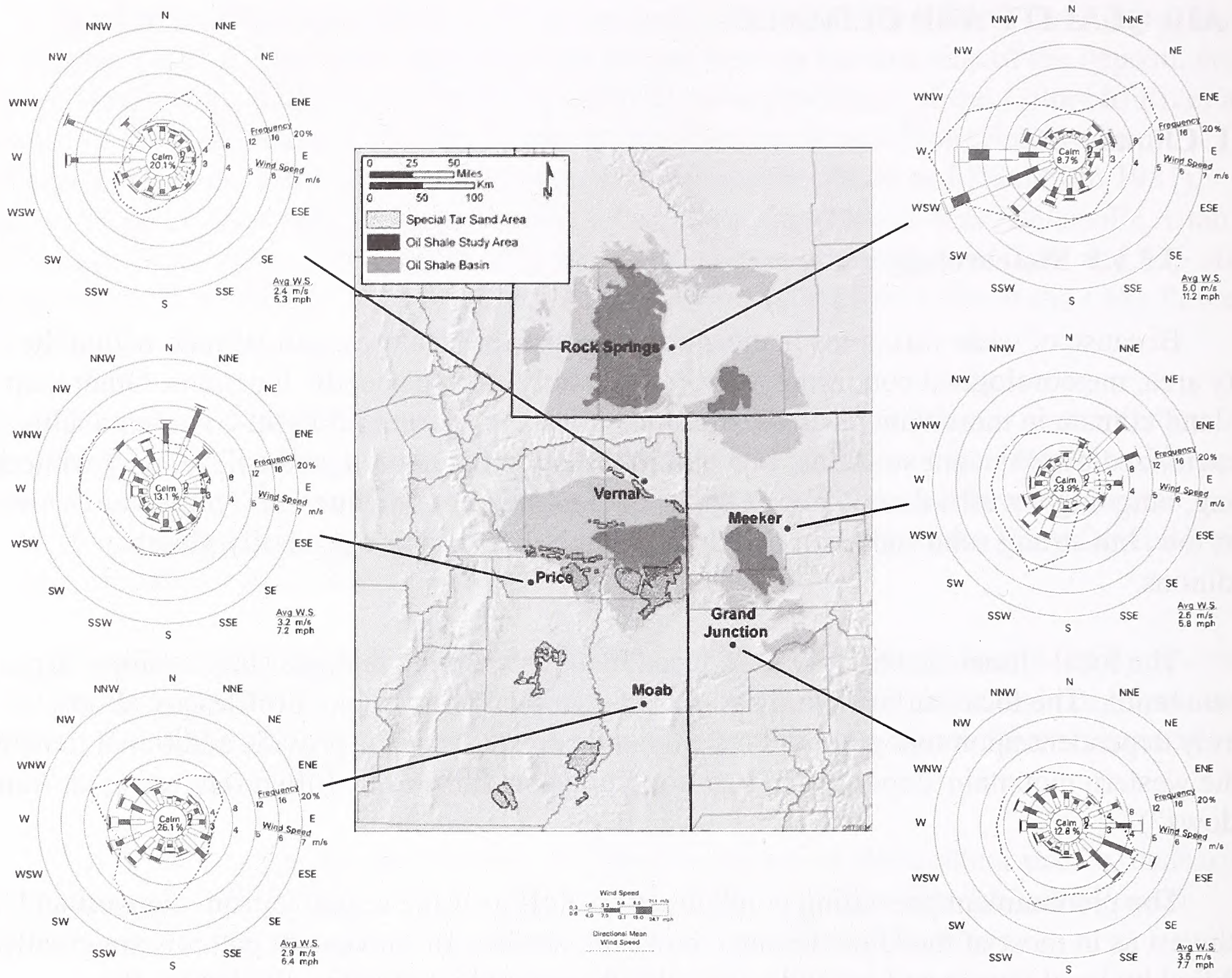

FIGURE 3.5.1-1 Wind Roses at the 33-ft Level for Selected Meteorological Stations around the Study Area, 2000–2005 (Source: NCDC 2006a)

Although limited monitoring occurs mostly in lower elevation towns, the average precipitation around the study area ranges from around 6 in. in Hanksville, Utah, to about 16 in. in Meeker, Colorado (WRCC 2006). Much higher values are expected in mountainous locations. At lower elevations, precipitation is greatest in spring and fall, and generally low in winter months; at higher elevations, precipitation is relatively evenly distributed. Snowfall is quite variable by location (ranging on average from about 6 in. in Hanksville, Utah, to more than 69 in. in Meeker, Colorado), with the snowiest months being December through February. In general, snowfall tends to increase with increasing latitude and elevation, while precipitation has a weak relationship with respect to latitude and elevation.

Complex terrain typically disrupts the mesocyclones associated with tornado-producing thunderstorms; thus, tornadoes are less frequent and destructive in this region. For example, tornado frequencies in counties within the oil shale study area in Colorado are about two orders of magnitude lower than those in the rest of the state. From January 1950 to April 2006, 67 tornadoes were reported in the counties within the study area, with 2,263 reported for all of

TABLE 3.5.1-1 Temperature and Precipitation Summaries at Selected Meteorological Stations in and around the Study Area

Station	State	County	Temperature (°F)[a]			Precipitation (in.)		Period of Record
			Average Monthly Minimum	Average Monthly Maximum	Mean[b]	Total Water Equivalent	Snowfall	
Grand Junction	CO	Mesa	16.0	92.7	51.8	8.70	21.6	1/1/1900 – 12/31/2005
Meeker	CO	Rio Blanco	6.9	85.7	45.4	16.41	69.5	1/1/1900 – 12/31/2005
Rifle	CO	Garfield	9.4	90.2	47.8	11.61	38.6	9/9/1910 – 12/31/2005
Hanksville	UT	Wayne	12.3	98.7	53.5	5.56	5.8	7/1/1948 – 12/31/2005
Price	UT	Carbon	13.4	90.0	50.0	9.42	20.4	9/1/1968 – 12/31/2005
Vernal	UT	Uintah	4.8	89.8	46.2	8.30	15.2	1/1/1928 – 12/31/2005
Big Piney	WY	Sublette	–5.3	80.0	35.8	7.46	28.6	8/1/1948 – 12/31/2005
Rawlins	WY	Carbon	12.6	83.7	44.1	9.08	51.9	3/6/1951 – 12/31/2005
Rock Springs	WY	Sweetwater	11.4	83.2	41.8	8.84	43.6	8/1/1948 – 12/31/2005

[a] "Average Monthly Minimum" denotes the monthly average of daily minimum values during the period of record, which normally occurs in January. "Average Monthly Maximum" denotes the monthly average of daily maximum values during the period of record, which normally occurs in July.

[b] NCDC 1971 to 2000 monthly normals.

Source: WRCC (2006).

Colorado, Utah, and Wyoming combined (NCDC 2006b). Most tornadoes that occurred in the study area were relatively weak, mostly F0 or F1 on the Fujita tornado scale[8] (except for three F2s and one F3); statewide, most (71%) tornadoes were reported in Colorado, with categories F0, F1, and F2 and above, each accounting for about 62, 30, and 8%, respectively, of the combined states' total.

3.5.1.2 Global Climate Change

Ongoing scientific research has identified the potential effects of so-called "greenhouse gas" (GHG) emissions (including carbon dioxide [CO_2], methane [CH_4]; nitrous oxide, water vapor; and several trace gasses) on global climate. Through complex interactions on a regional and global scale, these GHG emissions cause a net warming effect of the atmosphere, making surface temperatures suitable for life on earth, primarily by decreasing the amount of heat energy radiated by the earth back into space. Although GHG levels have varied for millennia, with corresponding variations in climatic conditions, recent industrialization and burning of fossil carbon sources have caused CO_2 concentrations to increase dramatically, and are likely to contribute to overall climatic changes, typically referred to as global warming. Increasing CO_2 concentrations also lead to preferential fertilization and growth of specific plant species.

The assessment of the relationship between GHG emissions and climate change is in its formative phase, and it is not yet possible to know with confidence the net impact on climate. Observed climatic changes may be caused by GHG emissions or may reflect natural fluctuations, but the Intergovernmental Panel on Climate Change (IPCC) (2007) recently concluded that "Warming of the climate system is unequivocal" and "Most of the observed increase in globally average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic [man-made] greenhouse gas concentrations."

Global mean surface temperatures have increased nearly 1.0°C (1.8°F) from 1890 to 2006 (Goddard Institute for Space Studies 2007). However, both observations and predictive models indicate that average temperature changes are likely to be greater in the Northern Hemisphere (especially the Arctic). Figure 3.5.1-2 demonstrates that northern latitudes (above 24° N, which includes all of the United States) have exhibited temperature increases of nearly 1.2°C (2.1°F) since 1900, with nearly a 1.0°C (1.8°F) increase since 1970 alone. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions, but increasing concentrations of GHG are likely to accelerate the rate of climate change.

In 2001, the IPCC indicated that by the year 2100, global average surface temperatures will rise 1.4 to 5.8°C (2.5 to 10.4°F) above 1990 levels. The IPCC also concluded that the combined effects of melting glaciers, melting ice caps, and sea water expansion due to warmer ocean temperatures would cause the global average sea level to rise 100 to 900 cm (4 to 36 in.) during this same time period.

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[8] Fujita scale F0, F1, F2, through F5 tornadoes are classified with wind speeds of 40 to 72 mph, 73 to 112 mph, 113 to 157 mph, and up to 261 to 318 mph, respectively.

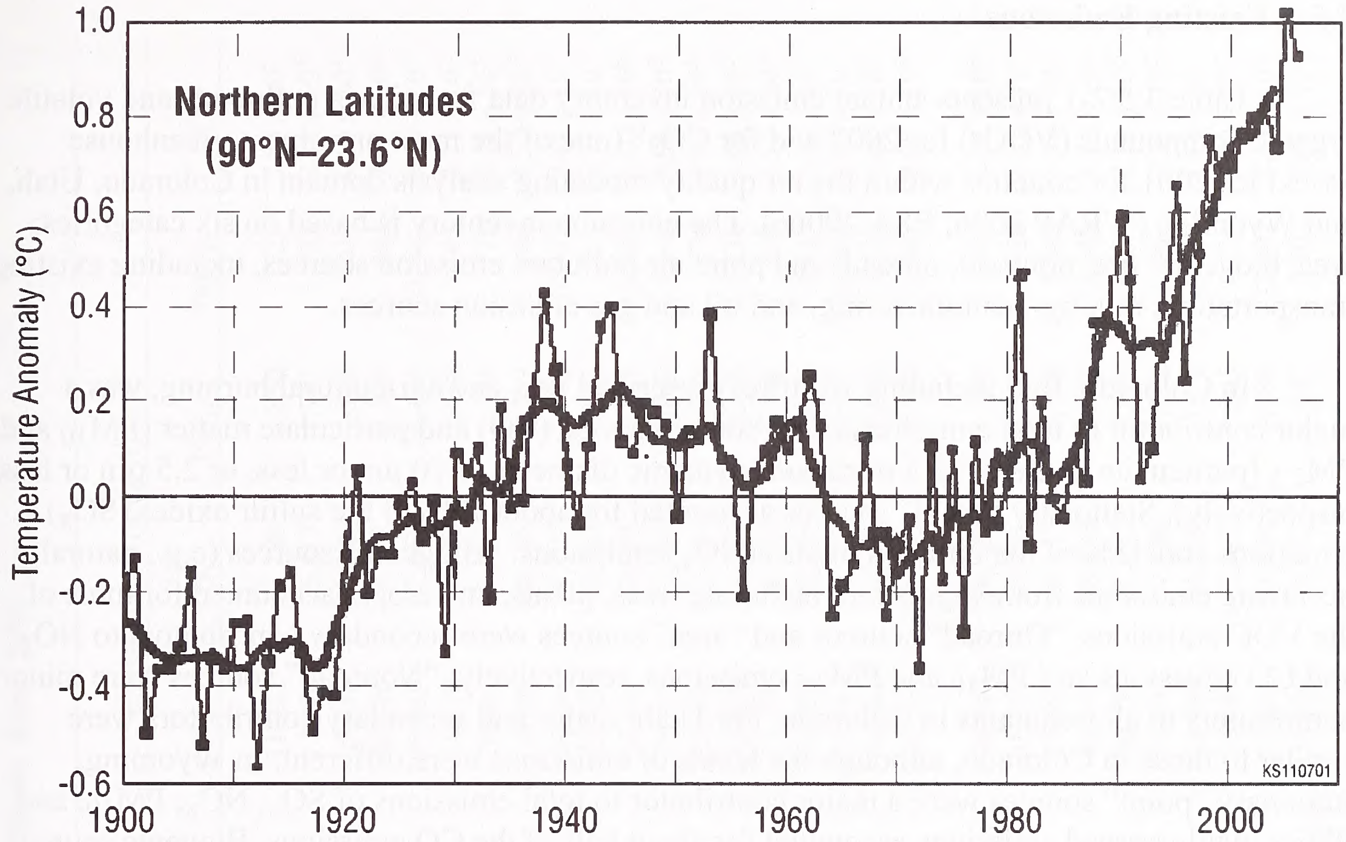

FIGURE 3.5.1-2 Annual Mean Temperature Change for Northern Latitudes (24–90° N) (Source: Adapted from Goddard Institute for Space Studies 2007)

The National Academy of Sciences (2006) has confirmed these findings, but also indicated that there are uncertainties about how climate change will affect different regions. Computer model predictions indicate that increases in temperature will not be equally distributed, but are likely to be accentuated at higher latitudes, such as in the Arctic, where the temperature increase may be more than double the global average. Warming during the winter months is expected to be higher than during the summer. Northern areas may also experience increased precipitation. However, neither the state of the science, nor current monitoring systems are adequate to indicate what influence global climate change may have throughout the study area.

The lack of scientific tools designed to predict climate change on regional or local scales limits the ability to quantify potential future impacts. However, potential impacts on air quality due to climate change are likely to be varied. For example, if global climate change results in a warmer and drier climate, increased particulate matter impacts could occur because of increased windblown dust from drier and less stable soils. Cool season plant species' spatial ranges are predicted to move north and to higher elevations, and extinction of endemic threatened and endangered plants may be accelerated. Because of the loss of habitat or competition from other species whose ranges may shift northward, the population of some animal species may be reduced. Less snow at lower elevations would be likely to impact the timing and quantity of snowmelt, which, in turn, could impact aquatic species.

3.5.2 Existing Emissions

Table 3.5.2-1 presents annual emission inventory data for criteria pollutants and volatile organic compounds (VOCs) for 2002 and for CO_2[9] (one of the most prominent greenhouse gases) for 2001 for counties within the air quality modeling analysis domain in Colorado, Utah, and Wyoming (WRAP 2006; EPA 2006e). The emission inventory is based on six categories: area, biogenic, fire, nonroad, onroad, and point air pollutant emission sources, including existing transportation, mining, manufacturing, and oil and gas emission sources.

In Colorado, fire, including wildfire, prescribed fire, and agricultural burning, was a major contributor to total emissions of carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$ [particulate matter with a mean aerodynamic diameter of 10 µm or less, or 2.5 µm or less, respectively]. Stationary "point" sources accounted for about 72% of the sulfur oxides (SO_x) emissions and 41% of the nitrogen oxides (NO_x) emissions. "Biogenic" sources (e.g., naturally occurring emissions from vegetation, including trees, plants, and crops) accounted for most of the VOC emissions. "Onroad" sources and "area" sources were secondary contributors to NO_x and CO emissions and PM_{10} and $PM_{2.5}$ emissions, respectively. "Nonroad" sources were minor contributors to all pollutants in Colorado. For Utah, major and secondary contributors were similar to those in Colorado, although the levels of emissions were different. In Wyoming, stationary "point" sources were a major contributor to total emissions of SO_x, NO_x, PM_{10}, and $PM_{2.5}$, while onroad emissions accounted for about half of the CO emissions. Biogenic sources composed the predominant source for VOC emissions. Area sources were secondary contributors to PM_{10} and $PM_{2.5}$ emissions, while nonroad and fire were minor contributors in Wyoming.

3.5.3 Air Quality

Table 3.5.3-1 presents the National Ambient Air Quality Standards (NAAQS) and the State Ambient Air Quality Standards (SAAQS) for Colorado, Utah, and Wyoming for six criteria pollutants—sulfur dioxide (SO_2), nitrogen dioxide (NO_2), CO, ozone (O_3), PM_{10} and $PM_{2.5}$, and lead (Pb) (40 CFR Part 50; CDPHE 2006a; EPA 2006a; UDEQ 2006a; WDEQ 2006a). In Utah, the standards are equivalent to the NAAQS for each pollutant. Colorado has more stringent standards than the NAAQS for SO_2 and Pb. In addition, the State of Wyoming has adopted standards for hydrogen sulfide (H_2S), suspended sulfates, fluorides, and odors, as well as more stringent standards for SO_2.

The existing air quality of the study area is in attainment with all ambient air quality standards, as demonstrated by the relatively low concentration levels presented in Table 3.5.3-2. No major population centers or industrial complexes occur within the study area. Accordingly, all counties containing oil shale and/or tar sands resources are currently in attainment for all criteria pollutants (40 CFR 81.306, 81.345, 81.351; EPA 2006b). One exception is Utah County, in which a small portion of tar sands resources are located, which is currently designated as a nonattainment area for PM_{10}. A request for redesignation of Utah County to an attainment area is

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9 Currently, CO_2 emissions at the county level are not available; their emissions were estimated from available state total emissions based on population distribution.

TABLE 3.5.2-1 Annual Air Pollutant Emissions for Counties within the Study Area, 2002

		County Contains:		Emission Rate (tons/yr)						
State	County	Oil Shale	Tar Sands	SO_x	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$	CO_2[a]
Colorado	Chaffee	No	No	125	1,009	11,931	17,286	850	321	3.63×10^5
	Delta	Yes	No	107	1,800	17,276	25,417	1,785	723	6.23×10^5
	Dolores	No	No	10	854	5,330	21,228	866	207	4.13×10^4
	Eagle	No	No	201	4,901	44,646	24,212	2,396	884	9.32×10^5
	Garfield	Yes[b]	No	1,749	15,937	293,869	67,861	26,434	21,641	9.80×10^5
	Grand	No	No	130	2,007	15,170	25,268	1,455	391	2.78×10^5
	Gunnison	No	No	69	1,311	20,044	36,498	1,534	778	3.12×10^5
	Jackson	No	No	17	574	6,108	28,565	259	140	3.53×10^4
	La Plata	No	No	923	8,870	154,403	38,107	15,062	12,152	9.83×10^5
	Lake	No	No	57	2,027	25,328	10,824	668	217	1.75×10^5
	Mesa	Yes	No	2,441	7,813	61,436	52,093	5,417	1,683	2.60×10^6
	Moffat	Yes	No	10,781	23,563	75,183	47,140	8,530	5,116	2.95×10^5
	Montezuma	No	No	98	2,328	23,540	35,141	1,518	724	5.33×10^5
	Montrose	No	No	1,606	3,225	22,456	30,354	3,568	1,136	7.48×10^5
	Pitkin	No	No	67	1,134	13,352	19,902	456	199	3.33×10^5
	Rio Blanco	Yes[b]	No	325	7,100	61,452	51,235	5,283	4,113	1.34×10^5
	Routt	No	No	4,075	14,610	202,581	48,283	20,677	15,989	4.40×10^5
	San Miguel	No	No	902	4,152	156,094	25,826	15,006	12,573	1.48×10^5
	Subtotal			23,683	103,215	1,210,199	605,240	111,764	78,987	9.95×10^6
Utah	Carbon	Yes[b]	Yes	8,218	7,540	40,095	28,722	2,484	1,665	6.22×10^5
	Daggett	Yes	No	318	2,288	55,378	21,731	5,122	4,323	2.81×10^4
	Emery	Yes	Yes	21,126	34,110	35,385	49,557	3,618	1,583	3.31×10^5
	Garfield	No	Yes	296	1,643	45,902	68,986	3,158	2,449	1.44×10^5
	Grand	Yes	Yes	913	6,076	160,774	61,092	13,680	11,595	2.58×10^5
	Juab	No	No	338	4,934	61,703	41,426	1,272	462	2.51×10^5
	Kane	No	No	106	999	19,289	74,159	374	182	1.84×10^5
	Piute	No	No	93	483	15,443	18,492	1,065	756	4.40×10^4
	San Juan	No	Yes	1,780	3,681	57,213	101,074	3,989	2,641	4.39×10^5
	Sanpete	No	No	512	1,853	25,230	28,421	1,885	805	6.93×10^5

TABLE 3.5.2-1 (Cont.)

		County Contains:		Emission Rate (tons/yr)						
State	County	Oil Shale	Tar Sands	SO_x	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$	CO_2[a]
Utah (Cont.)	Sevier	No	No	633	3,002	49,156	29,446	3,197	2,018	5.74×10^5
	Uintah	Yes[b]	Yes	1,192	11,915	30,010	73,930	2,735	1,559	7.68×10^5
	Wayne	No	Yes	162	469	8,778	35,508	341	72	7.64×10^4
	Subtotal			35,687	78,993	604,356	632,544	42,920	30,110	4.41×10^6
Wyoming	Carbon	Yes	No	4,362	13,614	32,885	81,356	2,370	832	2.17×10^6
	Sweetwater	Yes[b]	No	35,107	65,380	71,694	104,410	19,140	7,269	5.23×10^6
	Subtotal			39,469	78,994	104,579	185,766	21,510	8,101	7.40×10^6
Region	Total			98,839	261,202	1,919,134	1,423,550	176,194	117,198	2.18×10^7

a Emission data for the year 2001. Currently, CO_2 emissions at the county level are not available; thus, emissions were estimated from available state-total CO_2 emissions based on population distribution.

b Counties with the most geologically prospective areas with 25+ gal/ton and 25+ ft thick for Colorado and Utah, and 15+ gal/ton and 15+ ft thick for Wyoming.

Sources: WRAP (2006); EPA (2006e).

TABLE 3.5.3-1 Applicable Ambient Air Quality Standards and Prevention of Significant Deterioration Increments (μg/m³) for the Study Area

		National[b]		State			PSD Increment[d]	
Pollutant[a]	Averaging Time	Standard Value	Standard Type[c]	Colorado	Utah	Wyoming	Class I	Class II
SO_2	3 h	1,300	S	700	1,300	1,300	25	512
	24 h	365	P	–[e]	365	260	5	91
	Annual	80	P	–	80	60	2	20
NO_2	Annual	100	P, S	100	100	100	2.5	25
CO	1 h	40,000	P	40,000	40,000	40,000	–	–
	8 h	10,000	P	10,000	10,000	10,000	–	–
O_3	1 h	235[f]	P, S	235	–	–	–	–
	8 h	157[g]	P, S	–	157	157	–	–
PM_{10}	24 h	150	P, S	150	150	150	8	30
	Annual	Revoked[h]	P, S	50	50	50	4	17
$PM_{2.5}$	24 h	35[i]	P, S	–	65	65	–	–
	Annual	15.0[j]	P, S	–	15	15	–	–
Pb	Calendar quarter	1.5	P, S	–	1.5	1.5	–	–
	One month	–		1.5	–	–	–	–

[a] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤ 2.5 μm; PM_{10} = particulate matter ≤ 10 μm; SO_2 = sulfur dioxide.

[b] Refer to 40 CFR Part 50 for detailed information on attainment determination and reference method for monitoring.

[c] P = primary standards, which set limits to protect public health; S = secondary standards, which set limits to protect welfare.

[d] All NEPA analysis comparisons to the Prevention of Significant Deterioration (PSD) increments are intended to evaluate a threshold of concern and do not represent a regulatory PSD Increment Consumption Analysis.

[e] A dash indicates that no standard exists.

[f] The EPA's revised O_3 standards replaced the 1-h standard. As of June 15, 2005, the EPA revoked the 1-hr O_3 standard in all areas except the fourteen 8-h O_3 nonattainment Early Action Compact (EAC) Areas (EPA 2007).

[g] To attain this standard, the 3-yr average of the fourth highest daily maximum 8-h average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm (157 μm³).

[h] Because of a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the EPA revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).

[i] To attain the NAAQS, the 3-yr average of the 98th percentile of 24-h concentrations at each population-oriented monitor within an area must not exceed 35 μg/m³ (effective December 17, 2006).

[j] To attain this standard, the 3-yr average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 μg/m³.

Sources: 40 CFR Part 50; 40 CFR 52.21; CDPHE (2006a); EPA (2006a); UDEQ (2006a); WDEQ (2006a).

TABLE 3.5.3-2 Background Concentration Levels Representative of the Study Area[a,b] (μg/m³)

State	Pollutant	Averaging Time	Applicable Standard[c]	Concentration[d]	Note
Colorado	SO_2	3 h 24 h Annual	700 365 80	23 (3%) 13 (4%) 5 (7%)	Unocal, 1983–1984
	NO_2	Annual	100	15 (15%)	Rural default based on Southern Ute stations near Ignacio
	CO	1 h 8 h	40,000 10,000	1,140 (3%) 1,110 (11%)	American Soda, Piceance, 2003–2004
	O_3[e]	1 h 8 h	235 157	172 (73%) 145 (93%)	Based on Mesa Verde, 2003 Based on CASTNET in Mesa Verde, Canyonlands, and Gothic
	PM_{10}	24 h Annual	150 50[f]	41 (27%) 11 (22%)	American Soda, Piceance, 2003–2004
	$PM_{2.5}$	24 h Annual	65[g] 15	18 (28%) 8 (53%)	Based on 515 Patterson in Grand Junction, Mesa County
	Pb[h]	Calendar quarter	1.5	0.04 (3%)	Industrial, urban in Grand Junction, Mesa County, 2001
Utah	SO_2	3 h 24 h Annual	1,300 365 80	28 (2%) 12 (3%) 4 (5%)	Rural default based on the Intermountain Power Plant in Delta, 2001
	NO_2	Annual	100	20 (20%)	Rural default for areas with significant number of coal-fired power plants and oil/gas development
	CO	1 h 8 h	40,000 10,000	1,140 (3%) 1,110 (11%)	EPA Region VIII rural default, 2003–2004
	O_3	1 h 8 h	235 157	172 (73%) 145 (93%)	Based on Mesa Verde, 2003 Based on CASTNET in Mesa Verde, Canyonlands, and Gothic
	PM_{10}	24 h Annual	150 50[f]	72 (48%) 29 (58%)	Sevier Power, 2002–2003
	$PM_{2.5}$	24 h Annual	65[g] 15	18 (28%) 8 (53%)	Based on 515 Patterson in Grand Junction, Mesa County
	Pb	Calendar quarter	1.5	0.08 (5%)	Residential, suburban in Magna, Salt Lake County, 2005

TABLE 3.5.3.2 (Cont.)

State	Pollutant	Averaging Time	Applicable Standard[c]	Concentration[d]	Note
Wyoming	SO_2	3 h	1,300	65 (5%)	Desert, rural in Riverton, Fremont County, 2004
		24 h	260	16 (6%)	
		Annual	60	6 (10%)	
	NO_2	Annual	100	6 (6%)	Desert, rural in Sublette County, 2005
	CO	1 h	40,000	3,540 (9%)	Forest, rural (Grand Teton National Park), Teton County, 2003
		8 h	10,000	1,330 (13%)	
	O_3	1 h	235	141 (60%)	Desert, rural in Sublette County, 2005
		8 h	157	130 (83%)	
	PM_{10}	24 h	150	64 (43%)	Residential, urban in Rock Springs, Sweetwater County, 2001
		Annual	50[f]	26 (52%)	
	$PM_{2.5}$	24 h	65[g]	42 (65%)	Residential, suburban in Lander, Fremont County, 2004
		Annual	15	9.6 (64%)	Residential, suburban in Lander, Fremont County, 2002
	Pb	Calendar quarter	1.5	NA[i]	NA

[a] Monitored concentrations are the highest arithmetic mean for calendar-quarter Pb; 2nd highest for 3-hour and 24-h SO_2, 1-h and 8-h CO, 1-h O_3, and 24-h PM_{10}; 4th highest for 8-h O_3; 98th percentile for 24-h $PM_{2.5}$; and arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

[b] Background concentrations for Colorado and Utah are estimates of air pollution in the study area recommended by the Colorado Department of Public Health and Environment (CDPHE) and Utah Department of Environmental Quality (UDEQ), respectively. On the basis of the EPA's *AirData* 2000 to 2005 monitoring database, background concentrations for Wyoming representative of the study area were selected by considering proximity, land use, and/or environmental setting. For some pollutants, no monitored values representative of the study area are available (e.g., CO). However, monitored values considered to be relatively representative of the study area are presented to demonstrate compliance.

[c] Most restrictive national or state standard.

[d] Values in parentheses are monitored concentrations as a percentage of the applicable standard.

[e] One-hour O_3 standard is applied to Early Action Compact area in Colorado only.

[f] Effective December 17, 2006, the EPA revoked the annual PM_{10} standard of 50 μm^3.

[g] Effective December 17, 2006, the EPA revised the 24-h $PM_{2.5}$ standard from 65 μm^3 to 35 μm^3.

[h] Colorado has a more stringent standard for Pb; however, monitored data are reported per the calendar-quarter average national standard.

[i] NA = not available.

Sources: Chick (2006); EPA (2006c); Orth (2006).

pending EPA approval, since significant emission reductions from one steel plant have resulted in improved air quality.

Routine monitoring of criteria air pollutant concentrations is not currently conducted in the study area. Background concentrations representative of the study area are summarized in Table 3.5.3-2 for each state based on intermittent monitoring studies and routine monitoring data (Chick 2006; EPA 2006c; Orth 2006). On the basis of limited monitoring data, air quality in the region is expected to be good (i.e., concentration levels for most criteria pollutants [except O_3] are well below their applicable standards). Although no O_3 violations have been documented, some measurements are near the 8-h O_3 standard of 157 $\mu g/m^3$.

The Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21), which are designed to limit the growth of air pollution in "clean" areas, apply to all new sources within attainment and unclassified areas. PSD regulations limit the amount of additional air pollution above legally established baseline levels of SO_2, NO_2, and PM_{10}, as shown in Table 3.5.3-1. Incremental increases in PSD Class I areas are strictly limited, while those in Class II areas allow for moderate emission growth. Most of the oil shale and tar sands resource areas are classified as PSD Class II, except for the tar sands area in or around Arches, Canyonlands, and Capitol Reef National Parks in Utah, and the oil shale area immediately upwind of the Flat Tops Wilderness Area in Colorado. The PSD Class I and Colorado Class I SO_2 increment areas located within 50 mi of the study area are listed in Table 3.5.3-3.[10] Predominant wind direction aloft is from the southwest in the region; thus, potential air quality for the Class I areas located northeast of the study area would be affected.

The Clean Air Act Amendments of 1977 gave Federal Land Managers an affirmative responsibility through the New Source Review permitting process to protect the "air quality related values" (AQRVs), such as visibility and acid deposition, from the adverse impacts of air pollution. The Interagency Monitoring of PROtected Visual Environments (IMPROVE) monitoring program was established in 1985 to aid in the creation of federal and state implementation plans for the protection of visibility in mandatory federal PSD Class I areas (CIRA 2006). Continuous visibility-related data representative of PSD Class I areas (e.g., Canyonlands National Park and Flat Tops Wilderness Area) have been collected within the oil shale and tar sands study area. Visibility in the region is currently the best of the contiguous United States (2004 annual standard visual range of 185 to 220 km [114–137 mi]). The Clean Air Status and Trends NETwork (CASTNET) is the nation's primary source for data on dry acidic deposition and ground-level ozone and has been operating since 1987 to provide information for evaluating the effectiveness of national emission control strategies (EPA 2006d). Sample stations around the study area include Gothic, Colorado; Canyonlands National Park, Utah; and Pinedale, Wyoming.

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation chemistry monitoring sites (NADP 2006). Monitoring sites collect precipitation samples, which are analyzed at a central laboratory (including pH,

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[10] Although the area is not a designated PSD Class I area, it has been designated as a Category I area by the State of Colorado, with SO_2 increments equivalent to those applicable in a federal Class I area.

TABLE 3.5.3-3 PSD Class I and State Category I Areas Located within 50 mi of the Study Area

Classification	Sensitive Receptor Name	Managing Agency[a]	Area (Acres)	State	Distance (mi)[b]
PSD Class I Areas	Arches National Park	DOI-NPS	65,098	UT	32
	Bridger Wilderness Area	USDA-USFS	428,169	WY	30
	Bryce Canyon National Park	DOI-NPS	35,832	UT	47
	Canyonlands National Park	DOI-NPS	337,570	UT	0
	Capitol Reef National Park	DOI-NPS	221,896	UT	0
	Flat Tops Wilderness Area	USDA-USFS	235,230	CO	27
	Fitzpatrick Wilderness Area	USDA-USFS	198,525	WY	48
	Maroon Bells-Snowmass Wilderness Area	USDA-USFS	71,060	CO	45
Colorado Class I SO_2 Increment Areas[c]	Colorado National Monument	DOI-NPS	20,500	CO	34
	Dinosaur National Monument	DOI-NPS	210,000	CO/UT	7

[a] DOI = U.S. Department of the Interior; NPS = National Park Service; USDA = U.S. Department of Agriculture; USFS = U.S. Forest Service.

[b] Shortest distance between the potential lease area and the sensitive area.

[c] Federal Class II area under the CAA, but it has been designated a State of Colorado Class I SO_2 Increment Area.

cation/anion concentrations, etc.) (ISWS 2006). Sampling sites around the study area include Sand Spring, Ripple Creek Pass, Sunlight Peak, and Four Mile Park in Colorado; Green River and Canyonlands National Park in Utah; and Pinedale in Wyoming. In addition, the USGS also measures individual lake chemistry throughout the study area.

3.6 EXISTING ACOUSTIC ENVIRONMENT (NOISE)

Any variation of air pressure detectable by the human ear can be defined as sound. Noise is defined as "unwanted sound." Sound pressure levels are measured in units of decibels (dB).[11] The perceived pitch of a sound, a physiological property characterized by the highness or lowness of the sound, is determined by its frequency; the normal audible range for a healthy young person is approximately 20 to 20,000 Hz.

[11] The decibel scale is logarithmic. Scales for measuring most familiar quantities such as length, distance, and temperature are linear. Logarithmic scales compress the values of the measurements and are useful for measuring quantities like sound levels that can vary over a large range. For example, two linear measurements of 100 units and 1,000,000,000 units might correspond to values of 1 and 9, respectively, on a logarithmic scale. Logarithmic units also add differently than do linear units. For example, if one object is 6 ft long and a second is twice as long, the second object is 12 ft long. For sounds, however, if one sound level is 50 dB and a second is twice as loud, the second sound level will be 60 dB, not 100 (50 + 50) dB.

Various scales are used to measure sound. In considering noise, only sounds in the range of human hearing are of interest. The A-weighted scale, denoted by dBA, approximates the range of human hearing and correlates well with subjective reactions to noise, thereby deemphasizing the very low and very high components of a sound. Most noise standards, guidelines, and ordinances use the A-weighted scale.

Background noise is the noise from all sources other than the source of interest. The background noise level can vary considerably depending on the location. Background noise levels in a noisy urban setting can be as high as 75 dBA during the day. In isolated outdoor locations with no wind, vegetation, animals, or running water, background noise may be under 10 dBA. Typical noise levels in rural settings are about 40 dBA during the day and 30 dBA during the night; in wilderness areas, they are on the order of 20 dBA (Harris 1991). Noise levels in areas of low population density would be under 35 dBA as day-night average sound level (L_{dn}) (Miller 2002).

While no information is available defining existing noise levels on BLM-administered land in areas of oil shale or tar sands resources, these areas are largely undeveloped, sparsely populated, and remote, and would be expected to have background noise levels of about 35 dBA or less as L_{dn}. In addition to natural background, noise sources could include agricultural activities, oil and gas development, low-density traffic on rural roads, recreational activities, and aircraft overflights. The identification of specific noise sources, noise levels, and sensitive receptors, such as residences, schools, and hospitals, requires site-specific analyses.

3.7 ECOLOGICAL RESOURCES

This section presents information on ecological resources in potential oil shale and tar sands study areas. To the extent possible, descriptions are provided for specific study areas (oil shale basins and STSAs) on the basis of known resource distributions. In some cases, resource status and distributions are less well known and county-level or regional information is used. Descriptions are provided for aquatic resources (Section 3.7.1); plant communities and habitats (Section 3.7.2); wildlife (Section 3.7.3); and threatened, endangered, and sensitive species (Section 3.7.4).

3.7.1 Aquatic Resources

Aquatic habitats include perennial and intermittent streams, springs, and flatwater (lakes and reservoirs) that support fish or other aquatic organisms through at least a portion of the year. The oil shale and tar sands study areas considered within this PEIS fall within the Upper Colorado River Basin hydrographic area, as identified in Section 3.4. Aquatic habitats of the Upper Colorado River Basin in Colorado, Utah, and Wyoming include more than 300,000 acres of natural lakes and impoundments and more than 10,000 miles of perennial streams; of these, approximately 36,000 acres of reservoir habitat (Flaming Gorge Reservoir) and about 650 miles of perennial stream habitat occur within the geologically prospective portions of the oil shale and tar sands study area.

The condition of aquatic habitats is related to hydrologic conditions of associated upland and riparian areas that contribute to a specific stream or water body, and to stream channel characteristics. Aquatic habitat quality typically varies by location and orientation to geographic landforms and vegetation. Riparian vegetation moderates water temperatures, adds structure to the banks to reduce erosion, provides instream habitat for fish and other aquatic organisms, and provides organic material for aquatic macroinvertebrates. Vegetated floodplains dissipate stream energy, store water for later release, provide areas of infiltration for groundwater, and provide rearing areas for juveniles of some fish species when flooded during some periods of the year. The ranges of water temperature, turbidity, and dissolved oxygen within aquatic habitats largely define the areas that are suitable for use by different aquatic organisms. On the basis of these characteristics, aquatic communities within the potentially affected areas are broadly categorized as coldwater or warmwater, although there is actually a continuum of conditions.

Coldwater communities in the study areas typically include fish species in the family Salmonidae, such as mountain whitefish or trout. Conditions that support such species are usually found in ponds, lakes, or reservoirs at higher elevations and in the headwaters of selected rivers and streams that provide cool, clear waters with relatively high dissolved oxygen levels. Because hypolimnetic releases from dams on some large, deep reservoirs can introduce cold, clear waters into some rivers, coldwater assemblages may also become established in sections of warmwater rivers located immediately downstream of dams (i.e., tailwaters). In contrast, warmwater assemblages typically occur at lower elevations, where waters tend to be warmer and more turbid. Warmwater fish communities within the study areas normally include species such as minnows (family Cyprinidae), suckers (family Catostomidae), sunfishes (family Centrarchidae), and catfishes (family Ictaluridae).

Historically, only 12 species of fish were native to the Upper Colorado River Basin (Table 3.7.1-1), including 5 minnow species, 4 sucker species, 2 salmonids, and the mottled sculpin (Tyus et al. 1982). Four of these native species (humpback chub, bonytail, Colorado pikeminnow, and razorback sucker) are now federally listed as endangered, and critical habitat for these species has been designated within the Upper Colorado River Basin (Section 3.7.4). The roundtail chub, bluehead sucker, and flannelmouth sucker are native fishes that reside in large, slow-moving rivers as well as some of the smaller tributary streams within the oil shale and tar sands areas considered within this PEIS. Although these species are not federally listed as threatened or endangered, their populations have declined in recent years. These declines have been attributed, in part, to effects of water development and the introduction of non-native fishes (Bezzerides and Bestgen 2002). Because of the declining numbers and limited distribution, these species are considered species of special concern within the states of Colorado, Utah, and Wyoming, and are considered sensitive species by BLM. These three species are managed within Utah, Wyoming, and Colorado under interagency conservation agreements that include specific conservation measures (Utah Department of Natural Resources 2006a,b).

Another native fish species, the mountain sucker, is listed as a sensitive species by BLM in Colorado but not in Utah or Wyoming. This species is also listed as a species of special concern by the state of Colorado. However, it is not listed as a sensitive species by the states of Utah and Wyoming, where the populations appear to be stable (Belica and Nibbelink 2006). This species occurs in a wide range of aquatic habitats, including large rivers, lower elevation creeks,

TABLE 3.7.1-1 Fishes of the Upper Colorado River Basin

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cyprinidae (Carps and Minnows)			
Grass carp	*Ctenopharyngodon idella*	Introduced	Incidental in the Colorado River and in the lower Green River. Normally occurs in warm, large rivers with moderate diversity of habitats. May also be present in some warmwater impoundments within the Upper Colorado River Basin.
Red shiner	*Cyprinella lutrensis*	Introduced	Widespread, common to abundant. Its principal distribution is in middle and lower sections of larger rivers having warm and usually turbid water. It inhabits perennial or ephemeral riverine habitats and is tolerant of environmental extremes.
Common carp	*Cyprinus carpio*[b]	Introduced	Widespread, common to abundant. It is locally abundant in warmwater impoundments, slack-water riverine habitats, and seasonally flooded habitats. It prefers sheltered habitats with an abundance of aquatic vegetation in warmwater lakes, reservoirs, and rivers.
Utah chub	*Gila atraria*	Introduced	Incidental to rare in the Colorado River, Green River downstream of Flaming Gorge Dam, the lower Yampa River, Duchesne River drainage, and the Price River. It is abundant in Flaming Gorge Reservoir. It prefers littoral and pelagic zones of reservoirs and is generally not found in larger rivers.
Humpback chub	*Gila cypha*	Native	Federally listed as endangered (see Section 3.7.4). Population concentrations are located in Black Rocks and Westwater Canyon in the Colorado River, Desolation and Gray Canyons of the Green River, and Yampa Canyon in the Yampa River. The fish is incidental in the Green River in Whirlpool and Split Mountain Canyons, in the Yampa River in Cross Mountain Canyon; in the lower Little Snake River, and in the lower Gunnison River. It is highly adapted to life in canyon environments. Adult habitat includes deep pools and shoreline eddies; young occupy warm, quiet habitats such as backwaters and eddies.
Bonytail	*Gila elegans*	Native	Federally listed as endangered (see Section 3.7.4). It is considered to have been extirpated from the Green and Colorado River systems but may persist in extremely low numbers in the main stem. Stocking programs are currently in place to reintroduce this species. It is considered adapted to main-stem rivers, where it has been observed in pools and eddies.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cyprinidae (Carps and Minnows) (Cont.)			
Roundtail chub	*Gila robusta*	Native	Widespread in the Green and Colorado River systems, found in streams and rivers with warmer water. It is generally rare in the middle and extreme lower Green and Colorado Rivers; rare to common elsewhere. Adult habitat includes riffles, runs, pools, eddies, and backwaters with silt-cobble substrate and adjacent to higher-velocity areas. Young occupy low-velocity shoreline habitats.
Sand shiner	*Notropis stramineus*	Introduced	Common to abundant in the middle and lower sections of the Colorado and Green Rivers and the warmwater reaches of other tributaries. It prefers small- to large-sized streams and rivers with permanent flow, seasonally warm water, slow to moderate water velocities, and clear to turbid water.
Fathead minnow	*Pimephales promelas*[b]	Introduced	Widespread, common to abundant in middle and lower sections of larger rivers having warm and usually turbid water. It inhabits a variety of habitats in ponds, lakes, reservoirs, streams, and rivers.
Colorado pikeminnow	*Ptychocheilus lucius*	Native	Federally listed as endangered (see Section 3.7.4). Although rare, it is widely distributed in warmwater reaches of the Colorado and Green Rivers and lower sections of larger tributaries. Adult habitat includes deep, low-velocity runs, pools, and eddies or seasonally flooded lowlands. Young occupy low-velocity, shallow, shoreline habitats.
Speckled dace[b]	*Rhinichthys osculu*[b]	Native	Widespread, common to abundant. It occupies permanent or intermittent cool- or warmwater streams and rivers and small to large lakes. In streams and rivers, adults are generally found in shallow runs and riffles with rocky substrates. Young occupy low-velocity shoreline or seasonally flooded habitats.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Catostomidae (Suckers)			
Redside shiner	*Richardsonius balteatus*[b]	Introduced	Rare to common in the Yampa River and upper sections of the Green and Duchesne Rivers. It prefers cool water and is found in a variety of habitats. In streams, it may occur in slow to swift, clear to turbid water and over cobble, gravel, sand, clay, or mud substrates; it is frequently found associated with vegetation.
Creek chub	*Semotilus atromaculatus*	Introduced	Incidental to rare with a very sporadic distribution in the Upper Colorado River Basin. It prefers small streams with clear, cool water, moderate to high gradients, gravel substrate, and well-defined riffles and pools with abundant cover.
Longnose sucker	*Catostomus catostomus*	Introduced	Locally common in the upper portions of the Gunnison River and cool, clear tributaries of the upper Colorado River drainage. It is found in both lakes and streams.
White sucker	*Catostomus commersoni*	Introduced	Rare to common in reaches of the Yampa River and in upper and middle sections of the Green River; abundant in Flaming Gorge Reservoir; common to abundant in the Gunnison River. It is a habitat generalist found in lakes, reservoirs, streams, and rivers. In streams and rivers, it prefers deep riffles, pools, and shallow runs over gravel or cobble substrates.
Bluehead sucker	*Catostomus discobolus*	Native	Widespread, rare to common. It is found in a variety of habitats, ranging from cool, clear streams to warm, turbid rivers. Adults prefer deep riffles or shallow runs over rocky substrates. Young occupy low-velocity shoreline or seasonally flooded habitats.
Flannelmouth sucker	*Catostomus latipinnis*	Native	Widespread, rare to common. It is found in warmwater reaches of larger river channels. Adults typically occupy pools and deeper runs, eddies, and shorelines. Young occupy low-velocity shoreline or seasonally flooded habitats.
Mountain sucker	*Catostomus platyrhynchus*	Native	Common in the upper Green River drainage in Wyoming; incidental to rare in the Green River of Utah upstream of the Yampa River confluence and in headwaters of the Yampa and White Rivers; common in tributaries of the Duchesne, Price, and San Rafael Rivers in Utah; locally abundant in Piceance Creek in Colorado. It prefers cool, clear streams with rocky substrates.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Catostomidae (Suckers) (Cont.)			
Razorback sucker	*Xyrauchen texanus*	Native	Federally listed as endangered (see Section 3.7.4). It is found in warmwater reaches of the Green and Colorado Rivers and lower portions of major tributaries; it primarily occurs in flat-water sections of the middle Green River between the Duchesne and Yampa Rivers and between Palisade and Loma in the Colorado River. Adult habitat includes runs, pools, eddies, and seasonally flooded lowlands. Young presumably require nursery habitat with quiet, warm, shallow water such as tributary mouths, backwaters, and especially floodplain wetlands.
Ictaluridae (Bullheads and Catfishes)			
Black bullhead	*Ameiurus melas*[b]	Introduced	Sporadic distribution in middle and lower sections of the Green, Yampa, Duchesne, and White Rivers. It is incidental to rare in main-channel habitats and common to abundant in inundated floodplain habitat adjacent to the middle Green River. It is found in turbid backwaters, seasonally flooded habitats, impoundments, and low-gradient river reaches with muddy bottoms.
Channel catfish	*Ictalurus punctatus*[b]	Introduced	Widespread, common to abundant in middle and lower sections of larger rivers. Its optimum riverine habitat has warm water and a diversity of velocities, depths, and structural features that provide cover and feeding areas. In the Green and Yampa Rivers, it is most abundant in rocky, turbulent, high-gradient canyon habitats.
Esocidae (Pikes)			
Northern pike	*Esox lucius*	Introduced	Occurs in several rivers and impoundments but is infrequently collected, except in reaches of the Yampa River and middle Green River, where it is often caught during spring sampling for adult Colorado pikeminnow and razorback suckers. It primarily inhabits vegetated ponds, marshes, and larger lakes; deep pools, eddies, mouths of tributaries; and seasonally flooded habitats of larger rivers.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Salmonidae (Trouts)			
Cutthroat trout[c]	*Oncorhynchus clarki*[c]	Native and introduced[c]	Rare to common in certain upstream river reaches (e.g., Green River downstream of Flaming Gorge Dam; stocked in tailwaters) or impoundments. It prefers cold, clear headwater streams. Native Colorado River cutthroat trout are present mostly as remnant populations in isolated high-elevation tributaries and are managed under interagency conservation agreements among state, Tribal, and federal agencies (CRCT Conservation Team 2006).
Rainbow trout	*Oncorhynchus mykiss*	Introduced	Common to abundant in the Green River upstream of the Yampa River confluence (stocked in Flaming Gorge Reservoir and tailwaters), incidental to rare downstream, and common to abundant in upper sections of the Yampa, Duchesne, and White River drainages. It prefers pools, eddies, runs, and riffles in streams with gravel or cobble substrates.
Kokanee (landlocked form of Sockeye salmon)	*Oncorhynchus nerka*	Introduced	Common in Fontenelle and Flaming Gorge Reservoirs on the Green River and the Aspinall Reservoirs on the Gunnison River; rare in tailwaters, where it is a probable escapee from the reservoirs. It prefers pelagic zones of reservoirs.
Mountain whitefish	*Prosopium williamsoni*	Native	Incidental to rare in the Green River upstream of the Yampa River confluence and in lower sections of the Yampa and White Rivers; common in upper sections of the Yampa, White, and Duchesne Rivers. It prefers streams and rivers with cool, swift water and gravel or rubble substrates.
Brown trout	*Salmo trutta*	Introduced	Common in cool- and cold-water reaches of the Colorado River, rare to common in the Green River upstream of the Yampa River confluence and in upper sections of the Duchesne River drainage, and rare in the Yampa and White Rivers. It prefers deep pools, riffles, and runs with sand or cobble substrates and moderate to fast current.
Brook trout	*Salvelinus fontinalis*	Introduced	Rare to common in the Green River upstream of the Yampa River confluence (stocked in Flaming Gorge Dam tailwaters) and in Soldier Creek and Strawberry Reservoirs; found in headwater areas of tributaries. It prefers clear headwater streams with gravel substrate.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Salmonidae (Trouts) (Cont.)			
Lake trout	*Salvelinus namaycush*	Introduced	Present in Flaming Gorge and Fontenelle Reservoirs on the Green River and in Blue Mesa Reservoir on the Gunnison River. Prefers cold, deep waters of large lakes and reservoirs.
Gadidae (Cods)			
Burbot	*Lota lota*	Introduced	Relatively new introduction and abundance status is unclear. Present in the Green River, including Flaming Gorge and Fontenelle Reservoirs. The burbot prefers cold waters in streams and lakes and impoundments and usually occurs near the bottom.
Cyprinodontidae (Killifishes)			
Plains killifish	*Fundulus kansae*	Introduced	Locally common in some warmwater ponds and in some river backwaters in the Colorado River subbasin.
Poeciliidae (Livebearers)			
Western mosquitofish	*Gambusia affinis*	Introduced	Locally common in some warmwater ponds and in some river backwaters in the Colorado River subbasin; incidental to rare, very sporadic distribution in the Green River subbasin. It prefers warm, slack-water areas.
Gasterosteidae (Sticklebacks)			
Brook stickleback	*Culaea inconstans*	Introduced	Incidental in the upper Yampa River drainages and in the middle Green River between Jensen and Ouray, Utah (almost exclusively in floodplain habitat). It prefers clear, cool, densely vegetated waters of slow-flowing small streams or ponds.
Cottidae (Sculpins)			
Mottled sculpin	*Cottus bairdi*	Native	Rare to common in the portions of the Colorado and Green Rivers, and in the Gunnison, Yampa, Duchesne, Price, and San Rafael Rivers. It prefers cool-water riffles and deep runs with rocky substrates in streams and rivers.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cottidae (Sculpins) (Cont.)			
Bear Lake sculpin	*Cottus extensus*	Introduced	Naturally endemic to Bear Lake, on the Utah-Idaho border. It has been introduced and become established in Flaming Gorge Reservoir. It is listed as a sensitive species by the Utah Division of Wildlife Resources. It prefers bottom lake habitat and spawns among rocks close to the shoreline.
Centrarchidae (Sunfishes)			
Green sunfish	*Lepomis cyanellus*	Introduced	Common to abundant in some warmwater lakes and ponds. Generally rare in the middle Green and lower Yampa, Duchesne, and White Rivers; locally common in the Green River near the confluences of the Duchesne and White Rivers and in adjacent inundated floodplain habitat; locally common to abundant in some areas of the Gunnison and Colorado Rivers. It prefers backwater areas of warmwater streams or weed beds in warmwater lakes and reservoirs.
Bluegill	*Lepomis macrochirus*	Introduced	Incidental in riverine habitats, but locally common in some warmwater ponds and reservoirs. It prefers shallow, warm lakes and ponds or slow-moving areas of clear streams with abundant aquatic vegetation.
Smallmouth bass	*Micropterus dolomieui*	Introduced	Present in some cool and warmwater lakes, ponds, and reservoirs. Common along rocky shorelines in Flaming Gorge Reservoir. Generally rare along the Green River in Utah but locally common in areas near the confluences of the Duchesne and White Rivers; locally common in some areas of the middle and lower Yampa River. It prefers clear, wide, fast-flowing runs and flowing pools with gravel or rubble substrates.
Largemouth bass	*Micropterus salmoides*	Introduced	Present in some warmwater lakes and ponds and in the Colorado and Gunnison Rivers. Locally common in the lower Yampa River and in the Green River downstream of the Yampa River confluence; rare in Flaming Gorge Reservoir. It prefers clear, quiet waters in rivers with aquatic vegetation or vegetated littoral zones in lakes and reservoirs.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Centrarchidae (Sunfishes) (Cont.)			
Black crappie	*Pomoxis nigromaculatus*	Introduced	Present in some warmwater lakes and ponds; incidental in lower portions of the Colorado River and in the Green River near the confluences of the Duchesne and White Rivers. It inhabits clear, warm, quiet waters of ponds, lakes, and backwaters of larger rivers; it is generally found where there is abundant aquatic vegetation.
Percidae (Perches)			
Walleye	*Sander vitreus*[d]	Introduced	Incidental to rare in the Duchesne River, incidental in the Yampa and middle Green Rivers, and incidental in the lower Colorado River. It prefers large streams, rivers, and lakes with moderately deep, clear water, often found in slow, shallow runs, usually associated with emergent or bank vegetation.

[a] Abundant = occurring in large numbers and consistently collected in a designated area; common = occurring in moderate numbers and frequently collected in a designated area; rare = occurring in low numbers, either in a restricted area or having a sporadic distribution over a larger area; incidental = occurring in very low numbers and known from only a few collections.

[b] The Kendall Warm Springs dace (*Rhinichthys osculus thermalis*) is a federally listed endangered subspecies restricted to Kendall Warm Springs in the upper Green River drainage, Wyoming (see Section 3.7.4).

[c] Includes native Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*), non-native Snake River Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*), and non-native Bear Lake Bonneville cutthroat trout (*Oncorhynchus clarki utah*).

[d] Scientific name changed from *Stizostedion vitreum* (Nelson et al. 2004).

Sources: Behnke et al. (1982); Tyus et al. (1982); Miller and Hubert (1990); Muth and Nesler (1993); Muth et al. (2000); Lentsch et al. (1996); Modde and Haines (1996); McAda (2003); Woodling (1985); Tyrus and Saunders (1996).

and montane lakes and streams. Mountain sucker are common within the Green River drainage of Wyoming's Green River and Wakshakie Oil Shale Basins (Belica and Nibbelink 2006). In Utah, the mountain sucker is common in the Duchesne River drainage, but less commonly found elsewhere in the main-stem Green or Colorado River drainages of Uinta Oil Shale Basin (Belica and Nibbelink 2006). The mountain sucker is also found in Yampa, Green, White, and Colorado River drainages and is locally abundant in Piceance Creek in Colorado's Piceance oil shale (Belica and Nibbelink 2006).

In addition to native fish species, more than 25 non-native fish species are present in the basin (Table 3.7.1-1), often as a result of intentional introductions (e.g., for establishment of sport fisheries) (Tyus and Saunders 1996). While most of the trout species found within the Upper Colorado River Basin are introduced non-natives (e.g., rainbow, brown, and some strains of cutthroat trout), mountain whitefish and Colorado River cutthroat trout are native to the basin.

Although it was once common within the upper Green River and upper Colorado River watersheds, the Colorado River cutthroat trout is now found only in isolated subdrainages in Colorado, Utah, and Wyoming (Behnke 1992; Hirsch et al. 2006). The Colorado River cutthroat trout has been designated as a species of special concern by the states of Colorado and Wyoming and has been designated as a Tier I species in Utah. Regions 2 and 4 of the U.S. Forest Service and the BLM in Colorado, Utah, and Wyoming all classify the Colorado River cutthroat trout as a sensitive species. A conservation agreement for cutthroat trout in the states of Colorado, Utah, and Wyoming has been developed and agreed to by state fish and wildlife agencies, the Ute Indian Tribe, and by various federal agencies, including the BLM Colorado, Utah, and Wyoming State Offices (CRCT Conservation Team 2006). That conservation agreement identifies conservation objectives and conservation actions for this species (CRCT Conservation Team 2006).

The following subsections provide additional detail about aquatic resources within the vicinity of each of the oil shale basins and STSAs.

3.7.1.1 Oil Shale Basins

The principal hydrologic subbasins that could potentially receive waters from the four oil shale basins are the Great Divide-Upper Green River subbasin, the White-Yampa River subbasin, the Colorado Headwaters subbasin, and the Lower Green River subbasin. The major rivers draining these subbasins include the Green River, the White River, the Yampa River, and the Colorado River. The only major reservoir that falls within the potentially affected areas is Flaming Gorge Reservoir. In addition, several smaller rivers and streams, as well as a number of small natural lakes and impoundments, occur within the potentially affected areas.

3.7.1.1.1 Green River Oil Shale Basin. Riverine habitats within the Green River Oil Shale Basin are associated with portions of the main stem of the Green River in Wyoming, between Fontenelle Reservoir and Flaming Gorge Reservoir, and with various perennial and intermittent tributaries to the upper Green River. In total, there are approximately 205 mi of perennial stream habitat located within the geologically prospective portion of the Green River Oil Shale Basin. The upstream half of Flaming Gorge Reservoir (approximately 36,000 acres) and a number of small reservoirs, lakes, and ponds also fall within the potentially affected area. The oil shale areas are located at least 0.5 mi from Fontenelle Reservoir.

A significant trout fishery exists in the portion of the main stem of the Green River within this region; the fishery includes target species such as rainbow, brown, brook, and cutthroat trout. The Wyoming Game and Fish Department (WGFD) manages the fishery through the use of various regulations, including creel limits, size limits, and tackle restrictions. On the basis of surveys conducted in April 2005, the main stem of the Green River in the vicinity of Seedskadee National Wildlife Refuge was estimated to have high densities of catchable-sized trout (more than 190 trout per mile of river) (WGFD 2006).

The fish community in Flaming Gorge Reservoir consists primarily of introduced species, including lake trout, brown trout, rainbow trout, cutthroat trout, kokanee, white sucker, smallmouth bass, channel catfish, common carp, Utah chub, redside shiner, and the Bear Lake sculpin. It also supports small numbers of native fish species, including flannelmouth sucker, mountain whitefish, and the mottled sculpin (BOR 2005).

Rainbow trout have been annually stocked in Flaming Gorge Reservoir since it was filled, and this species provides the bulk of the angler harvest. Kokanee were stocked during the mid-1960s and have developed naturally reproducing fisheries. After rainbow trout, kokanee are typically second in harvest and popularity with anglers. Other sport fish occasionally stocked in the reservoir include brown trout and channel catfish. Lake trout entered Flaming Gorge Reservoir from the upper Green River drainage and have also become established as a wild population. Smallmouth bass were introduced into Flaming Gorge Reservoir in the 1960s to promote growth of rainbow trout by reducing the Utah chub population (Teuscher and Luecke 1996), and now occur in rocky shoreline habitat throughout Flaming Gorge Reservoir (BOR 2005).

Burbot (also called ling), a member of the cod family, were illegally introduced into the Green River in 2005 and have now become established in Flaming Gorge and Fontenelle Reservoirs as well as the connecting portion of the Green River and some tributaries (WGFD 2006). These fish are aggressive predators that feed on other fish and invertebrates, and there are concerns that this species could negatively affect both game and nongame fish populations in the upper Green River subbasin.

As indicated in Section 3.7.1, bluehead sucker, flannelmouth sucker, and roundtail chub are considered species of special concern within the state of Wyoming, and are considered sensitive species by BLM. All three of these species occur within the geologically prospective oil shale areas within the Green River Oil Shale Basin. Bluehead sucker occur in the Big and Little Sandy Rivers, the main-stem Green River, and the Blacks Fork River; they also occur in the Ringdahl Reservoir, located in the Henrys Fork drainage (WGFD 2008). Flannelmouth sucker are known to occur in the Big and Little Sandy Rivers, the main-stem Green River, Bitter Creek, the Blacks Fork, Hams Fork, Smiths Fork, Muddy Creek (tributary to Blacks Fork), and Henrys Fork drainages (WGFD 2008). At present, the only known population of flannelmouth sucker in

Wyoming that occurs separate from white sucker is found in the upper Bitter Creek drainage (WGFD 2008). Roundtail chub are known to occur in the Blacks Fork drainage, including the Hams Fork and Muddy Creek (WGFD 2008).

None of the four endangered Upper Colorado River fish species occur in the Flaming Gorge Reservoir or in the upstream portions of the Green River subbasin. Historically, the Colorado pikeminnow probably occurred in the upper Green River as far as Green River, Wyoming, and records indicate that the humpback chub and the bonytail were present upstream of the current location of Flaming Gorge Dam (Muth et al. 2000). Historic occurrence of the razorback sucker upstream of the location of Flaming Gorge Dam is less likely (Muth et al. 2000).

3.7.1.1.2 Washakie Oil Shale Basin. Two perennial streams (totaling less than 17 mi of stream habitat) pass through the portion of the Washakie Oil Shale Basin where extraction from the oil shale deposits is considered feasible. Approximately 7 mi of Vermillion Creek and 10 mi of Alkali Creek pass through the area. No significant fisheries are known to occur within these portions of these streams, although trout habitat exists in portions of the North Fork of the Vermillion River, located upstream of the prospective oil shale extraction areas. Historically, approximately 56 mi (0.3%) of the Vermillion Creek watershed were occupied by Colorado River cutthroat trout, although none of the historically occupied habitat currently contains Colorado River cutthroat trout (Hirsch et al. 2006).

Another perennial stream, Bitter Creek, is located within 0.25 mi of the potentially affected area. This stream drainage did not historically support Colorado River cutthroat trout (Hirsch et al. 2006), but does support a warmwater native fish assemblage identified by the WGFD as having a high conservation potential (WGFD 2006). Native species in this stream include flannelmouth sucker, speckled dace, and mountain sucker.

3.7.1.1.3 Uinta Oil Shale Basin. Aquatic habitats within the Uinta Oil Shale Basin are primarily associated with the Green River watershed, although some small perennial and intermittent tributaries of the upper Colorado River subbasin are present in the southeastern portion of the oil shale basin. In total, approximately 193 mi of perennial stream habitat falls within the geologically prospective area of the Uinta Oil Shale Basin. The portion of the Uinta Oil Shale Basin from which extraction is considered feasible neighbors approximately 70 mi of the middle Green River downstream from Ouray, Utah. In addition, a substantial portion of the lower White River, a significant tributary to the middle Green River, falls within the potentially affected area. Several reservoirs, ponds, and small lakes also fall within the Uinta Oil Shale Basin.

The portions of the Green River and the White River within and adjacent to the Uinta Oil Shale Basin are predominantly inhabited by warmwater native and non-native fishes (Lentsch et al. 2000; Muth et al. 2000). The predominant fish species likely to be present within adjacent portions of these two rivers and associated tributaries belong to families Cyprinidae (minnows), Catosomidae (suckers), Cottidae (sculpins), Centrachidae (sunfishes), and Ictaluridae (catfishes). This section of the Green River is a concentration area for federally endangered Colorado pikeminnow and razorback sucker; bonytail and humpback chub could also occur in this area (Section 3.7.4), although less commonly (Muth et al. 2000). Colorado pikeminnow have also been reported from the White River within this oil shale basin (Lentsch et al. 2000).

Bitter Creek and Evacuation Creek are intermittent through or adjacent to the study area and do not continually support populations of fish. Speckled dace and mountain sucker could be found within that portion of Bitter Creek flowing through the study area during high flow periods, although the stream frequently dries up during hot, dry summers. No fish species are known to use the streams or ponds emanating from springs or flowing wells in the Asphalt Wash drainage (BLM 2006f).

Pariette Draw, a tributary to the Green River in the northwestern portion of the study area, is used to supply water to the Pariette Wetlands. These wetlands, which are managed primarily for waterfowl, contain a number of small warmwater ponds.

3.7.1.1.4 Piceance Basin. As identified in Section 3.4, the Piceance Oil Shale Basin is drained by three major river systems: (1) the White River basin to the north, (2) the Colorado River basin through the central portion, and (3) the Gunnison River basin to the south. However, the Gunnison River subbasin does not fall within the portion of the Piceance Basin that is considered feasible for extraction of oil shale resources. In total, approximately 128 mi of perennial stream habitat occur within this oil shale basin.

Although the White River itself does not fall within the study area, two principal tributaries to the upper White River, Yellow Creek and Piceance Creek, are within the study area, along with several of their tributaries (Corral Gulch, Ryan Gulch, Black Sulphur Creek, Hunter Creek, and Willow Creek). Some portions of these smaller tributaries go dry during some seasons of the year and do not sustain fish for portions of the year. Two small tributaries to Parachute Creek (East and West Forks of Parachute Creek) are located within or adjacent to the study area. Parachute Creek itself is a tributary to the upper Colorado River. Because the conditions in these streams represent a transition between cold- and warmwater stream segments, fish species include trout, as well as some species of suckers and minnows. Piceance Creek supports populations of sensitive native fish, including flannelmouth sucker, mountain sucker (Belica and Nibbelink 2006), and speckled dace. Trout that appear occasionally in collections are probably stocked fish that have escaped from privately owned upstream ponds (BLM 2006e).

Although no endangered fish occur within the study area, Colorado pikeminnow occupy the lower White River downstream of Taylor Draw dam, located approximately 25 mi west of the study area (Martinez et al. 1994). The White River and its 100-year floodplain below Rio Blanco Lake have been designated as critical habitat for the Colorado pikeminnow. Martinez et al. (1994) reported that the Colorado pikeminnow has been extirpated upstream of Taylor Draw Dam. Additional information about the Colorado River Basin endangered fish species is presented in Section 3.7.4.

The upstream portion of Black Sulphur Creek within the study area supports a self-sustaining population of Colorado River cutthroat trout, although there is evidence of hybridization with rainbow trout. Because it is a relatively remote location with barriers to movement from downstream locations (i.e., physical barriers and water diversions), this stream has been identified as having potential as a reintroduction location for genetically pure strains of Colorado River cutthroat trout.

Angling opportunities within the vicinity of the Piceance Oil Shale Basin are provided by some of the perennial streams and by several nearby reservoirs that are located outside of the oil shale study area. Portions of the Yampa River currently provide smallmouth bass and northern pike angling opportunities, although the presence of these nonnative species is considered detrimental to efforts to recover Colorado River Basin endangered fish within the reaches of the Yampa River that are designated as critical habitat. Kenney Reservoir, located approximately 25 mi from the oil shale basin study area, provides angling opportunities for black crappie and other warmwater species. Rifle Gap Reservoir and Harvey Gap Reservoir, located east of the study area, provide angling opportunities for northern pike, walleye, yellow perch, and trout. Parachute Creek, located southwest of the oil shale study area, provides angling opportunities for trout.

At least five species of native freshwater mussel (fingernail and pill clams, family Sphaeriidae) inhabit streams and rivers in portions of Rio Blanco and Garfield Counties where oil shale development could occur (Wu and Brandauer 1978). Little is known about the historic distribution of this group of small clams, and the current status of these mussels in Colorado is unknown (Sovell and Guralnick 2004; Nelson and Guralnick 2007). However, some closely related species in other areas of North America have experienced significant declines in population in the past few decades (Wilson et al. 1995). Native mussel species have been collected in the both the White River and Piceance Creek in the vicinity of the Piceance Oil Shale Basin (Sovell and Guralnick 2004; Nelson and Guralnick 2007).

3.7.1.2 Special Tar Sand Areas

The Asphalt Ridge, Raven Ridge, Pariette, Hill Creek, and P.R Spring STSAs are all within areas that eventually drain to the Green River. Warmwater aquatic communities, similar to those described previously for the Uinta Oil Shale Basin occur within these areas. Many of the drainages within these areas are intermittent. However, the Asphalt Ridge area is adjacent to the Green River itself. Other perennial tributaries of the Green River within these STSAs include Ashley Creek, Cliff Creek, and Pariette Draw. While no endangered fishes would be expected to occur directly within these STSAs, they could occur in nearby areas of the Green River (Section 3.7.4). In total, approximately 107 mi of perennial stream habitat occur within the STSAs.

The Sunnyside STSA is drained by portions of Dry Creek, Cottonwood Canyon, and Nine Mile Creek, which eventually drain to the Green River via Nine Mile Creek. No significant fisheries are known to occur within these areas, although warmwater fish communities would be expected to be present in these drainages. In addition, an intermittent drainage, Range Creek, occurs within this area. Range Creek provides habitat for small populations of brown and cutthroat trout.

The Argyle Canyon STSA is within the vicinity of a single drainage, the South Fork of Avintaquin Creek. This creek, which is a tributary of the Strawberry River, may support trout, although information is limited. Hirsch et al. (2006) identify this creek as having poor habitat for Colorado River cutthroat trout.

In addition to being drained by a number of intermittent drainages, the San Rafael STSA surrounds a portion of the San Rafael River. Fish in the San Rafael River, which is a tributary to the lower Green River, include a high proportion of warmwater native fishes (approximately 70%), including bluehead sucker, flannelmouth sucker, roundtail chub, speckled dace, and Colorado pikeminnow (Tyus and Saunders 2001). The San Rafael River is also used by endangered fishes. Colorado pikeminnow have been captured in the lower 35 mi of the San Rafael River, and small numbers of razorback suckers occur in the Green River near the mouth of the San Rafael River (Muth et al. 2000; Tyus and Saunders 2001).

The Tar Sand Triangle STSA is drained by Big Water and Horse Canyons to the northeast and by French Spring Fork, Happy Canyon, and the Dirty Devil River to the northwest and west. Big Water and Horse Canyons are perennial tributaries to the Colorado River; French Spring Fork and Happy Canyon are ephemeral or intermittent drainages that enter the Dirty Devil River. The Dirty Devil River itself is a perennial stream that drains into the northern end of Lake Powell and supports a warmwater fish community. The Dirty Devil arm of Lake Powell is included in designated critical habitat for the razorback sucker (59 FR 13374), and small numbers of razorback suckers have been found in Lake Powell near the mouth of the Dirty Devil River (Section 3.7.4).

The Circle Cliffs and White Canyon STSAs both are also drained by intermittent or ephemeral tributaries that eventually drain to Lake Powell. Because these areas do not contain perennial flows, the presence of aquatic communities is likely limited. However, portions of the tributaries draining the Circle Cliffs and White Canyon areas may contain warmwater fish assemblages.

3.7.2 Plant Communities and Habitats

3.7.2.1 Piceance Basin

The Piceance Basin lies within the Colorado Plateau ecoregion. An ecoregion is an area in which ecosystems have a general similarity; an ecoregion is characterized by the spatial pattern and composition of biotic and abiotic features. Colorado ecoregions are described by Chapman et al. (2006) and are shown in Figure 3.7.2-1. The Colorado Plateau ecoregion is characterized by a rugged tableland of mesas, plateaus, mountains, and canyons, often with abrupt changes in local relief.

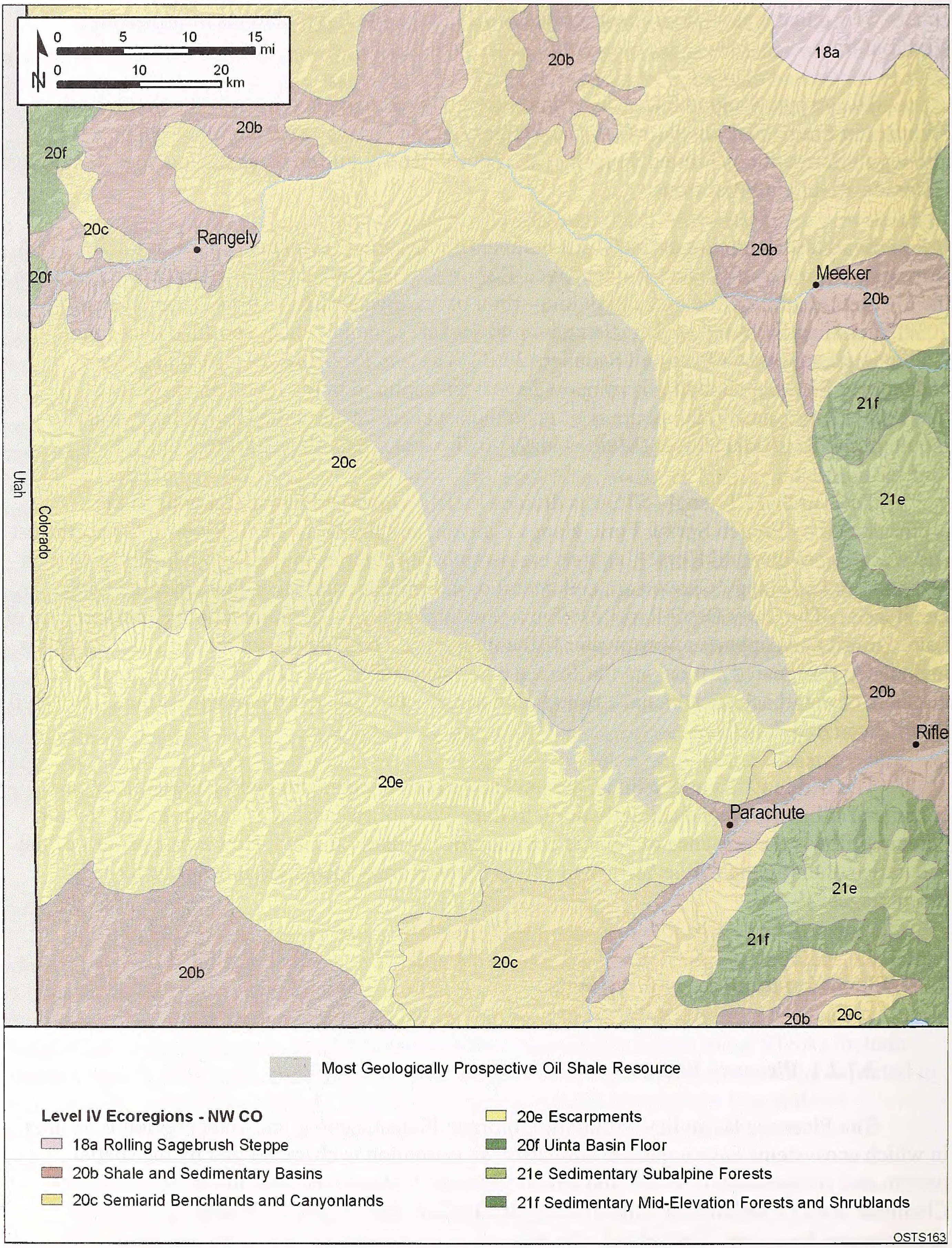

FIGURE 3.7.2-1 Ecoregions and Oil Shale Basin of Northwestern Colorado

Within this ecoregion, the northern portion of the basin, primarily located in Rio Blanco County, is included in the Semiarid Benchlands and Canyonlands subregion. Broad benches and mesas in alternating areas of high and low relief support grassland, shrub, and woodland vegetation types. Escarpments, hillslopes, cuestas, alluvial fans, and narrow canyons are also characteristic of this region. A few isolated peaks also occur. Elevations range from 5,400 to 9,200 ft, with local relief up to 1,000 ft. Deep soils of fine sand support sagebrush steppe with warm season grasses (i.e., galleta grass [*Pleuraphis jamesii*] and blue grama [*Bouteloua gracilis*]) and shrubs (primarily black sagebrush [*Artemisia nova*], winterfat [*krascheninnikovia lanata*], mormon tea [*Ephedra viridis*], fourwing saltbush [*Atriplex canescens*], and shadscale [*Atriplex confertifolia*]). Shallow stony soils support pinyon-juniper woodlands of two-needle pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*). Scattered woodlands of gambel oak (*Quercus gambelii*) occur at the higher elevations. Woodlands have expanded beyond their original range because of fire suppression and erosion. The average annual precipitation is about 10 to 18 in. in lower areas and 20 to 25 in. at the highest elevations. This subregion has a moderate to long growing season with 60 to 120 mean annual frost-free days. Vegetation is generally not as sparse as in the drier ecoregions.

The southern portion of the Piceance Basin, in Garfield County, lies within the Escarpments subregion. Extensive cliff-bench complexes characterize this region and ascend to the forested mountain rim. High, deeply dissected cliffs, escarpments, and mesa tops are typical of this region. Elevations range from 6,000 to 9,000 ft, with local relief up to 3,000 ft. The Book Cliffs and Roan Cliffs are major scarp slopes in the region, and the region is prone to landslides. The average annual precipitation is 15 to 25 in., with up to 32 in. at higher elevations. This subregion has a short to moderate growing season with 60 to 90 mean annual frost-free days. Lower drier sites in the region support desert and semidesert grassland or shrubland, while steep, north-facing slopes at higher elevations support Douglas fir (*Pseudotsuga menziesii*) forest with mountain mahogany (*Cercocarpus* sp.) and aspen (*Populus* sp.). The predominant vegetation type of shallow soils on escarpments and benches is pinyon-juniper woodland. Mountain mahogany and aspen woodlands are additional vegetation types.

The majority of the Piceance Basin lies within the White River Resource Area. Pinyon-juniper woodland is the predominant vegetation community, composing 46% of the resource area and occurring at elevations from about 5,200 to 8,000 ft (BLM 1997a). Pinyon pine and Utah juniper are the dominant species; however, common juniper and one-seed juniper may also occur. This community is frequent on dry ridgetops with shallow soils. Utah juniper is dominant on drier sites, such as lower elevations and south or west exposures, while pinyon pine is dominant on locations with higher soil moisture. The canopy ranges from open to closed, with understory shrub and herbaceous vegetation density subsequently ranging from high to low. The sagebrush vegetation type composes 21% of the resource area and includes various sagebrush species with a mixed short-to-tall growth. The shrub density ranges from open to closed with a corresponding high-to-low density of understory species. Big sagebrush (*Artemisia tridentata*) is the dominant species below 7,000-ft elevations, and associates may include shadscale and winterfat. Herbaceous associates include squirreltail (*Elymus elymoides*), Indian ricegrass (*Achnatherum hymenoides*), Colorado wildrye (*Leymus ambiguus*), needle-and-thread (*Hesperostipa comata*), goldenweed (*Haplopappus* sp.), and scarlet globemallow (*Sphaeralcea coccinea*). Sagebrush communities at higher elevations typically include species associated with mountain shrub communities, including wheatgrasses (*Agropyron* spp.), bluegrasses (*Poa* spp.), needlegrasses (*Stipa* spp.), bromegrasses (*Bromus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), and penstemons (*Penstemon* spp.).

Mountain shrub communities include medium-sized to large tree-like shrubs. These communities generally occur at upper elevations on east, west, and north slopes. The shrub canopy is open to dense, with some areas of open canopy having the highest levels of herbaceous species production and diversity of any plant association in the resource area. This community type covers only 11% of the resource area; however, it covers 41% of the NOSR 1, which includes the southern portion of the Piceance Basin. Quaking aspen (*Populus tremuloides*) communities occur at elevations above 7,000 ft on northern to northeastern exposures. The canopy ranges from open to dense, with open stands having a higher production and diversity of grasses and forbs, and dense stands supporting a thick understory of woody species. Aspen communities occupy less than 5% of the resource area, but about 12% of the NOSR 1. Greasewood shrub communities occur on drainage bottoms with poorly drained soils from 5,200 to 6,600 ft in elevation. Many drainages in the resource area, including the White River and Yellow Creek drainages, support extensive greasewood (*Sarcobatus vermiculatus*) stands. Dense stands have a sparse growth of short annual herbaceous species, while open stands include a mixture of other shrubs with perennial and annual grasses and forbs. Additional vegetation communities in the resource area include grasslands, saltbush-salt desert shrub, gambel oak woodlands, and above 7,000 ft, coniferous forest and woodlands of blue spruce (*Picea pungens*), Engelmann spruce (*Picea engelmannii*), Douglas fir, or subalpine fir (*Abies lasiocarpa*).

Barren areas of barren rock, rock outcrops, cliffs, talus slopes, and erosion pavements cover 9% of the resource area. These areas are sparsely vegetated or unvegetated and support many endemic and rare plant species. A number of species are endemic to semibarren outcrops of Green River shale, generally on soils of the Parachute Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 1993b, 2006k; Colorado Rare Plant Technical Committee 1999). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006j; Colorado Rare Plant Technical Committee 1999). Many oil-shale endemics, such as the Dudley Bluffs twinpod (*Physaria obcordata*), Dudley Bluffs bladderpod (*Lesquerella congesta*), Parachute beardtongue (*Penstemon debilis*), and Piceance bladderpod (*Lesquerella parviflora*), have extremely limited distributions and are found only in the Piceance Basin (USFWS 1993b, 2006k; Weber 1987). Others are also known from sites in Utah or Wyoming. Ephedra buckwheat (*Eriogonum ephedroides*) and dragon milk-vetch (*Astragalus lutosus*), for example, are endemic to Green River shale soils of the Piceance and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics (e.g., dragon milk-vetch) have no official conservation status (UDWR 2006).

The southwestern portion of the Piceance Basin lies within the Grand Junction Resource Area. Arid grassland terraces in the resource area support galleta, cheatgrass (*Bromus tectorum*), saline wildrye (*Leymus salinus*), and broom snakeweed (*Gutierrezia sarothrae*) (BLM 1987a). A number of shrubland communities occur in the resource area. Saltbush communities on benches include shadscale, galleta, broom snakeweed, and cheatgrass. Dominant species on eroded land include Nuttall's saltbush (*Atriplex nuttallii*), shadscale, and saline wildrye. Greasewood communities on uplands include black greasewood, cheatgrass, and burr buttercup (*Ranunculus testiculatus*). Associates of black greasewood in washes include perfoliate pepperweed (*Lepidium perfoliatum*) and cheatgrass. Sagebrush communities in valleys include big sagebrush, cheatgrass, wheatgrasses, and bluegrasses. Associates of big sagebrush on mesas include black sagebrush, galleta, and blue grama; associates on highlands include columbia needlegrass (*Achnatherum nelsonii*), lupines (*Lupinus* sp.), and gambel oak. Blackbrush (*Coleogyne ramosissima*) communities on slopes and terraces include prickly pear (*Opuntia* sp.) and blue grama.

Pinyon-juniper woodland occurs in the Grand Junction Resource Area at elevations from 4,800 to 7,500 ft. Pinyon pine is dominant at the higher elevations within that range, while Utah juniper dominates at the lower elevations. Associated species on arid mesas include big sagebrush and black sagebrush; gambel oak and big sagebrush occur on mesic mesas. Associated species on arid slopes include galleta and true mountain mahogany (*Cercocarpus montanus*); true mountain mahogany and serviceberry (*Amelanchier* sp.) occur on mesic slopes. Douglas fir forest generally occurs on steep side slopes at elevations between 7,000 and 9,000 ft. Associates include snowberry (*Symphoricarpos* sp.) and serviceberry. Quaking aspen woodland occurs above 7,000 ft on soils with relatively high moisture, such as north and northeast facing slopes. Associates include mountain snowberry (*Symphoricarpos oreophilus*), elk sedge (*Carex geyeri*), and aspen pea-vine (*Lathyrus laetivirens*).

The southeastern corner of the Piceance Basin lies within the Glenwood Springs Resource Area. Pinyon-juniper woodland composes 39% of the public land in the resource area, with juniper predominating in the western portions (BLM 1988). Mountain shrub communities cover 20% of the resource area and are primarily composed of oakbrush and serviceberry and include mountain mahogany, bitterbrush (*Purshia tridentata*), willow (*Salix* sp.), and alder (*Alnus* sp.). Semidesert shrub communities compose 27% of the public land; however, this type occurs primarily on low elevations below the Roan Plateau. The dominant shrubs are sagebrush species, including big sagebrush, low sagebrush (*Artemisia arbuscula*), and black sagebrush, as well as other sagebrush species. Additional semidesert shrub species include black greasewood, winterfat, shadscale, mat (*Atriplex corrugata*), and fourwing saltbush, as well as other saltbush species, and rabbitbrush (*Chrysothamnus* sp.). Aspen stands, conifer forest, and grassland habitat compose smaller portions of the resource area. Aspen is a short-lived, fast-growing, pioneer species that is eventually replaced by shade-tolerant conifers such as Engelmann spruce or subalpine fir. Harvesting promotes the perpetuation of aspen stands by stimulating root sprouting and regrowth. Conifer forest includes Douglas fir forest and Engelmann spruce-subalpine fir forest. Forest management promotes a balanced age class distribution that includes stands of all ages.

Noxious and invasive weeds can adversely affect native ecosystems. These aggressive, exotic plant species often displace native plants, thereby altering the species composition and community structure of native plant communities (BLM 2006a). They can contribute to increased soil erosion, reduced species diversity and structural diversity, and loss of habitat. The following noxious and problem weed species occur in the Piceance Basin: leafy spurge (*Euphorbia esula*); houndstongue (*Cynoglossum officinale*); knapweeds—Russian, spotted, and diffuse (*Acroptilon repens, Centaurea stoebe,* and *C. diffusa*); musk thistle (*Carduus nutans*); Canada thistle (*Cirsium arvense*); yellow toadflax (*Linaria vulgaris*); whitetop/hoary cress (*Cardaria draba*); bluebur stickseed (*Lappula redowski*); cheatgrass; and tall whitetop/perennial pepperweed (*Lepidium latifolium*).

The Duck Creek ACEC (3,430 acres), Ryan Gulch ACEC (1,440 acres), and Dudley Bluffs ACEC (1,630 acres) are located in the northern portion of the Piceance Basin (Figure 3.1.1-2). These ACECs include several federally listed threatened and candidate plant species, state rare species, sensitive species, and remnant vegetation associations. Additional ACECs are located outside of the geologically prospective area. Upper Greasewood Creek (in two units), Lower Greasewood Creek, and Yanks Gulch ACECs are located near the northern boundary of the basin and south of the White River. The White River Riparian ACEC is composed of numerous small blocks along the river, north of the basin and continuing downstream. Coal Draw, South Cathedral Bluff, and East Douglas Creek ACECs are also located near the basin to the west, and Deer Gulch is near the eastern boundary. (The Lower Colorado River Cooperative Management Area ACEC, located downstream of the basin to the south, is designated for the protection of riparian and wildlife values [BLM 1988].)

Two ACECs occur in the southeastern portion of the Piceance Basin. The Eastfork Parachute Creek proposed ACEC includes three rare plants: the hanging garden sullivantia (*Sullivantia hapemanii* var. *purpusii*), Utah fescue (*Festuca dasyclada*), and southwest stickleaf (*Mentzelia argillosa*) (BLM 2006a). In addition, three rare plant communities occur in the planning area. The montane riparian forest is predominantly composed of Colorado blue spruce and redosier dogwood (*Cornus sericea*). The boxelder riparian forest is primarily composed of boxelder (*Acer negundo*), narrowleaf cottonwood (*Populus angustifolia*), and redosier dogwood. The western slope grassland community, which occurs on south-facing slopes of shale or mudstone soils, is a shale barrens dominated by Indian ricegrass. The Trapper/Northwater Creek proposed ACEC includes two rare plants, hanging garden sullivantia and Utah fescue. Two rare plant communities also occur in this ACEC—sagebrush bottomland shrubland and western slope grassland.

Riparian vegetation communities occur along rivers, perennial and intermittent streams, lakes, reservoirs, and at springs (BLM 1987a, 1988). These communities generally form a vegetation zone along the margin or in the stream channel of upper drainages, distinct from the adjacent upland area in species composition and density. Riparian communities are dependent on the streamflows or reservoir levels and are strongly influenced by the hydrologic regime, which affects the frequency, depth, and duration of flooding or soil saturation. Peak flows on major streams generally occur in May and June as a result of snowmelt, with low flows in winter. Peak flows on smaller streams are often due to summer thunderstorms. Intermittent streams generally intersect the water table and have seasonal flow from groundwater discharge at seeps and springs, or they may have a surface water source. Ephemeral streams are directly dependent on precipitation, having a water table located below the soil surface, and having flow only during spring runoff and following intense summer storms (BLM 1997a). Ephemeral streams often do not support riparian vegetation.

Wetland areas are typically inundated, or have saturated soils for a portion of the growing season, and support plant communities that are adapted to saturated soil conditions. Unvegetated wetlands include mudflats, gravel beaches, and rocky shores (Cowardin et al. 1979). Riparian communities may include wetlands; however, the upper margins of riparian zones may be only infrequently inundated. Wetlands are generally associated with perennial water sources, such as springs, perennial segments of streams, or lakes and ponds. Functions of riparian and wetland areas include (1) erosion reduction and water quality improvement by dissipation of stream energy associated with high flows; (2) filtration of sediments and promotion of floodplain development; (3) improvement of floodwater retention and groundwater recharge of alluvial aquifers; (4) stabilization of stream banks by rootmass development; (5) provision of habitat, water depth, duration, and temperature for fish production, waterfowl breeding, and other wildlife uses, by development of diverse ponding and channel characteristics; and (6) support of greater biodiversity (BLM 1997a).

Moist meadow wetlands occur at the headwaters of drainages on the Roan Plateau (BLM 2006a). These wetlands are dominated by herbaceous species. Riparian shrub communities occur along the bottoms of major drainages. These communities include willow (*Salix* sp.), elderberry (*Sambucus* sp.), gooseberry (*Ribes* sp.), and riparian grasses. Lower reaches of the main drainages on the plateau support a narrow zone of coniferous woodland, composed primarily of blue spruce and Engelmann spruce with interspersed shrubs. A number of streams on the plateau support deciduous woodlands along their margins. These woodlands are composed of narrowleaf cottonwood, boxelder, and shrubs. Hanging gardens occur along canyon walls, predominantly north-facing walls where Green River shale beds are exposed, where seeps provide consistent moisture throughout the year.

In the Grand Junction Resource Area, nonwooded riparian areas support saltcedar (*Tamarix* sp.), saltgrass (*Distichlis spicata*), rush (*Juncus* sp.), and bulrush (*Scirpus* sp.); species of wooded riparian areas include cottonwood, boxelder, skunkbrush (*Rhus trilobata*), and willow (BLM 1987a). Along some rivers, fire has resulted in the removal of some Fremont cottonwood (*Populus fremontii*) stands greater than the rate of replacement. Overgrazing has impacted many riparian areas. Riparian and wetland habitats in the Glenwood Springs Resource Area include grassland with sedge (*Carex* sp.) and rush species (BLM 1988). Riparian habitats in this resource area also support cottonwood and willow, along with associated grasses and forbs. In this resource area, riparian habitats have been greatly impacted by such factors as road construction, gravel extraction, water diversions, and livestock grazing.

3.7.2.2 Uinta Basin

The Uinta Basin lies within the Colorado Plateau ecoregion. Ecoregions in Utah are described by Woods et al. (2001). The Colorado Plateau ecoregion is characterized by a dissected tableland of benches, buttes, mesas, plateaus, salt valleys, cliffs, and canyons (Figures 3.7.2-2 and 3.7.2-3).

Within this ecoregion, the Uinta Basin Floor subregion includes much of Uintah County and portions of Duchesne County. This region lies in a large, arid, synclinal basin with alluvial terraces, outwash terraces, floodplains, hills, and ridges; in some areas, mesas and benches alternate with lower arable land. Elevations mostly range from 4,300 to 6,400 ft, with local relief up to 1,200 ft. The basin receives a large amount of stream runoff from the adjacent mountains. The average annual precipitation is about 5 to 8 in., and the growing season is moderate to long, with 115 to 140 mean annual frost-free days. Vegetation is predominantly a saltbush-greasewood association with shadscale, Wyoming big sagebrush, fourwing saltbush, winterfat, Indian ricegrass, galleta, and needle-and-thread; black sagebrush may also be present.

The Semiarid Benchlands and Canyonlands subregion includes portions of Uintah, Duchesne, and Carbon Counties. Broad benches and mesas in alternating areas of high and low relief support grassland, shrub, and woodland vegetation types. Escarpments, hillslopes, cuestas, alluvial fans, and narrow canyons are also characteristic of this region. Elevations mostly range from 5,000 to 7,500 ft, with local relief up to 2,000 ft. A few isolated peaks of higher elevation also occur. Bare rock is common. Deep soils of fine sand over most of the region support sagebrush steppe with warm season grasses (i.e., galleta grass and blue grama) and shrubs (primarily black sagebrush, big sagebrush, blackbrush, winterfat, mormon tea, and fourwing saltbush). Shallow stony soils support pinyon-juniper woodlands of two-needle pinyon pine and Utah juniper. Sage parkland or mountain brush occurs on higher elevations. Woodlands have expanded beyond their original range because of fire suppression and erosion. The average annual precipitation is about 8 to 14 in. in lower areas and 20 to 25 in. at the highest elevations. This subregion generally has a moderate to long growing season with 80 to 160 mean annual frost-free days, but less than 50 days on the highest areas. Vegetation is generally not as sparse as in the drier ecoregions.

A number of species are endemic to the Green River shale barrens, generally on soils of the Evacuation Creek or Parachute Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006j). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006j). Occurrences of these endemics are often located within a narrow band along the southern margin of the Uinta Basin. Many oil-shale endemics, such as the shrubby reed-mustard (*Schoenocrambe suffrutescens*), have extremely limited distributions and are found only in the Uinta Basin in Utah (UDWR 2006). Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus albifluvis*) also occur only in the Uinta Basin, primarily in Utah, with some sites in immediately adjacent Colorado. Others are also known from oil shale basins in Colorado or Wyoming. Ephedra buckwheat (*Eriogonum ephedroides*) and dragon milk-vetch (*Astragalus lutosus*), for example, are endemic

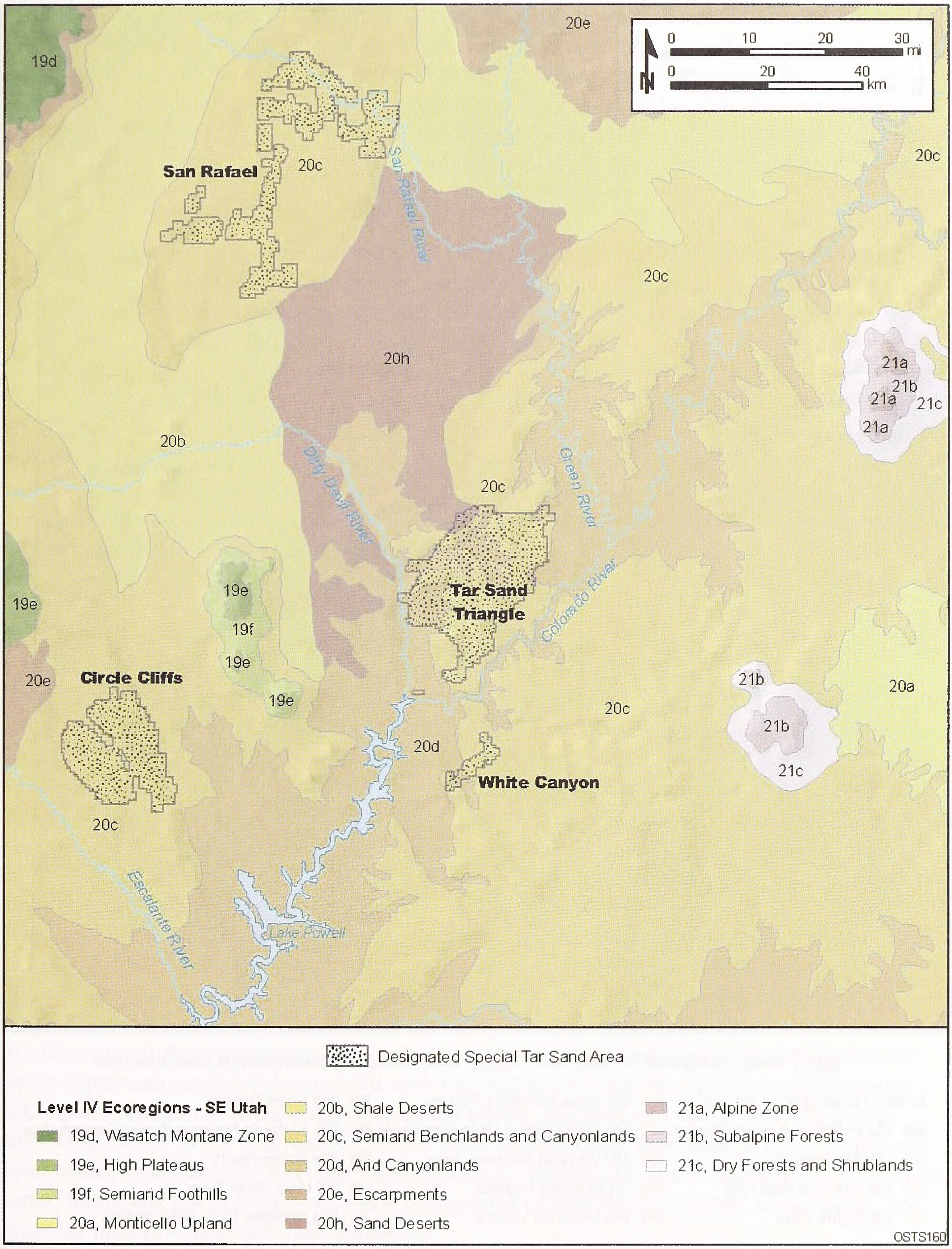

FIGURE 3.7.2-2 Ecoregions and Special Tar Sand Areas of Southeastern Utah

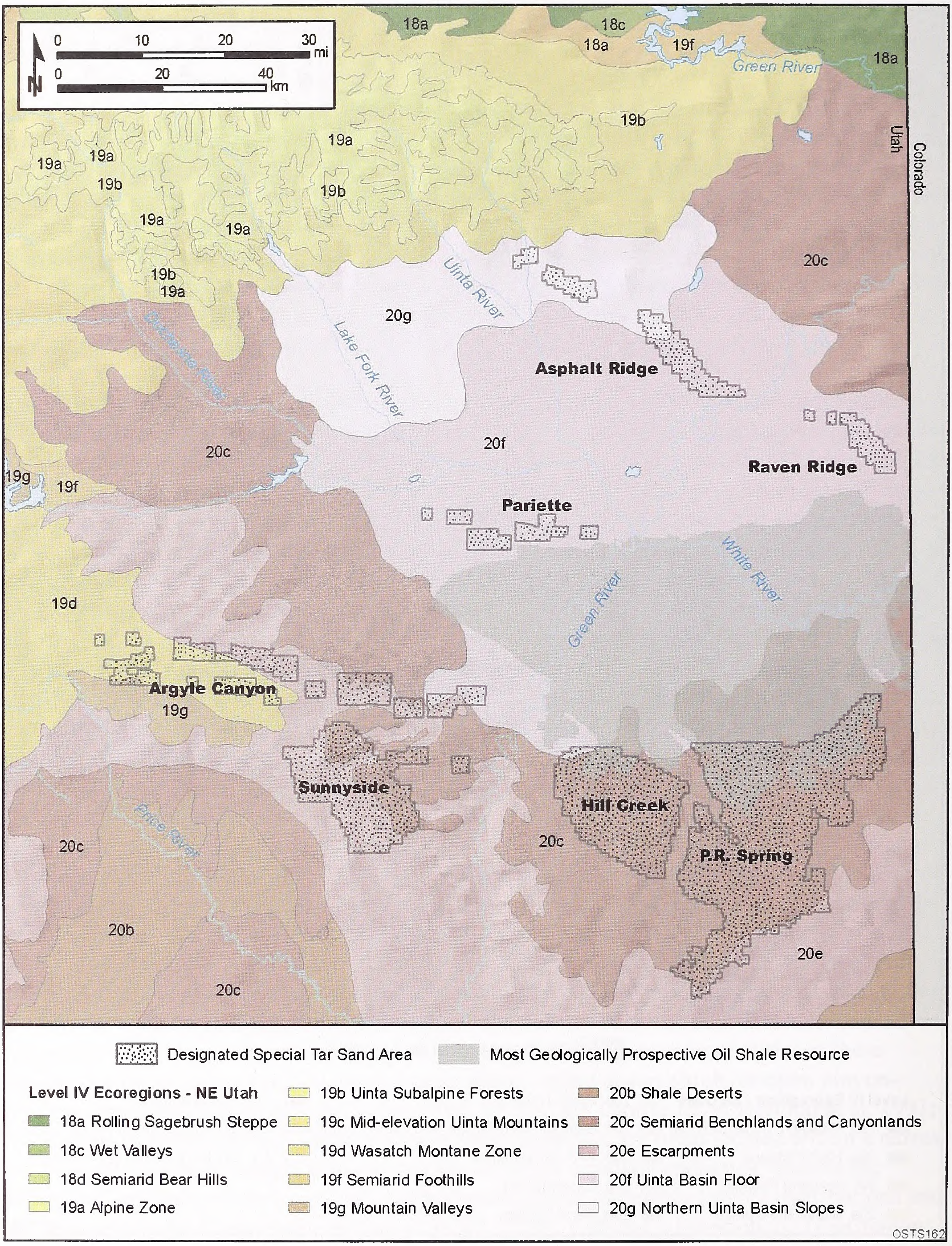

FIGURE 3.7.2-3 Ecoregions and Special Tar Sand Areas of Northeastern Utah

to Green River shale soils in the Piceance and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics (e.g., Graham's beardtongue, dragon milk-vetch, fragrant cryptantha [*Cryptantha grahamii*], Barneby's columbine [*Aquilegia barnebyi*], Barneby's thistle [*Cirsium barnebyi*], and Barneby's cryptantha [*Cryptantha barnebyi*]) have no official conservation status (UDWR 2006).

