4 EFFECTS OF OIL SHALE TECHNOLOGIES

This chapter of the PEIS contains a summary of information on current and emerging 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.

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, 4.14 Hazardous Materials and Waste Management, and 4.15 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 impact 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 25,000 to 30,000 bbl/day, and in situ facilities would produce at 30,000 to 50,000 bbl/day.[1] 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 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 25,000 to 30,000 bbl/day of oil. As discussed in Section 2.3.1 and Appendix A

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[1] These estimates represent a reduction from those in the 2008 OSTS PEIS where the corresponding estimates were 50,000 bbl/day for surface or underground mining operations and 200,000 bbl/day for in situ operations. These reduced estimates are based on discussions with industry representatives involved in the ongoing RD&D oil shale projects, the current timetables for those projects, and from revised projections for the rate of industry development given in the report Energy Development Water Needs Assessment, Phase II, Appendix A (AMEC 2011).

TABLE 4.1.1-1 Assumptions Associated with a Surface Mine with Surface Retort at Production Levels of 25,000–30,000 bbl of Shale Oil per Day[a]

Impact-Producing Factor	Value Used in Impact Analyses
Footprint of development area (acres)[b]	
Utah	300–700
Wyoming	500–1,200
Surface disturbance[c]	5,760
Water use (ac-ft/yr)[d]	3,050–5,640
Wastewater (gal/ton of shale)[e]	2–10
Direct employment for surface mining	
Construction	455–550
Operations	650–780
Direct employment for surface retort	
Construction	265–320
Operations	310–370
Total employment[f]	
Construction	1,100–1,320
Operations	1,450–1,800

[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 and includes the range of production. The methodology is discussed in Section 4.12 and Appendix G.

(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. Other estimates include a range of 1.45 to 4.33 bbl of water per 1 bbl of shale oil (AMEC 2011) and 2 to 4 bbl of water per 1 bbl of shale oil with an average of about 3 bbl of water per 1 bbl of shale oil (GAO 2011). 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 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, the ATP, or the Red Leaf Resources EcoShale In-Capsule Technology (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. (The Red Leaf Resources EcoShale In-Capsule Technology results in synthetic natural gas production, which allows for energy self-sufficiency, according to their Web site and pilot tests.)

- 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;[2]
  - 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[3]) of the resulting syncrude to allow for

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[2] 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.

[3] 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 lower API values.

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.[4]

- 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 25,000 to 30,000 bbl of shale oil per day.

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 acres/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.

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[4] 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 at Production Levels of 25,000–30,000 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]	1,050
Water use (ac-ft/yr)[d]	3,050–5,640
Wastewater (gal/ton of shale)[e]	2–10
Direct employment for underground mining	
Construction	470-560
Operations	650–780
Direct employment for surface retort	
Construction	265–320
Operations	310–370
Total employment[f]	
Construction	1,100–1,560
Operations	1,450–1,980

[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 900 acres used for spent shale disposal over a 20-year 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 and includes the range of production. The methodology is discussed in Section 4.12 and Appendix G.

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. Other estimates include a range of 1.45 to 4.33 bbl of water per 1 bbl of shale oil (AMEC 2011) and 2 to 4 bbl of water per 1 bbl of shale oil with an average of about 3 bbl of water per 1 bbl of shale oil (GAO 2011). 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.[5]

- 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 shale, and other nonconsumptive uses, to the extent allowable, given water quality considerations.[6] 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.

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5 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.

6 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.

- 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 30,000 to 50,000 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.[7] Other estimates for various methods include a range of −0.22 (negative due to water of combustion) to 1.61 bbl of water per 1 bbl of shale oil (AMEC 2011) and 1 to 12 bbl of water per 1 bbl of shale oil with an average of about 5 bbl of water per 1 bbl of shale oil (GAO 2011). 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, and so forth. 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.

- 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;

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[7] 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 at Production Levels of 30,000–50,000 bbl of Shale Oil per Day[a]

Impact-Producing Factor	Value Used in Impact Analyses
Footprint of development area (acres)[b]	
Colorado and Utah	22–150
Wyoming	150–500
Surface disturbance (acres)[c]	5,760 (5,120)
Water use (acre-ft/yr)[d]	1,410–7,050
Direct employment for in situ projects	
Construction	225–375
Operations	75–125
Total employment[e]	
Construction	345–725
Operations	120–340

[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 and includes the range of production. The methodology is discussed in Section 4.12 and Appendix G.

- Removal of ammonia 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, rail tank car, 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 4.12). 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 4.12 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.

For the purposes of analysis in this PEIS, the BLM has assumed that future in situ projects would require 600 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) and assuming the upper end of the projected production level of 50,000 bbl/day. (See footnote in Section 4.1 that discusses the reduction in this estimate from the 200,000 bbl/day used in the 2008 PEIS.) 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

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 (25,000 to 30,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	900–1,300	550–1,100
Local communities	600–900	1,300–2,000
Maximum size of employer-provided housing (acres)[b]	25–36	15–30
Underground mine with surface retort (25,000 to 30,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	750–1,300	450–1,100
Local communities	600–1,400	1,300–2,500
Maximum size of employer-provided housing (acres)[b]	22–36	13–25
In situ projects (30,000 to 50,000 bbl/day)		
Total population (including families)[a]		
Employer-provided housing	750–1,300	125–280
Local communities	650–1,700	350–700
Maximum size of employer-provided housing (acres)[b]	22–38	4–7

[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 4.12 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.