Large areas of the Uinta Basin lie within the Uinta Basin Floor subregion of the Colorado Plateau ecoregion. Streams have high levels of dissolved solids and suspended sediments; riparian areas support cottonwood trees and Russian olive (*Elaeagnus angustifolia*), an invasive exotic tree (Woods et al. 2001).

The Pariette Wetlands ACEC lies in the northwestern portion of the Uinta Basin. This ACEC is also adjoined with the Lower Green River ACEC, which includes riparian habitat and special status animal species. The Nine Mile ACEC is located at the southwestern margin of the basin and is also adjoined by the Lower Green River ACEC. The Raven Ridge-Addition ACEC is located in Colorado near the northeastern boundary of the basin. This ACEC is designated for the protection of federally listed plant species.

3.7.2.3 Green River and Washakie Basins

The Green River Basin lies within the Wyoming Basin ecoregion. Ecoregions in Wyoming are described by Chapman et al. (2004). The Wyoming Basin ecoregion occupies a broad arid basin with scattered hills and low mountains (Figure 3.7.2-4). The climate in the basin is influenced by the surrounding mountain ranges. The predominant vegetation types are grasslands and shrublands. The Rolling Sagebrush Steppe subregion is the predominant subregion within the Green River Basin, with large areas of the Salt Desert Shrub Basins subregion scattered throughout much of the basin. In addition, the Foothill Shrublands and Low Mountains subregion occurs in the southern and eastern portions of the basin. This region is characterized by isolated, dry mountain ranges and foothill slopes and includes alluvial fans, hills, ridges, and valleys. Elevations in foothills range from 5,000 to 7,000 ft, and more than 9,000 ft in some mountain ranges. Local relief can be up to 800 ft. The average annual precipitation is about 14 to 20 in., and the growing season is short to moderate with 75 to 100 mean annual frost-free days. Fine-textured soils occur at lower elevations and primarily support sagebrush steppe and grassland with big sagebrush, rabbitbrush (*Chrysothamnus* sp.), prickly pear, bluebunch wheatgrass (*Pseudoroegneria spicata*), and Idaho fescue (*Festuca idahoensis*), while rocky outcrops support woodlands of Rocky Mountain juniper (*Juniperus scopulorum*), Utah juniper, and mountain mahogany. Higher elevations support Rocky Mountain juniper, lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), aspen, Douglas fir, and ponderosa pine (*Pinus ponderosa*) forests.

The Washakie Basin lies within the Wyoming Basin ecoregion. The Rolling Sagebrush Steppe is the predominant subregion within the Washakie Basin. This subregion is a wide

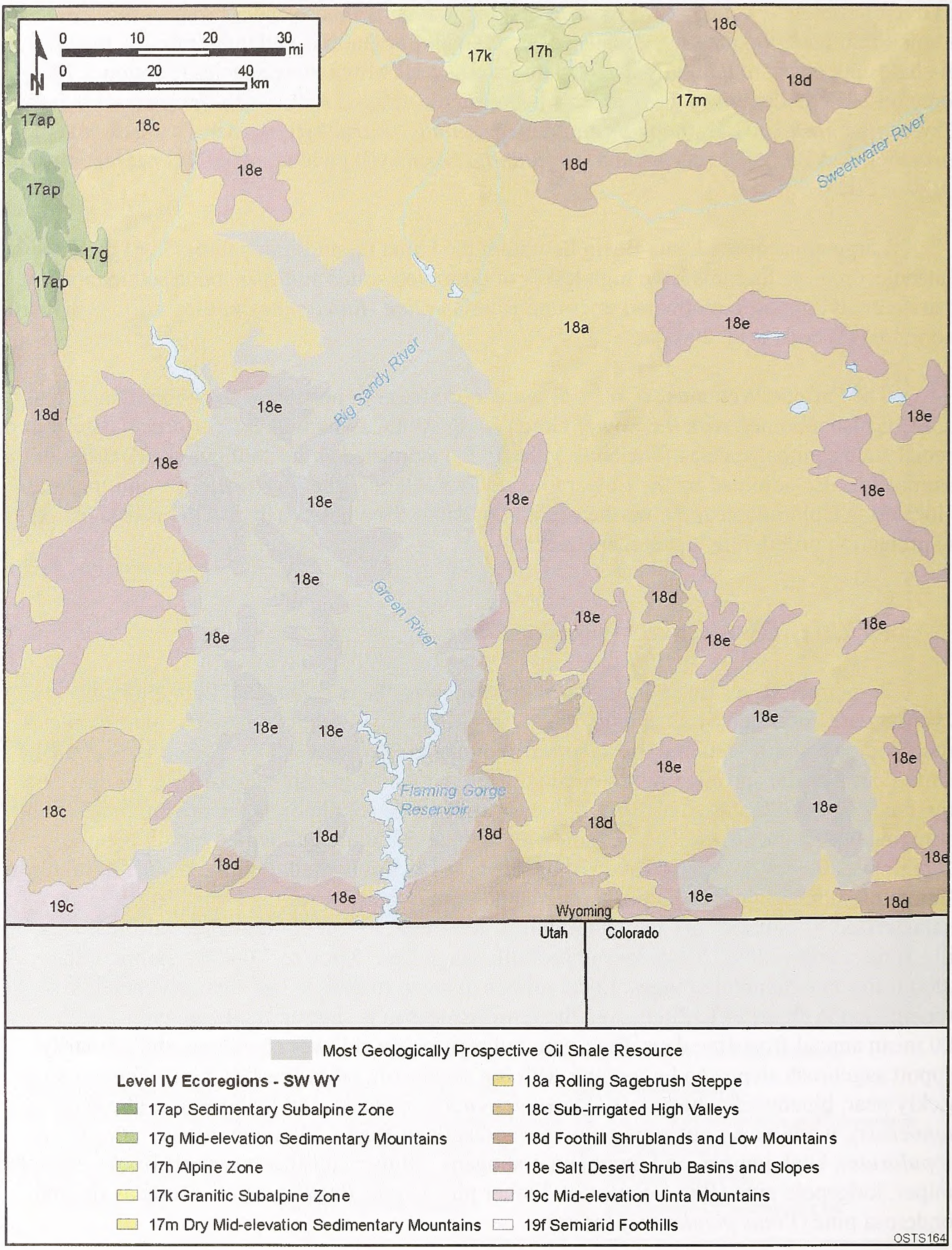

FIGURE 3.7.2-4 Ecoregions and Oil Shale Basins of Southwestern Wyoming

semiarid area of rolling plains with hills, mesas, cuestas, and nearly level floodplains and terraces. Footslopes, ridges, rolling alluvial fans, and outwash fans occur near the mountains. The average annual precipitation is 6 to 16 in., with a moderate growing season with 75 to 100 mean annual frost-free days. Elevations range from 4,900 to 7,200 ft. Local relief can be up to 400 ft. Sagebrush steppe shrubland is the predominant vegetation type, with mixed grass prairie predominating in the far eastern portions. The dominant shrub species is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Silver (*Artemisia cana*) and black sagebrush occur in the lowlands, and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) occurs at higher elevations. Associated species of Wyoming big sagebrush include western wheatgrass (*Pascopyrum smithii*), needle-and-thread, blue grama, Sandberg bluegrass (*Poa secunda*), junegrass (*Koeleria macrantha*), rabbitbrush, and fringed sage (*Artemisia frigida*). The sagebrush steppe has been affected by frequent fires and in some areas has been replaced by European annual grasses. Smaller areas of the Salt Desert Shrub Basins subregion are scattered throughout the Washakie Basin. This arid plains subregion is characterized by disjunct playas and sand dunes, nearly level floodplains and terraces, and rolling alluvial fans. Elevations range from 5,800 to 7,200 ft. The average annual precipitation is 6 to 10 in., with a moderate growing season with 75 to 100 mean annual frost-free days. Soils are more alkaline and less permeable than in the Rolling Sagebrush Steppe. Vegetation is sparse, consisting of desert shrublands with alkaline-tolerant shrubs and grasses. Shrubs include shadscale, greasewood, Gardner saltbush (*Atriplex gardneri*), bud sage (*Picrothamnus desertorum*), and big sagebrush. Stabilized sand dunes, which have greater moisture, higher permeability, and lower alkalinity, support a higher diversity of plant species, primarily alkali cordgrass (*Spartina gracilis*), indian ricegrass, blowout grass (*Redfieldia flexuosa*), alkali wildrye (*Leymus simplex*), and needle-and-thread. Non-native species, such as Russian thistle (*Salsola tragus*), cheatgrass, and halogeton (*Halogeton glomeratus*), may become established as a result of grazing pressure.

A number of species are endemic to semibarren shale outcrops, generally on soils derived from the Green River Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; University of Wyoming 2006). These soils are generally thin, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; University of Wyoming 2006). Many oil-shale endemics have extremely limited distributions. For example, tufted twinpod (*Physaria condensata*) is found only in the Green River Basin (University of Wyoming 2006). Others are also known from oil shale basins in Colorado or Utah. Rollins' cat's-eye (*Cryptantha rollinsii*), for example, is endemic to Green River shale soils in the Washakie, Green River, Piceance, and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4).

Large areas of the Green River and Washakie Basins lie within the Rolling Sagebrush Steppe subregion of the Wyoming Basin ecoregion. Within this subregion, streams and rivers with mountain headwaters have a moderate gradient with granite or limestone cobble substrates

(Chapman et al. 2004). Streams with headwaters in the Wyoming Basin center have a low gradient with finer gravel substrates of shales and are more incised. Small streams in the subregion are weakly intermittent or ephemeral, with substrates of sand or platy shale. Within the Salt Desert Shrub Basins subregion, streams are ephemeral or weakly intermittent; many are incised and flow into playas, which are seasonal with high levels of soluble salts (Chapman et al. 2004). Substrate is typically fine-textured or platy shale gravels. Within the Foothill Shrublands and Low Mountains subregion, streams originate in the nearby Rocky Mountains or are spring-fed streams originating on the higher ranges of the basin (Chapman et al. 2004). They generally have a steep gradient with riffle/run habitats and plunge pools. Streams generally have limestone or granite cobble or boulder substrates.

In the sand dunes area on the northeastern corner of the Green River Basin, ephemeral ponds fed by meltwater flockets are ecologically important wetlands because of their early season production of invertebrates and nesting habitat for waterfowl (BLM 2004d). In the northeastern corner of the Green River Basin, seeps and springs occur within the Jack Morrow Hills Planning Area (BLM 2004d).

Wetlands associated with high levels of soil moisture in typically arid areas support herbaceous species such as Baltic rush (*Juncus arcticus* ssp. *littoralis*), Nebraska sedge (*Carexnebrascensis*), water sedge (*Carex aquatilis*), and tufted hairgrass (*Deschampsia caespitosa*), with occasional species along the margin, including mountain iris (*Iris missouriensis*), sandbar willow (*Salix interior*), and narrowleaf cottonwood (BLM 2006g). Areas that are seasonally wet include Kentucky bluegrass (*Poa pratensis*), tufted hairgrass, foxtail barley (*Herdeum jubatum*), redtop (*Agrostis gigantea*), northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*), slender wheatgrass (*Elymus trachycaulus*), basin wildrye (*Leymus cinereus*), field horsetail (*Equisetum arvense*), wood rose (*Rosa woodsii*), shrubby cinquefoil (*Dasiphora fruticosa* ssp. *floribunda*), silver sage, basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), greasewood, and willows. Ephemeral washes may support a community of salt-tolerant herbaceous species, including inland saltgrass and western wheatgrass, along with greasewood and basin big sagebrush. Riparian areas often consist of a lower zone of sedges and willows, where soil is saturated more frequently, and an upper zone of silver sagebrush with basin wildrye, Kentucky bluegrass, streambank wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*), redtop, Baltic rush, clover (*Trifolium* sp.), checkermallow (*Sidalcea* sp.), aster (*Aster* sp.), and, in some areas, cottonwood and willow.

Basin big sagebrush is found as a dominant species along valley bottoms, canyons, and ephemeral streams. Greasewood shrublands occur along playas, desert lakes, ponds, and desert streams, often on terraces above wetter areas of silver sagebrush or basin big sagebrush. Associated species typically include shadscale, Gardner saltbush, alkali sagebrush (*Artemisia arbuscula* ssp. *longiloba*), basin big sagebrush, inland saltgrass, western wheatgrass, alkali sacaton (*Sporobolus airoides*), bottlebrush squirreltail, Sandberg bluegrass, biscuitroot (*Lomatium* sp.), pepperweed (*Lepidium* sp.), and sea blight (*Suaeda moquinii*).

Wetland and riparian areas generally are herbaceous wetlands, herbaceous riparian areas, and shrub-dominated riparian areas. Sedges, rushes, cattails (*Typha* spp.), and willows dominate wetter areas. In addition to margins of streams and bodies of open water, wetlands occur as open meadows that collect moisture in winter and spring. Many wetland areas are seasonally dry and infrequently inundated. Alkaline conditions can occur in areas of limited drainage. Riparian areas along major streams on nonirrigated, nonfederal land support woodlands of plains cottonwood (*Populus deltoides* ssp. *monilifern*), narrowleaf cottonwood, Fremont cottonwood, Geyer willow (*Salix geyeriana*), sandbar willow, and yellow willow (*Salix lutea*). Areas of shallow soil along the riparian margin or in rocky areas support predominantly herbaceous communities composed of riparian woodland understory species such as slender wheatgrass, thickspike wheatgrass (*Elymus lanceolatus*), smooth brome (*Bromus inermis*), tufted hairgrass, meadow foxtail (*Alopecurus* sp.), timothy (*Phleum pratense*), mountain iris, horsetail, gooseberry, currant (*Ribes* sp.), buffaloberry (*Shepherdia* sp.), and basin big sagebrush. Riparian habitats in foothills and mountain areas generally have high moisture levels throughout the growing season. The dominant species are generally willows with an understory of sedges, rushes, spikerush (*Eleocharis* sp.), and grasses. Open meadows and marshes support communities composed of these understory species.

Within the Green River Basin, the Greater Red Creek ACEC, composed of 131,890 acres located in the southeastern corner of the basin, is intended to protect unique ecological features, including Colorado River cutthroat trout (BLM 1997b). This ACEC includes the watersheds of Sage Creek and Currant Creek, which are tributaries of Red Creek. Management objectives include improving riparian habitats to achieve proper functioning condition throughout the ACEC, and improving watershed condition to improve channel stability, vegetation diversity, vegetation abundance, and water quality. The Special Status (Candidate) Plant Species ACEC, consisting of 900 acres on 58 sites, a number of which are located in the southwestern corner of the Green River Basin, is intended to protect populations of four plant species — Fremont County rockcress (*Arabis pusilla*), precocious milk-vetch (*Astragalus proimanthus*), mountain tansymustard (*Descurainia torulosa*), and hairy greenthread (*Thelesperma pubescens*) (BLM 1997b). Management objectives include preventing the destruction or loss of the plant communities and important habitat supporting the special status species, enhancing or expanding such habitat, and providing sufficient protection to the species to prevent their listing as threatened or endangered.

One location of the Special Status (Candidate) Plant Species ACEC occurs in the northwestern portion of the Washakie Basin. In addition, the Hells Canyon ACEC in Moffat County, Colorado, is located approximately 5 km (3 mi) south of the Washakie Basin.

3.7.2.4 Special Tar Sand Areas

A large number of plant communities are present in the STSAs and vary considerably according to moisture availability and elevation. Even within individual STSAs, a wide range of habitats may occur. Rare plant communities, such as remnant vegetation associations, and rare or endemic plant species occur near the STSAs, and potentially within them. The canyonlands area, which includes the three southernmost STSAs (San Rafael, Tar Sand Triangle, and White Canyon), contains a particularly large number of endemic plant species (BLM 1984b).

The STSAs lie primarily within the Colorado Plateau ecoregion; however, most of the Argyle Canyon STSA and a small portion of the Sunnyside TSA lie within the Wasatch and Uinta Mountains ecoregion.

- The Argyle Canyon STSA is primarily located in the Wasatch Montane Zone subregion of the Wasatch and Uinta Mountains ecoregion, with a small portion in the Mountain Valleys subregion of that ecoregion. The Escarpments subregion of the Colorado Plateau ecoregion intersects the northeastern corner of the STSA.
- The Asphalt Ridge STSA is located in the Uinta Basin Floor and North Uinta Basin Slopes subregions of the Colorado Plateau ecoregion.
- The Hill Creek STSA is located entirely in the Semiarid Benchlands and Canyonlands subregion of the Colorado Plateau ecoregion.
- The Pariette STSA is located entirely in the Uinta Basin Floor subregion.
- The P.R. Spring STSA is located primarily in the Semiarid Benchlands and Canyonlands subregion, with a small portion in the Escarpments subregion of the Colorado Plateau ecoregion.
- The Raven Ridge STSA is located entirely in the Uinta Basin Floor subregion.
- The San Rafael STSA is located entirely in the Semiarid Benchlands and Canyonlands subregion.
- The Sunnyside STSA is located primarily in the Escarpments and Semiarid Benchlands and Canyonlands subregions, with the northeastern corner intersecting the Uinta Basin Floor subregion. The Wasatch Montane Zone crosses a small portion of the northwestern corner of the STSA.
- The Tar Sand Triangle STSA is located mostly in the Semiarid Benchlands and Canyonlands subregion, with smaller portions in the Arid Canyonlands and Sand Deserts subregions.
- The White Canyon STSA is located mostly in the Semiarid Benchlands and Canyonlands subregion, with a smaller portion in the Arid Canyonlands subregion.

The Colorado Plateau ecoregion includes the following subregions: Semiarid Benchlands and Canyonlands, Arid Canyonlands, Escarpments, Uinta Basin Floor, North Uinta Basin Slopes, and Sand Deserts. Utah ecoregion descriptions are from Woods et al. (2001).

The Semiarid Benchlands and Canyonlands subregion includes all or portions of six STSAs, more than any other subregion. It includes pinyon-juniper woodland, with pinyon pine and Utah juniper, on shallow or stony soils, grassland, big sagebrush and black sagebrush shrubland, with sage parkland and mountain brush at the higher elevations. Additional species include winterfat, Mormon tea, fourwing saltbush, blackbrush, and warm-season grasses such as galleta and blue grama. Areas of unvegetated or sparsely vegetated exposed bedrock are common. Annual precipitation is generally 8 to 14 in., with 20 to 25 in. at the upper elevations. The mean number of frost-free days is mostly 80 to 160, with less than 50 at higher elevations.

The Arid Canyonlands subregion contains the inner gorge of the Colorado River and tributaries. Annual precipitation is only 5 to 8 in. Plant communities include blackbrush and saltbush-greasewood shrublands. Additional species include shadscale, galleta, indian ricegrass, fourwing saltbush, blue grama, mat saltbush, sand dropseed, sand sagebrush, and bud sagebrush. Blackbrush is common in deep canyons, and tamarisk, an invasive species, forms extensive stands in riparian zones in some areas. The mean number of frost-free days is 160 to 220 or more, and winters are mild.

The Escarpments subregion includes a wide range of habitats and elevation gradients with steep slopes. Scrubland, woodland, and Douglas fir forest are the predominant habitat types. Douglas fir forest occurs on northern upper elevation slopes. Desert and semidesert grassland and shrubland occur at low elevations. Pinyon-juniper woodland is often a dominant habitat on shallow soils. Additional habitats include high-elevation forests of Engelmann spruce, subalpine fir, Douglas fir, and Arizona pine forest, and mountain mahogany/oak scrub. Annual precipitation ranges from 8 to 30 in. The mean number of frost-free days is 40 to 150.

The Uinta Basin Floor subregion is arid, with only 5 to 8 in. of annual precipitation. The predominant habitat type is saltbush-greasewood shrubsteppe. Additional species present include grasses (indian ricegrass, galleta, and needle-and-thread) and shrubs (shadscale, Wyoming big sagebrush, four-wing saltbush, winterfat, and black sagebrush). This subregion receives abundant streamflows from the adjacent mountains. Common species in riparian areas are cottonwood and Russian olive, an invasive species. Irrigation has contributed to salinity levels in the Green River and tributaries. The mean number of frost-free days is 115 to 140, with cold winters.

The North Uinta Basin Slopes subregion includes numerous perennial streams originating from the adjacent mountains. Pinyon-juniper woodland is the most common habitat type in this subregion, with some sagebrush steppe. Upper elevations support mountain brush communities. Cottonwood, willow, ponderosa pine, and shrubs occur in canyons. Annual precipitation is 8 to 18 in., and the mean number of frost-free days is 100 to 130.

The Sand Deserts subregion is arid with only 5 to 8 in. of annual precipitation. The sandy soils have a low water-holding capacity. Vegetation is generally sparse or absent and is typically composed of desert or semidesert grasses, desert shrubs, and annual forbs. Galleta-three awn (*Aristida purpurea*) shrubsteppe is the most common habitat type, with saltbush-greasewood shrubsteppe and pinyon-juniper woodland also present. Grasses include indian ricegrass, sand dropseed, galleta, and three awn; shrubs include blackbrush in southern areas, and sandsage. Yucca (*Yucca angustissma*) is also present. This subregion includes areas of unstabilized sand dunes and exposed bedrock. The mean number of frost-free days ranges from 130 to 180.

The Wasatch and Uinta Mountains ecoregion includes the Wasatch Montane Zone and Mountain Valleys subregions. The predominant habitat type in the Wasatch Montane Zone subregion is Douglas fir forest. Forests of Engelmann spruce-subalpine fir are found mostly to the south. Aspen parkland, which includes big sagebrush, snowberry, elderberry, mountain grasses, and scattered Douglas fir, also occurs in this subregion. This subregion includes many good quality perennial streams. Willow and birch occur along streams. Annual precipitation is 16 to 50 in. or more, the east side being drier than the west side. The mean number of frost-free days ranges from less than 40 to 80, with long, cold winters.

The Mountain Valleys subregion is unforested. The predominant habitat type is Great Basin sagebrush steppe, with pinyon-juniper woodland also present. Cottonwood, Russian olive, and invasive species are found in riparian areas. Annual precipitation is 5 to 24 in. The mean number of frost-free days is 70 to 100.

A number of species are endemic to the Green River shale barrens, generally on soils of the Parachute Creek or Evacuation Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006j). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006j). Occurrences of these endemics are often located within a narrow band along the southern margin of the Uinta Basin. Many oil-shale endemics, such as the shrubby reed-mustard (*Schoenocrambe suffrutescens*), have extremely limited distributions, and are found only in Utah (UDWR 2006). Others are also known from sites in Colorado or Wyoming. A number of these endemic species are expected to occur in STSAs. For example, Graham's beardtongue (*Penstemon grahamii*) and the White River beardtongue (*Penstemon scariosus albifluvis*) potentially occur in the Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs. The White River beardtongue may also occur in the Asphalt Ridge STSA. Shrubby reed-mustard potentially occurs in the Hill Creek, Pariette, P.R. Spring, and Sunnyside STSAs. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics (e.g., Graham's beardtongue, dragon milk-vetch [*Astragalus lutosus*], fragrant cryptantha [*Cryptantha grahamii*], Barneby's columbine [*Aquilegia barnebyi*], Barneby's thistle [*Cirsium barnebyi*], and Barneby's cryptantha [*Cryptantha barnebyi*]) have no official conservation status (UDWR 2006). Each of these species potentially occurs in one or more STSAs. Flowers' penstemon (*Penstemon flowersii*), endemic to the Uinta Basin (although not endemic to shale soils), is restricted to a small area of Duchesne and neighboring Uintah counties and may occur in the Pariette STSA; it also has no formal conservation status (UDWR 2006).

A number of existing and potential ACECs intersect with the STSAs. Many of these ACECs contain riparian habitats, wetlands, remnant vegetation associations, and/or endemic plant species.

- Argyle Canyon STSA intersects with Nine Mile Canyon Expansion ACEC, which includes populations of special status plant species, and Lears Canyon ACEC, with relict plant communities and special status plant species.
- Asphalt Ridge STSA is located near the Red Mountain–Dry Fork Complex ACEC, which supports two relic vegetation communities.
- Hill Creek STSA intersects with Main Canyon ACEC.
- Pariette STSA intersects with Coyote Basin–Myton Bench ACEC and Pariette Wetlands ACEC, which includes special status and listed plant species and extensive wetlands.
- P.R. Spring STSA intersects with Main Canyon, Bitter Creek–P.R. Spring, and Bitter Creek ACECs.
- Raven Ridge STSA intersects with Coyote Basin–Snake John ACEC and is located near the Raven Ridge Addition ACEC.
- San Rafael STSA intersects with San Rafael Canyon, San Rafael Reef, which includes relict vegetation communities, Sids Mountain, Lucky Strike, Wild Horse, and I-70 Scenic Highway ACECs, and is located near the Muddy Creek ACEC, which has important riparian vegetation habitat.
- Sunnyside STSA intersects with Nine Mile Canyon, Nine Mile Canyon Expansion, Desolation Canyon, and Range Creek ACECs.
- Tar Sand Triangle STSA intersects with Horseshoe Canyon and Dirty Devil–North Wash ACECs.
- White Canyon STSA intersects with Scenic Highway Corridor ACEC and Dark Canyon ACEC, which is managed for protection of wildlife habitat, among other resources.

3.7.3 Wildlife

As discussed in Section 3.7.2, the various ecoregions encompassed by the oil shale and tar sands study area (i.e., counties within which commercial-scale development may occur) include a diversity of plant communities and species which, in turn, provide a wide range of habitats that support diverse assemblages of terrestrial wildlife (including wild horses

[*Equus caballus*] and wild burros [*E. asinus*]).[12] Table 3.7.3-1 lists the number of wildlife species that occur within the oil shale and tar sands study area. The wildlife species that may be associated with any particular project would depend on the specific location of the project and on the plant communities and habitats present at the site.

The BLM has active wildlife and wild horse management programs within each of its field offices. Wildlife management programs are largely aimed at habitat protection and improvement. The general objectives of wildlife management are to (1) maintain, improve, or enhance wildlife species diversity while ensuring healthy ecosystems, and (2) restore disturbed or altered habitat with the objective of obtaining desired native plant communities, while providing for wildlife needs and soil stability (BLM 1997b). The BLM is primarily responsible for managing habitats, while state agencies (i.e., Colorado Department of Natural Resources [CDNR], Utah Division of Wildlife Resources [UDWR], and Wyoming Game and Fish Department [WGFD]), in cooperation with the BLM, are responsible for managing the big game, small game, and nongame wildlife species that are nonmigratory. The USFWS has oversight of migratory bird species and of all federal threatened, endangered, or candidate species. BLM guidelines for the management of threatened and endangered species are provided in Section 3.7.4.

Consumptive and nonconsumptive recreational uses are associated with wildlife within BLM-administered lands. These include hunting of big game, small game, upland game birds, and fur trapping; wildlife viewing; and antler hunting (BLM 2004b).

TABLE 3.7.3-1 Number of Wildlife Species Occurring within the Oil Shale and Tar Sands Study Area

State	Amphibians	Reptiles	Birds	Mammals
Colorado	18 (18)[a]	49 (56)	290 (477)	82 (130)
Utah	9 (17)	23 (57)	264 (428)	76 (134)
Wyoming	6 (12)	10 (27)	318 (419)	96 (120)

[a] Numbers in parentheses are the number of species within the state.

Sources: CDW (2006); Colorado Field Ornithologists (2006); Colorado Herpetological Society (2000, 2006); Lepage (2006); UDWR (2006); WGFD (2005).

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12 Wild horses and burros are not considered to be, nor are they managed as, "wildlife" on BLM-administered lands. They are managed as a separate resource management category under the Wild Free-Roaming Horses and Burros Act. However, because wild horses and burros would be impacted by oil shale and tar sands development in a similar manner to that experienced by other large mammals, and since the consideration of site-specific impacts is not practicable within this PEIS, they are addressed under wildlife for ease of discussion.

The Wild Free-Roaming Horses and Burros Act passed by Congress in 1971 gave the BLM the responsibility to protect, manage, and control wild horses and burros. The general management objectives for wild horses and burros are to (1) protect, maintain, and control viable, healthy herds with a diverse age structure, while retaining their free-roaming nature; (2) provide adequate habitat for wild horses through principles of multiple use and environmental protection; (3) maintain a thriving natural ecological balance with other resources; (4) provide opportunities for the public to view wild horses; and (5) protect them from unauthorized capture, branding, harassment, or death (BLM 1991a, 1996, 1997b, 2005e).

The following discussions present general descriptions of the wildlife species and of wild horses and burros that may be affected by oil shale and tar sands projects on BLM-administered lands within the study area.

3.7.3.1 Amphibians and Reptiles

The counties within the three states in which oil shale and tar sands development may occur on BLM-administered land support a wide variety of amphibian (frogs, toads, and salamanders) and reptile (turtles, lizards, and snakes) species (Table 3.7.3-1). The number of amphibian species reported from the oil shale and tar sands study areas within these states ranges from 6 in Wyoming to 18 in Colorado, while the number of reptile species ranges from 10 in Wyoming to 49 in Colorado.

Common amphibian species include the tiger salamander (*Ambystoma tigrinum*), Great Basin spadefoot (*Spea intermontana*), northern leopard frog (*Rana pipiens*), and Woodhouse's toad (*Bufo woodhousii*). Reptile species common or widely distributed within the study areas include common gartersnake (*Thamnophis sirtalis*), racer (*Coluber constrictor*), gopher snake (*Pituophis catenifer*), midget faded rattlesnake (*Crotalus oreganus*), striped whipsnake (*Masticophis taeniatus*), western terrestrial garter snake (*Thamnophis elegans*), common side-blotched lizard (*Uta stansburiana*), eastern collared lizard (*Crotaphytus collaris*), eastern fence lizard (*Sceloporus undulatus*), and short-horned lizard (*Phrynosoma douglassii*). In Colorado, larval tiger salamanders, bullfrogs (*Rana catesbeiana*), snapping turtles (*Chelydra serpentina*), and prairie rattlesnakes (*Crotalus viridis*) are classified as game species, while all others are classified as nongame wildlife (CDW 2001). Threatened, endangered, and protected amphibian and reptile species are addressed in Section 3.7.4.

3.7.3.2 Birds

Several hundred species of birds have been reported from the three states where oil shale and tar sands development may occur: 290 for Colorado, 264 for Utah, and 318 for Wyoming (Table 3.7.3-1). These species totals were derived from county lists for Garfield and Rio Blanco Counties in Colorado (Colorado Field Ornithologists 2006), gap analysis mapping for eastern Utah (UDWR 2006), and general distributions for southwestern and southcentral Wyoming (WGFD 2004). Therefore, the number of species listed for each state, particularly Utah, do not imply that all species could be found in a potential oil shale or tar sands development area. For example, a number of bird species in Utah may occur only within the southern tar sands areas or within the northern oil shale and tar sands areas. Also, some species may be restricted to small areas within the oil shale area (e.g., only within the corridor of the Green River).

Many of the bird species identified from the three states are seasonal residents within individual states and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical songbirds. The area where commercial-scale oil shale and tar sands development may occur on BLM-administered lands falls primarily within the Central Flyway (Figure 3.7.3-1). Birds migrating north from wintering areas to breeding areas use this flyway in the spring, and birds migrating southward to wintering areas use it in the fall. The flyway encompasses a broad geographic area and includes a number of specific routes that would be an important parameter for identifying site-specific concerns related to migratory birds.

The Central Flyway includes the Great Plains–Rocky Mountain routes (Lincoln et al. 1998). These routes extend from the northwestern Arctic coast southward between the Mississippi River and the Rocky Mountains and encompass all or most of Colorado and

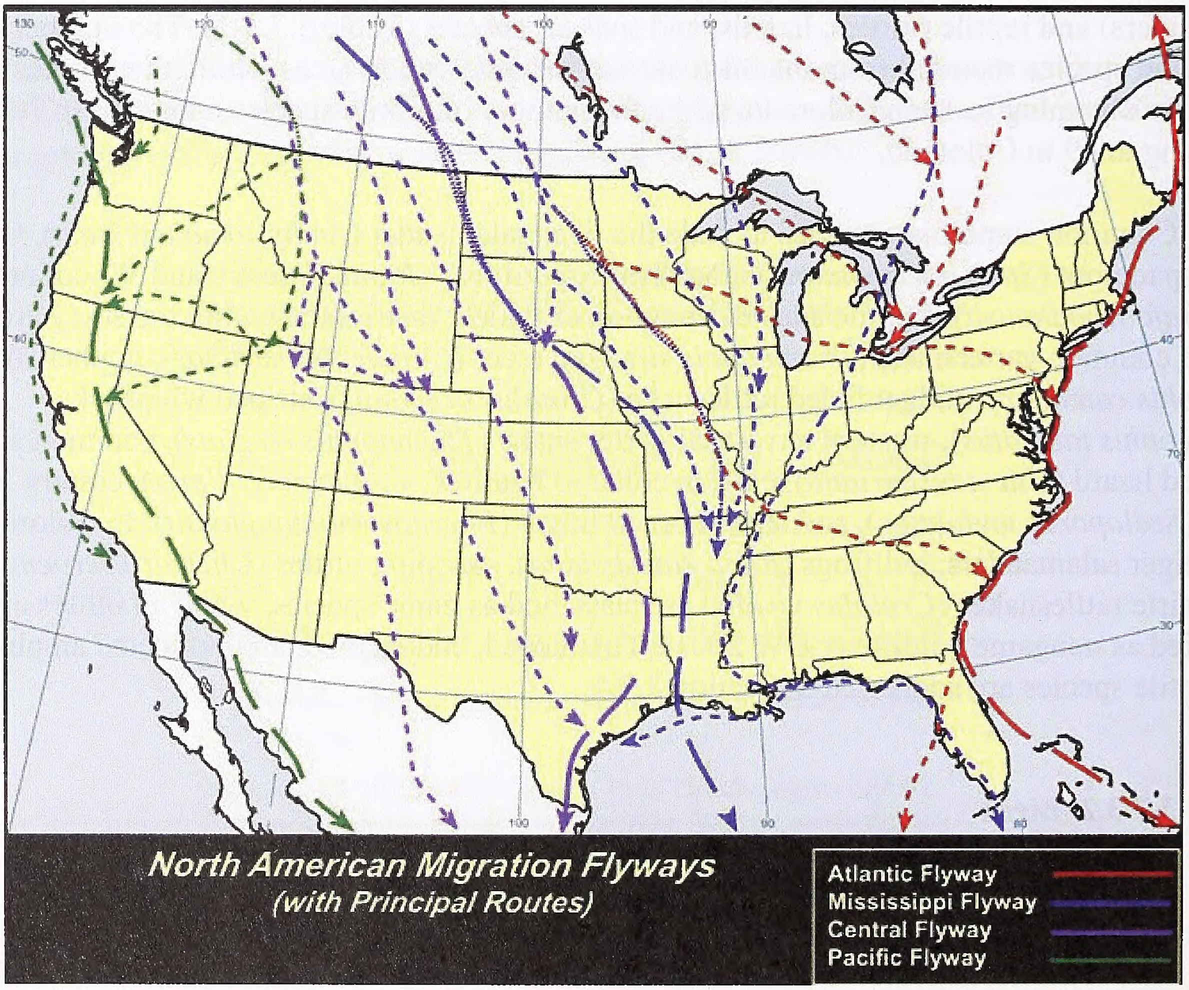

FIGURE 3.7.3-1 North American Migration Flyways (Coarse dashed lines are major flyways, medium dashed lines are principal migratory routes, fine dashed lines are merging routes; used with permission of birdnature.com, June 7, 2006.)

Wyoming and portions of Utah. The flyway is relatively simple; the majority of the birds make direct north and south migrations between northern breeding grounds and southern wintering areas (Birdnature.com 2001).

The following discussion describes important groups of birds that (1) have key habitats within or near the areas that could be developed for oil shale and tar sands, (2) are important to humans (e.g., waterfowl and upland game species), and/or (3) are representative of other species that share important habitats. Threatened, endangered, and protected bird species are addressed in Section 3.7.4.

3.7.3.2.1 Waterfowl, Wading Birds, and Shorebirds. Waterfowl (ducks, geese, and swans), wading birds (herons and cranes), and shorebirds (plovers, sandpipers, and similar birds) are among the more abundant groups of birds from the three states. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). Most are ground-level nesters, and many forage in flocks (sometimes relatively large) on the ground or water. Within the study area, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas (BLM 2005e).

Common to abundant waterfowl and shorebird species that occur within the oil shale and tar sands study area include Canada goose (*Branta canadensis*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), ring-necked duck (*Aythya collaris*), great blue heron (*Ardea herodias*), killdeer (*Charadrius vociferous*), spotted sandpiper (*Actitis macularius*), and Wilson's phalarope (*Phalaropus tricolor*) (BLM 1996). Major waterfowl species harvested in the three states include mallard and Canada goose. Other species commonly harvested include gadwall, American widgeon (*Anas americana*), teal (*Anas* spp.), northern pintail (*Anus acuta*), northern shoveler, and snow goose (*Chen caerulescens*) (USFWS 2003). A hunting season also occurs for sandhill crane (*Grus canadensis*).

3.7.3.2.2 Neotropical Migrants. Neotropical migrants are birds that breed in North America during spring and early summer and winter in Mexico, the Caribbean, and Central and South America. The several hundred species of neotropical migrants include songbirds, shorebirds, waterfowl, and some raptors. The BLM is a participant in Partners in Flight, a cooperative effort involving federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals that focuses on the conservation of landbirds and other bird species that require terrestrial habitats. Specific biological objectives and recommendations for landbirds are presented in the Bird Conservation Plan for each state (Beidleman 2000 [Colorado]; Nicholoff 2003 [Wyoming]; Parrish et al. 2002 [Utah]).

The neotropical migrants exhibit a wide range of seasonal movements; some species are year-round residents in some areas and migratory in other areas, while other species migrate hundreds of miles or more (Lincoln et al. 1998). Many of the neotropical migrants utilize riparian areas and corridors for nesting and migration purposes (BLM 2005e). Nesting occurs in vegetation from near ground level to the upper canopy of trees. Some species, such as thrushes and chickadees, are relatively solitary throughout the year; other species, such as swallows and blackbirds, may occur in small to large flocks at various times of the years. Foraging may occur in flight (e.g., swallows and swifts), in vegetation, or on the ground (e.g., warblers, finches, and thrushes).

Neotropical migrants common to the area include dusky flycatcher (*Empidonax oberholseri*), Say's phoebe (*Sayornis saya*), cliff swallow (*Petrochelidon pyrrhonota*), canyon wren (*Catherpes mexicanus*), Bewick's wren (*Thryomanes bewickii*), Mountain bluebird (*Sialia currucoides*), sage thrasher (*Oreoscoptes montanus*), black-throated gray warbler (*Dendroica nigrescens*), yellow warbler (*Dendroica petechia*), western tanager (*Piranga ludoviciana*), black-headed grosbeak (*Pheucticus melanocephalus*), Brewer's sparrow (*Spizella breweri*), chipping sparrow (*Spizella passerine*), Brewer's blackbird (*Euphagus cyanocephalus*), and brown-headed cowbird (*Molothrus ater*).

3.7.3.2.3 Upland Game Birds. Upland gamebirds that are native to the study area include blue grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), greater sage-grouse (*Centrocercus urophasianus*), and mourning dove (*Zenaida macroura*); introduced species include ring-necked pheasant (*Phasianus colchicus*), chukar (*Alectoris chukar*), gray partridge (*Perdix perdix*), and wild turkey (*Meleagris gallopavo*). All of the upland game bird species within the study area are year-round residents. Ring-necked pheasants and greater sage-grouse have experienced long-term declines because of the degradation and loss of important sagebrush steppe and grassland habitat (BLM 2005e). Most concerns over upland game in the West have focused on the greater sage-grouse because of its dependence on sagebrush.

Sage-Grouse. Populations of greater sage-grouse can vary from nonmigratory to migratory and can occupy an area that exceeds 1,040 mi^2 on an annual basis. The distance between leks (strutting grounds) and nesting sites can exceed 12.4 mi (Connelly et al. 2000). However, the greater sage-grouse has a high fidelity to a seasonal range (Connelly et al. 2000). The greater sage-grouse requires contiguous, undisturbed, high-quality habitats during the year during (1) breeding, (2) summer-late brooding and rearing, (3) fall, and (4) winter (Connelly et al. 2000). The greater sage-grouse occurs at elevations ranging from 4,000 to 9,000 ft. It is omnivorous and consumes primarily sagebrush, broad-leaved forbs, and insects. More than 99% of its diet in winter consists of sagebrush leaves and buds. Sagebrush is also important as roosting cover, and the greater sage-grouse cannot survive where sagebrush does not exist (USFWS 2006h).

Leks are generally areas supported by low, sparse vegetation or open areas surrounded by sagebrush that provide escape, feeding, and cover. They can range in size from small areas of 0.1 to 10 acres to areas of 100 acres or more (Connelly et al. 2000). The lek/breeding period occurs March through May, with peak breeding occurring from early to mid-April. Nesting generally occurs 1 to 4 mi from lek sites, although it may range up to 11 mi (BLM 2004d). The nesting/early brood-rearing period occurs from March through July. Sagebrush at nesting/early brood-rearing habitat is 12 to 32 in. above ground with 15 to 25% canopy cover. Tall, dense grass combined with tall shrubs at nest sites decreases the likelihood of nest depredation. Hens have a strong year-to-year fidelity to nesting areas (BLM 2004d). The late brood-rearing period occurs from July through October. Sagebrush at late brood-rearing habitat is 12 to 32 in. tall with a canopy cover of 10 to 25% (BLM 2004d). The greater sage-grouse occupies winter habitat from November through March. Suitable winter habitat requires sagebrush 10 to 14 in. above snow level with a canopy cover ranging from 10 to 30%. Wintering grounds are potentially the most limiting seasonal habitat for greater sage-grouse (BLM 2004d).

While no single factor or combination of factors has been proven to have caused the decline in greater sage-grouse numbers over the past half-century, the decline in greater sage-grouse populations is believed to be the result of a number of factors, including oil and gas wells and their associated infrastructure, traffic, power lines, urbanization, recreation, predators, and a decline in the quality and quantity of sagebrush habitat (due to alteration of historical fire regimes, water developments, drought, use of herbicides and pesticides, livestock and wild horse grazing, and establishment of invasive species) (see Connelly et al. 2000; Lyon and Anderson 2003; WGFD 2003; Crawford et al. 2004; Holloran 2005; Holloran et al. 2005; Rowland 2004; Schroeder et al. 2004; Bird and Schenk 2005; Braun 2006; Uinta Basin Adaptive Resource Management Local Working Group 2006; Aldridge and Boyce 2007; Bohne et al. 2007; The Southwest Wyoming Local Sage-Grouse Working Group 2007; Walker et al. 2007; Colorado Greater Sage-grouse Steering Committee 2008; Doherty et al. 2008 and references cited therein). West Nile virus is also a significant stressor of greater sage-grouse (Naugle et al. 2004). On February 26, 2008, the USFWS (2008a) initiated a status review for the greater sage-grouse as threatened or endangered. At the end of the review period, the USFWS will make a determination about whether listing is warranted.

The BLM manages a larger amount of greater sage-grouse habitat than any other entity; therefore, it has developed a National Sage-Grouse Habitat Conservation Strategy for BLM-administered public lands to manage public lands in a manner that will maintain, enhance, and restore greater sage-grouse habitat while providing for multiple uses of BLM-administered public lands (BLM 2004e). The strategy is consistent with the individual state sage-grouse conservation planning efforts. The purpose of the strategy is to set goals and objectives, assemble guidance and resource materials, and provide more uniform management directions for the BLM's contributions to the multistate sage-grouse conservation effort being led by state wildlife agencies (BLM 2004e).

3.7.3.2.4 Raptors. The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures (hereafter referred to collectively as raptors). Many of these species represent the top avian predators. Common species include the turkey vulture (*Cathartes aura*), sharp-shinned hawk (*Accipiter striatus*), red-tailed hawk (*Buteo jamaicensis)*, northern harrier (*Circus cyaneus*), Swainson's hawk (*Buteo swainsoni*), American kestrel (*Falco sparvenus*), golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), and short-eared owl (*Asio flammeus*). The raptors vary considerably among species with regard to their seasonal migrations; some species are nonmigratory, others may be migratory in the northern portion of their ranges and nonmigratory in the southern portions, and others are migratory throughout their ranges. Species that nest in the study area include the golden eagle, prairie falcon (*Falco mexicanus*), peregrine falcon (*Falco peregrinus*), red-tailed hawk, ferruginous hawk (*Buteo regalis*), American kestrel, Coopers hawk (*Accipiter cooperii*), sharp-shinned hawk, northern goshawk (*Accipiter gentilis*), great horned owl, northern saw-whet owl (*Aegolius acadicus*), and burrowing owl (*Athene cunicularia*) (BLM 2004a,c,e).

Depending on the species, the raptors consume a variety of prey, including small mammals, reptiles, other birds, fishes, invertebrates, and carrion. They typically perch on trees or man-made structures that provide a view of the surrounding topography; they may soar for extended periods of time at relatively high altitudes. Raptors typically forage from either a perch or on the wing (depending on the species). While generally nocturnal, some owl species may be active during the day (Owl Research Institute 2004). The other raptor species forage during the day.

3.7.3.3 Mammals

More than 75 species of mammals have been reported from each of the three states where oil shale and tar sands development may occur on BLM-administered lands (82 from Colorado, 76 from Utah, and 96 from Wyoming) (Table 3.7.3-1). Wild horses, as well as feral cats (*Felis catus*) and dogs (*Canis familiaris*), also occur in the study area. The following discussion emphasizes big game and small mammal species that (1) have key habitats within or near the study area that could be developed for oil shale and tar sands, (2) are important to humans (e.g., big game species), and/or (3) are representative of other species that share important habitats. Wild horses are discussed in Section 3.7.3.4, while threatened, endangered, and protected mammal species are addressed in Section 3.7.4.

3.7.3.3.1 Big Game. Big game species within the study area include elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocarpra americana*), bighorn sheep (*Ovis canadensis*), moose (*Alces americanus*), American black bear (*Ursus americanus*), and mountain lion (*Felis concolor*). The elk and mule deer are generally the most abundant, widely distributed, intensely managed, and sought-after big game in the region (BLM 2004c). A number of the big game species make migrations when seasonal changes reduce food availability, when movement becomes difficult (e.g., due to snowpack), or where local conditions are not suitable for calving or fawning. Established migration corridors for these species provide an important transition range between seasonal ranges and provide food for the animals during migration (Feeney et al. 2004). Water availability is a major factor affecting the distribution of big game species (BLM 2004d).

Elk. Elk are mostly migratory between their summer and winter ranges (BLM 2004a), although some herds do not migrate (i.e., occur within the same general area year-round) (UDWR 2005). Summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush-mixed grass, and mountain shrub habitat types are used for forage. Winter range occurs at mid to lower elevations where elk forage in sagebrush-mixed grass, big sagebrush-rabbitbrush, and mountain shrub habitat types (BLM 2004c). Elk are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they will congregate in large herds of 50 to more than 200 individuals (BLM 2004a). Crucial winter range is considered to be the part of the local elk range, where about 90% of the local population is located during an average of 5 winters out of 10 from the first heavy snowfall to spring greenup (BLM 2005e). Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer (BLM 2004a). Calving areas are mostly located where cover, forage, and water are in close proximity (BLM 2005e). Elk require water on all seasonal ranges and generally occur within 0.5 mi of a water source, although some herds will travel longer distances for water (UDWR 2005). Elk are susceptible to chronic wasting disease (BLM 2004a).

Mule Deer. Mule deer occur within most ecosystems within the region but attain their highest densities in shrublands characterized by rough, broken terrain with abundant browse and cover (BLM 2005e). Some populations of mule deer are resident (e.g., occur in the same location throughout the year), but those in mountainous areas are generally migratory between their summer and winter ranges (BLM 2004a). Summer range occurs at higher elevations that contain aspen and conifer and mountain browse vegetative types. Fawning occurs during the spring while they are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation types (BLM 2004a). Mule deer have a high fidelity to specific winter ranges where they will congregate within a small area at a high density. Winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation types. Winter forage is primarily sagebrush with true mountain mahogany, fourwing saltbush, and antelope bitterbrush also being important. Pinyon-juniper provides emergency forage during severe winters (BLM 2004a). Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas); they do best in habitats that are in the early stage of succession (UDWR 2003). Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population size of mule deer in the 1980s and early 1990s (BLM 2004a). In arid regions, they seldom occur more than 1.0 to 1.5 mi from water (BLM 2004d). Mule deer are also susceptible to chronic wasting disease. When it is present, up to 3% of a herd population can be affected by this disease. Some deer herds in Colorado and Wyoming have experienced significant outbreaks of chronic wasting disease (BLM 2004a).

Pronghorn. Pronghorn inhabit open vegetated areas such as desert, grassland, and sagebrush habitats (BLM 2005e). Herd size can commonly exceed 100 individuals, especially during winter (BLM 2004a). They consume a variety of forbs, shrubs, and grasses, with shrubs being most important in winter (BLM 2004a). Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability (BLM 2004a,c). Other pronghorn are migratory. Most herds range within an area of 5 mi or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 mi or more (NatureServe 2006). For example, in western Wyoming, pronghorn migrate 116 to 258 km (72 to 160 mi) between ranges (Sawyer et al. 2005). Severe winters with deep, crusted snow and below-zero temperatures can cause high pronghorn mortalities (BLM 2004d). Pronghorn populations have also been adversely impacted in some areas by historic range degradation and habitat loss and by periodic drought conditions (BLM 2004a,d; 2005e).

Bighorn Sheep. Rocky Mountain bighorn sheep (*Ovis c. canadensis*) and desert bighorn sheep (*O. Canadensis nelsoni*) are considered to be year-long residents within their ranges; they do not make seasonal migrations like elk and mule deer (BLM 2004a). However, they do make vertical migrations in response to the increasing abundance of vegetative growth at higher elevations in the spring and summer and when snow accumulation occurs in high-elevation summer ranges (NatureServe 2006). Also, ewes do move to reliable watercourses or sources during the lambing season; lambing occurs on steep talus slopes within 1 to 2 mi of water (BLM 2004a). Bighorn sheep prefer open vegetation types such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes (BLM 2004c). Their diet consists of shrubs, forbs, and grasses (BLM 2004a). In the early 1900s, bighorn sheep experienced significant declines because of disease, habitat degradation, and hunting (BLM 2005e). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, the BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat (BLM 2004a). In appropriate habitats, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat (BLM 2005e).

Moose. Although moose range widely among habitat types, they are mainly associated with boreal forests and riparian areas. Their preferred habitat is generally associated with early stages of seral development and shrub growth (BLM 2005e). Moose also will make use of dense stands of conifers for shelter in winter and for thermoregulation in summer (UDWR 2000). They are primarily browsers upon trees and shrubs such as willow, fir, and quaking aspen; grasses, forbs, and aquatic vegetation, however, make up a large portion of the summer diet (BLM 2005e). Moose habitat is thought to be improved by annual flooding and habitat management techniques such as prescribed burning (BLM 2005e). Moose generally occur singly or in small groups. Some moose make short elevational or horizontal migrations between summer and winter habitats (NatureServe 2006). In addition to predation, snow accumulation may have a controlling effect on moose populations. Habitat degradation resulting from a large number of moose can lead to population crashes (NatureServe 2006).

Mountain Lion. Mountain lions (cougars) inhabit most ecosystems in the study area but are most common in the rough, broken terrain of foothills and canyons, often in association with montane forests, shrublands, and pinyon-juniper woodlands (BLM 2005e). Their annual home range can be more than 560 mi^2, while densities are usually not more than 10 adults/100 mi^2 (NatureServe 2006). The mountain lion is generally found where its prey species (especially mule deer) are located (BLM 2004a). They also prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (CDW 2006). They are active year-round and are hunted on a limited and closely monitored basis (BLM 2004a).

Black Bear. American black bears are found mostly within forested or brushy mountain environments and woody riparian corridors (BLM 2005e). They are omnivorous and feed on fruits, insects, small vertebrates, and carrion (CDW 2006; UDWR 2006). Breeding occurs in June or July; the young are born in January or February (UDWR 2006). American black bears have a period of winter dormancy from November to April (BLM 2005e). The home range of the American black bear depends on the area in which it lives and the bear's gender; its range has been reported to be from about 1,250 to nearly 32,000 acres (NatureServe 2006).

3.7.3.3.2 Small Mammals. Small mammals include small game, furbearers, and nongame species. Small game species that commonly occur within the oil shale and tar sands study area include black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*Sylvilagus nuttallii*), snowshoe hare (*Lepus americanus*), white-tailed jackrabbit (*Lepus townsendii*), and yellow-bellied marmot (*Marmota flaviventris*). Common furbearers include American badger (*Taxidea taxus*), American beaver (*Castor canadensis*), American marten (*Martes americana*), bobcat (*Lynx rufus*), common muskrat (*Ondatra zibethicus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitus*), and weasels. Nongame species include bats, shrews, mice, voles, chipmunks, and other rodent species.

3.7.3.4 Wild Horses and Burros

The BLM establishes HMAs for the maintenance of wild horse and burro herds in compliance with the Wild Free-Roaming Horses and Burros Act (BLM 2004d). Herd population management is important for balancing herd numbers with forage resources and with other uses of the public and adjacent private lands (BLM 2004a,d). Wild horses and burros that are found outside of HMAs are considered excess and are subject to removal (BLM 2004d). Generally, their annual home range varies between 25 and 300 km^2 (NatureServe 2006). Because wild horse herds can increase in size by up to 25% annually, they can affect the condition of their range and increase competitive pressure among wild horses, livestock, and wildlife. Therefore, wild horse and burro herd size is maintained through gathers that are conducted every 3 to 5 years. Gathered horses and burros are placed for adoption through the Adopt-a-Horse Program or otherwise placed in long-term holding facilities. The BLM is currently researching the use of immunocontraceptives to slow the reproductive rate of wild horses (BLM 2004a).

Wild horses generally occur in common social groups of several females that are tended by a dominant male. Young males are expelled from the social group when they are 1 to 3 years old and form bachelor groups (NatureServe 2006). They feed on grass and grasslike plants and also browse on shrubs in winter. They visit watering holes daily and may dig to water in dry river beds (NatureServe 2006).

Wild burro males control a small territory during the breeding season. When not with females, older males are generally solitary. Females tend to be either alone with their foal or in groups with other females and foals (NatureServe 2006). The home range for the wild burro can range from 4 to 97 km^2 (2 to 37 mi^2). They feed on grasses, sedges, forbs, and browse. Table 3.7.3-2 lists the wild horse and burro HMAs within or near the areas where oil shale or tar sands may be developed. Horse and burro populations that occurred within the HMAs during FY 2006 are also provided. Figure 3.7.3-2 shows the distribution of the wild horse HMAs within the oil shale and tar sands study area.

3.7.4 Threatened and Endangered Species

This section addresses species that are federally or state-listed and are included in one of the following categories:

TABLE 3.7.3-2 Wild Horse Herd Management Areas within the Oil Shale and Tar Sands Study Area (FY 2006)

Herd Management Area Name (County)	Herd Management Area Size		Population[a]	
	BLM Acres	Other Acres	Horse	Burro
Colorado				
Piceance-East Douglas Creek (Rio Blanco)	158,281	31,741	349 (235)	0 (0)
Utah				
Canyon Lands (Wayne)	77,253	10,448	0 (0)	76 (100)
Hill Creek (Uintah)	54,245	32,919	310 (195)	0 (0)
Muddy Creek (Emery)	168,853	21,879	57 (50)	0 (0)
Range Creek (Carbon)	54,630	24,010	133 (125)	0 (0)
Sinbad (Emery)	203,767	26,830	52 (50)	93 (70)
Wyoming				
Little Colorado (Sweetwater, Sublette, and Lincoln)	527,307	105,020	101 (100)	0 (0)
White Mountain (Sweetwater)	207,981	185,092	295 (300)	0 (0)
Salt Wells Creek (Sweetwater)	688,632	483,993	1,133 (365)	0 (0)
Adobe Town (Sweetwater)	444,321	34,757	692 (800)	0 (0)

[a] Numbers in parentheses are the appropriate management level (i.e., number of wild horses and burros that the HMA can support).

Source: BLM (2007c).

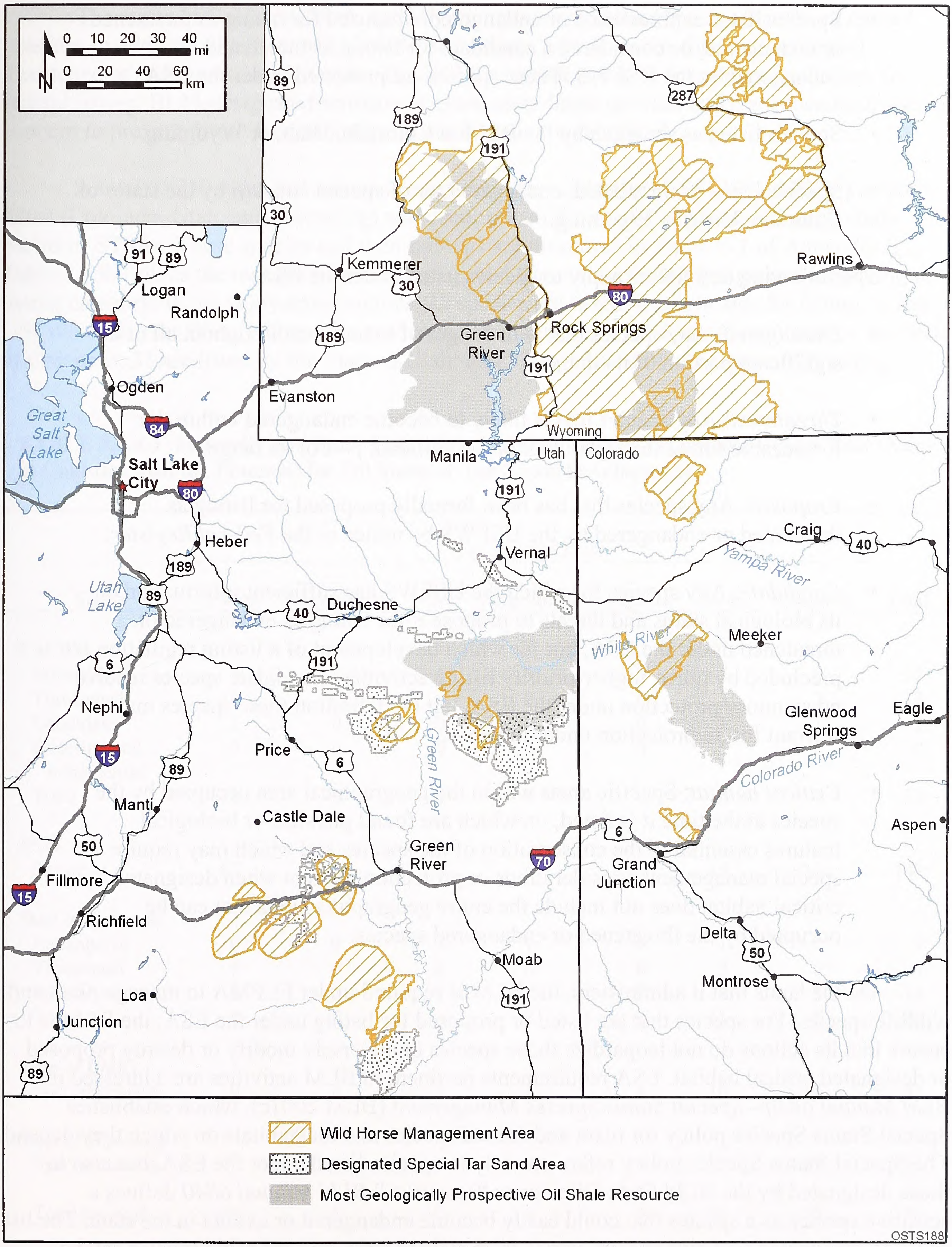

FIGURE 3.7.3-2 Distribution of Wild Horse Herd Management Areas within the Oil Shale and Tar Sands Study Area

- Species listed as threatened or endangered, proposed for listing as threatened or endangered, or considered a candidate for listing as threatened or endangered by the USFWS. These species are protected under the ESA.

- Species listed as sensitive by the BLM in Colorado, Utah, or Wyoming.

- Species listed as threatened, endangered, or of special concern by the states of Colorado, Utah, or Wyoming.

The following definitions apply to species listed under the ESA:

- *Endangered*: Any species that is in danger of extinction throughout all or a significant portion of its range.

- *Threatened*: Any species that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

- *Proposed*: Any species that has been formally proposed for listing as threatened or endangered by the USFWS by notice in the *Federal Register*.

- *Candidate*: Any species for which the USFWS has sufficient information on its biological status and threats to propose it for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other, higher-priority listing activities. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

- *Critical habitat*: Specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Except when designated, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species.

On the lands that it administers, the BLM is required under FLPMA to manage plant and wildlife species. For species that are listed or proposed for listing under the ESA, the BLM is to ensure that its actions do not jeopardize those species or adversely modify or destroy proposed or designated critical habitat. ESA requirements pertinent to BLM activities are addressed in *BLM Manual 6840—Special Status Species Management* (BLM 2001c), which establishes Special Status Species policy for plant and animal species and the habitats on which they depend. The Special Status Species policy refers not only to species listed under the ESA, but also to those designated by the BLM State Director as "sensitive." *BLM Manual 6840* defines a sensitive species as a species that could easily become endangered or extinct in the state. The list of BLM-designated sensitive species varies from state to state, and the same species can be considered sensitive in one state but not in another.

The states of Colorado, Utah, and Wyoming have identified species that are of special concern. In addition, the State of Colorado maintains a list of species that are considered threatened or endangered in that state. The BLM's current policy is to manage candidates for federal listing, BLM-designated sensitive species, state-listed species, and state species of special concern to prevent future federal listing as threatened or endangered.

A total of 250 plant and animal species are either federally (USFWS and BLM) or state-listed (Colorado, Utah, and Wyoming) and occur or could occur in counties within oil shale basins or STSAs. These species and their habitats are presented in Table E-1 of Appendix E. Table 3.7.4-1 gives the number of these species in different taxonomic groups and according to listing category. In the study area counties, 32 species are listed or candidates for listing by the USFWS under the ESA; 140 species are listed as sensitive by the BLM; 26 are listed by the State of Colorado; 33 are listed by the State of Utah; and 120 are listed by the State of Wyoming.

TABLE 3.7.4-1 Federally and State-Listed Species According to Taxonomic Group That Occur in Counties with the Potential for Oil Shale or Tar Sands Development

	Taxonomic Group							
Status	Plants	Invertebrates	Fish	Amphibians	Reptiles	Birds	Mammals	Total
USFWS								
Endangered	6	0	4	0	0	2	0	12
Threatened	10	0	0	0	0	1	2	13
Candidate	3	0	0	0	0	1	1	5
Experimental, nonessential	0	0	0	0	0	1	1	2
Total	19	0	4	0	0	5	4	32
BLM								
Sensitive	83	5	6	6	6	18	16	140
State of Colorado								
Endangered	0	0	2	1	0	1	4	8
Threatened	0	0	2	0	0	2	0	4
Special concern	0	0	2	1	2	8	1	14
Total	0	0	6	2	2	11	5	26
State of Utah								
Special concern	0	4	1	2	4	10	12	33
State of Wyoming								
Special concern	72	0	6	4	0	23	15	120
Total species[a]	158	5	10	6	6	39	26	250

[a] Totals represent the total number of listed species within oil shale basins and STSAs and do not represent the sum of row values. Species can be listed by both state and federal governments.

Table 3.7.4-2 gives the number of species, by listing category, that could occur within oil shale basins or STSAs where development could occur. The largest number of species listed or candidates for listing by the USFWS under the ESA potentially occurs within STSAs, but this reflects the more dispersed nature of these areas and consequently, the larger overall area and potential for a wider range of habitats.

3.7.4.1 Species Listed under the Endangered Species Act

There are 32 species that are listed or candidates for listing by the USFWS under the ESA and that occur in the counties in which oil shale basins and STSAs under consideration in this PEIS are located. The likelihood of occurrence in study areas cannot be fully determined at this

TABLE 3.7.4-2 Federally and State-Listed Species That Occur within Counties with the Potential for Oil Shale or Tar Sands Development

	Oil Shale Basins and STSAs					
Status	Green River	Washakie	Piceance	Uinta	STSAs	Total[a]
USFWS						
Endangered	0	0	2	7	10	12
Threatened	1	0	4	5	9	13
Candidate	0	0	3	2	2	5
Experimental, nonessential	1	1	2	1	1	2
Total	2	1	11	15	22	32
BLM						
Sensitive	48	35	43	48	96	140
State of Colorado						
Endangered	0	0	7	0	0	8
Threatened	0	0	3	0	0	4
Special concern	0	0	14	0	0	14
Total	0	0	24	0	0	26
State of Utah						
Special concern	0	0	0	18	23	33
State of Wyoming						
Special concern	120	85	0	0	0	120
Total species[b]	129	93	57	62	117	250

[a] Totals equal the number of species within listing categories and do not represent the sum of column values. Listed species can occur in more than one basin or STSA.

[b] Totals represent the total number of listed species within oil shale basins and STSAs and do not represent the sum of row values. Species can be listed by both state and federal governments.

time because actual project locations and footprints will not be determined until some later date. A complete evaluation of listed species in the study areas will be made at that time, before leasing or development is approved. Listed species that could occur in the study areas (based on National Heritage Program information and state and federal records) are discussed in this section and presented in alphabetical order. Basic information is provided on life history, habitat needs, and threats to populations. Included is the likelihood of their presence within oil shale basins and STSAs (Table 3.7.4-3).

3.7.4.1.1 Autumn Buttercup. The autumn buttercup is a perennial herbaceous plant that is endemic to the Sevier River Valley in western Garfield County, Utah (UDWR 2006). Currently, only two small autumn buttercup populations are known. Its habitat is low, herbaceous wet meadow communities on drier peat hummocks, or in open areas of these communities; it is found at elevations of about 1,940 to 1,980 m (6,365 to 6,496 ft). Sagebrush-dominated plant communities typically are found surrounding wetland communities. The presence of freshwater seeps and lack of livestock grazing seem to be important habitat elements needed for species survival (NatureServe 2006).

The autumn buttercup was listed as federally endangered on July 21, 1989 (54 FR 20550), and a recovery plan was prepared on September 16, 1991 (USFWS 1991a). The recovery plan had a goal of preventing extinction and establishing populations in unoccupied suitable habitat. Criteria for successful recovery included increasing the current population to about 1,000 plants on 10 acres, preserving the species under greenhouse conditions, and establishing additional populations of at least 20,000 individuals.

The Center for Plant Conservation (CPC 2006a) reports that a survey of the only known autumn buttercup population in 1982 indicated a total of 400 plants. By 1988, the population had dropped to only 10 to 20 individual plants. A 44-acre parcel supporting this population was purchased by the Nature Conservancy in 1989 and was named the Sevier Valley Preserve. An additional population of about 200 plants was found shortly after the land was purchased (CPC 2006a). The Nature Conservancy has fenced the 44-acre parcel to exclude livestock grazing in an attempt to protect the autumn buttercup and increase its chances of reproduction. By 1990, the total population was estimated to be 200 individuals with 42 plants producing flowers (USFWS 1991a). The following year, researchers counted 488 plants, a substantial increase over previous years (NatureServe 2006). Many of these plants were discovered in the vicinity of the population of 200 counted in 1990. No data were found on population results for subsequent years.

The autumn buttercup grows to a height of 1 to 2 ft and usually flowers in July and August with 6 to 10 yellow flowers per plant (USFWS 1991a). Seed production occurs in late July and is completed by early September.

Potential threats to the autumn buttercup include livestock grazing on areas suitable for introduction of new populations, herbivory by voles and other small mammals, limited habitat available, and interspecies competition (NatureServe 2006). The UDWR (2006) also suggests

TABLE 3.7.4-3 Occurrence of Species Listed or Candidates for Listing under the Endangered Species Act That Occur in Counties with the Potential for Oil Shale or Tar Sands Development

			Known or Potential Occurrence in Oil Shale Basins and STSAs[b]				
Species	Scientific Name	Listing Status[a]	Green River	Washakie	Piceance	Uinta	STSAs
Autumn buttercup	*Ranunculus aestivalis*	E	–	–	–	–	–
Barneby reed-mustard	*Schoenocrambe barnebyi*	E	–	–	–	–	×
Barneby ridge-cress	*Lepidium barnebyanum*	E	–	–	–	×	–
Black-footed ferret	*Mustela nigripes*	XN	×	×	×	×	×
Bonytail	*Gila elegans*	E	–	–	–	×	×
California condor	*Gymnogyps californianus*	E	–	–	–	–	×
Canada lynx	*Lynx canadensis*	T	×	–	×	×	×
Clay reed-mustard	*Schoenocrambe argillacea*	T	–	–	–	×	×
Colorado pikeminnow	*Ptychocheilus lucius*	E	–	–	×	×	×
Debeque phacelia	*Phacelia scopulina* var. *submutica*	C	–	–	×	–	–
Dudley Bluffs bladderpod	*Lesquerella congesta*	T	–	–	×	–	–
Dudley Bluffs twinpod	*Physaria obcordata*	T	–	–	×	–	–
Gunnison prairie dog	*Cynomys gunnisoni*	C	–	–	–	–	–
Humpback chub	*Gila cypha*	E	–	–	–	×	×
Jones cycladenia	*Cycladenia humilis* var. *jonesii*	T	–	–	–	–	×
Last chance townsendia	*Townsendia aprica*	T	–	–	–	–	×
Maguire daisy	*Erigeron maguirei*	T	–	–	–	–	×
Mexican spotted owl	*Strix occidentalis lucida*	T	–	–	–	×	×
Navajo sedge	*Carex specuicola*	T	–	–	–	–	–
Parachute beardtongue	*Penstemon debilis*	C	–	–	×	–	–
Razorback sucker	*Xyrauchen texanus*	E	–	–	×	×	×
San Rafael cactus	*Pediocactus despainii*	E	–	–	–	–	×
Shrubby reed-mustard	*Schoenocrambe suffrutescens*	E	–	–	–	×	×
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	–	–	–	×	×
Uinta Basin hookless cactus	*Sclerocactus glaucus*	T	–	–	×	×	×
Utah prairie dog	*Cynomys parvidens*	T	–	–	–	–	–
Ute ladies'-tresses	*Spiranthes diluvialis*	T	–	–	–	×	×
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	C	–	–	–	×	×
White River beardtongue	*Penstemon scariosus* var. *albifluvis*	C	–	–	×	×	×

TABLE 3.7.4-3 (Cont.)

Species	Scientific Name	Listing Status[a]	Known or Potential Occurrence in Oil Shale Basins and STSAs[b]				
			Green River	Washakie	Piceance	Uinta	STSAs
Whooping crane	*Grus americana*	XN	–	–	×	–	–
Winkler cactus	*Pediocactus winkleri*	T	–	–	–	–	×
Wright fishhook cactus	*Sclerocactus wrightiae*	E	–	–	–	–	×

[a] C = candidate; E = endangered; T = threatened; XN = experimental, nonessential population.

[b] A dash = not expected to occur in basin or STSA; × = known or potential occurrence in basin or STSA.

that habitat has been altered from presettlement times by water being diverted for irrigation and introduction of domestic livestock.

Within potential development areas, the autumn buttercup occurs only in a small area of the Sevier River Valley in western Garfield County, Utah. This area is located in the southeastern portion of Garfield County. There are no known autumn buttercup populations in this area of the county or in the Tar Sand Triangle STSA in the extreme northeastern portion of the county. No populations of this species are known to occur in potential oil shale development areas.

3.7.4.1.2 Barneby Reed-Mustard. The Barneby reed-mustard is a perennial herb that is endemic to the Colorado Plateau in Emery and Wayne Counties in Utah (UDWR 2006). It occurs on steep, north-facing slopes on red, fine-textured soils that are rich in selenium and gypsum, on the Moenkopi and Chinle Formations at elevations between 1,460 and 1,985 m (4,790 and 6,512 ft). The Barneby reed-mustard grows in mixed desert shrub and pinyon-juniper communities. Common plants growing in these communities are sagebrush (*Artemisia* sp.), rabbitbrush (*Chrysothamnus nauseosus*), and Mormon tea (*Ephedra* spp.) (USFWS 1994a).

The Barneby reed-mustard was federally listed as endangered on January 14, 1992 (57 FR 1398). The USFWS prepared a recovery plan that laid out goals for recovery and management of this species and two closely related mustard species (USFWS 1994a).

Population estimates have varied from about 1,000 individual plants in the two remaining populations in 1992 to about 2,000 individuals in 2000 (CPC 2006b). One of the known populations is on BLM-administered land near Muddy Creek in the southern portion of the San Rafael Swell. The other population is in Capitol Reef National Park in the Fremont River drainage west of Fruita (USFWS 1994a).

The Barneby reed-mustard grows to heights of 10 to 25 cm (4 to 10 in.) from a branched woody base. About 5 to 20 white- or lilac-colored flowers grow on racemes at the end of the plant's leafy stems. Flowers develop in late April through June (UDWR 2006), with seed production occurring during this period and continuing into July.

Potential threats to the Barneby reed-mustard include uranium mining activities near the population in the San Rafael Swell and foot traffic by park visitors in Capitol Reef National Park (USFWS 1994a). The range of the Barneby reed-mustard occurs near the San Rafael STSA.

3.7.4.1.3 Barneby Ridge-Cress. The Barneby ridge-cress is a perennial plant that occurs in Duchesne County, Utah. The USFWS determined that the entire known population occurs on the Uintah and Ouray Reservation of the Ute Indian Tribe (USFWS 1993a). It was first listed as endangered on September 28, 1990, and is endangered in its entire range (USFWS 2006c).

The Barneby ridge-cress occurs as a series of disjunct populations on marly shale barrens of the Uinta Formation on the three ridges at elevations between 1,890 and 1,980 m (6,201 and

6,496 ft) on both sides of Indian Creek south of the town of Duchesne (USFWS 1993a). It grows in isolated stands in desert shrub and pinyon-juniper woodland communities dominated by pinyon pine *(Pinus edulis)* and Utah juniper *(Juniperus osteosperma)*, and in association with other species that can tolerate the white shale barrens habitats situated as "islands" within unsuitable soil types from other geologic substrates. An estimated 5,000 individuals are known to grow in an area of about 200 ha (494 acres) (Nature Serve 2006). Flowering occurs in April and May, seed formation in late May and June, and seed shed in June and July.

Potential threats to the Barneby ridge-cress include a variety of ground-disturbing activities such as oil and gas exploration, drilling and production, and OHV use. The USFWS determined that the entire population is underlain by petroleum deposits that were being developed as of 1993 (USFWS 1993a), although listing the species as endangered has protected it by deterring development of petroleum resources in occupied habitats. Within potential development areas, the range of the Barneby ridge-cress occurs about 25 km (16 mi) from the Pariette STSA and the Uinta Basin.

3.7.4.1.4 Black-Footed Ferret. The black-footed ferret is a small, nocturnal member of the weasel family. Its historic range and habitat requirements are closely tied to prairie dogs (*Cynomys* spp.); it lives almost exclusively in prairie-dog colonies in open grassland and uses prairie-dog burrows as dens and for shelter (USFWS 1998a). The ferrets also hunt prairie dogs, which are their principal prey.

The primary cause of the black-footed ferret population decline was the reduction in prairie dogs during the nineteenth century (USFWS 1998a). Widespread poisoning of prairie dogs to improve livestock range, loss of habitat by conversion to agriculture, and disease greatly reduced prairie-dog populations (Lockhart et al. 2006). Other threats to black-footed ferrets have included predator-control programs and diseases such as canine distemper and plague.

When the black-footed ferret was listed as an endangered species, few wild populations were known to exist. When the last known wild population disappeared in 1974, the species was thought to be extinct (USFWS 1998a). However, a small population was discovered in Wyoming in 1981. Subsequent declines in this population prompted capture of the remaining ferrets in 1986 and 1987. Currently, the only known wild populations are the result of reintroductions in Arizona, Colorado, Montana, South Dakota, Utah, and Wyoming. Populations in Uintah and Duchesne Counties, Utah; Moffat and Rio Blanco Counties, Colorado; and a portion of Sweetwater County, Wyoming, are designated as nonessential, experimental populations (USFWS 1998a). Designation as nonessential, experimental populations assures that this is treated similarly to a species proposed for listing and may be subject to conferencing requirements under Section 7(a)(2) of the ESA to ensure that the federal actions will not jeopardize the species.

3.7.4.1.5 Bonytail. The bonytail is endemic to the Colorado River Basin and was historically common to abundant in warmwater reaches of larger rivers of the basin from Mexico to Wyoming. The species experienced a dramatic, but poorly documented, decline starting in about 1950 (USFWS 2002a). Critical habitat has been designated for the species in portions of the Colorado, Green, and Yampa Rivers (USFWS 1994b).

Currently, no self-sustaining populations of bonytail are known to exist in the wild, and very few individuals have been caught anywhere. Releases of hatchery-reared adults into riverine reaches in the Upper Colorado River Basin have resulted in low survival, with no evidence of reproduction or recruitment.

Bonytail can live up to about 50 years (Rinne et al. 1986). Their habitat requirements are poorly understood (USFWS 2002a). On the basis of observations of closely related species, it is expected that bonytail in rivers probably spawn in spring over rocky substrates. It has been recently hypothesized that flooded bottomlands may provide important bonytail nursery habitat. Adult bonytail captured in Cataract, Desolation, and Gray Canyons were sympatric with humpback chub in shoreline eddies among emergent boulders and cobble, and adjacent to swift current (Valdez 1990).

The bonytail could occur only in portions of the Uinta Basin (Green River watershed) and in the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green River and Colorado River watersheds).

3.7.4.1.6 California Condor. The California condor is an opportunistic scavenger that has been reintroduced into portions of its original range since nearing extinction in the 1970s. Prior to settlement by the pioneers in the mid-1800s, its range extended along the entire Pacific Coast from British Columbia to Baja California (USFWS 2006a). By the 1940s, the species distribution was limited to the coastal mountains of Southern California, with nesting sites located mainly in rugged, chaparral covered mountains. Foraging was mostly in the foothills and grasslands of the San Joaquin Valley at that time. The total species size numbered only 22 in 1982, and in 1985, the USFWS decided to capture all remaining condors for safety and to start a captive breeding program (Behrens and Brooks 2000). After a captive breeding program, the first condors were released in 1992 in the Sespe Condor Sanctuary managed by the Hopper Mountain National Wildlife Refuge (USFWS 2006b). At that time the population size was 63 individuals, all in captivity. Other reintroductions have taken place in south-central California and the Grand Canyon area of northern Arizona. The goal of the California Condor Recovery Plan completed in 1975 by the USFWS and numerous other agencies and societies was to establish two populations each with about 150 individuals and a minimum of 15 breeding pairs (Behrens and Brooks 2000). As of April 2000, the California condor population had increased to 157, of which 62 were released into the wild. The total population is estimated to be about 200 individuals today (National Parks Conservation Association 2006).

The diet of California condors consists of carcasses of dead animals, including deer, cattle, marine mammals, and the remains of field-dressed game (USFWS 2006a). Rock pools are important as bathing sites that condors use after feeding.

California condors nest in caves or crevices in rock formations, or rarely in cavities of giant sequoia trees (*Sequoia giganteus*). Courtship and breeding occur from December through the spring months in California. Incubation by both parents lasts about 56 days. Chicks fledge at 2 to 3 months of age but they remain near the nest site for another 3 months. First flight occurs at about 6 months and juveniles remain with adult condors until the following year. Condors do not breed until about 6 years of age (USFWS 2006a).

Potential threats to the continued existence of the California condor include injury or death from collisions with power lines, human homes being built in mountainous areas occupied by the condors, consuming carrion containing pesticide residues, lead poisoning from eating carrion containing shot gun pellets, and illegal shooting (Behrens and Brooks 2000; USFWS 2006a). The large size of adults [about 10 kg (20–22 lb)] and long wingspan (about 9 ft) make the condor vulnerable to collisions with power lines, resulting in injury or death from electrocution. The range of the California condor includes the Tar Sand Triangle and White Canyon STSAs.

3.7.4.1.7 Canada Lynx. The Canada lynx is a medium-sized cat. It is federally listed as endangered only in the contiguous United States. Critical habitat has not been designated for this species. Threats to the Canada lynx include habitat loss and modification from logging, fire suppression, and fragmentation, and isolation of suitable habitat; hunting and trapping resulting in severe population reductions; and increased human access into occupied habitat resulting in increased human disturbance. Competition with, and displacement by, the coyote and bobcat can also occur when these species move into occupied Canada lynx habitat (USFWS 1997b). The alteration of forests by human activities or the use of motorized vehicles, including snowmobiles, in lynx habitat may allow for the movement of coyotes into that habitat (USFWS 1998b).

The primary habitat of the Canada lynx for denning and shelter in western states is mature mesic coniferous forest, primarily composed of spruce and fir, with downed logs and windfalls, particularly those at montane and subalpine elevations (USFWS 1997b). Suitable denning stands are at least 1 ha (2.5 acres) in size, provide minimal human disturbance, and are near foraging habitat (USFWS 1998b). The snowshoe hare (*Lepus americanus*), the principal prey of the Canada lynx, prefers early successional forests with a shrubby understory. Thus, lynx depend on a mosaic of mature and early successional forest stands, a landscape habitat structure that was typically maintained by forest fires (USFWS 1997b). Lynx populations often rise and fall with those of the snowshoe hare. Other species, including red squirrels, other small mammals, and birds, are also taken by lynx. Populations in the contiguous United States have a greater reliance on these alternative prey species than northern populations (Ruediger et al. 2000). Canada lynx in shrub-steppe habitats prey on jackrabbits and ground squirrels.

Contiguous forest is important for connectivity between habitat blocks; however, dispersal may occur through nonforested habitats that are otherwise unattractive to lynx. Within these communities, riparian systems and relatively high ridge systems may be particularly important for landscape connectivity (Ruediger et al. 2000).

Although Canada lynx still occur in Colorado, Utah, and Wyoming, they are extremely rare (USFWS 1997b). In Utah, lynx are thought to occur in remote areas of the Uinta Mountains, particularly along the Wyoming border (USFWS 1998b). A self-sustaining resident population does not likely exist in Utah, but individuals may be present. Lynx habitat in Colorado is located within the Southern Rocky Mountains region, which also includes southeastern Wyoming, and is separated from the Northern Rocky Mountain region (which includes Utah) by natural barriers such as the Wyoming Basin and the Green River (USFWS 2000b). Few if any lynx remained in Colorado until reintroductions into the southwestern part of the state began in 1999.

The Canada lynx could occur in the Green River, Piceance, and Uinta Basins and in the vicinity of the Asphalt Ridge STSA.

3.7.4.1.8 Clay Reed-Mustard. Clay reed-mustard is a perennial herbaceous plant that occurs in the Uinta Basin of Uintah County, Utah (UDWR 2006). It grows on clay soils rich in gypsum overlain with talus derived from shales and sandstones in the zone of contact between the Uinta and Green River geologic formations (USFWS 1994a). The UDWR characterized the species as growing on the Evacuation Creek Member of the Green River Formation, on substrates consisting of bedrock at the surface, on scree, and on fine-textured soils on north-facing slopes at elevations from about 1,440 to 1,770 m (4,724 to 5,807 ft) (UDWR 2006; NatureServe 2006).

Clay reed-mustard is known from only three populations and totals about 6,000 individuals. All populations occur on lands administered by the BLM within an area about 30 km (19 mi) wide from the west side of the Green River to the east side of Willow Creek in southwestern Uintah County (USFWS 1994a). This species occurs in mixed desert shrub communities. Flowering occurs from April to May, with seed production in May and June.

The clay reed-mustard was listed as threatened on January 14, 1992 (57 FR 1398). Subsequently, the USFWS prepared a recovery plan for the clay reed-mustard and two other related mustard species in 1994 (USFWS 1994a). One of the top priority goals defined in the recovery plan was to conduct inventories of suitable habitat for the clay reed-mustard. No additional information on the results of inventories that further describe any new populations or abundance data is known at this time.

Potential threats to the clay-reed mustard include a variety of ground-disturbing activities, such as oil and gas exploration and development (its entire habitat is underlain by oil shale), building stone removal, and OHV use (USFWS 1994a). The clay reed-mustard potentially occurs in the Uinta Basin and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs.

3.7.4.1.9 Colorado Pikeminnow. The Colorado pikeminnow is endemic to the Colorado River Basin. Colorado pikeminnow persist in the San Juan, Colorado, and Green Rivers and their tributaries; however, populations are severely reduced in all but the Green River (Platania et al. 1991; Tyus 1991; Osmundson and Burnham 1996). Critical habitat designated for Colorado pikeminnow occurs in the upper Colorado, Duchesne, Green, White, Gunnison, and Yampa Rivers. In designated river reaches, critical habitat includes both the river and its 100-year floodplain.

Colorado pikeminnow are long-lived fish (up to 40 years) and become sexually mature at 5 to 7 years of age (Vanicek and Kramer 1969; Hamman 1981; Tyus 1991). Adults are the most widely distributed of the pikeminnow life stages and move to spawning areas in spring. Eggs deposited on gravel spawning bars hatch within 5 to 7 days. Once they emerge, larvae are swept downstream, sometimes for long distances (Hamman 1981; Haynes et al. 1984; Nesler et al. 1988; Bestgen and Williams 1994; Bestgen et al. 1998). Larvae drift to relatively low-gradient river reaches where low-velocity, shallow, channel-margin habitats (e.g., backwaters) are common, and they remain there throughout the summer (Vanicek and Kramer 1969; Tyus and Haines 1991; Muth and Snyder 1995).

The Colorado pikeminnow is known to occur in portions of the Uinta Basin (Green, Duchesne, and White Rivers), Piceance Basin (White River), and in the vicinity of the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green, San Juan, and Colorado Rivers).

3.7.4.1.10 Dudley Bluffs Bladderpod. The Dudley Bluffs bladderpod is a perennial herbaceous plant that occurs in Rio Blanco County, Colorado. It is restricted to white shale outcrops of the Green River (Thirteen Mile Creek Tongue) and Uinta Formations, along areas exposed through the deepening of stream cuts at elevations of 6,000 to 6,700 ft (CPC 2006c; USFWS 1993b), and is found mostly on BLM-administered lands. All of the known occupied habitat is located on lands with oil shale resources.

The Dudley Bluffs bladderpod was listed as threatened on February 6, 1990 (55 FR 4152). The USFWS prepared a recovery plan in 1993 that called for habitat protection and inventory work on suitable habitat in the vicinity of known populations (USFWS 1993b).

Dudley Bluffs bladderpod is a small herb measuring only about 2 cm (1 in.) across and is difficult to see. It produces bright yellow flowers in dense clusters during April and May, with semispherical fruits forming in May or June (CPC 2006c). The total species distribution is believed to be in five populations on about 50 acres over a range of 10 mi (USFWS 1993b). The two largest known populations of about 10,000 individuals each were found growing together at the junction of Piceance Creek and Ryan Gulch about 2 mi north of Dudley Bluffs. The Center for Plant Conservation notes that there are 7 known locations of Dudley Bluffs bladderpod in this same 10-mi-long area (CPC 2006c).

Potential threats to continued survival of the Dudley Bluffs bladderpod include oil shale development and other surface-disturbing activities. This species is so small that it was subjected to destruction during the annual monitoring of existing populations to such an extent that the USFWS suggested that the schedule and procedures for future monitoring activities by researchers be carefully assessed (USFWS 1993b).

The Dudley Bluffs bladderpod is known to occur in the Piceance Basin in Rio Blanco County, Colorado.

3.7.4.1.11 Dudley Bluffs Twinpod. The Dudley Bluffs twinpod is a small, herbaceous perennial that grows on white outcrop and steep slopes along exposed stream cuts. It is restricted to the Thirteen Mile Creek Tongue and Parachute Creek Member of the oil shale–bearing Green River Formation in Rio Blanco County, Colorado (USFWS 1993b). The Dudley Bluffs area also supports another federally listed threatened species (Dudley Bluffs bladderpod) in the same general area. Remnants of pinyon pine, Utah juniper woodlands, and cold desert shrub plant communities occur on mesas and along the slopes where Dudley Bluffs twinpod grows (USFWS 1993b; Colorado State Parks 2006b). The Dudley Bluffs area is designated as an ACEC. This designation means that the BLM will develop a habitat management plan that gives priority consideration to rare plant species (in this case) when considering the impacts of future activities approved by the BLM in the ACEC.

The USFWS listed the Dudley Bluffs twinpod as threatened on February 6, 1990 (55 FR 4152), and published a recovery plan in 1993 (USFWS 1993b). The recovery plan laid out objectives for future studies and protective measures for the species. The habitat for this species is on the surface of oil shale deposits that are suitable for either underground mining or surface mining of oil shale.

Dudley Bluffs twinpod is named for its distinct heart-shaped fruits. It flowers in May and June and produces fruits in June and July. There are 5 large populations on about 101 ha (250 acres) (USFWS 1993b). In total, about 10,000 individual plants occur in 12 sites 2 mi north of Dudley Bluffs near the junction of Piceance Creek and Ryan Gulch (CPC 2006d).

Potential threats to continued existence of the Dudley Bluffs twinpod include oil shale development activities and other surface disturbance (USFWS 1993b). The Dudley Bluffs twinpod occurs in the Piceance Basin in Rio Blanco County, Colorado.

3.7.4.1.12 Humpback Chub. The humpback chub is endemic to the Colorado River Basin. The species occurs primarily in relatively inaccessible canyon areas (Tyus 1998). The known historic distribution of the humpback chub includes portions of the main stem of the Colorado River and four of its tributaries, the Green, Yampa, White, and Little Colorado Rivers (USFWS 1990a). Critical habitat designated for humpback chub includes portions of the upper Colorado, Green, White, Gunnison, and Yampa Rivers.

Humpback chub complete their entire life cycle in canyons with deep water, swift currents, and rocky substrates (USFWS 2002b). Spawning occurs from April to June over cobble bars and shoals that are adjacent to low-velocity shoreline eddies as flow decreases from the annual spring peak (USFWS 2002b). Emerging humpback chub larvae do not drift long distances, but instead remain in the general vicinity of spawning areas (Valdez et al. 1982; Robinson et al. 1998; Chart and Lentsch 1999). Young require low-velocity shoreline habitats (including eddies and backwaters) that are more prevalent under base-flow conditions. Humpback chubs mature in 2 to 3 years and may live 20 to 30 years (Valdez et al. 1992; Hendrickson 1993).

The humpback chub occurs in the vicinity of potential development areas in the Uinta Basin and the Asphalt Ridge, Hill Creek, Sunnyside, Tar Sand Triangle, and White Canyon STSAs.

3.7.4.1.13 Jones Cycladenia. The Jones cycladenia is a perennial herb that occurs in the canyonlands region of the Colorado Plateau (UDWR 2006). It grows on gypsum-laden soils derived from the Summerville, Cutler, and Chinle Formations that are shallow, fine textured, and mixed with rock fragments. This species typically is found in mixed desert shrub, pinyon-juniper, and Eriogonum-ephedra (wild buckwheat-mormon tea) plant communities at elevations from about 1,220 to 2,075 m (4,002 to 6,808 ft).

Jones cycladenia is a long-lived perennial that overwinters as belowground rhizomes. It grows to heights of 10 to 15 cm (4 to 6 in.) and produces pinkish-rose colored flowers from mid-April to early June (CPC 2006e). Seed production does not seem to be as important for reproduction as asexual means by sending up new plants from the roots.

Potential threats to this species include surface-disturbing activities such as oil and gas development activities and OHV use. The Jones cycladenia occurs in Emery, Garfield, Grand, and Kane Counties in Utah. It could occur in the vicinity of projects in the Uinta Basin and the Hill Creek, Pariette, P.R. Spring, and San Rafael STSAs.

3.7.4.1.14 Last Chance Townsendia. The last chance townsendia is a perennial herb that occurs in Emery, Sevier, and Wayne Counties in Utah (UDWR 2006). It grows on barren, silty, silty clay, or gravelly clay soils of the Mancos Shale Formation at elevations ranging from 1,686 to 2,560 m (5,531 to 8,399 ft). Most plants grow on soils derived from a shale lens with a fine silty texture and high alkalinities, and are distributed as isolated pockets (USFWS 1993c). This species is found in desert shrub and pinyon-juniper communities.

The last chance townsendia flowers from April to May, and fruiting occurs in May and June (USFWS 1993c). Fifteen populations were known in 1993, each with a range numbering from 6 to about 2,000 individuals over an area of about 1 acre. The total population as of 1994 was estimated at 6,000 individuals. No recent information was available on population numbers within the known distribution range. Most of the populations of the last chance townsendia are on BLM-administered lands and in Capitol Reef National Park (USFWS 1993c). All known populations are in a band less than 5 mi wide and 30 mi long in southwestern Emery County and southeastern Sevier County, Utah.

The USFWS prepared a recovery plan in 1993 (USFWS 1993c). The last chance townsendia was listed as threatened on August 21, 1985 (50 FR 33734). It was given a rating with a high degree of threat and low recovery potential. The recovery plan set goals of maintaining a documented population of 30,000 individuals and maintaining 20 populations with at least 500 individuals each. The plan also called for formal land management designations on known populations to ensure the existence of long-term habitat.

Potential threats to continued existence of the last chance townsendia include disturbance or loss of habitat from mineral and energy development, road construction, and trampling by livestock. Future coal mining at the Emery coal field could eliminate populations if protective measures are not in place. The last chance townsendia could occur in the vicinity of the San Rafael STSA.

3.7.4.1.15 Maguire Daisy. The Maguire daisy is a small (up to 5 in. in height) perennial herb that occurs on sand- and detritus-weathered surfaces of the Navajo, Wingate, and Chinle Sandstone Formations in mountain shrub, Douglas-fir, ponderosa pine, and juniper woodland plant communities at elevations of 1,600 to 2,500 m (5,249 to 8,202 ft). Plants grow on slickrock crevices, ledges, and bottoms of washes. It is found in locations in Emery, Garfield, and Wayne Counties in Utah (UDWR 2006).

The Maguire daisy was originally listed as endangered but was downlisted to threatened status in 1996 on the basis of DNA evidence of what was thought to be two separate varieties (CPC 2006f). At the time of reclassification to threatened, the total population was believed to total about 3,000 individuals from 12 locations within the 3-county area that composed its known distribution.

Flowering occurs from mid-June through July. Plants typically have 1 to 5 flower heads with white to pinkish ray flowers around a yellow center that grows from a branched woody base (BLM 2006h). Seed formation likely occurs in July and August, although no specific information on the time of seed shed was found.

Potential threats to continued existence of the Maguire daisy include loss of habitat and genetic viability, trampling by hikers and livestock, OHVs, and mineral and energy exploration and development (CPC 2006f). The Maguire daisy could occur in the vicinity of the San Rafael STSA.

3.7.4.1.16 Mexican Spotted Owl. The Mexican spotted owl occurs from southern British Columbia, Canada, to central Mexico. It is a rare permanent resident in the southern and eastern parts of Utah on the Colorado Plateau (UDWR 2006). The primary habitat of the spotted owl in Utah is steep rocky canyons, although forested areas are also important habitat in Utah and elsewhere in the spotted owl's range (UDWR 2006). The spotted owl is most common in closed canopy forests in steep canyons with uneven-aged tree stands with high basal area, with an abundance of snags and downed logs. The State of Utah shows the Mexican spotted owl distribution to include sizeable portions of San Juan, Wayne, Garfield, Kane, and Iron Counties in Utah as well as a small area of extreme eastern Carbon County and extreme east-central Uintah County (UDWR 2006). The latter area is located near the Raven Ridge STSA.

The Mexican spotted owl was listed as threatened on March 16, 1993 (58 FR 14248). Critical habitat was designated on June 5, 1995 (63 FR 14378), but several court rulings resulted in the USFWS removing the critical habitat designation on March 25, 1998 (63 FR 14378). In March 2000, the USFWS was ordered by the courts to propose critical habitat that resulted in the current designation that includes 4.6 million acres in Arizona, Colorado, New Mexico, and Utah on federal lands (USFWS 2006e). A recovery plan for the Mexican spotted owl was published in December 1995 (USFWS 1995a). At the time of federal listing in 1993, the total population of Mexican spotted owls was estimated at 2,100.

A total of 2,252,857 acres in five areas of southern Utah were designated as critical habitat. Critical habitat within the study areas includes two parcels in Utah designated as CP-14 and CP-15. Area CP-15 is along the west side of the Green River and includes land north and south of the border between Carbon and Emery Counties (USFWS 2006e). Area CP-14 is farther south and includes lands on both sides of the Colorado River in portions of San Juan, Wayne, and Garfield Counties.

The Mexican spotted owl feeds mainly on rodents but also consumes rabbits, birds, reptiles, and insects. Nest sites are either in trees (typically those with broken tops), tree trunk cavities, and cliffs along canyon walls (BLM 2006h). Breeding takes place in the spring (March), with egg-laying in late March or early April. After a 30-day incubation period, hatching occurs and fledging takes place in 4 to 5 weeks. The young depend on the adults for food in the summer and eventually disperse from the nesting area in the fall (USFWS 2006f).

Potential threats to the Mexican spotted owl include habitat loss from logging of old growth forest, disturbance of owls by recreational use on federal lands, overgrazing, loss of habitat and disturbance of owls from road development within canyons, and habitat loss from catastrophic fires.

Within potential project areas, the Mexican spotted owl is likely to occur only in southern Utah (UDWR 2006). All areas in Colorado where the species occurs and where critical habitat has been designated are located well south of development areas (e.g., >160 km [100 mi]). The Mexican spotted owl could occur in the vicinity of the Raven Ridge, Tar Sand Triangle, and White Canyon STSAs. The range is within 5 km (3 mi) of the Uinta Basin.

3.7.4.1.17 Navajo Sedge. The Navajo sedge is a perennial plant that is restricted to shady seep pockets or alcoves in hanging garden habitats in Navajo Sandstone at elevations ranging from about 1,150 to 1,820 m (1,150 to 5,971 ft) (UDWR 2006). These habitats are characteristic of the deep, sheer-walled canyons of the Colorado Plateau. The Navajo sedge is known from San Juan and Kane Counties in Utah and on the Navajo Indian Reservation in Arizona (Coconino, Navajo, and Apache Counties) (AGFD 2006; CPC 2006g).

The Navajo sedge was federally listed as threatened on May 8, 1985, and critical habitat was described also in that listing (50 FR 10370). A recovery plan was approved on September 24, 1987. Critical habitat is on the Navajo Indian Reservation in Coconino County; the habitat contains three springs near Inscription House Ruins (50 FR 19370).

The Navajo sedge grows to a height of 25 to 40 cm (10 to 16 ft) and has grass-like leaves that droop downward. Flowers are arranged in spikes, with two to four spikes per stem, and develop during late June and July; seeds are produced in July and August (CPC 2006g; UDWR 2006).

Potential threats to continued existence of the Navajo sedge include groundwater pumping, water diversion projects, and livestock grazing (AGFD 2006). Sheep grazing and groundwater pumping are considered to be the greatest threats to the species in Utah (UDWR 2006).

The Navajo sedge occurs in San Juan County, Utah, with a very small portion of its range in extreme northern Kane County (UDWR 2006); these populations do not occur in the vicinity of any potential oil shale or tar sands development.