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, synthetic 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 scaled values for a 600-MW power 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

TABLE 4.1.6-1 Assumptions Associated with a 1,500-MW and a 600-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 600-MW Plant[b]
Land use (acres)	3,000 total (includes construction acreage)	1,200
Water use (ac-ft/yr)	8,000 ac-ft/yr	3,200
Employment (direct full-time equivalents)	Construction: 1,200–1,500; Operations: 150	Construction: 480–600; Operations: 60

[a] BLM (2007a).

[b] Values for 600-MW power plant scaled from values for 1,500-MW plant.

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, tanker truck, or rail tank car.

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, sale of water rights, 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 (1) the introduction of or increase in recreational use in new areas due to improved access, or alternatively, (2) avoidance of existing recreation use areas near transmission corridors for aesthetic reasons, and (3) 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 oil and gas leases issued in the oil shale areas of Colorado, Utah, and Wyoming, between 1968 and 1989. Four stipulations are 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 conducted 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 that were previously 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 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.

As discussed in Section 2.3.3, the BLM has determined that it will carry forward decisions in the White River RMP (BLM 1997) 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, additional population, and electric 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 would likely 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 is incompatible with recreational use (e.g., hiking, biking, fishing, hunting, bird watching, OHV use, and camping). Recreational use would be excluded from areas leased for oil shale production once development activities begin. Recreational use may be reestablished once oil shale operations have ceased and restoration has been completed. The change in the overall character of undeveloped BLM-administered lands to a more industrialized, developed area would displace people seeking more primitive surroundings in which to hunt, camp, ride OHVs, and so forth. 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 would displace this use. Even if access could be granted to portions of oil shale leases for recreational use, visitors might find the recreational experience to be compromised by the nearby development activities. Such impacts could also be incurred by recreational users of adjacent, off-lease lands. Impacts on vegetation, development of roads, and displacement of big game would 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 recreational uses would be magnified by changing the overall character of a larger area and by oil shale development dominating a larger portion of the landscape.

Once established, transmission line and pipeline ROWs would have less impact on recreational 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 transmission lines. The establishment of employer-provided housing, although not likely to be located on public lands, would preclude recreational land use on those lands and might cause indirect impacts through increases in recreational use on adjacent lands. Construction of new power plants, although this development also is not likely to occur on public lands, or expansion of existing plants, would displace any recreational use on the lands that are developed and may displace recreational uses on lands adjacent to the development.

4.2.1.5 Specially Designated Areas and Lands 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. However, these areas and areas managed by other federal or state agencies (e.g., units of the National Park System, State Parks) within the viewshed of commercial oil shale development and associated transmission and pipeline ROWs, may be adversely affected (e.g., degraded viewsheds, reduction in recreational use, and impaired night sky viewing opportunities) by development on nearby public lands. Section 4.9 discusses impacts on visual resources in greater detail.

Existing ACECs that are not closed to mineral development may be available for application for commercial oil shale leasing. Oil shale and transmission or pipeline development on any ACEC would result in a loss of all or a part of the resources or values for which the area was originally designated. Oil shale development within the viewshed of these areas may also result in adverse impacts on scenic values of these areas.

Another category of lands that may be available for application for commercial leasing are those that the BLM has identified as possessing wilderness characteristics. Commercial oil shale development and associated development of transmission line and pipeline ROWs within areas with wilderness characteristics would cause a loss of those characteristics in and around the disturbed areas. Development of oil shale and related facilities on nearby lands within the viewshed of an area with wilderness characteristics also could result in adverse impacts on wilderness characteristics.

All specially designated areas and lands with wilderness characteristics located in or near 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 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 desert regions of Utah and Colorado and may be present in the study area (see Belnap [2011] on cryptobiotic soils of the Colorado Plateau). These 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, and so forth. 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 long-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 long-term disturbance and 670 acres disturbed during construction). Likewise, newly constructed employer-provided housing would likely be built, with limited long-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 change the 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, 300 to 700 acres would be disturbed at any one time during commercial operations producing 25,000 to 30,000 bbl/day, with a total of 5,760 acres potentially disturbed (Table 4.1.1-1). In Wyoming, 500 to 1,200 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 and that the remainder would be 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 22 to 150 acres would be disturbed at any one time at a 30,000- to 50,000-bbl/day facility, while in Wyoming, the figure would be approximately 150 to 500 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 ecological recovery are also part of a reclamation phase (DOI and USDA 2007).

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 makes soil management 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 impact 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. 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 2007), 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 2007).

- 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 the stability of quarry walls, underground mines, and the 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 location of the project and the amount of land disturbance in areas where paleontological resources are present. 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 and loss of valuable scientific information could result from the clearing, grading, and excavation of the individual project area; 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 paleontological resources and their stratigraphic context 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 spills of oil or other contaminants 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 eroding away materials and portions of sites, the accumulation of sediment could serve to remove from scientific access, but otherwise 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 related disturbance (e.g., looting and vandalism) of exposed paleontological resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) increases the 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 (specimen, assemblage, locality, or site) is damaged or destroyed during oil shale development, this scientific resource would become irretrievable. Data recovery and resource removal are ways in which at least some information can be salvaged should a paleontological site be affected, but certain contextual data would be invariably lost. The discovery of otherwise unknown fossils would be beneficial to science and the public good, but only as long as sufficient data are recorded.

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. Coordination between the project developer and the BLM would be required for all projects before lease areas are developed. The use of BMPs, such as training and educational 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 project developer and the BLM.

A paleontological overview was completed for the study area (Murphey and Daitch 2007). The overview synthesized existing information and generated maps showing oil shale areas in Colorado, Utah, and Wyoming with the PFYC designation and paleontological sensitivity of formations that could be affected by oil shale development. This analysis did not identify geographical areas to be precluded from leasing. However, during the leasing phase, the overview will be used to aid developers and the BLM in determining areas of sensitivity and appropriate survey and mitigation needs.