3.7.4.1.18 Razorback Sucker. The razorback sucker, endemic to the Colorado River Basin, was once widely distributed in warmwater reaches of larger rivers of the basin from Mexico to Wyoming (Muth et al. 2000). Today, the species is one of the most imperiled fishes in the Colorado River Basin and exists naturally as only a few disjunct populations or scattered individuals (Minckley et al. 1991; Bestgen et al. 2002). Although the largest riverine population is in the middle Green River (Tyus 1987; Modde et al. 1996), the most recent estimate indicates that this population has been declining, that it has little or no recruitment, and that only about 100 individuals remain (Bestgen et al. 2002). The lack of recruitment has been attributed mainly to the cumulative effects of habitat loss and modification caused by water and land development and predation on early life stages by non-native fishes (Muth et al. 2000).

Habitats used by adult razorback suckers include deeper runs, eddies, backwaters, and flooded off-channel habitats in spring; runs and pools over submerged sandbars in summer; and low-velocity runs, pools, and eddies in winter (Tyus 1987; Osmundson and Kaeding 1989; Valdez and Masslich 1989; Tyus and Karp 1990; Modde 1997; Modde and Wick 1997; Modde and Irving 1998). Young razorback suckers require nursery environments with quiet, warm, shallow water, such as tributary mouths, backwaters, or inundated floodplain habitats (Taba et al. 1965; Gutermuth et al. 1994; Modde 1996, 1997; Muth et al. 1998).

Razorback suckers make annual spawning runs to specific river areas (Minckley 1973). Larval razorback suckers emerge from spawning substrates and are transported downstream into off-channel nursery habitats with quiet, warm, shallow water (e.g., tributary mouths, backwaters, and inundated floodplain habitats). The most important of these habitats are located in the middle Green River within Ouray National Wildlife Refuge.

The razorback sucker occurs in the vicinity of the Uinta Basin (Duchesne and Green Rivers), Piceance Basin (White River), and the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green and Colorado Rivers). Critical habitat designated for razorback sucker occurs in the upper Colorado, Duchesne, Green, and White Rivers. In designated river reaches, critical habitat includes both the river and its 100-year floodplain.

3.7.4.1.19 San Rafael Cactus. The San Rafael cactus is a perennial species that grows on fine-textured soils rich in calcium derived from the Carmel Formation and the Sinbad Member of the Moenkopi Formation. It occurs on benches, hilltops, and gentle slopes in open pinyon-juniper woodland and mixed desert shrub grassland communities at elevations ranging from 1,450 to 2,080 m (4,757 to 6,824 ft) (UDWR 2006).

The USFWS listed the San Rafael cactus as endangered on September 16, 1987 (52 FR 349917). A recovery plan was prepared in 1995 (USFWS 1995b). A major focus of the recovery plan was to conduct additional surveys in Emery County, Utah, in an attempt to identify new populations. Identifying at least five separate populations that are viable at the population level and maintaining these populations were set forth as important goals to realize recovery of the species.

The San Rafael cactus is extremely small, growing to a height of only about 1.5 to 2.0 in. and has a diameter ranging from 1.2 to 3.8 in. (USFWS 1995b). Flowering occurs during April and May, and fruiting occurs in May and June.

In 1995, the total size of the San Rafael cactus population was estimated to be about 20,000, located in three separate populations, all within the San Rafael Swell north of the San Rafael River in Emery County (USFWS 1995b; BLM 2006h). The estimated population had dropped to 6,000 in 1998.

Potential threats to the continued existence of the San Rafael cactus include habitat destruction from OHVs, trampling by hikers and livestock, oil and gas exploration activities, and from exploration and mining for gypsum and other minerals (USFWS 1995b).

The San Rafael cactus occurs in Emery County, Utah, and a small area in the northern extreme of Wayne County (UDWR 2006). There is a potential for the species to be present in the vicinity of the San Rafael STSA.

3.7.4.1.20 Shrubby Reed-Mustard. Shrubby reed-mustard is a perennial herb that is endemic to semibarren white shale layers of the Evacuation Creek Member of the Green River Formations in the Uinta Basin of Utah (NatureServe 2006; UDWR 2006). It grows in xeric, thin, fine-textured soils that overlay oil shale fragments at elevations ranging from 1,555 to 2,042 m (5,101 to 6,699 ft) (UDWR 2006). Plant communities where the shrubby reed-mustard occurs are mixed desert shrub and pinyon-juniper woodlands. The primary land use in the range of the shrubby reed-mustard is winter sheep grazing.

Currently, there are eight known populations totaling about 3,000 individual plants (NatureServe 2006). In 1994, the USFWS reported only three known populations (USFWS 1994a). The entire range of the shrubby reed-mustard is underlain by oil shale and conventional oil and gas deposits. It has a clump-forming growth form and produces yellow flowers during May and June (NatureServe 2006).

The shrubby reed-mustard was listed as endangered on October 6, 1987. A recovery plan for this species and two closely related mustard species was prepared by the USFWS (1994a). Some disagreement remains over the taxonomy of this species; some taxonomists consider it the sole member of the genus *Glaucocarpum* (NatureServe 2006).

Potential threats to continued existence of the species include ground-disturbing activities such as oil shale development, grazing, habitat destruction from collection of building stone, and oil and gas exploration and development (NatureServe 2006). The shrubby reed-mustard could occur within or in the vicinity of development areas in the Uinta Basin and the Hill Creek, Pariette, P.R. Spring, and Sunnyside STSAs (UDWR 2006).

3.7.4.1.21 Southwestern Willow Flycatcher. The southwestern willow flycatcher is a small, neotropical migrant bird. Its breeding range includes the southern portion of Utah, southwestern Colorado, western Texas, New Mexico, Arizona, southern Nevada, southern California, and northwestern Mexico (USFWS 2002d). It depends on riparian vegetation for nesting, foraging, and migratory habitat. The southwestern willow flycatcher historically nested primarily in willows, with a scattered overstory of cottonwoods. It now also nests in non-native tamarisk and Russian olive (USFWS 1997a). Nesting habitat is characterized by dense riparian shrubs, about 4 to 7 m (13 to 23 ft) tall, often with a high percentage of canopy cover, sometimes with a scattered overstory of cottonwood. Preferred nesting habitat seems to be associated with standing water, exposed sand bars, or nearby fluvial marshes. The southwestern willow flycatcher forages for insects within and occasionally above riparian vegetation.

Once common along rivers of the Southwest, the southwestern willow flycatcher population size is estimated to be between 1,200 and 1,300 pairs (USFWS 1997a). Population declines have been attributed to the loss, degradation, and fragmentation of its riparian habitat, and parasitism by brown-headed cowbirds (*Molothrus ater*). Suitable riparian habitats tend to be rare and widely separated. Impacts on its riparian habitat have resulted from urban, recreational, and agricultural development; fires; water diversion and impoundment; channelization; livestock grazing; and displacement of native shrubs by exotic species (USFWS 1997a).

The southwestern willow flycatcher is known to occur only in portions of the Uinta Basin and in the vicinity of the P.R. Spring, San Rafael, Tar Sand Triangle, and White Canyon STSAs. Critical habitat has not been designated for this species in the vicinity of potential development areas.

3.7.4.1.22 Uinta Basin Hookless Cactus. Recently, the USFWS proposed recognition of three separate, but related species that had been collectively referred to as the Uinta Basin hookless cactus (72 FR 53211). These species include the Pariette cactus (*Sclerocactus brevispinus*; found only in the Pariette Draw in the central Uinta Basin in Utah), *S. wetlandicus* (found in much of the Uinta Basin in Utah; proposed common name Uinta Basin hookless cactus), and *S. glaucus* (endemic to western Colorado; proposed common name Colorado hookless cactus). The USFWS found that the Pariette cactus warranted listing as endangered under the ESA, but that listing was precluded by other priorities. Each of the three species will continue to be considered threatened as part of the Uinta Basin hookless cactus complex until further action is taken. In the discussion below, all three species are referred to collectively as the Uinta Basin hookless cactus.

The Uinta Basin hookless cactus is a perennial species that occurs in Duchesne and Uintah Counties in Utah and in Delta, Garfield, Mesa, and Montrose Counties in Colorado (UDWR 2006). In Utah it is found growing on river benches, valley slopes, and rolling hills along the Duchesne River, Green River, and Mancos Formations. The Uinta Basin hookless cactus grows on xeric, fine-textured soils that have cobbles and pebbles on the surface at elevations from 1,360 to 2,000 m (4,461 to 6,562 ft) (UDWR 2006) and is typically found in salt desert shrub and pinyon-juniper plant communities. It is most abundant on south-facing slopes of about 30% grade. Other common plant species in communities where the Uinta Basin hookless cactus occurs include shadscale (*Atriplex confertifolia*), galleta (*Hilaria jamesii*), black sagebrush (*Artemisia nova*) and Indian rice grass (*Stipa hymenoides*) (USFWS 1990b).

The Uinta Basin hookless cactus flowers in April and May; fruiting occurs in May and June (USFWS 1990b). Seeds are typically small and are spread by gravity, water flow, and insects or birds. Total population numbers in Utah for the Uinta Basin hookless cactus are believed to be lower than the 10,000 estimate listed in the recovery plan prepared by the USFWS in 1990 (NatureServe 2006). Current population total numbers in Colorado are estimated at 10,000 individual plants.

Potential threats to the continued existence of this species include ground-disturbing activities, such as oil and gas exploration, drilling and removal, oil shale and tar sands mining, sand and gravel quarrying, building stone collection and quarrying, OHV use, road construction, parasitism by termite and beetle larvae, and moderate grazing by livestock resulting in trampling of cactus (USFWS 1990b; NatureServe 2006; UDWR 2006).

Within potential development areas, the Uinta Basin hookless cactus occurs mostly in Uintah County, Utah, with a smaller portion of the distribution range in eastern Duchesne County, south of the Duchesne River, and in southeastern Duchesne County along Nine Mile Creek. It occurs in Uintah County along the Green and White Rivers and on the Ouray National Wildlife Refuge just north of the town of Ouray (USFWS 1990b). The species is also known to occur in Garfield County, Colorado (Colorado Rare Plant Technical Committee 1999). On the basis of these distributions, the species could occur within or in the vicinity of development areas in the Piceance and Uinta Basins and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside STSAs.

3.7.4.1.23 Utah Prairie Dog. The Utah prairie dog occurs in grasslands, level mountain valleys, and in areas with deep well-drained soils with low-growing vegetation that allows for good visibility. It is one of three prairie dog species found in the state of Utah and occurs in the southwestern portion of the state (UDWR 2006). Utah prairie dogs are diurnal herbivores that live in colonies and spend much of their time underground. They are inactive or torpid during the winter months in severe winter weather (NatureServe 2006). Adults emerge from mid-March to early April. Breeding occurs in the spring, and young emerge from the burrows during May and early June. Adults are often dormant from mid-July to mid-August and are not often seen above ground during this period. Juveniles enter dormancy during October and November.

The Utah prairie dog feeds primarily on grasses and various seeds and flowers of shrubs and insects when available (NatureServe 2006). Common plant species consumed include alfalfa, leafy aster, European glorybind, and wild buckwheat seeds. Home range size of the Utah prairie dog varies from 1.2 to 8.2 ha (3 to 20 acres) and depends on habitat quality (NatureServe 2006).

The population size of the Utah prairie dog has varied considerably during historic times. In 1920, and prior to programs to control the Utah prairie dog, the total population was estimated at 95,000. Shooting and poisoning by ranchers, and likely periodic reductions from the plague, led to a decrease in population size, which was estimated at about 3,700 by 1984. By the spring of 1989, the adult population reached 9,200. The USFWS in its Report to Congress (as cited in NatureServe 2006) reported that this size was considered at risk of a population crash from a plague outbreak.

The Utah prairie dog was first listed as endangered in 1973. In 1984, it was reclassified as threatened by the USFWS and is currently the subject of a five-year status review to determine if listing the species as endangered is warranted. A recovery plan was prepared (USFWS 1991b) that described the current extent of existing populations and laid out management goals for continued survival of the species. A major goal was to improve the chances of long-term survival of the species in the following areas: West Desert in southern Beaver and Iron Counties, Paunsaugunt in western Garfield County, eastern Iron County and extreme northwestern Kane County, and the Awapa Plateau that extends from Sevier County southward through western Wayne and Piute Counties into northern Garfield County. The recovery plan also described plans to transplant Utah prairie dogs to unoccupied habitats and defined procedures to monitor transplants.

The 90-day finding on the petition to reclassify the Utah prairie dog from threatened to endangered (USFWS 2007a) acknowledged that impacts on Utah prairie dogs can occur as a result of many of the factors listed by the petitioners (e.g., loss of land conversion; livestock grazing; roads and OHV use; oil, gas, and mineral development; seismic exploration; and sylvatic plague). However, the USFWS determined that the petition did not identify or present substantial new information indicating that the level of threats to the species had changed significantly since its reclassification to threatened in 1984. The agency further stated that the current number of active colonies, and the number of Utah prairie dogs counted in 2005 (5,381) continues to be within the range of observed variation since 1976.

The Utah prairie dog occurs in Wayne and Garfield Counties in Utah. STSAs in these counties are in the northeastern and central portions of Garfield County and in southeastern portions of Wayne County. These areas are all east of known populations of the Utah prairie dog, on the basis of information presented in the recovery plan (USFWS 1991b).

3.7.4.1.24 Ute Ladies'-Tresses. The Ute ladies'-tresses is a perennial orchid. Flowering generally occurs from late July through August. Ute ladies'-tresses appears to have a very low reproductive rate. Individuals may require 10 years to reach reproductive maturity and thereafter do not flower every year. The percentage of flowering individuals in a population can range from 23 to 79% (Ward and Naumann 1998).

Ute ladies'-tresses typically occurs on sandy or loamy alluvial soils mixed with gravels in mesic to very wet meadows along streams and abandoned stream meanders, riparian edges, gravel bars, and near springs, seeps, and lakeshores, generally at elevations ranging from 1,300 to 2,000 m (4,265 to 6,561 ft) (USFWS 1992; NNHP 2001; UDWR 2002; NatureServe 2006). Threats to populations of Ute ladies'-tresses include modification of riparian habitats by urbanization, stream channelization and other hydrologic changes, conversion of lands to agriculture and development, heavy summer livestock grazing, and hay mowing. Most populations are small and vulnerable to extirpation by habitat changes or local catastrophic events (USFWS 1992). Many appear to be relict populations. Several historic populations in Utah and Colorado appear to have been extirpated.

The Ute ladies'-tresses is known to occur within Duchesne, Garfield, Uintah, and Wayne Counties, Utah, and could, therefore, occur within or in the vicinity of development areas located in the Uinta Basin and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs.

3.7.4.1.25 Whooping Crane. The whooping crane could only occur as a rare migrant in the study area. It is considered extirpated from Wyoming and Utah, and populations west of the Rocky Mountains are considered experimental and nonessential (USFWS 1997c).

Whooping crane populations declined from about 1,400 in 1860 to a low of 16 individuals in 1941 (Whooping Crane Conservation Association 2006). Captive breeding, reintroductions, and habitat protection by participants in the Whooping Crane Recovery Program have enhanced the species' chances of long-term survival. The number of whooping cranes has increased about 4% per year, with about 470 individuals in existence at the end of 2004 (Cornell Laboratory of Ornithology 2006), including 213 in the wild. An experiment to establish a second breeding population in Gray's Lake National Wildlife Refuge in southeastern Idaho was initiated in 1975. Whooping crane eggs were transferred to nests of sandhill cranes, which were intended to be used as foster parents that would raise the whooping cranes and lead them to the sandhill's wintering habitat at Bosque del Apache National Wildlife Refuge in south-central New Mexico. The experiment was unsuccessful because whooping cranes failed to bond with each other but instead paired with sandhill cranes. The program was discontinued in 1989 (Cornell Laboratory of Ornithology 2006).

Subsequent experiments to reintroduce whooping cranes involved the use of ultralight aircraft. In 1996, researchers successfully led imprinted sandhill cranes from their summer breeding habitat in southern Ontario to wintering grounds in Virginia. Sandhill cranes were used in the initial experiments to determine the feasibility of using ultralight aircraft to lead imprinted birds to wintering grounds. In 1997, sandhill cranes from Idaho that were imprinted on an ultralight aircraft and four whooping cranes flew to the Bosque del Apache National Wildlife Refuge. The whooping cranes survived the winter and returned on their own to Idaho the following spring (Whooping Crane Conservation Association 2006). During their spring and fall migrations, these whooping cranes and any offspring could pass over oil shale and STSA development areas of eastern Utah and western Colorado.

Grain fields, shallow lakes, and saltwater marshes compose the typical winter habitat. Grain fields, mud flats around reservoirs, and marshes are also important habitats during stopovers in the spring and fall migrations. Whooping cranes consume a variety of plants and animals, including mollusks, crustaceans, insects, fish, frogs, and waste grain in agricultural fields (Cornell Laboratory of Ornithology 2006).

Potential threats to the continued existence of the whooping crane are predation, collisions with power lines, and shooting by hunters who mistakenly identify them as sandhill cranes, which can be legally hunted in some states. A concerted effort is being made by the International Whooping Crane Recovery Team to establish new breeding populations.

Within potential development areas, and only in project areas in Colorado, the whooping crane could only occur as a rare migrant during the spring and fall migration periods. No breeding populations are known in the study area.

3.7.4.1.26 Winkler Cactus. The Winkler cactus is a small cactus that grows on fine-textured, mildly alkaline soils derived primarily from siltstones and shales of the Dakota Formation and also from the Brushy Basin Member of the Morrison Formation (BLM 2006h; UDWR 2006). It occurs on benches, hill tops, and gentle slopes (most commonly on south-facing slopes) on barren areas in salt desert shrub communities at elevations of 1,450 to 2,010 m (4,757 to 6,594 ft).

The Winkler cactus was listed as threatened on August 20, 1998 (161 FR 44587). The recovery plan for this species was published together with a related species, the San Rafael cactus (USFWS 1995b). In 1998, the USFWS estimated the total size of the Winkler cactus population at 20,000 individuals in four populations in Wayne and Emery Counties, Utah. Three of the four populations are distributed in an arc that extends from Notom in central Wayne County to the vicinity of Last Chance Creek in southwestern Emery County, Utah. The fourth population is located near Ferron, Utah, in western Emery County. Most populations occur on scattered sites along an area about 36 mi long and 0.3 mi wide. About two-thirds of the populations occur on BLM-administered land, and the remaining populations occur on Capitol Reef National Park. Its distribution range converges with that of the San Rafael cactus in Emery County (63 FR 44587).

Flowering of the Winkler cactus occurs from May to June; fruit formation occurs in June and July. Late winter and spring moisture conditions and temperature determine the actual time of flowering and fruit production in any given year.

Potential threats to the Winkler cactus include illegal collecting and loss of habitat or damage to individuals from trampling by hikers, mining activities, and oil and gas development (USFWS 1995b; BLM 2006h). Within the study area, the range of the Winkler cactus occurs about 10 km (6 mi) to the west of the San Rafael STSA in central Emery County. The population in Wayne County is located in the central portion of the county and about 70 km (43 mi) to the west of the Tar Sand Triangle STSA located in the southeastern part of the county (UDWR 2006).

3.7.4.1.27 Wright Fishhook Cactus. The Wright fishhook cactus occurs in portions of Emery, Sevier, and Wayne Counties, Utah (UDWR 2006). It is found growing on soils that range from clays to sandy silts to fine sands, typically on sites with well-developed biological soil crusts. This cactus grows in scattered pinyon-juniper and desert shrub plant communities at elevations ranging from 1,305 to 1,963 m (4,281 to 6,440 ft). The Wright fishhook cactus grows to heights of 6 to 12 cm (2 to 5 in.) and produces pink to white flowers in late April and May (BLM 2006h). Fruiting occurs in June and seed shed is in July.

Wright fishhook cactus was listed as endangered on October 11, 1979, and a recovery plan was published in 1985. The total population is estimated at fewer than 3,000 individuals on the basis of recent surveys (NatureServe 2006).

Potential threats to the Wright fishhook cactus include oil, coal, and gas exploration; OHV traffic; trampling of plants by livestock; road construction and maintenance; collection; and infestation by cactus-borer beetle larvae (CPC 2006h; NatureServe 2006).

The Wright fishhook cactus is known from Wayne County, southwestern Emery County, and southeastern Sevier County in Utah (UDWR 2006). The species occurs within the vicinity of the San Rafael and Tar Sand Triangle STSAs.

3.7.4.2 Species That Are Candidates for Listing under the Endangered Species Act

Species that are candidates for listing as threatened or endangered under the ESA are presented in this section. Their occurrence within oil shale basins and STSAs is presented in Table 3.7.4-3.

3.7.4.2.1 Debeque Phacelia. The Debeque phacelia is a small summer annual that grows in only one area of western Colorado. Its distribution is within 10 mi of the town of DeBeque, south of South Shale Ridge and southwest of the Roan Plateau in Garfield County, Colorado (Center for Native Ecosystems 2006a). This species grows on sparsely vegetated, steep slopes in the mud cracks of chocolate brown or gray clay soil. No information was found on the time of flowering and seed set for this species.

Within its known range, there have been 27 occurrences of Debeque phacelia. Population size varies widely from year to year, most likely because of variation in precipitation between years. Its association with a very specific geologic substrate and habitat type make it unlikely for a range extension to occur (NatureServe 2006).

Potential threats to the Debeque phacelia include a variety of ground-disturbing activities, such as oil and gas drilling, oil shale development, and OHV use. Because it is an annual species, it depends on a healthy production of seeds in the top few centimeters of the soil to survive from year to year (Center for Native Ecosystems 2006a).

The Debeque phacelia occurs within the Piceance Basin in Garfield County, Colorado.

3.7.4.2.2 Gunnison's Prairie Dog. The Gunnison's prairie dog is a candidate for listing in that portion of its range in central and south-central Colorado and north-central New Mexico. The USFWS recently published a 12-month finding for the Gunnison's prairie dog in which it determined that the species is not threatened or endangered throughout all of its range, but that the portion of the current range of the species located in central and south-central Colorado and north-central New Mexico represents a significant portion of the range where the Gunnison's prairie dog is warranted for listing under the ESA (USFWS 2008b). Although listing was precluded by higher priority actions, the USFWS assigned a listing priority number of 2 to this species because threats have a high magnitude, and are imminent.

The Gunnison's prairie dog is a colonial species in the family Sciuridae and historically occurred in large colonies over large areas (USFWS 2008b). Gunnison's prairie dog habitat includes level to gently sloping grasslands and semidesert and montane shrublands, at elevations from 6,000 to 12,000 ft (1,830 to 3,660 m). Foods include grasses, forbs, sedges, and shrubs.

The current distribution of the species includes northeastern Arizona; central, south-central, and southwestern Colorado; north-central and northwestern New Mexico; and extreme southeastern Utah (USFWS 2008). Between 1916 and the present, habitat occupied by Gunnison's prairie dogs throughout its range declined from approximately 24,000,000 acres (9,700,000 ha) to between 340,000 and 500,000 acres (136,000 and 200,000 ha). This represents a rangewide decline of greater than 95% (USFWS 2008b). Gunnison's prairie dogs occur in two separate range areas—higher elevations in the northeastern part of the range (montane areas) and lower elevations elsewhere (prairie areas).

Gunnison's prairie dogs are affected by a variety of anthropogenic and ecological factors. In evaluating these factors, the USFWS determined that the destruction and modification of Gunnison's prairie dog's habitat or range currently are not significant threats. Agriculture, urbanization, roads, and oil and gas development each currently affect a small percentage of Gunnison's prairie dog habitat. Effects of livestock grazing, while widespread, have not resulted in measurable population declines.

Plague has a significant effect on Gunnison's prairie dog populations (USFWS 2008b). Periodic epizootic plague events generally kill more than 99% of an affected population. Whether populations recover from these events depends on the availability of other populations to recolonize affected areas and the frequency of outbreaks. Populations in the more mesic montane areas of the species' range appear to have been widely and severely affected by plague (USFWS 2008b). Large populations have been repeatedly affected by plague and have shown no substantial recovery over long periods of time. This has left smaller, more scattered populations throughout the montane range portion. Evidence shows that many of the prairie populations recover more rapidly from plague epizootics, probably because of the availability of nearby colonizers.

On the basis of the map presented in USFWS (2008b), the Gunnison's prairie dog range is outside of the areas being considered for leasing for commercial oil shale and tar sands development.

3.7.4.2.3 Parachute Beardtongue. The Parachute beardtongue is a perennial herbaceous mat-forming species that grows on steep, oil shale outcrop slopes of white shale talus at 8,000 to 9,000 ft in elevation on the southern escarpment of the Roan Plateau (USFWS 2006i) in Garfield County, Colorado. It is known from six locations that occupy a total of about 200 acres. The Parachute beardtongue is restricted to the Piceance Basin and is found only in the Parachute Creek Member of the Green River Formation.

There are only four populations considered viable by the Colorado Rare Plant Technical Committee, and three of these are on land owned by an energy company. The other population occurs on BLM land (USFWS 2006i). Potential threats to this species include ground-disturbing activities, such as oil shale development, recreational use, and natural gas development (Center for Native Ecosystems 2006c; NatureServe 2006). The Parachute beardtongue occurs in Garfield County, Colorado, in the southern portion of the Piceance Basin.

3.7.4.2.4 Western Yellow-Billed Cuckoo. The western yellow-billed cuckoo became a candidate for federal listing on July 25, 2001 (USFWS 2001). The listing of this species as endangered was determined to be warranted but was precluded by higher-priority listing actions. The yellow-billed cuckoo was historically widespread and locally common in portions of its range, but was generally uncommon to rare in the study area (USFWS 2000a, 2001).

The western yellow-billed cuckoo is a neotropical migrant bird. It depends on large blocks of intact riparian habitat for nesting, especially woodlands of cottonwoods and willows, with a dense understory of shrubs (USFWS 2001). It is mostly insectivorous, with cicadas, katydids, and caterpillars forming the bulk of its diet.

The western yellow-billed cuckoo has faced significant population declines because of loss or degradation of riparian habitat, increased use of pesticides, reduced food supply, and low colonization rates (Hughes 1999; USFWS 2001). Habitat degradation and loss have been attributed to conversion to agriculture, grazing, dams and river regulation, bank protection and channelization for flood control, and invasion by exotic plants such as tamarisk. Additional impacts identified in the project area include recreation and oil and gas drilling (Howe and Hanberg 2000).

Suitable yellow-billed cuckoo habitat (cottonwood forest) occurs along the major rivers of the area, including the Colorado, Green, and White Rivers. The USFWS considers this species to be present only within portions of the study area within Utah (Appendix F). On this basis, the species could occur within or in the vicinity of development areas located in the Uinta Basin and the Asphalt Ridge STSA.

3.7.4.2.5 White River Beardtongue. The White River beardtongue is a perennial herbaceous plant that occurs in the Green River Formation in the Uinta Basin of northeastern Utah and Colorado. Existing populations occur in Duchesne and Uintah Counties in Utah and in Rio Blanco County, Colorado (UDWR 2006). It is found on semibarren areas on soils that are dry, shallow, and fine textured with fragmented shale. It can be found at elevations ranging from 1,500 to 2,040 m (4,921 to 6,693 ft) on dry substrates near the bottom of the Uinta Basin to upper slopes and ridge crests. White River beardtongue typically grows in pinyon-juniper, desert shrub, and mixed desert shrub communities, and flowers in late May and early June (USFWS 2006g).

The species range is composed of small scattered populations extending from Raven Ridge near the White River in Rio Blanco County, Colorado, westward into southern Uintah County, Utah, in the area of Evacuation Creek over a distance of about 30 km (20 mi) (USFWS 2006g). Of the estimated population of 22,780 individual plants in Utah in 1995, about 16,600 occurred on BLM-administered land within the Vernal Field Office (USFWS 2006g). As of 1998, only two populations totaling about 50 plants were known from Colorado in the vicinity of Raven Ridge.

Potential threats to the species include ground-disturbing activities such as oil and gas development, oil shale mining, OHV use, and impacts from livestock grazing. Several interstate gas and oil pipelines exist in the vicinity of known populations (USFWS 2006g). With such a small range and the fragmented population structure over the 20-mi range of the species, any habitat destruction poses a threat to the White River beardtongue.

The White River beardtongue could occur in or in the vicinity of development areas in the Uinta Basin and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs.

3.7.4.3 BLM-Designated Sensitive Species and State-Listed Species

The BLM and the states of Colorado, Utah, and Wyoming maintain lists of sensitive plant and animal species. Many of these species have restricted distributions within the states, limited population sizes, and specialized habitat requirements that make them particularly vulnerable to human or natural perturbations. Special status provides a measure of protection through consideration in planning processes and is intended, at least in part, to avoid the need for federal listing under the ESA. The BLM manages BLM-listed sensitive species and state-listed species as if they were candidates for federal listing under the ESA. The species and their habitats that could occur in potential development areas are presented in Table E-1 of Appendix E.

There are 140 BLM-listed sensitive species that occur in counties of potential development areas. Of these, 48 potentially occur in the Green River, 35 in the Washakie, 43 in the Piceance, and 48 in the Uinta Basins; 96 potentially occur in STSAs (Table 3.7.4-2). Of these BLM-listed species, 83 are plants, 5 are invertebrates, 6 are fish, 6 are amphibians, 6 are reptiles, 18 are birds, and 16 are mammals (Table 3.7.4-1).

3.7.4.4 Other Species of Concern

In addition to the species discussed in Section 3.7.4.1, there are four species that potentially occur in oil shale and tar sands areas and for which the USFWS has developed conservation measures. These species are the bald eagle, Colorado River cutthroat trout, Graham's beardtongue, and the sage-grouse. These species have either been recently removed from the list of threatened and endangered species list (bald eagle) or have recently undergone a formal status review by the USFWS, but listing was determined to be not warranted at this time (Colorado River cutthroat trout, Graham's beardtongue, and the sage-grouse). The Colorado River cutthroat trout (a BLM-sensitive species) is discussed in Sections 3.7.1 and 3.7.2, and the sage-grouse (a BLM-sensitive species) is discussed in Section 3.7.3.2.3. The bald eagle and Graham's beardtongue (a BLM-sensitive species) are discussed in this section. The USFWS recently published a 90-day finding on a petition to list the pygmy rabbit as threatened or endangered (73 FR 1312). The USFWS determined that the petition presented substantial scientific or commercial information indicating that listing the pygmy rabbit may be warranted. With publication of that finding, the USFWS began a status review to determine if listing the species is warranted. Impacts on the pygmy rabbit (a BLM sensitive species) are presented in Section 4.8.1.4.

The southern bald eagle was federally listed as endangered on March 11, 1967 (USFWS 1967). In 1978, bald eagle populations in all but five of the coterminous United States were listed as endangered; in the remaining five states, bald eagles were listed as threatened. The listing status throughout the conterminous United States was changed to threatened on July 12, 1995, and the bald eagle was proposed for delisting on July 6, 1999 (USFWS 1999). The bald eagle was removed from the list of endangered and threatened wildlife on August 8, 2007 (USFWS 2007b). The bald eagle continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The current U.S. range of the bald eagle includes all of the 48 conterminous states, plus Alaska and the District of Columbia.

Bald eagles typically nest in areas free of human disturbance, especially in large trees near water and occasionally on cliffs. The nesting season is about 6 months long. Most bald eagles migrate long distances to wintering areas. Wintering sites, which may attract large numbers of bald eagles, are generally near open water and include large trees for perching and night roosting. In potential development areas, bald eagles are most commonly seen along the major rivers such as the Colorado, Green, and White Rivers; they could occur in all of the oil shale basins and STSAs. Fish are the primary food source, although waterfowl, other birds, prairie dogs, and carrion are also eaten.

The Graham's beardtongue is a perennial herbaceous plant that occurs in small populations along a narrow band (approximately 80 mi long by 5 mi wide) from Raven Ridge, west of Rangely, in Rio Blanco County, Colorado, westward to a point where Carbon, Duchesne, and Uintah Counties meet in Utah's Uinta Basin (USFWS 2006d). Typical habitat consists of exposed raw shale knolls and slopes derived from the Parachute Creek and Evacuation Creek Members of the Green River Formation. Most populations occur on the surface of the oil shale Mahogany ledge (71 FR 19158).

Graham's beardtongue has 1 to 3 stems that arise from a taproot and grows to a height of 7 to 18 cm (3 to 7 in.). Plants have leathery leaves and large, light- to deep-colored tubular lavender flowers that develop in late May and early June. The UDWR (2006) describes Graham's beardtongue sites occurring at elevations ranging from 1,430 to 2,600 m (4,692 to 8,530 ft) in pinyon-juniper and desert shrub plant communities. The Center for Native Ecosystems (2006b) reported in November 2003 that, of the 36 known sites of Graham's beardtongue, one-fourth were composed of less than 10 plants.

The USFWS published a proposed rule to determine whether Graham's beardtongue should be listed as threatened under the ESA (71 FR 3158) and to designate critical habitat for the species. The USFWS withdrew the proposed rule on December 19, 2006 (71 FR 76023), stating that listing is not warranted because threats to the species are not significant and are not likely to threaten or endanger the species in the foreseeable future. This decision, at least in part, was based on existing BLM policies, land use planning, and on-the-ground protective measures provided to the USFWS during the public comment period on the proposed rule.

Potential threats to this species include oil and gas exploration (both drilling and field development), tar sands and oil shale mining, OHV use, livestock and wildlife grazing, and overutilization for horticultural purposes. The Graham's beardtongue could occur in the Uinta Basin and in the Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs. The portion of the Uinta Basin where overburden is less than 500 ft (Figure 2.3-1) contains approximately 90% of the area that had been proposed as critical habitat for the species.

3.8 VISUAL RESOURCES

3.8.1 Introduction

Visual resources refer to all objects (man-made and natural, moving and stationary) and features (e.g., landforms and water bodies) that are visible on a landscape. These resources add to or detract from the scenic quality of the landscape, that is, the visual appeal of the landscape.[13]

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[13] A visual impact is the creation of an intrusion or perceptible contrast that affects the scenic quality of a landscape. A visual impact can be perceived by an individual or group as either positive or negative, depending on a variety of factors or conditions (e.g., personal experience, time of day, and weather/seasonal conditions).

The BLM's responsibility for managing visual (scenic) resources of public lands is established by law. NEPA requires that measures be taken to "assure for all Americans … aesthetically pleasing surroundings," and FLPMA states that "public lands will be managed in a manner which will protect the quality of scenic values of these lands."

The BLM conducts visual inventories and analyses within the guidelines established in its Visual Resource Management (VRM) System (BLM 1984a; 1986a,b). The BLM uses the VRM procedures and methods to support decision making for planning activities and reviews of proposed developments on BLM-administered lands.

The VRM system consists of three phases: (1) inventory of scenic values and assignment of visual resource inventory (VRI) classes; (2) designation of BLM management classes for all public lands using the RMP process; and (3) use of the Visual Contrast Rating System (VCRS) to evaluate the compatibility of a proposed project with the existing VRM Class for the proposed project location, and to determine the nature and extent of visual impacts associated with the project. If the project is subsequently implemented, design considerations and impact mitigation measures may be used to minimize the visual impacts of the project.

A visual resource classification is based on the intrinsic scenic quality of a view, the level of public concern (sensitivity) to changes in that view, and the distance between viewers and the view. The final result of the VRM process is the assignment of a VRM Class that provides the basis for the consideration of visual resources in the BLM's resource management planning process. The text box that follows describes the BLM's VRM system for inventorying scenic values and assigning management classes. Designation of VRM classes is done through the RMP process and takes into account both the scenic qualities and potential uses of an area. Changes to VRM classes are also accomplished through the RMP process and may result from changes in scenic values over time, or as a result of land use decisions.

When a project is proposed, potential visual impacts are evaluated relative to an RMP's visual management objectives for the affected area with the use of the VCRS. The VCRS is a systematic process to analyze potential visual impacts of proposed projects and activities (BLM 1986b). Contrast rating assesses the visual contrast between a project and the existing landscape. Contrast is assessed by comparing project features (explained in a detailed project description) with the major features of the existing landscape (contained in the VRM classes/objectives) in terms of the basic design elements of form, line, color, and texture. Comparisons are made on the basis of views from key observation points, critical viewpoints, typical views of representative landscapes, and views of special features. Combining the assessment of a proposed project's impact on an area's visual resources with the VRM objectives from the RMP may result in project modifications and/or the development of mitigation measures. Visual contrasts inconsistent with the VRM class objectives for the affected area are prohibited.

BLM VRM System: Inventory of Scenic Values and Assignment of Management Classes

Scenic Quality Evaluation. BLM inventory guidelines rate the apparent scenic quality of discrete areas of land as A, B, or C on the basis of their landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications (BLM 1986a). A-rated areas have outstanding or distinctive diversity or interest, B-rated areas have common or average diversity or interest, and C-rated areas have minimal diversity or interest.

Sensitivity Level Analysis. Sensitivity levels measure public concern for scenic quality. Areas are assigned a high, medium, or low sensitivity level by analyzing indicators of public concern: types of users, amount of use, public interest, adjacent land uses, special areas, and other factors that may be indicators of visual sensitivity. Special areas such as Wilderness Study Areas, Wild and Scenic Rivers, and Scenic Roads or Trails require special consideration for protection of their scenic quality.

Distance Zone Delineation. The visual impact of a particular project will become less perceptible with increasing distance between the viewer and the project. The BLM VRM system uses three distance zones to account for this effect. It looks at likely viewing locations such as nearby highways, rivers, scenic overlooks, or other locations from which most viewers would observe a particular site. The foreground-middleground zone includes areas at a distance of less than 3 to 5 mi from the viewer. Areas viewed beyond the foreground-middleground zone but usually less than 15 mi from the viewer are in the background zone. Areas hidden from view in the foreground-middleground zone or background zone are in the seldom-seen zone.

Visual Resource Inventory Classification. Through an overlay analysis, areas are assigned to one of four visual resource inventory classes based on the scenic quality, visual sensitivity, and distance zones. Inventory classes are informational in nature and provide the basis for considering visual values in the RMP process.

Visual Resource Management Classification. Visual resource management classes are assigned through the RMP process by considering the visual resource inventory and management goals for the area. Areas are assigned to one of four management classes; the management objectives are as follows:

- Class I Objective: Preserve the existing character of the landscape. The level of change should be very low and must not attract attention.
- Class II Objective: Retain the existing character of the landscape. Allow a low level of change that should not attract the attention of a casual observer.
- Class III Objective: Partially retain the existing character of the landscape. Allow a moderate level of change that may attract attention without dominating the view of a casual observer.
- Class IV Objective: Provide for management activities that require major modifications of the existing character of the landscape. The level of change may be high and may dominate the view and be the major focus of viewer attention.

3.8.2 Oil Shale Areas

3.8.2.1 Piceance Basin

The oil shale area in Colorado, commonly referred to as the Piceance Basin, is largely contained within the Roan Plateau (see Figure 1.2-1). The Roan Plateau is composed of two major landform types: the extensive, deeply dissected, cliff-bench complexes and steep cliff formations of the Roan and Book Cliffs on the southern end of the plateau, and the grass-, shrub-, and woodland-covered benches and mesas of the Piceance Creek watershed to the north (Chapman et al. 2006) (Figure 3.8.2-1). Elevations range from approximately 5,200 ft above mean sea level (MSL) along the Colorado River to nearly 9,300 ft above MSL atop the plateau. The top of the plateau slopes generally northward and is dissected by tributaries of Parachute Creek and Piceance Creek. The eastern, southern, and western edges of the plateau are defined by steep slopes and prominent cliffs, known as the Roan Cliffs; the Book Cliffs extend farther westward along the south face of the Plateau into Utah (BLM 2004c).

The Roan and Book Cliffs are major scarp slopes that rise dramatically (3,000 to 4,000 ft) from the Colorado River valley to the forested plateau rim. Vegetation found on the escarpments and benches includes Douglas fir forest at higher elevations, to grassland or shrubland on lower, drier sites. Pinyon-juniper woodland often dominates escarpments and benches that are covered by shallow soils (Chapman et al. 2006).

FIGURE 3.8.2-1 Landscape in the Piceance Basin

The Roan and Book Cliffs are highly sensitive visual resources. The Roan Cliffs are visible from the communities of Parachute, Battlement Mesa, Rifle, Silt, and New Castle and to travelers on I-70 and State Highway 13. The massive forms of the steep cliffs dominate views from the valley floor and the I-70 corridor, providing dramatic color contrasts to the heavily vegetated upper slopes. Human-caused visual impacts are minimal, but some road cuts are visible on the face of the Roan Cliffs. Public sensitivity to alterations in these landscapes is high (BLM 1983b, 2004c), and most of the area is managed as VRM Class II. The faces of the Book Cliffs, the Roan Creek Area, and the I-70 corridor have also been identified as high-value scenic areas (BLM 1985c), as have NOSR 1 and 3, and the East Fork Parachute Creek Canyon, a regionally significant visual resource (BLM 2004c). Some segments of tributaries of Parachute Creek are eligible for WSR status because of their outstandingly remarkable scenic value (BLM 1994b). The Dinosaur Diamond National Scenic Byway (also known as the Dinosaur Diamond Prehistoric Highway) passes within approximately 7 mi of the western boundary of the oil shale area.

The northern portion of the plateau is characterized by broad, grass-, shrub-, and woodland-covered benches and mesas, with areas of high relief alternating with areas of low relief. On floodplains and terraces, some irrigated cropland occurs. Oil and natural gas wells are also present (Chapman et al. 2006). Scenic values are lower than for the Roan and Book Cliffs areas on the southern edge of the Roan Plateau. Many of the public lands in the area are managed as VRM Class III (BLM 1994b).

3.8.2.2 Uinta Basin

The oil shale area within the Uinta Basin is located in the Uinta Basin Floor ecoregion, an arid, saucer-shaped synclinal basin. The area contains mountain-fed streams, alluvial terraces, outwash terraces, floodplains, hills, and ridges. Mesas and benches alternate with lower, more arable land (Chapman et al. 2006). The area is dissected by several rivers, including the Green River, the White River, and their tributaries. Vegetation consists primarily of desert shrubs and grasses, but cottonwood and introduced Russian olive trees may be found in riparian areas.

Visual impacts from existing human activities in the area are abundant. They include impacts associated with intensive energy development in the area's major oil and gas fields, mining, irrigated agriculture, and grazing. Impacts associated with energy development include oil and gas wells, pipelines, pump and meter stations, roads (mostly unpaved), landing strips, and transmission lines. Streams are often diverted for irrigation, both for crops (such as alfalfa, small grain, and corn) on arable, gently sloping terraces and valley floors, and for pasture on stonier soils. Nonirrigated areas are used for livestock grazing (Chapman et al. 2006). OHV use has also resulted in significant visual impacts north of the White River (BLM 2005f) (Figure 3.8.2-2).

Within the Uinta Basin oil shale area, the highest scenic quality is found in the Bitter Creek Drainage and along portions of the White and Green River corridors (Bartel 2002). The Winter Ridge WSA, at the southern end of the oil shale area, is currently managed as VRM Class I. Areas managed as VRM Class II are Nine Mile Canyon (at the far western edge of the

FIGURE 3.8.2-2 Landscape in the Uinta Basin

oil shale area), the White River Corridor, and the Upper Green River. The proximity of intense exploration and development near areas of high scenic quality and the increasing number of people seeking recreation are creating resource use conflicts, particularly in the White River corridor (BLM 2005f). The remainder of the oil shale area is managed as either VRM Class III or VRM Class IV. The Lower Green River has been found to be suitable for WSR designation (in part for outstandingly remarkable scenic values), and portions of the White River are proposed for WSR designation (in part for outstandingly remarkable scenic values), under some alternatives in the Vernal Field Office Draft RMP (BLM 2005e). The Dinosaur Diamond National Scenic Byway passes within approximately 5 mi of the northeastern boundary of the oil shale area.

3.8.2.3 Green River Basin

The Green River Basin oil shale area includes the Green River Basin and lands to the east of it, including the Jack Morrow Hills, and it extends about 30 mi east of the eastern edge of the Jack Morrow Hills. Except for the extreme southern portion of the oil shale area (south of the Green River Basin), the area consists primarily of rolling sagebrush steppe, hills and low mountains, dunes, and playas, with shrub and grass vegetation. The landscape is varied and characterized by highly erodible soils and multicolored, horizontally layered sedimentary bedrock. Colorful badlands landscapes are common. Riparian vegetation is found along perennial streams, intermittent surface water locations, and rivers; sparser vegetation is located on side slopes and hillsides; and alkaline vegetation is found in some areas (BLM 2004e).

At the edges of the basin, elevations are higher, and some pinyon-juniper is found. The far southern portion of the oil shale area includes the northern slopes of the Uinta Mountains, characterized by mountain slopes with steep canyons, ponderosa and lodgepole pine, Douglas fir, and aspen woodlands. The Green River, its tributaries, and other permanent and intermittent streams drain the basin, generally southward (Chapman et al. 2006). Flaming Gorge Reservoir is a large water body in an area of deep canyons.

Although much of the Green River Basin oil shale area is relatively flat, featureless plains or rolling hills, there are several areas of high visual sensitivity. The Green River has been identified as an important scenic resource (BLM 2003). Many National Historic and Scenic Trails pass through the Green River Basin, including the Oregon Trail (and several cutoffs), the Overland Trail, the Mormon Pioneer Trail, the Northern and Southern Cherokee Trails, the Pony Express Trail, and the California Trail. The Devil's Playground/Twin Butte WSA is located within the southern portion of the Green River Basin oil shale area. ACECs within or partially within the Green River Basin oil shale area include the Currant Creek portion and Sage Creek portion of the Red Creek Badlands ACEC, Special Status Plant Species ACEC, and the Pine Springs ACEC. VRM Class II lands within the basin include areas within 2 to 3 mi of the Green River, Hams Fork, and the Flaming Gorge Reservoir; smaller areas along selected perennial streams (Smith and Blacks Forks); an area south of Meadow Springs Wash; and the area surrounding the Red Creek Badlands WSA. The Flaming Gorge Uintas National Scenic Byway passes within approximately 6 mi of the southern boundary of the oil shale area.

East of the Green River Basin, the Jack Morrow Hills area contains a variety of unusual landforms and several historical sites and roads, as well as landscapes of significance to Native Americans (BLM 2004d). The oil shale area includes portions of the Greater Sand Dunes ACEC and the Buffalo Hump WSA.

Cultural modifications within the basin include oil and gas production (such as well facilities, pipelines, roads, and power distribution lines), mining (including soda ash and coal), and livestock grazing operations and associated structures (such as fences and water developments) (BLM 2004e), as well as a number of small towns.

3.8.2.4 Washakie Basin

The Washakie Basin is an area of rolling sagebrush steppe, essentially a plain with hills, dunes, and playas, and with shrub and grass vegetation (BLM 2004e; Chapman et al. 2006). At the edges of the basin, elevations are higher, and some pinyon-juniper is found. A few, mostly intermittent, streams drain the basin.

The Washakie Basin is an area of active energy development, including oil and gas, coalbed methane, and other products. Visual disturbances associated with these types of activities, including roads, wells, pipelines, compressor stations, and meter stations, are found in the basin.

VRM classes in the basin are generally Class III and IV in the eastern portion (BLM 1990), but with Class I assigned to the Adobe Town WSA, and Class II assigned to the proposed Monument Valley ACEC (BLM 1997b). A small area of VRM Class II designation is found approximately 12 mi west of the Monument Valley ACEC. Just north of the oil shale area, the historic Overland Trail runs generally east-west through the northern portion of the Washakie Basin, and a BLM backcountry byway, Ft. Lacede Loop, is located in the northern portion of the basin. The Southern Route of the Cherokee Trail passes east to west through the basin, near the Colorado state line.

3.8.3 Special Tar Sand Areas

3.8.3.1 Argyle Canyon STSA

The Argyle Canyon STSA has a variety of landforms, including ridges, benches, and steep canyons. The area is dissected by numerous intermittent streams and a few perennial streams, and it has rugged, high-relief terrain, with local relief ranging from about 660 to 1,300 ft (USGS 1980b).

Scenic quality in the Argyle Canyon STSA varies, but is generally high, because of the variety of both landform and vegetation, which ranges from Douglas fir and Aspen at higher elevations to big sagebrush–grass communities and riparian areas along Argyle Creek (BLM 1984b). Most of the STSA is managed as VRM Class III.

Argyle Canyon is an area of the STSA of particular concern for visual values. Argyle Creek is eligible for WSR status because of its outstandingly remarkable scenic value (BLM 2005a). Much of the BLM portion of the STSA is bordered by a USFS roadless area to the north that includes small portions of the STSA. The Dinosaur Diamond National Scenic Byway passes through the eastern portion of the Argyle Canyon STSA. The Energy Loop: Huntington/Eccles Canyons National Scenic Byway passes within approximately 7 mi of the western boundary of the STSA.

3.8.3.2 Asphalt Ridge STSA

The three areas that compose the Asphalt Ridge STSA vary in scenic quality. The largest area closest to Vernal (Asphalt Ridge) is a cuesta or asymmetrical ridge, with mostly gently sloping topography. Vegetation consists primarily of pinyon-juniper and mixed shrubs.

The Asphalt Ridge portion of the STSA is generally of low scenic quality (BLM 1984b). It is in close proximity to the towns of Maeser, Vernal, and Naples, with urbanized areas that contain numerous visual intrusions visible from portions of the ridge. Cultural modifications that have existing visual impacts in the STSA include roads (e.g., State Highway 40), power lines, and industrial facilities. Some crops and pastureland are found in the far eastern portions of the STSA. The Asphalt Ridge portion of the STSA is proposed for VRM Class IV under all alternatives considered in the Vernal Draft EIS and RMP (BLM 2005e). The Dinosaur Diamond National Scenic Byway (State Highway 40) passes through the Asphalt Ridge portion of the STSA.

The two western portions of the STSA (north-northeast of Whiterocks) are areas of generally higher scenic quality than the Asphalt Ridge portion (BLM 1984b). These portions compose a dissected plain. The part closest to the Asphalt Ridge portion (primarily on the Uintah and Ouray Reservation) is proposed for VRM Class III under some alternatives considered in the Vernal Draft EIS and RMP (BLM 2005e). The westernmost portion of the STSA (on the Ashley National Forest) is an area of high scenic quality and sensitivity, with stone outcrops and riparian views along the White Rocks River, which provide pleasing visual contrasts with the predominant gray-green pinyon-juniper and shrub vegetation (BLM 1984b). Both areas abut USFS roadless areas on their northern and/or eastern boundaries.

3.8.3.3 Hill Creek STSA

The Hill Creek STSA is a well dissected, deeply incised, rugged upland. The entire area is a north-sloping cuesta in which the plateau surface slopes toward the north. The landform is generally rolling desert topography with deeply incised canyons and rocky buttes. Vegetation is generally sparse at lower elevations and more dense at higher elevations. Two north-flowing perennial streams drain the central and eastern portions of the STSA (USGS 1980c).

The scenic quality in the Hill Creek STSA is moderate; the STSA is managed as VRM Class III and Class IV. The STSA is visible from Big Pack Mountain to the north (BLM 1984b), and the Winter Ridge WSA (managed as VRM Class I) is less than 0.5 km (0.3 mi) from the eastern border of the Hill Creek STSA. Cultural modifications include roads, trails, and landing strips.

3.8.3.4 Pariette STSA

The Pariette STSA is a gently sloping dissected plain that includes low mesas and buttes, ranging up to about 300 ft maximum local relief, with relief generally less than 100 ft. The area is drained predominantly eastward by Pariette Draw and Castle Peak Draw.

Scenic quality in the Pariette STSA is low; the landscape is visually homogenous, with cold desert shrubs and flat to rolling landform with occasional low hills and ridges, which are common in the region (BLM 1984b). Cultural modifications with existing visual impacts in the STSA include roads and trails, a pipeline and meter station, and some croplands along the northern border of the STSA. Gas processing plants are located along the southern border of the STSA, with an electrical substation nearby. The Pariette STSA is proposed for VRM Class IV under all alternatives considered in the Vernal Draft EIS and RMP (BLM 2005e). The Pariette

Wetlands ACEC overlaps portions of the STSA. The Dinosaur Diamond National Scenic Byway passes within approximately 2 mi northwest of the extreme western boundary of the STSA.

3.8.3.5 P.R. Spring STSA

The P.R. Spring STSA is located on the East Tavaputs Plateau to the immediate east of the Hill Creek STSA. The southern edge of the P.R. Spring STSA borders the Book Cliffs–Roan Plateau divide. Like the Hill Creek STSA, the plateau surface slopes northward. The area is drained by perennial streams that run generally north and northwest (USGS 1980d). The terrain consists of long ridges running generally northwest to southeast, separated by canyons 820 to 1,475 ft deep. Vegetation consists primarily of mountain shrub and pinyon-juniper, with stands of Douglas fir and other conifers on east- and north-facing slopes (BLM 1984b).

The scenic quality of the STSA is generally low; most of it is managed as VRM Class IV. High-quality panoramic views of the Book Cliffs and other distant landforms, however, are available from the top of the Roan Cliffs along the southeastern boundary of the STSA (BLM 1984b). Cultural modifications include oil and gas development and associated structures, roads, trails, and landings strips. Much of the Winter Ridge WSA (managed as VRM Class I) is located within the western portion of the P.R. Spring STSA, and the far southern part of the STSA overlaps a small portion of the Flume Canyon WSA.

3.8.3.6 Raven Ridge STSA

The Raven Ridge STSA consists primarily of two parallel hogback ridges (Raven Ridge and Squaw Ridge) running northwest to southeast. The ridge extends beyond the Colorado state line to the southeast. The southwestern portion of the STSA is a slightly dissected plain. The ridge is drained by intermittent washes (USGS 1980a).

The scenic quality for this STSA is generally low; vegetation is cold desert shrubs, and the landform (rolling hills with sparse vegetation, except for the ridge itself) is relatively common in the region. Cultural modifications with existing visual impacts in the STSA include roads and trails, power lines, pipelines, and a natural gas facility. The Raven Ridge STSA is proposed for VRM Class IV under all alternatives considered in the Vernal Draft EIS and RMP (BLM 2005e). Portions of the STSA are visible from Dinosaur National Monument (BLM 1984b), the closest portion of which is located approximately 7 mi north of the northernmost portion of the STSA. The Dinosaur Diamond National Scenic Byway passes within approximately 1/8 mi of the northeastern boundary of the STSA. Raven Ridge is an area of high OHV use, with resultant visual impacts (BLM 2005e).

3.8.3.7 San Rafael Swell STSA

The San Rafael Swell STSA is located within the San Rafael Swell, a northeast-to-southwest trending dome approximately 70 mi long by 50 mi wide. An open, gently domed area

(Sinbad Country) about 40 mi long and 10 mi wide occupies the central part of the swell and contains most of the STSA. Sinbad Country is bordered on the east and southeast by the spectacular sandstone hogbacks of the San Rafael Reef. I-70 passes through the middle of the Swell and the STSA. The southwest and west sides of Sinbad Country are well dissected, and they feature many "castles," irregular mesas, and benches, as much as 700 ft above the general level of the swell. The land surface south of I-70 is not deeply dissected and is primarily gently rolling plain with isolated buttes and knolls. North of I-70, the relief is greater, with deeply dissected canyons and escarpments carved by the San Rafael River and its tributaries. Relief is greatest near the San Rafael River, where it is up to 1,700 ft (USGS 1980e).

The vegetation of the San Rafael Swell includes pinyon-juniper and Douglas fir near water sources. Cottonwood trees are found in areas along the perennial streams. Greasewood, sagebrush, and rabbitbrush are found along washes, and sparse grass and prickly pear are common (Williams 2002).

The San Rafael Swell area offers outstanding scenic quality and is one of the region's most well-known and popular scenic attractions. Within the San Rafael Swell, features such as the Wedge Overlook (Figure 3.8.3-1), San Rafael Reef, Mexican Mountain, Temple Mountain, and Buckhorn Draw attract high levels of recreation visitation, as does the I-70 corridor. The I-70 Scenic Corridor ACEC is managed to maintain the scenic qualities of the San Rafael Swell, where the interstate bisects the area. Old uranium mines, dirt roads, livestock improvements, and simple recreation facilities are evident in some locations, as are petroglyphs, pictographs, and

FIGURE 3.8.3-1 View from Wedge Overlook, San Rafael Swell near Castledale, Utah

some historic structures (BLM 2001b). Other scenic attractions include riparian areas along the San Rafael River and Muddy Creek. The Dinosaur Diamond National Scenic Byway passes within approximately 6.5 mi of the northeastern boundary of the STSA.

The STSA overlaps several ACECs, including four (the I-70 Scenic Corridor ACEC, San Rafael Canyon ACEC, San Rafael Reef ACEC, and Sid's Mountain ACEC) designated for scenic value. Significant portions of some STSA parcels not only cross the I-70 Scenic Corridor ACEC but overlap or are immediately adjacent to six WSAs, which are primarily designated as VRI Class II but are managed as VRM Class I in accordance with the 1991 San Rafael RMP. Major portions of the STSA are visible from the I-70 Scenic Corridor (BLM 1984b). Portions of STSA parcels outside the WSAs are mostly designated VRI Class III and IV and are managed as VRM Class III and IV, with some smaller VRI and VRM Class II areas. The Muddy Creek and Segers Hole ACECs are located approximately 2 and 10 mi south of the southwestern boundary of the STSA, respectively; both ACECs contain outstandingly remarkable scenic values.

3.8.3.8 Sunnyside STSA

The Sunnyside STSA is characterized by numerous rugged, mountainous forested areas and canyons, perennial streams, and mountaintop vistas. Bands of red rock cliffs are ubiquitous throughout and extend along most of the ridges. Many ridges extend downward off the plateaus, creating a sequence and layering of ridges that add much visual variety and spatial definition to the project area. Cliffs are often broken up and of varying heights. Vegetation consists of pinyon-juniper clumps, junipers, and firs, intermixed with sagebrush and grasses on the upper ridges and plateaus; sagebrush, rabbitbrush, greasewood, and grasses with groupings of aspens, cottonwoods, willows, tamarisks, and associated riparian species dominate the canyon floors (BLM 2004f).

The STSA and surrounding areas have very high scenic quality and have been described as offering "outstanding visual values" (BLM 1984b). The STSA lands are managed as VRM Class II and Class III, reflecting the high scenic values and sensitivity of the landscape to modification; portions of the STSA are visible from U.S. Highway 6, and to residents of Wellington, Price, and other local communities.

Nine Mile Canyon and the Nine Mile Canyon ACEC, an area of the STSA of particular concern for visual values, are managed as VRM Class II (BLM 2005e). The ACEC designation recognizes the scenic values of the canyon area. Nine Mile Canyon contains dramatic topography of high canyon walls, with steep side canyons, and with isolated buttes, mesas, and outcrops. A lush riparian zone of willow and cottonwood is found on the canyon bottom. Water features include the stream and beaver ponds. Farms and ranches provide a rural appearance to an otherwise natural-looking landscape. Other cultural modifications include roads, trails, and pipeline. The canyon walls contain numerous petroglyphs and other cultural resource sites visible from the county road that follows the canyon bottom. Within Nine Mile Canyon is the greatest concentration of rock art sites in the United States. The Nine Mile Canyon Scenic Byway, a State Scenic Byway and a BLM Backcountry Byway, follows the length of Nine Mile

Canyon (BLM 2004a). Nine Mile Creek has been determined to be eligible for WSR designation, in part because of its outstandingly remarkable scenic value (BLM 2005a; BLM 2004b).

The far western portion of the Sunnyside STSA overlaps the Lears Canyon ACEC. The far eastern portion of the main Sunnyside STSA parcel includes small portions of the Jack Canyon and Desolation Canyon WSAs. A small STSA parcel is located entirely within the two WSAs. Part of the BLM portion of the STSA is bordered by a USFS roadless area to the north.

3.8.3.9 Tar Sand Triangle STSA

The Tar Sand Triangle STSA is located in an area characterized by flat-topped mesas and steep-walled canyons. Elevation ranges from 4,800 to nearly 7,000 ft. The margins have stair-step topography, with mesas and buttes beyond the cliffs. The area is remote and very rugged, with relief up to 3,700 ft. Vegetation is sparse, with some desert shrubs and grasses, as well as scattered pinyon-juniper (BLM 1984b).

The high-quality scenic and recreational resources in and around the STSA are nationally significant (BLM 1984b). A significant portion of the STSA is in Glen Canyon NRA, and small portions are in Canyonlands National Park. More than half of the remainder of the STSA overlays the Fiddler Butte and French Spring–Happy Canyon WSAs. Scenic attractions in the STSA and the surrounding area constitute a major attraction for recreational users. Scenic attractions include unique landforms resulting from erosion, with flat-topped mesas, buttes, rugged cliffs, and canyons and slickrock formations. Mesas throughout the STSA offer views of the surrounding canyons and mountain ranges, such as the dramatic colorful landforms of the Maze portion of Canyonlands National Park and Glen Canyon NRA, the varied landforms of the deeply incised canyons of the Colorado and Dirty Devil Rivers, and Lake Powell. Panoramic views of the Colorado River canyons from the Orange Cliffs on the eastern edge of the STSA are particularly noteworthy, as is the staircase of terraces and vertical cliffs from the mesa tops to the bottom of Happy Canyon. Detached, sculptured buttes, monuments, and minarets are also found within the STSA (BLM 1984b).

Much of the BLM-managed public land in the STSA has been inventoried as VRI Class III or Class IV, except Happy Canyon and French Spring, which are VRI Class II. Smaller areas inventoried as VRI Class II are located south of Happy Canyon. In this case, the VRI classes correspond roughly to the designated VRM classes shown in the Henry Mountains MFP (BLM 1982).

3.8.3.10 White Canyon STSA

Much of the White Canyon STSA is a mesa incised by White Canyon (Figure 3.8.3-2). The southern portion of the STSA has bench and slope topography. Around the tar sands deposits, the ground slopes to the west, with elevations ranging from approximately 6,100 ft on the northeast end of the STSA to about 4,800 ft on the southwestern end. White Canyon is about 6 mi wide where it bisects the STSA, but much of the STSA is in Short Canyon (a side canyon of

FIGURE 3.8.3-2 White Canyon Bridge on State Route 95, San Juan County, Utah

White Canyon) (BLM 1984b). Vegetation is sparse; a mixture of desert shrubs on the benches and scattered cottonwood riparian communities in the canyons.

The scenic value of the STSA is high. The STSA contains highly scenic canyon landforms, eroded through colorful sandstone layers that contrast pleasingly with the shrub and pinyon-juniper vegetation. The southern portion of the STSA is crossed by the Bicentennial Scenic Byway (a segment of Highway U-95, designated as a Utah State Scenic Byway) in the Scenic Highway Corridor ACEC. This ACEC includes a portion of the White Canyon viewshed (BLM 1984b). White Canyon is managed as VRM Class II (BLM 1987b). A portion of the Dark Canyon WSA is adjacent to the northwest boundary of the White Canyon STSA. At its closest point, Glen Canyon NRA is approximately 2 mi from the STSA.

3.9 CULTURAL RESOURCES

Cultural resources include archaeological sites and historic structures and features that are addressed under the NHPA, as amended (P.L. 89-665). Cultural resources also include traditional cultural properties, that is, properties that are important to a community's practices and beliefs and that are necessary for maintaining the community's cultural identity. Cultural resources refer to both man-made and natural physical features associated with human activity and, in most cases, are finite, unique, fragile, and nonrenewable. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are historic properties (see text box). Federal agencies must take into consideration the effects on such properties of any undertakings under their direct or indirect jurisdiction before they approve expenditures or issue licenses.

National Register Criteria for Evaluation (36 CFR 60.4)[a]

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded or may be likely to yield, information important in prehistory or history.

[a] Additional *criteria considerations* are also provided in 36 CFR 60.4.

Cultural resources on BLM-administered land are managed primarily through the application of the laws identified in Appendix D. As required by Section 106 of the NHPA, BLM offices work with land use applicants to inventory and evaluate cultural resources in areas that may be affected by proposed development. The BLM has established a cultural resource management program as identified in its 8100 Series manuals and handbooks (see Section D.2 in Appendix D). The goal of the program is to locate, evaluate, manage, and protect cultural resources on public lands. (See Section 3.1, Land Use, for a description of designated ACECs, some of which are designated specifically to protect cultural resources.) Guidance on how to apply the NRHP criteria to evaluate the eligibility of sites located on public lands is provided in numerous documents prepared by the NPS and in the BLM 8100 Series manuals and handbooks. Further guidance on the application of cultural resource laws and regulations is provided through the 1997 BLM National PA and State Protocols developed among the BLM, the National Council of SHPOs, and the Advisory Council on Historic Preservation, and through state-specific PAs concerning cultural resources.

Although site-specific information regarding cultural resources would need to be collected to define the affected environment of an individual project, the types of sites listed on the NRHP in the broad project area for this PEIS include archaeological sites, historic buildings, bridges, historic trails, prehistoric dwellings, historic districts, water features (e.g., canals and ditches), and cultural landscapes. (See also Section 3.8 for a brief discussion of National Historic and Scenic Trails and other conservation areas established under the NLCS with a visual or scenic component.) A Class I cultural resource overview describing, in general, the types of resources known to be present in the oil shale and tar sands study area has been prepared in support of this PEIS and is summarized below for each of the oil shale basins and STSAs (O'Rourke et al. 2007).

Traditional cultural properties and other areas of concern to Native Americans and other cultural groups can include a wide range of tangible and intangible resources (e.g., archaeological sites, funerary objects, medicinal plants, and sacred landscapes). Government-to-government consultation provides a means of identifying the affected environment for a particular site-specific project. It is difficult, if not impossible, to place boundaries on locations of traditional significance. Where boundaries might be defined, Tribal members may not be willing to disclose such information for a variety of reasons. Cultural sensitivity to the need to protect important places is required. Types of valued traditional resources may include, but are not limited to, archaeological sites, burial sites, traditional harvest areas, trails, certain prominent geological features that may have spiritual significance (i.e., sacred landscapes), and viewsheds of sacred locations (including all of the above). An ethnographic overview also has been prepared to describe, in general, the lifeways and traditional property types of Native Americans who either currently live or previously lived in the region covered by this PEIS (Bengston 2007); this information is also summarized in Sections 3.9.1.3, 3.9.2.3, 3.9.3.3, and 3.9.4.3.

3.9.1 Piceance Basin

3.9.1.1 Prehistoric Context for Archaeological Sites, Features, and Structures

There is archaeological and ethnographic evidence to suggest that the Piceance Basin was inhabited and visited on a regular basis by human populations for more than 12,000 years. Abundant native faunal and floral resources were available to early human populations as part of a seasonal round of subsistence. Permanent seasonal water sources within the area attracted numerous animal species, including mule deer.

The cultural history for northwestern Colorado is divided chronologically into four major time periods, or eras, as defined by Reed and Metcalf (1999). These eras include the Paleoindian era (11,450 to 6,400 B.C), the Archaic era (6,400 to 400 B.C.), the Formative era (400 B.C. to A.D. 1300), and the Protohistoric era (A.D. 1300 to 1880). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting bison and other big game are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. The Archaic era represents a shift in diet and settlement patterns from a highly mobile hunting lifestyle to a greater reliance on gathering wild plant foods and hunting smaller game.

During the Formative era, there was a shift from the seasonal hunter-gatherer subsistence strategy toward that of early farming practices. However, hunting and gathering continued to play a major role in the economy, and use of the bow and arrow was introduced during this period. In northwestern Colorado, the Formative era is represented by two distinct traditions, the Fremont and Aspen. The development of horticulture is unique to the Fremont. The main crop was corn, with some evidence of beans and squash. The Fremont is also associated with the introduction of pottery and the appearance of unique rock art and modeled clay figurines. The Fremont sites in the Piceance Basin and vicinity would most closely relate to a Plains-influenced variant of the Fremont known as the Uinta Fremont. Important characteristics of the Uinta variant include the presence of shallow pit-houses and freestanding structures, and the complete absence of Fremont clay figurines. Fremont sites include rock art sites, open and sheltered artifact scatters, and architectural sites. According to Reed and Metcalf (1999), no confirmed

Fremont pit-houses have been found in the project area. Contemporaneous with the Fremont culture, the Aspen Tradition is assigned to nonhorticultural groups residing in the region during the Formative era; the sites are similar with the two exceptions of no evidence of farming and no Fremont-style pottery. It is not expected that the prehistoric populations practiced horticulture in the Piceance Basin per se, because of the relatively short growing season and inadequate soil conditions. However, horticultural sites are found very near to the basin to the west and northwest.

The Protohistoric era is defined by what appears to be a gradual ending to the Fremont horticultural lifeways and the adoption of a more mobile, hunter-gatherer life style similar to that of the earlier Archaic era. The cause of this shift is unknown, but it is speculated that either an outside group migrated in replacing or mixing with the Fremont and Aspen groups, or the Fremont chose to abandon horticulture. Most structures found at Protohistoric sites are wikiups, or brush structures. In the later portion of the Protohistoric era (after 1650), the horse is introduced and tipi rings appear in the archaeological record replacing the traditional wikiup structures. The Protohistoric hunter-gather groups were ancestral Ute, who resided in the vicinity until their removal to reservations in the 1880s.

3.9.1.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for northwestern Colorado is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2007) and is summarized briefly here. Historic period sites in this region broadly follow some general themes, notably early exploration and fur trade, ranching and settlement, and mining. Exploration of this region of Colorado began with two Spanish missionaries (Franciscan friars Dominguez and Escalante) in 1776 looking for a new route from New Mexico to California missions that avoided resistance from Hopi Indians in Arizona. They found no new route, and the area was not visited again until the 1820s when the fur trade began to flourish in the region. In addition to the use of the area by trappers, a number of explorers surveyed the area, but their descriptions of northwestern Colorado are limited to references to its being dry and useless. However, the discovery of gold in the Denver area in 1859 brought many prospectors to Colorado. A subsequent survey of the northwestern region a decade later indicated that while the area could not support agriculture without large-scale irrigation, it could support ranching. This in effect opened up the area to ranching, an economic practice that continues today. As more and more ranches and small settlements were being established, pressures with the existing bands of Ute Indians began to escalate as traditional Ute hunting territory was being encroached upon. Several treaties were established between 1849 and 1868 and culminated in the placement of the Ute bands into reservations.

Large-scale open range cattle ranching was at its peak in the region between 1880 and the early 1900s. Sheep herding was also getting a start as a local industry. "Sheep wars" broke out between 1890 and 1920 as the sheep started to encroach on cattle country. This prompted a reorganization of grazing rights in Colorado and the introduction of land allotments in 1934 through the establishment of the Taylor Grazing Service to control land use. These events essentially ended open range cattle grazing and significantly slowed down the process of additional homesteading in this area. It also eventually resulted in the formation of the BLM, which controls grazing rights through the issuance of permits to this day.

Coal and oil were known to be present in the region as early as 1870 and 1890, respectively. Most of the coal mining was conducted east and south of the Piceance Basin. It was not until World War II that the demand for oil sparked sufficient interest to get the industry underway in this region. In addition to the oil, oil shale deposits present in the Piceance Basin, particularly in the Mahogany Zone, were getting attention from industry, as different companies experimented with various recovery techniques. By 1920, DeBeque, Colorado, was known as the shale oil capitol of the United States. However, no economical technique was discovered to recover the oil from the shale, and the industry experienced a series of ups and downs as experimentation continued. In the late 1970s and early 1980s, there was a surge in interest, but this too was short-lived and resulted in some serious economic issues for the region.

3.9.1.3 Ethnohistoric Context and Traditional Cultural Properties

Ute oral tradition indicates an extensive presence of Ute people in Colorado and Utah and partially in New Mexico. Although they organized and identified themselves according to band membership, this membership appears to have been fairly fluid and interchangeable. Approximately nine different Ute bands are thought to have inhabited the three-state study area (Bengston 2007). The area was likely used by all of the Ute bands at one time or another for hunting, gathering, trading, or socializing. Seasonal migrations of Ute families involved traveling to deserts and valleys in the winter and up into the mountains in summer to meet their subsistence needs. The Ute families relied heavily on meat, particularly from big game, and the gathering of a wide variety of plant foods for subsistence. Families would gather at certain times of the year for communal hunting, ceremonial dances, or other social activities. The introduction of the horse prompted more distant traveling to hunt buffalo.

The Ute bands today are organized into four separate tribal entities, primarily located on three reservations. The Ute Indian Tribe lives on the Uintah and Ouray Reservation in eastern Utah. The Southern Ute Tribe lives on the Southern Ute Reservation and the Ute Mountain Ute Tribe lives on the Ute Mountain Ute Indian Reservation, both in western Colorado. The White Mesa Band of the Ute Mountain Ute Tribe is a semiautonomous entity that is part of the Ute Mountain Ute Tribe. The Ute Indian Tribe and the Ute Mountain Ute Tribe have expressed some interest in this PEIS, and consultation between the BLM and the Ute is ongoing at this time.

Traditional cultural properties are not indicated in the site data files of the Colorado SHPO. Although some archaeological sites recorded in the database may be considered traditional cultural properties by the Tribes, a traditional cultural property may not contain cultural materials at all. The presence of traditional cultural properties may be based more on specific geographic locations or visual features than attributable to specific archaeological features present on or buried under the ground surface. These places could include religious sites associated with oral tradition and oral stories; traditional gathering areas; offering areas, including altars and shrines; vision quest and other individual use sites; group ceremonial sites, such as sweat lodges and ceremonial dance grounds; ancestral habitation sites; petroglyphs and pictographs; individual burials and massacre sites; observatories and calendar sites; and other geographic features. Identification of these places occurs through government-to-government consultation with the contacted Native American Tribes and a careful and thorough ethnographic and ethnohistoric assessment. Other than the ethnohistoric overview conducted in support of this PEIS, no previous ethnographic overviews have been completed for this region in Colorado, and no specific properties have been identified (Bengston 2007). Further consultation with the Tribes may be needed.

3.9.1.4 Surveys and Sites in the Study Area

In the most geologically prospective oil shale area of the Piceance Basin project area, a total of 1,280 different survey blocks or linear segments underwent archaeological investigation, according to the Colorado SHPO database. These investigations are predominantly Class III intensive field surveys. These investigations are documented in 479 individual survey reports. Spatial analyses of the GIS data revealed that approximately 93,700 acres in the Piceance Basin have been subjected to some level of survey.

The total number of recorded sites within the geologically prospective oil shale areas of the Piceance Basin, on the basis of GIS data provided by the Colorado SHPO in 2006, is 1,161. The number of sites that correspond to each site type is shown in Table 3.9.1-1; not all sites have been categorized as a particular site type in the database, and the totals of prehistoric and historic site types do not add up to the total number of sites. Duplicates are also inherent in this data since many sites have both prehistoric and historic components; therefore, a site total is not meaningful and is not presented in the table. For future project-specific analyses, the data for sites in a specific project area can be collected from data in the site forms on file at the Colorado SHPO. In addition, the numbers of sites that have been attributed eligibility status and entered into the database are presented in Table 3.9.1-2.[14]

TABLE 3.9.1-1 Site Types of Known Archaeological Sites in the Piceance Basin, Colorado

Site Type	Number of Sites
Historic; Aspen art	5
Historic; Architecture	35
Historic; Graffitti	1
Historic; Isolated feature	4
Historic; Isolated find	28
Historic; Road or trail	13
Total historic sites and isolated finds	86
Isolated feature	15
Isolated find	501
Open architecture	35
Open camp	165
Open lithic	257
Rock art	2
Shelter camp	11
Stone quarry	1
Total prehistoric sites and isolated features	987

14 The cultural resource information obtained from the various historic preservation offices represents a snapshot in time. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data nor recent submittals that had not yet been entered digitally.

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of the relationships of known prehistoric sites and soil families (O'Rourke et al. 2007). High-sensitivity areas correspond to lower elevations in the central and northern portions of the Piceance Basin. Areas in the higher elevations in the southern third of the basin are considered areas of moderate site frequency, and areas that contained fewer sites than expected if site distribution were random correspond to the middle elevation ridges and valleys.

TABLE 3.9.1-2 Eligibility Status of Known Archaeological Sites in the Piceance Basin, Colorado

Eligibility Status	Number of Sites
Eligible	51
Not eligible	822
Eligibility undetermined	145
Data not available	143
Total number of sites	1,161

3.9.2 Uinta Basin

3.9.2.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in the Uinta Basin includes four major time periods: the Paleoindian Period (10,000 to 6,000 B.C), the Archaic Period (6,000 B.C. to A.D. 500), the Formative Period (A.D. 500 to 1300), and the Protohistoric Period (also known as the Shoshonean or Numic Era) (A.D. 1300 to 1850). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting big game, such as bison and mammoth, are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. The Archaic era represents a shift in diet and settlement patterns from a highly mobile hunting lifestyle to a greater reliance on gathering wild plant foods and hunting smaller game. The discussion in Section 3.9.1.1 regarding the Formative Period in Colorado also generally applies. This period is when horticulture comes into practice, as well as widespread pottery use. Modeled clay figurines, rock art, and basketry are also part of the archaeological record. The lifestyle during this period is more sedentary, and semisubterranean pit-houses are being constructed. The Uintah Fremont, also discussed in Section 3.9.1.1, is a local variant of the Fremont tradition during this period that is also present in the Uinta Basin. The Protohistoric Period refers to the period when European influence and artifacts first make an impact on native populations, including the introduction of the horse. In the Uinta Basin, as in the Piceance Basin, the populations revert to a more Archaic hunting and gathering lifestyle and cease to continue agricultural practices. Very little is known about this period in the Uinta Basin. The prehistoric context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2007) prepared in support of this PEIS.

3.9.2.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for the Uinta Basin is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2007) and is summarized briefly here. Historic period sites in this region broadly follow the themes of early exploration and fur trade; ranching and settlement; and mining. The early history of the Uinta Basin is essentially the same as that for northwestern Colorado, regarding early Spanish exploration and the establishment of the fur trade

(Section 3.9.1.2). Sites relating to these activities are relatively rare, but at least one early trading post (Fort Davy Crockett) has been located and excavated archaeologically in the area. However, unlike other parts of the west, but similar to northwestern Colorado, fur trade did not lead to settlement; it mostly led to further exploration and mapping in search of possible railroad routes through the area. The first Euroamerican settlement of the region coincides with the establishment of the Uintah and Ouray Reservation. A few small cattle ranches were established in the area, but these tended to stay close to the foothills of the Uinta Mountains in the northern portion of the basin. Also, during the latter part of the nineteenth century, Mormons began settling along the Green River. Irrigation was a necessity to the survival of any farming practices in this arid region, resulting in the construction of a network of canals and reservoirs. Sheep raising also grew to be an important industry in the early part of the twentieth century. The mining of gilsonite and oil shale, as well as oil and gas production, are the other historic industries of note within the Uinta Basin. Evidence of these practices and the roads, pipelines, and rail lines that support them are scattered throughout the area. Several gilsonite-related mining towns are now ghost towns.

3.9.2.3 Ethnohistoric Context and Traditional Cultural Properties

The ethnohistoric context presented in Section 3.9.1.3 is also applicable for the Uinta Basin. The Ute Indian Tribe has expressed some interest in development of oil shale and tar sands resources on reservation lands within the Hill Creek Extension of the Uintah and Ouray Reservation. Consultations between the Ute Indian Tribe and the BLM are ongoing.

Traditional cultural properties are not indicated as such in the site data files of the Utah SHPO; however, in some cases the possible cultural affiliation of a site is presented as part of the prehistoric-historic site categorization. Although some archaeological sites recorded in the database may be considered traditional cultural properties by the Tribes, a traditional cultural property may not contain cultural materials at all. The presence of traditional cultural properties may be based more on specific geographic locations or visual features than attributable to specific archaeological features present on or buried under the ground surface. These places could include religious sites associated with oral tradition and oral stories; traditional gathering areas; offering areas, including altars and shrines; vision quest and other individual use sites; group ceremonial sites, such as sweat and ceremonial dance grounds; ancestral habitation sites; petroglyphs and pictographs; individual burials and massacre sites; observatories and calendar sites; and other geographic features. Identification of these places occurs through government-to-government consultation with the contacted Native American Tribes and a careful and thorough ethnographic and ethnohistoric assessment. Several previous ethnographic overviews have been completed for this region in Utah (Bengston 2007). Further consultation with the Tribes may be needed.

3.9.2.4 Surveys and Sites in the Study Area

In the most geologically prospective oil shale area of the Uinta Basin project area, a total of 11,201 different survey blocks, linear segments, and point locations underwent archaeological investigation, according to the Utah SHPO database. These investigations are predominantly Class III intensive field surveys. These investigations are documented in 2,826 individual survey reports. Spatial analyses of the GIS data reveal that approximately 158,800 acres in the Uinta Basin have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear and point surveys that have been conducted in the region; linear surveys of approximately 2,750 mi have also been conducted in the Uinta Basin.

The total number of recorded sites within the geologically prospective oil shale areas of the Uinta Basin based on GIS data provided by the Utah SHPO in 2006 is 1,087. These sites are identified as having prehistoric and/or historic components tied to a particular period or group affiliation, unlike site data from Colorado and Wyoming, which are classified by site type or function. Details regarding prehistoric and protohistoric affiliation are not presented here. Duplicates are inherent in this data as many sites have both prehistoric and historic components; therefore, a site total is not meaningful and is not presented in Table 3.9.2-1. In addition, the numbers of sites that have been attributed eligibility status are presented in Table 3.9.2-2. There are many sites for which no data regarding site type or eligibility have been entered into the system.[15]

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2007). High-sensitivity areas correspond to the valley of the White River and uplands in the northeastern third of the Uinta Basin. Areas in the higher elevations of the East Tavaputs Plateau south of the

TABLE 3.9.2-1 Site Types of Known Archaeological Sites in the Uinta Basin, Utah

Site Type	Number of Sites	Site Type	Number of Sites
Prehistoric		***Historic***	
Archaic	35	Basque	1
Fremont	27	European/American	339
Late Prehistoric	8	Mexican	1
Paleoindian	3	Unknown	32
Protohistoric	46		
Unknown	408		
No information available	7		

15 The cultural resource information obtained from the various historic preservation offices represents a snapshot in time. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data nor recent submittals that had not yet been entered digitally.

White River and west of Two Water Creek are considered areas of moderate sensitivity. Areas that contained fewer sites than expected if site distribution were random correspond to bottomland soils on the floodplains of the Green River and White River and high-elevation areas along the southwestern edge of the basin.

TABLE 3.9.2-2 Eligibility Status of Known Archaeological Sites in the Uinta Basin, Utah

Eligibility Status	Number of Sites
Eligible	266
Not eligible	606
Eligibility undetermined	59
Data not available	156
Total number of sites	1,087

3.9.3 Green River and Washakie Basins

3.9.3.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in southwestern Wyoming includes four major time periods: the Paleoindian Period (10,000 to 6,500 B.C), the Archaic Period (6,500 B.C. to A.D. 0), the Late Prehistoric Period (A.D. 0 to 1500), and the Protohistoric Period (A.D. 1500 to 1800). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting megafauna, such as bison and mammoth, are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. Smaller dart points and early house-pits are characteristic of the subsequent and long-lived Archaic Period. The two main technological advances that mark the Late Prehistoric Period are the bow and arrow and the introduction of pottery, indicative of growing populations and a more sedentary (less mobile) lifestyle. The Protohistoric Period refers to the period when European influence and artifacts first made an impact on native populations, including the introduction of the horse. The prehistoric context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2007) prepared in support of this PEIS.

3.9.3.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for southwestern Wyoming is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2007) and is summarized briefly here. Significant historic period sites in southwestern Wyoming broadly follow some general themes, notably fur trade; settlement and transportation; ranching; and oil and coal mining. The area was heavily used by early fur trappers, and sites relating to this activity are relatively rare (e.g., early trading posts, annual meeting, or rendezvous, locations; and individual trappers' camps). However, the trails the trappers and Native American populations used were noted, and this information was passed along to others to subsequently form the main trails for westward expansion and migration.

The trail systems and the emigrant sites associated with these trails are a very important component of the history of this region. The Oregon Trail and its various cutoffs and deviations cut across a large portion of the Green River Basin; many of these trail segments have been determined significant historic properties. Portions of this trail system also coincide with other key events (establishment of Pony Express, California Gold Rush, and Mormon settlement of Utah) that result in numerous historic sites associated with these events (e.g., camps, stage stations, rock inscriptions, and wagon ruts). Similarly, the Overland, or Cherokee, Trail cuts across both the Washakie and Green River Basins. The first transcontinental railroad (Union Pacific) cuts across southern Wyoming following the Overland Trail route, as does the Lincoln Highway, the first road constructed for automobile use in the state. Associated with these developments are tent towns, stage stations, wagon roads, and various small related sites identifiable by a scattering of historic artifacts.

Ranching was also a significant industry in southwestern Wyoming, especially once the railroad was established and livestock could be shipped. From the main east-west rail line, ranches spread north and south, up and down the Green River and its tributaries. Cattle raising provided the single greatest impetus to settlement away from the main line of the Union Pacific and continues to be economically significant to the state. Sheep raising was also an important factor in the settlement and economic development of Wyoming. Sheep ranching rendered semiarid land economically productive and served to broaden the economic base that led to the growth and development of regional towns. Conflicts between cattle and sheep ranchers in the 1890s eventually were diminished as the open range was fenced, and later, as federal agencies regulated the use of public range lands. Numerous homesteads and ranches have been recognized as historic sites in the Green River Basin. Several irrigation ditches have been identified as potential historic engineering structures.

Sites related to the history of mining coal deposits and exploiting oil seeps are also important to the history of the region. Many of the early development sites coincide with the development of the emigrant trails. When the Overland Trail was laid out, some stage stations along the route appear to have been sited near coal outcrops specifically so that fuel would have been available for the blacksmith shops and for general heating purposes. Later, the Union Pacific rail line was routed near these readily accessible coal seams, since the fuel was needed to power the locomotives. Outlying prospecting pits, old mine shafts, and abandoned camps are some of the physical reminders of historic early mining operations in the area.

3.9.3.3 Ethnohistoric Context and Traditional Cultural Properties

Eastern Shoshone territory covered most of present-day western Wyoming and possibly northeastern Utah. An even larger range of land was used for hunting buffalo. The Eastern Shoshone generally wintered along the Green River (Bengston 2007). The Eastern Shoshones tended to form larger, highly militaristic groups or bands (Shimkin 1986). This was likely because of their greater dependence on the buffalo and the more frequent occurrence of warfare with the other Plains tribes. However, membership in the various bands was fluid and changeable as with other Shoshone bands (Bengston 2007; Shimkin 1947, 1986).

The lifeways of the Shoshone bands varied according to environment and whether they had horses. The bands that depended on horse and buffalo hunting, like their Plains counterparts, generally lived in Plains-style tepees. Their subsistence lifeways depended more on hunting and fishing than on plant gathering. The Shoshone bands that had horses relied on buffalo; those bands living near major rivers subsisted primarily on salmon and other fish. The Eastern

Shoshone depended mostly on faunal resources supplemented with berries, roots, and seeds (Bengston 2007).

The predominant territory of the Utes is in southeastern Colorado; however by the mid-1600s they had acquired horses and had migrated into northern Colorado and Utah and possibly southwestern Wyoming according to Ute oral tradition. The Utes also moved eastward into the Great Plains and adopted a plains lifestyle of buffalo hunting and living in tepees. Northern Arapaho also may have made use of lands in the study area, but there is less documented evidence of this. The Northern Arapaho territory expanded into eastern and northern Wyoming and Kansas from eastern North Dakota and Minnesota after the Arapahos began using horses in the early 1700s. The Arapahos specialized in big game hunting and supplemented their diet with roots, berries, fruits, nuts, and tubers (Bengston 2007).

The Eastern Shoshone and Northern Arapaho have expressed an interest in this PEIS, and consultations between the BLM and these Tribes are ongoing at this time (see Table 7.2-1).

Traditional cultural properties are not indicated in the site data files of the Wyoming SHPO Cultural Records Office (WYCRO). Although some archaeological sites recorded in the WYCRO database may be considered traditional cultural properties by the Tribes, such as some of the burials, cairns, rock alignments, and rock art sites, many traditional cultural properties may not contain archaeological materials that would indicate an archaeological site. The presence of traditional cultural properties may be based more on specific geographic locations or visual features than attributable to specific archaeological features present on or buried under the ground surface. These places could include religious sites associated with oral tradition and oral stories; traditional gathering areas; offering areas, including altars and shrines; vision quest and other individual use sites; group ceremonial sites, such as sweat lodges and ceremonial dance grounds; ancestral habitation sites; petroglyphs and pictographs; individual burials and massacre sites; observatories and calendar sites; and other geographic features. Identification of these places occurs through government-to-government consultation with the contacted Native American Tribes and a careful and thorough ethnographic and ethnohistoric assessment. Other than the ethnohistoric overview conducted in support of this PEIS, no previous ethnographic overviews have been completed for this region in Wyoming, nor have specific properties been identified (Bengston 2007). Further consultation with the Tribes may be needed.

3.9.3.4 Surveys and Sites in the Study Area

Past archaeological investigations in the most geologically prospective oil shale area of the Green River Basin project area total 4,315, according to the WYCRO database. In the Washakie Basin, 535 different survey blocks or linear segments underwent archaeological investigation (predominantly Class II sampling and Class III intensive field surveys). These investigations are documented in 2,270 and 96 individual survey reports, respectively, for the two basins. Spatial analyses of the GIS data reveal that approximately 120,990 acres in the Green River Basin and approximately 21,270 acres in the Washakie Basin have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear surveys that have been conducted in the region.

The total number of recorded sites within the geologically prospective oil shale areas of the Green River and Washakie Basins based on GIS data provided by the Wyoming SHPO in 2006 is 13,598. This total includes 12,369 sites in the Green River Basin and 1,228 sites in the Washakie Basin. These numbers from the WYCRO database contain duplicate entries if the sites were evaluated more than once or the site is located within multiple township and range sections, so the actual number is smaller. In an attempt to remove duplicate entries, the estimate for known sites in the Green River Basin is 6,522, and approximately 944 sites are located in the Washakie Basin. A variety of different site types are represented. The number of sites that correspond to each site type are shown in Table 3.9.3-1. In addition, the numbers of sites that have been attributed eligibility status are presented in Table 3.9.3-2.[16]

TABLE 3.9.3-1 Site Types of Known Archaeological Sites in the Green River and Washakie Basins, Wyoming

Site Type	Number of Sites in Green River Basin	Number of Sites in Washakie Basin	Total Number of Sites in Wyoming Project Area
Historic			
Exploration	1	0	1
General	323	44	367
Irrigation	13	0	13
Mining	4	1	5
Ranching	107	22	129
Transportation	821	59	880
Urban	9	0	9
Prehistoric			
Activity area	67	12	79
Habitation	2,893	190	3,083
Lithic	1,923	485	2,408
Open camp	229	93	322
Special[a]	69	13	82
Unspecified/other	27	9	36
Additional Site Types			
Historic Native American	3	0	3
Human remains	4	0	4
Miscellaneous	4	0	4
Multicomponent sites	12	16	28
Unknown/no information	13	0	13
Total number of sites	6,522	944	7,466

[a] The category "Special" includes rock alignments, cairns, stone circles, medicine wheels, rock art, rockshelters, buffalo and antelope kill sites, and ceremonial sites.

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[16] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data nor recent submittals that had not yet been entered digitally.

TABLE 3.9.3-2 Eligibility Status of Known Archaeological Sites in the Green River and Washakie Basins, Wyoming

Eligibility Status	Number of Sites in Green River Basin	Number of Sites in Washakie Basin	Total Number of Sites in Wyoming Project Area
Eligible	1,795	339	2,134
Not eligible	3,212	319	3,531
Eligibility undetermined	1,140	221	1,361
Data not available	375	65	440
Total number of sites	6,522	944	7,466

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2007). High-sensitivity areas in the Green River Basin correspond to soils of the dissected plains and open or somewhat broken terrain where sand dunes are present. High-sensitivity areas in the Washakie Basin correspond to soils in low elevations. No moderate areas were identified in either the Green River Basin or Washakie Basin. Low site densities occur in the most highly elevated terrain in the Green River Basin and the elevated ridge and dissected plateau in the central portion of the Washakie Basin.

3.9.4 Special Tar Sand Areas in East-Central and Southeastern Utah

Most of the STSAs are located within or adjacent to the geologically prospective area for oil shale development in the Uinta Basin. For these areas, the prehistoric and historic context presented in Sections 3.9.2.1 and 3.9.2.2, respectively, are applicable. The following is a summary of the contexts for those STSAs that are located farther south in central and southern Utah. Much of the discussion presented here is summarized from a highly relevant previous archaeological study conducted for a tar sands project in the 1980s (Tipps 1988). The prehistoric and historic context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2007) prepared in support of this PEIS.

3.9.4.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in central and southern Utah includes four major time periods: the Paleoindian Period (10,000 to 6,000 B.C.), the Archaic Period (6,000 B.C. to A.D. 500), the Late Prehistoric Period (A.D. 500 to 1300), and the Protohistoric Period (also known as the Shoshonean or Numic Era) (A.D. 1300 to 1850). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting big game, such as bison and mammoth, are characteristic artifacts of Paleoindian Period sites, and are usually found as isolated artifacts or in association with later period sites. Isolated

Paleoindian points have been recorded in the vicinity of the southern STSAs. The Archaic era represents a shift in diet and settlement patterns from a highly mobile hunting lifestyle to a greater reliance on gathering wild plant foods and hunting smaller game. Several rockshelters and caves in the region have been excavated and have greatly added to the regional understanding of the Archaic Period in terms of artifact typologies and chronologies.

The Late Prehistoric Period is when horticulture comes into practice, as well as widespread pottery use and use of the bow and arrow. Modeled clay figurines, rock art, and basketry are also part of the archaeological record. The lifestyle during this period is more sedentary, and storage and living structures (both pit dwellings and masonry structures) are being constructed. There is a great deal of archaeological debate concerning the various cultural traditions that have been proposed and surrounding the presence of both Fremont and Anasazi characteristics at many sites, so this description may be overly simplified. The San Rafael Fremont is a local variant of the Fremont cultural tradition found in Central Utah dating to this period; this tradition is distinct from the Uintah Fremont variant present in northeastern Utah and northwestern Colorado. The primary distinctions are the presence of stone-lined pit dwellings and adobe masonry structures and the pottery type; caves and overhangs were also used for storage and habitation. The Sunnyside and San Rafael Swell STSAs are located within the area considered to be associated with the San Rafael Fremont. Another cultural tradition of the Late Prehistoric Period that is present in the region is the Anasazi tradition linked to the Pueblo groups. This very complicated archaeological tradition with its many subperiods is used widely to describe the cultural chronology of the greater Southwest region of the United States. The Virgin, Mesa Verde, and Kayenta Anasazi are local variants of the Anasazi cultural tradition present in the southern portion of the state. The Circle Cliffs area is in a transition zone between the San Rafael Fremont and Virgin and Kayenta Anasazi cultures. The area of White Canyon and Tar Sand Triangle is most closely linked with the Kayenta and Mesa Verde Anasazi, although Fremont rock art is also common in the area. Anasazi presence does not appear to be continuous during the Late Prehistoric Period in the vicinity of these southern STSAs. The Protohistoric Period refers to the period when European influence and artifacts first make an impact on native populations, including the introduction of the horse. The inhabitants of the region are primarily Numic-speaking groups ancestral to the Ute and Paiute, although there is some evidence of Navajo presence near the White Canyon area.

3.9.4.2 Historic Context for Archaeological Sites, Features, and Structures

Historic period sites in this region broadly follow the themes of early exploration and fur trade, ranching and settlement, and mining. Early exploration in the region was primarily by the Spanish, followed by Euroamerican trappers and traders. Prior to Euroamerican settlement, the Old Spanish Trail was the main route through the region used by trappers, traders, Indians, and slave traders (people who peddled captured Paiute women and children). Early settlement of the area was initiated by the arrival of the Mormons in Utah. Much of the early settlement focused on cattle and sheep raising. Concurrently with Mormon settlement, government exploration in search of possible routes for a transcontinental railroad and mail delivery was also conducted throughout the region. The area became the backdrop for the Black Hawk War where southern settlements were raided by Utes, Paiutes, and Navajos. In addition, the area was known for cattle rustling and thievery in the late nineteenth century. Butch Cassidy and the Wild Bunch are known to have hidden away in this region, and several of their presumed escape routes follow old cattle and Indian trails. By the turn of the century, there was a shift in the economy from farming and ranching in Central Utah to coal mining coincident with the availability of the Denver and Rio Grande Western rail line. Oil was also drilled near the Green River. To the south, gold, silver, and copper mining became popular for a short time, followed by the mining of radioactive ore (e.g., uranium and radium). Near White Canyon, there was a mill constructed to process uranium ore from one of the richest uranium mines on the Colorado Plateau. A small settlement was established at the mouth of White Canyon, near the mill, to support the mining activities. In the twentieth century, large tracts of public lands were set aside for reclamation projects and recreational areas, including the construction of dams and reservoirs and the establishment of several National Monuments and National Parks.

3.9.4.3 Ethnohistoric Context and Traditional Cultural Properties

The ethnohistoric context presented in Section 3.9.1.3 is also applicable for several of the STSAs within or adjacent to the Uinta Basin. The Ute Indian Tribe has expressed some interest in development of oil shale and tar sands resources on reservation lands within the Hill Creek Extension of the Uintah and Ouray Reservation. Consultations between the Ute Indian Tribe and the BLM are ongoing. More southerly STSAs are located in areas of possible interest to Paiute, Navajo, and Puebloan Tribes. See Table 7.2-1 for the level of interest expressed by the various Tribes during government-to-government consultations.

Traditional cultural properties are not indicated as such in the site data files of the Utah SHPO; however, in some cases the possible cultural affiliation of a site is presented as part of the prehistoric or historic site categorization. Although some archaeological sites recorded in the database may be considered traditional cultural properties by the Tribes, a traditional cultural property may not contain cultural materials at all. The presence of traditional cultural properties may be based more on specific geographic locations or visual features than attributable to specific archaeological features present on or buried under the ground surface. These places could include religious sites associated with oral tradition and oral stories; traditional gathering areas; offering areas, including altars and shrines; vision quest and other individual use sites; group ceremonial sites, such as sweat lodges, and ceremonial dance grounds; ancestral habitation sites; petroglyphs and pictographs; individual burials and massacre sites; observatories and calendar sites; and other geographic features. Identification of these places occurs through government-to-government consultation with the contacted Native American Tribes and a careful and thorough ethnographic and ethnohistoric assessment. Several previous ethnographic overviews have been completed for this region in Utah (Bengston 2007). Further consultation with the Tribes may be needed.

3.9.4.4 Surveys and Sites in the Study Area

Within the 11 STSAs, a total of 2,602 different survey blocks, linear segments, and point locations underwent archaeological investigation, according to the Utah SHPO database. These investigations are predominantly Class III intensive field surveys. These investigations are documented in 533 individual survey reports. Spatial analyses of the GIS data reveal that more than 34,500 acres within the STSAs have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear and point surveys that have been conducted in the region; linear surveys of more than 430 mi have also been conducted within the 11 STSAs.

The total number of recorded sites within the 11 STSAs based on GIS data provided by the Utah SHPO in 2006 is 679 sites. These sites are identified as having prehistoric and/or historic components tied to a particular period or group affiliation. Details regarding the prehistoric and protohistoric affiliation are not presented here. Duplicates are inherent in these data as many sites have both prehistoric and historic components; therefore, a site total is not meaningful and is not presented in Table 3.9.4-1. The number of sites that have been attributed eligibility status are presented in Table 3.9.4-2. It should be noted that there are many sites for which no data regarding site type or eligibility have been entered into the system. Also, some of the sites are the same as those recorded in the Uinta Basin because of the study area overlap.[17]

Cultural resource sensitivity maps for many of the STSAs were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2007). However, sensitivity maps of all of the STSAs could not be developed from the soils data. Factors such as STSAs located within single soil families, archaeological surveys within STSAs limited to single soil families, and site frequencies that in some cases were not statistically different than expected for random distribution affected results for Argyle Canyon, San Rafael, Circle Cliffs, Asphalt Ridge, and Pariette STSAs. Sensitivity maps were generated for the remaining six STSAs on the basis of nonrandom associations between soil families and site frequency. In each of these STSAs, high-sensitivity areas are limited to one soil family each at White Canyon, Sunnyside, and Tar Sand Triangle STSAs, and two soil families each at Hill Creek, P.R. Spring, and Raven Ridge STSAs. The specific soil families are presented in O'Rourke et al. (2007).

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[17] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data nor recent submittals that had not yet been entered digitally.

This issue is especially critical for understanding the site concentrations associated with an archaeologically rich area known as Nine Mile Canyon for which much of the site information had not yet been entered into GIS. In addition, a nomination packet for listing a Nine Mile Canyon archaeological district on the NRHP was submitted in late 2007 (subsequent to the data collection for this PEIS).

TABLE 3.9.4-1 Site Types of Known Archaeological Sites in the 11 Special Tar Sand Areas, Utah

Site Type	Number of Sites in Each STSA										
	Argyle Canyon	Asphalt Ridge	Circle Cliffs	Hill Creek	P.R. Spring	Pariette	Raven Ridge	San Rafael Swell	Sunnyside	Tar Sand Triangle	White Canyon
Prehistoric Affiliation											
Paleoindian	0	0	0	0	0	0	0	0	0	0	0
Archaic	0	0	5	0	6	0	0	0	5	4	0
Late Prehistoric (general)	0	0	0	1	2	1	0	0	0	1	0
Anasazi	0	0	3	0	0	0	0	0	0	0	0
Fremont	0	0	0	3	6	1	2	0	79	0	0
Protohistoric	0	0	0	3	8	1	2	0	2	1	0
Unknown	0	11	14	13	53	50	13	0	112	9	1
FM[a]	0	0	0	0	0	0	1	0	0	0	0
Historic Affiliation											
European/American	1	1	9	1	14	12	4	0	17	2	0
Unknown	0	1	1	1	4	0	0	0	8	0	1

[a] Definition of this code is currently unknown.

TABLE 3.9.4-2 Eligibility Status of Known Archaeological Sites in the 11 Special Tar Sand Areas, Utah

Eligibility Status	Number of Sites in Each STSA											Total Number of Sites
	Argyle Canyon	Asphalt Ridge	Circle Cliffs	Hill Creek	P.R. Spring	Pariette	Raven Ridge	San Rafael Swell	Sunnyside	Tar Sand Triangle	White Canyon	
Eligible	0	1	15	10	27	26	2	0	187	8	0	276
Not eligible	1	13	13	12	57	37	16	0	21	14	0	184
Eligibility undetermined	0	0	4	3	11	0	2	0	4	4	1	29
Data not available	0	2	49	17	29	8	2	0	52	16	15	190
Total number of sites	1	16	81	42	124	71	22	0	264	42	16	679

3.10 SOCIOECONOMICS

3.10.1 Past Oil Shale Development

Although small quantities of oil shale were produced between 1915 and 1925, with additional exploration activities occurring in the 1950s, major attempts to develop oil shale resources did not occur until the early 1970s with the imposition of the Middle East oil embargo and the resulting attempt to reduce U.S. dependence on foreign oil supplies. The federal prototype leasing program begun in 1974 attracted bids from a number of companies. The Blanco Oil Shale Project on Yellow Creek south of Rangely in Colorado was started by Gulf Oil on tract C-a with the aim of producing 50,000 bbl/day by 1987, while TOSCO and Atlantic Richfield leased land on tract C-b, with both projects planning to use in situ processing to produce 57,000 bbl/day by 1982 (Lamm and McCarthy 1982). Sites U-a and U-b in Utah were also leased at this time by Sun Oil and Phillips Petroleum. In addition to planned developments on federal land, during this period, oil companies also bought land holdings on private land, with 14 companies having purchased land in the Piceance Basin by 1979. The largest development on private land was the Colony Project, begun by Atlantic Richfield, Shell, Ashland, Cleveland Cliffs, and TOSCO in the early 1970s. Using room-and-pillar mining and surface retorting, the project extended from Parachute Creek to the Roan Plateau and had produced 800 bbl/day by 1972, with 50,000 bbl/day planned by 1985. The Paraho Development Company also established a project using surface retorting in the U.S. Naval Oil Shale Reserve west of Rifle (Lamm and McCarthy 1982).

Despite the financial commitment by private companies, and the willingness of the federal government to lease lands for oil shale development, none of the projects begun in the 1970s were successful, and by 1976 a number of companies had withdrawn from the federal leasing program. Despite inflation in world oil markets following the 1973 Organization of Petroleum Exporting Countries (OPEC) oil embargo, no major technological breakthrough had been made to make oil shale viable on a commercial scale. In addition to economic and technological considerations, significant unresolved legal difficulties had emerged over title disputes, unpatented mining claims, and disputes over Ute Indian land claims (Lamm and McCarthy 1982). By the early 1980s, following the 1980 oil embargo, the political and economic environment for the development of synthetic fuels changed dramatically. The passing of the Energy Security Act of 1980 was intended to decrease U.S. dependency on foreign oil, and included a 5-year $19 billion program of incentives to encourage private industry to build synfuel plants in order to produce 500,000 bbl/day by 1987, and 1 million bbl/day by 1992. Although the Act provided massive incentives for development and significantly reduced the risks of development for private companies, the plan did not receive widespread political support in the western states, with concerns over states rights, ethical questions surrounding support for energy companies, water rights, environmental laws regarding strip mining, water and air pollution, and historic preservation (Lamm and McCarthy 1982).

In spite of serious doubts from western politicians, various companies, including TOSCO, which had previously invested in the Colony Project with Exxon, received loan guarantees from the federal government, and numerous subsidy applications were made by other companies. As a result of the Energy Security Act, several new projects were started in Colorado, including the Chevron Clear Creek project, which planned to produce 100,000 bbl/day by 1994, and the Mobil project, which aimed for 100,000 bbl/day (Lamm and McCarthy 1982). In Utah, Chevron began a processing plant near Farmington; TOSCO planned a 48,000-bbl/day plant at Sand Wash in the northeastern part of the state, while Paraho announced a project to be started near Vernal in 1982. The largest development, however, was the Colony Project announced by Exxon in 1980, which envisaged production of 47,000 bbl/day, to be built without the help of federal subsidies (Rasmussen 2008). In anticipation of continued increases in world oil prices, Exxon advocated the large-scale development of the U.S. synthetic fuel industry and produced highly optimistic projections of the role of the oil shale in domestic oil production, suggesting that up to 600,000 bbl/day could be produced by 1990, 1 million bbl/day by 1995, and 8 million bbl/day by 2010, involving the development of 80 plants in Garfield and Rio Blanco Counties. Despite the absence of a commercially viable processing technology, the company projected the development of 150 oil shale plants over a 20-year period, with 6 massive strip mines, each 3.5 mi long, 1.75 mi wide, and 0.5 mi deep. Each mine would require 22,000 workers, with 8,000 workers at each processing plant (Gulliford 1989).

To accommodate the workforce required to produce 1 million bbl/day, Exxon began construction of a new community at Battlement Mesa, which would double the population of Garfield County. It was estimated that 700 schools, 3,000 teachers and staff, 700 police officers and firemen, and 200 doctors would be required (Gulliford 1989). Population in the Colorado River Valley would grow to 1.5 million, with 75,000 new housing units required to accommodate the new workforce. It was suggested that 7,000 ac-ft/yr of water would be needed for one 50,000-bbl/day plant, with 350 ac-ft/yr needed for every additional 1,000 population. Although Exxon had water rights on water from the Colorado River, with additional supplies available from the Ruedi Reservoir (Rasmussen 2008), oil shale production of 4 million bbl/day would require almost 870,000 ac-ft/yr (Gulliford 1989). To satisfy water demand for the larger development, Exxon envisioned a pipeline from the Missouri River in South Dakota, with interbasin transfers thought to be possible with sufficient state and federal political will. Three 1,000-MW power plants were also to be built to provide the energy to pump the water through the pipeline into western Colorado.

Even before the Colony Project started in 1980, there had been significant property speculation in communities associated with oil shale development, and rapid inflation in property values was experienced in many communities. In Rifle, for example, lots selling for $12,000 in 1974 sold for $115,000 in 1979 (Gulliford 1989). Land parcels were often bought and sold two or three times a year as business in oil shale communities grew. Building permits worth a total of $500,000 were granted in 1976; by 1980, permits totaled $14 million. Often land was sold to speculators who were from outside the area and were not necessarily interested in the long-term well-being of the community. There was also rapid expansion in retail sales and retail prices, which led to considerable turnover in local small businesses, with local business owners also often from outside local oil shale communities (Gulliford 1989).

According to reports in the *Rifle Tribune*, a local newspaper established at the beginning of the oil shale boom, oil shale development affected many aspects of community economic and social life, even before the Colony Project, with the delicate social fabric of community and neighborliness that had evolved over generations overwhelmed by large-scale in-migration of transients from a wide range of communities outside the oil shale region, many of whom, it was perceived, had no intention of working (Gulliford 1989). Personal relationships typical of rural social life were quickly replaced by impersonal relationships based primarily on marketplace relations (see Section 3.10.2.2.5). The boom was particularly threatening to people on fixed incomes, with rapid increases in rents, grocery bills, etc. Massive increases in drug and alcohol abuse, and domestic violence were also reported, with corresponding increases in caseload for social and mental health workers. Rapid increases in poaching of elk and deer were reported, in addition to increases in off-road traffic, and little desire to buy homes. Local retailers moved quickly to supply in-migrant workers with cars, trucks, snowmobiles, boats, and a range of other smaller items, replacing goods traditionally purchased in small ranching communities. In addition to in-migrants searching for oil shale employment, there was also a large influx of professional workers looking for employment in growing oil shale community economies, resulting in considerable improvement in the availability and quality of local services. Oil shale towns were often professionally managed with sophisticated zoning and planning procedures (Gulliford 1989).

To address the emerging housing crisis, Union Oil built employee housing to the north of Parachute, with modular housing on 380 acres for 1,000 workers (Gulliford 1989). Although the employer-provided housing succeeded in keeping single, male construction workers isolated from the local community, the housing did not address the problem of low-income workers arriving without jobs, and living in campsites or in their cars. Expenses involved in evicting squatters in Garfield County led quickly to requests that Union Oil pay some of the costs associated with rapid population growth. By the time the Exxon Colony Project began, there were various stipulations included in the permit, including guaranteed housing for 80% of project workers, local road upgrades, prepayment for all water and sewer hookups and waste disposal, provision of worker transportation, and annual socioeconomic monitoring reports. The company also contributed to local education capital spending, and provided support for local fire, police, and emergency management services. Exxon also started construction on a purpose-built community at Battlement Mesa to house 25,000 people, which was to include 7,000 house and trailer spaces, a 100,000-ft^2 shopping center, office buildings, park, indoor recreation facility, schools, churches, and golf course (Gulliford 1989).

By early 1982, the Colony Project workforce had reached 2,100 and, in order to process up to 50,000 bbl/day, was projected to reach 6,992 by 1985 (Gulliford 1989). Rather than continued rapid development, however, in May 1982, Exxon decided to close the Colony Project, leaving thousands of oil shale and support workers unemployed. Within a week, an estimated 1,000 people had left Parachute and Garfield County. There were sharp changes in community expectations about growth, employment, and lifestyle, and social relationships and family ties changed radically. High-priced, former ranching land was sold back to previous owners at low prices, but was still subject to high taxes. Some farmland and drainage had been damaged by development and could not be recovered. The housing market immediately deflated with many houses for sale, and local contracts and orders for materials and supplies were cancelled. High rents for new apartment buildings in Battlement Mesa could not be recovered, thus impacting rental markets elsewhere in the region. Restaurants lost business, and office and retail space went vacant. For some time after closure, transient workers continued to arrive in

Parachute, remaining a problem for the local community, which impacted social and educational services. Churches closed or had to radically reduce their obligations to their congregations. Social services and other government departments suffered severe cutbacks and employee layoffs. Many local government departments were left with buildings and infrastructure that were too large for the remaining population, making them expensive to operate and impacting local tax rates. Although Battlement Mesa was later successfully marketed as a retirement community, to many the development represented 3,000 acres of sprawl, while Parachute was left with many older buildings in need of repair (Gulliford 1989).

The bust period lasted for multiple years after the initial announcement. Population in Mesa County fell from 94,000 in 1980 to 83,000 in 1985. Eighty-five million dollars in annual payroll was lost. Numerous businesses had been started throughout the region, and retail and transportation facilities had been built with the expectation of population and economic growth. Bankruptcies and housing foreclosures were commonplace; 200 businesses in Rifle alone had failed 18 months after the project closed, while foreclosures in Mesa County rose from 98 in 1981 to 1,042 in 1984 (Gulliford 1989). Occupancy rates in Battlement Mesa were at 35% in 1984. The closure of the Colony Project affected the entire western Colorado region, and by 1984, unemployment levels had reached 9.5%, and by 1985, 14.2% of all housing in Grand Junction was vacant. In many respects, it became apparent that preboom conditions would not return to the economy. Many businesses that had operated for generations had failed and would not be reopened. Together with the decline in the coal and oil and gas industry, the value of farm produce, and consequently ranching land, also declined. A survey identified 7,400 people that would leave in 1984, with losses in population from 1981 to 1984 representing 15 years of population growth in Mesa County. Foreclosures in Mesa County reached 1,600 by 1985. Garfield County had lost 6,472 jobs and 3,745 residents between 1981 and 1985 (Gulliford 1989).

The psychological impacts of the bust on the local community, in particular its suddenness, although not well-documented, may have been significant (see Section 3.10.2.2.5), with many financial and family decisions hinging on rapidly rising incomes and changing community social structures (Gulliford 1989). Although Exxon had promised an orderly closure, plant workers were not given advance notice. Many workers had expected to be in the area for many years and had borrowed money, purchased houses and other expensive items, moved their families into the local community, and placed their children in local schools. Individuals and institutions had trusted Exxon, had seen the size of the capital initially invested in the project and had assumed that progress on the project would continue. Even after closure of the project, many businesses remained open, and immediate population decline was not severe. Many long-term residents and those in-migrants that had remained after closure preferred not to believe that economic collapse was possible, and instead hoped for a government buyout of oil shale infrastructure, or that another major employer would move in (Gulliford 1989). Changes in social behavior also became apparent as a result of declining incomes, as people became isolated from their neighbors; communities began looking inwardly to help each other rather than to other communities in the Colorado River Valley. Divisions also developed between existing and new residents; while surviving social networks could be relied upon by older residents, newer residents had little informal community support, which produced alienation, family and marital problems, financial problems, domestic violence, drug and alcohol abuse, and divorce (Gulliford 1989) (see Section 3.10.2.2.5).

3.10.2 Current Conditions

The socioeconomic environment potentially affected by the development of oil shale and tar sands resources includes a region of influence (ROI) in each state (Colorado, Utah, and Wyoming), consisting of the counties and communities most likely impacted by development of oil shale and tar sands resources (Figure 3.10.2-1; Table 3.10.2-1). For each ROI, three key measures of economic development are described—employment, unemployment, and personal income. Five measures of social activity, population, housing, public service employment, and local government expenditures are also described. A number of measures of social well-being that may be affected by rapid population growth and "boom and bust" economic development—crime, alcoholism, drug use, divorce, and mental illness—are also described.

As it is likely that the viewpoints, perceptions, and attitudes individuals may have toward large-scale energy development form an important background to current and future conditions in each ROI, a series of interviews was conducted with key stakeholders in Garfield County and Rio Blanco County, Colorado, and Uintah County, Utah, to provide a context to the data presented in the following sections. Individuals contacted were those who provided comments as part of the project scoping process, people who have been involved from the early stages of oil shale development, including local and county planning officials, community leaders, community service providers, realtors, and individuals located in proximity to project developments likely to be impacted by specific aspects of energy development. Participants were asked about past developments, particularly those that have produced "boom-and-bust" economic and social conditions which are deemed relevant, the current situation, including the ongoing impact of oil and gas and recreation, and the likely impact of new developments that might occur alongside developments in oil and gas and in recreation (see Appendix H). Each of the following sections presents a brief summary of concerns expressed during these interviews, as a means of providing a context for the economic and social data presented for each ROI.

In the following sections that report the opinions and perceptions of interview respondents, it should be noted that solicited information may or may not be consistent with statistics compiled by local, state, and federal agencies.

3.10.2.1 Economic Environment

3.10.2.1.1 Employment and Unemployment. Developments in the oil and gas industry have produced rapid growth in employment in many communities in each ROI, exacerbated by growth in recreation and in retirement communities in the Colorado ROI, meaning that there are significant labor shortages in numerous service industries, such as restaurants, car dealerships, and auto repair. Local government agencies are also experiencing staffing difficulties, where teaching, health worker, public safety, road and bridge, and fire personnel positions are currently

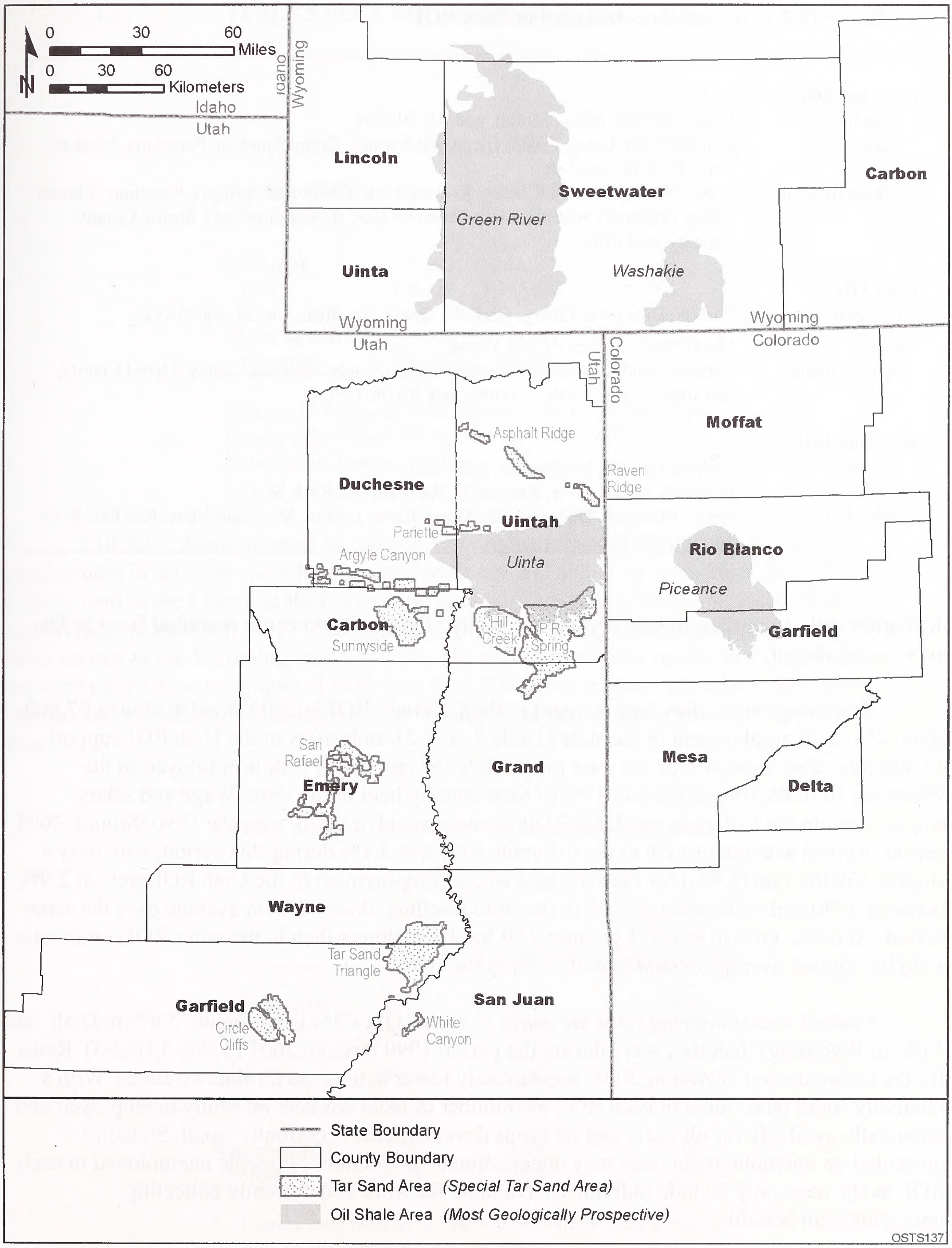

FIGURE 3.10.2-1 State ROIs for Oil Shale and Tar Sands Development Areas

TABLE 3.10.2-1 Jurisdictions Included in Each ROI

Colorado ROI	
Counties	Delta, Garfield, Mesa, Moffat, and Rio Blanco
Cities	Delta, Clifton, Craig, Fruita, Glenwood Springs, Grand Junction, Parachute, Meeker, Rangely, Rifle, and Silt
School districts	Craig, De Beque, Delta County, Roaring Fork (Glenwood Springs), Parachute, Plateau Valley (Colbran), Meeker, Mesa County Valley (Grand Junction), Moffat County, Rangely, and Rifle
Utah ROI	
Counties	Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, and Wayne
Cities	Moab, Price, Roosevelt, and Vernal
School districts	Carbon County, Duchesne County, Emery County, Garfield County, Grand County, San Juan County, Uintah County, and Wayne County
Wyoming ROI	
Counties	Carbon, Lincoln, Sweetwater, and Uinta
Cities	Evanston, Green River, Kemmerer, Rawlins, and Rock Springs
School districts	Afton, Evanston, Diamondville, Green River, Lyman, Mountain View, Rawlins, Rock Springs, and Saratoga

difficult to fill. According to one Wyoming County planner, workers are recruited from as far away as Michigan.

Total wage and salary employment in the Colorado ROI in 2004 stood at almost 97,800, about 4% of all employment in the state (Table 3.10.2-2). Industries in the Utah ROI support 42,300 jobs, also about 4% of the state total, while the number of people employed in the Wyoming ROI, 45,100, represents 17% of total employment in the state. Wage and salary employment in the Colorado and Utah ROIs grew relatively rapidly over the 1990 through 2004 period. Annual average growth in the Colorado ROI was 3.1% during this period, with only a slightly smaller rate (2.4%) for the state as a whole. Employment in the Utah ROI grew at 2.0% between 1990 and 2000, with growth in the state reaching almost 3% on average over the same period. At 0.8%, growth in the Wyoming ROI has been slower than in the other ROIs, with only a slightly higher average annual rate of 1.7% in the state.

Current unemployment rates are lower in each ROI (4.2% in Colorado, 5.6% in Utah, and 3.6% in Wyoming) than they were during the period 1990 through 2005 (Table 3.10.2-3). Rates for the Colorado and Wyoming ROIs are currently lower than those for the two states. With a relatively small labor force in each ROI, the number of local workers presently unemployed and potentially available for oil shale and tar sands developments is currently small. Statistics presented on unemployment rates may underestimate the number of people unemployed in each ROI, as the rates only include individuals available for work and currently collecting unemployment benefits.

TABLE 3.10.2-2 ROI Total Employment

	1990	2004	Annual Average Growth 1990–2004
Colorado ROI	63,681	97,755	3.1%
Colorado	1,654,843	2,317,759	2.4%
Utah ROI	31,923	42,318	2.0%
Utah	778,155	1,165,695	2.9%
Wyoming ROI	40,109	45,101	0.8%
Wyoming	212,768	269,651	1.7%

Sources: U.S. Bureau of the Census (2006d); Colorado State Demography Office (2007); Utah Governor's Office of Planning and Budget (2007).

3.10.2.1.2 Employment by Sector. Employment in each ROI is dominated by employment in services and wholesale and retail trade (Table 3.10.2-4). More than 65% of employment in the Colorado ROI is in these sectors (53,368 employed); almost 60% of employment in the Utah ROI (18,004) is in services and trade, with slightly less employed in these sectors in the Wyoming ROI (17,792). The service and trade sectors are slightly more important in each state compared with each ROI. The service sector includes employment in tourism and recreation, which has become an important part of the economy of the ROI in each state.

TABLE 3.10.2-3 State and ROI Unemployment Data[a]

	Average 1990–2005	Current Rate	Unemployed Persons (2005 Average)
Colorado ROI	4.9%	4.2%	5,667
Colorado	4.6%	5.0%	128,656
Utah ROI	7.6%	5.6%	2,760
Utah	4.3%	4.6%	53,927
Wyoming ROI	5.5%	3.6%	1,700
Wyoming	4.7%	4.0%	10,177

[a] Current state rates are for June 2006; current rates for each ROI are the annual average for 2005.

Source: U.S. Department of Labor (2006).

TABLE 3.10.2-4 State and ROI Employment by Industry, 2004

		Mining[a]									
	Agriculture	Oil and Gas	Coal	Total	Construction	Manufacturing	Transportation and Utilities	Wholesale and Retail	Finance, Insurance, and Real Estate	Services	Other
Colorado ROI	4,435	786	735	1,525	7,881	3,744	3,259	16,147	4,246	37,221	41
% of total	5.7	0.8	0.9	1.9	10.1	4.8	4.2	20.6	5.4	47.5	0.1
Colorado	47,445	8,980	2,052	13,572	147,767	137,726	65,022	346,128	148,849	1,047,287	717
% of total	2.4	0.4	0.1	0.7	7.6	7.0	3.3	17.7	7.8	53.6	0.0
Utah ROI	3,452	1,220	1,500	2,999	2,133	1,008	2,065	5,758	1,089	12,246	6.2
% of total	11.5	2.9	5.0	10.0	7.1	3.3	6.9	19.1	3.6	40.7	0.2
Utah	20,966	3,219	1,529	6,578	63,944	111,020	49,017	172,579	62,788	468,659	278
% of total	2.2	0.3	0.2	0.7	6.7	11.6	5.1	18.1	6.6	49.0	0.0
Wyoming ROI	1,418	2,145	925	3,474	1,977	2,643	2,523	5,877	1,204	11,915	99
% of total	4.6	4.8	3.0	11.2	6.4	8.5	8.1	18.9	3.9	38.3	0.3
Wyoming	11,032	13,046	4,829	17,976	15,613	10,244	9,960	36,590	10,591	85,908	375
% of total	5.6	4.8	2.4	9.1	7.9	.2	5.0	18.5	5.3	43.3	0.2

[a] In addition to oil and gas extraction and coal mining, the mining total includes metals mining, nonmetallic minerals mining, and support activities for mining.

Sources: U.S. Bureau of the Census (2006a); USDA (2006).

Although the oil and gas sector constituted only a relatively small share of total ROI employment in 2005 (0.8% in Colorado, 2.9% in Utah, and 4.8% in Wyoming), the sector has seen significant growth in a number of counties in each ROI. In Colorado, oil and gas employment in Mesa County grew from 190 to 350 between 1998 and 2004, while employment in the sector in Garfield County in 2004 was 287, growing from 120 in 2002. In contrast, oil and gas employment in Rio Blanco County fell from 340 in 1998 to 120 in 2004. In Utah, oil and gas employment is concentrated in Duchesne County, with between 250 and 300 employed in the sector over the period 2000 to 2004, and in Uintah County, where employment grew steadily from 450 to 700 between 1998 and 2004. Each of the four ROI counties in Wyoming has oil and gas employment, with the largest concentrations in 2004 in Sweetwater (705 employees) and Uinta Counties (1,015), with fairly steady growth in both counties since 1998.

Employment in natural gas–producing counties in each of the three states has continued to grow since 2004 (see Section 6.1.1.10.1).

A number of industries are more important in the ROIs than at the state level, notably transportation and utilities in each state ROI (4.2% of total employment in the Colorado ROI, 6.9% of the Utah ROI, and 8.1% of the Wyoming ROI); agriculture in the Colorado ROI (5.7%) and Utah ROI (11.5% of the total); and mining in the Utah ROI (10%) and in the Wyoming ROI (11.2%). The mining sector in each of the states includes the two sectors that would be directly impacted by oil shale and tar sands development—oil and gas extraction and coal mining. Coal mining has a slightly larger share of total employment in each ROI than other activities in the mining sector.

Employment in oil shale RD&D projects in Colorado and Utah has grown steadily since 1995, with an estimated workforce of 810 employed during construction and 535 during operations in the 5 current projects in Colorado, and with 120 employed during both construction and operation in the single current project in Utah. Indirect employment and income generated from these projects have also provided moderate additional benefits to the economy of each ROI (see Section 6.1.1.10.2).

3.10.2.1.3 Personal Income. In the Colorado and Utah ROIs, labor shortages in many nonenergy sectors and low unemployment rates described in Section 3.10.2.1.1 are partly due to an acute shortage of affordable housing (see Section 3.10.2.2.5), but also because wages paid by oil and gas companies usually attract people from these occupations into a wide range of manual labor positions requiring little or no college education. Equipment operators, according to a Colorado assistant county manager, "can make 50% more" in the oil and gas sector than in local government agencies, "with wages of $26/hour, and despite an improved benefits package." Currently there are numerous vacant positions for these workers in Garfield and Rio Blanco Counties in Colorado. Industries in Utah and Wyoming unable to pay wages comparable to those in the oil and gas industry also suffer labor shortages. In Utah, according to a Uintah County planner, wages for clerical services occupations have almost doubled because of competition from the oil and gas industry, increasing from "$6 to $7/hr to $9 to $11/hr."

Labor incomes in oil and gas production were significantly higher than the average in each ROI. At $77,500, labor incomes in the sector in the Colorado ROI in 2004 were more than 70% higher than average incomes, and at $54,300 in Utah, 30% higher, while at $78,400, oil and gas labor incomes in Wyoming were slightly less than twice the average for all sectors in the ROI. Labor incomes in oil and gas support activities were slightly higher than the ROI average in Colorado and lower than the ROI average in Utah, while labor incomes in oil and gas drilling were slightly lower than the ROI average in Colorado, and slightly higher than the average labor incomes in the Wyoming ROI.

Total personal income in 2004 in the Colorado ROI stood at $6.5 billion, in the Utah ROI it was $2.3 billion, and $2.9 billion in the ROI for Wyoming (Table 3.10.2-5). Annual average growth in personal income over the period 1990 through 2004 in the Colorado ROI was 3.8%, in the Utah ROI 2.3%, and 1.9% in the Wyoming ROI. Per capita personal income in the Colorado ROI grew from $23,906 in 1990 to $28,967 in 2004, from $18,737 to $23,162 in the Utah ROI over the same period, and from $25,963 to $33,330 in the ROI in Wyoming (U.S. Department of Commerce 2006). State per capita income in each state in 2004 was slightly higher than each ROI.

3.10.2.2 Social Environment

3.10.2.2.1 Quality of Life. Although a relatively small number of individuals directly affected by the "boom and bust" associated with the Colony oil shale project in the late 1970s and early 1980s remain in local communities in the vicinity of the project site, memories of the events before, during, and after the Colony development form an important part of the perception of large-scale energy development projects in western Colorado. The experience of the "boom and bust" and the long, slow recovery period in the 1980s and 1990s are both magnified and perpetuated, with many local government officers, city managers, and professional people

TABLE 3.10.2-5 State and ROI Personal Income ($ billions 2005)[a]

	1990	2004	Annual Average Growth, 1990–2004
Colorado ROI	3.9	6.5	3.8%
Colorado	100.1	177.9	4.2%
Utah ROI	1.7	2.3	2.3%
Utah	39.9	68.9	4.0%
Wyoming ROI	2.3	2.9	1.9%
Wyoming	12.6	18.6	2.8%

Sources: U.S. Department of Commerce (2006).

currently residing in the affected communities also present during each phase of development. According to a Colorado city mayor, about "a third" of current residents in Rifle remember "Black Sunday," May 2, 1982, when "Exxon closed the gates to the Colony Project." Some local residents come from families that have lived in the area for many years, while many became residents during the oil shale boom, looking for work as teachers, local government officers, and realtors during the boom years prior to 1982.

Many people living in the area apparently still remember exactly what they were doing on Black Sunday, a date which is locally accorded the same significance as the date of the Kennedy assassination and the attack on the World Trade Center. More than 2,000 workers lost their jobs with the closure of the Colony project, with many more out of work in the various supporting occupations in the economy of western Colorado, producing a "severe depression" throughout the region, according to a Colorado assistant county manager. Overnight, the housing market, which had struggled to keep pace with in-migration associated with the Colony development, with rapidly escalating prices for the few lower-priced homes that were available, collapsed. In the experience of one Colorado county manager, some properties lost "60% of their value in one week." Numerous recently constructed apartment buildings were left empty, many "businesses were lost," and banks closed, with "people standing in line to get their money" according to a Colorado assistant county manager, once the Federal Deposit Insurance Corporation had been called in. In Rifle, this signaled the beginning of a 10-year recession, with the economy of Garfield County not recovering until the mid-1990s.

Memories of the impact that the Colony project had on economic and social life in the region are still vivid for people living in the area. The "huge workforce" of 2,000 required for the project meant a large and rapid influx of workers to staff construction vacancies and people looking for work in the associated boom. With the in-migrant population growing daily, the immediate problem associated with the project was an acute housing shortage, with, according to one Colorado city mayor, people "living in tents, under bridges and in culverts," while differences in the relative fortunes of the oil shale workers and the remainder of the working population in the local communities was clear, with the perception that in-migrant oil shale workers were "walking around with dollars dripping out of their pockets." The size and pace of oil shale development meant that community infrastructure also had to be expanded rapidly to accommodate the new workers and their families. In Parachute, the housing development built by Exxon at Battlement Mesa was "oversized" compared even to the housing demands of in-migrating oil shale workers, according to a Colorado county manager. The supporting infrastructure provided by local government (notably library, schools, roads, and sewers) was sized for a larger project than was required even at the time. Elsewhere in Garfield County, local planners had estimated infrastructure demands for the long term, with County Road 215 rebuilt to accommodate truck and car traffic for a large new development, while funding was also provided for additional public buildings.

While funding infrastructure developments to support the Colony project put local jurisdictions under enormous financial pressure, with no severance tax revenues from oil shale production available during project construction, the additional infrastructure in Parachute and elsewhere in Garfield County, it is suggested, has provided a sound basis for the diversification of the area away from extractive energy and into recreation. With the Battlement Mesa development, together with smaller developments in the area and the associated public infrastructure, the Rifle area became "an affordable housing area for the entire region" according to a Colorado city mayor, with cheaper housing in the area eventually leading to population growth and recovery from the oil shale bust.

By the end of the 1990s, developments in the oil and gas industry in Colorado, Utah, and Wyoming had begun to place local communities under many of the same pressures they had experienced during the oil shale boom. Since 2003, the industry has created "a boom almost akin to oil shale," with "exponential growth" in population, large increases in the local working population, and higher employee income levels impacting community quality of life, according to a Colorado county manager. Many retail businesses, particularly grocery stores, have experienced problems maintaining sufficient stock to meet local demand. Beginning with the Colony oil shale project and continuing with current oil and gas development in both Colorado and Utah, patterns of retailing have changed from small, local general stores serving local retail demand, to the development of regional retail centers. Grand Junction, for example, which is 1.5 hours from Meeker, serves the region for most retail functions, with local stores limited to high-priced basic items, representing a "permanent change in life-style" that is perceived negatively by many local residents, according to a Colorado water commissioner. There is currently a single store in Meeker that sells feed, and people are prepared to drive 50 to 100 mi for large grocery purchases. Although Walmart stores have been built in Rifle and Vernal, where a Lowes has also been built, there is concern that these stores will have difficulties finding staff and will not be able to offer a range of goods at reasonable prices.

The lack of adequate transportation infrastructure has developed into a serious problem in Rio Blanco and Garfield Counties, with traffic levels on local roads particularly high during shift change times. Rapid development of oil and gas has meant that county authorities have had to "play catch up with traffic," according to a Colorado assistant county manager, with many local and county roads built only of gravel and not capable of supporting the necessary "12 to 18 80,000-lb" drilling rig and water tanker trucks required for oil and gas drilling activities. During the exploration phase, trucks are moved in and out of each well site "every 10 weeks" with older drilling technology, and "every 3 to 4 weeks" with newer production technology, according to the same county manager. At current employment levels, there are six people in each drilling crew, with three shifts for each rig. One worker is required for every six wells once production gets underway.

Lack of rail or interstate highway transportation infrastructure in Vernal, Utah, exacerbates the dependence on extractive industries, according to a Uintah County planner, with little opportunity for the town to develop as a retail hub. The additional infrastructure in Parachute and elsewhere in Garfield County on the other hand, it is suggested, has provided a sound basis for the diversification of the area away from extractive energy and into recreation.

To better plan for impacts of oil and gas development, various local and county citizen oversight groups have been formed in Colorado to provide for the communication of local community concerns to oil companies. Garfield County has established an Energy Advisory Board with representatives of oil companies and local citizens, and an Oil and Gas Liason Committee that receives complaint calls and has attempted to reflect the concerns of the local community by undertaking local impact studies in a number of topical areas, notably water wells, health risk, air quality, and land values. Unfortunately, not all oil companies provide representatives for meetings, leaving one Colorado mayor "disgusted." In an attempt to develop a long-term coping strategy to address dependence on one major regional source of employment, Garfield County has identified a series of sectors to be targeted for development to allow economic diversification away from energy development. An "energy village" has been established to host renewable energy developments, including bio, solar, and possibly wind energy, and it has been proposed to make Rifle a regional commercial retail center. An additional impact of high local wages in the oil and gas sector is that it affects the ability of local communities to diversify, with teenagers able to drop out of school and earn "$60,000 to $70,000" in oil and gas jobs, leading to "a degradation in the college bound population," according to a Colorado county manager. With large labor transfers from nonenergy into energy occupations, the perception is that the oil and gas companies need only "warm bodies" to continue to operate.

Water allocation is a significant regional problem with the development of energy production in Garfield and Rio Blanco counties, and the fact that energy companies have been buying historic water rights from ranchers is "a concern," according to a city mayor in Colorado. Often ranchers are bought out by companies and nonlocal parties, and then the land with no associated water rights is leased back to the original owners with only limited water available for stock but not for irrigated agriculture. Many apparently perceive this as a "sad" development. Often hay is the only crop still being produced on many ranches, with only "nominal involvement in agriculture" on these properties "to avoid higher property taxes," according to a Colorado water commissioner, with the perception that "there would be no agriculture in the area with commercial oil shale." In the experience of a Utah city manager, the perception is that regional water capacity "can handle" population increases from oil and gas development.

Dramatic increases in traffic with the Colony oil shale project and subsequent oil and gas development, often on roads into areas with very limited access, has often meant disruption to wildlife, in particular horse and elk herds. As a result, city government and many residents in Rifle oppose energy development on the Roan Plateau, not only because it interferes with a significant local source of income during the hunting season from September to November, but because the community in Rifle "is historically represented by hunting and fishing," according to a Colorado city mayor. To avoid the steady disappearance of agriculture in the region with the purchasing of land for historic water rights in both Colorado and Wyoming, land has been sold for conservation easements, where historic water rights remain associated with specific land parcels. Although this provides a safe haven for game and preserves the land in more traditional uses, these easements "are not popular with out-of-state hunters," according to a Colorado water commissioner, who can no longer access game. Conservation easements, particularly WSR designation, are also perceived as a threat to the traditional way of life in Utah, with the curtailment of vehicular access inhibiting hunters and anglers, according to a Duschesne County planner. Housing shortages also affect hunting, with insufficient local capacity during hunting months. Oil and gas workers are apparently excluded from some trailer park rentals, which are held exclusively for hunters. In Sweetwater County, Wyoming, in an attempt to preserve historic cultural heritage with the onset of energy development, "to understand why we live here," land in the community of Adobetown was recently excluded from coal mining, according to a Duschesne County planner.

Attitudes toward future energy developments vary from cautious optimism in the business community, according to a Colorado city mayor, "some of whom will benefit from new development," to skepticism among those that remember the "boom and bust" associated with the Colony Project, the problems associated with housing migrant workers, the social impacts associated with temporary workers without their families, and the difficulties associated with planning public services and infrastructure. Many individuals are leery of oil shale development and do not believe that the technology is mature enough for commercial production; they are suspicious of new development given the history of the industry in the area. Some want tighter controls on development, especially housing, with infrastructure costs paid by developers. Even though Exxon received no subsidies from the federal government for the Colony project, some believe that the involvement of the Synfuel Corporation in the development of oil shale made it easier for oil companies to pull out, blaming the "boom and bust" on the end of federal subsidies. This perception stands in contrast to the current situation with oil and gas, where people apparently perceive that private companies receive no direct financial help from federal authorities. In Utah, although natural gas developments have been "immense," there is "stability compared to oil shale," according to a city manager, with people apparently sharing the view of the oil companies that there will be "long lasting and steady growth" in the area. Others were more skeptical, however. One Uintah County planner stated that oil and gas development was "scary to a lot of people," and wondered "are we setting ourselves up for another bust?" In Wyoming, one county commissioner was highly supportive of oil and gas development despite the drawbacks of infrastructure provision to support local population growth. The commissioner stated that the checkerboard pattern used by planning agencies for land use designation tended to drive oil and gas development onto private land, creating a "lack of balance," with unfair demands on infrastructure and public services in drilling areas.

3.10.2.2.2 Population. After a number of years of slow population growth, by the early 1990s, counties in western Colorado began experiencing higher growth rates. Driving the growth was the proximity of the area to the fast-growing winter recreation communities in Glenwood Springs, Aspen, and Vail, while Battlement Mesa itself has become a retirement community. Although between a 70- and 90-mi drive, growth in these recreation communities, together with associated planning controls in these up-market communities, meant that there was little or no affordable housing for service workers in these resorts. As a result, Rifle and other communities in Garfield County have developed into "commuter towns," with "30,000 commuters" in the county predicted by 2025, according to a Colorado county manager. Over the past several years, population has grown rapidly in some communities hosting oil and gas developments, "at an annual rate of 4.9%, with rates of up to 7%" in Garfield County, according to a Colorado mayor. Local labor shortages have also led to an increase in the number of undocumented workers filling jobs in local service sector occupations, in the experience of a Colorado county manager.

In 2000, the population in the Colorado ROI stood at 207,050; the population in the Utah ROI was 101,019, and in the Wyoming ROI it was 87,567 (Table 3.10.2-6). The ROI population makes up a relatively small percentage of total population in Colorado (4.8%) and Utah (4.5%),

TABLE 3.10.2-6 ROI Population

	1990	2000	Annual Average Growth, 1990–2000
Colorado ROI	161,428	207,050	2.5%
Colorado	3,294,394	4,301,261	2.7%
Utah ROI	90,814	101,019	1.1%
Utah	1,722,850	2,233,169	2.6%
Wyoming ROI	86,812	87,567	0.1%
Wyoming	453,588	493,782	0.9%

Sources: U.S. Bureau of the Census (2006c,d).

and a larger percentage in Wyoming (17.7%). Population in the ROIs in each state grew relatively slowly over the 1990–2000 period. Annual average growth in the Colorado ROI was 2.5% during this period, slightly less than for the state as a whole (2.7%). In the Utah ROI, population grew at an average annual rate of 1.1% between 1990 and 2000, less than the state growth rate of 2.6% over the same period. At an annual rate of 0.1%, growth in the Wyoming ROI was slower than in the other ROIs, with only a slightly higher average annual rate of 0.9% in the state. State government estimates show that since 2000, population in each ROI has continued to grow. Section 6.1.1.10.1 provides projections of population in each ROI for the years 2009, 2012, 2016, 2022, and 2027.

Housing prices have risen rapidly in areas experiencing brisk population growth associated with oil and gas development. Rifle, Colorado, has witnessed "2% growth per month in the last three months," according to a Colorado mayor, and "26% over the last seven months," according to a Colorado county manager. Rental housing used by oil and gas drilling workers is "almost completely unavailable," with vacancy rates at about 2%, according to a Colorado realtor. Rental housing in Newcastle, Silt, Parachute, and Rifle is currently "all taken," and there are "no hotels" available because of the oil and gas boom, according to a Colorado county manager. Rental vacancy rates have changed significantly in the last two years, and for those able to find rental housing, rates "have doubled in the last two years." Home construction for oil and gas workers has been undertaken, often in areas annexed to smaller communities, together with speculative development of more expensive single-family homes, which are often priced at more than $500,000. Some local ranchers are selling 3- to 4-acre parcels to small builders, with homes then marketed locally and statewide. Homes are occupied by production workers, with some executives occupying higher-priced houses. There are numerous "overpriced" houses for sale, according to a Colorado realtor, producing an artificially high overall vacancy rate in state and federal statistics. Houses with three bedrooms and two bathrooms sell for $225,000 in Meeker, and for between $375,000 and $425,000 outside of town on 3 to 5 acres of land. Inflation in housing prices is "scary" to many potential buyers, according to a Colorado realtor, often meaning that houses are on the market for extended periods of time.

Affordable housing has become such "a critical issue" in Uintah County, Utah, "as part of the boom throughout Utah," that a housing specialist has been hired, according to a Utah city manager. Particularly hard hit are entry-level teachers (10 of whom recently rejected contracts because of housing issues), police officers, entry-level government workers, and retail sales workers. A plan has been suggested whereby the Uintah County School District buys housing in order to ensure affordable housing for teachers, while the idea of offering tax credits for housing has also been suggested. Many workers are using "campers and tents, or doubling or tripling up with relatives," according to a Uintah County planner. There are "many people in between welfare recipients and those that afford $300,000 homes," many of whom "are being told they will have to wait 6 months to qualify for a loan with the current mortgage crisis." High staff turnover among local merchants is also "blamed on the housing crisis." In Lincoln County, Wyoming, with median home prices at $290,000 in Kemmerer, the demand for new housing is so high that 900-ft^2 lots for 300 new homes were sold for $190,000 before construction had started, according to a County commissioner.

Tourism and recreation in Rio Blanco County has created additional demand for housing, with people from elsewhere buying second homes, often renting for 1 to 2 years before buying, and with some selling in response to the "harsh winters," according to a Colorado realtor. Some homes are bought by fishermen and hunters who are in search of "small town life."

In Colorado, energy development companies have begun to address housing shortages with the development of employer-provided housing. However, although only local and no state approval is required for employer-provided housing of up to 24 workers in Garfield County, state approval for larger employer-provided housing areas "has not been requested," according to a Colorado county manager. A larger housing area of 125 workers has been permitted in Rio Blanco County. In Sweetwater County, Wyoming, employer-provided housing has also been planned, with housing for up to 400 persons permitted for BP, with housing also permitted for Questar, both for a 20-year period. Commuting distances for oil and gas workers in Utah are often between 60 and 100 mi, and with workers on 12 to 14 hour shifts, 15% of the workforce is rotated through local motels, and the remainder through trailer home employer-provided housing. Regardless of their size, worker housing areas are still likely to produce social impacts, in the opinion of local officials, such as drug, alcohol, and spousal abuse, and mental health issues. Some local officials would prefer more local community housing rather than employer-provided housing to take advantage of the benefits of a locally resident workforce. The development of separate local and oil and gas communities has led to suspicion of oil and gas workers in local communities, resulting in having "to lock doors," while preferring "to leave doors open and trust everyone."

Housing stock in the Colorado ROI grew at an annual rate of 2.2% over the period of 1990 through 2000 (Table 3.10.2-7), with 86,627 total housing units in 2000. The rate of growth in owner-occupied units (3.6%) was higher than the overall rate of growth in the ROI. The annual growth in rental units was much lower at 0.4%, and the number of vacant units declined by 2% annually in the ROI during this period.

Annual growth in housing in the Utah ROI in the 1990 through 2000 period was 1.2%, with 42,469 total housing units in 2000. The annual rate of growth in owner-occupied units

TABLE 3.10.2-7 State and ROI Housing Characteristics

Parameter	1990	2000	Annual Average Growth, 1990–2000
Colorado ROI			
Owner-occupied	40,517	57,685	3.6%
Rental	21,730	22,714	0.4%
Vacant units	7,598	6,228	–2.0%
Total units	69,845	86,627	2.2%
Utah ROI			
Owner-occupied	21,862	26,187	1.8%
Rental	6,304	6,929	0.9%
Vacant units	9,668	8,853	–0.9%
Total units	37,834	42,469	1.2%
Wyoming ROI			
Owner-occupied	21,260	24,356	1.4%
Rental	8,379	7,967	–0.5%
Vacant units	6,350	6,747	0.1%
Total units	36,289	39,070	0.7%

Sources: U.S. Bureau of the Census (2006c,d).

(1.8%) was higher than the overall rate of growth in the ROI. Annual growth in rental units was much lower at 0.9%, and there was an annual average decline of 0.9% in the number of vacant units in the ROI between 1990 and 2000.

In 2000, there were 39,070 total housing units in the Wyoming ROI. The ROI housing market grew at an annual rate of 0.7% over the 1990 through 2000 period. The rate of growth in owner-occupied units (1.4%) was higher than the overall rate of growth. The number of rental units declined during the 1990s by an average of 0.5% annually, although the number of vacant units in the ROI increased slightly.

Statistics presented on housing vacancy rates are based on the total number of vacant housing units. In some areas of each ROI, rental vacancy rates may be lower than the published rate because there may be numbers of owner-occupied housing units that were for sale, or were occupied only seasonally or were second homes, and, therefore, recorded as vacant, when the data were collected.

3.10.2.2.3 Fiscal Conditions. Funding infrastructure during oil and gas development can put local jurisdictions under enormous financial pressure, and although some oil companies have contributed to the cost of new roads where there is no existing access to drilling areas in some areas, there often has been little support from energy companies where existing roads need to be upgraded. With the pace of energy development, local governments are experiencing difficulties funding infrastructure improvements, with escalation in the price of construction materials, particularly of gravel, in Garfield County increasing the cost of a two-lane road "from $1 to $2.5 million/mile," according to a Colorado county manager. While the county can get help from the state, which provides energy impact funds from severance tax revenues, with "$0.5 million provided per project," the county has to provide matching funds, only some of which have come from increased property tax revenues; paying for upgraded infrastructure "can be difficult," according to a Colorado county manager. Other sources of revenues, such as sales taxes, are often dedicated to other areas, such as public libraries. Some municipalities receive recirculated state sales taxes for roads. In Colorado, severance taxes are currently distributed directly to impacted communities based on energy worker residential locations, but with many workers living in Craig and Grand Junction and bussed in every day, the problem of providing infrastructure and service where they are used is exacerbated. Recently, three new road projects were put out for bid by Garfield County, and "none were taken," which, combined with a shortage of construction workers, means that county authorities are "losing a never-ending struggle," according to a Colorado county manager, to keep up with oil and gas development.

In Utah, mineral lease funds paid to the federal government are "distributed equitably" by the Community Impact Board to local jurisdictions, according to a Utah city manager, and are used to pay for water and sewer service, educational facilities, fire stations, recreation facilities, a shelter for women and the homeless, and administration buildings. In Vernal, the Board has not provided support for housing development to local communities, instead preferring to send dollars "to housing authorities, not us," according to a Utah city manager. Sales taxes "make up for shortfalls" from mineral lease payments. To offset the impact of energy development, mitigation plans were used during the White River oil shale boom before any royalty payments were available from energy production. Despite the flow of funds to local authorities affected by oil and gas development in both states, planning for the mitigation of impacts in the form of infrastructure development and provision of public services does not occur until oil and gas "development levels and timing are obvious," according to a Utah city manager. Although mitigation agreements exist between gas companies and local governments, many companies "are not sharing information" on crucial issues, such as development schedules. Various programs are used by oil and gas companies to help mitigate the impact of rapid resource development in each ROI, often in the form of financial assistance to local jurisdictions to offset the increasing cost of providing services. In Colorado and Utah, oil companies have provided wide-ranging help with the cost of road repair and upgrading to support higher traffic levels. In Lincoln County, Wyoming, companies provided $1.6 million for snow removal in 2007, and through the Hathaway Fund provide $7,000 per semester to graduating seniors with high grade point averages, according to a county commissioner.

The diversion of tax revenues away from areas suffering many of the adverse impacts of rapid energy development, primarily to areas with larger populations, was a significant issue at the county level, and has led to "resentment," according to a Uintah County planner. Although counties may collect property tax and ad valorem tax revenues, sales taxes and Community Impact Board funds are intended to help cities, and severance taxes are collected and distributed by the state, although these are used to mitigate impacts on county roads, according to a Duschesne County planner. A particular problem lies in funding the county school system, where land on which schools are built is held by a special trust and supported by a special royalty system. Revenues are circulated "to areas with the largest population base," and the county school system "can't get things done without support from Salt Lake City legislators." In Wyoming, there are also conflicts in the allocation of resources among counties and communities for mitigation of impacts of oil and gas development, with many nonmineral counties in the state, many of which are dependent on agricultural interests, and many counties that do not have significant natural resources, and, therefore, receive more state government funds.

Table 3.10.2-8 shows the current expenditures by the various local government jurisdictions in each ROI and in each state.

TABLE 3.10.2-8 State and ROI Public Service Expenditures ($ millions 2005)

	2005
Colorado ROI	416.8
Colorado	39,481
Utah ROI	215.4
Utah	19,455
Wyoming ROI	268.8
Wyoming	5,638

Sources:
Colorado—City of Craig (2003); City of Delta (2004); City of Fruita (2005); City of Glenwood Springs (2004); City of Grand Junction (2004); City of Rifle (2004); Colorado State Demography Office (2007); Delta County (2005); Mesa County (2003); Moffat County (2005); Rio Blanco County (2005); Town of Meeker (2005); Town of Parachute (2005); Town of Rangely (2004); Town of Silt (2005).
Utah—Carbon County (2004); City of Moab (2006); Duchesne County (2004); Emery County (2004); Garfield County (2004); Grand County (2004); Price Municipal Corporation (2005); Roosevelt City Corporation (2005); San Juan County (2004); Uintah County (2004); Utah Governor's Office of Planning and Budget (2006); Vernal City Corporation (2005); Wayne County (2004).
Wyoming—Carbon County (2006); City of Evanston (2005); City of Green River (2004); City of Kemmerer (2005); City of Rawlins (2005); City of Rock Springs (2005); Lincoln County (2006); Sweetwater County (2005); Uinta County (2005); Wyoming Department of Administration and Information (2006).
Overall—Standard and Poor's (2006); U.S. Bureau of the Census (2006b,d).

3.10.2.2.4 Public Service Employment. In addition to problems securing adequate funding for infrastructure development with energy development and the associated rapid growth rates in local population, differences in rates of pay between energy and nonenergy occupations mean that there are significant labor shortages in numerous service industries, such as restaurants, car dealerships, and auto repair, and in local government, where teaching, health worker, public safety, road and bridge, and fire personnel positions are difficult to staff.

Tables 3.10.2-9 and 3.10.2-10 present data on levels of service (number of employees per 1,000 population) for public safety and general local government services and employment. Table 3.10.2-10 provides health and services staffing data, and Table 3.10.2-11 provides data on school district staffing and performance indicators.

3.10.2.2.5 Social Disruption. Social problems associated with rapid population growth with the development of energy extraction and power generation projects in small rural communities were first studied extensively in the 1970s and 1980s. Gilmore and Duff (1975) and Gilmore (1976), for example, found that rapid growth led to higher divorce and school dropout rates, suicide attempts, social alienation and isolation, juvenile delinquency, and crime, while Gold (1982) found that resource

TABLE 3.10.2-9 State and ROI Local Government Employment, 2006

	Police		Fire[b]		General		Total[c]	
	Number	Level of Service[a]	Number	Level of Service	Number	Level of Service	Number	Level of Service
Colorado ROI	400	1.7	160	0.7	3,263	14.1	3,823	16.6
Colorado	9,179	1.9	4,980	1.0	173,392	36.1	187,551	39.0
Utah ROI	199	2.0	5	0.0	1,254	13.2	1,458	15.2
Utah	3,576	1.4	1,575	0.6	73,357	28.4	78,508	30.3
Wyoming ROI	229	2.6	58	0.6	1,384	15.5	1,671	18.7
Wyoming	1,188	2.3	372	0.7	31,428	61.0	32,988	64.0

a Level of service represents the number of employees per 1,000 persons in each geographic unit.

b The number of firemen does not include volunteers.

c Total employment does not include teachers, physicians, or health workers.

Sources: Bedont (2006); Behunin (2007); Bever (2007); Bird (2007); Chiaretta (2007); Colorado Bureau of Investigation (2006); Conant (2007); Contreras (2006); Dalpiaz (2007); Daniels (2006); Day (2006); Derragon (2006); Eldredge (2007); Fire Departments Net (2006); Guererro (2007); Guida (2007); Hancock (2006); Hoffmeister (2006); Hood (2006); Huntington (2006); Johnson (2007); Karsten (2007); Larson (2007); Lyon (2007); MacIntyre (2006); Mayham (2007); McClean (2007); McClure (2007); Nees (2007); Nelson (2006, 2007); Norman (2006); Phelps (2007); Piper (2006); Running (2006); Smith (2006); Stewart (2006); Tracy (2006); Urascaro (2007); U.S. Bureau of the Census (2007); Utah Department of Public Safety (2006); Wagner (2007); Wyoming Division of Criminal Investigation (2006).

TABLE 3.10.2-10 State and ROI Public Health Employment, 2003[a]

	Physicians		Staffed Hospital Beds	
	Number	Level of Service[a]	Number	Level of Service
Colorado ROI	492	2.2	970	4.4
Colorado	12,027	2.6	9,479	2.1
Utah ROI	86	0.9	248	2.5
Utah	5,156	2.1	4,406	1.9
Wyoming ROI	98	1.1	262	3.0
Wyoming	1,008	2.0	1,773	3.5

[a] Level of service represents the number of physicians or hospital beds per 1,000 persons in each geographic unit.

Source: U.S. Bureau of the Census (2006e).

TABLE 3.10.2-11 State and ROI Education Data, 2004[a]

	Teachers	Student-to-Teacher Ratio	School Dropout Rates
Colorado ROI	2,050	16.9	27.3
Colorado	65,305	16.9	30.2
Utah ROI	591	18.0	21.9
Utah	35,238	15.9	19.5
Wyoming ROI	1,196	13.9	25.2
Wyoming	10,774	15.9	27.8

[a] The student-to-teacher ratio is the number of students per teacher; dropout rates are based on data for the last three high school grades.

Source: Standard and Poor's (2006).

developments led to a weakening of social ties in the local community. Other studies suggested that boomtown growth was responsible for deterioration in the mental health of existing long-term residents and of in-migrants (Lantz and McKeown 1977; Dixon 1978; Weisz 1979; Freudenburg et al. 1982). Increases in crime, violence, and deviance were reported by Lantz and McKeown (1977), Little (1977), and Dixon (1978). Changes in the level of community integration were also studied (Little 1977; Jirovec 1979; Boulding 1981) as were changes in community satisfaction (Murdock and Schriner 1979). Drawing on the ideas of Ferdinand Toennies on the transition of small rural communities through industrialization and urbanization (Toennies 1887), it was often suggested that these changes occurred as a result of the breakdown of established informal social structures in small rural communities and the inadequacy of new, formal social institutions to provide social integration and social control (Cortese and Jones 1977; Little 1977; Moen et al. 1981; Cortese 1982).

The relationship between rapid energy boomtown growth and social disruption came under closer scrutiny in the early 1980s. It was suggested that many of the earlier studies relied on poorly documented or unreliable data and assertions on the nature and extent of boomtown social problems, preferring to accept the presence of social disruption largely in the absence of reliable evidence (Wilkinson et al. 1982). Problems with research design in many of the earlier studies also were highlighted, in particular, the tendency to base research findings on data collected in single communities rather than in numerous communities affected by energy developments (Krannich and Greider 1984), and the use of cross-sectional rather than longitudinal data to chart community social change over time (Brown et al. 1989).

Subsequent work replaced the widespread sense of "alarmed discovery" prevalent in earlier research by more cautious and systematic approaches to the analysis of social change (Smith et al. 2001). Much of the focus became the study of multiple communities in order to separate and understand social change affecting boomtowns and those affecting communities outside energy development regions (England and Albrecht 1984; Freudenburg 1984; Krannich and Greider 1984; Greider and Krannich 1985; Brown et al. 1989; Berry et al. 1990).

Numerous studies have found that rapid growth led to certain forms of social disruption. Brown et al. (1989) found that boomtown growth led to community dissatisfaction, while England and Albrecht (1984) and Greider and Krannich (1985) found evidence of dissatisfaction with community facilities and services. Freudenburg (1986) and Brown et al. (1989) found higher fear of crime in boomtown communities than elsewhere. Brown et al. (1989) also found a reduction in local friendship ties and increases in residential transiency. Greider et al. (1991) found increased isolation, while Greider and Krannich (1985) found a decline in social support among residents of boomtown communities compared with more stable communities. The conclusions of these studies are quite different from those of earlier work on boomtowns, and indicate that periods of rapid population growth are not necessarily associated with social disruption and change in small rural communities.

In addition to studies of impacts across multiple communities, various longitudinal studies of social change also were made. Data collected in communities experiencing rapid growth indicate that divorce and crime rates did not increase significantly (Brookshire and D'Arge 1980; Wilkinson 1983; Wilkinson et al. 1984), although there were increases in delinquency during boom years (Wilkinson and Camasso 1984). Freudenburg and Jones (1991) showed increases in victimization rates in some communities, although Krannich et al. (1989) found no increases in victimization during boom years in several energy communities.

While it is clear that some level of social disruption seems to have occurred during boom years, underlying social structures may not have fundamentally changed. England and Albrecht (1984), for example, found no evidence of the replacement of informal social ties common in rural areas with formal association found in urban areas. Informal and external ties may actually strengthen with length of residence, and boomtown development may facilitate rather than diminish informal social ties. England and Albrecht (1984) found no dramatic shift in community perceptions during years of population growth, and Seyfrit and Sadler-Hammer (1988) found only a limited connection between rapid growth and changing youth attitudes toward community and family. Berry et al. (1990) suggest that interactions among neighbors during rapid growth periods are relatively stable, while Greider et al. (1991) reported no large increases in the level of distrust among neighbors, and that increasing heterogeneity accompanying rapid population growth does not significantly decrease neighboring interaction (Greider and Krannich 1985). Residents of rapidly growing communities may experience expanded opportunities for obtaining social support beyond their local neighborhood, while at the same time maintaining adequate relations with their neighbors.

Rapid population growth seems to have had differential effects across social groups. Freudenberg (1984) considered the effects of social change across different social groups and found no differences in attitudes between adults in boomtowns and in neighboring communities, but noted higher levels of dissatisfaction and alienation among boomtown adolescents. Krannich and Greider (1984) noted deterioration in perceived social integration among temporary mobile home residents in boomtown communities.

Studies of the long-term effects on community attitudes and perceptions show varying levels of community social disruption during the different phases of energy development, with examination of social disruption including the boom, decline, and post-boom recovery periods. The disruptive effects associated with boom growth may not have been permanent in some communities, dissipating in the years after the boom phase ended (Smith et al. 2001), while community satisfaction often has rebounded after declining during boom growth periods, producing an improvement in the sense of community well-being at the end of the boom period (Brown et al. 2005). The decline in the sense of community identity and solidarity during periods of instability caused by rapid population growth rebounded fairly quickly with the return to more stable growth (Greider et al. 1991).

Social Disruption Impacts in Relevant NEPA Documents. Social impacts are not considered in any detail in the various NEPA-related assessments that have been made since the early 1970s of the potential impacts of shale/tar sands projects and other relevant large-scale energy resource developments. Consequently, there is little indication from these documents of the extent to which proposed oil shale and tar sands developments would produce social disruption in local communities located near these facilities.

In the *Final Environmental Impact Statement for the Prototype Oil Shale Leasing Program* (DOI 1973), it is recognized that community structures and organizations will be affected, together with community social structures and lifestyles. However, beyond a brief description of potential problems in the local community adjusting to the influx of in-migrants, and the impacts of contrasting urban and rural lifestyles and potential impacts on crime, cultural and social change are judged to be highly subjective in nature and therefore difficult to adequately measure. Subsequent EISs also recognize the potential social disruption associated with oil shale development. The *Final Programmatic Environmental Impact Statement on Development Policy Options for the Naval Oil Shale Reserves in Colorado* (DOE 1982), for example, suggests that rapid population growth and cultural differences between resident and nonresident groups may lead to social problems and social conflict. Alcoholism, drug abuse, mental illness, divorce, and juvenile delinquency are mentioned as potential impacts of rapid population growth associated with oil shale development, but no data or analysis are presented.

The *Final Environmental Impact Statement on Uintah Basin Synfuels Development* (BLM 1983) uses evidence of social impacts associated with oil and gas development to suggest that additional development would lead to deterioration in attitudes toward quality of life, notably with respect to the management of local growth, particularly on Indian reservations. The *Utah Combined Hydrocarbon Leasing Regional Environmental Impact Statement* (BLM 1984b) also draws attention to potential impacts associated with changes in lifestyle with decreasing local cultural homogeneity, particularly social alienation that might be experienced on Indian reservations.

In the absence of social baseline data, a number of EISs have suggested that social disruption is likely to occur once an arbitrary population growth rate associated with oil shale development has been reached. The Green River–Hams Fork EIS (BLM 1980) assumes that an annual rate of 10% would result in a breakdown in social structures, with a consequent increase in alcoholism, depression, suicide, social conflict, divorce, delinquency, and deterioration in levels of community satisfaction. In addition to population growth rates, the EIS suggests that cultural dissimilarities between existing and new residents and the perceived political helplessness of local residents also cause social disruption. The *Final Supplemental Environmental Impact Statement for the Prototype Oil Shale Leasing Program* (BLM 1983b) supports the growth rate approach to identifying communities likely to suffer social disruption, also indicating potential elements of social disruption that may affect small rural communities.

3.10.2.2.6 Social Change. Although an extensive literature in sociology documents the most significant components of social change in energy boomtowns, the nature and magnitude of the social impact of energy developments in small rural communities are still unclear. While some degree of social disruption is likely to accompany large-scale in-migration during the boom phase, there is insufficient evidence to predict the extent to which specific communities are likely to be impacted, which population groups within each community are likely to be most affected, and the extent to which social disruption is likely to persist beyond the end of the boom period (Smith et al. 2001).

A significant issue for local communities during oil and gas development is the lack of "commitment to the county" of many migrant workers, according to a Colorado county manager and Wyoming County planner. Many construction workers do not bring family members to the area, and this has led to "social issues," requiring an additional 33 social workers in Garfield County, often to deal with "child welfare issues," in particular, the collection of child support payments, according to a Colorado county manager. There has also been an increase in the number of sheriff's deputies to combat increases in gang-related crime.

While much of the literature on social disruption assesses the impact of energy and other large-scale developments on small, stable, isolated rural communities, many communities in the three ROIs have experienced extensive growth and development during the recent past associated with oil and gas development, tourism and recreation, and retirement and second home development. Given the scale of these developments, it is likely that some degree of social disruption may have already occurred in a number of communities, particularly in the Colorado ROI.

There are various measures of social change, including violent, drug-related, and juvenile crime rates, alcoholism and illicit drug use, divorce rates, and mental illness.

Crime rates vary between each ROI and between each ROI and each state (Table 3.10.2-12). Data for 2004 show that violent crime rates were lower in the Colorado and Utah ROIs than they were in Wyoming, with rates of 1.2 incidents per 1,000 population in the Colorado ROI and 1.6 per 1,000, compared with 2.3 per 1,000 in Wyoming. Rates of violent crime are higher in the state as a whole in Colorado and Utah than in the ROI in each state, while rates in Wyoming as a whole are lower than in the Wyoming ROI. Drug-related crime data are

TABLE 3.10.2-12 State and ROI Crime Rates[a]

	Violent Crime		Drug Crime		Juvenile Crime		Total Crime	
	2001	2004	2001	2004	2001	2004	2001	2004
Colorado ROI	1.2	1.2	5.7	3.9	32.3	22.6	45.6	30.9
Colorado	1.6	1.4	4.5	4.2	40.3	32.8	55.0	50.4
Utah ROI	NA[b]	1.6	NA	NA	NA	13.8	NA	67.5
Utah	NA	2.3	NA	NA	NA	11.8	NA	51.6
Wyoming ROI	2.4	2.3	NA	NA	7.6	5.1	31.0	27.2
Wyoming	1.2	1.0	NA	NA	10.9	9.3	52.2	52.7

a Rates are the number of crimes per 1,000 population.

b NA = not available.

Sources: Colorado Bureau of Investigation (2006); Utah Department of Public Safety (2006); Wyoming Division of Criminal Investigation (2006).

only available at the ROI level for Colorado, and show a slightly lower level in the ROI (3.9 incidents per 1,000 compared with 4.2 per 1,000 in the state). Juvenile crime is lower in each ROI than in the corresponding state, with 22.6 incidents per 1,000 in Colorado, 13.8 per 1,000 in the Utah ROI, and 5.1 in the Wyoming ROI. Overall crime rates are higher in the Utah ROI (67.5 incidents per 1,000) than in Colorado (30.9) and Wyoming (27.2). Over time, it would appear that crime rates in the Colorado and Wyoming ROIs are declining, with lower rates per 1,000 population in 2004 compared with 2001 for each category of crime in the Colorado ROI, and violent, juvenile and total crime in the Wyoming ROI. Rates in the two states have also declined between the same two years.

Although statistics on alcoholism, drug use, divorce, and mental health are not available for each ROI, data for each state may provide some information on social change in each ROI. Rates of alcoholism are higher in Colorado (9.2% of the total population with dependence or abuse of alcohol) and Wyoming (9.4%) than in the United States as a whole (7.6%), while rates in Utah (7.3%) are lower than in the other two states and in the nation (Table 3.10.2-13). Rates of drug use in Colorado (3.3% of the total population with dependence or abuse of illicit drugs) and Utah (3.5%) are slightly higher than the rate for Wyoming (2.9%), and both are higher than the national average (3.0%). Divorce rates in Colorado (4.7 per 1000 population) and Wyoming (5.4%) are slightly higher than the national average (4.1%) and the rate for Utah (4.1%). Data for mental health show that for Colorado, 11.4% of the population suffered from serious psychological stress, with slightly higher rates in Wyoming (13.3%) and Utah (14.6%), rates that were higher than in the nation as a whole (9.6%).

3.10.3 Recreation Economy

Large areas both within, and in the vicinity of, the oil shale and tar sands ROIs in Colorado, Utah, and Wyoming administered by the BLM, USFWS, NPS, U.S. Department of

TABLE 3.10.2-13 State Indices of Social Change[a]

	Alcoholism	Illicit Drug Use	Divorce[b]	Mental Health
Colorado	9.2	3.3	4.7	11.4
Utah	7.3	3.5	4.1	14.6
Wyoming	9.4	2.9	5.4	13.3
U.S.	7.6	3.0	4.1	9.6

a Data for alcoholism, drug use, and metal health represent percent of the population over 12 years of age with dependence or abuse of alcohol, illicit drugs, or suffering from serious psychological distress. Data are for 2005.

b Divorce rates are the number of divorces per 1,000 population. Data are for 2004.

Sources: SAMHSA (2006); CDC (2006).

Transportation (DOT), USFS, and the BOR are used for recreation, primarily hunting and other forms of dispersed outdoor activities. Table 3.1.2-1 lists the many recreational areas and other areas that may provide recreation opportunities located within about a 50-mi radius of the oil shale and tar sands resources.

Statistics available at the state level show that in 2001 almost 1.2 million people participated in hunting and fishing in Colorado, of whom 60% were state residents, and 1.6 million participated in wildlife watching (USFWS 2002c). In Utah, participation in these activities was lower, with 517,000 fishermen and hunters, 80% of whom, on average, were state residents, and 806,000 people wildlife watching; in Wyoming in 2001, there were 293,000 anglers and hunters, 45% of whom, on average, resided in the state, and 498,000 wildlife watchers.

Numerous popular state parks are located in the vicinity of federally administered land near oil shale and tar sands developments. Data from Utah show that three facilities in the state located in the oil shale and tar sands ROI—Anasazi Indian Village State Park, Dead Horse Point State Park, and Edge of the Cedars State Park—were together visited by 255,766 people in 1999 (Utah State Legislature 2000).

Hunters and anglers spent an estimated $797 million on trip expenses and related equipment in Colorado in 2002, almost 60% of which came from state residents, while the Colorado Department of Wildlife spent an additional $49 million on operations to support hunting and fishing (BBC Research and Consulting 2004). Once the indirect impacts on the remainder of the state economy of trip-related expenditures are included, hunting and fishing had an overall impact on the state of $1.5 billion, and supported 20,000 jobs. The overall impact of wildlife watching, including indirect impacts, on the state was $940 million, supporting 13,000 jobs.

Because public land in the three-state ROI is primarily used for hunting and other forms of dispersed outdoor activities, the number of visitors using these lands for these recreational activities is not available from all administering agencies; that is, the value of recreational resources in these areas, based solely on the number of recorded visitors, is likely to be underestimated. In addition to visitation rates, the economic valuation of certain natural resources can also be assessed in terms of the potential recreational destination for current and future users, that is, their nonmarket value. Another method is to estimate the economic impact of the various recreational activities supported by natural resources on public land in the vicinity of land proposed for oil shale and tar sands development.

3.10.3.1 Economic Valuation of Public Lands Used for Recreation

A simple way to quantify the value of recreation on public land would be to measure revenue generated by user fees and other charges for public use. However, visitation statistics are often incomplete, and, in many cases, federal and state agencies do not charge visitors a fee for entrance to recreational resources on public lands; where fees are charged, they may be nominal compared with the value of the visit to recreational users. Recreation undertaken using privately owned facilities, such as golf courses, horse ranches, or fishing on private waters, has a quantifiable market value, with the user paying rates for visiting these facilities, which reflect the value of the resource to its owners and the cost of providing access to it to visitors. With the majority of recreation in the immediate vicinity of proposed oil shale and tar sands facilities likely to occur on public lands, however, the economic value of these resources is more difficult to quantify, since no valuation of the use of these resources can be made through the marketplace.

A number of methods have been used to determine the use value of nonmarketed recreational goods, or the value of recreational resources on public lands that may be for used for recreation. Because resources on public lands are scarce, and recreational activities provide enjoyment and satisfaction, the amount visitors would pay over the actual cost of using these resources represents the value of the benefit of these resources to the public. One method of estimating the net willingness to pay, or consumer surplus, associated with resources on public lands used for recreation is the travel cost method. This method uses variation in the cost of traveling different distances, and the number of trips taken over each distance, as a way to represent the demand for recreational resources in any given location (Loomis and Walsh 1997).

In addition to use values, a certain portion of the value of resources used for recreation may lie in the passive use of a resource, or the extent of the availability of the resource to current and future generations. Attempts to establish passive use values, or the willingness to pay for, or accept compensation for the loss of, different levels of nonmarketed recreational resources on public lands have used contingent valuation methods, which rely on telephone interviews or questionnaire surveys. Typically, a description of a particular resource is presented to respondents, who are then asked to place a dollar value on their use of the resource, or on the preservation of the resource (Loomis 2000). Although the travel cost and contingent valuation methods have weaknesses, particularly with regard to the accuracy of questions asked and respondents' self-reporting errors, both have been used widely by government agencies and academics in cost-benefit analyses of outdoor recreation. The BOR, for example, used contingent valuation to place a value of the impact of hydropower activities in Utah and Colorado on fishing and rafting (BOR 1995). The method was used in establishing the value of natural resources damaged by oil spills in Alaska (DOI 1994; Carson et al. 1992), and various state agencies have the travel cost and contingent valuation methods for valuing wildlife-related recreation (Loomis 2000). Contingent valuation methods have also been used to value natural resource amenities, such as improvements in visibility in the Grand Canyon (Schulze and Brookshire 1983) and the value of protecting endangered species (Boyle and Bishop 1987) and wilderness areas (Koontz and Loomis 2005).

Loomis (2000) reports the results of various studies that used survey data and travel cost and contingent valuation methods to estimate the value of recreation in wilderness areas in Colorado and Wyoming. On the basis of data reported in these studies, the average value per day of visiting a wilderness area for recreation was estimated to be $26 (1996 dollars), meaning that a visitor would be willing to pay this amount more than trip travel cost rather than lose a day visiting an area for recreation. Multiplying this number by the number of visitors to a specific wilderness resource would give the value of the resource to the public (Loomis 2000).

Contingent valuation has also been used to establish willingness to pay to preserve existing wilderness areas, and additional acreage that might be designated as wilderness. On the basis of two surveys of Colorado and Utah residents, Walsh et al. (1984) and Pope and Jones (1990) found that passive use values varied with the level of wilderness already designated in a state, but at a decreasing rate. Passive use value was also found to represent about half of the economic value of a resource, equaling the use value of the resource to the household as a place for recreation. The same surveys found that residents in Colorado and Utah, and in the rest of the United States, would pay between $220 per additional acre, if 5–10 million acres of wilderness resources were to be preserved in the two states, and $1,246 per acre if only 1.2 million additional acres were preserved. Passive use values in the western United States were estimated to be $168 per acre, or about $7.2 billion when applied to all wilderness land in the west. Barrick (1986) estimated the value of the wilderness resources in the Washakie Basin, Wyoming, for future visits (option values) at $69 (1996 dollars) for on-site users, and $15 and $13 for urban and rural nonvisiting U.S. residents.

3.10.3.2 Economic Impact of Recreational Activities

The economic value of recreation in the oil shale and tar sands areas in each state can be estimated through the impact recreation has on the economy of the ROI in each state by identifying sectors in the ROI (see Table 3.10.3-1) economy in which expenditures on recreational activities occur. Not all activities in these sectors are directly related to

TABLE 3.10.3-1 ROI Recreation Sector[a] Activity, 2004

ROI[b]	Employment[b]	Share of ROI Employment (%)	Income ($ million)
Colorado	10,970	14.0	122.9
Utah	3,227	10.7	23.9
Wyoming	4,826	15.5	49.6

[a] The recreation sector includes amusement and recreation services, automotive rental, eating and drinking places, hotels and lodging places, museums and historic sites, recreational vehicle parks and campsites, scenic tours, and sporting goods retailers.

[b] The Colorado ROI includes Delta, Garfield, Mesa, Moffat, and Rio Blanco Counties; the Utah ROI includes Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, and Wayne Counties; the Wyoming ROI includes Carbon, Lincoln, Sweetwater, and Uinta Counties.

recreation on federal lands, with some expenditures made by business visitors, oil and gas workers, and interstate travelers, and some activity occurring on private land (e.g., dude ranches, golf courses, bowling alleys, and movie theaters).

Expenditures associated with recreational activities form an important part of the economy of the ROIs and states in which they are located. In 2004, 10,970 people were employed in the Colorado ROI in the various sectors identified as recreation, constituting 14% of total ROI employment (Table 3.10.3-1). Recreation spending also produced almost $123 million in income in the ROI in 2004. The recreation sector was smaller in the Wyoming ROI (4,486 persons employed, producing almost $50 million in income), although it represents a larger share (15.5%) of total ROI employment, and in Utah (3,227 employed, and almost $24 million in income), it contributed 10% of total ROI employment in 2004.

3.10.4 Transportation

3.10.4.1 Colorado

U.S. Interstate 70 (I-70) and Colorado State Highway 64 are the major east-west arterials bounding the general area of the Piceance Basin oil shale resource area in Colorado on the south and north, respectively. On the east side of the Basin is Colorado State Highway 13, the major north-south arterial. Rio Blanco County Roads such as 5, 24, 26, 29, 69, 85, 91, 122, and 144, which provide access to the basin interior, are accessed from State Highways 13 and 64. On the west side of the basin is north-south State Highway 139; this arterial, however, does not provide ready access to the interior of the oil shale area. There are numerous lesser gravel or dirt rural roads within the Piceance Basin that are used primarily by recreationists, ranchers, and oil and gas operators.

I-70, in addition to being a major east-west national corridor, is the major access between Denver and the winter and summer recreation areas in central Colorado. During peak use times and during inclement weather, primarily in the winter, traffic on I-70 is very congested and slow. Complicating this situation is the increasing amount of commuter traffic that supports both recreational tourism in central Colorado and the growth related to current oil and gas development on the Western Slope. For some time, Colorado has time been addressing possible actions that could be employed to minimize the current congestion in this corridor.

With the growth of the oil and gas industry in recent years, traffic in the Piceance Basin has increased markedly. Well drilling equipment, pipeline construction equipment, and construction and production traffic travel along these roads throughout the day. These roads were originally designed for rural and agricultural uses and were not intended for heavy loads and traffic volumes associated with oil and gas production and construction. The increasing traffic volume, frequency, and vehicle size on these rural roads has contributed to an increase in the costs associated with repair and maintenance of these county roads.

Table 3.10.4-1 gives average daily traffic numbers in 2005 compiled from the Colorado Department of Transportation (CDOT) and the Garfield and Rio Blanco County Road and Bridge Department for major roads in the Piceance Basin.

Repair and maintenance of county roads represents the single largest dollar impact on Rio Blanco County (Exxon Mobil 2006). These county roads, originally designed for rural and agricultural uses, are experiencing increased traffic volume, frequency of use, and size of vehicles. The commuting workforce and oversized loads typical of the oil and gas industry have contributed to the increased costs associated with repair and maintenance, particularly in the Piceance Basin area.

3.10.4.2 Utah

The primary access for the Uinta Basin oil shale and tar sands resources from the north is via U.S. Highways 40 and 191, and from the south via I-70. The major routes into the basin from U.S. Highways 40 and 191 are local roads 45 and 88 south from U.S. 40. U.S. Highway 6 parallels the southwest side of the Uinta Basin, and Road 123 links this highway with the interior of the basin in the vicinity of the Sunnyside STSA. Access to the San Rafael STSA is from I-70, which traverses that area. Access to the Tar Sand Triangle STSA is from Highways 24 and 95. There also are numerous other gravel or dirt rural roads within the Uinta Basin and tar sands resource areas that are used primarily by recreationists, local ranchers, and oil and gas operators.

Portions of eastern Utah within the PEIS study area are undergoing intensive oil and gas development, and traffic has both changed in character and increased markedly. As was mentioned for Colorado, well drilling and pipeline construction equipment and construction and production traffic utilize these roads throughout the day. County roads that were originally

TABLE 3.10.4-1 Baseline Average Daily Traffic Data for Project Area Roads

Road	Baseline Average Daily Traffic (number of vehicles per day)
Colorado Highway 13 between Rifle and the junction with the south end of Rio Blanco County (RBC) Road 5 (Piceance Creek Road)	2,300[a]
Colorado Highway 13 between south end of RBC Road 5 and Colorado Highway 64 near Meeker	2,300[a]
Colorado Highway 64 between Meeker and north end of RBC Road 5	830[a]
Colorado Highway 64 between north end of RBC Road 5 and Colorado Highway 139	1,700[a]
I-70 from Rifle to Grand Junction	14,300–23,100[a]
RBC Road 5 (Piceance Creek Road)	562–1,076[b]

a CDOT (2004).

b Lower traffic range was measured in May, and high traffic range was measured in late October/early November, coinciding with big game hunting season (BLM 2006j).

designed for lower traffic levels and for rural and agricultural uses were not intended for heavy loads and traffic volumes associated with oil and gas construction and production. The increasing traffic volume, frequency, and vehicle size on these roads have contributed to an increase in the costs associated with repair and maintenance. Although constructed to higher standards and for heavier uses, state highways are also subject to these higher traffic volumes and the concomitant need for increased levels of maintenance and repair.

3.10.4.3 Wyoming

I-80 traverses the central part of the Green River Basin and crosses the northern edge of the Washakie Basin in Wyoming and provides primary access to the oil shale resources in these areas. Additional major roads passing through or near the Green River Basin are U.S. Highways 30, 189, and 191. Other major roads in the Green River Basin are Highways 28, 240, 372, 410, 412, 414, and 530. The north-south Highways 430 and 789 also provide access to the Washakie Basin. Numerous other local roads occur in the oil shale resource areas, many of which are gravel or dirt and are used primarily by recreationists, local ranchers, and oil and gas operators. Increases in road use associated with oil and gas development are having effects similar to those described above for Colorado and Utah.

3.11 ENVIRONMENTAL JUSTICE

E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," (U.S. President 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs agencies to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of oil shale and tar sands development on environmental justice issues follows guidelines described in the CEQ's *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area; (2) an assessment of whether construction and operation would produce impacts that are high and adverse; and (3) if impacts are high and adverse, a determination as to whether these impacts disproportionately affect minority and low-income populations.

The analysis of environmental justice issues considers impacts at the state level in the three states—Colorado, Utah, and Wyoming. A 50-mi buffer was used to capture the effects of oil shale and tar sands development construction and operation that may occur beyond designated land.

The description of the geographic distribution of minority and low-income groups is based on demographic data from the 2000 Census (U.S. Bureau of the Census 2007). The following definitions were used to define minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic or Latino, (2) Black (not of Hispanic or Latino origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origins. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups as the basis of their racial origins. The term *minority* includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic or Latino origin and as White or "Other Race" (U.S. Bureau of the Census 2007).

  The CEQ guidance proposed that minority populations should be identified where either (1) the minority population of the affected area exceeds 50%, or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  In this PEIS, both criteria were applied in using the Census Bureau data for census block groups; consideration was given to the minority population that is both more than 50% and 20 percentage points higher than in the state (the reference geographic unit).

- **Low Income.** Individuals who fall below the poverty line are included in this category. The poverty line takes into account family size and age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. For any family below the poverty line, all family members are considered to be below the poverty line for the purposes of analysis (U.S. Bureau of Census 2007).

  The CEQ guidance proposed that low-income populations should be identified where either (1) the low-income population of the affected area exceeds 50%, or (2) the low-income population percentage of the affected area is meaningfully greater than the low-income population percentage in the general population or other appropriate unit of geographic analysis.

  In this PEIS, both criteria were applied in using the Census Bureau data for census block groups; consideration was given to the low-income population that is both more than 50% and 20 percentage points higher than in the state (the reference geographic unit).

Data in Tables 3.11-1 and 3.11-2 show the minority and low-income composition of total population located in the designated oil shale and tar sands development areas and associated

TABLE 3.11-1 Minority and Low-Income Populations in the Oil Shale Resource Area and Buffer

	Colorado Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	207,319	72,795	77,966
White, non-Hispanic	176,798	64,089	69,054
Hispanic or Latino	24,768	4,051	5,195
Non-Hispanic or Latino minorities	5,753	4,655	3,717
One race	3,284	3,646	2,736
Black or African American	761	131	369
American Indian or Alaskan Native	1,245	3,248	1,929
Asian	968	182	356
Native Hawaiian or other Pacific Islander	144	42	36
Some other race	166	43	46
Two or more races	2,469	1,009	981
Total minority	30.521	8,706	8,912
Low-income	18,765	9,713	6,953
ROI percent minority	14.7	12.0	11.4
State percent minority	34.0	19.8	14.3
ROI percent low-income	9.1	13.3	8.9
State percent low-income	9.0	9.2	11.1

Source: U.S. Bureau of the Census (2007).

50-mi buffers in the three states (based on 2000 Census data and CEQ Guidelines). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics or Latinos can be of any race, this number also includes individuals who identify themselves as being part of one or more of the population groups listed in the table.

On the basis of 2000 Census data, low-income and minority populations are located in each of the three states where oil shale and tar sands development may occur (Figures 3.11-1 through 3.11-4).

In Utah, there are six census block groups within 50 mi of the oil shale area where the minority population exceeds 50% of the total population in each block group; there are two block groups where the minority share of the total block group population exceeds the state average by more than 20 percentage points. This minority population is located in the northeastern part of the state in the immediate vicinity of the oil shale resource area itself, that is, in the southeastern portion of the Uintah and Ouray Indian Reservation, and in the north-central part of the state, to

TABLE 3.11-2 Minority and Low-Income Populations in the Tar Sands Resource Area and Buffer

	Arizona Block Groups	Colorado Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	3,051	117,465	388,585	6,721
White, non-Hispanic	58	102,109	337,000	6,252
Hispanic or Latino	18	11,823	27,012	315
Non-Hispanic or Latino minorities	3,033	3,533	24,573	154
One race	3,009	2,001	19,487	88
Black or African American	5	455	966	11
American Indian or Alaskan Native	2,945	734	13,195	55
Asian	0	596	3,328	14
Native Hawaiian or other Pacific Islander	1	105	1,648	1
Some other race	0	111	350	7
Two or more races	24	1,532	5,086	66
Total minority	2,993	15,356	51,585	469
Low-income	1,430	11,611	57,014	531
ROI percent minority	98.1	13.1	13.3	7.0
State percent minority	36.2	34.0	19.8	14.3
ROI percent low-income	46.9	9.9	14.7	7.9
State percent low-income	13.9	9.0	9.2	11.1

Source: U.S. Bureau of the Census (2007).

the east of Springville. Five census block groups within 50 mi of the oil shale area exceed the state percent low-income by more than 20 percentage points; one block group has more than 50% low-income. The low-income population is centered in roughly the same area as the minority population, with five block groups in the southeastern portion of the Uintah and Ouray Indian Reservation, and one located in the vicinity of Price.

Within 50 mi of the oil shale area in Colorado, there is one census block group that has a minority population exceeding 50% of the total population; it is located to the east of the oil shale area, in Carbondale. Two census block groups with a low-income population that exceeds the state average by more than 20 percentage points are located in Grand Junction. In Wyoming, there are two census block groups located in the Wind River Indian Reservation with a minority population that is more than 50% minority. One census block group with a low-income population exceeding the state average by more than 20 percentage points is also located in the Wind River Indian Reservation.

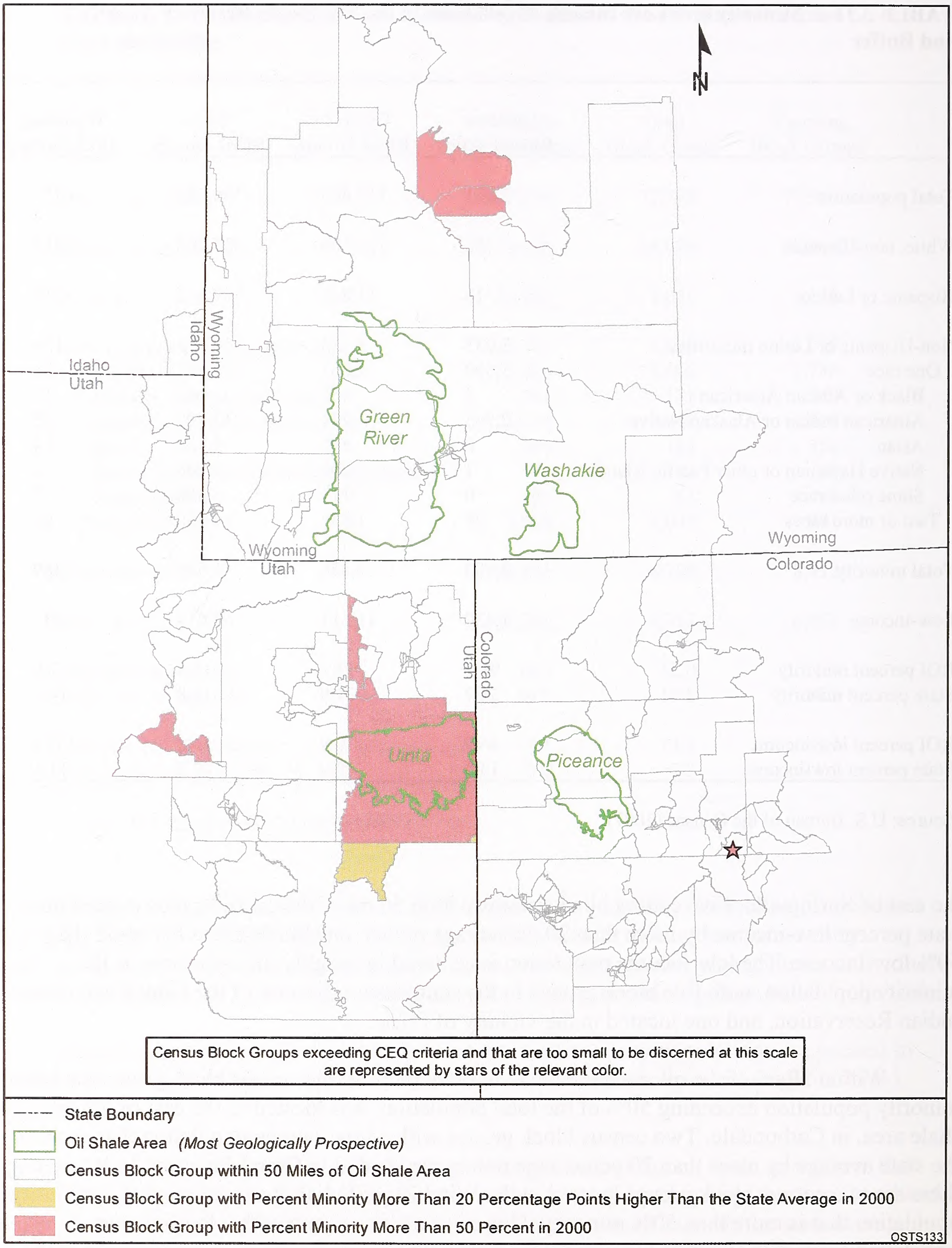

FIGURE 3.11-1 Minority Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

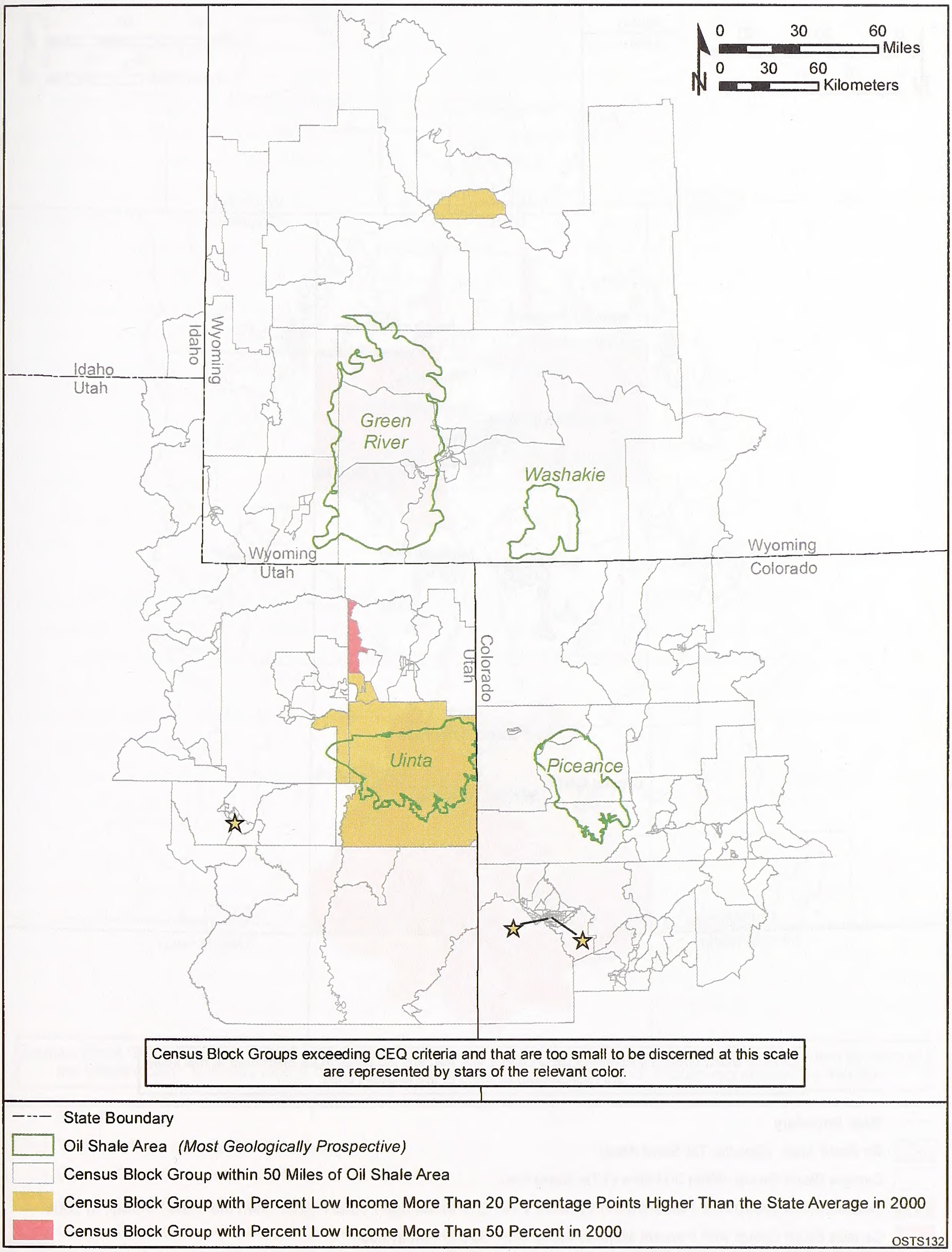

FIGURE 3.11-2 Low-Income Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

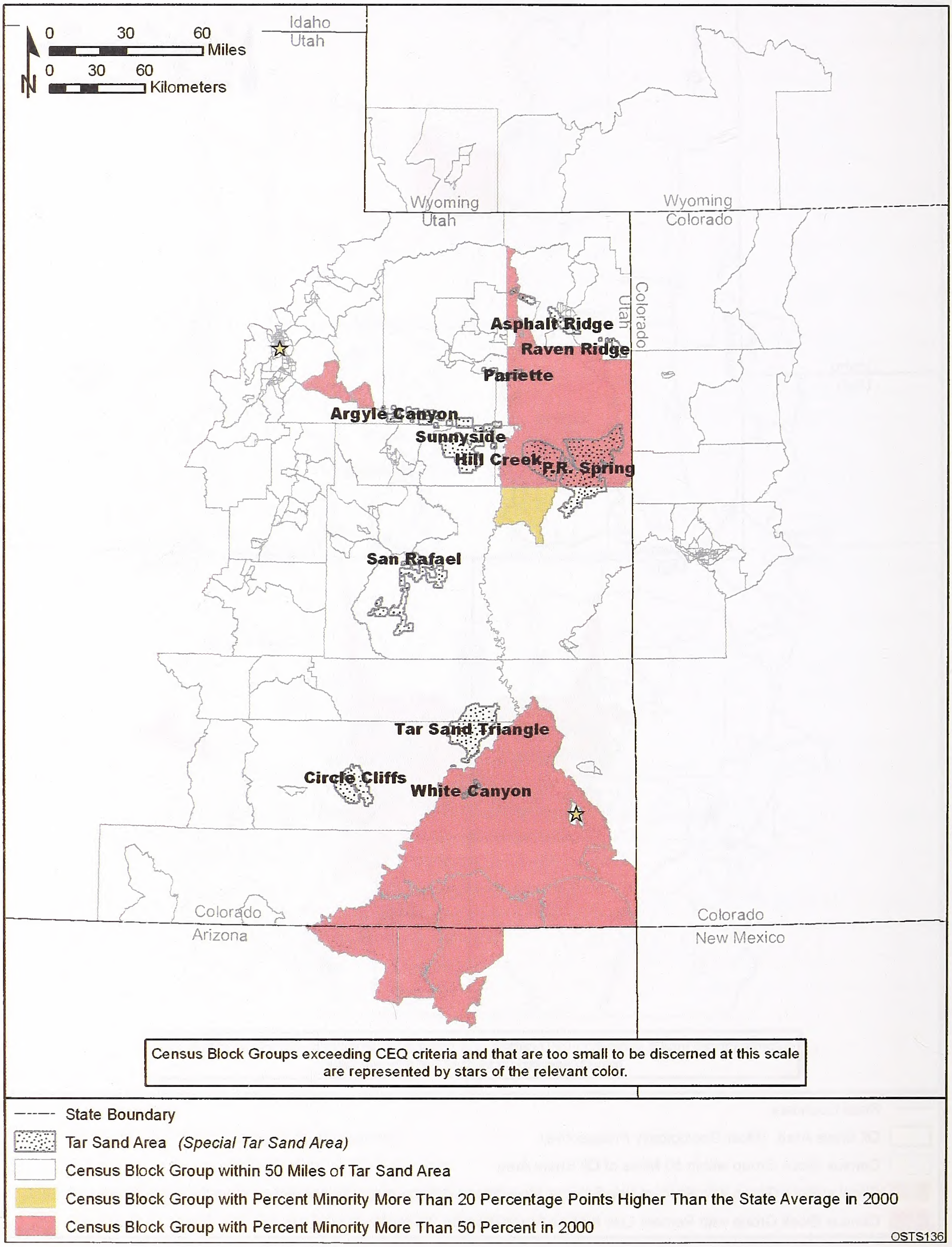

FIGURE 3.11-3 Minority Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

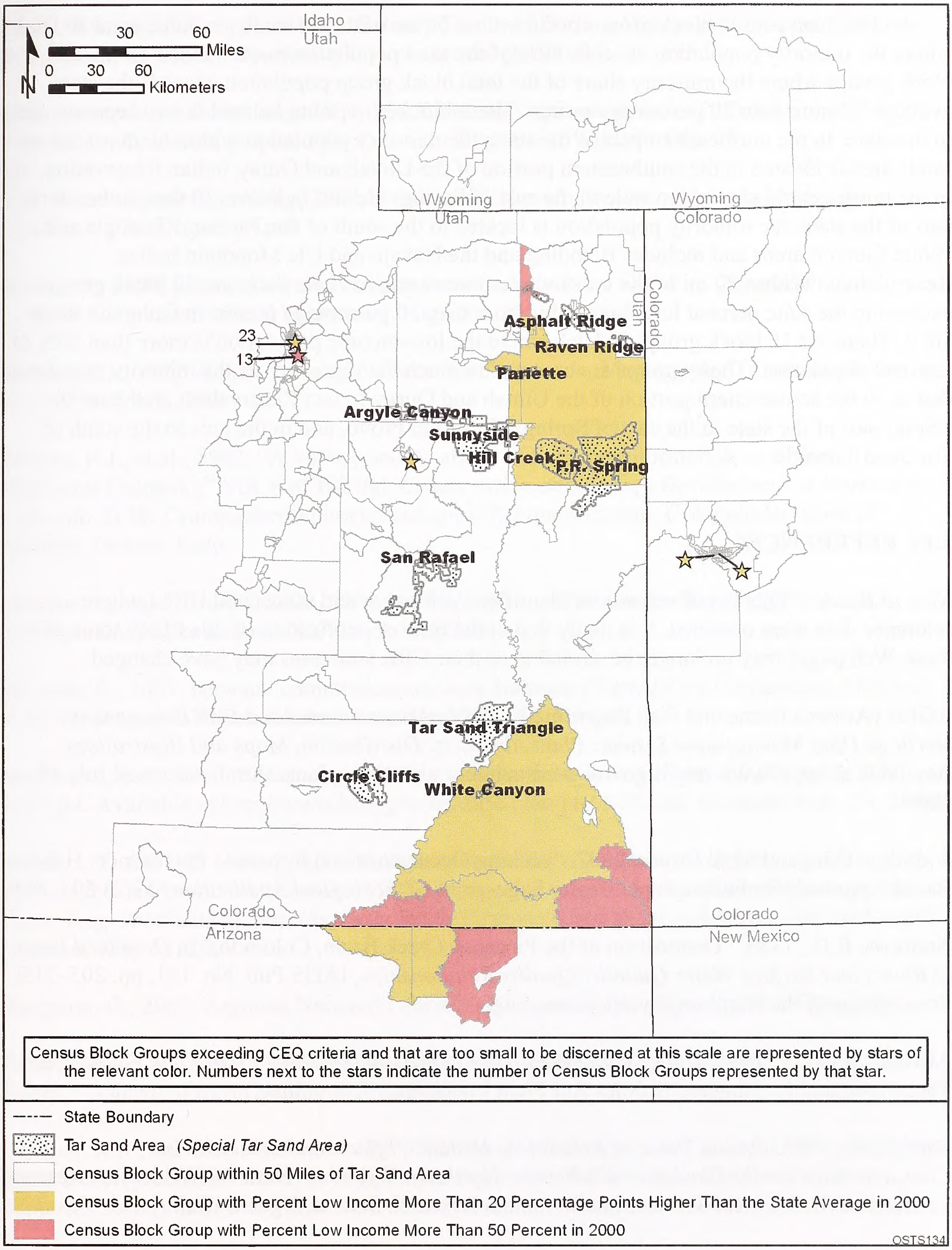

FIGURE 3.11-4 Low-Income Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

Fourteen census block groups occur within 50 mi of the tar sands resource areas in Utah where the minority population exceeds 50% of the total population in each block group, and four block groups where the minority share of the total block group population exceeds the state average by more than 20 percentage points. These block groups are located in two separate areas in the state. In the northeastern part of the state, the minority population within 50 mi of the tar sands area is located in the southeastern portion of the Uintah and Ouray Indian Reservation, and in the north-central part of the state to the east of Springville and in Provo. In the southeastern part of the state, the minority population is located to the south of the Tar Sand Triangle and White Canyon areas and includes Blanding and the Navajo and Ute Mountain Indian Reservations. Within 50 mi of the tar sands resource areas in Utah, there are 32 block groups exceeding the state percent low-income by more than 20 percentage points; in Colorado there are 2. There are 18 block groups in Utah where the low-income population is more than 50% of the total population. These groups are centered in much the same area as the minority population, that is, in the southeastern portion of the Uintah and Ouray Indian Reservation, in the north-central part of the state to the east of Springville and in Provo, and in the area to the south of Tar Sand Triangle.