Mitigation measures to reduce impacts on paleontological resources will be required based on the environmental analysis conducted prior to leasing and/or development and could include the following:

- Project developers should determine whether paleontological resources exist in an individual project area on the basis of the sedimentary context of the area and its potential to contain significant paleontological resources. 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 strata may be consulted. A paleontologist may be required to observe during active excavation at project sites. Depending on the extent of paleontological information, the BLM may require a paleontological survey. If paleontological resources are present at the site, or if areas with a high fossil yield potential are 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 fossil yield potential, monitoring by a qualified paleontologist may be required during all excavation and earthmoving in the area (even if no fossils were observed during the survey). 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 should be notified immediately. Work should 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 measures.

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 potential mitigative measures that follow the impact analysis.

4.5.1.1 Ground Surface Disturbance

It is assumed that surface mines with surface retort facilities and in situ facilities could have ground disturbance over their entire lease areas (up to 5,760 acres). Underground mines 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, employer-provided 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 and have the potential for downstream impacts.

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 whether 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 a surface mine with surface retort and an 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). A surface mine or underground mine with surface retort plants with capacities of 9 to 11 million bbl/yr (or 25,000 to

30,000 bbl/day) could consume 3,050 to 5,640 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 600-MW coal-fired power plant could require approximately 3,300 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 relative to those of an open channel 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 incur 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 would decrease and be more susceptible to warming due to solar radiation in summer time, while cooling of shallower stream water would be more rapid in cold weather. Diversions from small streams would have significantly greater overall impacts compared to diversions from larger rivers.

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 increases in 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.

Regardless of the location or technology for potential oil shale operations, water availability issues may be exacerbated by the effects of climate change. The U.S. Bureau of Reclamation (BOR 2007) investigated climate change related to the Colorado River Basin. In its report, the Bureau reviewed various climate change models and the associated predictions. Its findings include generally decreased runoff in the basin due to higher temperatures and constant or slightly decreased precipitation. Although the confidence level regarding higher temperatures is fairly high, a lower confidence is associated with precipitation changes due at least in part to difficulty in addressing such changes in mountainous terrain. BOR (2011) also analyzed the possible hydrologic changes from over 100 climate change projections. Findings for the Colorado River Basin included an increasing trend in temperature; decreasing trends in April 1 snow water equivalent and in spring-summer runoff; and a slight decrease in precipitation in the overall basin to the year 2099. BOR also noted a lack of calibration in the models and a need to refine them.

Similarly, a report on the effects of climate change in Colorado prepared by the Western Water Assessment (WWA 2008) suggests a reduction in total water supply in Colorado by midcentury. Hydrologic assessments in the report likewise point to a reduction in runoff, with the average of multiple models predicting decreases from 6% to 20% by 2050.

A climate change summary produced by USGCRP (2009) provides some details on the oil shale regions. In the Colorado and Utah study areas, the projected spring precipitation in 2080 to 2099 is predicted to range from a 0 to 5% increase under a low-emissions scenario to a 5 to 10% decrease under a high-emissions scenario. The study notes that water is already becoming limited in the region and that recent and projected conditions include rising temperatures and reduced river flows. In the Wyoming study area, the report predicts heat waves, high evaporation, drought, and heavy rainfall events. The summer temperatures are projected to increase 7 to 10 ºF by 2080 to 2099 under the low- and high-emissions scenarios, respectively. The projected spring precipitation in 2080 to 2099 is predicted to range from a 0 to 5% increase under a low-emissions scenario to a 0 to 10% decrease under a high-emissions scenario.

While there is uncertainty about the potential future effect of climate change on water availability, it is an important factor for consideration, as water rights and water usage may be influenced by an overall decrease in water availability in the region.

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.

Discharge of surface runoff at a mining site is exempted from NPDES permits 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. 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 the states of Colorado, Utah, and Wyoming administer their own NPDES programs. 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 chemicals 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 sediment input 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.

Limited information is available on groundwater monitoring studies at RD&D sites. The Colorado Division of Reclamation, Mining & Safety (DRMS) maintains an online database of site documents, some of which relate to the RD&D sites and their hydrogeology. Information provided to the State from Shell (Monson 2011) includes groundwater monitoring data for its Mahogany Research Project (MRP) site. The arsenic, benzene, and total benzene/toluene/ethylbenzene/total xylenes (BTEX) data for 2002 to 2011 are provided in individual graphs for 19 monitoring wells. No well location map, information on well depths, or stratigraphic details are included in the report. Inspection of the data indicates variability among different wells, with some having levels exceeding the drinking water standard for arsenic (0.01 ppm) and benzene (5 ppb). Shell generally attributes high levels (ranging up to 0.27 ppm for arsenic and more than 3,000 ppb for benzene) to the proximity of the well to prior formation heating tests. The DRMS database also includes annual groundwater monitoring reports for 2007 through 2010 for the Exxon Colony site. The 2010 Exxon report (Tavano 2011 [reclamation monitoring]) provides data for nine sampled wells. Arsenic is high relative to drinking water standards at two of the wells (up to 0.021 ppm in 2010, up to 0.46 ppm for the average from 1984 to 2009). No BTEX data, well location map, or stratigraphic information were included. Chevron (Justus 2011 [tracer model]) is proposing hydraulic testing and a tracer study focused on the A-groove of the Parachute Creek Member at its RD&D site. The purpose of the tests is to determine parameter values for use in groundwater flow and contaminant transport models in support of in situ oil shale operations. The report mentions that the site has 15 monitoring wells that were installed in 2008. No monitoring data were available for the RD&D site on the online database.