3.12 REFERENCES

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4 EFFECTS OF OIL SHALE TECHNOLOGIES

In the NOI announcing the preparation of this PEIS (70 FR 73791–73792), the BLM indicated its intent to amend land use plans to allow for leasing of oil shale and tar sands resources in Colorado, Utah, and Wyoming. Through a public scoping process, the BLM solicited comments on the proposed PEIS and undertook additional analysis and consultation as part of the PEIS process. After preparation and analysis of an internal draft PEIS and discussion with its cooperating agencies, the BLM elected not to issue leases for development of oil shale on the basis of this PEIS. For oil shale, rather than amending plans to support immediate issuance of leases for commercial development of these resources without further NEPA analysis, the BLM proposes to amend land use plans to (1) identify the most geologically prospective oil shale areas in Colorado, Utah, and Wyoming; (2) designate lands that will be open to application for commercial leasing, exploration, and development; (3) identify any technology restrictions; (4) stipulate requirements for future NEPA analyses and consultation activities; and (5) specify that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005. Specific land use plan amendments are provided in Appendix C. (See Chapter 5 for the discussion of tar sands resources.) In the case of both oil shale and tar sands, additional NEPA analysis will be conducted prior to the issuance of leases.

Although the proposal analyzed in this PEIS has now shifted away from supporting issuance of commercial leases of oil shale and tar sand resources, substantial information was identified regarding current and emerging development technologies that will still be useful for decision makers and the public with respect to the proposal to amend the land use plans. This chapter of the PEIS contains a summary of this information on oil shale technologies and their potential environmental and socioeconomic impacts. Some of the information on the environmental consequences of oil shale development in this chapter is based on past oil shale development efforts. For the purposes of analysis, in the absence of more specific information on the oil shale technologies to be implemented in the future and the environmental consequences of implementing those technologies, information derived from other types of mineral development (oil and gas, underground and surface mining of coal) was used in preparing this chapter. The BLM has taken this approach because it anticipates, to the best of its knowledge, that the surface-disturbing activities involved with these other types of mineral development are comparable to those that may result from oil shale and tar sands development. There is a wealth of information concerning the consequences of oil and gas and underground and surface mining activities, and formulating projections on the basis of this information, to the extent that it is applicable, permits a decision maker to decide whether to open areas to future application for leasing or to protect the specific resources by closing areas.

Also included in this chapter is a brief description of mitigation measures that the BLM may consider for use if warranted by the results of NEPA analysis undertaken prior to issuance of site-specific oil shale commercial leases and/or approval of detailed plans of development. Use of the mitigation measures will be evaluated at that time.

Some sections of this chapter are organized on the basis of potential impacts of specific technologies or practices involved in oil shale development, while other sections focus on the particular resource(s) impacted. For example, Sections 4.7 Noise Resources, 4.13 Hazardous Materials and Waste Management, and 4.14 Health and Safety are organized by technology or project activity, because impacts within these disciplines are distinguished on the basis of these project-specific elements. Alternately, Sections 4.4 Paleontological Resources, 4.5 Water Resources, 4.8 Ecological Resources, and 4.10 Cultural Resources are organized by type of impact on the particular resource, such as land disturbance, water use, or soil contamination, because focus on impacts on the particular resource provides more information, in these instances, than emphasis on specific technologies or practices (i.e., the types of impacts by technology are consistent and the magnitude of impacts would vary on the basis of site-specific considerations).

It is important to understand that information on the technologies presented here is provided for the purpose of general understanding and does not necessarily define the range of possible technologies and issues that may develop in the coming years. Prior to approval of future commercial leases, additional NEPA analysis would be completed that would consider site- and project-specific factors for proposed development activities. The magnitude of impacts and the applicability and effectiveness of the mitigation measures would need to be evaluated on a project-by-project basis in consideration of site-specific factors (e.g., existing land use, presence of paleontological and cultural resources, and proximity to surface water, groundwater conditions, existing ecological resources, and proximity to visual resources) and project-specific factors (e.g., which technologies would be used, magnitude of operations, water consumption and wastewater generation, air emissions, number of employees, and development time lines).

4.1 ASSUMPTIONS AND IMPACT-PRODUCING FACTORS FOR INDIVIDUAL FACILITIES BY COMMERCIAL OIL SHALE TECHNOLOGY

This section summarizes some of the assumptions and potential impact-producing factors related to the different commercial oil shale technologies being considered, as well as the potential impacts associated with establishing transmission line and crude oil pipeline ROWs, building employer-provided housing, and expanding the existing electricity supply. Impact-producing factors are defined as activities or processes that cause impacts on the environmental or socioeconomic setting, such as surface disturbance, water use, numbers of employees hired, and generation of solid and liquid waste. Specifically, this section identifies the data used and assumptions made to define potential impact-producing factors for hypothetical future oil shale development facilities. Future production levels from development projects are unknown at this time; for the purpose of analysis, it has been assumed that surface or underground mining based operations would produce at a level of 50,000 bbl/day, and in situ facilities would produce at 200,000 bbl/day. The information provided in Sections 4.1.1, 4.1.2, and 4.1.3 is based on this assumption. Subsequent NEPA analysis will occur prior to leasing when more information on specific technologies and production levels is available. The information presented here is summarized, in part, from more detailed discussions contained in Appendix A (the oil shale development background and technology overview), as well as previous environmental documents. In those instances where specific data are not available to define a potential impact-producing factor, best professional judgments have been made to establish reasonable assumptions. Discussions relating to air emissions are not included in this section but are instead presented in Section 4.6.

All applicable federal, state, and local regulatory requirements will be met (see Section 2.2 and Appendix D), and the effects of these requirements are included in the analysis of impacts. Within the following text, specific assumptions that have been made for each technology or major activity that could occur during commercial operations have been identified. In most instances, these assumptions represent good engineering practice or reflect the BLM's understanding of design or performance limitations of various oil shale development activities. In those instances where various options have equal standing as practicable within the industry, the option offering the greatest potential environmental impacts was selected so as not to inadvertently understate these impacts.

4.1.1 Surface Mine and Surface Retort Projects

The information presented in Table 4.1.1-1 identifies the key assumptions associated with surface mining and surface retorting of oil shale for a facility whose size would support production of 50,000 bbl/day of oil. As discussed in Section 2.3.1 and Appendix A (Section A.3.1.1), the scope of this PEIS does not include surface mining for commercial development of oil shale in Colorado; therefore, values presented in Table 4.1.1-1 are for surface mine with surface retort projects in Utah and Wyoming only. In addition, in both Utah and Wyoming, surface mining is restricted to those areas where the overburden is 0 to 500 ft thick.

As shown in Table 4.1.1-1, for surface mining facilities, development is assumed to occur with a rolling footprint so that, at any given time, portions of the lease area would be (1) undergoing active development; (2) in preparation for a future development phase; (3) undergoing restoration after development; and (4) occupied by long-term surface facilities, such as office buildings, laboratories, retorts, and parking lots. Permanent surface facilities would be expected to occupy about 100 acres (DOI 1973a). The mine area and spent shale disposal areas would be reclaimed on an ongoing basis. Spent shale may be disposed of by being returned to the mine as operations would permit; there also would be some spent shale disposal on other parts of the lease area. The amount of land used for spent shale disposal would vary from project to project but is expected to be encompassed within the estimated development area identified in Table 4.1.1-1.

Considering the possible range of technology components, it is assumed that 2.6 to 4 bbl of water would be required for production of 1 bbl of shale oil using surface mining with surface retort. Water sources would be varied but may include a combination of groundwater, surface water, and treated process water. Groundwater pumped from the mine or from dewatering wells would be of variable quality; the higher-quality water would most likely be used for industrial processes, dust control, and revegetation. Water of lower quality would be reinjected or otherwise disposed of pursuant to state requirements. Retorts produce 2 to 10 gal of wastewater per ton of processed shale that contains various organic and inorganic components that may need treatment depending on final use (DOI 1973a).

TABLE 4.1.1-1 Assumptions Associated with a Surface Mine with Surface Retort with Production of 50,000 bbl of Shale Oil per Day[a]

Impact-Producing Factor	Value Used in Impact Analyses
Footprint of development area (acres)[b]	
Utah	600–1,200
Wyoming	1,000–2,000
Surface Disturbance[c]	5,760
Water use (ac-ft/yr)[d]	6,100–9,400
Wastewater (gal/ton of shale)[e]	2–10
Direct employment for surface mining	
Construction	910
Operations	1,300
Direct employment for surface retort	
Construction	530
Operations	620
Total employment[f]	
Construction	2,200
Operations	2,900–3,000

[a] bbl = barrel; 1 bbl shale oil = 42 gal.

[b] These acreages represent the estimated range of surface disturbance that could occur at any given time during the life of the project once a surface mine with surface retort project reaches commercial levels of production. Development is expected to occur with a rolling footprint so that, ultimately, the entire lease area would be developed and then restored. Because the shales are not as rich in Wyoming as they are in Utah, a larger area is necessary to get the same oil equivalent.

[c] It is assumed that the entire lease area will be disturbed during the 20-year time frame analyzed in this PEIS. The assumed lease area of 5,760 acres is based on provisions of the MLA as revised by Section 369(j) of the Energy Policy Act of 2005.

[d] These estimates were calculated on the basis of estimates that surface mine with surface retort projects would require 2.6 to 4 bbl of water per barrel of shale oil produced. 1 bbl = 0.0470 ac-ft/yr.

[e] Source: DOI (1973a).

[f] Total employment numbers include both direct and indirect jobs for mining and retorting. The range represents the difference in indirect employment between states for a project of the same size. The methodology is discussed in Section 4.11 and Appendix G.

Assumptions regarding surface mining, surface retorts, spent shale from surface retorting, and upgrading activities associated with surface retorting include the following.

Surface Mining

- Only areas with overburden thicknesses of 500 ft or less would be developed by using surface mining techniques. This limit is based on factors such as surface area needed to dispose of the waste material, projected economics, and material rehandle and equipment capabilities.
- Topsoil and subsoil removed as overburden would be separately stockpiled and vegetated to mitigate or eliminate erosion.
- Where mine site dewatering is necessary, recovered water would be used for fugitive dust control, moisturizing spent shale, and other nonconsumptive uses, to the extent allowable given water quality considerations.
- Explosives would be used in the mining process to remove overburden and fracture the oil shale.
- Raw shale would be loaded by shovel into trucks for delivery to the crusher, which would be adjacent to the retort and would feed the retort by conveyor belt.
- Strip mine development would provide for disposal of spent shale in areas already mined, to the extent it can be accommodated by available capacity.
- Reclamation would be conducted contemporaneously with mining activities.

Surface Retorts

- Surface retorts would be patterned after the Paraho Direct Burn Retort, the TOSCO II Indirect Mode Retort, or the ATP (see Appendix A of the PEIS).
- Surface retorts are considered to be the primary rate-limiting step in any oil shale development process of which they are a part; consequently, because they operate at elevated temperatures (650°F or higher), they would be operated continuously for maximum energy efficiency. Mining and raw shale crushing operations that support the retorts would be of a size to provide a relatively constant supply of properly sized shale to allow the retort to operate continuously at its rated capacity; multiple, simultaneous mining and crushing operations may, therefore, be required.

- Retorts would be positioned at or near the mine entrance, and raw shale would be delivered by truck to the crushing operation, which would be adjacent to the retort and feed the retort by conveyor.

- Primary and secondary crushing would take place adjacent to the retort.

- Flammable gases from retorting would be captured, filtered to remove suspended solids, dewatered, and consumed on-site as supplemental fuel in external combustion devices.

- Condensable liquids would be filtered, dewatered, and delivered to the adjacent upgrading facility.

- Indirect heat sources for surface retort would be provided by external combustion sources fueled by natural gas delivered to the site by pipeline, propane stored in pressure tanks on-site, or diesel fuel provided by commercial suppliers and stored in on-site aboveground tanks. Each commercial fuel source would be supplemented by combustible gases recovered from the retort.

- Fuel for direct-burn surface retorts would be provided by natural gas, propane, or diesel fuel, each of which would be delivered to the site and stored as noted above and supplemented by combustible gases recovered from the retort.

Spent Shale from Surface Retorting Activities

- Regardless of the retort, spent shale volume would increase by 30% over the volume of raw shale introduced into the retort.

- All spent shale would be disposed of within the leased parcel.

Upgrading Activities Associated with Surface Retorting

- All crude shale oil recovered from surface retorting would require some degree of upgrading.

- Shale oil upgrading requirements would be based on factors such as initial composition of crude shale oil recovered from surface retorts or in situ retorts and desired endpoints.

- At a minimum, upgrading of crude shale oil would consist of:

  – Dewatering;
  – Filtering of suspended solids;

- Conversion of sulfur-bearing compounds to H_2S;
- Removal of H_2S and conversion to elemental sulfur by using a conventional Claus process or equivalent;[1]
- Conversion of nitrogen-bearing compounds to ammonia, recovery of ammonia gas, and temporary storage and sale of ammonia gas as fertilizer feedstock; and
- Hydrogenation or hydrocracking of organic liquids only to the extent necessary to sufficiently change physical properties (American Petroleum Institute [API] gravity, pour point[2]) of the resulting syncrude to allow for conveyance from the mine site by conventional means (tanker truck and/or pipeline).

• Hydrogen used in upgrading would be supplied by a commercial vendor and stored temporarily in transport trailers (high-pressure tube trailers) before use in upgrading reactions; no long-term storage of hydrogen would take place on-site; no steam reforming of CH_4 to produce hydrogen would be conducted on-site.

• Fuel for upgrading activities would be commercial natural gas, propane, or diesel, augmented to the greatest extent practical by combustible gases recovered from upgrading activities.

• Water for upgrading would be recovered from surface water bodies (including on-site stormwater retention ponds), mine dewatering operations, or on-site groundwater wells.[3]

• Treatment of wastewaters from upgrading activities would occur on-site; water recycling would be practiced to the greatest extent practical.

4.1.2 Underground Mine and Surface Retort Projects

The information presented in Table 4.1.2-1 identifies the key assumptions associated with underground mining and surface retorting of oil shale for a facility of a size to support production of 50,000 bbl of shale oil per day.

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1 The Claus process is one of many processes used by petroleum refiners to control H_2S, a common by-product of crude oil refining, in accordance with air emission regulations and permits. The H_2S is removed from the production gas stream by direct separation and/or by amine extraction. It then is converted into elemental sulfur by a combination of thermal oxidation and catalytic conversion.

2 The pour point is the temperature at which the petroleum liquid's viscosity is sufficiently low to allow pumping and transfer operations with conventional liquid handling equipment. API gravity is an arbitrary scale for expressing the specific gravity or density of liquid petroleum products. Heavier viscous petroleum liquids have the lower API values.

3 Water recovered from on-site treatment of sanitary wastewaters or from operation of an on-site drinking water treatment system (e.g., reverse osmosis back flushes) could also be used to support upgrading.

TABLE 4.1.2-1 Assumptions Associated with an Underground Mine with Surface Retort with Production of 50,000 bbl of Shale Oil per Day[a]

Impact-Producing Factor	Value Used in Impact Analyses[b]
Footprint of development area (acres)	150
Surface disturbance[c]	1,650
Water use (ac-ft/yr)[d]	6,100–9,400
Wastewater (gal/ton of shale)[e]	2–10
Direct employment for underground mining	
Construction	940
Operations	1,300
Direct employment for surface retort	
Construction	530
Operations	620
Total employment[f]	
Construction	2,200–2,600
Operations	2,900–3,300

[a] bbl = barrel; 1 bbl shale oil = 42 gal.

[b] The values apply to activities within all three states.

[c] For underground mines, it is assumed that 1,650 acres of the lease area would be disturbed (150 acres required for surface facilities; up to 1,500 acres used for spent shale disposal over a 20-yr project lifetime). An assumed lease area of 5,760 acres is based on provisions of the MLA as revised by Section 369(j) of the Energy Policy Act of 2005. The PRLA associated with the OSEC RD&D project is 5,120 acres as defined by the terms of the RD&D program (see Section 1.4.1).

[d] Calculated on the basis of estimates that underground mine with surface retort projects would require 2.6 to 4 bbl of water per barrel of shale oil produced. 1 bbl = 0.0470 ac-ft/yr.

[e] Source: DOI (1973a).

[f] Total employment numbers include both direct and indirect jobs for mining and retorting. The range represents the difference in indirect employment between states for a project of the same size. The methodology is discussed in Section 4.11 and Appendix G.

As shown in Table 4.1.2-1, permanent surface facilities supporting underground mining operations would be expected to occupy about 150 acres (DOI 1973a). It is assumed that up to 30% of the processed spent shale could be returned to the mine for disposal. If 30% of spent shale is returned to the mine, surface disposal is estimated to require approximately 60 ac-ft/yr with disposal heights and depths of 250 ft. To develop a conservative estimate of land surface disturbance for underground mining operations, if it is assumed that all spent shale is disposed of on the land surface, 75 acres/yr would be required for disposal (DOI 1973a). This would result in 1,500 acres disturbed over the 20-year study period (in addition to the 150 acres disturbed for surface facilities). The amount of land used for spent shale disposal would vary from project to project but is expected to be encompassed within the estimated development area identified in Table 4.1.2-1.

Considering the possible range of technology components, it is assumed that 2.6 to 4 bbl of water would be required for production of 1 bbl of shale oil. Water sources would be varied but may include a combination of groundwater, surface water, and treated process water. Groundwater pumped from the mine or from dewatering wells would be of variable quality; the higher quality water would most likely be used for industrial processes, dust control, and revegetation. Water of lower quality would be reinjected or otherwise disposed of pursuant to state requirements. Retorts produce 2 to 10 gal of wastewater per ton of processed shale that contains various organic and inorganic components that may need treatment depending on final use (DOI 1973a).

Assumptions regarding surface retorts and upgrading activities associated with surface retorting are discussed in Section 4.1.1. Additional assumptions regarding underground mining include the following.

Underground Mining

- Some mines would be "gassy"; both H_2S and CH_4 would be present, placing additional demands on the ventilation system for worker safety and introducing additional controls for the use of explosives.
- Explosives would be used in the mining process.
- Primary crushing would occur at the surface and not within the mine.[4]
- Conventional room-and-pillar techniques would be used.
- At least two levels of room-and-pillar development would occur.
- Mine dewatering would occur continuously throughout the life of the mine. Recovered water would be used for fugitive dust control, moisturizing spent

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4 Although some primary crushing typically takes place within the mine, to assess maximum potential impacts conservatively, it is assumed that all crushing and sizing of raw shale would take place on the surface.

shale, and other nonconsumptive uses, to the extent allowable given water quality considerations.[5] All recovered water would be contained on-site.

- No more than 30% of the spent shale would be disposed of within the mine; the remainder would be disposed of on the surface. This assumption is based on a best estimate of what may be feasible at any given site; specific mine development procedures may accommodate disposal of a greater percentage of the spent shale inside the mine.

- Resource extraction would depend on local structural features, but at no location would extraction go beyond 60% (by volume) of the mining horizon.

4.1.3 In Situ Retort Projects

The information presented in Table 4.1.3-1 identifies the key assumptions associated with in situ retort projects whose size would support production of 200,000 bbl of shale oil per day. Development is assumed to occur with a rolling footprint so that, at any given time, portions of the lease area would be (1) undergoing active development; (2) in preparation for a future development phase; (3) undergoing restoration after development; and (4) occupied by long-term surface facilities, such as office buildings, laboratories, retorts, and parking lots. Permanent surface facilities would be expected to occupy about 200 acres (BLM 2006c).

It is assumed that 1 to 3 bbl of water would be required for production of 1 bbl of shale oil (Bartis et al. 2005) using in situ technologies.[6] Water would come from wells, surface sources, and treated process water.

Groundwater and process water would be of variable quality, with the higher-quality water being used for industrial processes, dust control, revegetation, etc. Water of lower quality would be reinjected or otherwise disposed of pursuant to state requirements.

Additional assumptions regarding in situ retorting include the following:

In Situ Retorting

- Some degree of upgrading of initial kerogen pyrolysis products can be expected to occur within the formation, before product recovery occurs.

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[5] Water from an on-site treatment of sanitary wastewater or from the operation of on-site drinking water systems (e.g., reverse osmosis back flushes) could also be used for such activities.

[6] The uncertainty in this number is based on variation in the quality of initially recovered shale oil and the extent of mine-site upgrading that would be subsequently required to produce a syncrude product that would be accepted as a crude feedstock at a refinery.

TABLE 4.1.3-1 Assumptions Associated with an In Situ Retort Project with Production of 200,000 bbl of Shale Oil per Day[a]

Impact-Producing Factor	Value Used in Impact Analyses
Footprint of development area (acres)[b]	
Colorado and Utah	150–600
Wyoming	1,000–2,000
Surface disturbance[c]	5,760 (5,120)
Water use (acre-ft/yr)[d]	9,400–28,200
Direct employment for in situ projects	
Construction	1,500
Operations	500
Total employment[e]	
Construction	2,300–2,900
Operations	780–950

[a] bbl = barrel; 1 bbl shale oil = 42 gal.

[b] The acreages represent the estimated range of surface disturbance that could occur at any given time during the life of the project once an in situ project reaches commercial levels of production. Development is expected to occur with a rolling footprint so that, ultimately, the entire lease area would be developed and then restored. Because the shales are not as rich in Wyoming as they are in Colorado and Utah, a larger area is necessary to obtain the same oil equivalent.

[c] It is assumed that the entire lease area will be disturbed during the 20-year time frame analyzed in this PEIS. The assumed lease area of 5,760 acres is based on provisions of the MLA as revised by Section 369(j) of the Energy Policy Act of 2005. The PRLA associated with the five RD&D projects in Colorado is 5,120 acres as defined by the terms of the RD&D program (see Section 1.4.1).

[d] Calculated on the basis of estimates that in situ projects would require 1 to 3 bbl of water per barrel of shale oil produced (Bartis et al. 2005). 1 bbl equals 0.0470 ac-ft/yr.

[e] Total employment numbers include both direct and indirect jobs for in situ projects. The range represents the difference in indirect employment between states for a project of the same size. The methodology is discussed in Section 4.11 and Appendix G.

- Minimal upgrading of recovered products would be required and is likely to include:
  - Dewatering;
  - Gas/liquid separations;
  - Filtering of suspended solids from both gaseous and liquid fractions;
  - Removal of H_2S gas, conversion to elemental sulfur, temporary on-site storage, and sale;
  - Removal of H_2S gas, temporary on-site storage, and sale as fertilizer feedstock;
  - Hydrogenation/hydrotreating/hydrocracking performed on condensable liquids only if necessary to adjust API gravity; and
  - Viscosity adjustments to allow for transport by conventional means (tanker truck and/or pipeline) to a conventional petroleum refinery.
- Recovered and/or upgraded liquid products would be stored temporarily on-site in aboveground tanks before delivery to market or conventional petroleum refineries by tanker truck or pipeline.
- 100% of combustible gases recovered from the formation would be dewatered, filtered of suspended solids, and consumed on-site as supplemental fuel in external combustion sources.

4.1.4 Transmission Line and Crude Oil Pipeline ROWs

Oil shale projects would need to connect to the existing transmission grid (or to new regional transmission lines) to obtain electricity. The maximum distance from an existing 500-kV transmission line to any of the oil shale resources is approximately 150 mi. The maximum distance from an existing 230-kV transmission line to any of the oil shale resources is approximately 45 mi. The greater distance of 150 mi has been assumed for all oil shale projects, although some projects could be located closer to existing transmission lines. Project economics would likely select for sites closest to existing infrastructure.

For the purposes of analysis, it is assumed that one connecting transmission line and ROW would serve each project and would be 150 mi long, 100 ft wide, and with construction impacts extending up to 150 ft in width (equivalent to a disturbed area of 1,800 acres during operations and 2,700 acres during construction). The 150-mi distance assumption and 100-ft ROW size represent probable maximum sizes.

It also has been assumed that all processing required to upgrade the oil shale product to render it suitable for pipeline transport and acceptance at refineries would be conducted on-site. Oil shale projects would need to connect to existing regional crude pipelines (or to new regional pipelines) through the installation of new feeder pipelines. It is assumed that one pipeline and ROW would serve each project. It is assumed that the pipeline ROW would be 55 mi long, 50 ft wide, with construction impacting an area as wide as 100 ft (equivalent to a disturbed area of

330 acres during operations and 670 acres during construction). The 55-mi distance assumption and 50-ft ROW size represent probable maximum sizes.

Although new transmission lines and pipelines could very likely be utilized by more than one oil shale production facility, the resulting reduction in overall land disturbance is not considered, and as a result, this analysis could overestimate impacts from such infrastructure.

4.1.5 Workforce Operational Details and Employer-Provided Housing

A number of assumptions have been made regarding the workforce, operations schedule, and housing for workers who move into the three-state study area to support future commercial oil shale development. It is assumed that at commercial scale, all projects would operate 24 hours a day, 7 days a week. It is further assumed that about 30% of the construction and operations workers, including those hired directly to work on oil shale projects as well as those hired for jobs indirectly related to the development, would bring families with them, with an average family size of 2.6 (see Section 4.11). Some portion of these incoming people would live in housing provided by the operators. The locations of the employer-provided housing are unknown at this time; however, housing is not expected to be located on public lands. Employer-provided housing would be constructed as needed to house the workforce and also to provide facilities and infrastructure (e.g., groceries, basic medical care, schools, and recreation). A density of 35 people per acre is assumed for this employer-provided housing.

The BLM has made state-specific assumptions regarding what percentage of the workers and their families would be housed in employer-provided housing, as opposed to those that would move into existing communities. Section 4.11 provides a more detailed discussion of these and related assumptions. Table 4.1.5-1 provides estimates of the number of people that would be housed in local communities versus employer-provided housing, and the number of acres that would be required to support the employer-provided housing by technology.

4.1.6 Expansion of Electricity-Generating Capacity

Additional power generation capacity would need to be developed in the region to support commercial oil shale development; however, at this time, definitive information about the power requirements of commercial oil shale development is not available. Nonetheless, some general observations can be made: power needs would vary by phase of development (pilot-scale versus commercial-scale); power needs would vary by technology, even between the different in situ technologies being evaluated; and the in situ processes that use nonelectric heating technologies would use less power than those that rely on electricity for heating the shale. To meet these additional power needs, it is assumed that existing capacity would be expanded through a combination of construction of new power plants and expansion of existing power plants.

TABLE 4.1.5-1 Estimated Housing Distribution of Incoming People and Acres Impacted by Employer-Provided Housing for the Construction and Operations Phases of Commercial Oil Shale Development

	Construction	Operations
Surface mine with surface retort (50,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	1,800–2,100	1,100–1,800
Local communities	1,200–1,500	2,600–3,400
Maximum size of employer-provided housing (acres)[b]	51–60	31–51
Underground mine with surface retort (50,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	1,500–2,100	900–1,800
Local communities	1,200–2,400	2,600–4,100
Maximum size of employer-provided housing (acres)[b]	43–60	26–51
In situ projects (200,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	1,500–2,200	250–470
Local communities	1,300–2,800	700–1,200
Maximum size of employer-provided housing (acres)[b]	43–63	7–13

[a] The total population, including families, was calculated on the basis of the total number of new direct and indirect workers that would move into the three-state study area, assuming that 30% of them bring families with an average family size of 2.6 people. The ranges for employment numbers take into consideration state-specific conditions; the methodology is discussed in Section 4.11 and Appendix G.

[b] These estimates are based on an assumed density of 35 people per acre for employer-provided housing. This acreage is not expected to be on public lands.

For the purposes of analysis in this PEIS, the BLM has assumed that future in situ projects would require 2,400 MW of additional electricity generation capacity when commercial production levels are reached. This estimate is based in part on published information indicating that the Shell in situ technologies being evaluated as part of the oil shale RD&D program require about 1,200 MW of power for every 100,000 bbl of shale oil produced (Bartis et al. 2005). The BLM has projected that this new electricity capacity would be provided by conventional coal-fired plants. As noted above, in situ processes that use nonelectric heating technologies would use less power. For surface and underground mining projects, the BLM has assumed that power needs would be met through the expansion of existing power plants. Other types of electrical generation might be used, including natural gas, nuclear, and renewable energy, but for the purposes of this PEIS, coal is assumed to be the fuel to avoid underestimating the impacts.

Information on assumptions and impact-producing factors for a 1,500-MW coal-fired power plant is available (BLM 2007a; Thompson 2006c). Table 4.1.6-1 summarizes these assumptions and provides extrapolated values for a 2,400-MW power plant.

TABLE 4.1.6-1 Assumptions Associated with a 1,500-MW and a 2,400-MW Conventional Coal-Fired Electric Power Plant

Impact-Producing Factor	Value Used in Impact Analysis for a 1,500-MW Plant[a]	Value Used in Impact Analysis for a 2,400-MW Plant[b]
Land use (acres)	3,000 total (includes construction acreage)	4,800
Water use (ac-ft/yr)	8,000 ac-ft/yr	13,000
Employment (direct full-time equivalents)	Construction: 1,200–1,500; Operations: 150	Construction: 1,900–2,400; Operations: 240

[a] BLM (2007a).

[b] Values for 2,400-MW power plant extrapolated from values for 1,500-MW plant.

4.1.7 Refining Needs for Oil Shale Development Projects

Factors that would likely impact the incorporation of oil shale into the refinery market are discussed in Attachment A1 to Appendix A of this PEIS. This attachment specifically examines the anticipated refinery market response to potential oil shale production over the 20-year time frame assessed in this PEIS. It provides a brief overview of the U.S. petroleum refinery market and identifies some of the major factors that would influence decisions regarding construction or expansion of refineries and displacement of comparable volumes of crude.

During the initial period of oil shale development, when only pilot-scale production is anticipated, all product generated by oil shale projects would be transported to existing refineries located outside the study area via pipeline or tanker truck.

Refinery market development for the oil shale product is likely to occur in three phases: Phase 1, early adoption and local market penetration within the Rocky Mountain Region; Phase 2, market expansion outside of the Rocky Mountain Region (Petroleum Administration for Defense District) with increased logistical capability; and Phase 3, high-volume production and multimarket penetration of a mature shale oil industry. Phase 1 may be projected to occur during the first 5 years of commercial development of a facility. If approximately 1,000,000 bbl/day of oil shale were produced in Colorado during this time, that shale oil supply would be placed into a refinery market that already is experiencing excess domestic production. Transportation capacity would be the limiting factor during this phase. It is likely that the crude shale oil would only replace existing sources of crude of comparable quality, and that there would be construction of new crude pipelines in the Rocky Mountain refining region.

Phase 2, market expansion, is likely to involve an expansion of the crude oil transportation network to allow distribution of the crude shale oil outside the Rocky Mountain refining region. The most likely markets are the Midwest and the Gulf Coast refining markets.

New market penetration would require displacement of alternative sources of crude. There could be some expansion at existing refineries. It is unlikely that new refineries would be constructed.

During Phase 3, assuming large volumes of crude shale oil would be produced (approximately 2 million bbl/day), the shale oil would break into every U.S. refining market. By this time, it is reasonable to expect that West Coast refineries that have been utilizing Alaskan North Slope crude would be searching for alternative sources of supply, which could bring these refineries into the shale oil market equation. These West Coast refineries, and also Midwest refineries, would likely accept shale oil at that time, so there would not be a need for additional refinery capacity. Therefore, development of additional refinery capacity is not considered to be necessary as a result of oil shale development and is not considered further in this PEIS.

4.1.8 Additional Considerations and Time Lines

The above assumptions broadly describe the impact-producing factors for commercial oil shale development. Within these general facility descriptions, many permutations are possible. For example, various surface retort designs exist, each with its own unique set of environmental impacts and resource demands. In addition, indirect impacts may occur. For example, there may be a need for major upgrades to existing road systems; the magnitude of this impact, however, would depend upon project site locations. A detailed definition of each possible permutation and a subsequent analysis of its impacts would be impractical and speculative, because there is no way to identify the precise development schemes that may be proposed by future developers. Furthermore, while it is likely that commercial development would be accompanied by the centralization or consolidation of some services (e.g., product storage, waste management, and equipment maintenance), it is not possible at this time to predict how this would evolve. This PEIS, therefore, provides an analysis of the range of impacts from each of the major technologies that might be deployed in the future, along with an analysis of the supporting services that would be required by each technology, but it does not analyze specific facility configurations or technology combinations. Efficiencies and economies that would be realized from integrated systems or centralized services are not considered. As a result, outcomes from this analysis could inadvertently overstate some impacts, especially if the resulting impacts are added together to accommodate multiple projects.

Although there are many unknowns with respect to time lines for construction and operations of commercial-scale shale oil production facilities, in general, it can be assumed that projects using in situ technologies would require about 3 years of construction and permitting before pilot testing; that pilot testing would last 6 years; and that additional construction to scale up to commercial levels would take 2 more years. It can be assumed that the permitting and construction phases for both surface and underground mines would take longer than such phases for in situ projects, such that construction and permitting before pilot testing would take about 7 years, that pilot testing would last 6 years, and that permitting and construction to scale up to commercial levels would take 5 more years. For all commercial oil shale projects, regardless of the technologies used, it can be assumed that maximum production levels would be reached after 3 to 5 years of commercial operations.

4.2 LAND USE

4.2.1 Common Impacts

As discussed in Section 3.1, lands within the three-state study area where commercial oil shale development might occur are currently used for a wide variety of activities, including recreation, mining, hunting, oil and gas production, livestock grazing, wild horse and burro herd management, communication sites, and ROW corridors (e.g., roads, pipelines, and transmission lines). Commercial oil shale development activities could have a direct effect on these uses, displacing them from areas being developed to process oil shale. Likewise, currently established uses may also prevent or modify oil shale development. Valid existing rights represented by existing permits or leases may convey superior rights to the use of public lands, depending upon the terms of the permits or leases.

Indirect impacts of oil shale development would be associated with changing existing off-lease land uses, including conversion of land in and around local communities from existing agricultural, open space, or other uses to provide services and housing for employees and families that move to the region in support of commercial oil shale development. Increases in traffic, increased access to previously remote areas, and development of oil shale facilities in currently undeveloped areas would continue changing the overall character of the landscape, which has already begun as a result of oil and gas development. The value of private ranches and residences in the area affected by oil shale developments or associated ROWs either may be reduced because of perceived noise, human health, or aesthetic concerns, or may be increased by additional demand.

FLPMA directs the BLM to manage public lands for multiple use, and as a multiple-use agency, the BLM is required to implement laws, regulations, and policies for many different and often competing land uses and to resolve conflicts and prescribe land uses through its land use plans. FLPMA makes it clear that the term "multiple use" means that not every use is appropriate for every acre of public land and that the Secretary can "…make the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use. . . ." [FLPMA, Section 103(c) (43 USC §1702(c)]. Like hunting, grazing, oil and gas development, and recreation, commercial oil shale operations are statutorily authorized uses of BLM lands. The BLM is aware that not all authorized uses can occur on the same lands at the same time; conflicts among resource uses are not new, and this PEIS is not intended to solve all potential conflicts involving oil shale leasing. The intent of FLPMA is for the Secretary of the Interior to use land use planning as a mechanism for allocating resource use, including energy and mineral development, as well as conserving and protecting other resource values for current and future generations. Future decisions regarding oil shale leasing and approval of operating permits will be informed by NEPA analysis of the conflicting or alternative land uses of individual areas.

Although transmission and pipeline ROWs associated with commercial oil shale development would not necessarily preclude other land uses, they would result in both direct and indirect impacts. Direct impacts (e.g., the loss of available lands to physical structures, maintenance of ROWs free of major vegetation, maintenance of service roads, and noise and visual impacts on recreational users along the ROW) would last as long as the transmission lines and pipelines were in place. Indirect impacts, such as the introduction of or increase in recreational use to the area due to improved access, avoidance of the area adjacent to public lands for residential or recreational use for aesthetic reasons, and increased traffic, could occur and be long term.

The specific impacts on land use, and their magnitude, would depend on project location; project size and scale of operations; proximity to roads, transmission lines, and pipelines; and development technology. The following sections discuss the common impacts on different types of land uses and potential mitigation measures that may be applicable on a site-by-site basis.

4.2.1.1 Other Mineral Development Activities

A significant portion of the land within the most geologically prospective oil shale areas is already undergoing mineral development, particularly for the development of oil and gas resources. Commercial oil shale development, using any technology under consideration in this PEIS, is largely incompatible with other mineral development activities and would likely preclude these other activities while oil shale development and production are ongoing. Areas with oil shale resources where there are existing oil and gas or other mineral leases may be precluded from development, since currently, with some exceptions, the leases that are first in time have priority.

An exception to this is that for oil and gas leases issued in the oil shale areas of Colorado, Utah, and Wyoming, between 1968 and 1989, there are four stipulations attached to these leases that state: (1) no wells will be drilled for oil or gas except upon the approval of the authorized officer, it being understood that drilling will be permitted only in the event that it is established to the satisfaction of the authorized officer that such drilling will not interfere with the mining and recovery of oil shale deposits or the extraction of oil shale by in situ methods or that the interest of the United States would be best served by; (2) no wells will be drilled for oil or gas at a location, which in the opinion of the authorized officer, would result in undue waste of oil shale deposits or constitute a hazard to or unduly interfere with mining or other operations being conducted for the mining and recovery of oil shale deposits or the extraction of oil shale by in situ methods; (3) when it is determined by the authorized officer that unitization is necessary for orderly oil and gas development and proper protection of oil shale deposits, no well shall be drilled for oil or gas except pursuant to an approved unit plan; and (4) the drilling or abandonment of any well on this lease shall be done in accordance with applicable oil and gas operating regulations, including such requirements as the authorized officer may prescribe as necessary to prevent the infiltration of oil, gas, or water into formations containing oil shale deposits or into mines or workings being utilized in the extraction of such deposits. For purposes of this directive, the oil shale areas of Colorado, Wyoming, and Utah are defined as those lands withdrawn by E.O. 5327 of April 15, 1930 (U.S. President 1930). Where these oil shale stipulations do not exist in oil and gas leases, without some accommodation being made between oil shale developers and prior leases holders, oil shale development may not be able to proceed.

It is the BLM's policy to optimize the recovery of both resources in an endeavor to secure the maximum return to the public in revenue and energy production; prevent avoidable waste of the public's resources utilizing authority under existing statutes, regulations, and lease terms; honor the rights of each lessee, subject to the terms of the lease and sound principles of resource conservation; and protect public health and safety and mitigate environmental impacts. Conflicts among competing mineral resource uses would be resolved in the future at the leasing or plan of development stages.

While it is possible that undeveloped portions of an oil shale lease area could be available for other mineral development, such development would be unlikely to occur on a widespread basis, except possibly in areas where a single company was developing multiple resources. Similarly, it is possible that oil shale extraction technologies could evolve to a point where other mineral development activities could be conducted simultaneously; however, predicting how that would translate into land use impacts is not possible at this time.

Overall, it is BLM policy to optimize the recovery of all public mineral resources, where they occur together or in close proximity, to secure the maximum return to the public in revenue and mineral production; to prevent avoidable waste of the public's resources utilizing authority under existing statutes, regulations, and lease terms; to honor the rights of each lessee, subject to the terms of the lease and sound principles of resource conservation; and to protect public health and safety and mitigate environmental impacts. Accordingly, as discussed in Section 2.3.3, the BLM has determined that it will carry forward decisions in the White River RMP (BLM 1997a) establishing the Multimineral Zone within which mineral development would be allowed, only if recovery technologies are implemented to ensure that the development of one mineral does not prevent recovery of other minerals (see Section 3.1.1.3 and Figure 3.1.1-3). As a result, impacts on nahcolite and dawsonite development are expected to be negligible within the Multimineral Zone. The BLM also has determined that it will not carry forward decisions in the White River RMP to restrict oil shale leasing from the Piceance Creek Dome area. By making lands within the Piceance Creek Dome area available for application for commercial leasing, potential conflict between oil shale and oil and gas development could occur.

The authorization of ROWs for connecting transmission lines and oil pipelines would result in fewer impacts on other mineral development activities than would commercial oil shale development projects. It is assumed that ROWs serving oil shale development could be located in a manner that would largely avoid impacts on other mineral development activities by avoiding areas of mineral development or by being co-located in a manner that is consistent with planned resource development.

4.2.1.2 Acquisition, Conversion, or Transfer of Water Rights

Demand for reliable, long-term water supplies to support oil shale development could lead to the acquisition of unallocated water supplies (depending on availability) or to conversion of existing water rights from current uses. Water would be needed to support direct oil shale operations and to support both additional population and potential power plant operation. In the Piceance Basin, there has already been acquisition of agricultural water rights by oil shale development companies. While it is not presently known how much surface water will be needed to support future development of an oil shale industry, or the role that groundwater would play in future development, it is likely that additional agricultural water rights could be acquired. Depending on the locations and magnitude of such acquisitions, there could be a noticeable reduction in local agricultural production and land use when the water is eventually converted to supporting oil shale development.

4.2.1.3 Grazing Activities

Grazing activities would be precluded by commercial oil shale development in those portions of the lease area that were (1) undergoing active development; (2) in preparation for a future development phase; (3) undergoing restoration after development; or (4) occupied by long-term surface facilities, such as office buildings, laboratories, retorts, and parking lots. Grazing might be possible in the remaining undeveloped portions of the lease area or on portions that were successfully restored after development. On the basis of assumptions discussed above regarding the amount of land that would be disturbed at any given time for different technologies, it is possible that 3,120 to 4,970 acres within a 5,760-acre lease area would remain available for grazing. Depending on conditions unique to the individual grazing allotment, temporary or long-term reductions in authorized grazing use may be necessary because of loss of a portion of the forage base.

Once established, transmission line and pipeline ROWs would not prevent use of the land for grazing other than the areas physically occupied by aboveground facilities. The establishment of employer-provided housing might preclude grazing activities, depending upon how the housing is developed and the location, although this development is not expected to occur on public lands. Construction of new power plants or expansion of existing ones would likely preclude grazing on lands within the 4,800-acre development footprint, although this development is also not expected to occur on public lands.

4.2.1.4 Recreational Use

Commercial oil shale development activities are largely incompatible with recreational land use (e.g., hiking, biking, fishing, hunting, bird watching, OHV use, and camping). As discussed in Section 4.2.1.3 regarding grazing activities, recreational land use could be precluded from those portions of the lease area, depending on the technology employed. While recreational use could be possible in undeveloped or restored portions of a lease area, the amount of land that would be available would vary from project to project. The change in the overall character of the undeveloped BLM-administered lands to a more industrialized, developed area would displace people seeking more primitive surroundings in which to hunt, camp, ride OHVs, etc. Many BLM field offices have designated lands as open, closed, or available for limited OHV use. Areas that would be open to application for commercial oil shale development may be currently available for some level of OHV use, and commercial oil shale development in these areas could displace this use. Even if access could be granted to portions of the lease area for recreational use, visitors might find the recreational experience to be compromised by the nearby development activities. Such impacts could also occur on recreational users of adjacent, off-lease lands. In addition, impacts on vegetation, development of roads, and displacement of big game could degrade the recreational experiences and hunting opportunities near commercial oil shale projects. To the extent that commercial developments might be clustered together (e.g., possibly in the Piceance Basin), the effect on recreation uses would be magnified by changing the overall character of a larger area and by dominating a larger portion of the landscape.

Once established, transmission line and pipeline ROWs would present fewer impacts on recreation users than would the actual commercial development projects. Access to the land in the ROWs would not be precluded; however, depending on the type of recreation, the overall recreational experience could be adversely affected by the visual disturbance to the landscape and potential noise impacts associated with overhead transmission lines. The establishment of employer-provided housing, although not likely to be located on public lands, would preclude recreational land use and might cause indirect impacts on recreational land use on adjacent lands, depending upon how the housing is developed and the location. Construction of new power plants, although this development also is not likely to occur on public lands, or expansion of existing plants would likely preclude recreational use on lands within the 4,800-acre plant footprint and may displace recreation uses on adjacent lands.

4.2.1.5 Specially Designated Areas, Potential ACECs (in Utah), and Areas with Wilderness Characteristics

As discussed in Section 1.2, the BLM has determined that certain designated areas are excluded from commercial oil shale leasing. These areas include all designated Wilderness Areas, WSAs, other areas that are part of the NLCS (e.g., National Monuments, NCAs, WSRs, and National Historic and Scenic Trails), and existing ACECs that are closed to mineral development. Because of these exclusions, these designated areas would not incur direct impacts associated with commercial oil shale development. They might, however, incur indirect impacts (e.g., dust and degraded viewshed) resulting from commercial oil shale development on adjacent lands or areas within the general vicinity. Section 4.9 discusses impacts on visual resources in greater detail.

Existing ACECs that are not closed to mineral development and potential ACECs that are currently under consideration for designation as part of ongoing land use planning efforts would be available for application for commercial leasing in the future. See Section 1.4.3 for a discussion of ongoing BLM planning activities. Decisions regarding either designating potential ACECs or committing the areas to other uses would be made by local BLM field offices utilizing the BLM planning process and NEPA analyses.

Another category of lands available for application for commercial leasing in the future are those that have been recognized by the BLM as having one or more wilderness characteristics, yet are not eligible for formal recognition as a WSA. Lands that have been identified in this manner by the BLM are discussed in Section 3.1. Commercial oil shale development activities and the development of transmission line and pipeline ROWs within these areas would cause a loss of the wilderness characteristics in and around the disturbed areas. Decisions regarding either the protection and management of these wilderness characteristic areas or committing the areas to other uses would be made by local BLM field offices utilizing the BLM planning process and NEPA analyses.

All specially designated areas, potential ACECs, and areas with wilderness characteristics that are located in the vicinity of the most geologically prospective oil shale areas evaluated in this PEIS are identified in Section 3.1.

4.2.1.6 Wild Horse and Burro Herd Management Areas

As discussed in Section 3.1.1, the most geologically prospective oil shale resources evaluated in this PEIS coincide with a number of designated Wild Horse HMAs; they do not coincide with any Wild Burro HMAs. Specifically, the following HMAs overlie the oil shale resources: the Piceance–East Douglas Creek HMA in the White River Field Office, Colorado; the Hill Creek HMA in the Vernal Field Office, Utah; and the Adobe Town, Little Colorado, Salt Wells Creek, and White Mountain HMAs in the Rawlins and Rock Springs Field Offices, Wyoming. At least some portion of each of these HMAs coincides with lands proposed to be available for application for leasing under the oil shale alternatives.

As discussed in Section 4.2.1.3 regarding grazing activities, the management of wild horse herds is not compatible within those portions of commercial oil shale lease areas that are (1) undergoing active development; (2) in preparation for a future development phase; (3) undergoing restoration after development; or (4) occupied by long-term surface facilities, such as office buildings, laboratories, retorts, and parking lots. Animals would likely be displaced from the areas of commercial development, and, depending upon the conditions in the individual HMA, it might be necessary to reduce herd numbers to match forage availability on the undisturbed portion(s) of the HMA. If horses emigrate out of HMA boundaries because of the disturbance within the HMA, they could be removed via the capture and adoption program. Transmission line and pipeline facilities would not prevent use of the land by horses or burros other than in the areas physically occupied by aboveground facilities, although they could be subject to disturbance or harassment from people using the ROWs for access. For more information about impacts on wild horses, see Section 4.8.1.3 and Table 4.8.1-3.

4.2.1.7 Different Oil Shale Development Technologies

For the most part, impacts on land use would be the same regardless of the development technology used. There are a few exceptions, as follows:

- In situ technologies would not generate spent shale and other waste rock (e.g., overburden) for disposal. Spent shale would be generated by retorting of mined oil shale. The volume of spent shale could be very significant. Spent shale would be disposed of on the lease area as approved by the BLM. Additional lands beyond the mine footprint could be disturbed for spent shale disposal. Following successful reclamation, these additional lands could be largely available for other land uses again.

- Underground mines would require fewer acres of surface disturbance than surface mines. To some degree, they might also impact fewer surface acres than in situ projects. The amount of surface disturbance will depend on the technology employed, the characteristics of the project site, and the approved plan of development.

4.2.2 Mitigation Measures

The direct and indirect impacts on land use described above could be mitigated to some extent by a number of actions, including in some instances application of specific engineering practices. The effectiveness of these potential mitigation measures and the extent to which they are applicable would vary from project to project and need to be examined in detail in future NEPA reviews of leasing and project plans of development. Potential mitigation measures include the following:

- Consulting with federal and state agencies, property owners, and other stakeholders as early as possible in the planning process to identify potentially significant land uses and issues, rules that govern commercial oil shale development locally, and land use concepts specific to the region;

- During the project design and planning phase, incorporating considerations regarding the use of lands in undeveloped or restored portions of the lease area to maximize their potential for other uses (e.g., grazing, recreational use, or wild horse herd management);

- During the project design and planning phase, incorporating considerations regarding the use of adjacent lands to minimize direct and indirect off-lease land use impacts;

- During the project design and planning phase, providing for consolidation of infrastructure wherever possible to maximize efficient use of the land;

- During the siting, design, and planning phase for employer-provided housing, incorporating considerations regarding the use of adjacent lands to minimize direct and indirect off-lease land use impacts;

- During the siting, design, and planning phase for the construction of additional electricity power generation, providing for consolidation of infrastructure wherever possible and incorporating considerations regarding the use of adjacent lands to minimize direct and indirect off-lease land use impacts; and

- Developing and implementing effective land restoration plans to mitigate long-term land use impacts.

To address more specific impacts on land use, such as impacts on grazing, recreational use, and wild horse herd management, potential mitigation measures also could include the following:

- Coordinating the activities of commercial operators with livestock owners to ensure that impacts on livestock grazing on a portion of a lease area were minimized. Issues that would need to be addressed could include installation of fencing and access control, delineation of open range, traffic management (e.g., vehicle speeds), and location of livestock water sources.

- Coordinating the activities of the commercial operators with the BLM and local authorities to ensure that adequate safety measures (e.g., access control and traffic management) were established for recreational visitors.

- Coordinating the activities of the commercial operators with the BLM to ensure that impacts on the wild horse herds and their management areas were minimized. Issues that would need to be addressed could include installation of fencing and access control, delineation of open range, traffic management (e.g., vehicle speeds), and access to water sources.

4.3 SOIL AND GEOLOGIC RESOURCES

4.3.1 Common Impacts

The potential impacts on soil and geologic resources vary somewhat according to the three different technologies under consideration. There are also some basin-specific impacts. However, many of the impacts are common to each technology and among project phases (construction, operations, and reclamation). Thus, this section discusses the common impacts on soil and geologic resources, including phase-specific impacts within each subsection.

4.3.1.1 Soil Resources

Oil shale operations pose an impact on soil resources. A significant concern is increased soil erosion resulting from ground disturbance. This problem pertains to each technology considered in this PEIS.

Soil erosion by water and wind is common across the four basins. In the Piceance Basin, upland soil is thin and the slopes are high. The soils of relatively flat areas in valleys are also subject to localized erosion. Critically high erosion is prevalent in the Uinta Basin. Cryptobiotic soils are present in some portions of Utah and may be present in the study area. The biological soil crusts serve to reduce wind and water erosion of these soils when intact. The Green River and Washakie Basins have moderate to high erosion, with wind erosion playing a larger role than water erosion because of the arid conditions.

Soil erosion can be increased in areas disturbed through construction activities. The maximum land area that is assumed to be disturbed for oil shale facilities is the entire leased area for surface mines and in situ facilities (up to 5,760 acres), or about 1,650 acres for underground mine facilities. The degree of the impact depends on factors such as soil properties, slope, vegetation, weather, and distance to surface water. Specific activities that could create soil erosion (and possibly increase turbidity in surface water) include removal and stockpiling of overburden for surface mining (and to a lesser extent for subsurface mining); traffic on unpaved roads; vegetation clearing, grading, and contouring that can affect the vegetation, soil structure, and biological crust; and erosional gullies formed on land regraded for in situ work areas, support facilities, roads, etc. The drainage along roads may contribute additional soil erosion as surface runoff is channeled into the drainages. Compaction by vehicles or heavy equipment may reduce infiltration, promote surface runoff, and decrease soil productivity. Wind erosion is enhanced through ground disturbance.

In addition to buildings, construction or installation of other facilities and utilities would require disturbance of soil. These activities would include, but not be limited to, utility tower installation, telephone pole installation, parking area construction, buried utility installation (e.g., water mains, wastewater lines, and electrical or communication cables), drilling for installation of electrical subsurface heating and freeze-wall equipment (for in situ processing), drilling for resource evaluation, and drilling for groundwater monitoring well installation. Some of these activities, such as exploratory drilling and road grading, may also take place during preliminary site assessment.

It is assumed that ROWs for transmission lines would be built to connect new project sites with regional utilities (up to 1,800 acres of longer-term disturbance and 2,700 acres of disturbance during construction; see Section 4.1.4). A pipeline ROW is also assumed to be constructed for each project site (up to 330 acres of longer-term disturbance and 670 acres disturbed during construction). Likewise, newly constructed employer-provided housing would likely be built, with limited longer-term disturbance (see Table 4.1.5-1). The locations of employer-provided housing are unknown at this time; however, housing is not expected to be located on public lands.

Erosion rates are expected to be higher along ROWs and at construction sites, access roads, surface mines, and river banks. Site grading and drainage design would cause changes to local hydrology and may result in increased runoff focused at certain discharge locations. This activity may cause increased erosion in creeks and drainages and on hill slopes, with subsequent increases in downstream sediment loads. Following site construction, soil conditions may stabilize, resulting in reduced erosion and sediment input to surface water. Localized erosion may continue to take place, requiring maintenance and remedial measures.

The pipelines associated with oil shale development include those conveying hydrocarbons extracted from in situ retorting or from surface retorts or upgrading facilities, as well as possible pipelines for water or sanitary waste. Flood events have the potential to cause pipeline breakage and subsequent contamination of surface water.

Soil and geology impacts would differ during oil shale operations depending on the technological approach. All techniques would involve ongoing issues with soil erosion and runoff management in disturbed soil areas (water and wind erosion, rutting, potential salinity impacts, etc.) as described above. The use of pesticides and herbicides and accidental spills or leaks of product, fuels, or chemicals could result in soil contamination. The potential soil contamination would be localized in extent and could be addressed with appropriate remediation measures.

The surface mining approach requires removing and stockpiling the overburden, source rock, and waste rock, thereby creating a potentially large source of sediment and salinity in site runoff. The various stockpiles are also susceptible to wind erosion. No surface mining is anticipated for Colorado. In Utah, 600 to 1,200 acres would be disturbed at any one time during commercial operations producing 50,000 bbl/day, with a total of 5,760 acres potentially disturbed (Table 4.1.1-1). In Wyoming, 1,000 to 2,000 acres would be disturbed at any one time, also with a total of 5,760 acres potentially disturbed. Some of the spent shale could be returned to the mine, but there would be overflow in disposal areas outside of the excavation. Ongoing stabilization of the waste piles would likely be required.

In underground mining, the disturbed soil footprint would be smaller than that for surface mining; source rock stockpiles and spent oil shale piles, however, would occupy a large amount of space and would be sources of sediment and salinity in runoff (total area assumed to be disturbed is 1,650 acres over 20 years; Table 4.1.2-1). Current assumptions regarding spent shale are that from 0 to 30% of the spent material could be returned to the mine for disposal, with the remainder disposed of at the surface. Ongoing stabilization of the waste piles would likely be required.

In situ techniques would result in rolling operations and would result in continuous ground disturbance areas and reclamation areas. In Colorado or Utah, approximately 150 to 600 acres would be disturbed at any one time at a 200,000-bbl/day facility, while in Wyoming, the figure would be approximately 1,000 to 2,000 acres (Table 4.1.3-1). A total of 5,760 acres (5,120 acres for any RD&D projects that go to commercial production) would potentially be disturbed and subject to erosion and sediment runoff, although various approaches and technologies could result in a smaller disturbed area.

During reclamation, potential geologic and soil impacts would be similar to those of the construction phase. The replacement of stockpiled topsoil on former work or support areas, roads, or in reclaimed surface mines would require time to reestablish with stabilizing vegetation and may be a source of erodible material, depending on factors such as slope and weather conditions. Monitoring of soil reclamation areas for erosion and ecology are also part of a reclamation phase (DOI and USDA 2006).

A key concern for impacts on soil is the associated impact on water quality. As discussed in Section 4.5, soil erosion increases both the sediment load to streams and the salinity of runoff reaching these streams. The sensitivity of the surface water throughout the PEIS study area causes soil management to be a key factor in environmentally acceptable energy development. Infiltration of precipitation through stockpiled oil shale or through waste piles of spent material has the potential of impacting surface water or shallow aquifers with leached hydrocarbons and salts.

4.3.1.2 Geologic Resources

Oil shale development could have an impact on other geologic resources, including the loss of these resources. Various geologic resources are present in the four oil shale basins. Sand and gravel and crushed stone supplies are widespread throughout the study areas, and their use at project sites (for construction, fill, etc.) would not be expected to impact their availability.

Halite, dawsonite, and nahcolite are distributed within the Piceance Basin. They are associated with the Green River Formation and occur at thicknesses and proportions that vary depending on location and depth. The central Piceance Basin contains an area known as the Multimineral Zone, within which oil shale, nahcolite, and dawsonite cannot be developed without the loss of one of the others. A designated KSLA surrounds the Multimineral Zone. Oil, natural gas, and coal are also present. In the Uinta Basin, the oil shale extends into two STSAs. Gilsonite, oil, and gas are also present. The Green River Basin contains trona and halite, and the MMTA is off-limits to oil shale development. Oil, gas, and coal are also present. Little or no economic geologic resources other than oil shale are available in the Washakie Basin.

4.3.2 Mitigation Measures

Various mitigation measures may be taken to reduce the impact of oil shale activities on soil and geologic resources during construction, operations, and reclamation and could include the following. The subsequent effects on water quality may therefore be reduced (see Section 4.5).

- Guidance, recommendations, and requirements related to management practices are described in detail in the BLM Solid Minerals Reclamation Handbook (BLM 1992), the BLM Gold Book (DOI and USDA 2006), BLM pipeline crossing guidance (Fogg and Hadley 2007), and in BLM field office RMPs. These actions include, but are not limited to, minimizing the amount of disturbed land; stockpiling topsoil prior to construction or regrading; mulching and seeding in disturbed areas; covering loose materials with geotextiles; using silt fences to reduce sediment loading to surface water; using check dams to minimize the erosive power of drainages or creeks; and installing proper culvert outlets to minimize erosion in creeks.

- Surface pipeline crossings must be constructed above the highest anticipated flood stage, and subsurface crossings must be installed below the scouring depth. The BLM (Fogg and Hadley 2007) provides guidance on hydraulic analysis necessary for proper design of pipeline crossings.

- Mapping of highly erosive soils and soils of high salt content should be performed in proposed project areas and their connecting roads, so that site-specific information can be used to guide project planning. A proper road grading analysis should be performed to reduce the potential for problems such as erosion or cut slope failure (DOI and USDA 2006).

- The revegetation and restoration potential of soil, as with many other soil factors described previously, is site-specific and would be addressed in a project-level NEPA analysis. Mitigation measures involving soil erosion control, stabilization, and reseeding would limit the impact of soil erosion.

- Stockpiling of topsoil prior to the construction of roads, parking areas, buildings, work areas, or surface mining is a practice that should aid reclamation efforts following the completion of work activities in a certain area. During restoration, replacement of the stockpiled topsoil would aid in a return to somewhat natural conditions for local vegetation.

- Detailed geotechnical analyses would be required to address stability of quarry walls, underground mines, and stability of slopes, including assessment of slope cuts and the creation of roads or work areas.

- Literature and field studies focused on the basin's surrounding region should be undertaken to assess faulting and earthquake potential.

4.4 PALEONTOLOGICAL RESOURCES

4.4.1 Common Impacts

Significant paleontological resources could be affected by commercial oil shale development. The potential for impacts on paleontological resources from commercial oil shale development, including ancillary facilities such as access roads, transmission lines, pipelines, and employer-provided housing, and from construction of possible new power plants, is directly related to the amount of land disturbance and the location of the project. Indirect effects, such as impacts resulting from the erosion of disturbed land surfaces and from increased accessibility to possible site locations, are also considered.

Impacts on paleontological resources could result in several ways as described below.

- Complete destruction of the resource could result from the clearing of the project area; grading, excavation, and construction of facilities and associated infrastructure; and extraction of the oil shale resource, if paleontological resources are located within the development area.

- Degradation and/or destruction of near-surface resources could result from the alteration of topography; alteration of hydrologic patterns; removal of soils; erosion of soils; runoff into and sedimentation of adjacent areas; and oil or other contaminant spills if near-surface paleontological resources are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively impact near-surface paleontological localities downstream of the project area by potentially eroding away materials and portions of sites, the accumulation of sediment could serve to protect some localities by increasing the amount of protective cover. Agents of erosion and sedimentation include wind, water, ice, downslope movements, and both human and wildlife activities.

- Increases in human access and subsequent disturbance (e.g., looting and vandalism) of near-surface paleontological resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes paleontological sites to a greater probability of impact from a variety of stressors.

Paleontological resources are nonrenewable, and, once damaged or destroyed, they cannot be recovered. Therefore, if a paleontological resource is damaged or destroyed during oil shale development, it would constitute an irretrievable commitment of this scientific specimen. Data recovery and resource removal are ways in which at least some information can be salvaged should a paleontological site be developed, but certain contextual data are invariably lost. The discovery of otherwise unknown fossils would be beneficial to the scientific community, even if such resources are ultimately lost, but only as long as sufficient data can be recorded prior to destruction or loss.

4.4.2 Mitigation Measures

For all potential impacts, the application of mitigation measures developed in consultation with the BLM could reduce or eliminate (if avoidance of the resource is chosen) the potential for adverse impacts on significant paleontological resources. Consultations between the operator and the BLM would be required for all projects before lease areas could be developed. The use of BMPs, such as training/education programs to reduce the amount of inadvertent destruction to paleontological sites, could also reduce the occurrences of human-related disturbances to nearby sites. The specifics of these BMPs would be established in project-specific consultations between the operator and the BLM.

A paleontological overview was completed for the project area (Murphey and Daitch 2007). The overview synthesized existing information and generated maps showing areas with the PFYC and paleontological condition. This phase of the analysis did not identify geographical areas that would preclude moving areas forward for leasing. During the leasing phase, the overview will be reviewed to help determine areas of sensitivity and appropriate survey and mitigation needs.

Mitigation measures to reduce impacts on paleontological resources will be required and could include the following:

- The sedimentary context of the project area and its potential to contain paleontological resources would be identified prior to development in consultation with the BLM. A records search of published and unpublished literature may be required for past paleontological finds in the area. Paleontological researchers working locally in potentially affected geographic areas and rock units may be consulted in order to obtain invaluable information and insights that should be taken into account when considering alternative actions and developing mitigation strategies. Depending on the extent of paleontological information, the BLM may require completion of a paleontological survey. If paleontological resources are present at the site, or if areas with a high potential to contain paleontological material have been identified, the development of a paleontological resources management plan may be required to define required mitigation measures (i.e., avoidance, removal, and monitoring) and the curation of any collected fossils.

- If an area has a high potential but no fossils are observed during survey, monitoring by a qualified paleontologist may be required during all excavation and earthmoving in the area. Monitoring of high-potential areas during earthmoving activities would be conducted by a professional paleontologist, when required by the BLM. Development of a monitoring plan is recommended. An exception may be authorized by the BLM.

- If fossils are discovered during construction, the BLM will be notified immediately. If feasible (i.e., when safe to do so), work will be halted at the fossil site and continued elsewhere until a qualified paleontologist can visit the site and make site-specific recommendations for collection or (other) resource protection.

If these types of mitigation measures are implemented during the initial project design and planning phases and are adhered to throughout the course of development, the potential impacts on paleontological resources discussed under the common impacts section would be mitigated to the fullest extent possible. Adopting this approach does not mean that there would be no impacts on paleontological resources. The exact nature and magnitude of the impacts would vary from project to project and would need to be examined in detail in future NEPA reviews of lease areas and project plans of development.

4.5 WATER RESOURCES

4.5.1 Common Impacts

In general, the impacts on water resources from oil shale development can be attributed to the interdependent factors of ground surface disturbance, water withdrawal and use, wastewater disposal, alteration of hydrologic flow systems for both surface water and groundwater, and the interaction between groundwater and surface water. In addition, the locations where oil shale development may occur may not match the locations where water supplies are available. This last issue might require development of new infrastructure for water transport and water storage, which would cause additional adverse environmental impacts on water resources.

Common impacts could include:

- Degradation of surface water quality caused by increased sediment load or contaminated runoff from project sites;
- Surface disturbance that may alter natural drainages by both diverting and concentrating natural runoff;
- Surface disturbance that becomes a nonpoint source of sediment and dissolved salt to surface water bodies;
- Withdrawal of water from a surface water body that reduces its flow and degrades the water quality of the stream downgradient from the point of the withdrawal;
- Withdrawals of groundwater from a shallow aquifer that produce a cone of depression and reduce groundwater discharge to surface water bodies or to the springs or seeps that are hydrologically connected to the groundwater;
- Accidental chemical spills or product spills and/or leakages could potentially contaminate surface water and/or groundwater.
- Construction of reservoirs that might alter natural streamflow patterns, alter local fisheries, increase salt loading, cause changes in stream profiles downstream, reduce natural sediment transport mechanisms, and increase evapotranspiration losses;
- Discharged water from a project site that could have a lower water quality than the intake water that is brought to a site;
- Spent shale piles and mine tailings that might be sources of contamination for salts, metals, and hydrocarbons for both surface and groundwater;
- Degradation of groundwater quality resulting from injection of lower quality water; from contributions of residual hydrocarbons or chemicals from retorted zones after recovery operations have ceased; and, from spent shales replaced in either surface or underground mines;

- Reduction or loss of flow in domestic water wells from dewatering operations or from production of water for industrial uses; and
- Dewatering operations of a mine, or dewatering through wells that penetrate multiple aquifers, that could reduce groundwater discharge to seeps, springs, or surface water bodies if the surface water and the groundwater are connected.

The following sections place these common impacts in the context of specific operating parameters and also show that many of the impacts are interconnected to the multiple activities that could occur in a single operation. Indeed, it is necessary to understand the context of each of the above summary findings to clearly understand the impact dynamics and the rationale behind the mitigative measures that follow the impact analysis.

4.5.1.1 Ground Surface Disturbance

It is assumed that surface mine with surface retort facilities and in situ facilities could have ground disturbance over their entire lease areas (up to 5,760 acres). Underground mine with surface retort facilities are assumed to involve somewhat less ground disturbance (up to about 1,650 acres). Any of the technologies would have associated additional off-lease disturbance for transmission lines, pipelines, employee housing, and possibly new power plants (see Section 4.1 for details on ground disturbance assumptions).

Ground surface disturbance would tend to degrade surface water quality and increase streamflow in areas downstream of development sites. Disturbance caused by a wide array of activities (e.g., access roads, building construction, spoil disposal piles, mining or other recovery operations, power line construction) would expose fresh soil to intensified surface runoff caused by precipitation as well as to wind erosion leading to increases in sediment and salt contributions to streams. The flow of streams downstream of disturbed areas would increase before the areas are stabilized.

Surface mines associated with production of oil shale would have the potential to alter natural drainages by both diverting and concentrating natural runoff. Downstream areas would be altered as a result of these actions. Depending on the construction of the mine and the ability to return spent shale from retort operations back into the excavation, additional surface disturbance associated with spent shale disposal would also occur that would have the potential to have impacts downstream.

Underground mines, while having a much smaller amount of surface disturbance associated with actual mining operations, would have a relatively larger amount of surface disturbance associated with the disposal of spent shale. Until successfully revegetated, these spent shale areas could contribute to increased runoff; be a source of contamination for salts, metals, and hydrocarbons; and would be exposed to wind erosion. Depending on the placement of the disposal areas, disruption of natural drainage patterns through diversion and concentration of flow may also occur. Such alteration and diversion could change the streamflow downstream of a project site.

Because of the uncertainty of the size of the blocks of land that would be disturbed at any one time to support in situ production, and the unknown length of time between disturbance and reclamation of production areas, the effect of this technology on surface drainage is not yet known. Of the various types of in situ technologies, it is not yet known if there will be any difference in surface disturbance or effects on surface drainage between the various in situ technologies.

Disturbed areas can become nonpoint sources of sediment and dissolved salt to surface water bodies. Airborne dust is expected to increase as a result of surface disturbance, processing and mining operations, and vehicle traffic. Because high salt content in soils is common in arid and semiarid environments, salt could be transported by wind and surface runoff from disturbed areas, even with the use of mitigation during site preparation. The impact would be larger during the construction and reclamation phases than during the operational phase of projects, when some sort of process to stabilize sites can be expected to be employed. The level of impact would decrease with time as the disturbed areas are reclaimed and stabilized with protective vegetation or other measures. The intensity of the impact would decrease with increasing distance between the disturbed areas and surface water bodies.

4.5.1.2 Water Use

Water uses in both surface mine with surface retort and underground mine with surface retort projects could include water for mining and drilling operations; cooling of equipment; transport of ore and processed shale; dust control for mines, crushers, overburden and source rock storage piles, and retort ash piles; cooling of spent shale exiting the retort; wetting of spent shale prior to disposal; fire control for the mine and industrial area; irrigation for revegetation; and sanitary and potable uses. Additional water uses required for in situ projects include water for hydrofracturing, steam generation, water flooding, quenching of kerogen products at producer holes, cooling of productive zones in the subsurface, cooling of equipment, and rinsing of oil shale after the extraction cycle. Depending on the quality of the shale oil produced directly from in situ processes, water may be required for additional processing of the product at the surface.

A large amount of water is required during the operations phase. Because of the uncertainty in process water requirements, this assessment assumes that 2.6 to 4.0 bbl of water could be required for each barrel of shale oil produced for surface mine with surface retort and underground mine with surface retort projects, and that 1 to 3 bbl of water could be required for each barrel produced for in situ projects (see Section 4.1). Surface mine or underground mine with surface retort plants with capacities of 18 million bbl/yr (or 50,000 bbl/day) could consume 6,100 to 9,400 ac-ft of water per year. Depending on availability and quality, water may be obtained from major streams, groundwater, or reservoirs. A major portion of the water may be lost in cooling towers and evaporation and must be replaced on an ongoing basis.

At power plants that may be constructed to meet the energy demands of oil shale facilities, water is required for steam generation, scrubber operation, cooling, and dust control. In a refinery, water is primarily used for steam, cooling the scrubber, and other refinery processes. Water is lost through various processes and needs to be replenished. Water is also needed for sanitary and potable uses. A 2,400-MW coal-fired power plant could require approximately 13,000 ac-ft of water per year. The impacts on water resources depend on the locations of the refinery or power plants. If they are assumed to be within 150 mi of an oil shale project site, they are likely to be located within the four oil shale basins and will create additional demands on water supplies in the basins.

The potential impact of transferring agricultural water rights for oil shale development can be attributed to the potential change of delivery systems and return flows from agricultural lands. Oil shale project sites need not be in the same general locations as the irrigated lands where the original water applies, which implies that new delivery systems would be built or some existing systems would be modified. The use of old systems may be reduced or abandoned. The construction of the new systems would cause new ground disturbance. Sediment and dissolved solids from the disturbed area would be carried by surface runoff and transported to downgradient water bodies. If the new system is constructed with pipes rather than ditches or canals, water loss during the delivery through evaporation or percolation would be reduced. Because water rights are based on consumptive uses, water loss due to evaporation, percolation, and surface runoff during water delivery is not counted as part of the water rights. Using a pipe delivery system would reduce the amount of water diverted from a water body to meet the same water rights. The impacts on the water resource by using a pipe delivery system include:

- Increased streamflow because of the reduction of the amount of water diverted to meet the same water rights,
- Improved water quality of the stream because of streamflow increase,
- Improved water quality because the returned flow from percolated water (which generally contains higher dissolved solids) during the delivery is reduced,
- Reduced groundwater recharge from infiltrated water because of the reduction of percolation, and
- Reduced evaporation from open ditches or canals.

As agricultural water rights are transferred, the acreage of agricultural lands is expected to decline. Irrigation is reduced as well as the base flow of the irrigated water to surface water bodies. The impacts on the water resources include:

- Improved water quality of the streams receiving the base flows from farms as leaching by base flows is reduced,
- Reduced groundwater recharges from the percolation of base flows, and

- Reduced yield of groundwater wells that relied on base flow recharge.

Additional impacts would be caused by the use or recycling of wastewater at project sites; such impacts are described in Section 4.5.1.

Water may be drawn from surface water bodies or underground aquifers, depending on project locations, water availability, and water quality. Withdrawal from a surface water body would reduce its flow and cause sediment deposition in the stream channel. In the case of streams receiving groundwater discharge (which generally has a higher dissolved salt content), the withdrawal can degrade the water quality of the stream downgradient from the point of withdrawal because the relative proportion of groundwater remaining in the stream would increase. Because of the generally poor groundwater quality, the receiving stream may result in increases of dissolved salt, selenium, and other metals.

Withdrawal of water from local streams can inadvertently affect water temperature. With reduced flow, water depths in depleted streams tend to decrease. Stream temperature would increase with the same amount of solar radiation in summer time. On the other hand, cooling of stream water is going to be more effective in cold seasons. Groundwater withdrawals from a shallow aquifer would produce a cone of depression and reduce groundwater discharge to surface water bodies or to the springs or seeps that are hydrologically connected to the groundwater. The withdrawal could reduce streamflows, and the effects would increase with the amount of water withdrawn.

Groundwater may be extracted from aquifers for use as a resource or for dewatering to control groundwater inflow into a mine. Mine dewatering would be necessary where saturated conditions, including perched aquifers, are present. Dewatering would lower the potentiometric surfaces and/or water table of the aquifers that are intercepted by the surface mine. Because some deeper groundwater is the source for springs and seeps in the region, the lowering of the potentiometric surface could have a similar effect as withdrawals from shallow, surficial aquifers—reducing or eliminating the flow of the connected springs and seeps. Existing groundwater supply wells within the cones of depression also would have reduced yields or could be dewatered. Permanent changes to the groundwater flow regime due to mining and drilling could affect water rights to specific aquifers. The growth of a cone of depression may be time-delayed and affect water rights in the future.

If surface water is used to supply oil shale operations, it may be necessary to construct storage reservoirs to accumulate enough water to provide the necessary supply. If reservoirs are required, they have their own set of impacts that would need to be addressed. Effects frequently associated with reservoirs include alteration of natural streamflow patterns, impacts on local fisheries, temporary increase of salt loading, changes in downstream channel profiles, loss of natural sediment transport mechanisms, increase in evapotranspiration losses, and loss of existing land uses in the reservoir area.

The water quality of surface water bodies and shallow alluvial aquifers generally is higher than that of deeper aquifers. Therefore, surface water or shallow groundwater is generally preferred as a source of supply if it is available. Withdrawal of surface water would reduce streamflow downstream from the point of diversion. Because of the reduced flow, the stream's capacity for carrying sediment would also be reduced, and in-channel sediment deposition would be increased. The morphology of the stream channel would also adjust to the reduced flows. For stream segments where natural groundwater discharge into the stream occurs, the water withdrawal could increase the relative proportion of the groundwater contribution to the stream, thereby lowering the overall quality of the stream.

For in situ processes, the impact of in situ processing on groundwater during the operations phase is twofold. First, the permeabilities of the aquifers and perhaps the aquitards between the aquifers in the retort areas would likely be permanently increased because of rock fracturing and removal of hydrocarbons. Second, the residual hydrocarbons, salts, and trace metals in rock and the reagents or chemicals used in flooding treated areas that are not removed would be exposed for later groundwater leaching as a result of the increase of the permeabilities. It appears that there would be some risk in allowing vertical flow of groundwater between previously isolated aquifers through fractures created by thermal expansion and contraction. The extent to which there would be the possibility of introducing lower-quality water into higher-quality aquifers previously isolated from one another is not yet known. In addition, water rights to specific aquifers could be affected by a change in the groundwater flow regime.

4.5.1.3 Discharge, Waste Handling, and Contaminant Sources

Controlled discharge of water from a project site to a surface water body constitutes a point-source discharge. The discharged water may be from process wastewater, cooling, collected leachate from overburden rocks or spent shale, sewage, tailing ponds, utilities, and dewatering wells. Discharged waters generally have lower water quality than the water in the receiving water body and could potentially degrade the surface water quality. Discharged cooling water from coal-fired power plants commonly is warmer than local stream water, resulting in potential thermal contamination and its associated effects. In addition, contaminants released by nonpoint sources associated with the project (access roads, air emissions, and groundwater discharge) could further degrade the surface water quality.

Since discharge of surface runoff at a mining site, provided that the runoff is not contaminated by contact with any overburden, raw materials, intermediate product, finished product, by-product, or waste product located on the site of the operation, is exempted from NPDES permits. Surface runoff not intercepted at these sites could create a nonpoint source of contaminants and degrade the water quality of downgradient surface water bodies. It should be noted that Colorado, Utah, and Wyoming have been granted with NPDES authorization. The states' NPDES programs must be at least as stringent as the federal program.

For in situ processes, groundwater extracted to dewater the oil shale zone is likely to be used on-site for general purposes with or without treatment, such as for dust control or as process water, or it may be discharged to surface streams. The degree of water treatment required before discharge or reuse of the water would need to be determined on a site-specific basis to protect the receiving streams. The discharged water from an oil shale project site would generally have a lower water quality than the intake water.

Underground injection, as a means to dispose of low-quality water, could affect groundwater quality. Commonly, the water quality of the receiving aquifer is less than that of the injected water. The impact on the aquifer being injected also may be positive. Permitting is governed by the EPA's Underground Injection Control (UIC) program in Colorado. Utah and Wyoming administer their own programs, except on Tribal land, which is managed by the EPA. Tribes may complete a process to gain eligibility to self enforce UIC. The potential for induced seismicity would require evaluation for proposed injection wells.

Another source of potential water contaminants is from the air, such as air emissions from retort facilities and power plants, and dust from access roads, overburden, and spent shale piles. Winds common in semiarid and arid environments could allow particulates to be dispersed and deposited on surface water bodies. Generally, the dust from spent shale piles and other disturbances is reduced after areas are reclaimed and stabilized or as a consequence of specific dust abatement practices.

If not properly designed, retention ponds for process water, leachate from spent shale, and fly ash could be sources of contamination for shallow groundwater. Overburden rock commonly is disposed of near a project site without underlying liners. Because the overburden rock generally has a high content of soluble salts, leachate from the rock piles may contain high salt content and become a contaminant source for groundwater as well as for surface water.

Spills of chemicals and oil shale products on-site are possible. They are also potential sources of contaminants for nearby surface water bodies and shallow aquifers. Another potential source of water contamination is from pesticides and herbicides, which are commonly used to control vegetation growth along pipelines and transmission lines. These treatments may adhere to soil particles and be carried by wind and surface runoff into nearby surface water bodies, creating nonpoint sources of contaminants for those waters. Vehicle traffic would also raise airborne dust levels along access roads and increase the sediment and salt loadings of nearby streams.

At river crossings, pipelines may be placed under streambeds or foundations may be built for elevated pipelines. A temporary increase of stream sediment at the crossings would likely occur during their construction. Regular disturbance of river banks through maintenance activities or vehicular traffic can also increase the sediment loading of the river. In the case of natural drainage channels that are rerouted, modified, or diverted, the surface runoff could be altered accordingly, affecting downstream flow.

There are also technology-specific impacts. At both surface and underground mining sites, the spent shale piles and mine tailings could be sources of contamination for salts, metals, and hydrocarbons. If surface retorting is used to upgrade oil shale, fly ash and boiler bottom ash would also be produced by the retorts as wastes. Leachates containing associated contaminants may enter nearby surface water bodies or groundwater and continue to degrade the water quality well after site reclamation, if the wastes are not properly managed.

In situ retorting could produce water as a by-product. One in situ retorting experiment produced organic groundwater contaminants, including aromatic hydrocarbons, phenols, azaarenes, and aliphatic ketones (Lindner-Lunsford et al. 1990). Inorganic leachate constituents from in situ retorted oil shale were studied in a laboratory setting by Bethea et al. (1983). Investigators reported that the amount of material leached depended on a variety of factors. The retort temperature had the greatest effect on leachate composition. The use of CO_2 during retorting reduced the formation of base-forming (alkaline) materials. Higher groundwater purity used in the leaching tests produced an increase in the amount of leaching. The researchers also concluded that the leaching of retorted oil shale is complex and difficult to study in a laboratory.

As groundwater levels rebound and approach their original condition after in situ operations cease, residual hydrocarbons and inorganics in rocks and the chemicals used in the subsurface to enhance shale oil recovery may be leached by the groundwater. Such leaching could create a potential contaminant source in the subsurface. The source may contaminate groundwater and hydrologically connected seeps, springs, and surface water bodies, depending on the local interaction between groundwater and surface water.

Oil shale development eventually results in population growth in local communities near project sites and on-site (see Section 4.11.1). With population growth, the loading in local wastewater treatment plants or on-site treatment plants would increase. The effluent from the plants is likely to be an additional source of nutrients, such as phosphorus and nitrogen-containing compounds, and other potential pollutants to nearby waters. Such impacts are closely related to where people would settle and the streamflow of the receiving water. A relatively large water quality impact is expected in areas where population growth is large and the receiving water is small.

4.5.1.4 Alteration of Hydrologic Flow Systems

Because a large volume of rock is disturbed in surface mining operations, the permeability of the geologic material in the mine and in overburden disposal areas is permanently increased. The porosity and permeability of spent shale backfill is also relatively high. Precipitation could infiltrate these materials and produce leachate with relatively high dissolved solids and organics, potentially causing long-term contaminant sources for groundwater. The discharge of this groundwater through springs or seeps feeding water bodies located downgradient of the mine could negatively impact surface water quality. In addition, the filled mine could become a vertical conduit for groundwater, resulting in a discharge area for the shallow aquifer and a recharge area for the deeper aquifer. Alternatively, in the case of an upward vertical gradient, flow from the deeper aquifer could travel up a conduit and into a shallow aquifer.

The dewatering operations of a mine or dewatering through wells that penetrate multiple aquifers can reduce groundwater discharge to seeps, springs, or surface water bodies if the surface water and the groundwater are connected. The consequence could be diminished flows of seeps, springs, or water courses even at areas remote from the mine. Depending on pumping rates and site-specific hydrogeological factors, significant groundwater withdrawals for dewatering the overburden, or for meeting operational needs, may reduce surface water base flow, spring discharges, and water levels in nearby wells.

In one of Shell's RD&D sites, Shell conducted a preliminary regional groundwater flow model to evaluate the impact of the drawdown in the upper aquifer from dewatering on potential stream depletions. The preliminary model results indicate that 1 ft of drawdown could extend up to 2 mi from the dewatering well location, causing a reduction of groundwater discharge to Yellow Creek on the order of 0.04 cfs as a result of the groundwater extraction (BLM 2006c).

Streamflow could be affected by both water withdrawal and wastewater discharge (after water treatment). The streamflow would be reduced in areas downstream of water intakes and increased in areas downstream from discharge outfalls. The change of the streamflow can trigger the deposition or erosion of sediments along a stream channel.

Because of the large openings created in underground mining operations, the hydrologic properties of the geologic material in the mine are permanently altered. Abandoned mine shafts, as well as partially refilled (by spent shale) mines, will enhance vertical and lateral groundwater movement in the mined area after dewatering ceases. Groundwater levels and the groundwater flow field may not return to baseline conditions, and, therefore, water rights may be affected well into the future. Enhanced leaching of formation rocks fractured during mining operations and spent shale backfill could result in poor-quality groundwater. The discharge of this groundwater through springs or seeps feeding water bodies located downgradient of the mine could negatively impact surface water quality.

At sites with a dewatered surface mine or in situ operations, groundwater levels would begin to recover after dewatering activities cease. As groundwater regains its original water level, surface water previously depleted by the dewatering would be replenished by seeps and springs, and the streamflow would eventually return to predevelopment patterns.

For in situ processes, after kerogen as well as some soluble minerals are removed from the source rock, rock porosity and permeability increase, and subsidence may occur. The thermal fractures and fractures created by steam, water, CO_2, or subsidence in the source rock could potentially enhance the groundwater flow within aquifers and potentially increase the vertical hydraulic conductivities of aquitards after the retorted areas are refilled by groundwater. In other words, the flow system in the subsurface may be modified, as will be the groundwater discharge to surface water bodies. This may increase the salinity of nearby streams, depending on site-specific factors.

In the case of natural drainage channels that are rerouted or modified for the construction of roads or facilities, the surface runoff would be altered, affecting existing downstream flow. Access roads are likely to be added or modified with oil shale development. The construction activities on access roads involve clearing vegetation, grading, and building drainages. These activities would increase salt loading of streams near the roads. Sediment load could also be increased by the fallout of airborne dust and surface runoff, although these could be reduced or minimized by BMPs. In the case where natural drainage channels are rerouted or modified because of access roads, the impact on the streams downgradient would be similar to that described in the previous paragraph. Whether the water for operations is derived from a surface water body with or without the use of a reservoir, the downstream flow would be reduced, which could cause deposition of steam sediment and change the morphology of the stream. If a reservoir is built for regulating water supply, sediment would be trapped upstream of the dam. The flow pattern of the stream could change depending on the discharge of the reservoir. The degradation (erosion of streambed) and deposition along the stream channel would adjust to the new streamflows. Losses due to evaporation and seepage in the reservoir would affect the amount of water available (Keefer and McQuivey 1979).

The improvement of the drainage tends to increase surface runoff drainage efficiency, and, thus, the erosion power of the runoff. The receiving stream downgradient would be impacted by additional loading of dissolved salt and sediments.

4.5.2 Water Budget for Individual Oil Shale Projects

In Table 4.5.2-1, a possible scenario of water demand and consumptive use for individual oil shale development projects is provided, and the estimated amounts are compared with the remaining available amounts of Upper Colorado River water, both from 2000 and projected to 2030 for Colorado and Wyoming, and to 2050 for Utah.[7] These are estimated potentially available volumes from the Colorado River for use in oil shale development and other uses in the three states. Although a certain amount of water is calculated to be available on the basis of current and projected consumptive use and Upper Colorado River Compact allocations (see Section 3.4.1.4), this calculation does not imply that the water is readily or physically available for oil shale development. Whether enough water is available for the development depends on the results of negotiations among various parties, including water rights owners, state and federal agencies, and municipal water providers, as well as developers. Recurrence of severe drought conditions and higher temperatures are likely to occur in the Colorado Basin (National Research Council 2007). The latter would increase evaporation and, therefore, reduce runoff and streamflows (National Research Council 2007), which would reduce the water availability shown in Table 4.5.2-1. In addition, the recovery program for endangered Colorado River fishes has identified flow recommendations for major rivers in the Colorado River Basin, and these recommended flows could reduce the availability of water for oil shale as well as for other development projects.

The sustainable groundwater usage in the oil shale basins was estimated on the basis of groundwater recharge rate or practical yield. Withdrawal of the groundwater for oil shale development could reduce groundwater discharge to downgradient seeps, springs, or surface water bodies that are hydrologically connected to the groundwater. Finally, the estimated amount of groundwater in storage and the streamflows of major rivers in the area are also presented for reference purposes. Table 4.5.2-1 gives a summary of the above estimates.

This assessment assumes that additional power plants may be constructed to support in situ facilities (especially those using electric heating of the oil shale formation). It is assumed that underground mine with surface retort and surface mine with surface retort facilities could obtain adequate power from existing facilities.

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7 See Section 3.4.1.4 for details on the amount of water projected to be available. In this section, the water availability is projected to different years on the basis of the availability of projection data from the three states.

TABLE 4.5.2-1 Water Budget for Oil Shale Development Projects[a]

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]	
Colorado	**Technology**	Assumption	Demand (1,000 ac-ft/yr)	Consumption (1,000 ac-ft/yr)
	In situ project at 150,000–200,000 bbl/day	1–3 bbl of water/bbl oil produced per 200,000-bbl/day plant[c]	7.1–28.2	5.4–21.4[d]
	Sanitary and potable use for in situ projects	4,440 in-migrants at 135 gal/day/person	0.67	0.23[e]
	Underground mine/surface retort (UM/SR) project at 50,000 bbl/day	2.6–4 bbl of water/bbl oil produced per 50,000-bbl/day plant[c]	6.1–9.4	4.6–7.1
	Sanitary and potable use for UM/SR project	6,512 in-migrants at 135 gal/day/person	0.98	0.34
	Coal-fired power plant[f] associated with Shell in situ conversion process-type project	13,000 ac-ft/yr		13 (for in situ only)
		Total for each in situ project (includes power production)		18.6–34.6
		Total for each UM/SR project		4.9–7.4
	Water Resource			
	State Water Allocation (1,000 ac-ft/yr)	Locations		
	Projected remaining available surface water[g]	Upper Colorado Basin projected from 2000 to 2030 for Colorado state (see Table 3.4.1-2)		340 in 2000; 268–412 in 2030
	Water Resources	Locations	Flow or recharge rate (1,000 ac-ft/yr)	
	Major streamflow	White River (where the targeted oil shale basin is located) average flow at Meeker (58-yr record) (see Section 3.4.2.2)	460	
	Estimated natural groundwater recharge	Piceance Basin (Taylor 1982)	35	
	Groundwater storage	Locations	Storage (1,000 ac-ft)[h]	
	Groundwater in storage (excluding alluvial aquifers)	Northern province of Piceance Basin (Czyzewski 2000)	up to 25,000	

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]	
Utah	**Technology**	Assumption	Demand (1,000 ac-ft/yr)	Consumption (1,000 ac-ft/yr)
	In situ project at 150,000–200,000 bbl/day	1–3 bbl of water/bbl oil produced for a 200,000-bbl/day plant	7.1–28.2	5.4–21.4[d]
	Sanitary and potable use for in situ projects	4,736 in-migrants at 135 gal/day/person	0.72	0.38[i]
	UM/SR or surface mine/surface retort (SM/SR) project at 50,000 bbl/day	2.6–4 bbl of water/bbl oil produced for a 50,000-bbl/day plant	6.1–9.4	4.6–7.1
	Sanitary and potable use for UM/SR projects	5,328 in-migrants at 135 gal/day/person	0.81	0.43
	Sanitary and potable use for SM/SR projects	6,808 in-migrants at 135 gal/day/person	1.03	0.55
	Coal-fired power plant	13,000 ac-ft/yr		13 (for in situ only)
		Total for each in situ project (includes power production)		18.8–34.8
		Total for each UM/SR project		5.0–7.5
		Total for each SM/SR project		5.2–7.7
	Water Resource			
	State Water Allocation (1,000 ac-ft/yr)[g]	Locations		
	Projected remaining available surface water	Upper Colorado Basin projected from 2000 to 2050 for Utah state (see Table 3.4.1-3)		396 in 2000; 193 in 2050
	Water Resources	Locations	Flow or recharge rate (1,000 ac-ft/yr)	
	Major streamflow	Average flow of Green River at Ouray (combined flow of the White, Duchesne, and Green Rivers), based on 1965–1979 records (see Section 3.4.3.2)	4,270	

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]	
Utah (Cont.)	Estimated practical limit of groundwater withdrawal other than alluvial aquifer in Uinta Basin	Average flow of Duchesne River near Randlett, based on 50-yr records (see Section 3.4.3.2)	460	
			No information available	
Wyoming	**Technology**	Assumption	Demand (1,000 ac-ft/yr)	Consumption (1,000 ac-ft/yr)
	In situ project at 150,000–200,000 bbl/day	1–3 bbl of water/bbl oil produced for a 200,000-bbl/day plant	7.1–28.2	5.4–21.4
	Sanitary and potable for in situ projects	3,848 people at 135 gal/day/person	0.58	0.31[i]
	UM/SR or SM/SR project at 50,000 bbl/day	2.6–4 bbl of water/bbl oil produced for a 50,000-bbl/day plant	6.1–9.4	4.6–7.1
	Sanitary and potable for UM/SR projects	4,440 people at 135 gal/day/person	0.67	0.36
	Sanitary and potable for SM/SR projects	4,292 people at 135 gal/day/person	0.65	0.34
	Coal-fired power plant	13,000 ac-ft/yr		13 (for in situ only)
		Total for each in situ project (1,000 ac-ft/yr)		18.7–34.7
		Total for each UM/SR project (1,000 ac-ft/yr)		5.0–7.5
		Total for each SM/SR project (1,000 ac-ft/yr)		4.9–7.4
	Water Resource			
	State Water Allocation (1,000 ac-ft/yr)[g]	Locations		
	Projected remaining available surface water	Upper Colorado Basin projected from 2000 to 2030 for Wyoming state (see Table 3.4.1-4)		226 in 2000; 80–202 in 2030

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]
Wyoming (Cont.)	Water Resources	Locations	Flow or recharge rate (1,000 ac-ft/yr)
	Major streamflow	Green River below the Fontenelle Reservoir (see Section 3.4.4.2)	1,290
	Groundwater yield (estimate for Tertiary-age aquifer); no information available on groundwater storage	Green River and Washakie Basins where the targeted oil shale deposits are located (States West Water Resources Corporation 2001)	50–100[j]

a The water uses of refineries are not included because the refineries' needs are not known.

b Demand indicates total surface water and/or groundwater extraction; consumption indicates the net water use, assuming water treatment and return to the original source.

c bbl = barrel; 1 barrel = 42 gal.

d To convert the demand to consumption for oil shale water use, a factor of 0.76 (based on self-supplied industries in northwestern Colorado) was used.

e To convert the demand to consumption for sanitary and potable water use in Colorado, a conversion factor of 0.35 was used.

f New power plants are only assumed to be needed to support in situ oil shale facilities (see Section 4.1). For these plants, a hybrid cooling system is assumed; therefore, the water use is assumed to be consumptive.

g Based on Colorado's Statewide Water Supply Initiative 2004 (CWCB 2004); Utah State Water Plan—Southeast Colorado River Basin (UDNR 2000a); Utah State Water Plan—Uinta Basin (UDNR 1999); Utah State Water Plan—Western Colorado River Basin (UDNR 2000b); Utah's Water Resources, Planning for the Future for Utah (UNDR 2001); Green River Basin Water Plan, Basin Water Use Profile—Agricultural (SWWRC 2001a); and Green River Basin, Water Planning Process for Wyoming (SWWRC 2001b). Water rights may already have been allocated and may require purchasing for oil shale development.

h The estimates of groundwater in storage represent volumes. They do not indicate sustainable aquifer yield.

i To convert the demand to consumption for sanitary and potable water use in Utah and Wyoming, a conversion factor of 0.53 was used (based on state data for Uinta Basin).

j The yield was estimated from an area about five times the size of the basins studied in this PEIS.

4.5.2.1 Colorado

For the in situ processing sites, the amount of water required is estimated to be 1 to 3 bbl of water per barrel of shale oil produced (Wilson et al. 2006). Assuming water conservation measures are practiced, the consumption of water for a 200,000-bbl/day project would be about 18,600 to 34,600 ac-ft/yr (this estimate includes an assumed new power plant, which would be required to provide adequate power). Water consumption for a projected 50,000 bbl/day underground mine with surface retort project would be about 4,900 to 7,400 ac-ft water/yr, which assumes that 2.6 to 4 bbl of water are needed for each barrel of oil produced but does not assume any new power plants (see Section 4.1 for details on these assumptions).

The remaining available water from the Colorado River in Colorado is projected to be 340,000 ac-ft/yr in 2000 and in the range of 268,000 to 412,000 ac-ft/yr in 2030.[8] With a range of 4,900 to 34,600 ac-ft/yr required for individual oil shale development projects, the possible water requirements represent 1.4 to 10.2% of the currently available water and would be 1.1 to 12.9% of the water available in 2030 (assuming the lower end of the projected range is available). This projection also assumes that the available water is stored and/or transported to the oil shale areas from various other water basins. Also, there could be an additional 35,000 ac-ft/yr from natural groundwater recharge in the Piceance Basin (Table 4.5.2-1), while the total groundwater storage in the northern province of the Piceance Basin is estimated to be 2.5 million ac-ft. Because this recharge is distributed over a large geographical area, only a limited portion of this groundwater would be available in the vicinity of an individual project site. It is expected that both the surface water and groundwater could be needed for oil shale development.

Wilson et al. (2006) analyzed surface water availability of the White River (where the principal Colorado oil shale basin is located) with consideration of climate variability, minimum streamflow, and existing uses. They estimated that the river should be able to support a new water demand of 100 cubic foot per second (cfs) (or 72,000 ac-ft/yr), if an additional 16,000 ac-ft of reservoir capacity is built. The White River drains to the Green River, a tributary of the Colorado River, in Utah. Withdrawal of water from the White River would reduce the flow in the Green River in Utah as well as the Colorado River downstream.

Within the White River hydrologic basin, Piceance Creek is a major regional groundwater discharge stream in the Piceance Basin (BLM 2006c). A groundwater discharge stream obtains a percentage of its surface flow from groundwater contributions that enter the stream channel. Yellow Creek is also a groundwater discharge stream, but to a lesser degree. Both of these streams are located in close proximity to the Colorado RD&D project sites. Dewatering operations in the vicinity of these streams could lower the local groundwater potentiometric surface to a depth of as much as 1,600 ft (see Appendix A), and thus reduce groundwater discharge to local springs or streams that are hydraulically connected to the groundwater. However, Shell's in situ conversion process (ICP) technology involving a freeze wall could contain the extent of the groundwater cone of depression to within the freeze wall, resulting in less impact on connected systems.

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8 The upper end of the range assumes that water will be released from agricultural use in the future.

4.5.2.2 Utah

For a 200,000-bbl/day in situ project in Utah, the amount of water consumption is estimated to be 18,800 to 34,800 ac-ft/yr (Table 4.5.2-1). A 50,000-bbl/day underground mine with surface retort project or surface mine with surface retort project is estimated to have a water consumption rate of 5,000 to 7,700 ac-ft/yr, assuming 2.6 to 4 bbl of water needed for each barrel of oil produced.

The remaining available water from the Colorado River in Utah is expected to decline from 396,000 ac-ft/yr in 2000 to 193,000 ac-ft/yr in 2050 (Table 4.5.2-1). With a range of 5,000 to 34,800 ac-ft/yr required for individual oil shale development projects, the water requirements represent 1.3 to 8.8% of the currently available water and would be 2.5 to 18.0% of the water available in 2050.

4.5.2.3 Wyoming

For a 200,000-bbl/day in situ project in Wyoming, the amount of water consumption is estimated to be 18,700 to 34,700 ac-ft/yr (Table 4.5.2-1). Underground mine with surface retort or surface mine with surface retort projects at 50,000 bbl/day are estimated to consume 4,900 to 7,500 ac-ft/yr of water (Table 4.5.2-1).

The remaining available water from the Colorado River in Wyoming is expected to decline from 226,000 ac-ft/yr in 2000 to a range of 80,000 to 202,000 ac-ft/yr in 2030. With a range of 4,900 to 34,700 ac-ft/yr required for individual oil shale development projects, the water requirements represent 2.2 to 15.4% of the currently available water and would be 2.4 to 43.4% of the water available in 2030.

4.5.3 Mitigation Measures

The potential impacts on water resources are closely related to the technologies used to mine, extract, process, and upgrade the shale oil from the source rocks. At the programmatic level, the impacts can be reduced tremendously starting from the planning stage. Local hydrologic conditions, including those of surface water and groundwater and the interactive relationship between them, should be characterized and considered in selecting areas for developmental sites, access roads, pipelines, transmission lines, and/or reservoirs. Sensitive areas should be avoided or receive special attention in oil shale development activities. Important factors include but are not limited to:

- Highly erodible geologic material;
- Steep terrain prone to soil erosion;

- Highly saline soils; and
- Groundwater discharge and recharge areas.

In selecting the technologies to develop oil shale, the technologies that would minimize potential contaminant sources should be considered. Several important factors to reduce impacts on water resources include technologies that:

- Result in minimum footprint of disturbed areas;
- Minimize total water consumption;
- Can use wastewater or brackish water in processing source rocks;
- Minimize disturbance between groundwater flow regimes to avoid cross flows between aquifers; and
- Have the highest recovery of shale oil or bitumen, leaving spent material with the least amount of contaminants to be leached.

Mitigation measures that the BLM might consider requiring, if warranted by the result of the lease-stage or plan of development–stage NEPA analyses, are related to engineering practices. They are as follows:

- Water should be treated and recycled as much as practical.
- The size of cleared and disturbed lands should be minimized as much as possible and disturbed areas should be reclaimed as quickly as possible.
- Erosion controls that comply with county, state, and federal standards and BLM guidelines (Fogg and Hadley 2007; USFS Region 2 2000) should be applied.
- Existing roads and borrow pits should be used as much as possible.
- Earth material would not be excavated from, nor would excavated material be stored in, any stream, swale, lake, or wetland.
- Vegetated buffers would be maintained near streams and wetlands. Silt fences could be used along edges of streams and wetlands to prevent erosion and transport of disturbed soil, including spoil piles.
- Earth dikes, swales, and lined ditches could be used to divert work-site runoff that would otherwise enter streams.

- Topsoil removed during construction should be stockpiled and reapplied during reclamation. Practices such as installing jute netting, silt fences, and check dams should be applied near disturbed areas.

- Operators should identify unstable slopes and local factors that can induce slope instability (such as groundwater conditions, precipitation, earthquake potential, slope angles, and dip angles of geologic strata). Operators also should avoid creating excessive slopes during excavation and blasting operations. Special construction techniques should be used where applicable in areas of steep slopes, erodible soil, and stream channel or wash crossings.

- Existing drainage systems should not be altered, especially in sensitive areas such as erodible soils or steep slopes. Culverts of adequate size should be in compliance with applicable state and federal requirements and take the flow regime into consideration for temporary and permanent roads. Potential soil erosion should be controlled at culvert outlets with appropriate structures. Catch basins, roadway ditches, and culverts should be cleaned and maintained regularly.

- Runoff controls should be applied to disconnect new pollutant sources from surface water and groundwater.

- Foundations and trenches should be backfilled with originally excavated material as much as possible. Excess excavated material should be disposed of only in approved areas.

- Pesticides and herbicides should be used with the goal of minimizing unintended impacts on soil and surface water bodies. Common practices include but would not be limited to (1) minimizing the use of pesticides and herbicides in areas with sandy soils near sensitive areas; (2) minimizing their use in areas with high soil mobility; (3) maintaining the buffer between herbicide and pesticide treatment areas and water bodies; (4) considering the climate, soil type, slope, and vegetation type in determining the risk of herbicide and pesticide contamination; and (5) evaluating soil characteristics prior to pesticide and herbicide application, to assess the likelihood of their transport in soil.

- Pesticide use should be limited to nonpersistent, immobile pesticides and should only be applied in accordance with label and application permit directions and stipulations for terrestrial and aquatic applications.

- An erosion and sedimentation control plan, as well as a Stormwater Pollution Prevention Plan (SWPPP), should be prepared in accordance with federal and state regulations.

Adopting mitigation measures such as these does not mean that there would be no impacts on water resources. The exact nature and magnitude of the impacts would vary from project to project and would need to be examined in detail in future NEPA reviews of lease areas and project plans of development.

4.6 AIR QUALITY AND CLIMATE

4.6.1 Common Impacts

The potential for air quality impacts from commercial oil shale development, including ancillary facilities such as access roads, upgraded facilities, gas pipelines, and compressors, is directly related to the amount of land disturbance, drilling and mining operations, processing methods, and the quantity of oil and gas equivalent produced. Indirect effects, such as impacts resulting from the need for additional electrical generation and increased secondary population growth, are also considered.

Impacts on air quality from oil shale development would occur in several ways, as described below:

- Temporary, localized impacts (primarily PM and SO_2, with some CO and NO_x emissions) would result from the clearing of the project area; grading, excavation, and construction of facilities and associated infrastructure; and mining (extraction) or drilling of the oil shale resource.
- Long-term, regional impacts (primarily CO and NO_x, with lesser amounts of PM, SO_2, and VOCs) would result from oil shale processing, upgrading, and transport (pipelines). Depending on site-specific locations, meteorology, and topography, NO_x and SO_2 emissions could cause regional visibility impacts (through the formation of secondary aerosols) and contribute to regional nitrogen and sulfur deposition. In turn, atmospheric deposition could cause changes in sensitive (especially alpine) lake chemistry. In addition, depending on the amounts and locations of NO_x and VOC emissions, photochemical production of O_3 (a very reactive oxidant) is possible, with potential impacts on human health and vegetation. Similar impacts could also occur from the additional coal-fired power plants that would be needed to supply electricity for in situ oil shale extraction. Localized impacts due to emissions of hazardous air pollutants (HAPs) (particularly benzene, toluene, ethylbenzene, xylene, and formaldehyde) and diesel PM could also present health risks to workers and nearby residences.

It is not possible to predict site-specific air quality impacts until actual oil shale projects are proposed and designed. Once such a proposal is presented, impacts on these resources would be further considered in project-specific NEPA evaluations and through consultations with the BLM prior to actual development.

Although oil shale is found in the states of Colorado, Utah, and Wyoming, there are two high-yield areas of the Piceance Basin in western Colorado with the greatest potential for development. Table 4.6.1-1 identifies those counties where direct and indirect air pollutant emissions could result from oil shale leasing.

Impacts on air quality would be limited by applicable local, state, Tribal, and federal regulations, standards, and implementation plans established under the CAA and administered by the applicable air quality regulatory agency, with EPA oversight. These agencies include, but are not limited to, the Colorado Department of Public Health and Environment–Air Pollution Control Division (CDPHE-APCD), the Utah Department of Environmental Quality–Division of Air Quality (UTDEQ-DAQ), and the Wyoming Department of Environmental Quality–Division of Air Quality (WYDEQ-DAQ). Air quality regulations require that proposed new or modified existing air pollutant emission sources undergo a permitting review before their construction can begin. Therefore, these state agencies have the primary authority and responsibility to review

TABLE 4.6.1-1 Counties within the Study Area That Could Be Affected by Air Pollutant Emissions

State	County	Land Area (mi^2)	Population (July 1, 2001, estimate)	Population (July 1, 2005, estimate)
Colorado	Garfield	2,947	45,545	49,810
	Moffat	4,742	13,213	13,417
	Rio Blanco	3,221	5,878	5,973
	Subtotal	10,910	64,636	69,200
Utah	Carbon	1,478	19,768	19,437
	Duchesne	3,238	14,563	15,354
	Emery	4,452	10,751	10,711
	Garfield	5,174	4,691	4,470
	Grand	3,682	8,490	8,743
	San Juan	7,820	13,607	14,104
	Uintah	4,477	25,773	26,995
	Utah	1,998	389,866	443,738
	Wasatch	1,177	16,172	18,974
	Wayne	2,460	2,529	2,450
	Subtotal	35,956	506,210	564,976
Wyoming	Lincoln	4,069	14,736	15,999
	Sublette	4,883	5,936	6,926
	Sweetwater	10,425	36,766	37,975
	Uinta	2,082	19,537	19,939
	Subtotal	21,459	76,975	80,839
Regional	Total	68,325	647,821	715,015

Source: U.S. Bureau of the Census (2007a,b).

permit applications and to require emission permits, fees, and control devices prior to construction and/or operation. The U.S. Congress (through CAA Section 116) authorized local, state, and Tribal air quality regulatory agencies to establish air pollution control requirements more (but not less) stringent than federal requirements.

All leases and approvals of plans of development will require lessees to comply with all applicable state, federal, or Tribal environmental regulations within the leased area, including air quality standards and implementation plans.

Before oil shale development could occur, additional project-specific NEPA analyses would be performed, subject to public and agency review and comment. The applicable air quality regulatory agencies (including the states and EPA) would also review site-specific preconstruction permit applications to examine potential projectwide air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impact analyses or mitigation measures. Those evaluations would take into consideration the specific project features being proposed (e.g., specific air pollutant emissions and control technologies) and the locations of project facilities (including terrain, meteorology, and spatial relationships to sensitive receptors.) Project-specific NEPA assessments would predict site-specific impacts, and these detailed assessments (along with BLM consultations) would result in the required actions by the applicant to avoid or mitigate significant impacts. Under no circumstances can the BLM conduct or authorize activities that would not comply with all applicable local, state, Tribal, or federal air quality laws, regulations, standards, or implementation plans.

Ongoing scientific research has identified the potential effects of so-called "greenhouse gas" (GHG) emissions (including CO_2, methane, nitrous oxide, water vapor; and several trace gases) on global climate. Recent industrialization and burning of fossil carbon sources have caused CO_2 concentrations to increase dramatically and are likely to contribute to overall climatic changes. Increasing CO_2 concentrations also leads to preferential fertilization and growth of specific plant species. The assessment of GHG emissions and climate change is in its formative phase, and it is not yet possible to know with confidence the net impact on climate. However, the IPCC (2007) recently concluded that "warming of the climate system is unequivocal," and "most of the observed increase in globally average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic [man-made] greenhouse gas concentrations."

Global mean surface temperatures have increased nearly 1.0°C (1.8°F) from 1890 to 2006 (Goddard Institute for Space Studies 2007). However, the northern latitudes (above 24°N—which includes all of the United States) have exhibited temperature increases of nearly 1.2°C (2.1°F) since 1900, with nearly a 1.0°C (1.8°F) increase since 1970 alone. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions; but increasing concentrations of GHG, however, are likely to accelerate the rate of climate change. The direct emissions of climate change air pollutants from oil shale development facilities are likely to be a small fraction of global emissions.

The lack of scientific tools designed to predict climate change on regional or local scales limits the ability to quantify potential future impacts. However, potential impacts on air quality due to climate change are likely to be varied. For example, if global climate change results in a warmer and drier climate, increased PM impacts could occur because of increased windblown dust from drier and less stable soils. Cool season plant species' spatial ranges are predicted to move north and to higher elevations, and extinction of endemic threatened and endangered plants may be accelerated. Because of loss of habitat or competition from other species whose ranges may shift northward, the population of some animal species may be reduced. Less snow at lower elevations would be likely to impact the timing and quantity of snowmelt, which, in turn, could impact aquatic species.

4.6.1.1 Impacts from Emissions Sources for Oil Shale Facilities

To estimate total potential air pollutant emissions, emission factors for a specific activity must be identified and then multiplied by activity levels and engineering control efficiencies. The emission factors from proposed project activities would be estimated in future NEPA analyses by using appropriate equipment manufacturer's specifications, testing information, EPA AP-42 emission factor references (EPA 1995), and other relevant references. Anticipated levels of operational activities (e.g., load factors, hours of operation per year, and vehicle miles traveled) would be computed. Emission inventories would be made for selected years during the assumed plant life (including construction, operation, maintenance, and reclamation).

4.6.1.1.1 Construction. Mining and surface process technologies may include construction of a surface or underground mine and mine bench, with primary crushing facilities, processing and upgrading facilities, spent material disposal areas, and reservoirs for flood control and a catchment dam below the disposal pile. For thermally conductive ICPs, considerable construction and preproduction development work include extensive drilling, placement of heating elements, construction of upgrading/refining facilities, power plants, and possibly cryogenic (freeze wall) plants.

Irrespective of surface or in situ technologies, additional construction activities include access roads, power supply and distribution systems, pipelines, water storage and supply facilities, construction staging areas, hazardous materials handling facilities, housing, and auxiliary buildings.

Impacts on air quality associated with these construction activities include fugitive dust emissions and engine exhaust emissions of heavy equipment, as well as commuting and delivery vehicles on paved and/or unpaved roads. Another emission source affecting air quality is wind erosion of soil disturbed by construction activities or from soil stockpiles.

4.6.1.1.2 Production. Emissions impacting air quality could result from surface operations, such as mining and crushing, processing (such as pyrolysis of the base material at high temperatures), upgrading the hydrocarbon products, support utilities, and disposing of waste products. Major processing steps for in situ processes would include heating the base material in place, extracting the liquid from the ground, and transporting it to an upgrading/refining facility. Because in situ processing does not involve mining, with limited waste material disposal, it does not permanently modify land surface topography and therefore produces fewer air pollutant emissions.

4.6.1.1.3 Maintenance. Maintenance activities primarily include access road maintenance and periodic visits to facilities and structures away from the main facilities. The primary emissions that could affect air quality would be fugitive dust and engine exhaust emissions.

4.6.1.1.4 Reclamation. During reclamation activities, which proceed continuously throughout the life of the project, waste material disposal piles would be smoothed and contoured by bulldozers. Topsoil would be placed on the graded spoils, and the land would be prepared for revegetation by furrowing, mulching, and the like. From the time an area is disturbed until the new vegetation emerges, all disturbed areas are subject to wind erosion. Fugitive dust and engine exhaust emissions from reclamation activities are similar to those from construction activities, although with a lower level of activity.

4.6.1.1.5 Population Growth. Population growth and related emission increases associated with potential development would include direct employment; other industry workers (such as those associated with additional power plants); workers from suppliers (e.g., related to equipment, materials, supplies, and services); consumer effects (e.g., related to additional retail stores); additional employment in federal, state, and local governments; and families.

4.6.1.1.6 Mobile (onroad and nonroad). Additional air pollutant emissions that could affect air quality would be associated with onroad mobile sources (e.g., cars, trucks, and buses), and nonroad mobile sources (e.g., graders and backhoes used in construction).

4.6.2 Mitigation Measures

Since all activities either conducted or approved through use authorizations by the BLM must comply with all applicable local, state, Tribal, and federal air quality laws, statutes, regulations, standards, and implementation plans, it is unlikely that future oil shale development would cause significant adverse air quality impacts.

However, on a case-by-case basis, future individual leases and use authorizations could include specific measures to minimize potential air quality impacts. These mitigation measures could include but are not limited to (1) treating access roads with water or other surfactants to reduce fugitive dust from traffic; (2) reducing vehicle speeds on dirt roads to reduce fugitive dust from traffic; (3) specifying emission control devices on production equipment to reduce potential

CO, NO_x, $PM_{2.5}$, PM_{10}, and VOC emissions; (4) specifying low-sulfur-content fuels to reduce potential SO_2 emissions; and/or (5) regulating the timing of emissions to reduce the formation of O_3 in the atmosphere from NO_x and VOC emissions.

In addition, to ensure that BLM-authorized activities comply with applicable ambient air quality standards, as well as potential impacts on AQRVs (such as visibility, atmospheric deposition, noise, etc.), specific monitoring programs may be established.

Potential global warming impacts could be reduced if oil shale–derived fuels were substituted for other fossil carbon-based energy sources, or if atmospheric loadings were reduced by emission controls or sequestration methods.

4.7 NOISE

Generic noise impacts of construction, operation, and reclamation of oil shale development facilities were estimated; however, detailed information on equipment types, schedules, layouts, and locations was not available at the programmatic level. When available, published estimates of noise impacts from technology assessments and EAs for facilities expected to be similar to those considered here were used as the basis for this assessment. Use of these existing studies required making reasonable assumptions and extrapolations. In addition, this lack of detailed information also precludes making quantitative estimates of the impacts of noise mitigation measures that might be applied, if warranted by the results of the lease-stage and/or plan of development–stage NEPA analyses.

The characteristics of the area around a noise source influence the impacts caused by that source. However, sources produce the same amount of noise independent of their location and, to a first approximation, noise propagates identically everywhere. At the programmatic level, information that could help differentiate between noise impacts in different locations is unavailable as are estimates of the noise levels associated with some of the technologies. The approach taken here assesses the impacts of technologies. Noise levels are assumed to be independent of location. Thus, differences in impacts due solely to restrictions in areas available for leasing are not considered.

When published estimates for facilities were unavailable, simple noise modeling was used to estimate noise impacts (HMMH 1995). To predict an impact, the model requires that the noise level associated with the technology be assessed. Noise levels were not available for some technologies. In these cases, noise levels associated with similar technologies were used.

Published information was generally for a single-capacity facility. To use these data, their noise impacts were extrapolated by using a conservative approach equivalent to the 3-dBA rule of thumb.[9] For example, if noise levels were available for a reference facility of 20,000 bbl/day,

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9 A 3-dB change in sound level is considered barely noticeable based on individuals' responses to changes in sound levels (NWCC 1998; MPCA 1979).

the noise impact of a 40,000-bbl/day facility was assumed to be 3 dBA higher, an assumption equivalent to locating two 20,000-bbl/day facilities at the same point.

Noise Modeling Parameters

All calculations:	
Ground type	Soft
For calculating L_{dn}:	
Daytime background noise level	40 dBA (typical of rural areas)
Nighttime background noise level	30 dBA (typical of rural areas)
Daytime hours	15 hours from 7 a.m. to 10 p.m.
Nighttime hours	9 hours from 10 p.m. to 7 a.m.

As is generally the practice, this PEIS uses the EPA guideline of 55 dBA (L_{dn}), deemed adequate to protect human health and welfare, as a significance criterion for assessing noise impacts (EPA 1974). However, oil shale development would occur mostly in remote rural locations. In these areas, background (already existing) noise levels are low (40 dBA during the day and 30 dBA during the night are representative levels), and an increase in noise levels to 55 dBA would be noticeable and annoying to people (Harris 1991). This guideline may not be appropriate for people seeking solitude or a natural, wilderness experience. Depending on ambient conditions, the activities being pursued by the receptors, and the nature of the sound, wildlife and human activities can be affected at levels below 55 dBA, but quantitative guidelines were unavailable. In addition, the NPS has determined that L_{dn} and equivalent sound pressure level (L_{eq}) alone are not appropriate for determining impacts within National Parks and typically uses audibility metrics to characterize impacts on humans and wildlife. Site-specific impacts on resources administered by the NPS would be assessed using audibility-based metrics and other appropriate data and methodologies. See Sections 4.8 and 4.9 for impacts on wildlife and human aesthetic experiences, respectively, that could occur as a result of increased levels of noise.

The Colorado noise regulation specifies maximum noise levels of 55 and 50 dBA for daytime and nighttime hours in residential areas, with excursions of up to 60 dBA for up to 15 minutes in an hour.[10] These levels cannot be directly compared with the EPA guideline. Where appropriate, the Colorado limits are used as another significance criterion. The use of the EPA guideline level and the Colorado levels for residential zones provides a conservative approach for a programmatic level of analysis. At specific sites, less stringent levels, such as the levels for light industrial zones in the Colorado regulation, may be appropriate. When site-specific noise analyses are conducted in conjunction with leasing and preparation of a plan of development, the appropriate noise levels will be used.

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10 In addition, Rio Blanco County has a regulation specifying a maximum of 65 dBA at the boundary.

4.7.1 Common Impacts

Noise impacts from construction and reclamation of oil shale facilities would be largely independent of the type of facility being constructed and are discussed below. Noise impacts from associated onroad vehicular traffic would also be largely independent of the facility type. Deviations from these general discussions are noted in the discussions of specific technologies. The noise from electric transmission lines and the product pipelines associated with these facilities is also discussed.

4.7.1.1 Construction

Construction would include a variety of activities, including building of access roads, grading, drilling, pouring concrete, trenching, laying pipe, cleanup, revegetation, and, perhaps, blasting. With the exception of blasting, construction equipment constitutes the largest noise source at construction sites. Table 4.7.1-1 presents noise levels for typical construction equipment. For a programmatic assessment of construction impacts, it can be assumed that the two noisiest pieces (derrick crane and truck) would operate simultaneously and in close proximity to each other. Together these would produce a noise level of 91 dBA. Assuming a 10-hour workday, noise levels would exceed the EPA guideline of 55 dBA (L_{dn}) up to about 850 ft from the location where the equipment was operating. The Colorado maximum hourly level of 50 dBA would be exceeded up to about 1,800 ft from this location. (The difference between the two distances is due largely to the 14 hours when construction equipment is not operating; hours when only low-level background noise is present are included in the calculation

TABLE 4.7.1-1 Noise Levels at Various Distances from Typical Construction Equipment

Construction Equipment	Noise Level $L_{eq(1\text{-}h)}$[a] at Distances (dBA) 50 ft	250 ft	500 ft	1,000 ft	2,500 ft	5,000 ft
Bulldozer	85	66	58	50	40	32
Concrete mixer	85	66	58	50	40	32
Concrete pump	82	63	55	47	37	29
Crane, derrick	88	69	61	53	43	35
Crane, mobile	83	64	56	48	38	30
Front-end loader	85	66	58	50	40	32
Generator	81	62	54	46	36	28
Grader	85	66	58	50	40	32
Shovel	82	63	55	47	37	29
Truck	88	69	61	53	43	35

[a] $L_{eq(1\text{-}h)}$ is the equivalent steady-state sound level that contains the same varying sound level during a 1-hour period.

Source: HMMH (1995).

of L_{dn} but do not affect the maximum hourly noise.) Construction impacts could last up to 2 years and could recur during the operational phase if additional processing facilities needed to be constructed.

If used, blasting would create a compressional wave with an audible noise portion. Potential impacts on the closest sensitive receptors could be determined; however, most sensitive receptors, at least human sensitive receptors, would probably be located at a considerable distance from the construction sites.

4.7.1.2 Vehicular Traffic

Heavy-duty trucks produce most of the noise associated with vehicular traffic during construction.[11] Vehicular traffic includes hauling of materials, transport of equipment, delivery of water for fugitive dust control, and worker personal vehicles. Light-duty trucks, such as pickups and personal vehicles, produce less noise than heavy-duty trucks (10 passenger cars make about the same noise as a single heavy-duty truck on an L_{eq} basis). Except for short time periods when workers are arriving and leaving the construction site, heavy truck traffic would dominate the vehicular traffic. Table 4.7.1-2 presents the noise impacts from heavy trucks estimated at various distances from a road for different hourly levels of truck traffic. In making these estimates, a peak pass-by noise level from a heavy-duty truck operating at 35 mph was based on Menge et al. (1998) and a 10-hour working day. Except for locations very close to the road or at high traffic levels, noise levels would exceed neither the EPA guideline level nor the Colorado daytime maximum level. At night, the Colorado nighttime maximum level (50 dBA) might be exceeded by lower levels of truck traffic. However, for 15 minutes in any hour, the Colorado standard permits noise levels up to 60 dBA, levels that would not be reached except very close to the road or at high traffic levels.

TABLE 4.7.1-2 Noise Levels at Various Distances from Heavy Truck Traffic

Hourly Number of Trucks	Noise Level L_{dn} (dBA)[a]					
	50 ft	75 ft	100 ft	125 ft	250 ft	500 ft
1	48	45	43	42	37	32
10	58	55	53	52	47	42
50	65	62	60	58	54	49
100	68	65	63	62	57	52

[a] Estimated assuming a 10-hour daytime shift and heavy trucks operating at 35 mph.

Source: Menge et al. (1998).

[11] The average noise of a passing car is about 15 dBA less than that from a passing truck (BLM 2006a).

4.7.1.3 Surface Mining with Surface Retort

This assessment relies on data on noise from a mine supporting a 20,000-bbl/day surface retort (Section 5.7), which would be equivalent to 61 dBA at 500 ft. This is almost identical to the noise level from the crusher and thus, even if the mine and crusher were co-located, noise levels with the surface mine would only be about 3 dBA higher than those with an underground mine. However, the surface mine must be considered separately during the site-specific NEPA analyses that should consider all major noise sources, including the surface mine, crushers, conveyors, on-site or nearby upgrading facilities, and pumps, and should consider the operating schedules detailed in operations plans. If high noise impacts are projected, noise-reduction equipment such as mufflers, blowdown mutes, pipe wrap, barriers, application of sound-absorbing material, and enclosures may be required (Daniels et al. 1981; Teplitzky et al. 1981). Planning for space buffers between the mine, crushers and conveyors, and sensitive receptors and the site boundary may be a feasible method of mitigating noise impacts from these sources.

4.7.1.4 Underground Mining with Surface Retort

Underground mines with surface retorts are assumed to be commercial implementations of the OSEC RD&D technology (see Appendix A, Section A.5.3.4). For the OSEC underground mining and surface retort process, the design-basis capacity for the commercial facilities would be about 13 to 800 times larger than that of the RD&D facility. No information specific to noise from construction of the OSEC ATP was available. General construction noise is discussed in Section 4.7.1.1. However, for a large commercial facility, site-specific construction noise would need to be addressed during the NEPA analyses. These analyses should consider the detailed construction schedule, including the likely repetition of construction activities as different portions of the lease site are developed, and the proximity of these activities to off-site receptors.

Given that noise levels from the OSEC RD&D operation might exceed the EPA guideline beyond 1,000 ft from the crusher and conveyor operations, there could be off-site noise issues related to a commercial-scale facility. The number of crushing and conveyor operations is unknown but is likely to be small. During the NEPA analyses that would be conducted for approval of individual projects, operational noise levels must be analyzed in detail. These analyses should include the effects of all major noise sources, including crushers, conveyors, on-site or nearby upgrading facilities, and pumps, and should consider the operating schedules detailed in operations plans. If high noise impacts are projected, noise-reduction equipment may be required (Daniels et al. 1981; Teplitzky et al. 1981). Planning for space buffers between crushers and conveyors and sensitive receptors and the site boundary may be a feasible method of mitigating noise impacts from these sources.

4.7.1.5 In Situ Processing

In situ processes are assumed to be commercial implementations of the Chevron, Shell, and EGL RD&D technologies (see Appendix A, Section A.5.3). For the Chevron in situ process, the projected capacity of commercial facilities (i.e., 200,000 bbl/day) would be 3,000 to

10,000 times larger than that of the RD&D facility. Construction noise associated with the Chevron RD&D facility might exceed the EPA guideline level of 55 dBA out to about 1,500 ft. Construction of a larger commercial facility would be noisier. The overall impact, however, would depend on the details of the construction schedule, including the likely repetition of the construction activities as different portions of the lease site are developed, and on the proximity of construction activities to off-site receptors. These considerations are site-specific and should be addressed during the site-specific NEPA analyses.

It appears that pumps would be major contributors to overall noise levels and the number, size, and placement of pumps in relation to each other and to nearby receptors must be considered in assessing the overall noise impact. During the NEPA analyses that would be conducted for approval of individual projects, both construction and operational noise levels for the proposed project must be analyzed in detail. These analyses should include all major noise sources, including those associated with any on-site or nearby upgrading facility, and should consider the operating schedules detailed in the operations plans. If high noise impacts are projected, noise-reduction equipment may be required (Daniels et al. 1981; Teplitzky et al. 1981).

The projected capacity of commercial facilities would be 100 to 400 times larger than that of the Shell in situ RD&D facility. Construction of commercial-scale projects would require drilling hundreds of holes (e.g., 190 for the RD&D project). Noise associated with the Shell RD&D facility might exceed the EPA guideline level of 55 dBA out to about 1,300 ft. Drilling additional holes for a commercial-scale facility would probably cause higher noise levels. The overall impact would depend on the number of drill rigs operating simultaneously, the spacing between the rigs, their overall configuration, and the schedule for drilling, including the likely repetition of drilling activities as different portions of the lease site are developed, as well as the rigs' proximity to off-site receptors. These considerations are site-specific and should be addressed during the site-specific NEPA analyses.

During operation, the Shell RD&D facilities would employ pumps in the producer holes that would muffle noise. Aboveground pumps would be a major noise source. If commercial-scale facilities are designed to employ aboveground pumps, the noise impacts would need to be addressed in the site-specific NEPA analyses. The number, size, and placement of the pumps in relation to each other and nearby receptors and their interactions with on-site upgrading facilities would be key factors in these analyses. If high noise impacts are projected, noise-reduction equipment may be required (Daniels et al. 1981; Teplitzky et al. 1981).

In addition, the site-specific analyses would need to address transformer noise. The Shell ICPs use electricity and would require the use of transformers, which could be a noise source. Their impact would depend upon their sizes, numbers, and locations in relation to the other large noise sources, and their relative importance would increase if underground pumps were retained in the commercial facilities. A transformer produces a constant low-frequency hum. The average A-weighted sound level at about 490 ft for a transformer of about 400 MW is about 49 dBA (Wood 1992). The number and size of the transformers are currently unknown, but a single transformer could exceed the EPA guideline at 500 ft. Transformer noise and mitigating measures must be addressed in the site-specific NEPA analyses, especially if underground pumps are used or the transformers are far removed from the locations of aboveground pumps.

Commercial-scale in situ technologies could require up to 2,400 MW in new coal-fired generating capacity (Section 4.1). Currently, a typical large power plant might be about 1,000 MW. The noisiest continuous sources at power plants are the steam boilers and turbine generators: about 89 dBA and 80 dBA at 50 ft, respectively, for a 500-MW boiler (Teplitzky et al. 1981). These sources would be enclosed in a building, and noise suppression could be included in the plant design. In addition, there are intermittent noise sources associated with coal car shaking, car dumping, coal crushing, conveyors, and transfer towers. Noise levels from dumping can exceed 90 dBA. The pollution control equipment associated with power plants also causes noise, and installation of this equipment has given rise to complaints from nearby residents. The noise levels associated with the generation of the electric power that may be needed by commercial-scale in situ technologies should be considered when the facilities are constructed. Table 4.7.1-3 presents approximate noise reductions achievable by noise-reduction techniques on the basis of experience at power plants (Teplitzky et al. 1981).

The projected capacity for commercial facilities would be about 200 to 800 times larger than that of the EGL RD&D facility. Drill rigs would constitute a major source of construction noise associated with the EGL RD&D facility. Drilling additional holes for a commercial-scale facility would probably cause higher noise levels. The overall impact would depend on the number of drill rigs operating simultaneously, the spacing between the rigs, their overall configuration, and the schedule for drilling, including the likely repetition of drilling activities as different portions of the lease site are developed, as well as the rigs' proximity to off-site receptors. These considerations are site-specific and should be addressed during the site-specific NEPA analyses.

Boilers may be a major noise-producing source. The number and size of the boilers associated with a commercial facility are unknown, as is the potential number of pumps. If large pumps are used, they would constitute a major noise source. Although individual large boilers may be noisier than pumps, they would be located in a boiler house that would provide some noise reduction (Teplitzky et al. 1981). During the NEPA analyses that would be conducted for approval of individual projects, the number, size, and placement of the pumps and boilers in relation to each other and nearby receptors and their interactions with on-site upgrading facilities would be key factors in assessing noise levels. If high noise impacts are projected, noise-reduction equipment may be required (Daniels et al. 1981; Teplitzky et al. 1981).

TABLE 4.7.1-3 Maximum Achievable Noise Reductions for Design Features

Feature	Achievable Noise Reduction (dBA)
Barrier	Up to 15
Partial enclosure	Up to 10
Complete enclosure	Up to 30
Sound absorption material	Up to 10
Mufflers	Up to 30
Lagging	Up to 15
Vibration damping	Up to 10
Vibration isolation	Up to 10

Source: Teplitzky et al. (1981).

4.7.1.6 On-Site Upgrading Operations

Noise levels from on-site upgrading operation could be substantial and should be accounted for in the site-specific NEPA analyses. No information specific to the noise associated with upgrading facilities was available. However, many of the operations employed in an upgrading facility would be the same as those in oil refineries. The EPA (1971) presents results of noise field measurements taken around an oil refinery of unspecified capacity. The major sources are furnaces and their associated heat exchangers and compressor systems. The highest noise levels at the plant boundary (at unknown distances from the noise sources) range from 67 to 71 dBA depending on the time of day and day of the week. These levels would correspond to levels in excess of the EPA guideline level of 55 dBA (L_{dn}) and indicate that the on-site upgrading facility should be included in the site-specific noise analyses.

4.7.1.7 Reclamation

In general, noise impacts from reclamation activities would be similar to but less than those associated with construction activities because the activity type and level would be similar but shorter in duration. Most reclamation would also occur during the day when noise is better tolerated by people, and noise levels would return to background levels during the night and would be intermittent in nature. Reclamation activities would last for a short period compared with the period of construction operations.

4.7.1.8 Transmission Lines

General construction impacts are discussed in Section 4.7.1.1. During operation, the main sources of noise from the transmission line would be substation noise and corona discharge. Substation noise comes primarily from transformers and switchgear. A transformer produces a constant low-frequency hum. The average A-weighted sound level at about 490 ft for a transformer of about 400 MW is about 49 dBA (Wood 1992). The number and size of transformers are currently unknown, but a single transformer could exceed the EPA guideline at 500 ft. Transformer noise and mitigating measures must be addressed if substations are required along the transmission lines. Switchgear noise is generated when a breaker opens, producing an impulsive sound, which is loud but of short duration. These occur infrequently, and the industry trend is toward breakers that generate significantly less noise. The potential impacts of switchgear noise would be temporary, infrequent, and minor.

Transmission lines generate corona discharge, which produces a noise having a hissing or crackling character. During dry weather, transmission line noise is generally indistinguishable from background noise at the edge of typical ROWs. During rainfall, the level would be less than 47 dBA at a distance of 100 ft from the center of a 500-kV transmission line (BPA 1996). This noise level is the level typical of a library (MPCA 1979). Even if several transmission lines of this capacity were required, the overall corona noise would be lost even in rural background noise within several hundred feet.

4.7.1.9 Pipeline

General construction impacts are discussed in Section 4.7.1.1. Depending on the topography, a pipeline 55 mi long could require several pump stations. Pumps will generally be the noisiest equipment associated with a pump station. Large pumps would be needed to handle the assumed output of 200,000 bbl/day for in situ facilities. Contra Costa County (2003) gives a noise level of 94 dBA at 3 ft from a 400-hp pump but does not specify the throughput. Assuming three pumps, the EPA guideline would be exceeded out to about 260 ft from the pumps. Pumps are almost always located in structures for protection from the weather and for security. The enclosure would reduce noise levels. Because the pumps needed to move the assumed output may be larger and noisier than those assumed here, noise impacts would need to be assessed during planning for the actual pump stations.

4.7.2 Mitigation Measures

Regulatory requirements regarding noise already largely address the mitigation of impacts. To reinforce those regulatory requirements, mitigation measures will be required and could include the following:

4.7.2.1 Preconstruction Planning

- Developers should conduct a preconstruction noise survey to identify nearby sensitive receptors (e.g., residences, schools, child care facilities, hospitals, livestock, ecological receptors of critical concern, and areas valued for solitude and quiet) and establish baseline noise levels along the site boundary and at the identified sensitive receptors.

- On the basis of site-specific considerations identified through the preconstruction noise survey, proponents should develop a noise management plan to mitigate noise impacts on the sensitive receptors. The plan would cover construction, operations, reclamation, and site restoration. The plan should ensure that the standards to be implemented reflect conditions specific to the lease site.

  This plan could provide for periodic noise monitoring at the facility boundary and at nearby sensitive receptors on a monthly or more frequent basis at a time when the facility is operating at normal or above-normal levels. Monitoring results could be used to identify the need for corrective actions in existing mitigation measures or the need for additional noise mitigation.

4.7.2.2 Construction and Reclamation

Wherever there are sensitive receptors, as identified in the preconstruction survey, construction noise should be managed to the extent necessary to mitigate adverse impacts on the sensitive receptors. Efforts to mitigate these impacts could include the following measures:

- A noise complaint manager could be designated to receive any noise complaints from the public. This employee could have the responsibility and authority to convene a committee to investigate noise complaints, determine the causes of the noise leading to the complaints, and recommend mitigation measures.

- General construction activities could be limited to daytime hours between 7 a.m. and 7 p.m. On the basis of the results of the baseline noise survey, these hours could be extended to between 7 a.m. and 10 p.m. in areas remote from sensitive receptors.

- Particularly noisy activities, such as pile driving, blasting, and hauling by heavy trucks, could be limited to daytime hours between 8 a.m. and 5 p.m. on weekdays and prohibited on weekends and state and federal holidays. The noise management plan could identify alternate methods for conducting noisy activities and available mitigation methods. The least noisy of these could be chosen for use during construction unless its use is precluded by site-specific characteristics.

- When feasible, different particularly noisy activities could be scheduled to occur at the same time, since additional sources of noise generally do not add significantly to the perceived noise level. That is, less frequent noisy activities may be less annoying than frequent less noisy activities.

- If blasting or other impulsive noisy activities are required, nearby sensitive human receptors could be notified in advance.

- All construction equipment should have sound control devices no less effective than those provided on the original equipment. Construction equipment and the equipment's sound control devices could be required to be well tuned, in good working order, and maintained in accordance with the manufacturer's specifications. Appropriate record keeping of these maintenance activities could be required.

- Where possible, construction traffic could be routed to minimize disruption to sensitive receptors.

- Temporary barriers could be erected around areas where construction noise could disturb sensitive receptors.

- To the extent possible, stationary noisy equipment (such as compressors, pumps, and generators) could be located as far as practicable from sensitive receptors.

4.7.2.3 Operation

Wherever there are sensitive receptors, as identified in the preconstruction survey, noise from operations should be managed to the extent necessary to mitigate adverse impacts on the sensitive receptors. Efforts to mitigate these impacts could include the following measures:

- A noise complaint manager could be designated to handle noise complaints from the public. This employee could have the responsibility and authority to convene a committee to investigate noise complaints, determine the causes of the noise leading to the complaints, and recommend mitigation measures.

- Noisy equipment (such as compressors, pumps, and generators) could be required to incorporate noise-reduction features such as acoustic enclosures, mufflers, silencers, and intake noise suppression.

- Facilities could be required to demonstrate compliance with the EPA's 55-dBA guideline at the nearest human sensitive receptor. Sensitive ecological receptors and appropriate associated lower noise levels could also be considered. In special areas where quiet and solitude have been identified as a value of concern, a demonstration that a lower noise level would be attained might be required. Such demonstrations might require use of additional or different criteria such as audibility.

- Based on the specific site, maintenance of off-site noise at suitable levels might require establishment of an activity-free buffer inside the fence line.

- Facility design could include all feasible noise-reduction methods, including, but not limited to, the mounting of equipment on shock absorbers; use of mufflers or silencers on air intakes, exhausts, blowdowns, and vents; noise barriers; noise-reducing enclosures; use of noise-reducing doors and windows; sound-reducing pipe lagging; and low-noise ventilation systems.

- Where feasible, facility design could be required to incorporate low-noise systems such as ventilation systems, pumps, generators, compressors, and fans.

4.8 ECOLOGICAL RESOURCES

4.8.1 Common Impacts

4.8.1.1 Aquatic Resources

Impacts on aquatic resources from the operation of oil shale projects could occur because of (1) direct disturbance of aquatic habitats within the footprint of construction or operation activities; (2) sedimentation of nearby aquatic habitats as a consequence of soil erosion from operational areas; (3) changes in water quantity or water quality as a result of construction (e.g., grading that affects surface runoff patterns), operations (e.g., depletions or discharges of water into nearby aquatic habitats), or releases of chemical contaminants into nearby aquatic systems. These impacts could occur to some degree during the construction period and throughout the operational life of the projects. In addition, some impacts could continue to occur beyond the operational life of the project. Potential impacts on aquatic resources from various factors associated with oil shale development are discussed below and are summarized in Table 4.8.1-1. The potential magnitudes of the impacts that could result from oil shale development are presented separately for aquatic invertebrates and for fish. Potential impacts on federally listed, state-listed, and BLM-designated sensitive aquatic species are presented in Section 4.8.1.4, and potential impacts on other types of organisms that could occur in aquatic habitats (e.g., amphibians and waterfowl) are presented in Section 4.8.1.3.

Depending on the characteristics of specific development projects, new aquatic habitats could be formed after site development. For example, over time, drainage patterns associated with sediment control ponds that caught runoff from disturbed surfaces could create habitats that would support aquatic plants and invertebrates as well as fish. Although the development of such habitats could be beneficial in some instances, their ecological value would depend on the amount of habitat created and the types and numbers of species supported. In general, it is anticipated that the ecological value of these created habitats would be limited. Habitats that promote the survival and expansion of non-native aquatic species that compete with or prey upon native species could have negative ecological impacts on existing aquatic habitats.

Turbidity and sedimentation from erosion are part of the natural cycle of physical processes in water bodies, and most populations of aquatic organisms have adapted to short-term changes in these parameters. However, if sediment loads are unusually high or last longer than they would under natural conditions, adverse impacts could occur (Waters 1995). Increased sediment loads could suffocate aquatic vegetation, invertebrates, and fish; decrease the rate of photosynthesis in plants and phytoplankton; decrease fish feeding efficiency; decrease the levels of invertebrate prey; reduce fish spawning success; and adversely affect the survival of incubating fish eggs, larvae, and fry (Waters 1995). The addition of fine sediment to aquatic systems is considered a major factor in the degradation of stream fisheries (Waters 1995). Thus, although the organisms in many aquatic systems are capable of coping with smaller, short-term increases in sediment loads, exceeding (largely unmeasured) threshold levels or durations would be expected to have detrimental effects on the affected aquatic ecosystems.

TABLE 4.8.1-1 Potential Impacts on Aquatic Resources Resulting from Commercial Oil Shale Development

	Potential Magnitude of Impacts According to Organism Group[a]	
Impact Category	Aquatic Invertebrates	Fish
Sedimentation from runoff	Large	Large
Water depletions	Large	Large
Changes in drainage patterns	Small	Small
Disruption of groundwater flow patterns	Moderate	Moderate
Temperature increases in water bodies	Moderate	Moderate
Increases in salinity	Small	Small
Introduction of nutrients	Small	Small
Oil and contaminant spills	Moderate	Large
Movement/dispersal blockage	Small	Small
Increased human access	Small	Small

[a] Potential impact magnitude (without mitigation) is presented as none, small, moderate, or large. A small impact is one that is limited to the immediate project area, affects a relatively small proportion of the local population (less than 10%), and does not result in a measurable change in carrying capacity or population size in the affected area. A moderate impact could extend beyond the immediate project area, affect an intermediate proportion of the local population, and result in a measurable but moderate change (less than 30%) in carrying capacity or population size in the affected area. A large impact would extend beyond the immediate project area, could affect more than 30% of a local population, and result in a large measurable change in carrying capacity or population size in the affected area.

The potential for soil erosion and sediment loading of nearby aquatic habitats is proportional to the amount of surface disturbance, the condition of disturbed areas at any given time, and the proximity to aquatic habitats. The presence of riparian vegetation buffers along waterways helps control sedimentation in waterways because it reduces erosion by binding soil, due to the presence of root systems, and by dissipating the water energy of surface runoff during high flow events. Vegetation also helps to trap sediment contained in surface runoff. Consequently, oil shale development activities that affect the presence or abundance of riparian vegetation would be expected to increase the potential for sediment to enter adjacent streams, ponds, and reservoirs. Because fine sediments may not quickly settle out of solution, impacts of sediment introduction to stream systems could extend downstream for considerable distances.

It is anticipated that areas being actively disturbed during construction or operations would have a higher erosion potential than areas that are undergoing reclamation activities, and that reclamation areas would become less prone to erosion over time because of completion of site grading and reestablishment of vegetated cover. Assuming that reclamation activities are successful, restored areas should eventually become similar to natural areas in terms of erosion potential. In addition to areas directly affected by construction and operations, surface disturbance could occur as a result of the development of access roads, utility corridors, and employer-provided housing. Implementation of measures to control erosion and runoff into aquatic habitats (e.g., silt fences, retention ponds, runoff-control structures, and earthen berms) would reduce the potential for impacts from increased sedimentation.

Changes in flow patterns of streams and depletion of surface water within oil shale development areas could affect the quality of associated aquatic habitats and the survival of populations of aquatic organisms within affected bodies of water. Most obviously, perhaps, complete dewatering of streams or stream segments would preclude the continued presence of aquatic communities within the affected areas. However, changes in flows and flow patterns could affect the nature of the aquatic communities that are supported even if there is not complete dewatering. Reductions in flow levels can result in depth changes and reductions in water quality (e.g., water temperatures and dissolved oxygen levels) that some species of fish and invertebrates may be unable to tolerate. Reduced depths can also affect the susceptibility of some fish species to predation from avian and terrestrial predators. Depending upon the magnitude of the water depletion in a particular waterway, aquatic habitat in all downstream portions of a watershed could be affected. Water depletions in the Colorado River Basin are of particular concern to native fish in the basin, including the four endangered Colorado River Basin fish species (humpback chub, razorback sucker, Colorado pikeminnow, and bonytail). As identified in Section 4.8.1.4, any water depletions from the upper Colorado River Basin are considered an adverse effect on endangered Colorado River fishes.

Aquatic organisms have specific temperature ranges within which survival is possible, and exceeding those temperatures, even for short periods, can result in mortality. In addition, aquatic organisms such as fish and macroinvertebrates use oxygen dissolved in the water to breathe, and if dissolved oxygen levels fall below the tolerances of those organisms, they will be unable to survive unless there are areas with suitable conditions nearby. The level of dissolved oxygen in water is highly dependent on temperature, and the amount of oxygen that can dissolve in a given volume of water (i.e., the saturation point) is inversely proportional to the temperature of water. Thus, with other chemical and physical conditions being equal, the warmer the water, the less dissolved oxygen it can hold. In the arid regions where the oil shale deposits described in this PEIS are found, surface water temperatures during hot summer months can approach lethal limits, and the resulting depressed dissolved oxygen levels are often already near the lower limits for many of the aquatic species that are present, especially in some of the smaller streams. Consequently, increasing water temperatures even slightly may, in some cases, adversely affect survival of aquatic organisms such as fish and mussel species in the affected waterways.

Oil shale development activities could affect water temperatures through removal of surface vegetation, especially riparian vegetation, and by reducing streamflows or inputs of cooler groundwater into nearby waterways due to water depletions. Removing vegetation alters the amount of shading of the earth's surface and increases the temperature of overlying waters or surface water runoff. Fish typically avoid elevated temperatures by moving to areas of groundwater inflow, to deeper holes, or to shaded areas where water temperatures are lower. If temperatures exceed thermal tolerances for extended periods and no refuge is available, fish kills may result. The level of thermal impact associated with clearing of riparian vegetation would be expected to increase as the amount of affected shoreline increases. The potential for water depletions to affect surface water temperatures by depressing groundwater flows is not easily predicted, although as the proportion of groundwater discharge decreases, surface water temperatures during critical summer months would be expected to increase.

As identified in Section 4.5.1.1, surface disturbance in the oil shale areas could also negatively affect water quality by increasing the salinity of surface waters in downstream areas. Depending upon the existing salinity levels and the types of aquatic organisms present in receiving waters, such increases could affect species composition in affected areas. The potential for surface disturbance to increase salinity levels in surface waters would decrease as the distance between disturbed areas and waterways increases (Section 4.5.1.1). Once salts have entered waterways, they are not generally removed from solution. Consequently, salinity tends to increase with increasing downstream distance in a watershed, representing the accumulation of salt from many different sources. Section 4.5.3 identifies a number of potential mitigation measures that could be implemented to reduce the potential for negative effects on water quality from salinity arising from oil shale development.

Nutrients (especially dissolved nitrogen and phosphorus) are required in small quantities for the growth and survival of aquatic plants. When the levels of nutrients become excessive, plant growth and decay are promoted. This, in turn, may favor the survival of certain weedy species over others and may result in severe reductions in water quality aspects such as oxygen levels. As discussed in Section 4.11, oil shale development would be expected to result in increases in human populations within the immediate area of specific developments and within the region as a whole. If these population increases resulted in increased nutrient loading of streams due to additional inputs from sewage treatment facilities, survival of some aquatic species could be affected and changes in biodiversity could result. Depending upon the magnitude of nutrient inputs, aquatic habitat in extended downstream portions of a watershed could be affected. The loss of native freshwater mussel species in some aquatic systems has been partially attributed to increases in nutrient levels (Natural Resources Conservation Service and Wildlife Habitat Council 2007). Because the water quality of effluents from such facilities is typically regulated under permits issued by state agencies, negative impacts on aquatic systems from increases in nutrient levels are expected to be small.

Contaminants could enter aquatic habitats as a result of leachate runoff from exposed oil shale; the accidental release of fuels, lubricants, or pesticides; or spills from pipelines. Spent shale remaining on the surface could become a chronic source of contaminated runoff unless adequate containment measures are implemented or unless it is transported off-site for disposal. Oil shale development would be subject to stormwater management permits and the application of BMPs that would control the quality and quantity of runoff. Chronic exposure to the leachate from spent oil shale has been shown to reduce the survival of some fish and invertebrate species if the concentrations are high enough (Woodward et al. 1997). Because the resulting concentrations in aquatic habitats would depend largely on the dilution capability, and, therefore, the flow of the receiving waters, impacts would be more likely if runoff entered small perennial streams than if it entered larger streams.

Toxic materials (e.g., fuel, lubricants, and herbicides) could also be accidentally introduced into waterways during construction and maintenance activities or as a result of leaks from pipelines. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. In general, lubricants and fuel would not be expected to enter waterways as long as heavy machinery is not used in or near waterways, fueling locations for construction and maintenance equipment are situated away from the waterway, and measures are taken to control potential spills. Because tanker trucks are often used to transport petroleum production from collection sites, there is a potential for roadway accidents to release toxicants into adjacent streams. Such releases could result in substantial mortality of fish and other aquatic biota.

In areas where access roads, pipelines, or utility corridors cross streams, obstructions to fish movement could occur if culverts, low-water crossings, or buried pipelines are not properly installed, sized, or maintained. During periods of low water, vehicular traffic can result in rutting and accumulation of cobbles in some crossings that can interfere with fish movements. In streams with low flows, flow could become discontinuous if disturbance of the streambed during construction activities results in increased porosity or if alteration of the channel spreads flows across a wider area. Restrictions on fish movement would likely be most severe if they occur in streams that support species that need to move to specific areas in order to reproduce.

In addition to the potential for the direct impacts identified above, indirect impacts on fisheries could occur as a result of increased public access to remote areas via newly constructed access roads and utility corridors. Fisheries could be impacted by increased fishing pressure, and other human activities (e.g., OHV use) could disturb riparian vegetation and soils, resulting in erosion, sedimentation, and potential impacts on water quality, as discussed above. Such impacts would be smaller in locations where existing access roads or utility corridors that already provide access to waterways would be utilized. Oil shale development also has the potential to affect fishing pressure in locations outside the immediately affected watershed if the development results in a loss of current fishing opportunities, either because developed locations become unavailable or because development results in decreases in catchable fish within adjacent or downstream areas. In such cases, displaced anglers could utilize nearby reservoirs or other streams or rivers, resulting in greater exploitation of fishery resources in those waterways. If water depletions associated with oil shale development affect water storage within reservoirs in nearby areas, fishing opportunities in those reservoirs could be affected.

4.8.1.2 Plant Communities and Habitats

Potential impacts on terrestrial and wetland plant communities and habitats from activities associated with oil shale development would include direct and indirect impacts. Impacts would be incurred during initial site preparation and continue throughout the life of the project, extending over a period of several decades. Some impacts may also continue beyond the termination of shale oil production. The potential magnitude of the impacts that could result from oil shale development is presented for different habitat types in Table 4.8.1-2.

TABLE 4.8.1-2 Potential Impacts on Plant Communities Resulting from Commercial Oil Shale Development

	Potential Magnitude of Impacts According to Habitat Type[a]	
Impact Category	Upland Plants	Wetland and Riparian Plants
Vegetation clearing	Large	Large
Habitat fragmentation	Moderate	Moderate
Dispersal blockage	Moderate	Moderate
Alteration of topography	Moderate	Large
Changes in drainage patterns	Moderate	Large
Erosion	Large	Large
Sedimentation from runoff	Large	Large
Oil and contaminant spills	Moderate	Large
Fugitive dust	Moderate	Moderate
Injury or mortality of individuals	Large	Large
Human collection	Moderate	Moderate
Increased human access	Moderate	Moderate
Fire	Large	Large
Spread of invasive plant species	Large	Large
Air pollution	Moderate	Moderate
Water depletions	Small	Large
Disruption of groundwater flow patterns	Small	Moderate
Temperature increases in water bodies	None	Moderate

[a] Potential impact magnitude (without mitigation) is presented as none, small, moderate, or large. A small impact is one that is limited to the immediate project area, affects a relatively small proportion of a plant community or local species population (less than 10%), and does not result in a measurable change in community characteristics or population size in the affected area. A moderate impact could extend beyond the immediate project area, affect an intermediate proportion of a plant community or local species population (10 to 30 %), and result in a measurable but moderate (not destabilizing) change in community characteristics or population size in the affected area. A large impact would extend beyond the immediate project area, could affect more than 30% of a plant community or local species population, and result in a large, measurable, and destabilizing change in community characteristics or population size in the affected area.

Direct impacts would include the destruction of habitat during initial land clearing on the lease site, as well as habitat losses resulting from the construction of ancillary facilities such as access roads, pipelines, transmission lines, and employer-provided housing, as well as the construction of new power plants for in situ facilities. Land clearing on the site would be required for construction of processing facilities, storage areas for soil and spent shale, and excavation areas. Land clearing would also occur incrementally throughout the life of the project, resulting in continued losses of habitat. Native vegetation communities present in project areas would be destroyed and may include rare communities and remnant vegetation associations. Storage of woody vegetation cleared from project areas would impact additional areas of vegetation. E.O. 11990, "Protection of Wetlands," requires all federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands (U.S. President 1977). Impacts on jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404, and the USACE) on or near the project site or locations of ancillary facilities would be avoided or mitigated. Preconstruction surveys would identify wetland locations and boundaries, and the permitting process would be initiated with the USACE for unavoidable impacts.

Reclamation of impacted areas would include reestablishment of vegetation on restored soils. Although revegetation of disturbed soils may successfully establish a productive vegetation cover, with biomass and species richness similar to local native communities, the resulting plant community may be quite different from native communities in terms of species composition and the representation of particular vegetation types, such as shrubs (Newman and Redente 2001). Revegetation of spent shale covered with a topsoil layer may also potentially result in a productive species-rich native plant community (Sydnor and Redente 2000). Community composition of revegetated areas would likely be greatly influenced by the species that are initially seeded, particularly perennial grasses, and colonization by species from nearby native communities may be slow (Paschke et al. 2005; Newman and Redente 2001; Sydnor and Redente 2000). The establishment of mature native plant communities may require decades. Successful reestablishment of some vegetation types, such as shrubland communities or stabilized sand dunes, may be difficult and would require considerable periods of time, likely more than 20 years (BLM 2004a). Restoration of plant communities in areas with arid climates (generally averaging less than 9 in. of annual precipitation), such as the Uinta Basin Floor ecoregion in Utah and portions of the Rolling Sagebrush Steppe and Salt Desert Shrub Basins ecoregions in Wyoming, would be especially difficult (Monsen et al. 2004) and may be unsuccessful. The loss of intact native plant communities could result in increased habitat fragmentation, even with the reclamation of impacted areas.

Disturbed soils may provide an opportunity for the introduction and establishment of non-native invasive species. Seeds or other propagules of invasive species may be inadvertently brought to a project site from infested areas by heavy equipment or other vehicles used at the site. Invasive species may also colonize disturbed soils from established populations in nearby areas. Important invasive species on disturbed lands include Russian thistle (*Salsola kali*), Russian knapweed (*Centaurea repens*), cheatgrass (*Bromus tectorum*), halogeton (*Halogeton glomeratus*), and Canada thistle (*Cirsium arvense*). The establishment of invasive species may greatly reduce the success of establishment of native plant communities during reclamation of project areas and create a source of future colonization and subsequent degradation of adjacent undisturbed areas. In addition, the planting of non-native species in reclamation areas may result in the introduction of those species into nearby natural areas. The establishment of invasive species may alter fire regimes, including an increase in the frequency and intensity of wildfires, particularly from the establishment of annual grasses such as cheatgrass. Native species, particularly shrubs, that are not adapted to frequent or intense fires may be adversely affected and their populations may be reduced.

Indirect impacts on terrestrial and wetland habitats on or off the project site could result from land clearing and exposed soil; soil compaction; and changes in topography, surface drainage, and infiltration characteristics. Impacts on surface water and groundwater systems, which subsequently affect terrestrial plant communities, wetlands, and riparian areas, are described in Section 4.5. Deposition of fugitive dust, including associated salts, generated during clearing and grading, construction, and use of access roads, or resulting from wind erosion of exposed soils, could reduce photosynthesis and productivity in plants near project areas, and could result in foliar damage. Plant community composition could subsequently be altered, resulting in habitat degradation. In addition, pollinator species could be affected by fugitive dust (Section 4.8.1.3), potentially reducing pollinator populations in the vicinity of an oil shale project. Temporary, localized effects on plant populations and communities could occur if seed production in some plant species is reduced. Soil compaction could reduce the infiltration of precipitation or snowmelt and, along with reduced vegetation cover, result in increased runoff and subsequent erosion and sedimentation. Reduced infiltration and altered surface runoff and drainage characteristics could result in changes in soil moisture characteristics, reduced recharge of shallow groundwater systems, and changes in the hydrologic regimes of downgradient streams and associated wetlands and riparian areas. Soils on steep slopes could be particularly susceptible to increased erosion resulting from changes in stormwater flow patterns.

Erosion and reductions in soil moisture could alter affected terrestrial plant communities adjacent to project activities, resulting in reduced growth and reproduction. Altered hydrologic regimes—particularly reductions in the duration, frequency, or extent of inundation or soil saturation, potentially resulting from elimination of ephemeral or intermittent streams—could result in species or structural changes in wetland or riparian communities, changes in distribution, or reduction in community extent. Increased volume or velocities of flows could impact wetland and riparian habitats, removing fine soil components, organic materials, and shallow rooted plants. Large-scale surface disturbance that reduces infiltration may increase flow fluctuations, reduce base flows, and increase flood flows, resulting in impacts on wetland and riparian community composition and extent. Sedimentation, and associated increases in dissolved salts, could degrade wetland and riparian plant communities. Effects may include reduced growth or mortality of plants, altered species composition, reduced biodiversity, or, in areas of heavy sediment accumulation, a reduction in the extent of wetland or riparian communities. Disturbance-tolerant species may become dominant in communities impacted by these changes in hydrology and water quality. Increased sedimentation, turbidity, or other changes in water quality may provide conditions conducive to the establishment of invasive species.

Alterations of groundwater flow or quality in project areas, such as during shale extraction, may impact wetlands and riparian areas that directly receive groundwater discharge, such as at springs or seeps, or occur in streams with flows maintained by groundwater. Wetlands and riparian communities miles downgradient from shale extraction or retorting activities may be affected by reduced flows or reduced water quality. Flow reductions in alluvial aquifers from shale extraction, water withdrawals, or pipeline installation may also result in reductions in wetland or riparian communities associated with streams receiving alluvial aquifer discharge or in changes in community composition. Water withdrawals from surface water features, such as rivers and streams, may reduce flows and water quality downstream. Reduced flows and water quality may reduce the extent or distribution of wetlands and riparian areas along these water bodies or degrade these plant communities. The construction of reservoirs may also impact downstream wetlands and riparian areas by reducing flows and sediment transport and increasing salt loading.

Plant communities and habitats could be adversely affected by impacts on water quality, resulting in plant mortality or reduced growth, with subsequent changes in community composition and structure, and declines in habitat quality. Leachate from spent shale or overburdened stockpiles may adversely affect terrestrial, riparian, or wetland plant communities as a result of impacts on surface water or groundwater quality. Produced water from shale retorting or saline water pumped from lower aquifers, if discharged on the land surface, may result in impacts on terrestrial, riparian, or wetland communities because of reduced water quality. Herbicides used in ROW maintenance could be carried to wetland and riparian areas by surface runoff or may be carried to nearby terrestrial communities by air currents. Impacts on surface water quality from deposition of atmospheric dust or pollutants from equipment exhaust or power plant operation could degrade terrestrial, wetland, and riparian habitats. Accidental spills of chemicals, fuels, or oil would adversely impact plant communities. Direct contact with contaminants could result in mortality of plants or degradation of habitats. Spills could impact shallow groundwater quality and indirectly affect terrestrial plants contacting shallow groundwater.

Oil shale endemic species would be potentially subject to the direct and indirect impacts described above. Habitats occupied by these species could be degraded or lost, and individuals could be destroyed. Local populations could be reduced or lost as a result of oil shale development activities. Establishment and long-term survival of these species on reclaimed land may be difficult. The potential introduction and spread of noxious weed species from project areas into the habitat of oil shale endemics could threaten local populations. In addition, the increased accessibility resulting from new roads could result in increased impacts from human disturbance or collection. Because of the generally small, scattered populations of oil shale endemics, impacts could result in greater consequences for these species than for commonly occurring species. However, many oil shale endemics are federally listed, state-listed, or BLM-designated sensitive species, and are protected by applicable federal or state regulations and agency policies. Those endemics that occur within ACECs would likely have some protection by RMP stipulations to avoid or minimize impacts on sensitive species and their habitats.

4.8.1.3 Wildlife (Including Wild Horses and Burros)

All oil shale leasing projects that would be constructed and operated have the potential to affect wildlife, including wild horses (*Equus caballus*) and burros (*E. asinus*), over a period of several decades. Reclamation that would occur in parallel with or after extraction activities are completed would reduce or eliminate ongoing impacts to the extent practicable by recreating habitats and ecological conditions that could be suitable to wildlife species. The effectiveness of any reclamation activities would depend on the specific actions taken; the best results, however, would occur where original site topography, hydrology, soils, and vegetation patterns could be reestablished. However, as discussed in Section 4.8.1.2, this may not be possible under all situations.

The following discussion provides an overview of the potential impacts on wildlife that could occur from the construction and operation of an oil shale project. The use of mitigation measures and standard operating procedures (e.g., predisturbance surveys, erosion and dust suppression control practices, establishment of buffer areas, reclamation of disturbed areas using native species, and netting of on-site ponds) would minimize impacts on wildlife species and their habitats. The specifics of these practices would be established through consultations with federal and state agencies and other stakeholders.

Impacts on wildlife from oil shale projects could occur in a number of ways and are related to (1) habitat loss, alteration, or fragmentation; (2) disturbance and displacement; (3) mortality; and (4) increase in human access. These impacts can result in changes in habitat use; changes in behavior; collisions with structures or vehicles; changes in predator populations; and chronic or acute toxicity from hydrocarbons, herbicides, or other contaminants.

Wildlife may also be affected by human activities that are not directly associated with the oil shale project or its workforce, but that are instead associated with the potentially increased access to BLM-administered lands that had previously received little use. The construction of new access roads or improvements to old access roads may lead to increased human access into the area. Potential impacts associated with increased access include (1) the disturbance of wildlife from human activities, including an increase in legal and illegal take and an increase of invasive vegetation, (2) an increase in the incidence of fires, and (3) increased runoff that could adversely affect riparian or other wetland areas that are important to wildlife.

Wildlife impacts from the impacting factors discussed below are summarized in Table 4.8.1-3. The potential magnitude of the impacts that could result from oil shale development is presented for representative wildlife species types. Impacts are designated as small, moderate, or large. A small impact is one that is limited to the immediate project area, affects a relatively small proportion of the local population (less than 10%), and does not result in a measurable change in carrying capacity or population size in the affected area. A moderate impact could extend beyond the immediate project area, affect an intermediate proportion of the local population, and result in a measurable but moderate change (less than 50%) in carrying capacity or population size in the affected area. A large impact would extend beyond the immediate project area, could affect more than 50% of a local population, and result in a large measurable change (50% or more) in carrying capacity or population size in the affected area.

4.8.1.3.1 Habitat Disturbance. The reduction, alteration, or fragmentation of habitat would result in a major impact on wildlife. Habitats within the construction footprint of the projects, utility ROWs, access roads, and other infrastructure would be destroyed or disturbed. The amount of habitat impacted would be a function of the current degree of disturbance already present in the project site area. With certain exceptions, areas lacking vegetation (e.g., operational areas, access roads, and active portions of oil shale mining) provide minimal habitat. The construction of the projects would not only result in the direct reduction or alteration

TABLE 4.8.1-3 Potential Impacts on Wildlife Species Resulting from Commercial Oil Shale Development

Impact Category	Potential Magnitude of Impacts According to Species Type[a]						
	Amphibians and Reptiles	Shorebirds and Waterfowl	Landbirds	Raptors	Small Game and Nongame Mammals	Big Game Mammals	Wild Horses and Burros
Vegetation clearing	Large	Small	Large	Large	Large	Large	Large
Habitat fragmentation	Large	Small	Moderate	Moderate	Large	Large	Large
Movement/dispersal blockage	Large	Small	Small	Small	Large	Large	Large
Alteration of topography	Small	Small	Small	Small	Small	Small	Small
Water depletions	Large	Large	Moderate	Moderate	Moderate	Moderate	Moderate
Erosion and sedimentation	Moderate	Small	Small	Small	Small	Small	Small
Contaminant spills	Small	Small	Small	Small	Small	Small	Small
Fugitive dust	Small	Small	Small	Small	Small	Small	Small
Injury or mortality	Moderate	Moderate	Large	Moderate	Large	Large	Moderate
Collection	Moderate	Small	Small	Small	Small	Small	Small
Human disturbance/harassment	Small	Moderate	Large	Large	Large	Large	Large
Increases in predation rates	Moderate	Moderate	Moderate	Small	Moderate	Moderate	Small
Noise	Small	Large	Large	Large	Large	Large	Large
Spread of invasive plant species	Small	Small	Moderate	Moderate	Moderate	Small	Small
Air pollution	Small	Small	Small	Small	Small	Small	Small
Fire	Small	Small	Moderate	Small	Moderate	Small	Small

[a] Potential impact magnitude (without mitigation) is presented as small, moderate, or large. A small impact is one that is limited to the immediate project area, affects a relatively small proportion of the local population (less than 10%), and does not result in a measurable change in carrying capacity or population size in the affected area. A moderate impact could extend beyond the immediate project area, affect an intermediate proportion of the local population (10 to 30%), and result in a measurable but moderate (not destabilizing) change in carrying capacity or population size in the affected area. A large impact would extend beyond the immediate project area, could affect more than 30% of a local population, and result in a large, measurable, and destabilizing change in carrying capacity or population size in the affected area.

of wildlife habitat within the project footprint but could also affect the diversity and abundance of area wildlife through habitat fragmentation. Habitat fragmentation causes both a loss of habitat and habitat isolation.

A decline in wildlife use near roads or other facilities would be considered an indirect habitat loss. Avoidance of habitat associated with roads has been reported to be 2.5 to 3.5 times as great as the actual habitat loss associated with the road's footprint (Reed et al. 1996). Mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) may avoid areas up to 0.25 mi from a project area (BLM 2006b). Similarly, bird nesting may be disrupted within 0.25 mi of construction activities during the nesting and brooding periods (e.g., February 1 to August 25) (BLM 2006e). Road avoidance by wildlife could be greater in open landscapes compared with forested landscapes (Thomson et al. 2005). Mule deer use declined within 2.7 to 3.7 km of gas well pads, suggesting that indirect habitat loss can be larger than direct habitat loss (Sawyer et al. 2006). Density of sagebrush obligates, particularly Brewer's sparrow (*Spizella breweri*) and sage sparrow (*Amphispiza belli*), was reduced 39 to 60% within a 100-m buffer around dirt roads with low traffic volumes. The declines may have been due to a combination of traffic, edge effects, habitat fragmentation, and increases in other passerine species along road corridors. Thus, declines may persist until roads are fully reclaimed (Ingelfinger and Anderson 2004). Those individuals that make use of areas within or adjacent to project areas could be subjected to increased physiological stress. This combination of avoidance and stress reduces the capability of wildlife to use habitat effectively (WGFD 2004). As noise and human presence are reduced (e.g., as may occur from the switch from construction to operation), wildlife may increase their use of otherwise suitable habitats, although probably not at the same levels as before disturbance initially began (BLM 2006c).

Some species such as the common raven (*Corvus corax*) are more abundant along roads because of automobile-generated carrion, whereas ravens and other raptors are more common along transmission lines because of the presence of perch and nest sites (Knight and Kawashima 1993).

Displaced animals would likely have lower reproductive success because nearby areas are typically already occupied by other individuals of the species that would be displaced (Riffell et al. 1996). Increasing the concentration of wildlife in an area may result in a number of adverse effects, including potential mortality of the displaced animals from depletion of food sources, increased vulnerability to predators, increased potential for the propagation of diseases and parasites, increased intra- and interspecies competition, and increased potential for poaching.

Long-term displacement of elk, mule deer, pronghorn (*Antilocapra americana*), or other species from critical (crucial) habitat because of habitat disturbance would be considered significant (BLM 2004a). For example, activities around parturition areas have the potential to decrease the usability of these areas for calving and fawning. An oil shale project located within a crucial winter area could directly reduce the amount of habitat available to the local population. This placement could force the individuals to use suboptimal habitat, which could lead to debilitating stress. Habitat loss and associated decrease in raptor prey base could increase the foraging area necessary to support an individual and/or decrease the number of foraging raptors an area could support (BLM 2006c). With decreasing availability of forbs and grasses, greater sage-grouse (*Centrocercus urophasianus*) broods could move longer distances and expend more energy to find forage. Increased movement, in addition to decreased vegetative cover, could expose chicks to greater risk of predation (BLM 2006c). More detailed information about how greater sage-grouse may be impacted by oil shale development, including information about possible measures to mitigate impacts, is provided in the following text box.

Water needs for construction and operation could lead to localized to regional water depletions depending on local conditions, process methods, and number of leases developed. Water depletions can be expressed in a number of ways ranging from decreases in soil moisture, reduced flow of springs and seeps, loss of wetlands, and drawdowns of larger rivers and streams. A number of direct and indirect impacts on wildlife can result from water depletions. These include reduction and degradation of habitat; reduction in vegetative cover, forage, and drinking water; attraction to human habitations for alternative food sources; increase in stress, disease, insect infestations, and predation; alterations in migrations and concentrations of wildlife; loss of diversity; reduced reproductive success and declining populations; increased competition with livestock; and increased potential for fires (IUCNNR 1998; UDWR 2006).

Potential impacts on waterfowl and shorebirds could primarily occur from impacts on habitat or changes in habitat. Construction could cause short-term changes in water quality resulting from increases in siltation and sedimentation related to ground disturbance. Long-term impacts could result from habitat alterations (i.e., changing forested wetlands to scrub-shrub and emergent wetlands within the ROWs). This alteration could have a slight beneficial impact on most waterfowl and shorebird species.

The presence of an oil shale project and associated facilities could disrupt movements of wildlife, particularly during migration. Migrating birds would be expected to simply fly over the project and continue their migratory movement. However, herd animals, such as elk, deer, and pronghorn, could potentially be affected if the corridor segments transect migration paths between winter and summer ranges or in calving areas. The utility corridor segments would be maintained as areas of low vegetation that may hinder or prevent movements of some wildlife species. It is foreseeable that utility corridor segments may be used for travel routes by big game if they lead in the direction of their normal migrations.

Migration corridors are vulnerable, particularly at pinch points where physiographic constrictions force herds through relatively narrow corridors (Berger 2004). Loss of habitat continuity along migration routes would severely restrict the seasonal movements necessary to maintain healthy big game populations (Sawyer and Lindsay 2001; Thomson et al. 2005). Any activity or landscape modification that prevents the use of migration corridor constrictions (migration bottlenecks or pinch points) could effectively reduce the use of habitats either above or below the constriction (BLM 2004b). As summarized by Strittholt et al. (2000), roads have been shown to impede the movements of invertebrates, reptiles, and small and large mammals. For large mammals, blockages of a route between foraging or bedding areas and watering areas could cause the animals to abandon a larger habitat area altogether (BLM 2004b). High snow embankments as a result of plowing can greatly influence the mobility of wildlife such as moose (*Alces alces*) (WGFD 2004). Barriers to movement that prevent snakes from accessing wintering

Oil Shale Leasing and the Greater Sage-Grouse

Most concerns about the effects of oil shale development on greater sage-grouse (*Centrocercus urophasianus*) have focused on potential impacts associated with the reduction, fragmentation, and modification of grassland and shrubland habitats.

Populations of greater sage-grouse can vary from nonmigratory to migratory (having either one-stage or two-stage migrations) and can occupy an area that exceeds 1,040 mi^2 on an annual basis. The distance between leks (strutting grounds) and nesting sites can exceed 12 mi (Connelly et al. 2000; Bird and Schenk 2005). Nonmigratory populations can move 5 to 6 mi between seasonal habitats and have home ranges of up to 40 mi^2. The distance between summer and winter ranges for one-stage migrants can be 9 to 30 mi apart. Two-stage migrant populations make movements among breeding habitat, summer range, and winter range. Their annual movements can exceed 60 mi. The migratory populations can have home ranges that exceed 580 mi^2 (Bird and Schenk 2005). However, the greater sage-grouse has a high fidelity to a seasonal range. They also return to the same nesting areas annually (Connelly et al. 2000, 2004).

The greater sage-grouse needs contiguous, undisturbed areas of high-quality habitat during its four distinct seasonal periods: (1) breeding, (2) summer-late brooding and rearing, (3) fall, and (4) winter (Connelly et al. 2000). The greater sage-grouse occurs at elevations ranging from 4,000 to 9,000 ft. It is omnivorous and consumes primarily sagebrush and insects. More than 99% of its diet in winter consists of sagebrush leaves and buds. Sagebrush is also important as roosting cover, and the greater sage-grouse cannot survive where sagebrush does not exist (USFWS 2004).

Leks are generally areas supported by low, sparse vegetation or open areas surrounded by sagebrush that provide escape, feeding, and cover. They can range in size from small areas of 0.1 to 10 acres to areas of 100 acres or more (Connelly et al. 2000). The lek/breeding period occurs March through May, with peak breeding occurring from early to mid-April. Nesting generally occurs 1 to 4 mi from lek sites, although it may range up to 11 mi (BLM 2004a). The nesting/early brood-rearing period occurs from March through July. Sagebrush at nesting/early brood-rearing habitat is 12 to 32 in. above ground, with 15 to 25% canopy cover. Tall, dense grass combined with tall shrubs at nest sites decreases the likelihood of nest depredation. Hens have a strong year-to-year fidelity to nesting areas (BLM 2004a). The late brood-rearing period occurs from July through October. Sagebrush at late brood-rearing habitat is 12 to 32 in. tall, with a canopy cover of 10 to 25% (BLM 2004a). The greater sage-grouse occupies winter habitat from November through March. Suitable winter habitat requires sagebrush 10 to 14 in. above snow level with a canopy cover ranging from 10 to 30%. Wintering grounds are potentially the most limiting seasonal habitat for greater sage-grouse (BLM 2004a).

While no single or combination of factors has been proven to have caused the decline in greater sage-grouse numbers over the past half-century, the decline in greater sage-grouse populations is thought to be caused by a number of factors, including drought, oil and gas wells and their associated infrastructure, power lines, predators, and a decline in the quality and quantity of sagebrush habitat (due to livestock grazing, range management treatments, and development activities) (Connelly et al. 2000; Crawford et al. 2004). West Nile virus is also a significant stressor of the greater sage-grouse (Naugle et al. 2004).

Loud, unusual sounds and noise from construction and human activities disturb greater sage-grouse, cause birds to avoid traditional use areas, and reduce their use of leks (Young 2003). Disturbance at leks appears to limit reproductive opportunities and may result in regional population declines. Most observed nest abandonment is related to human activity (NatureServe 2006). Thus, site construction, operation, and site-maintenance activities could be a source of auditory and visual disturbance to the greater sage-grouse.

Oil shale lease area facilities, transmission lines, pipelines, access roads, and employer-provided housing may adversely affect important greater sage-grouse habitats by causing fragmentation, reducing habitat value, or reducing the amount of habitat available (Braun 1998). Transmission lines, aboveground portions of pipelines,

Continued on next page.

and other structures can also provide perches and nesting areas for raptors and ravens that may prey upon the greater sage-grouse.

Measures that have been suggested for management of greater sage-grouse and their habitats (e.g., Paige and Ritter 1999; Connelly et al. 2000; WGFD 2003) that have pertinence to oil shale projects and associated facilities include the following:

- Identify and avoid both local (daily) and seasonal migration routes.
- Consider greater sage-grouse and sagebrush habitats when designing, constructing, and utilizing project access roads and trails.
- Avoid, when possible, siting energy developments in breeding habitats.
- Adjust the timing of activities to minimize disturbance to greater sage-grouse during critical periods.
- When possible, locate energy-related facilities away from active leks or near other greater sage-grouse habitat.
- When possible, restrict noise levels to 10 dB above background noise levels at lek sites.
- Minimize nearby human activities when birds are near or on leks.
- As practicable, do not conduct surface-use activities within crucial greater sage-grouse wintering areas from December 1 through March 15.
- Maintain sagebrush communities on a landscape scale.
- Provide compensatory habitat restoration for impacted sagebrush habitat.
- Avoid the use of pesticides at greater sage-grouse breeding habitat during the brood-rearing season.
- Develop and implement appropriate measures to prevent the introduction or dispersal of noxious weeds.
- Avoid creating attractions for raptors and mammalian predators in greater sage-grouse habitat.
- Consider measures to mitigate impacts at off-site locations to offset unavoidable greater sage-grouse habitat alteration and reduction at the project site.
- When possible, avoid establishing artificial water bodies (e.g., stormwater and liquid industrial wastewater ponds) that could serve as breeding habitat for mosquitoes.

The BLM manages more habitats for greater sage-grouse than any other entity; therefore, it has developed a National Sage-Grouse Habitat Conservation Strategy for BLM-administered public lands to manage public lands in a manner that will maintain, enhance, and restore greater sage-grouse habitat while providing for multiple uses of BLM-administered public lands (BLM 2004c). The strategy is consistent with the individual state greater sage-grouse conservation planning efforts. The purpose of this strategy is to set goals and objectives, assemble guidance and resource materials, and provide more uniform management directions for the BLM's contributions to the multistate greater sage-grouse conservation effort being led by state wildlife agencies (BLM 2004c). The BLM strategy includes guidance for (1) addressing sagebrush habitat conservation in BLM land use plans, and (2) managing sagebrush plant communities for greater sage-grouse conservation. This guidance is designed to support and promote the rangewide conservation of sagebrush habitats for greater sage-grouse and other sagebrush-obligate wildlife species on public lands administered by the BLM and presents a number of suggested management practices (SMPs). These SMPs include management or reclamation activities, restrictions, or treatments that are designed to enhance or restore sagebrush habitats. The SMPs are divided into two categories: (1) those that will help maintain sagebrush habitats (e.g., practices or treatments to minimize

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unwanted disturbances while maintaining the integrity of the sagebrush communities), and (2) those that will enhance sagebrush habitat components that have been reduced or altered (BLM 2004c).

SMPs that are or may be pertinent to energy transmission facilities include the following:

- Development of monitoring programs and adaptive management strategies.
- Control of invasive species.
- Prohibition or restriction of OHV activity.
- Consideration of greater sage-grouse habitat needs when developing reclamation plans.
- Avoidance of placing facilities in or next to sensitive habitats such as leks and wintering habitat.
- Location or construction of facilities so that facility noise does not disturb greater sage-grouse activities or leks.
- Consolidation of facilities as much as possible.
- Initiation of reclamation practices as quickly as possible following land disturbance.
- Installation of antiperching devices on existing or new power lines in occupied greater sage-grouse habitat.
- Design of facilities to reduce habitat fragmentations and mortality to greater sage grouse.

In addition to the BLM's national greater sage-grouse habitat conservation strategy, the Western Association of Fish and Wildlife Agencies has produced two documents that together comprise a Conservation Assessment for Greater Sage-Grouse. The first is the *Conservation Assessment of Greater Sage-Grouse and Sagebrush Habitats* (Connelly et al. 2004). The second document is the *Greater Sage-Grouse Comprehensive Conservation Strategy* (Stiver et al. 2006). In addition, state agencies have proposed statewide and, in some cases, regional greater sage-grouse conservation or management plans that include mitigation measures to minimize impacts on the species (e.g., Bohne et al. 2007; Colorado Greater Sage-Grouse Steering Committee 2008; The Southwest Wyoming Local Sage-Grouse Working Group 2007; Uinta Basin Adaptive Resource Management Local Working Group 2006; UDNR 2002; WGFD 2003).

dens or that isolate amphibian breeding pools from feeding areas could affect or even eliminate a population (BLM 2004b).

Larger and/or more mobile wildlife, such as medium-sized or large mammals and birds, would be most likely to leave an area that experiences habitat disturbance. Development of the site would represent a loss of habitat for these species, resulting in a long-term reduction in wildlife abundance and richness within the project area. A species affected by habitat disturbance may be able to shift its habitat use for a short period. For example, the density of several forest-dwelling bird species has been found to increase within a forest stand soon after the onset of fragmentation as a result of displaced individuals moving into remaining habitat (Hagan et al. 1996). However, it is generally presumed that the habitat into which displaced individuals move would be unable to sustain the same level of use over the long term (BLM 2004b). The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individual into the resident populations. If it is assumed that areas used by wildlife before development were preferred habitat, then an observed shift in distribution because of development would be toward less preferred and presumably less suitable habitats (Sawyer et al. 2006). Overcrowding of species such as mule deer in winter ranges can cause density-dependent effects such as increased fawn mortality (Sawyer et al. 2006).

Rather than being displaced, smaller animals such as small mammals, reptiles, and amphibians may be killed during clearing and construction activities. If land clearing and construction activities occurred during the spring and summer, bird nests and eggs or nestlings could be destroyed. Fossorial species could be crushed or buried by construction equipment.

The creation of edge habitat along the boundary between two habitats can (1) increase predation and parasitism of vulnerable forest or sagebrush interior animals in the vicinity of edges; (2) have negative consequences for wildlife by modifying their distribution and dispersal patterns; or (3) be detrimental to species requiring large undisturbed areas, because increases in edge are generally associated with concomitant reductions in habitat size and possible isolation of habitat patches and corridors (habitat fragmentation). Species that could benefit from the proposed utility or access road ROWs include those that prefer or require some open areas, edge habitat, and/or shrubs and small trees. Access roads through forested areas have been found to be positively correlated with bat activity since these areas can provide productive foraging areas and/or travel corridors (Zimmerman and Glanz 2000).

The utility and access road ROWs may hinder or prevent movements of some small mammals. In particular, species preferring heavy cover in forested areas may be adversely affected (Oxley et al. 1974; Forman and Alexander 1998). The degree to which roads serve as barriers to wildlife movement depends on traffic volume and speed, roadside vegetation, traditional movement patterns, and environmental factors motivating animal movement (e.g., predator avoidance).

Periodic removal of woody vegetation to maintain the ROW, particularly in forested areas, would maintain those sections of the ROW in an early stage of plant community succession that could benefit small mammals that use such habitats (e.g., hares) and their predators (e.g., bobcat [*Lynx rufus*]). Temporary growth of willows and other trees following brush cutting could benefit moose and other ungulates that use browse. Conversely, habitat maintenance would have localized adverse effects on species such as the red squirrel (*Tamiasciurus hudsonicus*), southern red-backed vole (*Myodes gapperi*), and American marten (*Martes americana*), which prefer late-successional or forested habitats (BLM 2002). Except where annual vegetation maintenance may be required over the pipelines to facilitate periodic corrosion and leak surveys, routine vegetation maintenance within a ROW segment conducted once every few years would lessen impacts on migratory bird species and other wildlife species that may make permanent use of the ROW segments. As ROWs become more densely vegetated toward the end of each maintenance cycle, bird species diversity would probably increase.

Overall, impacts on most wildlife species would be proportional to the amount of their specific habitats that are directly and indirectly lost and the duration of the loss (BLM 2006c). For example, impacts on mule deer would proportionally increase with the amount of crucial winter habitat that is disturbed. Project development within oil shale project areas could impact crucial winter and summer ranges for mule deer and elk; crucial lambing and rutting grounds and water sources for bighorn sheep (*Ovis canadensis*); substantial value habitat for pronghorn, black bear (*Ursus americanus*), and cougar (*Puma concolor*); portions of several wild horse and burro herds; yearlong, nesting, or strutting grounds for greater sage-grouse; and foraging habitat for raptors (BLM 1984a). Impacts on neotropical migrants that do not breed within the project area would be minor. Nonbreeders generally use riparian areas for feeding, and these areas would be minimally impacted by project construction and operation.

4.8.1.3.2 Wildlife Disturbance. Activities associated with construction and operation of an oil shale project may cause wildlife disturbance, including interference with behavioral activities. The response of wildlife to disturbance is highly variable and species specific. Intraspecific responses can also be affected by the physiological or reproductive condition of individuals; distance from disturbance; and the type, intensity, and duration of disturbance. Wildlife can respond to disturbance in various ways, including attraction, habituation, and avoidance (Knight and Cole 1991). All three behaviors are considered adverse. For example, wildlife may cease foraging, mating, or nesting or vacate active nest sites in areas where construction is occurring; some species may permanently abandon the disturbed areas and adjacent habitats. In contrast, wildlife such as bears, foxes, and squirrels readily habituate and may even be attracted to human activities, primarily when a food source is accidentally or deliberately made available. Human food wastes and other attractants in developed areas can increase the population of foxes, gulls, common ravens, and bears, which in turn prey on waterfowl and other birds.

Disturbance can reduce the relative habitat value for wildlife such as mule deer, especially during periods of heavy snow and cold temperatures. When wildlife are experiencing physiological stress, which requires higher levels of energy for survival and reproductive success, increased human presence can further increase energy expenditures that can lead to reduced survival or reproductive outcome. Furthermore, disturbance could prevent access to sufficient amounts of forage necessary to sustain individuals (BLM 2006d). Hobbs (1989) determined that mule deer doe mortality during a severe winter period could double if they were disturbed twice a day and caused to move a minimum of 1,500 ft per disturbance.

The average mean flush distance for several raptor species in winter was 118 m due to walk disturbance and 75 m due to vehicle disturbance (Holmes et al. 1993). Bighorn sheep have been reported to respond at a distance of 1,640 ft (500 m) from roads with more than one vehicle per day, while deer and elk response occurs at a distance of 3,280 ft (1,000 m) or more (Gaines et al. 2003). Snowmobile traffic was found to affect the behavior of moose located within 984 ft (300 m) of a trail and displaced them to less favorable habitats (Colescott and Gillingham 1998).

Mule deer will habituate to and ignore motorized traffic provided that the deer are not pursued (Yarmoloy et al. 1988). Harassment, an extreme type of disturbance caused by intentional actions to chase or frighten wildlife, generally causes the magnitude and duration of displacement to be greater. As a result, there is an increased potential for physical injury from fleeing and higher metabolic rates due to stress (BLM 2004b). Bears can be habituated to human activities, particularly moving vehicles, and these animals are more vulnerable to legal and illegal harvest (McLellan and Shackleton 1989). Wild horses and burros could also be impacted by increased encounters with vehicles. Noise and the presence of humans and vehicles could force herds to move to other areas. They would be most susceptible during spring foaling.

Disturbed wildlife can incur a physiological cost either through excitement (i.e., preparation for exertion) or locomotion. A fleeing or displaced animal incurs additional costs through loss of food intake and potential displacement to lower-quality habitat. If the disturbance becomes chronic or continuous, these costs can result in both reduced animal fitness and reproductive potential (BLM 2004b). Disturbance associated with a project would likely result in fewer nest initiations, increased nest abandonment and/or reproductive failure, and decreased productivity of successful nests (BLM 2006c). Factors that influence displacement distance include:

- Inherent species-specific characteristics,
- Seasonally changing threshold of sensitivity as a result of reproductive and nutritional status,
- Type of habitat (e.g., longer disturbance distances in open habitats),
- Specific experience of the individual or group,
- Weather (e.g., adverse weather such as wind or fog may decrease the disturbance),
- Time of day (e.g., animals are generally more tolerant during dawn and dusk), and
- Social structure of the animals (e.g., groups are generally more tolerant than solitary individuals) (BLM 2004b).

Regular or periodic disturbance could cause adjacent areas to be less attractive to wildlife and result in long-term reduction of wildlife use in areas exposed to a repeated variety of disturbances such as noise. Principal sources of noise would include vehicle traffic, operation of machinery, and blasting. The response of wildlife to noise would vary by species; physiological or reproductive condition; distance; and type, intensity, and duration of disturbance (BLM 2002). Wildlife response to noise can include avoidance, habituation, or attraction. Responses of birds to disturbance often involve activities that are energetically costly (e.g., flying) or affect their behavior in a way that might reduce food intake (e.g., shift away from a preferred feeding site) (Hockin et al. 1992). On the basis of a review of the literature by Hockin et al. (1992), the effects of disturbance on bird breeding and breeding success include reduced nest attendance, nest failures, reduced nest building, increased predation on eggs and nestlings, nest abandonment, inhibition of laying, increased absence from nest, reduced feeding and brooding, exposure of eggs and nestlings to heat or cold, retarded chick development, and lengthening of the incubation period. The most adverse impacts associated with noise could occur if critical life-cycle activities were disrupted (e.g., mating and nesting). For instance, disturbance of birds during the nesting season can result in nest or brood abandonment. The eggs and young of displaced birds would be more susceptible to cold or predators. Construction noise could cause a localized disruption to wild horses, particularly during the foaling season (BLM 2006b).

4.8.1.3.3 Noise. Much of the research on wildlife-related noise effects has focused on birds. This research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Reijnen and Foppen 1994; Foppen and Reijnen 1994; Larkin 1996). Several studies have examined the effects of continuous noise on bird populations, including the effects of traffic noise, coronal discharge along electric transmission lines, and gas compressors. Some studies (e.g., Reijnen and Foppen 1994, 1995; Foppen and Reijnen 1994; Reijnen et al. 1995, 1996, 1997) have shown reduced densities of a number of species in forest (26 of 43 species) and grassland (7 of 12 species) habitats adjacent to roads, with effects detectable from 66 to 11,581 ft from the roads. On the basis of these studies, Reijnen et al. (1996) identified a threshold effect sound level of 47 dBA for all species combined and 42 dBA for the most sensitive species; the observed reductions in population density were attributed to a reduction in habitat quality caused by elevated noise levels. This threshold sound level of 42 to 47 dBA (which is somewhat below the EPA-recommended limit for residential areas) is at or below the sound levels generated by truck traffic that would likely occur at distances of 250 ft or more from the construction area or access roads, or the levels generated by typical construction equipment at distances of 2,500 ft or more from the construction site.

Blast noise has been found to elicit a variety of effects on wildlife (Manci et al. 1988; Larkin 1996). Brattstrom and Bondello (1983) reported that peak sound pressure levels reaching 95 dB resulted in a temporary shift in hearing sensitivity in kangaroo rats, and that they required at least 3 weeks for the hearing thresholds to recover. The authors postulated that such hearing shifts could affect the ability of the kangaroo rat to avoid approaching predators. A variety of adverse effects of noise on raptors have been demonstrated, but in many cases, the effects were temporary, and the raptors became habituated to the noise (Andersen et al. 1989; Brown et al. 1999; Delaney et al. 1999).

4.8.1.3.4 Mortality or Injury. Construction, operation, maintenance, and reclamation activities would result in mortality of wildlife that are not mobile enough to avoid these activities (e.g., reptiles and amphibians, small mammals, and the young of other wildlife), that utilize burrows (e.g., ground squirrels and burrowing owls [*Athene cunicularia*]), or that are defending nest sites (such as ground-nesting birds). More mobile species of wildlife, such as deer and adult birds, may avoid direct impacts by moving into habitats in adjacent areas. However, it can be conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional biota from impacted areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individual into the resident populations.

The presence of the oil shale and ancillary facilities (e.g., buildings, transmission lines, elevated portions of the pipelines, and other ancillary facilities) would create a physical hazard to some wildlife. In particular, birds may collide with transmission lines and buildings, while mammals may collide with fences. However, collisions with oil shale facilities would probably be infrequent, as human activity and project-related noise would discourage wildlife presence in the immediate project area. An open pipeline trench can trap small animals and injure larger wildlife trying to cross it, particularly at night. Artificial lighting can potentially affect birds by providing more feeding time (i.e., by allowing nocturnal feeding) and by causing direct mortality or disorientation (Hockin et al. 1992). Areas of standing water (e.g., stormwater and liquid industrial waste ponds) could potentially provide habitat for mosquitoes that are vectors of West Nile virus, which is a significant stressor on sage-grouse and probably other at-risk bird species (Naugle et al. 2004).

Direct mortality from vehicle collisions would be expected to occur along new access roads, while increases in road mortality would occur along existing roads because of increased traffic volumes (e.g., associated with increased numbers of construction and operational personnel). Collision with vehicles can be a source of wildlife mortality, especially in wildlife concentration areas or travel corridors. When major roads cut across migration corridors, the effects can be dangerous for animals and humans. Between Kemmerer and Cokeville, Wyoming, hundreds of mule deer are killed during spring and fall migrations when they attempt to cross U.S. Highway 30 (Feeney et al. 2004). In unusual cases, mass casualties of wildlife occur from vehicular collision incidents, particularly in winter when animals may congregate near snow-free roads. Since 2003, there have been four vehicular incidents where 7 to 21 pronghorn were killed or injured per incident in Wyoming. There was also an incident where 41 pronghorn were killed by a train (Maffly 2007).

Being somewhat small and inconspicuous, amphibians are vulnerable to road mortality when they migrate between wetland and upland habitats, while reptiles are vulnerable because they will make use of roads for thermal cooling and heating. Greater sage-grouse are susceptible to road mortality in spring because they often fly to and from leks near ground level. They are also susceptible to vehicular collision along dirt roads because they are sometimes attracted to them to take dust baths (Strittholt et al. 2000). Utility ROWs and access roads increase use by recreationists and other public land users, which can increase the amount of human presence and the potential for harassment and legal or illegal harvesting of wildlife. This activity may include the collection of live animals, particularly reptiles and amphibians, for pets. Direct mortality from snowmobiles may occur because of crushing or suffocation of small mammals occupying subnivean spaces and from increased access to predators over compacted vehicular trails (Gaines et al. 2003).

No electrocution of raptors would be expected when they are perching on the transmission line structures because the spacing between the conductors and between a conductor and ground wire or other grounding structure would exceed the wing span of the largest raptors in the project area (i.e., bald and golden eagles [*Haliaeetus leucocephalus* and *Aquila chrysaetos*]). However, although a rare event, electrocution can occur to flocks of small birds that cross a line or when several roosting birds take off simultaneously because of current arcing. This occurrence is most likely in humid weather conditions (Bevanger 1998; BirdLife International 2003). Arcing can also occur by the excrement jet of large birds roosting on the crossarms above the insulators (BirdLife International 2003).

Electromagnetic field exposure can potentially alter the behavior, physiology, endocrine system, and the immune function of birds, which, in theory, could result in negative repercussions on their reproduction or development. However, the reproductive success of some wild bird species, such as ospreys (*Pandion haliaetus*), does not appear to be compromised by electromagnetic field conditions (Fernie and Reynolds 2005).

Any species of bird capable of flight can collide with power lines. Birds that migrate at night, fly in flocks, and/or are large and heavy with limited maneuverability are at particular risk (BirdLife International 2003). The potential for bird collisions with a transmission line depends on variables such as habitat, relation of the line to migratory flyways and feeding flight patterns, migratory and resident bird species, and structural characteristics of the line (Beaulaurier et al. 1984). Near wetlands, waterfowl, wading birds, shorebirds, and passerines are most vulnerable to colliding with transmission lines; while in habitats away from wetlands, raptors and passerines are most susceptible (Faanes 1987). The highest concern for bird collisions is where lines span flight paths, including river valleys, wetland areas, lakes, areas between waterfowl feeding and roosting areas, and narrow corridors (e.g., passes that connect two valleys). A disturbance that leads to a panic flight can increase the risk of collision with transmission lines (BirdLife International 2003).

The shield wire is often the cause of bird losses involving higher voltage lines because birds fly over the more visible conductor bundles only to collide with the relatively invisible, thin shield wire (Faanes 1987; Thompson 1978). Young inexperienced birds, as well as migrants in unfamiliar terrain, appear to be more vulnerable to wire strikes than resident breeders. Also, many species appear to be most highly susceptible to collisions when alarmed, pursued, searching for food while flying, engaged in courtship, taking off, landing, when otherwise preoccupied and not paying attention to where they are going, and during night and inclement weather (Thompson 1978). Sage-grouse and other upland game birds are vulnerable to colliding with transmission lines because they lack good acuity and because they are generally poor flyers (Bevanger 1995).

Meyer and Lee (1981) concluded that while waterfowl (in Oregon and Washington) are especially susceptible to colliding with transmission lines, no adverse population or ecological results occurred because all species affected were common and because collisions occurred in fewer than 1% of all flight observations. A similar conclusion was reached by Stout and Cornwell (1976) who suggested that fewer than 0.1% of all nonhunting waterfowl mortality nationwide result from collisions with transmission lines. The potential for waterfowl and wading birds to collide with the transmission lines could be assumed to be related to the extent of preferred habitats crossed by the lines and the extent of other waterfowl and wading bird habitats within the immediate area.

Raptors have several attributes that decrease their susceptibility to collisions with transmission lines: (1) they have keen eyesight; (2) they soar or use relatively slow flapping flight; (3) they are generally maneuverable while in flight; (4) they learn to use utility poles and structures as hunting perches or nests and become conditioned to the presence of lines; and (5) they do not fly in groups (like waterfowl), so their position and altitude are not determined by other birds. Therefore, raptors are not as likely to collide with transmission lines unless distracted (e.g., while pursuing prey) or when other environmental factors (e.g., weather) contribute to increased susceptibility (Olendorff and Lehman 1986).

Some mortality resulting from bird collisions with transmission lines is considered unavoidable. However, anticipated mortality levels are not expected to result in long-term loss of population viability in any individual species or lead to a trend toward listing as a rare or endangered species, because mortality levels are anticipated to be low and spread over the life of the transmission lines. A variety of mitigation measures, such as those outlined in *Avian Protection Plan (APP) Guidelines* (APLIC and USFWS 2005) and *Utah Field Office Guidelines for Raptor Protection from Human and Land Use Disturbances* (Romin and Muck 1999) would minimize impacts on birds.