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 4.12.1). 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 and cause 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 would 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. Erosion of streambeds may occur in this case and affect downstream water quality. 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. 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

Table 4.5.2-1 provides a possible scenario of water demand and consumptive use for individual oil shale development projects, 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.[8] 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

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[8] 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 30,000–50,000 bbl/day	1–3 bbl of water/bbl oil produced per 30,000–50,000-bbl/day plant[c]	1.1–7.1	0.8–5.4[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 25,000–30,000 bbl/day	2.6–4 bbl of water/bbl oil produced per 25,000–30,000-bbl/day plant	3.1–5.6	2.3–4.3
	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 consumption for each in situ project (includes power production)		14.0–18.6
		Total consumption for each UM/SR project		2.6–4.6
	State Water Allocation	**Location**		**Allocation (1,000 ac-ft/yr)**
	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	**Location**		**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

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions		Estimated Budget Components[b]
Colorado (Cont.)	**Water Resources**	**Location**		**Flow or recharge rate (1,000 ac-ft/yr)**
	Estimated natural groundwater recharge	Piceance Basin[h]		35
	Groundwater storage	**Location**		**Storage (1,000 ac-ft)[i]**
	Groundwater in storage (excluding alluvial aquifers)	Northern province of Piceance Basin[j]		2,500 to 25,000
Utah	**Technology**	**Assumption**	**Demand (1,000 ac-ft/yr)**	**Consumption (1,000 ac-ft/yr)**
	In situ project at 30,000–50,000 bbl/day	1–3 bbl of water/bbl oil produced for a 30,000–50,000-bbl/day plant	1.1–7.1	0.8–5.4[d]
	Sanitary and potable use for in situ projects	4,736 in-migrants at 135 gal/day/ person	0.72	0.38[k]
	UM/SR or surface mine/surface retort (SM/SR) project at 25,000–30,000 bbl/day	2.6–4 bbl of water/bbl oil produced for a 25,000–30,000-bbl/day plant	3.1–5.6	2.3–4.3
	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 consumption for each in situ project (includes power production)		14.2–18.8
		Total consumption for each UM/SR project		2.7–4.7
		Total consumption for each SM/SR project		2.9–4.9

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]	
Utah (Cont.)	**State Water Allocation**	**Location**		**Allocation (1,000 ac-ft/yr)[g]**
	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 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
		Average flow of Duchesne River near Randlett, based on 50-yr records (see Section 3.4.3.2)		460
	Estimated practical limit of groundwater withdrawal	Alluvium along Parachute Creek and Douglas Creek in southeastern Uinta Basin[l]		20
Wyoming	**Technology**	**Assumption**	**Demand (1,000 ac-ft/yr)**	**Consumption (1,000 ac-ft/yr)**
	In situ project at 30,000–50,000 bbl/day	1–3 bbl of water/bbl oil produced for a 30,000–50,000-bbl/day plant	1.1–7.1	0.8–5.4
	Sanitary and potable for in situ projects	3,848 people at 135 gal/day/person	0.58	0.31[k]
	UM/SR or SM/SR project at 25,000–30,000 bbl/day	2.6–4 bbl of water/bbl oil produced for a 25,000–30,000-bbl/day plant	3.1–5.6	2.3–4.3
	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)

TABLE 4.5.2-1 (Cont.)

	Technology and Water Resources	Supporting Information and Assumptions	Estimated Budget Components[b]	
Wyoming (Cont.)	**Technology**	**Assumption**	**Demand (1,000 ac-ft/yr)**	**Consumption (1,000 ac-ft/yr)**
		Total consumption for each in situ project (includes power production)		14.1–18.7
		Total consumption for each UM/SR project		2.7–4.7
		Total consumption for each SM/SR project		2.7–4.7
	State Water Allocation	**Location**		**Allocation (1,000 ac-ft/yr)[g]**
	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
	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[m]		50–100[n]

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.

Footnotes continued on next page.

TABLE 4.5.2-1 (Cont.)

[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] Source: Taylor (1982).

[i] The estimates of groundwater in storage represent volumes. They do not indicate sustainable aquifer yield.

[j] Source: Czyzewski (2000).

[k] 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).

[l] Source: Lindskov and Kimball (1984).

[m] Source: SWWRC (2001b).

[n] The yield was estimated from an area about five times the size of the basins studied in this PEIS.

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 an underground mine with a surface retort project and a surface mine with surface retort facilities could obtain adequate power from existing facilities.

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 30,000- to 50,000-bbl/day project would be about 2,800 to 8,700 ac-ft/yr (this estimate includes an assumed new power plant, which would be required to provide adequate power). Water consumption for a projected 25,000- to 30,000- bbl/day underground mine with a surface retort project would be about 2,450 to 4,440 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.[9] With a range of 2,450 to 8,650 ac-ft/yr required for individual oil shale development projects, the possible water requirements per project represent 0.7 to 2.6% of the currently available water and would be 0.6 to 3.2% 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, although the environmental impacts of reservoir construction or pipeline construction would be significant, especially for projects of

9 The upper end of the range assumes that water will be released from agricultural use in the future.

larger magnitude. In addition, 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 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.

4.5.2.2 Utah

For a 30,000- to 50,000-bbl/day in situ project in Utah, the amount of water consumption is estimated to be 2,800 to 8,700 ac-ft/yr (Table 4.5.2-1). A 25,000- to 30,000-bbl/day underground mine with a surface retort project or a surface mine with a surface retort project is estimated to have a water consumption rate of 2,500 to 4,620 ac-ft/yr, assuming 2.6 to 4 bbl of water is 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 2,500 to 8,700 ac-ft/yr required for individual oil shale development projects, the water requirements per project represent 0.7 to 2.2% of the currently available water and would be 1.3 to 4.5% of the water available in 2050. Water supply and water quality issues in Utah surrounding oil shale and tar sands development are highlighted in a 2010 report by Western Resource Advocates (WRA 2010).