4.8.1.3.5 Exposure to Contaminants. Wildlife may be exposed to accidental spills or releases of product, fuel, herbicides, or other hazardous materials. Exposure to these materials could affect reproduction, growth, development, or survival. Potential impacts on wildlife would vary according to the type of material spilled, the volume of the spill, the media within which the spill occurs, the species exposed to the spilled material, and home range and density of the wildlife species. For example, as the size of a species' home range increases, the effects of a spill would generally decrease (Irons et al. 2000). Generally, small mammal species that have small home ranges and/or high densities per acre would be most affected by a land-based spill. A population-level adverse impact would only be expected if the spill was very large or contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for either event would be unlikely. Because the amounts of most fuels and other hazardous materials are expected to be small, an uncontained spill would affect only a limited area. In addition, wildlife use of the project area where contaminant spills may occur would be limited, thus greatly reducing the potential for exposure.

The potential effects on wildlife from a spill could occur from direct contamination of individual animals, contamination of habitats, and contamination of food resources. Acute (short-term) effects generally occur from direct contamination of animals; chronic (long-term) effects usually occur from such factors as accumulation of contaminants from food items and environmental media (Irons et al. 2000). Moderate to heavy contact with a contaminant is most often fatal to wildlife. In aquatic habitats, death occurs from hypothermia, shock, or drowning. In birds, chronic oil exposure can reduce reproduction, result in pathological conditions, reduce chick growth, and reduce hatching success (BLM 2002). Contaminated water could reduce emergent vegetation and invertebrate biomass, which provide a food resource for wildlife such as waterfowl, amphibians, and bats. The reduction or contamination of food resources from a spill could also reduce survival and reproductive rates. Contaminant ingestion during preening or feeding may impair endocrine and liver functions, reduce breeding success, and reduce growth of offspring (BLM 2002).

A land-based spill would contaminate a limited area. Therefore, a spill would affect relatively few individual animals and a relatively limited portion of the habitat or food resources for large-ranging species (e.g., moose, mule deer, pronghorn, elk, and black bear). It would be unlikely that a land-based spill would cause major impacts on movement (e.g., block migration) or foraging activities at the population (herd) level, largely because of the vast amount of surrounding habitat that would remain unaffected (BLM 2002).

Human presence and activities associated with response to spills would also disturb wildlife in the vicinity of the spill site and spill-response staging areas. In addition to displacing wildlife from areas undergoing contaminant cleanup activities, habitat damage could also occur from cleanup activities (BLM 2002). Avoidance of contaminated areas by wildlife during cleanup because of disturbance would minimize the potential for wildlife to be exposed to contaminants before site cleanup is completed.

Most herbicides used on BLM-administered lands pose little or no risk to wildlife or wild horses and burros unless they are exposed to accidental spills, direct spray, or herbicide drift, or they consume herbicide-treated vegetation. The licensed use of herbicides would not be expected to adversely affect local wildlife populations. Applications of these materials would be conducted by following label directions and in accordance with applicable permits and licenses. Thus, any adverse toxicological threat from herbicides to wildlife is unlikely. The response of wildlife to herbicide use is attributable to habitat changes resulting from treatment rather than direct toxic effects of the applied herbicide on wildlife. However, accidental spills or releases of these materials could impact exposed wildlife. Effects could include death, organ damage, growth decrease, and decrease in reproductive output and condition of offspring (BLM 2005).

Herbicide treatment reduced structural and floral complexity of vegetation on clear-cuts in Maine, resulting in lower overall abundance of birds and small mammals because of a decrease in invertebrate and plant foods and cover associated with decreased habitat complexity (Santillo et al. 1989a,b). However, some researchers have found increases in small mammal numbers because of increases in species that use grassy habitats (particularly microtine rodents). Nevertheless, small mammal communities rapidly returned to pretreatment numbers (e.g., within a 2-year period) because of regrowth of vegetation damaged by herbicides (Anthony and Morrison 1985). Moose tended to avoid herbicide-treated areas of clear-cuts as browse was less available for 2 years post-treatment. When they did feed in treated clear-cuts, they fed heavily in areas that were inadvertently skipped by spraying (Santillo 1994; Eschholtz et al. 1996). Selective herbicide use (e.g., cut-stump treatments) encourages the development of shrub habitat without negatively impacting birds nesting in such habitats (Marshall and Vandruff 2002).

Wildlife can be exposed to herbicides by being directly sprayed, inhaling spray mist or vapors, drinking contaminated water, feeding on or otherwise coming in contact with treated vegetation or animals that have been contaminated, and directly consuming the chemical if it is applied in granular form (DOE 2000). Raptors, small herbivorous mammals, medium-sized omnivorous mammals, and birds that feed on insects are more susceptible to herbicide exposure since they either feed directly on vegetation that might have been treated or feed on animals that feed on the vegetation. The potential for toxic effects would depend on the toxicity of the herbicide and the amount of exposure to the chemical. Generally, smaller animals are more at risk as it takes less substance for them to be affected (DOE 2000).

Indirect adverse effects on wildlife from herbicides would include a reduction in availability of preferred forage, habitat, and breeding areas because of a decrease in plant diversity; decrease in wildlife population densities as a result of limited vegetation regeneration; habitat and range disruption because wildlife may avoid sprayed areas following treatment; and increase in predation of small mammals because of the loss of ground cover (BLM 2005). However, population-level impacts on unlisted wildlife species are unlikely because of the limited size and distribution of treated areas relative to those of the wildlife populations and the foraging area, and the behavior of individual animals (BLM 2005).

Wildlife species that consume grass (e.g., deer, elk, rabbits and hares, quail, and geese) are at potentially higher risk from herbicides than species that eat other vegetation and seeds because herbicide residue tends to be higher on grass. However, harmful effects are not likely unless the animal forages exclusively within the treated area shortly after application. Similarly, bats, shrews, and numerous bird species that feed on herbicide-contaminated insects could be at risk (BLM 2005).

4.8.1.3.6 Erosion and Runoff. As described in Section 4.8.1.1, it is assumed that the potential for soil erosion and the resulting sediment loading of nearby aquatic or wetland habitats would be proportional to the amount of surface disturbance, the condition of disturbed lands at any given time, and the proximity to aquatic habitats. It is also assumed that areas being actively disturbed during mining or construction activities would have higher erosion potential than areas that are undergoing reclamation activities, and that areas being restored become progressively less prone to erosion over time because of the completion of site grading and the reestablishment of vegetated cover. Erosion and runoff from freshly cleared and graded sites could reduce water quality in aquatic and wetland habitats that are used by amphibians, potentially affecting their reproduction, growth, and survival. Any impacts on amphibian populations would be localized to the surface waters receiving site runoff. Although the potential for runoff would be temporary, pending completion of construction activities and stabilization of disturbed areas with vegetative cover, erosion could result in significant impacts on local amphibian populations if an entire recruitment class is eliminated (e.g., complete recruitment failure for a given year because of siltation of eggs or mortality of aquatic larvae). Implementation of measures to control erosion and runoff into aquatic and wetland habitats would reduce the potential for impacts from increased turbidity and sedimentation. Assuming that reclamation activities are successful, restored areas should eventually become similar to natural areas in terms of erosion potential.

4.8.1.3.7 Fugitive Dust. Little information is available regarding the effects of fugitive dust on wildlife; however, if exposure is of sufficient magnitude and duration, the effects may be similar to the respiratory effects identified for humans (e.g., breathing and respiratory symptoms). A more probable effect would be from the dusting of plants that could make forage less palatable. Fugitive dust that settles on forage may render it unpalatable for wildlife and wild horses, which could increase competition for remaining forage. Highest dust deposition would generally occur within the area where wildlife and wild horses would be disturbed by human activities (BLM 2004b). Fugitive dust generation during construction activities is expected to be short term and localized to the immediate construction area and is not expected to result in any long-term individual or population-level effects. Dusting impacts would be potentially more pervasive along unpaved access roads.

4.8.1.3.8 Invasive Vegetation. Utility corridors and access roads can facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wild or human vectors (Trombulak and Frissell 2000). Wildlife habitat could be impacted if invasive vegetation becomes established in the construction-disturbed areas and adjacent off-site habitats. The establishment of invasive vegetation could reduce habitat quality for wildlife and affect wildlife occurrence and abundance locally. The introduction or spread of non-native plants would be detrimental to wildlife such as neotropical migrants and sage-grouse by reducing or fragmenting habitat, increasing soil erosion, or reducing forage (BLM 2006a).

4.8.1.3.9 Fires. Increased human activity can increase the potential for fires. In general, short-term and long-term effects of fire on wildlife are related to fire impacts on vegetation, which in turn affect habitat quality and quantity, including the availability of forage shelter (Groves and Steenhof 1988; Sharpe and Van Horne 1998; Lyon et al. 2000b; USDA 2008a,b,c; Hedlund and Rickard 1981; Knick and Dyer 1996; Watts and Knick 1996; Schooley et al. 1996).

While individuals caught in a fire could incur increased mortality, depending on how quickly the fire spreads, most wildlife would be expected to escape by either outrunning the fire or seeking underground or aboveground refuge within the fire (Ford et al. 1999; Lyon et al. 2000a). However, some mortality of burrowing mammals from asphyxiation in their burrows during fire has been reported (Erwin and Stasiak 1979).

In the absence of long-term vegetation changes, rodents in grasslands usually show a decrease in density after a fire; they often recover, however, to achieve densities similar to or greater than those of preburn levels (Beck and Vogel 1972; Lyon et al. 2000b; USDA 2008d). Long-term changes in vegetation from a fire (such as loss of sagebrush or the invasion or increase of non-native annual grasses) may affect food availability and quality and habitat availability for wildlife; the changes could also increase the risk from predation for some species (Hedlund and Rickard 1981; Groves and Steenhof 1988; Knick and Dyer 1997; Watts and Knick 1996; Schooley et al. 1996; Lyon et al. 2000b; USDA 2008b,c).

Raptor populations generally are unaffected by, or respond favorably to, burned habitat (Lyon et al. 2000b). In the short term, fires may benefit raptors by reducing cover and exposing prey; raptors may also benefit if prey species increase in response to post-fire increases in forage (Lyon et al. 2000b; USDA 2008d). Direct mortality of raptors from fire is rare (Lehman and Allendorf 1989), although fire-related mortality of burrowing owls has been documented (USDA 2008d). Most adult birds can be expected to escape fire, while fire during nesting (prior to fledging) may kill young birds, especially of ground-nesting species (USDA 2008d). Fires in wooded areas, such as pinyon-juniper woodlands, could decrease population of raptors that nest in these habitats.

4.8.1.4 Threatened, Endangered, and Sensitive Species

The evaluation in this PEIS presents the potential for impacts on federally or state-listed threatened or endangered species, BLM-designated sensitive species, or species that are proposed or candidates for listing if oil shale development occurs. The discussion of impacts in this section presents the types of impacts that could occur if mitigation measures are not developed to protect listed and sensitive species. Project-specific NEPA assessments, ESA consultations, and coordination with state natural resource agencies will address project-specific impacts more thoroughly. These assessments and consultations will result in required actions to avoid or mitigate impacts on protected species.

The potential for impacts on threatened, endangered, and sensitive species of commercial oil shale development, including ancillary facilities such as access roads, power plants, and transmission systems, is directly related to the amount of land disturbance, the duration and timing of construction and operation periods, and the habitats affected by development (i.e., the location of the project). Indirect effects such as impacts resulting from the erosion of disturbed land surfaces and disturbance and harassment of animal species are also considered, but their magnitude also is considered proportional to the amount of land disturbance.

Impacts on threatened and endangered species are fundamentally similar to or the same as those described for impacts on aquatic resources; plant communities and habitats; and wildlife in Sections 4.8.1.1, 4.8.1.2, and 4.8.1.3, respectively. The most important difference from these impacts is the potential consequence of the impacts. Because of low population sizes, threatened and endangered species are far more vulnerable to impacts than more common and widespread species. Low population size makes them more vulnerable to the effects of habitat fragmentation, habitat alteration, habitat degradation, human disturbance and harassment, mortality of individuals, and the loss of genetic diversity. Specific impacts associated with development would depend on the locations of projects relative to species populations and the details of project development.

The potential magnitude of the impacts that could result from oil shale development is presented for different species types in Table 4.8.1-4. Unlike some projects where there are discrete construction and operation phases with different associated impacts, oil shale development projects include facility construction and extraction activities that would have similar types of impacts throughout the life of the project. Project construction and extraction activities would occur over a period of several decades. Reclamation that would occur after extraction activities are complete would serve to reduce or eliminate ongoing impacts by recreating habitats and ecological conditions that could be suitable for threatened, endangered, and sensitive species. The effectiveness of any reclamation activities would depend on the specific actions taken, but the best results would occur if site topography, hydrology, soils, and vegetation patterns were reestablished.

Post-lease land clearing and construction activities could remove potentially suitable habitat for threatened, endangered, and sensitive plant and animal species. Any plants present within the project areas would be destroyed, and plants adjacent to project areas could be affected by runoff from the site either through erosion or sedimentation and burial of individual

TABLE 4.8.1-4 Potential Impacts of Commercial Oil Shale Development on Threatened, Endangered, and Sensitive Species

Impact Category	Potential Magnitude of Impacts According to Species Type[a]					
	Upland Plants	Wetland and Riparian Plants	Aquatic and Wetland Animals[b]	Terrestrial Amphibians and Reptiles	Terrestrial Birds	Terrestrial Mammals
Vegetation clearing	Large	Large	Large	Large	Large	Large
Habitat fragmentation	Moderate	Moderate	Moderate	Large	Large	Large
Blockage of movement and dispersal	Moderate	Moderate	Large	Moderate	Small	Moderate
Water depletions	Small	Large	Large	Small	Moderate	Moderate
Stream impoundment and changes in flow pattern	Large	Large	Large	Large	Large	Large
Alteration of topography and drainage patterns	Moderate	Large	Large	Small	Small	Small
Erosion	Large	Large	Large	Small	Small	Small
Sedimentation from runoff	Large	Large	Large	Small	Small	Small
Oil and contaminant spills	Moderate	Large	Large	Large	Small	Small
Fugitive dust	Moderate	Moderate	Small	Small	Small	Small
Injury or mortality of individuals	Large	Large	Large	Large	Large	Large
Human collection	Large	Moderate	Small	Moderate	Small	Small
Human disturbance/harassment	None	None	Large	Moderate	Large	Large
Increased human access	Moderate	Moderate	Moderate	Moderate	Large	Large
Increased predation rates	None	None	Moderate	Moderate	Moderate	Moderate
Noise	None	None	None	Small	Large	Large
Spread of invasive plant species	Large	Large	Moderate	Moderate	Moderate	Moderate
Air pollution	Moderate	Moderate	Small	Small	Small	Small
Disruption of groundwater flow patterns	Small	Moderate	Moderate	Small	Small	Small
Temperature increases in water bodies	None	Moderate	Moderate	None	None	None

[a] Potential impact magnitude (without mitigation) is presented as none, small, moderate, or large. A small impact is one that is limited to the immediate project area, affects a relatively small proportion of the local population (less than 10%), and does not result in a measurable change in carrying capacity or population size in the affected area. A moderate impact could extend beyond the immediate project area, affect an intermediate proportion of the local population 10 to 30%, and result in a measurable but moderate (not destabilizing) change in carrying capacity or population size in the affected area. A large impact would extend beyond the immediate project area, could affect more than 30% of a local population, and result in a large, measurable, and destabilizing change in carrying capacity or population size in the affected area.

[b] Aquatic and wetland animals include invertebrates (mollusks and arthropods), fish, amphibians, reptiles, birds, and mammals.

plants or habitats. In addition, fugitive dust from site activities could accumulate in adjacent areas occupied by listed plants. Dust that accumulates on leaf surfaces can reduce photosynthesis and subsequently affect plant vigor. Disturbed areas could be colonized by non-native invasive plant species.

Larger, more mobile animals such as birds and medium-sized or large mammals would be most likely to leave the project area during site preparation, construction, and other project activities. Development of the site would represent a loss of habitat for these species and potentially a reduction in carrying capacity in the area. Smaller animals, such as small mammals, lizards, snakes, and amphibians, are more likely to be killed during clearing and construction activities. If land clearing and construction activities occurred during the spring and summer, bird nests and nestlings in the project area could be destroyed.

Operations could affect protected plants and animals as well. Animals in and adjacent to project areas would be disturbed by human activities and would tend to avoid the area while activities were occurring. Site lighting and operational noise from equipment would affect animals on and off the site, resulting in avoidance or reduction in use of an area larger than the project footprint. Runoff from the site during site operations could result in erosion and sedimentation of adjacent habitats. Fugitive dust during operations could affect adjacent plant populations.

For all potential impacts, the use of mitigation measures, possibly including predisturbance surveys to locate protected plant and animal populations in the area, erosion-control practices, dust suppression techniques, establishment of buffer areas around protected populations, and reclamation of disturbed areas using native species upon project completion, would greatly reduce or eliminate the potential for effects on protected species. The specifics of these practices should be established in project-specific consultations with the appropriate federal and state agencies. ESA Section 7 consultations between the BLM and the USFWS would be required for all projects that have the potential to affect listed species before leased areas could be developed. Those consultations would identify conservation measures, allowable levels of incidental take, and other requirements to protect listed species. Potential conservation measures for oil shale development have been developed jointly by the BLM and USFWS to avoid and minimize impacts of commercial oil shale development on federally listed threatened and endangered species (Appendix F) and could be applied, if deemed appropriate, and in consultation with the USFWS, at the lease or development stage of potential future projects.

Tables 4.8.1-5 and 4.8.1-6 identify the federally and state-listed threatened, endangered, and sensitive species that could be affected by commercial oil shale development in Colorado, Utah, and Wyoming counties. The two tables consider separately the impacts on state-listed threatened and endangered species and species of special concern, federal candidates for listing, and BLM-designated sensitive species (Table 4.8.1-5), and on federally listed threatened, endangered, and proposed species (Table 4.8.1-6). For species in Table 4.8.1-5, a determination is made regarding the "potential for negative impact"; for species in Table 4.8.1-6, a similar determination is made but the terminology follows the ESA Section 7 convention of "adverse effect." Potential for impact or effect was determined on the basis of conservative estimates of species distributions, and it is possible that impacts on some species would not occur because

TABLE 4.8.1-5 Potential Impacts of Commercial Oil Shale Development on BLM-Designated Sensitive Species, Federal Candidates for Listing, and State Species of Special Concern

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants				
Adobe thistle	*Cirsium perplexans*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Alcove bog-orchid	*Habenaria zothecina*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in wetland habitats of Utah project areas.
Beaver Rim phlox	*Phlox pungens*	BLM-S; WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Blue elderberry	*Sambucus cerulea*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in wetland and riparian habitats of Wyoming project areas.
Caespitose cat's-eye	*Cryptantha caespitosa*	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Cedar Mountain Easter-daisy	*Townsendia microcephala*	BLM-S; WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Cedar Rim thistle	*Cirsium aridum*	BLM-S; WY-SC	WY-Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Colorado bedstraw	*Galium coloradoense*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Crandall's rockcress	*Boechera crandallii*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Crisp-leaf wild buckwheat	*Eriogonum corymbosum* var. *corymbosum*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland and riparian habitats of Wyoming project areas.
Debeque milkvetch	*Astragalus debequaeus*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Debeque phacelia	*Phacelia scopulina* var. *submutica*	ESA-C	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Debris milkvetch	*Astragalus detritalis*	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Deep Creek cinquefoil	*Potentilla multisecta*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Desert glandular phacelia	*Phacelia glandulosa* var. *deserta*	WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Divergent wild buckwheat	*Eriogonum divaricatum*	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Dorn's twinpod	*Physaria dornii*	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Douglas' campion	*Silene douglasii*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Dwarf mountain mahogany	*Cercocarpus ledifolius* var. *intricatus*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Dwarf ninebark	*Physocarpus alternans*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Dwarf woolly-heads	*Psilocarphus brevissimus*	WY-SC	WY-Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Entire-leaved peppergrass	*Lepidium integrifolium* var. *integrifolium*	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in wetland habitats of Wyoming project areas.
Ephedra buckwheat	*Eriogonum ephedroides*	BLM-S	CO-Rio Blanco; UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Ferron milkvetch	*Astragalus musiniensis*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Fremont cottonwood	*Populus deltoides* var. *wislizeni*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in riparian areas of Wyoming project areas.
Fullstem	*Chamaechaen-actis scaposa*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Garrett's beardtongue	*Penstemon scariosus* var. *garrettii*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Gibbens' beardtongue	*Penstemon gibbensii*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Goodrich cleomella	*Cleomella palmeriana* var. *goodrichii*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Goodrich's blazingstar	*Mentzelia goodrichii*	BLM-S	UT-Duchesne	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Goodrich's penstemon	*Penstemon goodrichii*	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Graham's beardtongue	*Penstemon grahamii*	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas. Not found in Piceance Basin.
Grand buckwheat	*Eriogonum contortum*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Great Basin downingia	*Downingia laeta*	WY-SC	WY-Uinta	**Potential for negative impact.** Possible occurrence in wetland and riparian habitats of Wyoming project areas.
Green Mormon tea	*Ephedra viridis* var. *viridis*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Greene rabbitbrush	*Chrysothamnus greenei*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in riparian and upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Green River greenthread	*Thelesperma caespitosum*	BLM-S	UT-Duchesne	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Hamilton's milkvetch	*Astragalus hamiltonii*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Harrington beardtongue	*Penstemon harringtonii*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Hayden's milkvetch	*Astragalus bisulcatus* var. *haydenianus*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland habitats of Wyoming project areas.
Hooker wild buckwheat	*Eriogonum hookeri*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in riparian and upland habitats of Wyoming project areas.
Huber's pepperplant	*Lepidium huberi*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Intermountain phacelia	*Phacelia demissa*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Jones blue star	*Amsonia jonesii*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Juniper prickly-pear	*Opuntia polyacantha* var. *juniperina*	WY-SC	WY-Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
King's milkvetch	*Astragalus calycosus* var. *calycosus*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Large-flower collomia	*Collomia grandiflora*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Large-fruited bladderpod	*Lesquerella macrocarpa*	BLM-S; WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Ligulate feverfew	*Parthenium ligulatum*	BLM-S	CO-Rio Blanco	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Little-leaf mock-orange	*Philadelphus microphyllus* var. *occidentalis*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Little-leaved brickell-bush	*Brickellia microphylla* var. *scabra*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Long-awned alkali wild-rye	*Elymus simplex* var. *luxurians*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Many-headed broom groundsel	*Senecio spartioides* var. *multicapitatus*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Maybell locoweed	*Oxytropis besseyi* var. *obnapiformis*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Moab milkvetch	*Astragalus coltonii* var. *moabensis*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Mystery wormwood	*Artemisia biennis* var. *diffusa*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Narrow-leaved bladderpod	*Lesquerella parvula*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Narrow-stem gilia	*Gilia stenothyrsa*	BLM-S	CO-Rio Blanco; UT-Carbon, Duchesne, Emery, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Naturita milkvetch	*Astragalus naturitensis*	BLM-S	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Nelson phacelia	*Phacelia salina*	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Nevada sweetpea	*Lathyrus lanszwertii* var. *lanszwertii*	WY-SC	WY-Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Northern twayblade	*Listera borealis*	BLM-S	CO-Garfield; UT-Duchesne, San Juan; WY-Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Nuttall sandwort	*Minuartia nuttallii*	BLM-S	UT-Duchesne, WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Utah and Wyoming project areas.
Ownbey's thistle	*Cirsium ownbeyi*	BLM-S; WY-SC	UT-Uintah; WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Utah and Wyoming project areas.
Parachute beardtongue	*Penstemon debilis*	ESA-C	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Park rockcress	*Arabis vivariensis*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Payson's tansy mustard	*Descurainia pinnata* var. *paysonii*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Persistent sepal yellowcress	*Rorippa calycina*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Piceance bladderpod	*Lesquerella parviflora*	BLM-S	CO-Garfield, Rio Blanco	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Precocious milkvetch	*Astragalus proimanthus*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Prostrate bladderpod	*Lesquerella prostrate*	WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Red poverty-weed	*Monolepis pusilla*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Rock hymenoxyz	*Hymenoxys lapidicola*	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Rollins' cat's-eye	*Cryptantha rollinsii*	BLM-S; WY-SC	CO-Rio Blanco; UT-Uintah; WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Rufous-spine prickly-pear	*Opuntia polyacantha* var. *rufispina*	WY-SC	WY-Lincoln, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Saffron groundsel	*Packera crocata*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in wetland and upland habitats of Wyoming project areas.
San Rafael daisy	*Erigeron compactus* var. *consimilis*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Selby's rockcress	*Boechera selbyi*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Sickle saltbush	*Atriplex falcata*	WY-SC	WY-Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Slender cryptantha	*Cryptantha gracilis*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Sodaville milkvetch	*Astragalus lentiginosus* var. *salinus*	WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in wetland habitats of Wyoming project areas.
Stemless beardtongue	*Penstemon acaulis* var. *acaulis*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Strigose Easter-daisy	*Townsendia strigosa*	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Swallen mountain-ricegrass	*Achnatherum swallenii*	WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Ternate desert-parsley	*Lomatium triternatum* var. *anomalum*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Tiny phacelia	*Phacelia tetramera*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in wetland and upland habitats of Wyoming project areas.
Tree-like oxytheca	*Oxytheca dendroidea*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Trelease's racemose milkvetch	*Astragalus racemosus* var. *treleasei*	BLM-S; WY-SC	WY-Sublette, Uinta	**Potential for negative impact.** Possible occurrence in riparian and upland habitats of Wyoming project areas.
Tufted twinpod	*Physaria condensata*	BLM-S; WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Uinta Basin spring-parsley	*Cymopterus duchesnensis*	BLM-S	CO-Rio Blanco; UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Uinta draba	*Draba juniperina*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Uinta greenthread	*Thelesperma pubescens*	BLM-S; WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Untermann's daisy	*Erigeron untermanii*	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Utah gentian	*Gentianella tortuosa*	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Utah greasebush	*Glossopetalon spinescens* var. *meionandrum*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Utah mountain lilac	*Ceanothus martinii*	WY-SC	WY-Lincoln, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Plants (Cont.)				
Western phacelia	*Phacelia incana*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
White beardtongue	*Penstemon laricifolius* ssp. *exilifolius*	WY-SC	WY-Sublette	**Potential for negative impact.** Possible occurrence in Wyoming project areas.
White fir	*Abies concolor*	WY-SC	WY-Sweetwater	**No impact.** Only known record from Little Mountain outside of project area.
White River beardtongue	*Penstemon scariosus* var. *albifluvis*	ESA-C	CO-Rio Blanco; UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas. Not found in Piceance Basin.
White-margined phlox	*Phlox albomarginata*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in Wyoming project areas.
Wilcox eriastrum	*Eriastrum wilcoxii*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Wolf's orache	*Atriplex wolfii*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Yellow water-crowfoot	*Ranunculus flabellaris*	WY-SC	WY-Uinta	**Potential for negative impact.** Possible occurrence in wetland habitats of Wyoming project areas.
Invertebrates				
Eureka mountainsnail	*Oreohelix eurekensis*	UT-SC	UT-Duchesne	**No impact.** Populations occur outside of project areas.
Great Basin silverspot butterfly	*Speyeria nokomis nokomis*	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in wetland habitats of Utah project areas.
Fish				
Bluehead sucker	*Catostomus discobolus*	BLM-S; WY-SC	Co-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Colorado, Utah, and Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Fish (Cont.)				
Bonneville cutthroat trout	*Oncorhynchus clarkii utah*	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Wyoming project areas.
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	BLM-S; CO-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Colorado, Utah, and Wyoming project areas.
Flannelmouth sucker	*Catostomus latipinnis*	BLM-S; WY-SC	UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Utah and Wyoming project areas.
Leatherside chub	*Gila copei*	BLM-S; UT-SC; WY-SC	UT-Duchesne, WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Wyoming project areas. Populations occur outside of project areas in Utah.
Roundtail chub	*Gila robusta*	BLM-S; CO-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic habitats of Colorado, Utah, and Wyoming project areas.
Amphibians				
Boreal toad	*Bufo boreas*	BLM-S; CO-E; WY-SC; UT-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Colorado, Utah, and Wyoming project areas.
Columbia spotted frog	*Rana luteiventris*	BLM-S; WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Wyoming project areas.
Great basin spadefoot	*Spea intermontana*	BLM-S; WY-SC	CO-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne; WY-Lincoln, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland and upland habitats of Colorado, Utah, and Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Amphibians (Cont.)				
Northern leopard frog	*Rana pipiens*	BLM-S; CO-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Colorado, Utah, and Wyoming project areas.
Reptiles				
Longnose leopard lizard	*Gambelia wislizenii*	BLM-S; CO-SC	CO-Garfield	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Midget faded rattlesnake	*Crotalus oreganus concolor*	BLM-S; CO-SC	CO-Garfield, Rio Blanco; WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Wyoming project areas.
Smooth greensnake	*Liochlorophis vernalis*	BLM-S; UT-SC	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland and wetland habitats of Utah project areas.
Birds				
American bittern	*Botaurus lentiginosus*	WY-SC	WY-Lincoln, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland and aquatic habitats of Wyoming project areas.
American peregrine falcon	*Falco peregrinus anatum*	BLM-S; CO-SC	CO-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Jan, Uintah, Wayne; WY-Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
American white pelican	*Pelecanus erythrorhynchos*	BLM-S; UT-SC	CO-Garfield; UT-Uintah	**Potential for negative impact.** Possible occurrence in wetland and aquatic habitats of Colorado and Utah project areas.
Bald eagle	*Haliaeetus leucocephalus*	CO-T, WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland, aquatic, and upland habitats of Colorado and Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Birds (Cont.)				
Barrow's goldeneye	*Bucephala islandica*	BLM-S	CO-Garfield, Rio Blanco	**Potential for negative impact.** Possible occurrence in wetland and aquatic habitats of Colorado project areas.
Black swift	*Cypseloides niger*	CO-SC; UT-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Black-backed woodpecker	*Picoides arcticus*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Bobolink	*Dolichonyx oryzivorus*	BLM-S; UT-SC	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Boreal owl	*Aegolius funereus*	WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Wyoming project areas.
Burrowing owl	*Athene cunicularia*	BLM-S; CO-T; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Bushtit	*Psaltriparus minimus*	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Caspian tern	*Sterna caspia*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Wyoming project areas.
Clark's grebe	*Aechmophorus clarkii*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Wyoming project areas.
Columbian sharp-tailed grouse	*Tympanuchus phasianellus columbianus*	BLM-S; CO-SC	CO-Garfield, Rio Blanco	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado project areas.
Common loon	*Gavia immer*	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Birds (Cont.)				
Ferruginous hawk	*Buteo regalis*	BLM-S; CO-SC; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Forster's tern	*Sterna forsteri*	WY-SC	WY-Lincoln	**Potential for negative impact.** Possible occurrence in aquatic and wetland habitats of Wyoming project areas.
Greater sandhill crane	*Grus canadensis tabida*	CO-SC	CO-Garfield, Rio Blanco	**Potential for negative impact.** Possible occurrence in a wetland and upland habitats of Colorado project areas.
Juniper titmouse	*Baeolophus ridgwayi*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Lewis's woodpecker	*Melanerpes lewis*	BLM-S; UT-SC; WY-SC	UT-Duchesne, Uintah; WY-Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Utah and Wyoming project areas.
Loggerhead shrike	*Lanius ludovicianus*	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Long-billed curlew	*Numenius americanus*	BLM-S; CO-SC; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland and upland habitats of Colorado, Utah, and Wyoming project areas.
McCown's longspur	*Calcarius mccownii*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Mountain plover	*Charadrius montanus*	BLM-S; CO-SC; WY-SC	CO-Rio Blanco; WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Wyoming project areas.
Northern goshawk	*Accipiter gentilis*	BLM-S; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Pygmy nuthatch	*Sitta pygmaea*	WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Birds (Cont.)				
Sage grouse	*Centrocercus urophasianus*	BLM-S; CO-SC; UT-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Sage sparrow	*Amphispiza belli*	BLM-S	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Scott's oriole	*Icterus parisorum*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Short-eared owl	*Asio flammeus*	BLM-S; UT-SC	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Three-toed woodpecker	*Picoides tridactylus*	BLM-S: UT-SC	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah project areas.
Trumpeter swan	*Cygnus buccinator*	WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Possible occurrence in wetland and aquatic habitats of Wyoming project areas.
Western scrub-jay	*Aphelocoma californica*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	ESA-C; BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in riparian habitats of Utah project areas.
White-faced ibis	*Plegadis chihi*	BLM-S; WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in wetland habitats of Colorado and Wyoming project areas.
Mammals				
Big free-tailed bat	*Nyctinomops macrotis*	BLM-S; UT-SC	CO-Garfield; UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Canyon mouse	*Peromyscus crinitus*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Mammals (Cont.)				
Cliff chipmunk	*Tamias dorsalis utahensis*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Fringed myotis	*Myotis thysanodes*	BLM-S; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Idaho pocket gopher	*Thomomys idahoensis*	BLM-S; WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Kit fox	*Vulpes macrotis*	BLM-S; CO-E; UT-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Long-eared myotis	*Myotis evotis*	BLM-S	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Pallid bat	*Antrozous pallidus*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland, wetland, and aquatic habitats of Wyoming project areas.
Pinon mouse	*Peromyscus truei*	WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Preble's shrew	*Sorex preblei*	WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Pygmy rabbit	*Brachylagus idahoensis*	BLM-S; UT-SC; WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.
Spotted bat	*Euderma maculatum*	BLM-S; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland, aquatic, and wetland habitats of Colorado, Utah, and Wyoming project areas.
Swift fox	*Vulpes velox*	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

TABLE 4.8.1-5 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Impact[b]
Mammals (Cont.)				
Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM-S; CO-SC; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah; WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Water vole	*Microtus richardsoni*	WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Possible occurrence in wetland and aquatic habitats of Wyoming project areas.
White-tailed prairie dog	*Cynomys leucurus*	BLM-S; UT-SC; WY-SC	UT-Duchesne, Uintah; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Possible occurrence in upland habitats of Utah and Wyoming project areas.
Wolverine	*Gulo gulo*	CO-E; WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Sublette	**Potential for negative impact.** Possible occurrence in upland habitats of Colorado and Wyoming project areas.
Wyoming pocket gopher	*Thomomys clusius*	BLM-S	WY-Sweetwater	**Potential for negative impact.** Possible occurrence in upland habitats of Wyoming project areas.

[a] Status categories: BLM-S = listed by the BLM as sensitive; CO = Colorado; E = listed as endangered; ESA-C = candidate for listing under the Endangered Species Act; SC = listed as species of special concern; T = listed as threatened; UT = Utah; WY = Wyoming.

[b] Potential impacts based on general habitat preference are presented in Table 4.1.8-3. Specific habitat preferences for species are presented in Appendix E.

suitable habitat may not be present in project areas or impacts on those habitats could be avoided.

The Barneby ridge-cress and whooping crane are the only federally listed species in project area counties that are not expected to be affected by commercial oil shale development. The Barneby ridge-cress is not likely to be affected because known population distributions are clearly outside of the potential lease areas. The whooping crane is a rare migrant through the area, and the population that could migrate through the area is considered experimental and nonessential.

Federally listed plant species that could occur in project areas and that could be affected by project activities include clay reed-mustard, Dudley Bluffs bladderpod, Dudley Bluffs twinpod, shrubby reed-mustard, Uinta Basin hookless cactus, and Ute ladies'-tresses (Table 4.8.1-6). All but the Ute ladies'-tresses are upland species that could be affected by a variety of impacting factors, including vegetation clearing, habitat fragmentation, dispersal

TABLE 4.8.1-6 Potential Effects of Commercial Oil Shale Development on Federally Listed Threatened, Endangered, and Proposed Species

Common Name	Scientific Name	Status [a]	States and Counties in Project Area Where Species Occur	Potential for Effect[b]
Plants				
Barneby ridge-cress	*Lepidium barnebyanum*	E	UT-Duchesne	**Not likely to affect.** Populations occur outside of project area.
Clay reed-mustard	*Schoenocrambe argillacea*	T	UT-Uintah	**Potential adverse effect.** Possible occurrence in upland habitats of Utah project areas.
Dudley Bluffs bladderpod	*Lesquerella congesta*	T	CO-Rio Blanco	**Potential adverse effect.** Possible occurrence in upland habitats of Colorado project areas.
Dudley Bluffs twinpod	*Physaria obcordata*	T	CO-Rio Blanco	**Potential adverse effect.** Possible occurrence in upland habitats of Colorado project areas.
Shrubby reed-mustard	*Schoenocrambe suffrutescens*	E	UT-Duchesne, Uintah	**Potential adverse effect.** Possible occurrence in upland habitats of Utah project areas.
Uinta Basin hookless cactus	*Sclerocactus glaucus*	T	CO-Garfield; UT-Duchesne, Uintah	**Potential adverse effect.** Possible occurrence in upland habitats of Colorado and Utah project areas.
Ute ladies'-tresses	*Spiranthes diluvialis*	T	UT-Duchesne, Uintah	**Potential adverse effect.** Possible occurrence in riparian and wetland habitats of Utah project areas.
Fish				
Bonytail	*Gila elegans*	E	UT-Duchesne, Uintah	**Potential adverse effect.** Possible occurrence in aquatic habitats of Utah project areas. All depletions from the Colorado River Basin are considered an adverse effect.
Colorado pikeminnow	*Ptychocheilus lucius*	E	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential adverse effect.** Possible occurrence in aquatic habitats of Colorado and Utah project areas. All depletions from the Colorado River Basin are considered an adverse effect.
Humpback chub	*Gila cypha*	E	UT-Uintah	**Potential adverse effect.** Although occurrence in aquatic habitats of Utah project areas is unlikely, all depletions from the Colorado River Basin are considered an adverse effect.

TABLE 4.8.1-6 (Cont.)

Common Name	Scientific Name	Status[a]	States and Counties in Project Area Where Species Occur	Potential for Effect[b]
Fish (Cont.)				
Razorback sucker	*Xyrauchen texanus*	E	CO-Garfield, Rio Blanco; UT-Uintah	**Potential adverse effect.** Possible occurrence in aquatic habitats of Colorado and Utah project areas. Depletions from the Colorado River Basin are considered an adverse effect.
Birds				
Mexican spotted owl	*Strix occidentalis lucida*	T	UT-Uintah	**Potential adverse effect.** Possible occurrence in upland habitats of Utah project areas.
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	UT-Uintah	**Potential adverse effect.** Possible occurrence in wetland and riparian habitats of Utah project areas.
Whooping crane	*Grus americana*	XN	CO-Garfield, Rio Blanco	**Not likely to affect.** Rare migrant through Colorado.
Mammals				
Black-footed ferret	*Mustela nigripes*	XN	CO-Rio Blanco; UT-Duchesne, Uintah; WY-Sublette, Sweetwater	**Potential adverse effect.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.
Canada lynx	*Lynx canadensis*	T	CO-Garfield, Rio Blanco; UT-Uintah; WY-Lincoln, Sublette, Uinta	**Potential adverse effect.** Possible occurrence in upland habitats of Colorado, Utah, and Wyoming project areas.

[a] Status categories: E = listed under the ESA as endangered; T = listed under the ESA as threatened; XN = experimental, nonessential population.

[b] Potential impacts based on general habitat preference are presented in Table 4.8.1-3. Specific habitat preferences are presented in Appendix E.

blockage, alteration of topography, changes in drainage patterns, erosion, sedimentation from runoff, oil and contaminant spills, fugitive dust, injury or mortality of individuals, human collection, increased human access, spread of invasive plant species, and air pollution (Table 4.8.1-4). Clay-reed mustard, Dudley Bluffs bladderpod, Dudley Bluffs twinpod, and shrubby reed-mustard are all found on shale-derived soils and are therefore more likely to occur in potential development areas.

The Ute ladies'-tresses could occur in Utah project areas in wetland habitats and along the Green River or White River. This species is dependent on a high water table and, in addition to the factors affecting upland plants, could be adversely affected by any water depletions from the Green River or White River basins associated with oil shale development in Utah.

Oil shale development in any of the oil shale basins could affect federally listed endangered Colorado River fishes (bonytail, Colorado pikeminnow, humpback chub, and razorback sucker) either directly, if projects are adjacent to occupied habitats, or indirectly if project activities are located within occupied watersheds (e.g., Green River and White River). Direct and indirect effects could result from vegetation clearing, alteration of topography and drainage patterns, erosion, sedimentation from runoff, oil and contaminant spills, water depletions, stream impoundment and changes in streamflow, and disruption of groundwater flow patterns. Any activities within watersheds that affect water quality (e.g., land disturbance or water volume changes that affect sediment load, contaminant concentrations, total dissolved solids, and temperature of streams) or quantity (e.g., stream impoundments or withdrawals that affect base flow, peak flow magnitude, and seasonal flow pattern) could have effects in occupied areas far downstream. The Upper Colorado River Endangered Fishes Recovery Implementation Program considers any water depletions from the upper Colorado River Basin, which includes the watersheds of the Green River and the White River, an adverse effect on endangered Colorado River fishes that requires consultation and mitigation. Water depletions for individual projects could be quite large and represent a significant adverse impact on these riverine fish.

On the basis of proximity of populations and critical habitat to potential lease areas, the greatest potential for direct impacts on endangered fishes is related to development in Utah, where the Green River and White River flow through oil shale areas. If these areas are made available for leasing, there is a relatively high probability that these species would be directly or indirectly affected by oil shale development. In Colorado, the White River is outside potential lease areas (the closest distance is about 3 mi); however, tributaries to the White River (e.g., Yellow Creek and Piceance Creek) flow through potential lease areas, and downstream indirect effects are possible. Indirect impacts on critical habitat downstream from oil shale development in Wyoming is considered unlikely because the nearest critical habitat is located on the Green River about 60 mi downstream of oil shale areas and below Flaming Gorge Reservoir. Flaming Gorge Reservoir would likely ameliorate any water quality or temperature effects in areas downstream of the reservoir.

Listed bird species that could be affected by commercial oil shale development include the Mexican spotted owl and southwestern willow flycatcher (Table 4.8.1-6). The Mexican spotted owl could occur year-round in steep forested canyons in Utah and could be affected if these types of habitats are disturbed during oil shale development. Impacts on individual owls could result from injury or mortality (e.g., collisions with transmission lines), human disturbance or harassment, increased human access to occupied areas, increases in predation rates, and noise from facilities.

The southwestern willow flycatcher is most commonly found in riparian areas, especially along large rivers (e.g., Green River). These riparian habitats could be affected directly by surface disturbance or indirectly by activities in their watersheds that resulted in alteration of topography, changes in drainage patterns, erosion, sedimentation from runoff, and oil and contaminant spills. In addition, impacts on riparian habitats that support these species could result if the habitats were crossed by project transmission lines or roads. Impacts on individual birds could result from injury or mortality (e.g., collisions with transmission lines), human disturbance or harassment, increased human access to occupied areas, increases in predation rates, and noise from facilities.

Listed mammals that could be affected by oil shale development include the black-footed ferret and Canada lynx (Table 4.8.1-6). The black-footed ferret occurs in grassland and shrublands that support active prairie dog towns and potentially occurs in both Utah and Colorado project areas. The Canada lynx occurs in coniferous forests and potentially occurs in project areas in all three states. Impacts on these species could result from impacts on habitat (including vegetation clearing, habitat fragmentation, and movement-dispersal blockage) and individuals (injury or mortality [e.g., collisions with vehicles], human disturbance or harassment, increased human access to occupied areas, increases in predation rates, and noise from facilities).

4.8.2 Mitigation Measures for Ecological Resources

Various mitigation measures would be required to reduce the impact of oil shale development on ecological resources during construction, operations, and reclamation. Existing guidance, recommendations, and requirements related to management practices are described in detail in the BLM Gold Book (DOI and USDA 2006), and BLM field office RMPs. The BLM has also developed a guidance document, *Hydraulic Considerations for Pipeline Crossing Stream Channels*, for construction of pipeline crossings of perennial, intermittent, and ephemeral stream channels. This guidance can be found at: http://www.blm.gov/nstc/library/techno2.htm. BLM Manual 6840—*Special Status Species Management* describes BLM policy to protect species identified by the BLM as sensitive (BLM 2001).

In addition to the actions described in these guidance documents, the mitigation actions below could be used to reduce the potential for impacts on various ecological resources. Other mitigation measures may be identified by the BLM or USFWS prior to project development. Developing effective mitigation measures that avoid, reduce, or eliminate the impacts of oil shale development on ecological resources will represent a significant challenge because of the potentially large-scale, long operational time period, and reclamation difficulties that will be characteristic of many oil shale projects.

4.8.2.1 Aquatic Resources

- Protect wetlands, springs, seeps, ephemeral streams, and riparian areas on or adjacent to development areas through mitigation. This objective would be accomplished by conducting predisturbance surveys in all areas proposed for development following accepted protocols established by the USACE, the BLM, or state regulatory agencies, as appropriate. If any wetlands, springs, seeps, or riparian areas are found, plans to mitigate impacts would be developed in consultation with those agencies and the local BLM field office prior to the initiation of ground disturbance. Examples of potential protective measures include (1) establishing buffer zones adjacent to these habitats in which development activities would be excluded or modified, (2) using erosion-control techniques to prevent sediment runoff into these habitats, (3) using runoff control devices to prevent surface water runoff into these areas, and (4) identifying and implementing spill prevention technologies that would prevent or reduce the potential for oil or other contaminants from entering these habitats.

- Minimize and mitigate changes in the function of the 100-year floodplain or flood storage capacity in accordance with applicable requirements. To achieve this, either no activities or limited activities within floodplains would be allowed, and floodplain contours could be restored to predisturbance conditions following short-term disturbances. The effectiveness of mitigation measures would be evaluated and modified, if necessary.

- Minimize or mitigate water quality degradation (e.g., chemical contamination, increased salinity, increased temperature, decreased dissolved oxygen, and increased sediment loads) that could result from construction and operation. Water quality in areas adjacent to or downstream of development areas would be monitored during the life of the project to ensure water quality in aquatic habitats is protected.

- Minimize or mitigate the impacts on aquatic habitats (including springs, seeps, and ephemeral streams), wetlands, and riparian areas that could result from changes to surface or groundwater flows. Hydrologically connected areas would be monitored for changes in flow that are development related.

4.8.2.2 Plant Communities and Habitats

- Mitigate impacts on rare natural communities and remnant vegetation associations. Predisturbance surveys would be used to identify these communities in and adjacent to development areas. Examples of potential protective measures include (1) establishing buffer zones adjacent to these habitats and excluding or modifying development activities within those areas, (2) using erosion-control techniques to prevent sediment runoff into these habitats, (3) using runoff control devices to prevent surface water runoff into these areas, and (4) identifying and implementing spill prevention technologies that would prevent or reduce the potential for oil or other contaminants from entering these habitats. Mitigation could also include reclamation or establishment of similar habitats elsewhere as compensation.

- Reclaim excavated areas and disturbed areas following backfilling operations. Spent shale returned to mined areas would be covered with subsoil and then topsoil. Exposed soils would be seeded and revegetated as directed under applicable BLM requirements. Only locally native plant species would be used for the reclamation of disturbed areas to reestablish native plant communities.

- Prevent the establishment and spread of invasive species and noxious weeds, thus protecting developing plant communities on the project site from colonization by these species and increasing the potential for the successful development of diverse, mature native habitats in disturbed areas. Degradation of nearby habitats by invasive species colonization from project areas would also be avoided.
- Protect plant communities and habitats near all project areas from the effects of fugitive dust. This objective could be achieved by implementing dust abatement practices (e.g., mulching, water application, paving roads, and plantings) that would be applied to all areas of regular traffic or areas of exposed erodible soils.

4.8.2.3 Wildlife (Including Wild Horses and Burros)

- Identify important, unique, or high-value wildlife habitats in the vicinity of the project, and design the project to mitigate impacts on these habitats. For example, project facilities, access roads, and other ancillary facilities could be located in the least environmentally sensitive areas (i.e., away from riparian habitats, streams, wetlands, drainages, and critical or crucial wildlife habitats). The lessee would consult with the BLM and state agencies to discuss important wildlife use areas in order to assist in the determination of facility design and location that would avoid or minimize impacts on wildlife species and their habitats to the fullest extent practicable. The lessee would, at a minimum, follow the *Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats* (WGFD 2004).
- Habitat enhancement or in-kind compensatory habitat are options available when developing a wildlife management plan for a project.
- Evaluate the project site for avian use (particularly by raptors, greater sage-grouse, neotropical migrants, and birds of conservation concern) and design the project to mitigate the potential for adverse impacts on birds and their habitat. Conduct predisturbance surveys for raptor nesting in all areas proposed for development following accepted protocols and in consultation with the USFWS and state natural resource agencies. If raptor nests are found, an appropriate course of action would be formulated to mitigate impacts, as appropriate. For example, impacts could be reduced if project design avoided

locating transmission lines in landscape features known to attract raptors. The lessee would also, at a minimum, follow guidance provided in the APP Guidelines prepared by the APLIC and USFWS (APLIC and USFWS 2005).

- Design facilities to discourage their use as perching or nesting sites by birds and minimize avian electrocutions.

- Any surface water body created for a project may be utilized to the benefit of wildlife when practicable; however, netting and fencing may be required when water chemistry demonstrates a need to prevent use by wildlife.

- Mitigate wildlife mortality from vehicle collisions. To achieve this objective, important wildlife habitats could be mapped and activities within them avoided (if possible) or mitigated. Education programs could be implemented to ensure that employees are aware of wildlife impacts associated with vehicular use. These would include the need to obey state- and county-posted speed limits. Carpooling, busing, or other means to limit traffic (and vehicle collisions with wildlife) would be emphasized.

- Develop a habitat restoration plan for disturbed project areas that includes the establishment of native vegetation communities consisting of locally native plant species. The plan would identify revegetation, soil stabilization, and erosion-reduction measures that would be implemented to ensure that all disturbed areas are restored. Restoration would be implemented as soon as possible after completion of activities to reduce the amount of habitat converted at any one time and to hasten the recovery to natural habitats.

- Minimize habitat loss and fragmentation due to project development. For example, habitat fragmentation could be reduced by consolidating facilities (e.g., access roads and utilities would share common ROWs, where feasible), reducing access roads to the minimum number required, and, where possible, locating facilities in areas where habitat disturbance has already occurred. Transportation management planning can be used as an effective tool to minimize habitat fragmentation to meet this performance goal.

- Protect wildlife from the negative effects of fugitive dust. Dust abatement practices include measures such as mulching, water application, road paving, and plantings.

- Avoid (to the extent practicable) human interactions with wildlife (and wild horses and burros). To achieve this objective, the following measures could be implemented: (1) instruct all personnel to avoid harassment and disturbance of wildlife, especially during reproductive (e.g., courtship and nesting) seasons; (2) make personnel aware of the potential for wildlife interactions around facility structures; (3) ensure that food refuse and other garbage are not available to scavengers (e.g., by use of covered dumpsters); and (4) restrict pets from project sites.

- Mitigate noise impacts on wildlife during construction and operation. This objective could be accomplished by limiting the use of explosives to specific times and at specified distances from sensitive wildlife areas, as established by the BLM or other federal and state agencies. Operators would ensure that all construction equipment was adequately muffled and maintained to minimize disturbance to wildlife.

- Protect wildlife from chronic and acute pesticide exposure. This objective could be accomplished by measures such as using pesticides of low toxicity, minimizing application areas where possible, and by using timing and/or spatial restrictions (e.g., do not use pesticide treatments in critical staging areas). All pesticides would be applied consistent with their label requirements and in accordance with guidance provided in the *Final Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* (BLM 2007b).

- Construct wildlife- and wild-horse-friendly cattleguards for all new roads or improve existing ways and trails that require passing through existing fences, fence line gates, or new gates, in addition to standard wire gates alongside them.

- Construct fencing (as practicable) to exclude livestock, wild horses, or wildlife from all project facilities, including all water sites built for the development of facilities and roadways.

- Mitigate existing water sources used by wildlife or wild horses in the vicinity of the project if adversely impacted during project construction or operation.

- Protect or avoid important big game habitat (e.g., crucial winter habitat and birthing areas) to the extent practicable.

4.8.2.4 Threatened and Endangered Species

At the outset of the development of this PEIS, when the BLM planned to issue leases on the basis of the analyses conducted here, the BLM began the process of consultation with the USFWS pursuant to its obligations under Section 7 of the ESA. During this preliminary consultation, the BLM and USFWS jointly developed conservation measures to support conservation of species listed under the ESA. Because the proposed action (land use plan amendments setting out allocation of areas that will be available for application for leases) has been altered, the BLM has determined that the proposed action will result in no effect on listed species. Section 6.3 of this PEIS discusses compliance with the ESA. The conservation measures developed in this initial consultation with USFWS, then, will not necessarily be applied, unless warranted by the results of the consultation that will take place at the time the BLM prepares to issue leases. These measures are described in brief here, however, and more fully in Appendix F, in order to provide some general understanding of the kinds of measures that might be applicable to commercial oil shale development leases.

For purposes of the PEIS, these conservation measures are assumed to be generally consistent with existing conservation agreements, recovery plans, and completed consultations. It is the intent of the BLM and USFWS to ensure that the conservation measures are consistent with those currently applied to other land management actions where associated impacts are similar. However, it is presumed that potential impacts from development described in the PEIS are likely to vary in scale and intensity when compared with land management actions previously considered (e.g., oil and gas exploration and production, surface mining, and underground mining). Thus, final conservation measures would be developed for individual projects prior to leasing and ground-disturbing activities and will be consistent with agency policies. Current BLM guidance on similar actions (e.g., fluid mineral resources) requires that the least restrictive stipulation that effectively accomplishes the resource objectives or resource uses for a given alternative should be used while remaining in compliance with the ESA. Mitigation measures, generally applicable to all listed species, are presented below. Species-specific measures are listed in Appendix F.

- Protect federally listed and state-listed threatened and endangered species and BLM-designated sensitive species through siting and development decisions to avoid impacts. Conduct predisturbance surveys in all areas proposed for development following accepted protocols and in consultation with the USFWS and/or state agencies. If any federally listed species are found and it is determined that the proposed development "may affect" the listed species or their critical habitat, the USFWS will be consulted as required by Section 7 of the ESA, and an appropriate course of action will be developed to mitigate impacts and address any potential incidental take from the activity. If any state-listed or BLM-designated sensitive species are found, plans to mitigate impacts will be developed prior to construction consistent with guidance provided in BLM Manual 6840 (BLM 2001).

- Mitigate harassment or disturbance of federally listed threatened and endangered animals, BLM-designated sensitive animal species, and state-listed threatened and endangered animals and their habitats in or adjacent to project areas. This objective can be accomplished by identifying sensitive areas and implementing necessary protection measures based upon consultation with the USFWS (Section 7 of the ESA). Education programs could be developed to ensure that employees are aware of protected species and requirements to protect them. Prohibition of nonpermitted access and gating could be used to restrict access to sensitive areas.

- Mitigate impacts on federally listed and state-listed threatened and endangered species and BLM-designated sensitive species and their habitats during construction and operations. If deemed appropriate by the USFWS, activities and their effects on these species will be monitored throughout the duration of the project. To ensure that impacts are avoided, the effectiveness of mitigation measures will be evaluated and, if necessary, Section 7 consultation will be reinitiated.

- Protect federally listed and state-listed threatened and endangered species and BLM-designated sensitive species (especially plants) and their habitats from the adverse effects of fugitive dust. This objective could be achieved by implementing dust abatement practices near threatened and endangered species' habitats or other special habitats of importance (to be determined at the local field office level). Dust abatement practices (e.g., mulching, water application, paving roads, and plantings) could be applied to all areas of regular traffic or areas of exposed erodible soils, especially in areas near occupied habitats.

- Avoid the release of oil to aquatic habitats in quantities that could result in subsequent adverse impacts on federally listed and state-listed threatened and endangered species and BLM-designated sensitive species. This objective could be accomplished by applying spill prevention technology to all oil pipelines that cross or are in proximity to rivers or streams with threatened or endangered aquatic species. For example, pipelines crossing rivers with listed aquatic species could have remotely actuated block or check valves on both sides of the river; pipelines could be double-walled pipe at river crossings; and pipelines could have a spill/leak contingency plan that includes timely notification of the USFWS and/or state agencies.

4.9 VISUAL RESOURCES

Because of the subjective and experiential nature of visual resources, the human response to visual changes in the landscape cannot be quantified, even though the visual changes associated with a proposed development can be described (Hankinson 1999). There is, however, some commonality in individuals' experiences of visual resources, and while it may not be possible to quantify subjective experience and values, it is possible to systematically examine and characterize commonly held visual values and to reach general consensus about visual impacts and their trade-offs. The BLM's VRM procedures provide a means of describing visual impacts systematically and of evaluating their impact on the scenic qualities of affected landscapes so that defensible decisions about the relative worth and disposition of visual resources relative to competing resource demands can be made (BLM 1984b). The following text box describes the factors that influence individuals' perceptions of visual impacts and that are considered within the BLM's VRM system.

Factors That Influence an Individual's Perception of Visual Impacts

Visibility Factors: Circumstances or activities that eliminate views of the impact area or impacting feature will reduce the level of perceived visual impact. Intervening topography, vegetation, or structures that effectively screen views can greatly reduce impacts of even large visual changes. Conversely, projects placed at higher elevations relative to viewers, particularly along ridgelines, may be conspicuously visible over larger areas, and thus have greater visual impact. Viewer elevation and aspect can also affect impact visibility by increasing or decreasing the viewable area and reducing or increasing screening effectiveness.

View Duration: Impacts that are viewed for a long period of time are generally judged to be more severe than those viewed briefly. For example, a transmission line that closely parallels a hiking trail may be in continuous view of hikers for several hours and would have a greater perceived visual impact than the same transmission line crossed by a perpendicular highway, which would be viewed relatively briefly by drivers and would have a smaller perceived visual impact.

Viewer Distance and Angle: Viewer distance from the impacted area is a key factor in determining the level of impact. The BLM's VRM system defines distance zones—foreground-middleground (less than 3–5 mi), background (5–15 mi), and seldom seen (beyond 15 mi)—with perceived impact diminishing as distance between the viewer and the impact increases (BLM 1986a). Viewer angle relative to the impact may also affect perceived visual impact; when people view landscapes from angles approaching 90° (e.g., views of canyon walls or steep mountain slopes), the landscapes may be scrutinized more closely than those viewed from low angles (e.g., views of plains and other low-relief areas).

Landscape Setting: Landscape setting provides the context for judging the degree of contrast in form, line, color, and texture between the proposed project and the existing landscape, as well as the appropriateness of the project to the landscape. Because of their physical properties, some landscapes are perceived by most viewers to have intrinsically higher scenic value than other landscapes, and physical landscape properties also determine the visual absorption capacity of the landscape (i.e., the degree to which the landscape can absorb visual impacts without serious degradation in perceived scenic quality). Scenic integrity describes the degree of "intactness" of a landscape, which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances. A development project in a pristine, high-value scenic landscape with low visual absorption capacity will typically be more conspicuous and perceived as having greater visual impact than if that same project were present in an industrialized landscape of low scenic value where similar projects were already visible. Special landscapes (also called special areas) have special meanings to some viewers because of unique scenic, cultural, or ecological values, and are, therefore, perceived as being more sensitive to visual disturbances. Other landscapes are regarded as more sensitive to visual disturbances because they are near or adjacent to high-value landscapes, such as national parks or historic trails. Rarity of the landscape setting may also affect visual impact assessment; impacts on landscape settings that are relatively rare within a given region may be of greater concern than impacts on a landscape setting that is regionally very common.

Continued on next page.

Seasonal and Lighting Conditions: Seasonal and lighting conditions that affect contrast may affect perceived visual impact. The presence of snow cover, fall-winter coloration of foliage, and leaf drop may drastically alter color and texture properties of vegetation and soil, thereby altering visual contrasts between a proposed project and the landscape. Sun angle that changes by season and time of day affects shadow casting and color saturation, which, in turn, affect both perceived scenic beauty and contrast.

Number of Viewers: The BLM's VRM system considers impacts to be generally more acceptable in areas that are seldom seen, and conversely, less acceptable in areas that are heavily used and/or viewed.

Viewer Activity, Sensitivity, and Cultural Factors: The type of activity a viewer is engaged in when viewing a visual impact may affect his or her perception of impact level. Recreationists, particularly hikers and others who may visit an area with the specific goal of scenic appreciation, are generally more sensitive to visual impacts than workers, for example, oil and gas workers. Some individuals and groups are also inherently more sensitive to visual impacts than others, as a result of educational and social background, life experiences, and other cultural factors.

Sources: BLM (1984b, 1986a,b); USFS (1995).

The BLM's VRM system defines visual impact as the contrast perceived by observers between existing landscapes and proposed projects and activities. Contrasts between an existing landscape and a proposed project or activity are expressed in terms of the landscape elements of form, line, color, and texture. These basic design elements are routinely used by landscape designers to describe and evaluate landscape aesthetics. They have been incorporated into the BLM's VRM system to lend objectivity, integrity, and consistency to the process of assessing visual impacts of proposed projects and activities on BLM-administered lands (BLM 1986b).

Visual impacts can be either positive or negative, depending on the type and degree of visual contrasts introduced to an existing landscape. Where modifications repeat the general forms, lines, colors, and textures of the existing landscape, the degree of visual contrast is lower, and the impacts are generally perceived less negatively. Where modification introduces pronounced changes in form, line, color, and texture, the degree of contrast is greater, and impacts are often perceived more negatively.

Visual changes associated with oil shale development can be produced through a range of direct and indirect actions or activities, including:

- Vegetation and landform alterations;
- Additions of structures;
- Additions or upgrades to roads;

- Additions or upgrades to utilities and/or ROWs, for example, expansion of ROW width, addition of electric transmission lines or pipelines, or upgrading of transmission voltage or pipeline size;
- Vehicular and worker activity;
- Dust and other visible emissions; and
- Light pollution.

Site-specific impact assessment is needed to systematically and thoroughly assess visual impact levels for a particular project. Without precise information about the location of a project, a relatively complete and accurate description of its major components and their layout, and information about the number and types of viewers, it is not possible to assess the visual impacts associated with the facility precisely. However, if the general nature of the facility is known, as well as the general possible location of facilities, a more generalized but still useful assessment of the possible visual impacts can be made by describing the range of expected visual changes and discussing contrasts typically associated with these changes. In addition, a general analysis can be used to identify sensitive resources that may be at risk if a future project is sited in a particular area.

The impact analysis for this PEIS makes use of distance zones specified by the BLM's VRM system to identify potentially sensitive visual resources that might be impacted if they are within view of an oil shale project. The distance between the viewer and the project elements that are the source of visual contrast is a critical element in determining the level of perceived impact. The BLM's VRM system specifies three distance zones in its visual resource inventory process:

- *Foreground-middleground* (0–5 mi). This zone includes areas where management activities can be seen in detail. This zone has the highest visibility; visual changes are more noticeable than at farther distances and are more likely to trigger public concern.
- *Background* (5–15 mi). This zone includes the area beyond the foreground/middleground up to 15 mi and includes the area where some detail beyond the form or outline of the project is visible.
- *Seldom Seen* (beyond 15 mi). This zone includes areas beyond 15 mi or where only the form or outline of the project can be seen or the project cannot be seen at all (BLM 1986a).

The GIS-based impact analysis used for this PEIS identifies potentially sensitive visual resource areas for which some portions are either within the potential leasing area under an alternative examined in the PEIS, within the 5-mi foreground-middleground distance from the potential leasing area, or within the 15-mi background distance from the leasing area. Assuming an unobstructed view of the project, viewers in these areas would be likely to perceive some level of visual impact from the project, with impacts expected to be greater for resources within the foreground-middleground distance, and lesser for those areas within the background distance. Beyond the background distance, the project might be visible but would likely occupy a very small visual angle and create low levels of visual contrast such that impacts would be minor to negligible.

The impact analysis did not account for topography; in many cases, intervening terrain might obstruct all or part of the view of a project from a given location, for example, a canyon or river bottom. The analysis shows areas that might be affected, but the actual number of affected areas is likely less than that indicated by the analysis. A more precise visibility analysis could be conducted when a site-specific environmental analysis is performed for a particular project, at which point more precise spatial data would be available. This analysis is limited to data that were available in GIS format at the time of analysis; it is recognized that additional scenic resources exist at the national, state, and local levels. While the GIS is capable of extremely high spatial accuracy, it is limited by the accuracy of the data used in the analysis, which were obtained from many sources and subject to error.

Because of a lack of data in a usable GIS format, the analysis did not include examination of BLM VRM classes for all lands potentially affected by the oil shale projects analyzed in the PEIS; however, general statements about the compatibility of visual impacts associated with oil shale facilities with BLM VRM classes can be made. These statements would apply to locations where projects and their associated facilities are located, and in some cases to adjacent lands from which the project would be visible.

The BLM's VRM system specifies the degree of contrast resulting from a project or management activity that is permissible for a given VRM classification. BLM activities must conform to the VRM objectives that apply to the project area, as established in the RMP process. The management objectives for the VRM classes are as follows:

- *Class I Objective.* To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.

- *Class II Objective.* To retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but must not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

- *Class III Objective.* To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

- *Class IV Objective*. To provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

Regardless of the technologies employed for oil shale extraction and processing, commercial production of oil shale at the scales projected for analysis in the PEIS would entail industrial processes eventually requiring more than 5,000 acres of land disturbance and the presence and operation of large-scale industrial facilities, and equipment that would introduce major visual changes into nonindustrialized landscapes and would create strong visual contrasts in line, form, color, and texture. These processes also would involve constant, noticeable human and vehicle activity during operation, and particularly during construction. Where visible to observers within the foreground-middleground distance, facilities would normally be expected to attract attention, and in many cases would be expected to dominate the view. While mitigation measures, such as painting the facilities in earth tones and using nonreflective surfaces, might reduce color contrasts, the strong, complex, regular geometry of the structures, combined with the large sizes of the facilities, would preclude repeating of the basic elements of form, line, color, and texture found in the predominant natural landscape features found in a nonindustrialized landscape. While some of the lesser elements of an oil shale project might be compatible with VRM Class III or Class II objectives, the siting of the major facility elements would be expected to be compatible with Class IV objectives only, unless careful siting hid them from view. VRM Class II or Class III areas in close proximity to the major facilities where open lines of sight existed between the Class II or Class III lands and the major facilities would in some cases be expected to be subject to visual impacts from the strong visual contrasts that would result, particularly if the distance was within the foreground-middleground range, but possibly farther in some cases. These impacts might be incompatible with the VRM objectives for these areas.

The following impact analysis provides a general description of the visual changes that are likely to occur as a result of the construction, operation, and reclamation of oil shale projects (and associated facilities).

While visual impacts associated with the construction, operation, and reclamation of oil shale projects considered in the PEIS differ in some important aspects on the basis of the oil shale extraction and processing technologies employed, there are many impacts that are common to the development approaches. Direct visual impacts associated with construction, operation, and reclamation of commercial oil shale projects can be divided into generally temporary impacts associated with activities that occur during the construction and reclamation phases of the projects, and longer-term impacts that result from the presence of and operation of the facilities themselves. Impacts are presented below by oil shale extraction and processing technology approach.

While mitigation measures (see Section 4.9.2) might lessen some visual impacts associated with these projects, in large part the visual impacts associated with commercial oil shale projects could not be effectively mitigated.

4.9.1 Common Impacts

4.9.1.1 Surface Mining with Surface Retorting

4.9.1.1.1 Construction and Reclamation. Major construction activities associated with the development of an oil shale project utilizing surface mining and surface retorting would include vegetation clearing, recontouring of landforms, road building and/or upgrading, and pad and utility ROW construction. Buildings and structures associated with mining and processing (e.g., ore crushing facilities) and upgrading would be constructed (e.g., multiple liquid storage tanks). Other construction activities would include digging of drilling reserve pits and possibly retention ponds, construction of berms around some tanks, and the addition of fencing around some or all of the lease site. Employer-provided housing would also be constructed off-lease to house workers and their families during the construction phase. (See Section 4.9.1.4 for discussion of impacts associated with electric transmission lines, pipelines, and employer-provided housing.)

The various construction activities described above would require work crews, vehicles, and equipment that would add to visual impacts during construction. Small-vehicle traffic for worker access and large-equipment (trucks, graders, excavators, and cranes) traffic for road construction, site preparation, and tower-pipeline installation would be expected. Both would produce visible activity and dust from disturbance of dry soils. Suspension and visibility of dust would be influenced by vehicle speeds, road surface materials, and weather conditions. Temporary parking for vehicles would be needed at or near work locations. Unplanned and unmonitored parking could likely expand these areas, producing visual contrast by suspended dust and loss of vegetation. Piles of building materials would be visible at times, as well as brush piles and soil piles. Construction equipment might produce emissions and visible exhaust plumes.

Construction would introduce contrasts in form, line, color, and texture, as well as a relatively high degree of human activity into what are generally natural-appearing existing landscapes with generally low levels of human activity. In general, visual impacts associated directly with construction activities would be temporary in nature, but because of the "rolling footprint" approach to mining, recovery, and upgrading during the operations phase of the project, some construction activities would occur several times during the course of the project, giving rise to brief periods of intense construction activity (and associated visual impacts) followed by periods of inactivity.

During reclamation, visual impacts would be similar to those encountered during construction but likely of shorter duration. These impacts probably would include road redevelopment, removal of aboveground structures and equipment, and the presence of idle or dismantled equipment, if allowed to remain on-site. Reclamation activities would involve heavy equipment, support facilities, and lighting. The associated visual impacts would be substantially the same as those in the construction phase. Reclamation likely would be an intermittent or phased activity persisting over extended periods of time and would include the presence of workers, vehicles, and temporary fencing at the work site.

Restoring a site to preproject conditions would also entail recontouring, grading, scarifying, seeding, and planting, and perhaps stabilizing disturbed surfaces, although obtaining the preproject state might not be possible in all cases (i.e., the contours of restored areas might not always be identical to preproject conditions). Newly disturbed soils might create visual contrasts that could persist for several seasons before revegetation would begin to disguise past activity. Invasive species might colonize reclaimed areas, likely producing contrasts of color and texture.

4.9.1.1.2 Operation. Oil shale projects utilizing surface mining and surface retorting technologies could utilize pit or strip mines, depending on site characteristics and applicable BLM policies. A pit mining approach would likely involve one or more mine pits, while a strip mining approach would involve rolling footprint activities whereby small sections of the site would be worked in succession, with equipment, crews, and some structures moving from section to section throughout the life of the project. Under the rolling footprint scenario, some buildings and structures and activities would be centrally located and thus have a permanent presence and associated visual impact, while others would "follow" the rolling footprint, and thus the associated visual impacts might change on the basis of viewing conditions.

Some amount of restoration and remediation of the site would commence soon after a given section was worked. This pattern of activities would create the appearance of construction, operation, and reclamation activities occurring simultaneously on some portion or portions of the site throughout the operational life of the project.

Visual impacts from the operation of a commercial oil shale project employing surface mining and retorting would be generated by vegetation clearing, the presence of the mine pit or strip; mining, retorting, upgrading, and support facilities; utilities and other infrastructure; and the presence and activities of workers, vehicles, and equipment. These impacts would occur in some degree throughout the operational life of the projects, and some impacts might occur beyond the operational life of the project.

Visible project components and activities that would likely result in visual impacts include:

- *Vegetation clearing* (eventually involving approximately 5,760 acres per site) with associated debris. For a pit mine, much of the site might be cleared at the beginning of the project. If a rolling footprint approach is utilized, clearing would not take place all at once; rather, it would be progressive and would likely involve repeated clearing of sections of several hundred acres. Vegetation clearing could result in strong visual contrasts in color, line, and texture between cleared and uncleared areas, depending on viewing conditions. Invasive species might colonize cleared areas if revegetation and other control activities are not completely successful. These species might be introduced naturally or in seeds, plants, or soils introduced for intermediate restoration, or by vehicles.

- *The mine pit or strip*. For a pit mining project, the mine pit would have the appearance of a large depression, possibly several hundred to one thousand acres in size at a given time, and possibly up to 500 ft deep, depending on site characteristics and applicable regulations. The pit would be permanent over the life of the project and might change in size and depth over time; some spent shale would likely be returned to the pit as the project progresses. For a strip mining project, the depression would likely be smaller in area (at a given time) and would move across the site over time. It is projected that surface mining projects in Utah would have 600 to 1,200 acres of surface disturbance at any one time, while surface mines in Wyoming could have 1,000 to 2,000 acres of surface disturbance at any one time. It is projected that the total lease area would be affected over a 20-year project life, but that mine areas and spent shale disposal areas would be reclaimed on an ongoing basis much like many surface coal mines currently are. In both cases, the mine pit or strip would introduce strong visual contrasts in form, line, color, and texture (where visible) to the existing landscape, and because of the large size of the pit or strip, these strong visual contrasts could be conspicuous to viewers within several miles of the project, depending on visibility and viewing conditions.

- *Recontouring of landforms*. The creation of the mine pit or strip, retention ponds, soil and shale piles, roads and pads for facilities, and restoration activities would require extensive recontouring of land throughout the lifetime of the project. Soil scars, exposed slope faces, eroded areas, and areas of compacted soil that could result from recontouring could introduce noticeable color contrasts, depending on soil type, as well as contrasts in form, line, and texture. Color and texture contrasts might be mitigated by revegetation activities over time.

- *New or upgraded roads*. Both new road construction and upgrading of existing roads would be required for site access, materials hauling, and general transport within the site. The presence of new roads could introduce contrasts in line, color, and texture to existing landscapes, while the upgrading of existing roads could increase contrasts in color and texture, depending on treatment, and may increase the visible area if the road is widened. The process of road building and upgrading would likely continue to some degree throughout the life of the project as new sections are worked, particularly for strip mining projects.

- *Pads for structures and/or equipment*. A variety of paved or gravel pads would be required for building and equipment sites, wells, and other activities such as vehicle parking. The presence of pads would introduce contrasts in line, color, and texture into existing landscapes and could introduce contrasts in form if substantial recontouring is required.

- *Buildings, retorts, ore crushing and processing buildings and structures, and other buildings and structures.* The mining, ore handling, retorting, and upgrading processes all require a variety of buildings and built structures, for example, storage tanks, pipelines, flare and smoke stacks, and wells. In addition, a variety of support buildings and structures would be constructed, such as administration buildings, work trailers, guardhouses, storage structures, fences, etc. In general, these buildings and structures would contrast strongly in form, line, color, and texture with existing, generally natural-appearing landscapes because of the built structures' rectilinear geometry, symmetry, and surface characteristics. In particular, those buildings and structures associated with oil shale extraction, ore processing, retorting, upgrading, storage, and transport would have a "heavy industry" look, similar in appearance to an oil refinery. For the larger operations, buildings and structures would likely cover 100 acres. While color contrasts might be partially mitigated by painting buildings and structures in earth tones and using nonreflective coatings, in general the buildings and structures would be visually prominent for any nearby viewers. To varying degrees (depending on the mining technology and other project-specific factors), the buildings and structures would be found in multiple locations and might be moved periodically to follow the mining activities across the site. Flare and smoke stacks could be as tall as 300 ft and could be visible for several miles in daylight, and farther at night.

- *Utilities.* Electric transmission lines, pipelines, and communication data lines and towers (with associated ROWs and structures) would be required. New utilities could be located within and/or outside the lease boundaries. Where visible, these generally linear features would introduce contrasts in line to existing landscapes, while cleared ROWs and structures associated with utilities could introduce contrasts in form, line, color, and texture (Figures 4.9.1-1 and 4.9.1-2).

- *Retention ponds, runoff-control structures, and earthen berms.* Retention ponds would likely be required to control runoff on the project site and to store various liquids used for oil shale processing or reclamation; other runoff control structures such as earthen berms might also be constructed. Earthen berms would likely also be constructed around many of the storage tanks that would be present on the project site. Retention ponds and berms would introduce contrasts in form, line, and texture into existing natural-appearing landscapes. Depending on their size and on visibility and viewing conditions, retention ponds in particular might be visible at long distances.

- *Mounds of stored soil and raw and spent shale.* Depending on the amount of overburden present at the project site, millions of tons of soil could be removed from on top of the oil shale deposits. This soil would be stored in mounds on-site for use in reclamation. If the project involved strip mining, the soil would be used in reclamation immediately after a section was worked,

FIGURE 4.9.1-1 ATP Processor Retort Technology at Stuart Oil Shale Facility, Queensland, Australia (This is a demonstration-scale [4,800-bbl/day] oil shale facility. A portion of the oil shale mining area is visible in background. Photo courtesy of Queensland Energy Resources Limited, Queensland, Australia, and UMATAC Industrial Processes, Calgary, Alberta, Canada. Reprinted with permission.)

FIGURE 4.9.1-2 Stuart Oil Shale Facility, Queensland, Australia (This is a demonstration-scale [4,800 bbl/day] aboveground oil shale retorting and processing facility. Photo courtesy of Queensland Energy Resources Limited, Queensland, Australia, and UMATAC Industrial Processes, Calgary, Alberta, Canada. Reprinted with permission.)

and the total amount visible in storage mounds would be significantly smaller than if the project involved pit mining. In either case, the soil mounds would be vegetated to reduce visual impacts and erosion, but revegetation would require a number of years before texture and color contrasts would be reduced. The mounds would likely be visible for several miles where clear lines of sight existed, and could introduce strong contrasts in form to existing landscapes. Invasive species might colonize disturbed and stockpiled soils and compacted areas. In addition to soil, an estimated 17 to 23 million tons of spent shale would be produced each year for each retort (multiple retorts would be utilized for a given project) and would be stored on-site in large mounds, although a significant amount of the spent shale would be returned to the mine cavity eventually. Because of the expansion of oil shale during heating, much of the spent shale would remain on the surface and would constitute a permanent visual impact unless it was transported off-site. Smaller, but still substantial, mounds of raw shale could be present while awaiting crushing and retorting.

Vehicular equipment and worker presence and activity. The large size of the project, the number of operations being conducted simultaneously (e.g., mining, ore processing, retorting, and upgrading), and the operating schedule of 24 hours per day, 7 days per week, would require that a substantial amount of equipment and a significant number of workers and vehicles be active on the site at most times throughout the life of the project. Small-vehicle traffic for worker access and nearly constant large-equipment traffic for raw and spent shale hauling and other activities would be expected. Both would produce visible activity and dust in dry soils, and some of the large-vehicle traffic would likely generate visible exhaust plumes. Suspension and visibility of dust would be influenced by vehicle speeds, road surface materials, and weather conditions, but might be at least partially controlled by dust-suppression measures. The presence of workers could also result in litter and debris that could create negative visual impacts within and around the project site.

- *Dust and emissions*. Large equipment used to mine and crush oil shale would likely create large amounts of dust, which, if uncontrolled, could produce visible dust plumes, particularly for projects located on ridges or other exposed locations. Equipment and vehicles would also produce dust and emissions, as would explosives used in the mining process. Retort smokestacks, up to 300 ft (approximately 100 m) or more in height would likely generate visible plumes under certain atmospheric conditions that could be visible for great distances (Commission on Geosciences, Environment and Resources 1993). Smaller stacks associated with other activities might also create visible emission plumes. In addition to their direct visibility, dust and emissions could also contribute to atmospheric haze in the region that could decrease landscape visibility, especially for long-distance views.

- *Light pollution.* Because the projects would operate "around the clock," they would generate light pollution from a variety of sources such as flare stacks, navigation warning lights on smokestacks, operations and security lighting, and vehicles. Lighting needs for operations would be substantial. This operational state could result in skyglow (an increase in brightness in the night sky) above and around the project area, depending on viewing and atmospheric conditions, and could also result in direct illumination of the facilities where lines of sight exist.

4.9.1.2 Underground Mining with Surface Retorting

While still introducing major visual changes to natural-appearing existing landscapes and creating strong visual contrasts in line, form, color, and texture that in large part could not be mitigated, commercial production of oil shale involving underground mining and surface retorting would involve fewer and less severe visual impacts compared with oil shale projects utilizing surface mines (see Section 4.9.1.1), primarily because of reduced surface disturbance from mining and related activities. Visual impacts associated with reclamation would also likely be less than for projects utilizing surface mines, because of the greatly reduced level of ground disturbance.

4.9.1.2.1 Construction and Reclamation. Construction and reclamation of commercial oil shale projects utilizing underground mining and surface retorting would generate visual impacts similar in nature to those generated by projects utilizing surface mines. A rolling footprint development approach would not be utilized; however, a large mine pit would not be developed during operation either, so that ultimately, far less surface would need reclamation after operations, and, therefore, reclamation activities would be less extensive, take less time, and thus would generate fewer visual impacts than reclamation activities for surface mines. A larger pile of spent shale would remain on the surface after operations; this material could require increased duration and intensity of reclamation activities for the affected portion of the site, which could increase associated visual impacts.

It is assumed that there would be one connecting transmission line and ROW and one pipeline and ROW serving each project site. Employer-provided housing also would be constructed off-lease to house workers and their families during the construction phase (see Section 4.9.1.4 for discussion of impacts associated with electric transmission lines, pipelines, and housing construction).

4.9.1.2.2 Operation. Visual impacts associated with commercial oil shale production using underground mines are generally similar in nature to impacts associated with projects using surface mines; however, some major visual impacts associated with surface mining are absent or greatly diminished. Although mine adits and some ancillary facilities would be present, the associated visual impacts would be small, relative to either a pit or strip mine. In addition, because the adits would be created at permanent locations and the rolling footprint development approach would not be utilized, far less vegetation clearing, recontouring, and road building would be required, thereby greatly reducing the visual impacts relative to projects involving surface mines. It is expected that an area of approximately 150 acres would have a highly industrialized appearance with a core area of buildings, ore processing facilities, tank farms, up to eight retorts, and other ancillary structures and equipment. Because of the reduced level of land disturbance, there would likely be less need for retention ponds and other erosion-water control structures relative to surface mining operations. Because much of the activity associated with mining would take place underground, there likely would also be fewer and less severe visual impacts associated with worker and equipment presence and activity, and likely reduced dust and emissions as well.

Impacts associated with surface retorting, upgrading, and materials storage and transport would likely be similar to those described for projects utilizing surface mines (see Section 4.9.1.1). There would likely be slightly less light pollution because mining activity would be moved underground. Because most of the mined shale could not be disposed of in the mine, much larger amounts of spent shale would be present on the surface, and visual impacts associated with spent shale piles would be proportionally larger. Depending on the disposal areas chosen within the lease area, spent shale disposal areas may eventually cover approximately 1,500 acres at a depth of material up to 250 ft. Disposal areas would be revegetated as an ongoing part of the operation. The increased impact from spent shale piles would be partially offset by the absence of soil mounds associated with overburden removal.

4.9.1.3 In Situ Processing

Similarly to projects utilizing surface or underground mining, commercial oil shale projects utilizing in situ processing are large-scale industrial concerns that would introduce major visual changes to natural-appearing existing landscapes. During the life of the project, in large part these visual impacts could not be effectively mitigated; however, in situ processing would likely generate the lowest total visual impacts of the three technical approaches, primarily because it does not require mining, ore processing, or retorting, and there would be no spent shale pile. After successful remediation, many visual impacts associated with in situ oil shale development could likely be eliminated or substantially attenuated.

4.9.1.3.1 Construction and Reclamation. In general, construction and reclamation of commercial oil shale projects utilizing in situ processing would utilize a rolling footprint development approach, with the appearance of continual construction and reclamation throughout the life of the project. Construction and reclamation impacts for in situ projects would likely be lower than for oil shale projects utilizing mines and surface retorting because of the relatively low level of recontouring and the absence of spent shale and soil mounds.

It is assumed that there would be one connecting transmission line and ROW and one pipeline and ROW serving each project site. Employer-provided housing also would be constructed off-lease to house workers and their families during the construction phase (see Section 4.9.1.4 for discussion of impacts associated with electric transmission lines, pipelines, and housing construction).

4.9.1.3.2 Operation. Many visual impacts associated with commercial production of oil shale using in situ processing are generally similar in nature to impacts associated with projects using mining and surface retorting. The major visual impacts associated with mining and retorting are absent, however, and the overall visual impact would likely be substantially lower because of the absence of mines, ore processing facilities, retorts and ancillary facilities, spent-raw shale piles, and retention ponds and water-erosion control structures. Relatively little recontouring would be required. There likely would also be, on average, less activity visible on the site because there would be no mining or shale-hauling activities. There would likely be a lower level of visual impacts from dust and emissions because there would be no ore crushing, and there would be less traffic and equipment activity on the site. There would, however, be extensive clearing of vegetation in each section and large numbers of wells and well pads in areas where shale oil was being extracted as it was worked, in accordance with the rolling footprint development process that would be employed. For projects in Colorado and Utah, between 150 and 600 acres are likely to be disturbed at a given time, and for projects in Wyoming, 1,000 to 2,000 acres would likely be disturbed at a given time. It is projected that the total lease area of up to 5,760 acres would be affected over a 20-year project life. Buildings and structures would be associated with pumping shale oil and coolant for freeze-wall maintenance, as well as facilities for upgrading, storage, and transport of shale oil. Because of the large demand for power to heat and cool underground formations, more structures associated with power generation, transmission, and distribution would likely be required, which would increase visual impacts. These permanent facilities are estimated to occupy approximately 200 acres. Other visual impacts (for infrastructure, employee-provided housing, and roads) would likely be similar to those described for oil shale projects utilizing surface mines.

Oil shale projects utilizing in situ processes are expected to have electric power requirements that would necessitate construction of new power plants to supply the required electricity. It is expected that the new power plants would be conventional 1,500-MW coal-fired plants. Visual impacts associated with the construction and operation of the new power plants are discussed in Section 4.9.1.4.2.

4.9.1.4 Other Associated Oil Shale Project Facilities

While many visual impacts expected from commercial oil shale development projects under consideration in the PEIS are site- or technology-specific, the oil shale projects have some common elements that would be expected to create similar visual impacts regardless of location or the oil shale extraction and processing technologies employed. These elements include transmission lines and pipelines (required for all commercial oil shale projects), employer-provided housing (required for all commercial oil shale projects), and new power generation facilities (required for commercial oil shale projects utilizing in situ processing). The elements and related visual impacts are discussed here separately from impacts associated with specific oil shale extraction and processing technologies.

4.9.1.4.1 Electric Transmission Lines and Pipelines. Construction and operation of electric transmission lines and oil pipelines could be required for commercial oil shale development. However, the projected linear extent of the facilities varies by project type and technology employed. Visual impacts associated with construction, operation, and reclamation of the electric transmission and pipeline facilities include temporary impacts associated with activities that occur during the construction and reclamation phases of the projects, and longer-term impacts that result from construction and operation of the facilities themselves. For a given oil shale project, up to 150 mi of transmission line ROW might be required, and up to 55 mi of pipeline ROW might be required.

Potential visual impacts that could result from construction activities include ROW clearing with associated debris; trenching (for pipelines); road building and upgrading; construction and use of staging areas and laydown areas; mainline and support facility construction; blasting of rock faces and other cavities; vehicular, equipment, and worker presence and activity; and associated vegetation and ground disturbances, dust, and emissions. Pipeline construction may also involve pipeline bridge construction for crossings of rivers and canyons. During reclamation, visual impacts would be similar to those encountered during construction, but likely of shorter duration, and generally occurring in reverse order from construction impacts.

Construction of a ROW requires clearing of vegetation, large rocks, and other objects. Vegetation clearing and topographic grading would be required for construction of access roads, maintenance roads, and roads to support facilities (e.g., electric substations or pump stations). Vegetation clearing activities can cause visual impacts by creating contrasts in form, line, color, and texture with existing natural landscapes, depending on site-specific factors, such as existing vegetation. Road development may introduce strong visual contrasts in the landscape depending on the route relative to surface contours, and the width, length, and surface treatment of the roads. Construction access roads would be reclaimed after construction ended, but some visual impacts (e.g., vegetation disturbance) associated with them might be evident for some years afterwards, gradually diminishing over time. Staging areas and laydown areas would be required for stockpiling and storage of equipment and materials needed during construction. These areas may require vegetation clearing, may cover 2 to 30 acres, and be placed at intervals of several miles along a ROW.

Transmission line construction activities include clearing, leveling, and excavation at tower sites, as well as assembly and erection of towers followed by cable pulling. Pipeline mainline construction activities include clearing, leveling, trenching, and laying of pipe. Both electric and pipeline mainline construction activities would potentially have substantial but temporary visual impacts. Because both types of facilities are linear, construction activities would generally proceed as a "rolling assembly line," with a work crew gradually moving through an area at varying rates depending on circumstances.

The operation and maintenance of electric transmission lines or pipelines and their associated facilities, roads, and ROWs would potentially have substantial long-term visual effects. Some impacts are common to both types of structures; however, the mainline structures are fundamentally different in terms of visual impacts. Electric transmission lines generally involve stronger visual contrasts than pipelines. In the following discussion, impacts similar for both types of projects are discussed, while impacts that are significantly different are discussed separately.

The width of cleared area for the permanent ROW for a given project would be determined at a project-specific level, but in general would be expected to be substantially wider for electric transmission line projects than for pipelines. Cleared ROWs might open up landscape views, especially down the length of the ROW, and introduce potentially significant changes in form, line, color, and texture. While the opening of views for viewers close to a cleared ROW might in some circumstances be a positive visual impact, the introduction of strong linear and color contrasts from clearing of ROWs in mid-ground and background views could create negative visual impacts, particularly in forested areas where either the viewer or the ROW is elevated such that long stretches of the ROW are visible. Viewing angle could also be an important factor in determining the perceived visual impact in these settings. In some situations, the impacts could be visible for many miles.

Where visible, electric transmission and distribution towers could create strong visual contrasts. The tower structures, conductors, insulators, aeronautical safety markings, and lights would all create visual impacts. Electric transmission towers would create vertical lines in the landscape, and the conductors would create horizontal lines that would be visible depending on viewing distance and lighting conditions. In the open landscapes present in much of the West and under favorable viewing conditions, the towers and conductors might be easily visible for several miles, especially if skylined, that is, placed along ridgelines. A variety of mitigation measures could be used to reduce impacts from these structures, but because of their size, in many circumstances it is difficult to avoid some level of visual impact except at very long distances. A transmission line's visual presence would last from construction throughout the life of the project.

Oil pipelines in the United States are generally buried several feet below the surface, except at valves, compressor stations, pigging stations, city gate stations, metering facilities, some river crossings, or where very steep topography, bedrock, or other subsurface conditions preclude burial. Visual impacts are therefore typically less for buried portions of a pipeline than for aboveground portions and are limited primarily to those impacts associated with ROW clearing. Aboveground pipeline would generally introduce a strong, generally horizontal line into natural landscapes and might introduce significant color contrast as well, depending on surface treatment. Pipeline bridges might be conspicuously visible at some river or canyon crossings.

Both electric transmission projects and pipelines have associated ancillary structures that would contribute to perceived visual impacts. Electrical substations are located at the start and end points of transmission lines and may be required at locations where line voltage is changed. Substations may be several acres in size and include a variety of visually complex structures, conductors, fencing, lighting, and other features that result in an "industrial" appearance. The industrial look of a typical substation, together with the substantial height of its structures (up to 40 ft or more) and its large areal extent, may result in negatively perceived visual impacts for nearby viewers.

Pipeline systems include aboveground structures, including valves, compressor and pump stations, metering stations, and pig launch and recovery facilities. Valves may occupy a few hundred square feet, while pump stations may exceed 25 acres in size and include several buildings and sections of aboveground pipeline. All of these facilities are industrial in appearance, with visually complex and generally rectilinear geometry, and the facilities typically introduce strong visual contrasts in line, form, texture, and color where they are located in nonindustrial surroundings, particularly for nearby viewers.

4.9.1.4.2 Power Generation Facilities. New conventional coal-fired power plants or expansion of existing plants are projected to be required to supply electricity for certain commercial oil shale projects utilizing in situ processing. The power plants would be major industrial facilities occupying a total of approximately 4,800 acres during construction and operations. The location of new plants is not likely to occur on public lands. Direct visual impacts associated with construction, operation, and reclamation of the required power plants can be divided into generally temporary impacts associated with activities that occur during the construction and reclamation phases of the projects, and longer-term impacts that result from construction and operation of the facilities themselves.

Major construction activities associated with the new power plants would include vegetation clearing; recontouring of landforms; road building and/or upgrading; and pad, parking lot, and building construction, as well as construction of other structures such as smokestacks or cooling towers. Other construction activities could include laying of railroad track; construction of berms, ditches and/or ponds; and the addition of fencing around some or all of the facility site. Transmission towers and lines would be constructed to transmit the generated electricity off-site (impacts associated with electric transmission ROW construction and operation are discussed separately above).

These construction activities would require work crews, vehicles, and equipment that would add to visual impacts during construction. During reclamation, visual impacts would be similar to those encountered during construction, but they would likely be of shorter duration and generally occur in reverse order from construction impacts.

Visual impacts from the operation of the power plants would be primarily caused by visual contrasts associated with vegetation removal and the presence of buildings and other structures with strong geometric lines, spatial symmetry, and flat, monochromatic surfaces. These man-made industrial facilities would draw visual attention because of their size, color, and shape. The presence and activities of workers, vehicles, and equipment also would cause visual impacts. In addition, emission plumes would be expected to be visible in some atmospheric conditions, and the plumes could be visible for long distances. The emissions from the plants could contribute to atmospheric haze that would reduce visibility over long distances, thereby impacting scenic quality. The facilities also would be expected to contribute to local light pollution at night. These impacts would occur throughout the operational life of the power plants, and some impacts might occur beyond the operational life of the project.

Expected impacts associated with the construction and operation of a conventional coal-fired power plant would differ to some degree depending on the specific site location, the technologies employed, and the configuration of the facility. Regardless of these factors, the presence and operation of industrial-appearing power plant facilities and equipment would introduce major visual changes to natural-appearing existing landscapes by creating strong visual contrasts in line, form, color, and texture. While mitigation measures might lessen some visual impacts associated with the power plants, in large part the visual impacts associated with the power plants could not be effectively mitigated. If the new power plants were sited adjacent to existing power plants or similar industrial facilities, the impacts could be significantly smaller, because the addition of an industrial facility to an already industrial-appearing landscape would involve a lower degree of visual contrast between the new plant and its surroundings.

4.9.1.4.3 Employer-Provided Housing. Employer-provided housing would be constructed for each project; the locations are unknown, but not likely to be located on public lands. Employer-provided housing would likely consist of clusters of prefabricated buildings or trailer homes used for worker housing, and some common buildings (e.g., recreation centers, stores, schools, and medical facilities). The size of the housing development would vary depending on the type of project and project phase (see Section 4.1), ranging from 7 to 63 acres in size. Employer-provided housing developments might be fenced around the perimeter, and street and/or security lighting would likely be provided. Paved or gravel pads might be constructed under the buildings/trailer homes. Visual impacts associated with the employer-provided housing would include contrasts in form, line, color, and texture caused by the introduction of buildings, fences, pads, possible land forming to level the area, and vegetation clearing; the addition of utilities such as electric transmission and distribution lines, telephone lines, etc.; the addition of roads both within and outside of the development; and the presence of workers, their families, their vehicles, and litter and other debris associated with the presence of humans. Light pollution would be generated at night from buildings, vehicles, and outdoor lighting. The extent and exact nature of the visual contrasts created would depend on site-specific factors but might be very noticeable for nearby viewers with unobstructed views of the housing area.

Visual impacts associated with employer-provided housing would first occur during construction of the housing and would normally continue throughout the life of the oil shale project. However, employer-provided housing needs are predicted to be smaller during facility operation than during facility construction, and the unneeded housing would be removed after facility construction is completed. When the oil shale project is decommissioned, the remaining employer-provided housing and associated structures and facilities would likely be removed, and the area remediated to preconstruction conditions. Primarily because of the length of time required for vegetation restoration, some visual impacts associated with employer-provided housing might last for many years after removal of the housing.

4.9.2 Mitigation Measures

Development activities will implement visual impact mitigation measures to the extent applicable and practicable. Potential mitigation measures that may be applied to siting, development, and operation of oil shale leases, as warranted by the result of the lease-stage or plan of development–stage NEPA analyses include the following. However, it should be noted that while mitigation measures might lessen some visual impacts associated with oil shale development, in large part the visual impacts associated with commercial oil shale projects could not be mitigated.

- Siting projects outside of the viewsheds of key observation points (KOPs), or if this cannot be avoided, as far away as possible.
- Siting projects to take advantage of both topography and vegetation as screening devices to restrict views of projects from visually sensitive areas.
- Siting facilities away from and not adjacent to prominent landscape features (e.g., knobs and waterfalls).
- Avoiding placement of facilities on ridgelines, summits, or other locations such that they will be silhouetted against the sky from important viewing locations.
- Co-locating facilities to the extent possible to utilize existing and shared ROWs, existing and shared access and maintenance roads, and other infrastructure in order to reduce visual impacts associated with new construction.
- Siting linear facilities so that generally they do not bisect ridge tops or run down the center of valley bottoms.
- Siting linear features (aboveground pipelines, ROWs, and roads) to follow natural land contours rather than straight lines (particularly up slopes) when possible. Fall-line cuts should be avoided.
- Siting facilities, especially linear facilities, to take advantage of natural topographic breaks (i.e., pronounced changes in slope) to avoid siting facilities on steep side slopes.
- Where possible, siting linear features such as ROWs and roads to follow the edges of clearings (where they will be less conspicuous) rather than passing through the centers of clearings.
- Siting facilities to take advantage of existing clearings to reduce vegetation clearing and ground disturbance, where possible.

- Choosing locations for ROWs and other linear feature crossings of roads, and streams, and other linear features to avoid KOP viewsheds and other visually sensitive areas, and to minimize disturbance to vegetation and landform.
- Siting linear features (e.g., trails, roads, and rivers) to cross other linear features at right angles whenever possible to minimize viewing area and duration.
- Minimizing the number of structures required.
- Constructing low-profile structures whenever possible to reduce structure visibility.
- Siting and designing structures and roads to minimize and balance cuts and fills and to preserve existing rocks, vegetation, and drainage patterns to the maximum extent possible.
- Selecting and designing materials and surface treatments in order to repeat and/or blend with existing form, line, color, and texture of the landscape.
- Using appropriately colored materials for structures, or appropriate stains/coatings, to blend with the project's backdrop.
- Using nonreflective or low-reflectivity materials, coatings, or paints whenever possible.
- Painting grouped structures the same color to reduce visual complexity and color contrast.
- Designing and installing facility lighting so that the minimum amount of lighting required for safety and security is provided but not exceeded and that upward light scattering (light pollution) is minimized.
- Siting construction staging areas and laydown areas outside of the viewsheds of KOPs and visually sensitive areas, where possible, including siting in swales, around bends, and behind ridges and vegetative screens.
- Developing a site reclamation plan and implementing it as soon as possible after construction begins.
- Discussing visual impact mitigation objectives and activities with equipment operators prior to commencement of construction activities.
- Mulching slash from vegetation removal and spreading it to cover fresh soil disturbances or, if not possible, burying slash.

- If slash piles are necessary, staging them out of sight of sensitive viewing areas.
- Avoiding installation of gravel and pavement where possible to reduce color and texture contrasts with existing landscape.
- Using excess fill to fill uphill-side swales resulting from road construction in order to reduce unnatural-appearing slope interruption and to reduce fill piles.
- Avoiding downslope wasting of excess fill material.
- Rounding road-cut slopes, varying cut and fill pitch to reduce contrasts in form and line, and varying slope to preserve specimen trees and nonhazardous rock outcroppings.
- Leaving planting pockets on slopes where feasible.
- Providing benches in rock cuts to accent natural strata.
- Using split-face rock blasting to minimize unnatural form and texture resulting from blasting.
- Segregating topsoil from cut and fill activities and spreading it on freshly disturbed areas to reduce color contrast and aid rapid revegetation.
- If topsoil piles are necessary, staging them out of sight of sensitive viewing areas.
- Where feasible, removing excess cut and fill from the site to minimize ground disturbance and impacts from fill piles.
- Burying utility cables where feasible.
- Minimizing signage and painting or coating reverse sides of signs and mounts to reduce color contrast with existing landscape.
- Prohibiting trash burning during construction, operation, and reclamation; storing trash in containers to be hauled off-site for disposal.
- Controlling litter and noxious weeds and removing them regularly during construction, operation, and reclamation.
- Implementing dust abatement measures to minimize the impacts of vehicular and pedestrian traffic, construction, and wind on exposed surface soils during construction, operation, and reclamation.

- Undertaking interim restoration during the operating life of the project as soon as possible after disturbances.

- During road maintenance activities, avoiding the blading of existing forbs and grasses in ditches and along roads.

- Recontouring soil borrow areas, cut-and-fill slopes, berms, waterbars, and other disturbed areas to approximate naturally occurring slopes during reclamation.

- Randomly scarifying cut slopes to reduce texture contrast with existing landscape and to aid in revegetation.

- Covering disturbed areas with stockpiled topsoil or mulch, and revegetating with a mix of native species selected for visual compatibility with existing vegetation.

- Removing or burying gravel and other surface treatments.

- Restoring rocks, brush, and forest debris whenever possible to approximate preexisting visual conditions.

To mitigate visual impacts on high-value scenic resources in lands outside of, but adjacent to or near, oil shale leasing areas, the following mitigation measures should be applied to siting, development, and operation of oil shale leases, as warranted by the result of the lease-stage or plan of development–stage NEPA analyses.

- Oil shale-related development and operation activities within 5 mi of National Scenic Highways, All-American Roads, state-designated scenic highways, WSRs, and river segments designated as eligible for wild and scenic river status should conform to VRM Class II management objectives, with respect to impacts visible from the roadway/river. Beyond 5 mi but less than 15 mi from the roadway/river, development activities should conform to VRM Class III objectives.

- Development activities within 15 mi of high-potential sites and segments of National Trails, National Historic Trails, and National Scenic Trails should conform to VRM Class II management objectives, with respect to impacts visible from the adjacent trail high-potential sites and segments. Beyond 15 mi, development activities should conform to VRM Class III objectives.

- Development activities on BLM-managed public lands within 15 mi of KOPs (e.g., scenic overlooks, rest stops, and scenic highway segments) in National Parks, National Monuments, NRAs, and ACECs with outstandingly remarkable values for scenery should conform to VRM Class II management objectives, with respect to impacts visible from the KOPs. Beyond 15 mi, development activities will conform to VRM Class III objectives. KOPs for non-BLM-managed lands should be determined in consultation with the managing federal agency.

4.10 CULTURAL RESOURCES

4.10.1 Common Impacts

Significant cultural resources, listed or eligible for listing on the NRHP, could be affected by commercial oil shale leasing and development.

The potential for impacts on cultural resources from commercial oil shale development, including ancillary facilities such as access roads, transmission lines, pipelines, employer-provided housing, and construction of possible new power plants, is directly related to the amount of land disturbance and the location of the project. Indirect effects, such as impacts on the cultural landscape resulting from the erosion of disturbed land surfaces and resulting from increased accessibility to possible site locations, are also considered. Leasing itself has the potential to impact cultural resources to the extent that the terms of the lease limit an agency's ability to avoid, minimize, or mitigate adverse effects of proposed development on cultural properties. However, the addition of stipulations to the leases would clarify the necessary protective requirements for historic properties present within a lease area.

Impacts on cultural resources could result in several ways as described below.

- *Complete site destruction* could result from the clearing of the project area, grading, excavation, and construction of facilities and associated infrastructure if sites are located within the footprint of the project.

- *Site degradation and/or destruction* could result from the alteration of topography, alteration of hydrologic patterns, removal of soils, erosion of soils, runoff into and sedimentation of adjacent areas, and oil or other contaminant spills if sites are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively impact sites downstream of the project area by potentially eroding away materials and portions of sites, the accumulation of sediment could serve to protect some sites by increasing the amount of protective cover. Contaminants could affect the ability to conduct analysis of material present at the site and thus the ability to interpret site components.

- *Increases in human access* and subsequent disturbance (e.g., looting, vandalism, and trampling) of cultural resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes archaeological sites and historic structures and features to greater probability of impact from a variety of stressors.

- *Visual degradation of setting* associated with significant cultural resources could result from the presence of commercial oil shale development and associated land disturbances and ancillary facilities. This could affect significant cultural resources for which visual integrity is a component of the sites' significance, such as sacred sites and landscapes, historic trails, and historic landscapes.

Cultural resources are nonrenewable, and, once damaged or destroyed, they are not recoverable. Therefore, if a cultural resource is damaged or destroyed during oil shale development, it would constitute an irretrievable commitment of this particular cultural location or object. For cultural resources that are significant for their scientific value, data recovery is one way in which some information may be salvaged should a cultural resource site be adversely impacted by development activity. Certain contextual data are invariably lost, but new cultural resources information is made available to the scientific community. Loss of value for education, heritage tourism, or traditional uses is less easily mitigated.

4.10.2 Mitigation Measures

For all potential impacts, the application of mitigation measures developed in consultation under Section 106 of the NHPA will avoid, reduce, or mitigate the potential for adverse impacts on significant cultural resources. Section 106 consultations between the BLM and the SHPOs, appropriate Tribes, and other consulting parties would be required at the lease stage and at the plan of development stage. The use of BMPs, such as training/education programs, could reduce occurrences of human-related disturbances to nearby cultural sites. The specifics of these BMPs would be established in project-specific consultations between the applicant and the BLM, as well as with the SHPO and Tribes, as appropriate. The addition of special stipulations to specific leases would ensure that resulting decisions from project-specific consultations are applied to the resources present in the lease areas.

An ethnohistory and cultural resources overview were completed for the project area (Bengston 2007 and O'Rourke et al. 2007, respectively). The overviews synthesized existing information on cultural resources that had been previously identified. Also, Tribal consultation was initiated to further identify significant cultural resources. This phase of analysis did not identify geographical areas that will preclude moving areas forward for leasing. During the leasing phase, the overviews and ongoing Tribal consultation will be reviewed to help determine areas of sensitivity and appropriate survey and mitigation needs.

The BLM will conduct a phased approach to meet the agency's obligations under Section 106 of the NHPA. This approach is necessary for identification and evaluation efforts where alternatives under consideration consist of large land areas across a multistate region and when effects on historic properties cannot be fully determined prior to approval of leasing. Each phase of development will require an appropriate level of Section 106 analysis. Oil shale leasing may require additional consultation and information gathering (e.g., cultural resource inventories) prior to the lease sale. The final phase is that the lessee will then submit a plan of development for a site-specific project. Additional site-specific NEPA analyses and a Section 106 review will be conducted on these individual project plans of development. The BLM will complete comprehensive identification (e.g., field inventory), evaluation, protection, and mitigation following the policies and procedures contained within the 1997 BLM National Programmatic Agreement and State Protocols (BLM 1997b) and as indicated in any lease stipulations. Also, the BLM will continue to implement government-to-government consultation with Tribes and with other consulting parties on a case-by-case basis for plans of development.

The BLM does not approve any ground-disturbing activities that may affect any historic properties, sacred landscapes, and/or resources protected under the NHPA, American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act (NAGPRA), E.O. 13007 (U.S. President 1996), or other statutes and E.O.s until it completes its obligations under applicable requirements of the NHPA and other authorities. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized, or mitigated. The BLM attaches this language to all lease parcels.

In some instances, additional special stipulations to the leases may be required for protection of specific cultural resources on the basis of the Ethnohistoric Overview and Class I Cultural Resource Overview (Bengston 2007 and O'Rourke et al. 2007, respectively), cultural resource inventories conducted prior to leasing, and information received from Tribal consultations, if it will not be possible to adequately avoid, minimize, or mitigate such resources under existing statute, regulation, or BLM policy subsequent to lease issuance.

The BLM develops specific mitigation measures to implement the lease stipulations on a project-by-project basis. Mitigation for adverse effects on the most common resource type, archaeological sites significant for their scientific value, is data recovery. To protect portions of historic trails that are potentially eligible for listing on the NRHP from visual intrusion and to maintain the integrity of the historic cultural setting, the BLM would require that surface disturbance be restricted or prohibited within the viewshed of the trail along those portions of the trail for which eligibility is based on the viewshed.

4.11 SOCIOECONOMICS

The analysis of the socioeconomic impacts of oil shale developments in Colorado, Utah, and Wyoming consists of two interdependent parts. The analysis of economic impacts estimates the impacts of oil shale facilities and associated facilities (e.g., power plants and coal mines)[12] on employment and personal income in an ROI in which oil shale resources are located in each

[12] The impact of coal mining to support coal-fired power plants that are projected to be required for in situ projects is only addressed for socioeconomics and environmental justice in this PEIS. Although impacts from coal mining may be important factors for the socioeconomic analysis, the need for additional coal mining is speculative. Future site-specific NEPA analyses would be needed to address the full range of socioeconomic concerns for a development project.

state. Because of the relative economic importance of oil shale developments in small rural economies and the lack of available local labor and economic infrastructure, large-scale oil shale developments are likely to cause a large influx of temporary population. As population increases are likely to be rapid, local communities may be unable to quickly absorb new residents, resulting in impacts on local finances and public service infrastructure. Social and psychological disruption may also occur, together with the undermining of established community social structures. Given these considerations, the analysis of social impacts assesses the potential impacts of oil shale developments on population, housing, public service employment, and community public finances in the ROI in each of the three states. The analysis also assesses the potential impact of oil shale projects on social disruption that may be associated with rapid population growth in small rural communities hosting large resource development projects.

The assessment of the socioeconomic impacts of oil shale developments was based on a number of key assumptions:

- *Material and equipment procurement*. Many of the industries that would likely provide the appropriate materials, equipment, and other supplies in sufficient quantity for construction and operation of oil shale facilities and the associated power plants and coal mines are presently located outside the ROI in each state; thus, it was assumed that the majority of these resources would be purchased outside each ROI and shipped to the relevant oil shale, power plant, and coal mine facility locations. Specifically, for each ROI it was assumed that 15% of materials and equipment during the construction phase were purchased in each local economy, with 20% purchased locally during the operations phase. Given the more likely local availability of materials and services for housing construction, it was assumed that 25% of materials required for the construction of temporary employer-provided housing and housing provided in local communities would come from each ROI.

- *Wages and salary spending*. Since oil shale, power plant, and coal mine construction workers would reside in the ROI in each state for extended periods of time, it was assumed that 75% of wages and salaries paid to these workers would be spent in the ROI in each state, with 25% of income used to cover existing expenses, such as housing payments, in locations outside each ROI. As it was assumed that all oil shale, power plant, and coal mine operations workers would move permanently into the ROI in each state, 100% of wages and salary spending by these workers was assumed to occur within the ROI in each state. It was assumed that 50% of housing construction workers would reside in the ROI in each state and would spend their wages and salaries locally and that housing construction workers not residing in the ROI would commute from elsewhere, with no wage-spending impacts associated with commuting workers.

- *Worker in-migration*. Because of the relatively small local labor force and fairly low unemployment rates in each ROI (see Section 3.10.1), it was assumed that the entire construction and operations labor force for oil shale facilities and the associated power plants and coal mines would come from outside the ROI in each state. It was also assumed that 33% of oil shale facility, power plant, and coal mine workers (direct and indirect) during construction and operations would be accompanied by their families and would be accommodated in temporary employer-provided housing or in housing provided by local communities. The national average household size of 2.59 (U.S. Bureau of the Census 2007c) was used to calculate the number of additional family members per worker. It was assumed that, given the presence of workers in the relevant occupations in each ROI, 50% of the workers required for temporary housing construction would already reside in local ROI communities. The remainder would commute from outside the ROI on a daily basis or use temporary accommodations (rental housing, hotels, campsites, etc.).

- *Worker housing*. Given the size of the potential demand for housing by the in-migrating oil shale facility, power plant, and coal mine workers and families compared with the number of housing units projected to be available in each ROI, it was assumed that all temporary housing required would be new construction. Based on population density, the relative remoteness of rural communities, and likely driving distances to oil shale facilities, it was assumed that a relatively large percentage of oil shale and power plant workers and families would be housed in employer-provided housing, the location of which is unknown at this time, but which is not expected to be on public lands (Table 4.11-1). The remainder would be accommodated in temporary housing of similar quality built in local communities in each ROI. Although temporary housing built for oil and gas and other energy project construction workers has typically been in trailer homes, and often in employer-provided housing, housing provided for oil shale and ancillary facility workers may be of more substantial construction and may include a wider range of health and recreation services than previously provided. Housing provided in local

TABLE 4.11-1 Temporary Housing Assumptions

	Employer-Provided Housing (%)	Provided in Local Communities (%)
Colorado		
Construction		
Direct workers	60	40
Indirect workers	10	90
Operations		
Direct workers	25	75
Indirect workers	10	90
Utah		
Construction		
Direct workers	80	20
Indirect workers	35	65
Operations		
Direct workers	50	50
Indirect workers	25	75
Wyoming		
Construction		
Direct workers	70	30
Indirect workers	30	70
Operations		
Direct workers	30	70
Indirect workers	15	85

Source: Thompson (2006a).

communities, especially that provided for operations workers, may be similar to that built for the residential market and may be located in existing residential areas. A small number (15%) would be accommodated in rental housing and motels in the ROI. Indirect workers producing goods and services needed as a result of increased local demand associated with oil shale, power plant, and coal mine worker wage and salary spending would also be partially accommodated in employer-provided housing (Table 4.11-1). It was assumed that temporary housing built for direct and indirect workers and family members during project construction would be occupied by direct and indirect workers during operations, meaning that no new worker housing would be required during facility operating phases.

Planned temporary housing developments of employer-provided housing for oil shale workers could be the most effective means of minimizing the impacts of rapid population growth on local housing, local community fiscal resources, and local public services funded locally. Since these temporary housing developments could have adequate food service, security, health, and recreational facilities, these facilities might also help avoid social and psychological disruption that might occur as a result of conflicts between the permanent and temporary populations and the potential consequent impact on established community social structures.

- *Power plants and coal mines.* As stated in Section 4.1, employment in a 2,400-MW power plant would range from 1,900 to 2,400 during construction, with 240 employees during operations. If needed, coal production to support power plants was assumed to come from an underground mine in both Colorado and Utah; each mine would employ 753 workers during construction and between 529 and 635 workers during operations. If a power plant were needed in Wyoming, it was assumed to be a surface mine, which would employ 135 workers during both construction and operation (Hill and Associates, Inc. 2007). An additional coal-fired power plant is only projected to be needed for certain in situ projects, depending on technologies used and production levels.

- *Peak construction year and first year of operations.* Although the exact schedule that would be used for construction and operation of oil shale facilities is not known, in order to assess the magnitude of the impacts of facilities on the economic and social baseline in each ROI, specific years were used for each project phase for each facility. For the peak construction year, 2022 was assumed for an in situ facility and 2027 for a surface and underground mine. The first year of operation of an in situ facility was assumed to occur in 2027, while operations of a surface and underground mine were assumed to occur beyond the end of the planning period 2008–2027. Peak construction of a power plant and coal mine was assumed to occur in 2013, with operation of both facilities beginning in 2017. The peak year of construction for housing required for oil shale, power plant, and coal mine construction workers was assumed to occur in the year immediately preceding the peak construction year for each facility.

4.11.1 Common Impacts

4.11.1.1 Economic Impacts

Methods. The economic impacts of each facility on ROI employment and personal income are presented. To estimate economic impacts, the assessment used representative data from a number of NEPA assessments covering the potential impacts of large energy resource development projects (DOI 1973b; BLM 1980, 1983a,b, 1984a; DOE 1982a). These data included direct workforce projections for project construction and operation for various oil shale technologies, different sizes of operations, and temporary housing requirements. Employment data for proposed oil shale developments and for the associated power plants and coal mines were provided by the BLM (Thompson 2006b,c,d), from DOE (EIA 2007a,b,c), and industry sources (Hill and Associates, Inc. 2007). IMPLAN® economic data were then used to calculate the indirect impacts associated with oil shale project wage and salary spending, material procurement spending, and the construction of temporary employer-provided housing and housing provided by local communities in each ROI (Minnesota IMPLAN Group, Inc. 2007). Details of this methodology are presented in Appendix G. Underlying employment numbers are also presented in Appendix G.

A gravity model was used to assign oil shale workers and their families not accommodated in temporary employer-provided housing to specific ROI communities (see Section 3.10). Gravity models mathematically estimate the interaction between pairs of points (the number of construction and operations workers and family members associated with each technology, nominally located at the oil shale resource centroid in a state, and the population of each community in a state ROI) weighted by the linear distance between each pair of points. Worker and family population data associated with each technology were used to calculate the number of housing units required and the impact on vacant housing, as well as, in association with existing levels of service, the number of local government employees (policemen, firemen, general government workers, and teachers) and the relative impact on local government finances. A qualitative assessment of the potential impact of a large number of in-migrants on social disruption in small rural communities was made on the basis of evidence from extensive literature in sociology on potential social problems associated with boomtown energy development.

In the following sections, impacts are presented for a variety of facilities relevant to the development of oil shale resources in each state ROI. Impacts associated with construction of adequate temporary employer-provided housing and housing provided by the local community for each oil shale facility for each ROI are also discussed, together with an assessment of the impact of power plant and coal mine construction and operation and the associated employer-provided housing and housing provided in local communities.

Although there are a wide range of restrictions governing the potential location of oil shale developments and associated facilities on public lands, these are not reflected in the analysis of socioeconomic impacts. Direct and indirect employment associated with oil shale developments would lead to population in-migration into each ROI and increases in housing, public service employment, and expenditures and may lead to changes in quality of life and social change in local communities, regardless of the proposed locations of each facility within each ROI.

To assess the magnitude of the impacts resulting from project construction on the baseline in each ROI, the percentage change in a number of key economic (peak construction employment) and social (population, vacant housing, and local government expenditures) variables in specific years was used. For any variable, impacts would be small if the percentage change compared with the baseline is less than 5%, moderate if the percentage change is between 5 and 10%, and large if the percentage change compared with the baseline is more than 10%.

Impacts. Construction and operation of oil shale facilities and the associated temporary employer-provided housing and housing constructed in local communities in the ROI for oil shale facility, power plant, and coal mine workers and family members would impact the economy of each ROI. Oil shale technologies and the associated energy production facilities and housing would create significant new sources of employment and income at each facility. Wages and salaries spent by facility workers and by housing construction workers would create demand for a range of durable and nondurable goods and services sold by ROI retailers, which, together with the purchase of equipment, materials, and supplies required during energy project and housing construction and project operation in each ROI, would provide significant new sources of indirect employment and income to ROI residents.

Surface mining with surface retorting would produce about 2,200 total (direct plus indirect) jobs in the two ROIs in the peak year of construction and between \$110 million and \$131 million in income (Table 4.11.1-1). Project operations would produce between 2,900 and 3,000 jobs and between \$145 million and \$173 million in income. Underground mining would create between 2,200 and 2,600 jobs and between \$112 million and \$159 million in personal income, with between 2,900 and 3,300 jobs created during the operating period. Construction of an in situ processing facility would create between 2,300 and 2,900 jobs and between \$116 million and \$169 million in personal income, producing between 780 and 950 jobs and between \$38 million and \$56 million in income during the operating period. Construction employment for each facility would represent an increase of between 1.5% and 4.7% over the projected employment baseline in the three ROIs in the peak construction year.

Construction of power plants in association with in situ facilities would produce between 2,700 and 2,900 total jobs in the three ROIs during the peak construction year and between \$151 million and \$210 million in income (Table 4.11.1-2). During plant operations, between 300 and 330 employees would be required in the ROIs, producing between \$17 million and \$23 million in income. Construction employment for the power plants would represent an increase of between 2.4 and 5.9% over the projected employment baseline in the three ROIs in the peak year. Coal mine development in each ROI would produce between 200 and 1,300 jobs

TABLE 4.11.1-1 ROI Economic Impacts of Oil Shale Development[a]

	Housing Construction		Oil Shale Development: Construction		Oil Shale Development: Operation	
	Employment	Income ($ million)	Employment	Income ($ million)	Employment	Income ($ million)
Surface mining with surface retorting						
Direct	467–496	8.2–8.4	1,443	95.2–114.6	1,923	126.8–152.8
Indirect	112	2.5	724–789	14.7–16.2	975–1,038	18.5–19.9
Total	578–608	10.7–10.8	2,167–2,232	109.8–130.8	2,898–2,960	145.3–172.7
Underground mining with surface retorting						
Direct	439–505	8.3–10.4	1,470	97.0–130.7	1,910	126.0–169.8
Indirect	114–145	2.5–4.1	738–1,083	15.0–28.4	969–1,391	18.4–34.8
Total	584–619[b]	10.9–14.5	2,208–2,553	111.9–159.1	2,879–3,301	144.4–204.6
In situ processing						
Direct	476–526	8.8–11.3	1,500	98.9–133.4	500	33.0–44.5
Indirect	118–157	2.6–4.4	814–1,360	16.6–35.7	275–449	5.2–11.3
Total	625–644	11.5–15.7	2,314–2,860	115.6–169.0	775–949	38.2–55.8

[a] The direct employment data presented in this table for the construction and operation of commercial surface and underground mining projects are based on data provided in DOI (1973b). Some of these data were extrapolated from data presented for construction and operation of an underground mine with a capacity of 50,000 bbl/day and 100,000 bbl/day, and a surface mine with a capacity of 100,000 bbl/day. In situ facility data are from Thompson (2006b), with data for Colorado multiplicative of a single facility with a capacity of 200,000 bbl/day. Direct employment numbers and multiplier data from the IMPLAN model (Minnesota IMPLAN Group, Inc. 2007) were used to calculate indirect employment and income numbers for housing and each technology.

[b] Direct and indirect employment and income numbers in each range do not necessarily add to the corresponding totals. Across the ROIs, for housing construction and any given technology, power plant, and coal mine, variations in the size of indirect impacts do not necessarily correspond to variations in the size of direct impacts.

in the ROI during construction and between $12 million and $79 million in income in the ROIs (Table 4.11.1-2). Plant operations would require between 200 and 940 employees in the ROIs, producing between $12 million and $56 million in income. Construction employment for the coal mines would represent an increase of between 0.4% and 2.4% over the projected peak year employment baseline in the three ROIs.

In addition to oil shale, power, and coal production facilities, employer-provided temporary housing and housing constructed in local communities would also produce employment and income in each ROI. Housing provided for surface mine workers and their families would create between 580 and 610 jobs and approximately $11 million in income in the ROIs (Table 4.11.1-1). Construction of housing for underground mine workers and families

TABLE 4.11.1-2 ROI Economic Impacts of Power Plant and Coal Mine Development[a]

	Housing Construction		Construction		Operation	
	Employment	Income ($ million)	Employment	Income ($ million)	Employment	Income ($ million)
Power plant						
Direct	571–666	10.8–13.6	2,150	141.8–191.1	240	19.1–21.3
Indirect	148–188	3.3–5.3	632–929	13.2–24.9	61–91	1.2–2.3
Total	759–816[b]	14.1–18.9	2,782–3,079	155.1–216.0	301–331	16.8–23.4
Coal mine						
Direct	44–259	0.8–5.4	135–753	10.7–66.9	135–635	10.7–47.0
Indirect	10–74	0.2–2.1	74–555	1.5–14.6	73–384	1.4–9.6
Total	54–317	1.0–7.4	209–1,308	12.2–81.5	203–941	11.9–55.8

[a] The direct employment data presented in this table are based on data provided in Thompson (2006c,d). Direct employment numbers and multiplier data from the IMPLAN model (Minnesota IMPLAN Group, Inc. 2007) were used to calculate indirect employment and income numbers for housing and each technology.

[b] Direct and indirect employment and income numbers in each range do not necessarily add to the corresponding totals. Across the ROIs, for housing construction and any given technology, power plant, and coal mine, variations in the size of indirect impacts do not necessarily correspond to variations in the size of direct impacts.

would produce between 580 and 620 jobs and between $11 million and $15 million in income in the ROIs. Construction of housing for in situ project workers and their families would produce employment of between 625 and 640 jobs and between $12 million and $16 million in income in the ROIs. Construction of temporary housing for power plant workers and families in the ROI would create between 760 and 820 jobs, while housing for mine workers would produce between 50 and 320 jobs. Between $14 million and $19 million in income would be produced during construction of housing for power plant workers and between $1 million and $7 million during construction of coal mine worker housing (Table 4.11.1-2).

4.11.1.2 Social Impacts

Worker in-migration to local communities in each ROI during construction and operation of oil shale facilities and the associated power plants and coal mines would impact population in each ROI. In the absence of temporary accommodations in local communities for oil shale workers during project construction and operation, the influx of oil shale workers and family members would have a relatively large impact on the housing market in each ROI. The new residential population associated with the project construction and operation would also require the hiring of additional local public service employees (police officers, fire personnel, local government employees, and teachers) in each ROI. Increases in ROI public service employment would also require increases in local revenues and expenditures to meet the necessary additional local public service provision.

During the peak year of construction of a surface mine facility, between 1,158 and 1,502 new residents are expected in the ROIs, with between 2,581 and 3,397 relocating to the ROIs during operations (Table 4.11.1-3). Construction of an underground mine would mean between 1,180 and 2,383 new residents in the ROI during the peak construction year, with between 2,564 and 4,093 expected during operations. Construction of an in situ facility would mean between 1,264 and 2,781 new residents during the peak construction year, with between 695 and 1,189 workers and their families required during facility operations. Population increases associated with the construction of an underground mine project would represent an increase of between 0.6% and 1.4% over the baseline population in the three ROIs during construction and between 1% and 3.2% during operations, with similar increases expected for a surface mine.

Construction of a power plant would bring between 1,282 and 2,587 new residents to the ROIs during the peak construction year, with between 253 and 400 workers and their families required during facility operations (Table 4.11.1-4). Coal mine construction would mean between 140 and 1,220 new residents during construction and between 238 and 1,132 in-migrants during operations. Population increases associated with the construction of power plants would represent increases of between 0.8% and 1.7% in the population baseline in the three ROIs during construction and between 0.1% and 0.3% during operations. Coal mine construction would increase baseline populations in the three ROIs by between 0.1% and 0.4%, with operations adding between 0.2% and 0.3% to the baseline populations in the three ROIs.

Population increases associated with construction of a surface mine project would require between 334 and 443 housing units in the ROIs, absorbing between 2.9% and 5.3% of vacant housing units (Table 4.11.1-3). For an underground mine, between 340 and 687 housing units, or between 3.0% and 5.4% of the vacant housing stock in the three ROIs, would be required. For an in situ facility, population increases associated with project construction would require between 365 and 802 housing units, or between 3.4% and 6.2% of the vacant housing stock in the three ROIs. For a power plant, population increases associated with project construction would require

TABLE 4.11.1-3 ROI Demographic and Housing Impacts of Oil Shale Development

	In-Migration to Local Communities		Housing Demand in Local Communities	
	Construction	Operation	Number of Units	Percent Vacant
Surface mining with surface retorting	1,158–1,502	2,581–3,397	334–443	2.9–5.3
Underground mining with surface retorting	1,180–2,383	2,564–4,093	340–687	3.0–5.4
In situ processing	1,264–2,781	695–1,189	365–802	3.4–6.2

TABLE 4.11.1-4 ROI Demographic and Housing Impacts of Power Plant and Coal Mine Development

	In-Migration to Local Communities		Housing Demand in Local Communities	
	Construction	Operation	Number of Units	Percent Vacant
Power plant	1,282–2,587	253–400	370–746	3.8–6.4
Coal mine	140–1,220	238–1,132	40–352	0.5–2.9

between 370 and 746 housing units, or between 3.8% and 6.4% of the vacant housing stock in the three ROIs, while coal mine development would require between 40 and 352 housing units, or between 0.5% and 2.9% of vacant units in the ROIs (Table 4.11.1-4).

Construction of a surface mine facility would require between 28 and 48 new local government employees in the three ROIs during construction and between 63 and 109 employees during operations (Table 4.11.1-5). The additional local public service provision during the peak construction year would require an increase of between 1.1% and 1.7% in local expenditures in the three ROIs, with increases of between 2.5% and 3.8% during operations. Construction of an underground mine would require between 29 and 60 local government employees during construction, and between 63 and 110 during operations. The increase in local public service provision would represent an increase of between 1.0% and 1.7% in expenditures in the three ROIs during construction and between 1.8% and 3.9% during operations. Construction of an in situ facility would require between 31 and 73 local government employees during construction and between 17 and 31 during operations, with the increase in local public service provision requiring an increase of between 1.2% and 1.9% in expenditures during construction and between 0.5% and 1.1% during operations. Construction of a power plant would require between 25 and 71 local government employees in the three ROIs during construction and between 4 and 11 during operations, with the increase in local public service provision requiring an increase of between 1.1% and 1.9% in expenditures in the three ROIs during construction and between 0.2% and 0.4% during operations (Table 4.11.1-6). Coal mine development would require between 2 and 33 local government employees in the three ROIs during construction, requiring an increase of between 0.2% and 0.6% in local government expenditures in the three ROIs, and between 3 and 31 during operations, which would necessitate an increase in local government expenditures of between 0.3% and 0.5%.

Higher local government expenditures would mean the potential for better quality local public services and infrastructure in some communities. In addition to providing employment and higher wages for some occupational groups, oil companies may also provide funds to upgrade portions of the road system in each ROI, and fund school scholarships and vocational training in some communities. Financing needed to support increases in local public expenditures that would be required to facilitate expansion in local public services, education,

TABLE 4.11.1-5 ROI Community Impacts of Oil Shale Development

	Government Employees		Change in Local Government Expenditures (%)	
	Construction	Operation	Construction	Operation
Surface mining with surface retorting (one 50,000-bbl/day project)	28–48	63–109	1.1–1.7	2.5–3.8
Underground mining with surface retorting (one 50,000-bbl/day project)	29–60	63–110	1.0–1.7	1.8–3.9
In situ processing (one 200,000-bbl/day project)	31–73	17–31	1.2–1.9	0.5–1.1

and local infrastructure impacted by oil shale and associated facilities might come from a number of sources. In communities impacted by the oil and gas industry, increases in property tax revenues resulting from increases in assessed valuations with increased demand for employee housing have often provided local communities with funds to support local finances in each ROI and have often occurred without the need to increase property tax rates (see Section 3.10.2). In addition, revenues from oil and gas severance taxes are currently distributed by state authorities to local communities to support local public service and infrastructure development by using a range of different mechanisms, while payments in lieu of taxes are often made by federal agencies to support local community responses to energy developments on public land. Royalty bonus payments have also been provided to local communities with the leasing of public lands for energy development. Some communities might also receive increased sales tax revenues resulting from local energy development and consequent increases in economic activity that could be used to support local government expenditures.

4.11.1.3 Social Disruption Impacts

Although it is likely that social and psychological disruption would occur during the boom phase of the development of oil shale facilities in small rural communities, the precise relationship between development projects and particular forms of social disruption and social change are difficult to predict. It has been suggested, for example, that social disruption is likely to occur once an arbitrary population growth rate associated with oil shale development has been reached, with an annual rate of between 5 and 10% growth in population assumed to result in a breakdown in social structures, with a consequent increase in alcoholism, depression, suicide, social conflict, divorce, delinquency, and deterioration in levels of community satisfaction (BLM 1980, 1983a,b).

TABLE 4.11.1-6 ROI Community Impacts of Power Plant and Coal Mine Development

	Government Employees		Change in Local Government Expenditures (%)	
	Construction	Operation	Construction	Operation
Power plant	25–71	4–11	1.1–1.9	0.2–0.4
Coal mine	2–33	3–31	0.2–0.6	0.3–0.5

The review of the literature assessing the relationship between social disruption and the rapid development of various energy projects in small rural communities suggests that there is insufficient evidence to predict the extent to which specific communities are likely to experience social disruption, which population groups within each community are likely to be most affected, and the extent to which social disruption is likely to persist beyond the end of the boom period. However, the number of new residents from outside the producing regions and the pace of population growth associated with the commercial development of oil shale resources, which would include large-scale production facilities and ancillary power plants, coal mines, and housing developments, are likely to lead to substantial demographic and social change in small rural communities. Communities hosting these developments are likely to be required to adapt to a different quality of life, with a transition away from a more traditional lifestyle involving ranching and taking place in small, isolated, close-knit, homogenous communities with a strong orientation toward personal and family relationships, toward a more urban lifestyle, with increasing cultural and ethnic diversity and increasing dependence on formal social relationships within the community.

While much of the literature on social disruption assesses the impact of energy and other large-scale developments on small, stable, isolated rural communities, many communities in the three ROIs have experienced extensive growth and development during the recent past associated with oil and gas development, tourism and recreation, and retirement and second home development. Given the scale of these developments, it is likely that some degree of social disruption may have already occurred in a number of communities, particularly in the Colorado ROI.

4.11.1.4 Agricultural Impacts

As it is likely that oil shale technologies will require large quantities of water, water transfers from other industries may be required in each ROI. To facilitate new oil and gas development, historic water rights have often been purchased from agricultural landowners, primarily ranchers (see Section 3.10.2.2). Although the transfer of water rights to energy companies has not always meant that agricultural land is lost, the loss of water rights has often meant that irrigated agriculture is no longer possible and has led to the conversion of land to dryland farming and ranching activities. At higher levels of oil shale development, it is possible that water may be transferred into each ROI from other areas, which may limit the impact of reduced access by agriculture to water resources in some areas of each ROI. With restrictions on water use for irrigation, some agricultural land may consequently be sold and developed for second homes, condos, and other real estate types, which may create quality of life impacts in some farming communities (see Section 3.10.2.2.1). Water availability on agricultural land and land sales might also fragment wildlife habitat and affect the behavior of migratory big game species such as elk and mule deer, which form an important basis for recreational activities in many parts of each ROI.

The impacts of substantial conversion of agricultural water rights could have large impacts on the economy of each ROI, the extent of which would depend on the amount of agricultural production lost, the extent of local employment in agriculture (see Section 3.10.2.1.2), the reliance of other industries in each ROI on agricultural production, the extent of local procurement of equipment and supplies by agriculture in the economy of each ROI, and the local impact of spending of wages and salaries by farmers, ranchers, and farmworkers. In addition to income from agricultural activities, agricultural income comes from "agri-tourism," including hunting and fishing; hiking and other farm- and ranch-related experiences may also be affected by losses of agricultural land or changes in agricultural land use. Oil shale and ancillary facility development may fragment or destroy wildlife habitat and affect the behavior of migratory big game species such as elk and mule deer, which form an important basis for recreational activities in many parts of each ROI. Loss of revenues from recreation activities may also affect wildlife and habitat agency management practices. The impact of losses in employment and income from a reduction in agriculture likely would be more than offset in some parts of each ROI by increases in revenues coming from oil shale development. Changes in economic activity would also likely produce social impacts associated with the loss of traditional quality of life and the adoption of a more urban lifestyle.

4.11.1.5 Recreation Impacts

Estimating the impact of oil shale development and the associated power plant and coal mine facilities on recreation is problematic, as it is not clear how activities under each alternative in each ROI would impact recreational visitation. While it is clear that some federal land in each state ROI would no longer be accessible for recreation, the majority of popular wilderness locations would be precluded from oil shale development. It is also possible that oil shale developments and associated transmission lines and transportation infrastructure elsewhere in each ROI would be visible from popular recreation locations (see Section 4.9), thereby reducing visitation and consequently impacting the economy of each ROI.

Because the impact of each oil shale technology and alternative on visitation is not known, this section presents two simple scenarios to indicate the magnitude of the economic impact of oil shale development on recreation: the impact of a 10% and a 20% reduction in ROI recreation employment in each state ROI. Impacts include the direct loss of recreation employment in the recreation sectors in each ROI, and the indirect effects, which represent the impact on the remainder of the economy in each ROI as a result of a declining recreation employee wage and salary spending, and expenditures by the recreation sector on materials, equipment, and services. Impacts were estimated by using IMPLAN data for each ROI (Minnesota IMPLAN Group, Inc. 2007). IMPLAN is an input-output modeling framework designed to capture spending flows among all economic sectors and households in each ROI economy.

In the Colorado ROI, the total (direct plus indirect) impacts of oil shale development on recreation would be the loss of 1,415 jobs with a 10% reduction in recreation employment, and 2,830 jobs if recreation employment were to decline 20% (Table 4.11.1-7). Income lost as a result of the 10% decrease in recreational employment would be $18.3 million, with $36.5 million lost for the 20% loss in employment. In the Utah ROI, 388 jobs and $3.2 million in income would be lost in the ROI as a whole as a result of a 10% reduction in recreation employment, and 776 jobs and $6.3 million in income would be lost with the 20% reduction. In the Wyoming ROI, 1,360 jobs and $7.2 million in income would be lost under the 10% scenario, with 2,719 jobs and $14.4 million in income lost if 20% of recreation-related employment were lost in the ROI.

4.11.1.6 Property Value Impacts

There is concern that oil shale developments and their associated power plants, transmission lines, and coal mines might affect property values in ROI communities located nearby. Property values might decline in some locations as a result of the deterioration in aesthetic quality, increases in noise, real or perceived health effects, congestion, or social disruption. In other locations, property values might increase because of access to employment opportunities associated with oil shale developments.

TABLE 4.11.1-7 Total ROI[a] Impacts of Reductions in Recreation Sector[b] Employment Resulting from Oil Shale Development

ROI	10% Reduction Employment	10% Reduction Income ($ million)	20% Reduction Employment	20% Reduction Income ($ million)
Colorado	1,415	18.3	2,830	36.5
Utah	388	3.2	776	6.3
Wyoming	1,360	7.2	2,719	14.4

[a] The Colorado ROI includes Delta, Garfield, Mesa, Moffat, and Rio Blanco Counties; the Utah ROI includes Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, and Wayne Counties; the Wyoming ROI includes Carbon, Lincoln, Sweetwater, and Uinta Counties.

[b] The recreation sector includes amusement and recreation services, automotive rental, eating and drinking establishments, hotels and lodging facilities, museums and historic sites, RV parks and campsites, scenic tours, and sporting goods retailers.

In general, potentially hazardous facilities can directly affect property values in two ways (Clark et al. 1997; Clark and Allison 1999). First, negative imagery associated with these facilities could reduce property values if potential buyers believed that any given facility might produce an adverse environmental impact. Negative imagery could be based on individual perceptions of risk associated with proximity to these facilities or on perceptions at the community level that the presence of such a facility might adversely affect local economic development prospects. Even though a potential buyer might not personally fear a potentially hazardous facility, the buyer might still offer less for a property in the vicinity of a facility if there was fear that the facility would reduce the rate of appreciation of housing in the area. Second, there could be a positive influence on property values associated with accessibility to the workplace for workers at the facility, with workers offering more for property close to the facility to minimize commuting times. Workers directly associated with the facility would probably also have much less fear of the technology and operations at the facility than would the population as a whole. The importance of this influence on property values would likely vary with the size of the workforce involved.

Although there is no evidence of the impact of oil shale facilities on local property values, there is limited evidence of the impact of gas drilling on property values in western Colorado. In communities adjacent to drilling activities, property values declined with the announcement of drilling, and during the first stages of extraction, the values rebounded, at least partly, once production was fully underway (BBC Research and Consulting 2006). Other studies have assessed the impact of other potentially hazardous facilities—such as nuclear power plants and waste facilities (Clark and Nieves 1994; Clark et al. 1997; Clark and Allison 1999) and hazardous material and municipal waste incinerators and landfills (Kohlhase 1991; Kiel and McClain 1995)—on, for example, local property markets. Many of these studies used a hedonic modeling approach to take into account the wide range of spatial influences—including noxious facilities, crime (Thaler 1978), fiscal factors (Stull and Stull 1991), and noise and air quality (Nelson 1979)—on property values.

The general conclusion from these studies is that while there may be a small negative effect on property values in the immediate vicinity of noxious facilities (i.e., less than 1 mi), this effect is often temporary and often associated with announcements related to specific project phases, such as site selection, the start of construction, or the start of operations. At larger distances, over longer project durations, no significant, enduring, negative property value effects have been found. Depending on the importance of the employment effect associated with the development of the various activities analyzed in these studies, a positive impact on property values was found to be associated with increases in demand for local housing.

Under conditions of moderate population growth and housing demand, it appears that property values could increase with the expansion in local employment opportunities resulting from oil shale development. However, with multiple oil shale technologies under construction in each ROI (particularly toward the end of the planning period), increases in population and the associated congestion—in the absence of adequate private sector real estate investment and appropriate local community planning—might have adverse impacts on property values. It has also been suggested that once the annual growth in population is between 5% and 15% in smaller rural communities, a breakdown in social structures would occur, with a consequent increase in alcoholism, depression, suicide, social conflict, divorce, and delinquency and a deterioration in levels of community satisfaction (BLM 1980, 1983b, 1996), with the resulting deterioration in local quality of life adversely affecting property values.

Energy transmission lines could also affect property values in communities located on land adjacent to oil shale developments, primarily as a result of the visibility of electricity transmission structures; the health and safety issues (in particular, electric and magnetic field [EMF]), noise, and traffic congestion associated with transmission lines would likely be less important. Although various studies have attempted to measure the impact of transmission lines on property values, significant data and methodological problems are associated with many of the studies, and the results are often inconclusive (Kroll and Priestley 1992; Grover, Elliot and Company 2005).

4.11.1.7 Environmental Amenities and Economic Development Impacts

Over recent decades, many areas of the western United States have been able to diversify their economies away from largely extractive industries toward knowledge-based industries, the professional and service sector, and retirement, recreation, and tourism (Bennett and McBeth 1998). It is apparent that growth in these parts of the economy has become highly sensitive to changes in environmental amenities; that is, environmental quality and access to environmental amenities may have become important factors in the economic development of the rural West. Although not all sectors of the economy are highly responsive to changes in environmental quality, with various other factors, including quality and availability of regional human resources, energy availability and reliability of energy supply, and the prevailing relative cost of doing business, there is extensive literature that indicates that perceived deterioration of the natural environment and the natural amenities offered in specific locations, particularly those available on public lands, may have an important impact on the ability of communities in adjacent regions to foster sustainable economic growth (Rudzitis and Johansen 1989; Johnson and Rasker 1995; Rasker 1994; Power 1996; Rudzitis 1999; Rasker 2004; Chipeniuk 2004; Holmes and Hecox 2005; Reeder and Brown 2005).

Since the 1980s, western Colorado and eastern Utah have diversified their economies toward tourism and recreation, much of which is based on natural amenities, notably hunting, fishing, bird watching, skiing, etc. To the extent that existing and potential new economic activities sensitive to changes in environmental quality and the amenity-based activities they support are in each ROI, oil shale and tar sands and associated power plant and coal mining developments may create conflicts with the ability of each ROI to attract future economic growth in economic activities that are sensitive to environmental amenities.

4.11.1.8 Transportation Impacts

Project development that could occur in any of the three states would lead to increases in traffic on any roads needed for access to project sites. In areas undergoing simultaneous oil and gas or other development, oil shale–related development would add to traffic volumes and maintenance needs. The amount of additional heavy vehicles associated with oil shale development is not large compared with the number of light vehicles transporting employees; however, they would add to the congestion and may require special consideration when designing or upgrading access roads and highways.

Providing adequate access roads to oil shale development sites may involve upgrading existing roads and road facilities or constructing completely new roads and bridges. Specifications for the access roads would be dictated by the expected volume and type of traffic. Significant increases in traffic loads would cause increased costs for maintenance and repair of roads and bridge structures.

Because some of the construction and processing equipment components are large, ROW clearances and minimum turning radii become critical parameters for road design. Typically, access roads would be a minimum of 10 ft (3 m) wide, but they may need to be as much as 30 ft (9 m) wide or more to accommodate continuous access needs. Depending on design requirements and local geology/soil characteristics, surface soils may need to be excavated, and road material may need to be imported to establish an adequate road base.

The majority of transportation-related environmental impacts would occur while creating access to development sites from existing public roads, but existing public or private roadways may also need to be altered to accommodate heavy and/or oversized transport vehicles or additional traffic volumes. It is reasonable to expect that special road transportation permits would be required for some vehicles. Excessive load weight may require fortification of existing bridges. Large loads may require the temporary removal of height or turning radius obstacles.

4.11.2 Mitigation Measures

Mitigation measures to reduce socioeconomic impacts will be required and could include the BLM working with state and local agencies to identify potential socioeconomic impacts and develop mitigation measures. In doing so, a suite of potential measures could be implemented, including but not limited to the following actions:

- Operators could be required to provide housing and basic services for all direct project hires and their families in order to minimize potential (1) social disruption associated with large numbers of in-migrants locating in small rural communities, (2) short-term adverse impacts on regional housing markets and overnight accommodation facilities, (3) adverse impacts on regional consumer products' availability and price, and (4) adverse impacts on public services provided by local communities in the surrounding region.

- Operators could work with state and local agencies to develop community monitoring programs that will be sufficient to identify and evaluate socioeconomic impacts resulting from commercial development. Monitoring programs should collect data reflecting economic, fiscal, and social impacts of the development at both the state and local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services (police, fire, and public health), and educational services. Programs also could monitor indicators of social disruption (e.g., crime, alcoholism, drug use, and mental health) and the effectiveness of community welfare programs in addressing these problems.

It is possible that some community development programs, with participation from energy resource developers, and local, state, and federal governments, will be implemented proactively in each ROI to avoid, manage, or mitigate negative social, economic, and fiscal consequences of oil shale development, prior to development of oil shale.

Operators could work with state and local agencies to develop community outreach programs that would help communities adjust to changes triggered by commercial development. Such programs could include any of the following activities:

- Establishing vocational training programs for the local workforce to promote development of skills required by the commercial development industries.

- Developing instructional materials for use in area schools to educate the local communities on the commercial development industries.

- Supporting community health screenings, especially those addressing potential health impacts related to commercial development activities.

- Providing financial support to local libraries for development of information repositories on commercial development and processing, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

Additional impact mitigation strategies could be designed and implemented at the local and state level, notably market-based mitigation strategies to coordinate ecosystem management practices, and rotational schedules for direct workers once the location, timing, and magnitude of impacts of specific projects are known. The role of tax revenues in attempts to diversify local economies and reduce dependency on natural resource extraction industries, thereby reducing the susceptibility of local communities to the boom-and-bust economic cycle associated with energy development in rural areas, could also be considered. The BLM cannot direct that government funds be paid to state and local governments to mitigate impacts from oil shale development. The BLM can only show those impacts in NEPA documents and address how impacts were mitigated in the past by direction from Congress to use the bonus bids from the federal leases.

Mitigation measures that could be implemented include:

- Maintain and/or upgrade existing roads utilized for the proposed project, as necessary, to conditions equal to, or better, than those that existed prior to project-related use.

- Develop and maintain close working relationships with state and county highway departments during all phases of project construction and maintenance.
- Encourage employees and contractors to carpool to and from the site.
- Emphasize to contractors and employees the need to comply with all posted speed limits to prevent accidents as well as to minimize fugitive dust.
- Comply with county and state weight restrictions and limitations and overweight/size permitting requirements.
- Control dust along unsurfaced access roads and minimize the tracking of mud onto roads.
- Restore unsurfaced roads to equal or better condition than preconstruction levels after construction is completed.
- Develop measures to control unauthorized OHV use in cooperation with the BLM and interested landowners.
- Require all projects to develop transportation management plans; new road construction or road upgrades on BLM-administered public lands would be expected to follow minimum guidelines as provided in the BLM Gold Book (DOI and USDA 2006), including road maintenance requirements.

4.12 ENVIRONMENTAL JUSTICE

Construction and operation of oil shale developments and associated power plants and housing could impact environmental justice if any adverse health and environmental impacts resulting from either phase of development are significantly high and if these impacts would disproportionately affect minority and low-income populations. If health and environmental impacts are not significant, there can be no disproportionate impacts on minority and low-income populations. If the impacts are significant, disproportionality is determined by comparing the proximity of high and adverse impacts with the location of low-income and minority populations. Details of the methodology for assessing environmental justice issues are presented in Appendix G. For each of the alternatives, the following sections describe impacts on various resources located in the oil shale resource areas within the three-state study area that would be impacted by oil shale development. Local demographic and social disruption impacts, property value impacts, land use, air and water quality and use, and visual impacts are described. This discussion is followed by a determination of the extent to which impacts of oil shale development would have a disproportionate effect on low-income and minority groups on the basis of the location of low-income and minority populations.

4.12.1 Common Impacts

4.12.1.1 Impact-Producing Factors

Rapid population growth in small rural communities hosting large oil shale development projects may produce social and psychological disruption, together with the undermining of established community social structures. Various studies have suggested that social disruption may occur in small rural communities when annual population increases are between 5% and 15% (see Section 4.11.1.3).

Property value impacts on private land in the vicinity of oil shale development projects and associated transmission lines may affect minority and low-income populations. These impacts would depend on the range of alternate uses of specific land parcels to landowners, current property values, and the perceived value of costs (e.g., visual impacts, traffic congestion, noise and dust pollution, air quality impacts, and EMF effects) and benefits (e.g., infrastructure upgrades, employment opportunities, and local tax revenues) from proximity to oil shale–related facilities to potential real estate purchasers of property owned by minority and low-income individuals in local communities.

Construction activities would produce fugitive dust emissions and engine exhaust emissions from heavy equipment, as well as from commuting and delivery vehicles on paved and/or unpaved roads, and wind erosion of soil disturbed by construction activities or from soil stockpiles. Emissions associated with these activities would consist primarily of particulate matter ($PM_{2.5}$ and PM_{10}), and criteria pollutants, VOCs, CO_2, and certain HAPs released from heavy construction equipment and vehicle exhaust. Emissions during oil shale facility operations would consist of CO, NO_2, $PM_{2.5}$, PM_{10}, and SO_2. Construction of transmission lines and access roads required for the delivery of equipment and materials to project sites would produce fugitive dust impacts, the magnitude of which would depend, in part, on the terrain and road length, and the length of time that they would be used for construction traffic.

Water consumption and quality impacts on land in the vicinity of oil shale development projects and associated transmission lines might affect minority and low-income populations, both in terms of water used for domestic consumption and water that may be used to support wildlife populations used for subsistence agriculture and for cultural and religious purposes. The impact on water resources during construction would consist primarily of increases in surface runoff, and, consequently, in dissolved solids and in the volumetric flow of nearby streams near the project sites. The amount of water used during the operation of oil shale development projects is expected to be large at higher levels of facility production and could potentially impact minority and low-income populations if there are shortages of drinking water or water that might be used for agriculture.

Construction and operation of oil shale and supporting facilities, power plants, housing, and transmission lines would produce noise impacts, and operation of transmission lines may lead to EMF effects.

Oil shale facilities and associated transmission towers may potentially alter the scenic quality in areas of traditional or cultural significance to minority and low-income populations, depending on the facility's size and location. Construction would introduce contrasts in form, line, color, and texture, as well as a relatively high degree of human activity into existing landscapes with generally low levels of human activity.

Land used for oil shale facilities might impact certain animals or vegetation types that may be of cultural or religious significance to certain population groups or that form the basis for subsistence agriculture. Similarly, land used for facilities that has additional economic uses might affect access to resources by low-income and minority population groups.

4.12.1.2 General Population

Population in-migration would occur in each year of oil shale resource development. Workers would be required to move into each state during construction and operation of oil shale and power plant facilities and to facilitate the demand for goods and services resulting from the spending of oil shale, power plant, and housing construction worker wages and salaries. In-migration in the peak year of construction of a power plant would increase population in the three-state study area by up to 1.7%. During the period in which an underground mine would be operated in the study area, and also the period during which power plants and coal mines would be operating, population in the three-state study area is projected to increase by 3.2%. In-migration associated with oil shale development would also require additional housing to be constructed in the three-state study area, with up to 6.4% of vacant housing units required during the peak year for power plant construction, and up to 6.2% of vacant units required during the peak year of coal mine construction.

Because oil shale development projects and the associated power plant and housing developments would lead to rapid population growth in many of the communities in each ROI, particularly in situ projects in Colorado, and given evidence presented in the literature (see Section 3.10.2.2), it is highly possible that some degree of social disruption would accompany these developments. In the absence of appropriate levels of local and regional planning, rapid demographic change may lead to the undermining of local community social structures with contrasting beliefs and value systems among the local population and in-migrants, and consequently, to a range of changes in social and community life, including increases in crime, alcoholism, drug use, etc. Higher local government expenditures would partially offset some of these developments, with the potential for better quality local public services and infrastructure in some communities. In addition to providing employment and higher wages for some occupational groups, oil companies may also provide funds to upgrade portions of the road system in each ROI, and fund school scholarships and vocational training in some communities.

The precise nature of the impact of oil shale facility construction and operation on property values was not evaluated for this PEIS. The impact would depend on the range of alternate uses of specific land parcels by landowners, current property values, and the perceived value of costs (visual impacts, traffic congestion, noise and dust pollution, air quality impacts, and EMF effects) and benefits (infrastructure upgrades, employment opportunities, and local tax revenues) from proximity to oil shale-related facilities to potential real estate purchasers of property owned by minority and low-income individuals in local communities.

Emissions associated with construction activities would consist primarily of particulate matter ($PM_{2.5}$ and PM_{10}), criteria pollutants, VOCs, CO_2, and certain HAPs released from heavy construction equipment and vehicle exhaust. Since all activities either conducted or approved by the BLM through use authorizations must comply with all applicable local, state, Tribal, and federal air quality laws, statutes, regulations, standards, and implementation plans, it is unlikely that future oil shale development would cause significant adverse air quality impacts.

Because of the limited surface water and groundwater, the amount of water needed in Colorado for the project sites, power plant, coal mine, and associated population growth would mean that additional water resources would be needed. In Utah, water from the Colorado River plus the estimated sustainable groundwater yield is likely to be sufficient to support the amount of water needed for oil shale and tar sands developments, ancillary power and coal facilities, and associated population growth. It should be noted that prolonged drought conditions may occur and constrain water availability in Utah. Similarly in Wyoming, water from the Colorado River in Utah plus the estimated sustainable groundwater yield would be sufficient to support development of oil shale in Wyoming. Although discharges could have significant impacts on water quality if not properly controlled, water quality impacts of oil shale development are expected to be temporary and local, provided that mitigation measures are implemented, in part because of the dry climate where the sites are located. However, steep slopes in some areas may channel surface runoff and result in localized soil erosion.

Oil shale facilities might impact certain animals or vegetation types that may be of cultural or religious significance to certain population groups, or that form the basis for subsistence agriculture. Similarly, land used for these facilities that has additional economic uses might affect access to resources by low-income and minority population groups.

Surface mine and surface retorting would involve the most surface disturbance, and visible activity (including dust and emissions) would be expected to generate the largest visual impacts relative to the other projects of similar size but utilizing underground mining or in situ processes. Underground mining and surface retorting projects would involve fewer and less severe visual impacts compared with oil shale projects utilizing surface mines, primarily because of reduced surface disturbance from mining and related activities. Visual impacts associated with reclamation also would likely be less than for projects utilizing surface mines because of the greatly reduced level of ground disturbance. Projects utilizing in situ technologies would likely generate the smallest levels of visual impacts because of the absence of spent shale piles, shale-crushing facilities, and other mining-related facilities and activities. These projects also would likely have the smallest reclamation impacts because of reduced surface disturbance and the absence of spent shale piles.

4.12.1.3 Environmental Justice Populations

Construction and operation of oil shale developments could impact environmental justice if the adverse health and environmental impacts resulting from either phase of development identified in the previous sections are significantly high, and if these impacts would disproportionately affect minority and low-income populations. Where impacts are significant, disproportionality is determined by comparing the proximity of high and adverse impacts with the location of low-income and minority populations.

A number of census block groups have low-income and minority populations, where the minority population exceeds 50% of the total population in each block group. There are four block groups where the minority share of total block group population exceeds the state average by more than 20 percentage points in each of the three states potentially hosting oil shale development (see Section 3.11). Within 50 mi of the oil shale area in Colorado, there is one census block group with a low-income population; it is located to the east of the oil shale area in Carbondale; two census block groups are located in Grand Junction. In Utah, the minority population is located in the northeastern part of the state in the immediate vicinity of the oil shale resource area itself, in the southeastern portion of the Uintah and Ouray Indian Reservation, and in the north-central part of the state, to the east of Springville. The low-income population is centered in roughly the same area as the minority population, with five block groups in the southeastern portion of the Uintah and Ouray Indian Reservation and one located in the vicinity of Price. In Wyoming, the minority population is located in the Wind River Indian Reservation, also the location of the low-income population.

Given the location of environmental justice populations in each state, construction and operation of oil shale facilities, power plants, and employee housing required for the operation of oil shale development projects may produce impacts that may be experienced disproportionately by minority and low-income populations in a number of locations in each ROI. Of particular importance would be social disruption impacts of large increases in population in small rural communities, the undermining of local community social structures, and the resulting deterioration in quality of life. The impacts of facility operations on air and water quality and on the demand for water in the region would also be important. Depending on their locations, impacts on low-income and minority populations may also occur with the development of transmission lines associated with power development and the supply of power to oil shale facilities in each state. Land use and visual impacts might be significant depending on the location of land parcels impacted by oil shale projects and the associated power plant and housing facilities, their importance for subsistence, their cultural and religious significance, and alternate economic uses.

4.12.2 Mitigation Measures

Various procedures might be used to protect low-income and minority groups from high and adverse impacts of oil shale development and associated facilities. Most important of these would be to develop and implement focused public information campaigns to provide technical and environmental health information directly to low-income and minority groups or to local agencies and representative groups. Included in these campaigns would be descriptions of existing air and groundwater monitoring programs; the nature, extent, and likelihood of existing and future airborne or groundwater releases from oil shale facilities; and the likely characteristics of environmental and health impacts. Key information would include the extent of any likely impact on air quality, drinking water supplies, subsistence resources, and the relevant preventative measures that may be taken.

Rapid population growth following the in-migration of the construction and operations workers associated with oil shale development and ancillary facilities into communities with low-income and minority populations could lead to the undermining of local community social structures as beliefs and value systems among the local population and in-migrants contrast and, consequently, could lead to a range of changes in social and community life, including increases in crime, alcoholism, drug use, etc. In anticipation of these impacts, key information on the scale and time line of oil shale developments, and on the experience of other communities that have followed the same energy development path, could be made available to low-income and minority populations, together with information on planning activities that may be initiated to provide local infrastructure, public services, education, and housing.

4.13 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

4.13.1 Common Impacts

Impacts related to hazardous materials and wastes are generally independent of location. Such impacts would be derivatives of the technologies employed for resource recovery and for the subsequent processing of recovered products rather than of the locations at which these activities occur.

Hazardous materials and wastes are unique to the technology combinations used for oil shale development. However, hazardous materials and waste impacts are common for some of the ancillary support activities that would be required for development of any oil shale facility regardless of the technology used. These activities include the development or expansion of support facilities, such as employer-provided housing and power plants.

Hazardous materials impacts associated with construction or expansion of off-site support facilities would be minimal and limited only to the hazardous materials typically utilized in construction of such facilities, including hazardous materials required to support construction equipment and vehicles (fuels, other vehicle and equipment fluids such as lubricating oils, hydraulic fluids, and glycol-based coolants) and miscellaneous hazardous materials typically associated with construction such as solvents, adhesives, and corrosion control coatings. Construction-related wastes would include landscape wastes from clearing and grading of the construction sites and other wastes typically associated with construction, none of which are expected to be hazardous and all of which, except for landscape wastes, are expected to be disposed of in permitted sanitary landfills. Landscape wastes are expected either to be burned on-site or delivered to permitted off-site facilities for disposal or composting.

Once these support facilities become functional, different hazardous materials and waste impacts would result. It is expected that virtually no hazardous materials would be associated with employer-provided housing. However, wastes would include nonhazardous solid wastes and sanitary wastewaters. Solid wastes are expected to be containerized and hauled to permitted sanitary landfills or other appropriate waste disposal facilities. As conditions permit, sanitary wastewaters are expected to be treated on-site through such technologies as septic systems or active biological treatment; all such activities would be controlled by permits issued to state or local authorities. Depending on the location of the employer-provided housing and other circumstantial factors, it is also possible that sanitary wastewaters would be delivered by truck or sewer to existing or expanded municipal treatment works for treatment.

Hazardous materials associated with power plant operation would include that complement of hazardous materials typically used to support the maintenance and repair of mechanical equipment. The most notable waste stream associated with power plant operation would be coal combustion waste (CCW), primarily a mixture of fly ash and bottom ash. CCW is expected to be disposed of at the power plant site under state or local permits, or alternatively, delivered back to the mine site to support reclamation.

Commercial oil shale development activities may include surface mining and/or underground mining with surface retort or in situ technologies. As production rates and resulting associated waste volumes increase, different waste management schemes are likely to be implemented, potentially including more on-site treatment, storage, and disposal. For example, larger volumes of wastewaters from industrial activities and contaminated pyrolysis water are likely to dictate on-site treatment (under the auspices of permits issued by state or local regulatory authorities) because containerization and transport to off-site treatment facilities could become prohibitively expensive. Similarly, at commercial production levels, the expansion in the workforce would likely result in the installation of on-site treatment facilities for sanitary wastewaters. Except for spent shale, nonhazardous solid wastes, whether from industrial activities or from support of the workforce (e.g., kitchen wastes) would increase in proportion to production and workforce levels but is expected still to be managed by collection and delivery to established off-site sanitary landfills, regardless of the volume increases that result. For those projects involving surface retorting, spent shale would be the largest volume solid waste stream and is likely to be disposed of on-site (under a permit issued by state or local authorities). Likewise, industrial hazardous wastes would increase proportionally to production and upgrading activities (where they occur), but in all instances, are expected to be managed by containerization, brief periods of on-site storage, and ultimate delivery to permitted hazardous waste treatment, storage, and disposal facilities (TSDFs). No treatment of hazardous waste is expected to occur on-site, except as may be necessary to stabilize extremely unstable waste for transport or to neutralize free acidity, both actions that can occur without benefit of a permit.

One of the by-products of surface retorting is water (sometimes referred to as pyrolysis water). Pyrolysis water is also created in all in situ retorting technologies and recovered from production wells, together with hydrocarbon pyrolysis products. This water will often contain hydrocarbon pyrolysis products that have enough polar character to be water soluble; however, the quality of pyrolysis water will vary. The water would likely be collected in lined ponds and treated before release. Pyrolysis water with little to no contamination (e.g., hydrocarbon, heavy metals) can be put to beneficial uses on the site, such as for fugitive dust control on on-site roads or as a wetting agent for the spent shale to promote adequate compaction). It can also be reinjected downgradient of the retort zone to help the groundwater contours reequilibrate. Contaminated pyrolysis water would require treatment before discharge, either to surface water or to groundwater downgradient of the retort zone.

Some amount of upgrading of the shale oil product may be necessary before it would be attractive to refineries as a replacement for conventional crude oil feedstocks, especially for shale oil produced from mining and surface retorting. Upgrading would dramatically increase the amount and type of hazardous materials present, such as additional commercial fuels to provide the necessary energy and hydrogen for hydrocracking and hydrotreating reactions. In all likelihood, the hydrogen would be produced on-site through steam reforming of commercially available natural gas. It is also likely that the hydrogen would generally be produced as needed and that no large amounts of hydrogen would be kept in storage. The products of such upgrading, synthetic crudes, would themselves exhibit some hazardous properties (e.g., flammability). Prudent engineering design suggests that on-site storage capacity for synthetic crudes would represent at least 2 to 3 days of production capacity. By-products of synthetic crude production would include some additional light-weight fuel gases (C-1 through C-4) that are likely to be used on-site to augment commercial fuels in external combustion sources such as boilers and steam generators, and ammonia (NH_3) and H_2S, both of which are expected to be treated or incinerated as they are produced. Other wastes associated with upgrading would be spent catalysts, some of which might require management as hazardous waste, and sludge accumulating in reaction vessels and storage tanks that would be removed periodically according to cleaning and maintenance schedules.

4.13.1.1 Surface Mining

Hazardous materials needed to support surface mining activities primarily include diesel fuel, lubricating oils, hydraulic fluids, coolants, and other chemicals associated with the fueling, operation, maintenance, and repair of mining-related vehicles and equipment. Because of their large size, maintenance and repair activities for these machines would likely occur on-site. Other hazardous materials potentially include cleaning solvents, welding gases, corrosion control coatings, and herbicides (for vegetation clearing and control). The amount of hazardous waste generated from these activities is expected to be small and would likely be containerized for temporary on-site storage and then shipped by licensed haulers to permitted off-site facilities.

Some locations may use explosives (typically, ammonium nitrate and fuel oil [ANFO] mixtures) to facilitate oil shale extraction. Explosives management plans are expected to be implemented at these sites.

The amount of solid waste resulting from surface mining activities is expected to be minimal. Sources include removed vegetation (e.g., tree stumps), items associated with the maintenance and repair of mining vehicles and equipment, putrescible solid wastes from kitchen activities, solid wastes associated with administrative activities, and shale fines too small for retorting. Landscape waste may be used to create wildlife shelters sold for commercial purposes or composted on-site. Other solid waste would be containerized on-site and shipped to appropriate permitted off-site disposal facilities. The shale fines are likely to be returned to the mine site or disposed of with spent shale from the surface retort.

Disturbance of the ground surface that occurs with surface mining can potentially contaminate surface water runoff, resulting primarily in increased levels of suspended particulates. However, SWPPPs are expected to mitigate such surface water contamination. Any contaminated surface water runoff is likely to be diverted to holding ponds until it can be treated and released. Stormwater runoff from stockpiled overburden is a wastewater unique to surface mining operations. Such runoff may need to be captured and treated (e.g., filtered to remove suspended solids) before being released to surface waters.

As is the case for underground mining, surface mining would require a larger workforce than in situ operations. Consequently, nonhazardous solid wastes and wastewaters related to workforce support activities would be greater in volume. Regardless of the volumes produced, solid wastes are expected to be containerized and hauled to off-site permitted sanitary landfills for disposal. Sanitary wastewaters would likely undergo treatment on-site through septic systems (when conditions allow) or active biological treatment under the auspices of appropriate permits issued by state or local authorities. Depending on the locations of the developments, some sanitary wastes might be delivered to nearby municipal treatment facilities (either by truck or by sewer). Pyrolysis water would result from retorting. Depending on the degree of contamination of this water (by polar hydrocarbons and/or heavy metals), this water could be used for beneficial purposes (fugitive dust control or wetting of spent shale prior to disposal) or would require treatment before release to surface or groundwater systems. Such treatment, when necessary, would likely occur in on-site facilities.

The only other wastewater that would result from surface mining operations would be the glycol-based coolants that would be periodically removed from mining equipment and vehicles during maintenance. Sanitary wastewater is likely to be treated and disposed of on-site according to permits issued by state or local regulatory authorities.

Potential adverse health and environmental impacts associated with the improper management of hazardous materials and waste streams associated with surface mining activities could be significant. However, if hazardous materials are stored, used, and disposed of according to all applicable regulations, impacts are expected to be minimal to nonexistent. Similarly, if solid waste and wastewater are handled appropriately, no adverse impacts are expected.

4.13.1.2 Surface Retorting and Subsequent Upgrading

During the 1970s and 1980s, when extensive R&D of oil shale retorting processes were undertaken, a number of agencies prepared environmental impact analyses of commercial-scale operations (BLM 1973, 1977; DOE 1982b, 1983, 1988; EPA 1977, 1979; OTA 1980a,b; Stevens et al. 1984). Engineering projections were made for a number of surface retorts, including the Paraho Direct-Burn Retort, TOSCO II Indirect Burn Retort, and ATP. Each of these technologies is discussed in Appendix A. For the purposes of this impact analysis, it is assumed that the commercial-scale surface retort technologies would be equivalent to these three types of surface retorts with respect to associated hazardous materials and waste streams. Because some amount of upgrading is likely to be required for products recovered from surface retorts, this discussion also addresses typical upgrading activities. In addition, because upgrading is always conducted in conjunction with aboveground retorting, the impacts of such upgrading on hazardous materials and wastes are also addressed.

Hazardous materials associated with surface retorting and upgrading include the flammable fuel gases that are produced during retorting (typically, molecules in the C-1 through C-4 size range), as well as the crude shale oil and its subsequent upgraded products. Some of the fuel gas is expected to be used on-site to augment commercial fuels. The remainder would be stored on-site pending transport to off-site refining facilities. Upgrading would include the use of flammable hydrogen gas, which could be produced on-site or purchased from commercial sources. Upgrading would also likely result in the production of elemental sulfur and anhydrous ammonia, both of which would likely undergo minimal purification and be stored on-site until they are transported to respective markets. Solid wastes from upgrading activities may have to be characterized as hazardous wastes primarily because of the presence of certain catalysts, as well as toxic heavy metals (e.g., arsenic and selenium) that could accumulate in reaction vessel sludge or residues. Sludge from the treatment of process water may also exhibit hazardous characteristics because of the presence of heavy metals. Hazardous wastes would be containerized and shipped to a permitted disposal facility following applicable regulations.

The operation of surface retorts results in the largest volumes of solid wastes of any oil shale development step. These include spent shale, raw shale fines created during the shale crushing operations but unsuitable for retorting, spent shale fines recovered from crude shale oils, and shale wastes unsuitable for retorting. The specific retorting technology will influence both the volume and character of the spent shale wastes (see Appendix A for more details.)

Other sources of solid wastes result from the subsequent crude shale oil upgrading activities (spent catalysts, and tank and reaction vessel residues and sediments) and associated water treatment activities (boiler blowdown, water softening salts, and sludges from treatment of industrial or sanitary wastewaters or domestic sewage). Relatively small amounts of nonindustrial solids wastes are anticipated. These include landscape waste and domestic solid wastes such as food, kitchen scraps, and office waste.

Nonhazardous solid wastes can be disposed of in landfill cells specifically created for that purpose or disposed of in the mined out portions of strip mines or subsurface mines. For the purposes of analysis, this assessment assumes that no more than 30% of the entire volume of spent shale produced could be disposed of within former mine footprints. Consequently, a substantial volume of spent shale (roughly equal to the volume of oil shale mined) would need to be disposed of in surface areas within the oil shale facility's boundary.

Disposal techniques might also include permanent storage in a nearby canyon or valley or temporary surface storage until final placement within the mine footprint is possible (DOE 1988). Landfill disposal outside the mine footprint would require permits for construction, operation, and closure in most jurisdictions. Disposal of spent shale within the mine footprint would also need disposal permits and would have to be compatible with closure and reclamation plans established for the mine.

Disposal of spent shale back into a subsurface mine presents various logistical issues that may prevent or limit such disposal. For example, mine development design may prevent convenient access to retired portions of the mine. Also, leaching as a result of the interaction of groundwater must be anticipated. Nevertheless, disposal in retired subsurface mines can effectively diminish the potential for future surface settling (which can affect, for example, surface drainage patterns) and incurs no additional labor-intensive surface reclamation requirements.

Water intrusion controls and waste pile cover designs can limit the potential for leaching or erosion of the spent shale to create contaminated surface water effluents. Such controls are expected to be developed within the context of a SWPPP. However, the principal method for erosion control (establishing a vegetative cover) may be difficult in relatively arid regions.

Regardless of the disposal option selected, a number of issues would need to be addressed, including the character of the leachates from spent shale, the structural integrity of the emplaced spent shale, and the increase in volume (decrease in density) of spent shale over the raw shale as a result of retorting (see Appendix A for details).

Impacts on the quality of surface waters can occur from the generation, management, and release of water produced during retorting (pyrolysis water) and upgrading, industrial wastewaters from ancillary activities (e.g., well drilling fluids, steam condensates, and boiler blowdown water), and sanitary and domestic wastewaters resulting from activities related to supporting the on-site workforce. Because of the presence of various contaminants, wastewater effluents would require treatment before use, discharge, or recycling (see Appendix A for details). Some pyrolysis water free of hydrocarbon or heavy metal contamination can be put to beneficial use such as for control of fugitive dust on on-site roads or for wetting spent shale to ensure proper compaction.

Surface retorting and upgrading activities could cause potentially significant environmental and health impacts if appropriate safety measures are not used in the handling and storage of hazardous materials and in the management of hazardous, solid, and wastewater waste streams. However, if applicable regulations governing the use, storage, and disposal of hazardous materials and of wastes are followed, the impacts are expected to be minimal. Likewise, appropriate engineering features and operational controls for spent shale disposal sites can successfully preempt or mitigate anticipated adverse environmental impacts.

4.13.1.3 Underground Mining with Surface Retorting

The complement of hazardous materials required to support underground mining would be virtually the same as that used in surface mining and would primarily involve equipment and vehicle fuels and fluids, and, on some occasions, explosives (that are likely only to be brought to the site on the occasions of their use rather than being stored on-site in any significant quantity).

Cleaning solvents, welding gases, and corrosion control coatings would also be used, all in limited volumes.

Surface and underground mining projects are projected to produce similar wastes, both resulting in solid industrial wastes associated with the maintenance and repair of vehicles and mining equipment, the majority of which would not be capable of traveling public roads to off-site maintenance and repair facilities. Wastes associated with equipment support would include primarily waste engine fluids (lubricating oils, hydraulic fluids, and glycol-based coolants) but may also result in small amounts of asbestos-containing wastes from gasket and brake component replacements and small amounts of refrigerants from air-conditioning system maintenance.

Some degree of surface disturbance would occur with underground mining; the amount of contaminated surface water effluents, however, would be minimized by properly designed and implemented SWPPPs. Mine dewatering is expected to occur for the duration of the subsurface mining operation. Recovered groundwater is expected to be free of contamination and eligible for reinjection into a near-surface aquifer in downgradient locations. It is also expected to be used for fugitive dust control and to moisten spent shale from the surface retorts to facilitate its handling and disposal. Mine dewatering waters are known to have elevated levels of chlorine, sodium, fluorine, sulfur, and boron (DOE 1988).

Section 4.13.1.2 provided details on the hazardous materials and wastes associated with surface retorting and subsequent upgrading. Regardless of whether underground or surface mining techniques are employed to recover the resource, the hazardous materials and waste impacts from the subsequent surface retorting and upgrading activities are virtually identical.

4.13.1.4 In Situ Processing

Proponents of in situ technologies believe that products recovered will be able to be forwarded directly to off-site refining facilities. Consequently, the hazardous materials that would be present on-site to support surface upgrading reactions would not be needed. The retorting products themselves would, however, be hazardous. These would include the primary products (flammable gases, volatile and flammable organic liquids, and heavier molecular weight organic compounds) as well as by-products such as NH_3 and H_2S (in some cases, further converted to elemental sulfur). It is reasonable to expect that facilities operating at commercial scale would arrange for transport of primary products to refineries for further processing and by-products to permitted off-site facilities for treatment or disposal. It is also reasonable to expect that prudent facility engineering designs would include provisions for temporary storage of substantial volumes of products between production and transport off-site. Storage of flammable gases is not expected because such materials would be introduced into interstate pipelines, diverted for immediate use in external combustion sources on-site, or destroyed by incineration stacks. Hazardous materials needed to support ancillary functions as well as on-site vehicles and equipment would also be present.

Some technologies may require subsurface refrigeration to retard or preempt the flow of groundwater into the zone undergoing retorting. Such refrigeration is likely to be provided by commercial-scale systems using refrigerants such as anhydrous or aqueous ammonia. The system proposed by EGL anticipates using a critical fluid to sweep the formation to enhance recovery of petroleum products (see Appendix A, Section A.5.3). One of the fluids cited is CO_2. In the concentrated form in which it would be used as a flushing agent, the CO_2 is both an asphyxiant and toxic.

In situ and aboveground retorting scenarios have dramatically different solid waste profiles. Most significantly, the largest solid waste stream from aboveground retorting (spent shale) is virtually eliminated in true in situ retorting. If future technology enhancements reduce or eliminate the need for additional upgrading at the surface, substantial or even total elimination of solid wastes associated with typical upgrading activities can be expected. In addition, such in situ upgrading can be expected to result in reductions in solid wastes associated with sanitary and domestic wastewater treatment or workforce support activities, since the number of workers for such a facility may be dramatically reduced.

The quality and sources of water effluents are dramatically different for in situ and aboveground retorting scenarios. Surface runoff effluents associated with aboveground retorting are effectively eliminated or greatly reduced by in situ processes. In their place are waters from dewatering operations (formation water), waters created during kerogen pyrolysis (retort water), and waters formed during subsequent in situ upgrading reactions. Also, groundwater's subsequent interactions with retorted zones may result in additional effluents after resource extraction has ended. However, additional wastewaters would be produced from surface support facilities such as boilers and steam generators. Both would produce blowdown wastewaters and sludge from treatment of condensates that would necessarily be part of water recycling.[13]

There are limited field data on observed impacts of in situ retorting on groundwater quality, and most involve modified in situ rather than true in situ technologies. Information regarding studies that looked at the impacts on groundwater from in situ technologies can be found in Appendix A.

Potential adverse health and environmental impacts associated with the improper management of hazardous materials and waste streams associated with in situ processes could be significant. However, if regulations regarding handling of hazardous materials and management of various waste streams are followed, no adverse impacts are expected. In comparison with surface retorting processes, in situ retorting nearly eliminates the generation of spent shale.

It is possible for some waste streams to be eliminated or reduced in volume or hazardous character as a result of efforts to substitute nonhazardous materials into the waste-producing process, or as a result of the identification and installation of waste recycling management strategies. However, given the relative newness of oil shale development technologies, identification of such waste elimination and waste recycling opportunities may not result until

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13 Hazardous materials in the form of water treatment chemicals would also be introduced at those projects where steam or hot water is used in industrial applications.

substantial volumes of field experiences are assembled. Finally, it is also possible that as the refinery industry continues to make adjustments to refining processes to accommodate the heavier crude oil feedstocks that are becoming more prevalent in the market, such modifications may relax the quality factors for feedstocks such as synthetic crude oils, thus reducing the degree of mine site upgrading that may be required. If that were to occur, reductions in the amounts and types of hazardous materials and waste streams associated with mine site upgrading may occur, and upgrading-related wastes would become less voluminous and less hazardous in character.

4.13.2 Mitigation Measures

Hazardous wastes will be present at an oil shale facility throughout construction, operation, and reclamation. During construction, hazardous wastes will be limited in both variety and volume, consisting mostly of wastes from the maintenance of construction equipment and the field applications of protective coatings. During operation, a greater variety of hazardous wastes can be expected, with volumes generally proportional to the scale of the operation. Although facility owners/operators may elect to treat and even dispose of their hazardous wastes at the oil shale facility (with appropriate state-issued permits in place), it is reasonable to expect that most would adopt a strategy that minimizes the times and volumes of on-site storage of hazardous wastes, with expeditious transport to off-site, properly permitted TSDFs. Elementary neutralizations of strongly corrosive wastes, as well as preliminary treatment of wastes to stabilize them for storage and transport, might occur on-site but only to the extent that is minimally necessary.

Regulatory requirements to address hazardous materials and waste management already largely address the mitigation of impacts. To reinforce the regulatory requirements, additional mitigation measures and management plans could include the following:

- An individual, written management strategy for each hazardous waste anticipated;

- Written procedures for waste evaluations, containerization, on-site storage, and off-site disposal;

- Inspection procedures for hazardous material transportation vehicles and storage areas;

- Storage requirements for each hazardous material, including container type, required design elements and engineering controls for storage and handling areas (e.g., secondary containment for liquids, fire protection for areas where flammables are used), and chemical incompatibilities;

- Dedicated, restricted access areas for hazardous waste storage, including adequate separations of chemically incompatible wastes;

- Formal, routine, inspections of hazardous waste storage and handling areas;

- In addition to hazardous communication (HAZCOM) training required for workers who handle hazardous materials, awareness training for all facility personnel, including an identification of explicit roles and responsibilities for each individual;

- Limiting access to hazardous material storage and use areas to authorized personnel;

- A comprehensive inventory of all hazardous materials at the facility, including notations of incompatibilities;

- Formal, written standard operating procedures addressing "cradle-to-grave" management, including receipt, containerization, storage, use, emergency response, and management and disposal of spent materials for each hazardous material at the facility;

- "Just-in-time" purchasing strategies to limit the amounts of hazardous materials present at the facility to just those quantities immediately needed to continue operations;

- Preventive maintenance on all equipment and storage vessels containing hazardous materials;

- Aggressive pollution prevention programs to identify less hazardous alternatives and other waste minimization opportunities;

- Establishment of comprehensive in-house emergency response capabilities to ensure expeditious response to accidental releases; and

- Documentation of all accidental releases of hazardous materials and corrective actions taken; conduct of root cause analyses; determination of the adequacy of response actions (making changes to response capabilities as necessary); assessment of long- and short-term impacts on the environment and public health; initiation of necessary remedial actions; and identification of policy or procedural changes that will prevent reoccurrence.

4.14 HEALTH AND SAFETY

Potential health and safety impacts from recovering oil from oil shale can be associated with the following activities: (1) mining of the oil shale (if processing is not in situ); (2) the obtaining and upgrading of the crude oil, either through surface retorting or in situ processing; (3) transport of construction and raw materials to the upgrading facility and transport of product from the facility; and (4) exposure to water and air contamination associated with oil shale development. Hazards from oil shale development are summarized in Table 4.14-1.

TABLE 4.14-1 Potential Health Impacts Associated with Oil Shale Development[a]

Process or Product	Possible Hazard
Mining	Pneumoconiosis and/or increased cancer risk from inhalation of rock dust, shale particles, and/or diesel exhaust; physical hazards, including explosions; heat stress; and noise.
Retorting	Inhalation of or dermal exposure to fumes or particles; noise; inhalation or dermal exposure to contaminants in wastewater (e.g., hydrocarbons, phenols, trace elements, salts, suspended solids, oil, sulfides, ammonia, polycyclic aromatic hydrocarbons [PAHs], and radionuclides).
In situ processing	Physical hazards associated with well drilling, use of explosives, noise, and use of steam at high temperature and pressure; inhalation of or dermal contact with fumes or particles in product, recovered process water, or process chemicals.
Raw and spent shale storage	Exposure to contaminants in drinking water; concentrations of contaminants in edible aquatic organisms; inhalation of airborne particulates.
Shale oil products	Potential cancers from dermal contact with or inhalation of volatile products.
Combustion products	Inhalation of HAPs from emissions of chemicals (e.g., criteria pollutants, trace elements, sulfur and nitrogen compounds, PAHs, and radionuclides).
All	Increased physical hazards and exposure risks from transportation of raw materials and products to and from the facility.

[a] Adapted from DOE (1988) and Brown (1979).

For mining and upgrading activities, the primary health and safety impacts are on facility workers. These worker impacts include physical hazards from accidents (including asphyxiation, heat stress or stroke, explosion, or injuries related to working with large, moving equipment); health risks from chemical exposures (usually inhalation or dermal) to hazardous substances present in oil shale, the oil product, other process chemicals, and wastes; and loss of hearing because of potentially high on-the-job noise levels. This section primarily addresses worker physical hazards and worker chemical exposure risks. Noise risks are discussed in Section 4.7. Potential water and air contamination, which could lead to exposures of the general public, are discussed in Sections 4.5 and 4.6, respectively. Since, in general, water and air standards are set to be protective of public health, the discussion in those sections addresses potential health impacts on the public.

A potential safety impact on the local off-site population that must be considered is risk that arises from an increased volume of vehicular traffic. The presence of construction and product transport trucks on narrow, two-lane roads could create unique hazards for children waiting at the roadside for their school buses. Such hazards would extend, for example, to exposure to particulate dusts created by the large trucks, as well as the increased potential for accidents. Transport of shale oil and other by-products is expected to occur by tractor trailer or by pipeline. Traffic accidents involving those movements or accidents involving the pipelines could also impact public safety.[14]

Several types of potential worker health and safety issues associated with oil shale development were assessed in the early 1980s. One study looked at the potential health effects associated with a 1-million bbl/day oil shale industry employing 41,000 workers (IWG Corp. 1984; Gratt et al. 1984). The health impacts estimated for workers and the general public in that study are summarized in Table 4.14-2 and include uncertainty ranges. The highest number of potential worker deaths is predicted to occur as a result of lung disease caused by inhalation exposures to dusts, although the uncertainty ranges for these estimates are quite large. It was found that the highest number of deaths would occur in the mining population of workers, which represented 50% of the assumed workforce but accounted for 70% of the expected fatalities (Gratt et al. 1984).

TABLE 4.14-2 Estimated Health Effects Associated with a Hypothetical One Million-bbl/day Oil Shale Industry[a]

		Risk per year (Uncertainty Range)	
Health Effect	Exposure[b]	Cases	Deaths
Workers			
Injuries	Accident with days lost	2,400 (1,700–3,700)	13 (9–22)
Injury	Accident without days lost	1,500 (1,200–2,200)	NA[c]
Cancers	Hydrocarbons, radiation, As	26 (0–300)	4 (0–49)
Silicosis	Dust	232 (0–1,070)	76 (0–387)
Pneumoconiosis	Dust	100 (33–310)	17 (9–98)
Chronic bronchitis	Dust	41 (13–130)	17 (9–98)
Airway obstruction	Dust	10 (3–36)	5 (1–17)
High-frequency hearing loss	Noise	3 (0–8)	NA
Public			
Premature death	Particulate air pollution	NA	6 (0–47)
Internal cancers	As, Cd, Cr, Ni, radiation, PAHs	NA	6 (0–47)

[a] The type of production assumed was 13 facilities using underground mining with aboveground retorting and one facility using a modified in situ technology. The total number of workers assumed was 41,000 (14,200 mining, 6,200 crushing, 9,400 retorting/upgrading, 3,300 construction, 5,600 refining, and 2,200 transportation).

[b] As = arsenic; Cd = cadmium; Cr = chromium, Ni = nickel; PAH = polycyclic aromatic hydrocarbon.

[c] NA = not available.

Source: IWG Corp. (1984).

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14 Spent shale would be generated in large quantities in any surface processing technology. However, it is expected that disposal of these tailings would occur on the leased site. Consequently, little if any spent shale would be transported to disposal areas over public roadways. However, other chemical wastes associated with the operation may not be acceptable for on-site disposal and would, therefore, be transported by truck to permitted treatment or disposal facilities.

A small number of premature deaths and cancer deaths were also predicted to occur in the general public population, again subject to considerable uncertainty. The uncertainties are in large measure due to the inability to accurately predict actual exposures that would occur. If exposures were limited through emission controls and worker safety precautions, the actual number of deaths from dust inhalation would decrease substantially.

Rom et al. (1981) summarized health studies conducted for Scottish and Estonian oil shale workers; both countries have had commercial oil shale industries for lengthy time periods (e.g., Scotland from the mid-1800s until the 1960s; Estonia from the mid-1950s to the present). The carcinogenicity of oil shales was first noted in the Scottish workers at the end of the nineteenth century; oil shales produced at higher temperature were found to produce more PAHs, and hydrotreating the shale oil was shown to reduce its carcinogenicity (Twort and Twort 1930). In the Estonian workers, it was also found that the carcinogenicity was highest for the oil shale fractions retorted at the highest temperatures, and that there was no general pattern between the irritant and general toxic and carcinogenic effects of shale oils (Bogovski 1962). A significant excess of skin cancer has also been observed in long-term oil shale workers in comparison with an urban control group (Purde and Etlin 1980). In the United States, several underground oil shale mines and one aboveground retort existed near Rifle, Colorado, from 1946 to 1978. However, studies of these workers have been inconclusive with respect to health impacts.

4.14.1 Common Impacts

4.14.1.1 Surface Mining

The hazards associated with surface mining would be similar to those associated with surface mining of other materials. These include the following (Bhatt and Mark 2000; Daniels et al. 1981):

- Injuries from highwall-spoilbank failures;
- Hazards associated with the storage, handling, and detonation of explosives;
- Accidents and injuries from working in close proximity to large equipment (such as shovels, trucks, and loaders) and equipment with moving parts;
- Injury hazards from lifting, stooping, and shoveling; exposure to climate extremes and sun while working outside;
- Inhalation of dust and particulates, possibly containing oil shale; inhalation of exhaust fumes from mining equipment; and
- Elevated noise levels (discussed in Section 4.7).

Highwall failures are very dangerous, often resulting in fatalities when the falling material hits workers. Mine Safety and Health Administration (MSHA) statistics show that there were 428 accidents caused by highwall instability in active coal and nonmetal surface mines from 1988 to 1997; 28 fatalities were recorded (Bhatt and Mark 2000). About one-half of the injuries occurred when the workers were hit directly with the failed highwall material; the other injuries involved the material hitting heavy or miscellaneous equipment. More than one-half of the accidents resulted in lost workdays.

Deaths and injuries from accidental ignition of explosives used to blast the formations and allow removal of the oil shale are a serious hazard of mining operations. Injuries and fatalities may also occur because of the high physical demands of surface mining. Although in some cases large machinery (e.g., draglines and loading machines) could be used to remove the oil shale, a truck-and-shovel approach might also be used. This approach can be more efficient, but it also requires a larger number of employees to conduct the work. It is most likely that excavated oil shale would be trucked to the retorting facility. The degree of mechanization in the surface mining processes used would greatly influence the number of worker injuries. In general, more mechanization would be expected to result in a lower number of worker injuries, because fewer workers would be needed to conduct the mining (although the number of machinery-related injuries would increase).

Injury and fatality incidence from oil shale surface mining is likely to be lower than that from the mining industry generally, since the latter also includes the more hazardous underground mining accidents. However, as an indicator, the recent statistics for the mining industry as a whole are provided here. Statistics for work-related injuries and deaths show that mining is one of the most hazardous occupations, with approximately 28.3 deaths per 100,000 mine workers in the United States in 2004 (NSC 2006). Because of improved safety practices and the use of more advanced machinery, mining deaths have decreased since the 1970s. For example, the death rate in 1970 was 200 per 100,000 workers; the rate has decreased to about 30 deaths per 100,000 in recent years (DOL 2006). The number of work-related injuries for miners was 3.8 nonfatal injuries per 100 mine workers annually in 2004 (NSC 2006).

Inhalation of dusts generated during the mining process can cause disease. If these are oil shale dusts, they will likely contain polycyclic aromatic hydrocarbons (PAHs),[15] a carcinogenic component of the shale (further discussed in Section 4.14.1.2 below). Chronic inhalation of irritants such as mineral or metal particles causes pneumoconiosis or miner's lung, a condition characterized by nodular fibrotic lung tissue changes. Prolonged inhalation of silica dusts causes a form of pneumoconiosis termed silicosis, which is a severe fibrosis of the lungs that results in shortness of breath. Both conditions can be fatal. Although concentrations of these dusts are lower for surface mining in comparison with underground mining, additive exposures may nonetheless result in these diseases.

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15 Also known as polynuclear aromatic hydrocarbons or polynuclear aromatic compounds.

4.14.1.2 Surface Retorting

Oil shales are fine-grained sedimentary rocks containing relatively large amounts of organic matter (kerogen) that can yield petroleum when the shale is heated. Oil shales have a wide range of organic and mineral composition. Retorting technologies can potentially allow exposures to gaseous and liquid organic compounds from the crude shale oil formed during kerogen pyrolysis, volatile and gaseous end products (e.g., low molecular weight organic compounds such as methane, ethane, or propane; or by-products such as H_2S and NH_3), as well as exposures to dusts and fumes from material handling operations. Also of concern is the potential for exposure to char, the organic residue remaining on the spent shale.

Retorting conditions determine the precise composition of the organic compounds that are produced as gases, which are present in the crude shale oil liquid or present in the solid char residues. It can generally be expected that many of the compounds in the char will be members of the chemical family known as PAHs, exposures to which may result in various health impacts, including carcinogenic effects (ATSDR 1995; EPA 2006; IARC 1983).

The International Agency for Research on Cancer (IARC) has published a monograph on PAHs (IARC 1983), a monograph on shale oils (IARC 1985), and a supplement to that monograph (IARC 1987). Concerns were expressed in the 1985 IARC Monograph about the potential for workers at oil shale development facilities to be exposed to crystalline silica, inorganic gases and vapors (including CO and H_2S), and gases and vapors of organic compounds, including low levels of PAHs.

Studies on which the 1985 IARC Monograph were based included testing the carcinogenicity of crude shale oils and other by-products and wastes resulting from retorting of oil shales from various parts of the world, including the Green River Formation. The majority of the tests supporting the 1985 IARC Monograph were conducted on laboratory animals. However, human exposure data also were reviewed. While there were subtle differences between oil shale samples, the general conclusions of the report applied to all of the samples investigated. Salient results of the studies reported on in the 1985 IARC Monograph include the following:

- Dermal exposures of laboratory rats to crude shale oils resulting from retorting of Green River Formation oil shale resulted in the induction of benign and malignant skin tumors.

- Lung tumors in mice were also caused by exposures to crude shale oil from the Green River Formation.

- Spent oil shale samples also were investigated. Dusts from a retorted Green River Formation spent oil shale sample caused lung tumors in rats that experienced inhalation exposures.

- Samples analogous to wastes, by-products, and intermediates of crude shale oil upgrading also were investigated. A "pot residue" from distillation of Green River Formation crude oil shale was carcinogenic to mouse skin after dermal exposures. This pot residue was presumed to be equivalent to the shale oil coke residues that would be produced on-site during crude shale oil upgrading.

- Water recovered from retorts (pyrolysis waters) was found to elicit DNA damage and mutations in bacteria and in cultured mammalian cells following metabolic or photoinduced activations.

Primarily on the basis of the above results and positive results in some mutation assays, the IARC concluded that "there is sufficient evidence for the carcinogenicity in experimental animals of high-temperature crude shale-oils, low-temperature crude shale-oils, fractions of high-temperature shale-oil, crude shale-oil distillation fractions, shale-oil bitumens, and commercial blends of shale-oils" (IARC 1985). The monograph went on to conclude that there was insufficient evidence for similar carcinogenic effects from raw oil shale, spent oil shale, and a residue of shale-oil distillation, and that "there is sufficient evidence that shale-oils are carcinogenic in humans." The 1987 IARC Supplement reaffirmed the conclusions regarding carcinogenic properties of raw oil shale, crude shale oil, and derivatives obtained through upgrading activities that were contained in the original 1985 IARC Monograph. The Supplement also indicated that no data were available on the genetic and related effects of shale oils in humans (IARC 1987).

Retorting technologies that use open-flame impingement on oil shale (in either aboveground or in situ retorting circumstances) can be expected to result in the evolution of gases of nitrogen, sulfur, and carbon oxides, all of which produce health effects from inhalation exposure). Exposure to PAHs may be further increased for those retorting technologies that purposefully combust the char to recover latent heat energy.

Crude shale oil contains higher concentrations of nitrogen-bearing compounds than conventional crude oils. Not only does the presence of these compounds introduce complexity into the upgrading or refining of the crude shale oil, they also represent additional exposure hazards to retort and upgrade workers since many of the chemicals exhibit toxic properties. Routson et al. (1979) has summarized the individual nitrogen-bearing compounds that have been identified as being present in typical condensable liquids from kerogen pyrolysis. Researchers have found that the nitrogen content of whole shale oils (i.e., before any upgrading) ranges from 1 to 20% by weight, depending on the source and retorting process used, with the majority of these compounds being in the pyridine family.

Many oil shales contain significant amounts of arsenic. The fate of this arsenic as a result of typical surface retorting often involves the formation of organo-arsenical compounds in crude shale oil. Upgrading activities will commonly include the removal of arsenic compounds through the use of a caustic wash or by adsorption on suitable materials. Both actions result in a solid waste stream or sludge with predictably high concentrations of arsenic. Exposure to these arsenic-bearing wastes can cause toxicity in upgrade facility workers through multiple exposure pathways.

Finally, it is important to note that other technology permutations may introduce additional chemical exposure potentials. For example, chemically assisted techniques for enhanced oil recovery may be used. Substantial quantities of chemicals may be brought to a facility to implement these chemically assisted techniques. Also, in addition to the array of organic chemicals that would be produced during shale oil recovery and processing, other chemicals, including caustic agents, would be present for treatment of steam condensates and raw water to allow for recycling of steam that would most likely be necessary to control costs. Evaluation of the hazards posed by storage and use of these chemicals would be included in required site-specific documentation for facilities using these techniques.

Physical hazards to facility workers during retorting can be associated with equipment and systems. These hazards include potential contact with hot pipes, fluids, and vapors; exposure to ruptured pipes and their contents; accidents from maintenance operations; and physical contact with chemical agents. Comprehensive facility safety plans and worker safety training can minimize these hazards.

4.14.1.3 Underground Mining

The greatest concern for chemical hazards associated with underground mining centers on potential inhalation of airborne dusts (including silica dusts), inorganic gases (e.g., CO and H_2S), and organic gases (e.g., methane) by workers. Chronic inhalation of irritants such as mineral or metal particles causes pneumoconiosis or miner's lung, a condition characterized by nodular fibrotic lung tissue changes. Prolonged inhalation of silica dusts causes a form of pneumoconiosis termed silicosis, which is a severe fibrosis of the lungs that results in shortness of breath. Both conditions can be fatal. Underground mining activities also present potential inhalation hazards from exhaust fumes from diesel-powered equipment, including diesel fuel vapors and criteria pollutants.

In conventional methods to date, deep oil shale deposits have generally been extracted by drilling and blasting (room and pillar mining). Experimental mine and laboratory tests have shown that, given the proper predispersed concentrations, particle size, and kerogen or sulfur content, oil shale and sulfide ore dust can be ignited and cause an explosion (DOI 1995). When fine particles of a combustible dust (oil shale, sulfide oil, etc.) are suspended in an atmosphere that contains sufficient oxygen to support combustion, a dust explosion can occur.

Physical hazards associated with oil shale mining are similar to those from coal mining and include possible injuries or deaths from cave-ins, asphyxiation, or machinery malfunctions; hearing loss; and heat stress. As stated in Section 4.14.1.1, mining in general (both surface and underground) is one of the most hazardous occupations; there were approximately 28.3 deaths per 100,000 mine workers and 3.8 nonfatal injuries per 100 mine workers in the United States in 2004 (NSC 2006).

4.14.1.4 In Situ Processing

The hazards for steam injection in situ processes are similar to those for thermal retorting, although there is much less potential for exposure to the spent shale, since the shale would remain underground. Steam injection can occur without prior modification to the formation or could be preceded by explosive or hydraulic fracturing of the formation to enhance shale oil recovery. Occupational hazards particularly associated with in situ steam injection processes include the following:

- Physical hazards associated with the high-pressure steam boilers and pumps and compressors used for injection;
- Hazards associated with the storage, handling, and detonation of explosives for modified in situ processes employing explosives to cause or enhance reservoir fracturing;
- Physical hazards associated with well drilling; and
- Exposures to hazardous substances in the recovered shale oil, in recovered process water, and in chemicals used to treat and recycle recovered water.

The hazards associated with the use of explosives are discussed in Section 4.14.1.1. A hazard associated with in situ processes that is not applicable to mined oil shale is well drilling, in order to pump the mobilized shale oil to the surface. The phases of drilling wells include site preparation, drilling, well completion, servicing, and abandonment; each is associated with unique physical hazards (e.g., falling from heights, being struck by swinging equipment or falling tools, and burns from cutting and welding equipment or steam).

In comparison with aboveground retorting, many exposure pathways are more limited for in situ retorting technologies although not completely eliminated. Exposures to char are expected to be greatly minimized if not eliminated, except when purposeful burning of the char for additional heat recovery is practiced. Formation waters and pyrolysis waters recovered from in situ retorting are likely to contain contaminants such as chlorine, carbonates, sulfates, mercury, selenium, arsenic, and various organic compounds such as phenols and carboxylic acids (Walsh et al. 1981). Gaseous and liquid retort products produced in situ will ultimately be recovered to the surface or may dissolve in formation and/or pyrolysis waters that also would be recovered to the surface and handled, treated, or disposed of. Worker dermal and ingestion exposures to pyrolysis waters would be limited through facility safety procedures; however, workers could inhale substances volatilizing from these wastewaters.

4.14.2 Mitigation Measures

Regulatory requirements to address occupational health and safety issues already largely address the mitigation of impacts. For example, Occupational Safety and Health Administration (OSHA) standards under 29 CFR Parts 1910 and 1926 (1910.109 is specific for explosives) and

MSHA standards under 30 CFR Parts 1–99. Also, electrical systems must be designed to meet applicable safety standards (e.g., National Electric Code [NEC] and International Electrochemical Commission [IEC]). To reinforce the regulatory requirements, additional mitigation measures could include the following:

- To address traffic safety, installation of appropriate highway signage and warnings to alert the populace of increased traffic and to alert vehicle operators to road hazards and pedestrian traffic. Construction of safe bus stops for children waiting for school buses; these stops should be located well away from the roadway.

- Recommended mitigation measures to avoid highwall-spoilbank failure include benching, using blasting patterns specifically designed for each mine site, adequate compacting of spoilbanks, and adequate miner training allowing for recognition and remediation of hazardous conditions (Bhatt and Mark 2000).

- The use of appropriate personal protective equipment (PPE) can minimize some safety and exposure hazards.

- Safety assessments for oil shale facilities should be conducted to describe potential safety issues and the means that could be taken to mitigate them.

- A comprehensive facility health and safety program for all project phases should be developed. The program should identify all applicable federal and state occupational safety standards, establish safe work practices for each task, establish fire safety evacuation procedures, and define safety performance standards.

- A comprehensive training program and HAZCOM program should be developed for workers, including documentation of training and a mechanism for reporting serious accidents or injuries to appropriate agencies.

- Secure facility access control should be established and maintained for all oil shale project facilities. Site boundaries should be defined with physical barriers and site access restricted to only qualified personnel.

- Low incendive explosives, coupled with good blasting procedures, should be used in underground mining as a means of greatly reducing the occurrences of dust and/or gas ignitions following blasting operations. Also, general safety measures (e.g., good housekeeping for explosives storage areas; requiring safety training for all workers using explosives) should be followed.

- Hazards from well drilling may be mitigated through the use of measures recommended by OSHA (2007).

4.15 REFERENCES

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