4.5.2.3 Wyoming

For a 30,000- to 50,000-bbl/day in situ project in Wyoming, the amount of water consumption is estimated to be 2,800 to 8,700 ac-ft/yr (Table 4.5.2-1). An underground mine with a surface retort project or a surface mine with surface retort projects at 25,000 to 30,000 bbl/day are estimated to consume 2,450 to 4,500 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 per project represent 1.1 to 3.9% of the currently available water and would be 1.2 to 10.9% 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. 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.

- Diversions from small streams should be avoided or limited as appropriate, especially during relatively dry base flow periods.

- 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 NO_x, with some CO, VOC, and SO_2 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 NO_x and CO, with lesser amounts of PM, VOCs, and SO_2) 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.

- During all phases of oil shale development, GHG emissions of CO_2 and lesser amounts of CH_4 and N_2O from combustion sources could contribute to climate change.

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. As additional NEPA analysis is done for leasing and site specific development, it may be necessary as part of the air quality analysis to conduct air quality modeling. The types of modeling that may be performed, when warranted, include near-field modeling, far-field modeling, and photo-chemical grid modeling.

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

TABLE 4.6.1-1 Area and Population for Counties in Which Oil Shale Emissions Could Occur

State	County	Land Area (mi²)	Population (2000)	Population (2010)
Colorado	Garfield	2,947	43,791	56,389
	Rio Blanco	3,221	5,986	6,666
	Subtotal	6,168	49,777	63,055
Utah	Carbon	1,478	20,425	21,403
	Duchesne	3,238	14,371	18,607
	Uintah	4,477	25,224	32,588
	Subtotal	9,193	60,020	72,598
Wyoming	Lincoln	4,069	14,573	18,106
	Sublette	4,883	5,920	10,247
	Sweetwater	10,425	37,613	43,806
	Uinta	2,082	19,742	21,118
	Subtotal	21,459	77,848	93,277
Regional	Total	36,820	187,645	228,930

Source: U.S. Census Bureau (2011).

state and local air quality regulatory agencies. 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 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 local, state, tribal, and federal air regulations within the leased area.

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 the EPA) would also review site-specific preconstruction permit applications to examine potential project-wide air quality impacts. As part of these reviews, the air quality regulatory agencies could require additional air quality impact analyses or mitigation measures. Those reviews 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 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.

4.6.1.1 Climate Change

Analyzing the potential effects associated with an activity's potential contribution to climate change includes consideration of several factors, including GHG emissions (including CO_2, CH_4, and N_2O), land use management practices, and surface albedo (a measure of how strongly a surface reflects light from light sources such as the sun). Decreased albedo (e.g., due to melting snow and ice) means that more light (and heat) is absorbed by the earth's surface.

For many activities with mature technologies, it is possible to make reasonable, quantitative predictions of the GHG emissions or the amount of carbon that would likely be sequestered from proposed activities.

For example, calculating oil and gas production GHG emissions is relatively straightforward due to the long history of this type of activity. When adequate data are available to prepare an emissions inventory of a proposed project or activity, the BLM can account for and disclose factors that may contribute to global climate change. Once quantified, GHG emissions can be compared across appropriate sectors (where information is available), and then put into context for the public and the decision maker.

Even for such activities with known technologies, however, there is no scientifically accepted method to quantify the incremental climatic impacts of those activities, either to the global climate, or to the climate of any area or region.

Compounding the problem for the present analysis is the fact that there is no commercially proven technology for extracting liquid fuels from oil shale or tar sands. Thus, any quantitative prediction of the GHG emissions from commercial operations for oil shale or tar sands would be, at best, professional judgment based on technologies under research and development or deployed in non-commercial contexts, and at worst would be speculation.

The decisions to be made on the basis of this PEIS are land allocation decisions, which do not themselves result in emission of any GHGs. However, if and when oil shale and tar sands development activities are authorized, those activities are likely to result in GHG emissions . As a programmatic analysis appropriate to support allocation decisions, this PEIS analyzes the potential environmental impacts of oil shale and tar sands activities in general. Further, since the particular technology and methodology with which the shale oil and/or tar sands will be extracted is currently in the R&D phase, specific information regarding activity data related to equipment usage cannot be known at this time. Because adequate equipment and activity assumptions are unavailable at this time, preparing an emissions inventory for this PEIS is not a scientifically defensible effort. When project applications are submitted to the BLM and more specific information is known, including what types of mining technology (surface mining or underground mining) are planned to be utilized for resource development, an appropriate air resource analysis would be conducted and could include an emission inventory. Therefore, this section describes the potential GHG emissions of oil shale and tar sands development in a qualitative manner. Existing climatic conditions and an assessment of future potential climatic changes for the region are described in Section 3.5.

The following assumptions are central to this analysis.

- The assessment of climate-changing pollutant emissions and climate change is in its formative phase, so it is not yet possible to know with confidence the net impact on resources from GHG emissions.

- The lack of scientific tools to predict climate change due to localized changes in GHG emissions limits the ability to quantify potential future impacts for each alternative.

- Climate change is a global phenomenon in which larger changes in global GHG emissions are almost certain to have greater impacts on resources in the study area than are GHG emissions from commercial oil shale and tar sands industries in the study area.

- Future EPA regulatory actions to reduce GHG emissions are not considered in this analysis.

- In the future, should tools improve for predicting climate changes due to resource management actions, the BLM may be able to reevaluate decisions made as part of this planning process and to adjust management accordingly.

GHG emissions and changes in biological carbon sequestration would occur as a result of authorizing shale oil and tar sands activities. These emissions would occur during the construction, operation, and maintenance phases of potential future projects. Sources of emissions could include some of the following activities, depending on the types of extraction and processing technologies to be included in a potential future project:

- Construction of buildings and processing facilities;

- Construction of roads and other infrastructure (e.g., pipelines, electricity transmission, railroads);

- Electricity generation;

- Oil shale surface or underground mining;

- Tar sands surface or underground mining;

- Well drilling activities;

- In situ processes to recover bitumen from tar sands or oil shale kerogen pyrolysis products;

- Solid material crushing, sizing, and sorting;

- Retorting;

- On-site solid and liquid material conveyance, loading, and unloading;

- Stationary diesel- or gas-fired engines;

- Liquid product storage;

- Waste or overburden disposal;

- Vehicle exhaust associated with heavy equipment;

- Vehicle exhaust associated with construction, delivery, product transport, and commuting activities; and

- Site reclamation.

4.6.1.1.1 GHG Emissions Regulations and Trends. The EPA is in the early stages of regulating GHGs as air pollutants under the CAA. In its *Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act*, the EPA determined that GHGs are air pollutants subject to regulation under the CAA. The EPA is regulating CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs. In addition, aggregate GHG emissions are regulated in terms of CO_2e emissions.

The first EPA regulation to limit emissions of GHGs imposed CO_2 emission standards on light-duty vehicles, including passenger cars and light trucks (40 CFR Part 98). As of August 2011, the EPA had not promulgated GHG emission limits for stationary sources, such as compressor stations. However, the EPA is gathering detailed GHG emission data from thousands of facilities throughout the United States and will use the data to develop an improved national GHG inventory and to inform future GHG emission control regulations. Beginning in 2010, many facilities across the United States estimated GHG emissions in accordance with the EPA's "Greenhouse Gas Mandatory Reporting Rule" and began reporting annual GHG emissions on March 31, 2011. Many oil and gas facilities will begin estimating GHG emissions in 2011 and will submit their first annual GHG emission reports on March 31, 2012, in accordance with Subpart W of 40 CFR, Part 98. Under 40 CFR Part 98, underground coal mines that are subject to quarterly or more frequent sampling by the Mine Safety and Health Administration (MSHA) of ventilation systems are required to report their GHG emissions, such that the annual GHG report must cover stationary fuel combustion sources, miscellaneous use of carbonates, and all applicable source categories listed under 40 CFR Part 98 Subpart A. Greenhouse gases are not required to be controlled, however.

The EPA proposed oil and natural gas system emission control regulations on August 23, 2011 (76 FR 52738). These regulations are expected to decrease CH_4 emissions and increase CO_2 emissions. The net effect of the proposed emission controls is a 62 million metric ton decrease in CO_2e, which would represent approximately a 26% decrease in baseline CH_4 emissions from 2009 emission estimates for this industry sector (76 FR 52738).

4.6.1.1.2 Environmental Consequences. The EPA estimates that national GHG emissions in 2009 were 6,633,200,000 metric tons CO_2e (EPA 2011), which represented a 7.3% increase from estimated 1990 national GHG emissions (6,181,800,000 metric tons CO_2e). The EPA categorized the major economic sectors contributing to U.S. emissions of GHG compounds as:

- Electric power industry (33.1%),
- Transportation (27.3%),
- Industry (19.9%),
- Agriculture (7.4%),
- Commercial (6.2%),
- Residential (5.4%), and
- U.S. Territories (0.7%).

The three most commonly emitted GHGs likely from development and production of oil shale and tar sands sources are CO_2, CH_4, and N_2O. Other GHGs, including SF_6, HFCs, and PFCs, are not emitted by these activities or are emitted in trace quantities.

Changes in biological carbon sinks may result from surface-disturbance activities associated with oil shale and tar sands development. Numerous methodologies are available for calculating biological carbon sequestration, and depending on the methodology used, estimates of biologically stored or removed carbon can vary greatly. Because there is not yet a single generally accepted standard for estimating biological carbon sinks and removals and insufficient activity data are available, a discussion of potential biological carbon changes due to oil shale and tar sands activities is beyond the scope of this analysis.

Impacts from Air Quality Management. Air quality management actions require compliance with federal and state air quality regulations; therefore, future applicable GHG reduction requirements imposed by the EPA or state governments would apply to any future authorized activities and could potentially reduce GHG emissions and climate change impacts. In addition, many emission limits and standards that apply to criteria emissions have co-benefits of reducing CO_2, CH_4, or N_2O emissions. Therefore, any future emission restrictions on non-GHG pollutants may also effectively reduce GHG emissions.

For example, air quality management could include the following provisions that would decrease GHG emissions, compared to uncontrolled emissions:

- Capture and destruction or beneficial use of methane from mines;
- Carbon dioxide sequestration in geologic formations;
- Use of natural gas fuel rather than diesel fuel for stationary source engines;
- Emission capture and destruction of vapors from hydrocarbon storage tanks;
- Piping products to destinations rather than trucking products;
- Use of vehicles with low GHG emissions;
- Use of renewable energy for electricity generation; and
- Decreasing vehicle idling times.

When future air resource analyses are performed during the consideration of authorization of proposed activities, project-specific GHG emissions would then be compared to relevant and available information, such as those emissions described in Table 4.6.1-2 below.

4.6.1.1.3 Cumulative Climate Change Impacts. GHG emissions generally increase with population growth, industrial activity, transportation use, energy production, and fossil fuel energy use. As discussed in Chapter 3, GHG emission increases contribute to climate change. Oil shale and tar sands activities' emissions may or may not increase state, national, or global GHG emissions due to regulatory and market forces. Possible cumulative impacts that may be associated with oil shale and tar sands development are summarized below.

- Cumulative GHG emissions may increase if project GHG emissions add to global GHG emissions.
- Cumulative GHG emissions may not increase or may increase by a smaller quantity if some or all project emissions are offset due to decreased energy production from other sources (e.g., oil and gas production in other oil and gas basins with greater GHG emissions on a unit-production basis).

TABLE 4.6.1-2 Greenhouse Gas Emission Comparisons

Inventory Description	CO_2e Emissions (10^6 metric tons/yr)
State Inventories, Consumption-Based (2010)[a]	
Colorado	129.3 (+2.9)[b]
Utah	75.6 (–8.4)
Wyoming	60.3 (–30.4)
U.S. Inventories (2009)[c]	
Total US Greenhouse Gases	6,633.2
U.S. natural gas systems[d]	253.4
U.S. coal mining[e]	76.5
U.S. landfills	117.5
U.S. fossil fuel combustion	5,209.0

[a] Sources: Bailie et al. (2007); Roe et al. (2007); Strait et al. (2007).

[b] The value in the parenthesis denotes emissions related to net imported/exported electricity, for which negative values represent exports. Thus, production-based emission is about 50% higher than consumption-based emission in Wyoming.

[c] Source: EPA (2011).

[d] Natural gas systems include natural gas production (e.g., wells), processing, transmission, and distribution.

[e] Including abandoned underground coal mines.

- GHG emissions from oil shale and tar sands may be offset, in part, by reduced transportation emissions from the site of production to the site of use. For example, transportation emissions from U.S. oil shale and tar sands production may be less than transportation emissions for oil that is transported from foreign countries.

Quantification of cumulative climate change impacts, such as changes in temperature, precipitation, and surface albedo, is beyond the scope of this analysis. The maximum potential increase in cumulative GHG emissions from all potential oil shale and tar sands activities cannot be predicted with accuracy. Furthermore, such GHG emissions and changes to carbon sinks would be small relative to state, regional, and global GHG emission inventories. Consequently, global- or regional-scale modeling may be unlikely to yield meaningful predictions of climate change impacts in relation to GHG emissions attributable to oil shale and tar sands activities alone.

4.6.1.2 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 developed for selected years during the assumed plant life (including construction, operation, maintenance, and reclamation).

4.6.1.2.1 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.

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 and materials stockpiles.

4.6.1.2.2 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 particulate emissions.

4.6.1.2.3 Maintenance. In addition to maintenance at the primary operations facility, 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.

4.6.1.2.4 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.

4.6.1.2.5 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.

4.6.1.2.6 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 reduce potential air quality impacts. These mitigation measures could include but are not limited to (1) treating access roads with water or dust suppressants 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 NO_x, CO, $PM_{2.5}$, PM_{10}, VOC, and GHG 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.

GHG emissions that may be related to climate change impacts may be reduced, regardless of their source (e.g., oil shale or conventionally-derived carbon-based energy sources) through the use of emission controls or by sequestering GHGs.

4.7 NOISE

Generic noise impacts of construction, operation, and reclamation of oil shale development facilities have been estimated; however, detailed information on equipment types, schedules, layouts, and locations is 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 requires 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 assumes noise levels are 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 (Hanson et al. 2006). 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 those 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.[10] For example, if noise levels were available for a reference facility of 20,000 bbl/day, 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.

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

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[10] A 3-dB change in sound level is considered barely noticeable based on individuals' responses to changes in sound levels (NWCC 2002; MPCA 1979).

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.

are 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 Oil and Gas Conservation Commission (COGCC) noise regulation specifies maximum noise levels of 55 and 50 dBA for daytime and nighttime hours in residential/agricultural/rural areas, with allowing excursions of up to 10 dBA for up to 15 minutes in any hour between 7 a.m. and 7 p.m. (COGCC 2009).[11] These levels cannot be directly compared to the EPA guideline of 55 dBA L_{dn}. Where appropriate, the COGCC limits are used as another significance criterion. The use of the EPA guideline level and the COGCC levels in residential/agricultural/rural areas 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 COGCC 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.

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.

[11] In addition, Rio Blanco County has a regulation specifying a maximum of 65 dBA at the boundary.

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 (Hanson et al. 2006). Together these would produce a noise level of 91 dBA at a distance of 50 ft. 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. (Background levels are included in the calculation of L_{dn} but do not affect the noise levels much at the aforementioned distance.) The COGCC daytime maximum level of 55 dBA in residential/agricultural/rural areas would be exceeded up to about 1,200 ft from the construction site. 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.

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	67	59	51	40	32
Concrete mixer	85	67	59	51	40	32
Concrete pump	82	64	56	48	37	29
Crane, derrick	88	70	62	54	43	35
Crane, mobile	83	65	57	49	38	30
Front-end loader	85	67	59	51	40	32
Generator	81	63	55	47	36	28
Grader	85	67	59	51	40	32
Shovel	82	64	56	48	37	29
Truck	88	70	62	54	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: Hanson et al. (2006).

4.7.1.2 Vehicular Traffic

Heavy-duty trucks produce most of the noise associated with vehicular traffic during construction.[12] 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 and/or at high traffic levels, noise levels would exceed neither the EPA guideline level of 55 dBA L_{dn} nor the COGCC daytime maximum level of 55 dBA in residential/agricultural/rural areas. At night, the COGCC nighttime maximum level (50 dBA) might be exceeded by medium to high levels of truck traffic and up to 500 ft.

TABLE 4.7.1-2 Noise Levels at Various Distances from Heavy Truck Traffic[a]

Hourly Number of Trucks	Distances from a Road					
	50 ft	75 ft	100 ft	125 ft	250 ft	500 ft
	Noise Level $L_{eq(1\text{-}h)}$ (dBA)					
1	48	45	43	42	37	32
10	58	55	53	52	47	42
50	65	62	60	59	54	49
100	68	65	63	62	57	52
	Noise Level L_{dn} (dBA)[b]					
1	46	44	43	42	41	40
10	54	52	50	48	45	42
50	61	58	56	55	50	46
100	64	61	59	58	53	49

[a] Estimated assuming a 10-hour daytime shift and heavy trucks operating at 35 mph.

[b] Daytime and nighttime background noise levels of 40 and 30 dBA, respectively, are included.

Source: Menge et al. (1998).

[12] 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 6 to 500 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.

Noise levels from the OSEC RD&D operation might exceed the EPA guideline up to 1,500 ft from the crusher and conveyor operations if assuming 24 hour-per-day operation. Accordingly, there could be off-site noise issues related to a commercial-scale facility if sensitive receptors are located nearby. 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., 30,000 to 50,000 bbl/day) would be 450 to 2,500 times larger than that of the RD&D facility. Construction noise associated with the Chevron RD&D facility might exceed the COGCC daytime regulation of 55 dBA in residential/agricultural/rural areas out to about 1,500 ft and the EPA guideline of 55 dBA L_{dn} out to about 1,100 ft, assuming 10 working hours per day. 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 COGCC daytime regulation of 55 dBA in residential/agricultural/rural areas out to about 1,300 ft and the EPA guideline of 55 dBA L_{dn} out to about 950 ft, assuming 10 working hours per day. 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 500 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 600 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. Mechanical draft cooling towers may also be a continuous source of noise at power plants that employ them. 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 30 to 200 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

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).

noise impacts are projected, noise-reduction equipment may be required (Daniels et al. 1981; Teplitzky et al. 1981).

4.7.1.6 On-Site Upgrading Operations

Noise levels from on-site upgrading operations 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 500 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. This occurs 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 (Lee et al. 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 30,000 to 50,000 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 240 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 based on analysis prepared prior to leasing and/or development, 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 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 the 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) construction associated sedimentation in nearby aquatic habitats as a consequence of settled dust and soil erosion from operational areas; and/or (3) changes in water quantity or water quality as a result of construction (e.g., grading that affects surface water runoff, water levels, or hydrologic connectivity), operations (e.g., surface or groundwater withdrawals or discharges of water into nearby aquatic habitats), or releases of chemical contaminants into nearby aquatic systems (e.g., accidental spills, controlled discharges, and contaminated groundwater discharge into surface water). 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 and settled dust 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,

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, discharge, and recharge	Moderate	Moderate
Temperature increases in water bodies	Moderate	Moderate
Increases in salinity	Small	Small
Introduction of nutrients, inorganic and organic contaminants	Small	Small
Oil and contaminant spills	Moderate	Large
Movement/dispersal blockage	Small	Small
Increased human access	Small	Small

[a] Potential impact magnitude (without mitigation) that might be expected from individual development projects 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.

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.

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 that can serve as temporary refuge. 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 stress existing biota or alter 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 4.12, 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 recharge of contaminated ground water; leachate runoff from exposed oil shale; controlled point source discharges; the accidental release of fuels, lubricants, or pesticides; or spills from pipelines. Contamination of surface water by groundwater recharge could occur if contaminants were to leach into the groundwater as groundwater levels increased after in situ operations ceased. Potential contaminants include residual hydrocarbons and inorganics as well as chemicals used in the subsurface to enhance shale oil recovery.

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.

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 restoration 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

TABLE 4.8.1-2 Potential Impacts on Plant Communities Resulting from Commercial Oil Shale Development

Impact Category	Potential Magnitude of Impacts According to Habitat Type[a]	
	Upland Plants	Wetland and Riparian Plants
Vegetation clearing	Large	Large
Habitat fragmentation	Large	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) that might be expected from individual development projects 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.

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, which 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 (see Table 4.8.1-3, footnote a, for the definition of small, moderate, and large impacts).

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 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 who 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 2010). 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. Common ravens and raptors are more common along transmission lines because of the presence of perch and nest sites (Knight and Kawashima 1993).

1 **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	Moderate	Large	Large	Large
Habitat fragmentation	Large	Small	Moderate	Moderate	Large	Large	Large
Movement/dispersal blockage	Large	Small	Small	Small	Moderate	Moderate	Moderate
Alteration of topography	Small	Small	Small	Small	Small	Small	Small
Water depletions	Moderate	Moderate	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	Moderate	Moderate	Moderate	Moderate	Small
Collection	Small	Small	Small	Small	Small	Small	Small
Human disturbance/harassment	Small	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Increases in predation rates	Small	Small	Small	Small	Small	Small	Small
Noise	Small	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
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	Small	Small	Small

[a] Potential impact magnitude is presented as small, moderate, or large. A small impact is one for which most impacts on the affected resource could be avoided with proper mitigation; and, if impacts occur, the affected resource will recover completely without mitigation once the impacting stressor is eliminated. A moderate impact is one for which impacts on the affected resource are unavoidable. The viability of the affected resource is not threatened, although some impacts may be irreversible; or the affected resource would not recover completely if proper mitigation is applied during the life of the project or proper remedial action is taken once the impacting stressor is eliminated. A large impact is one for which impacts on the affected resource are unavoidable. The viability of the affected resource may be threatened; and the affected resource would not fully recover even if proper mitigation is applied during the life of the project or remedial action is implemented once the impacting stressor is eliminated. No population-level effects are expected from small and moderate impacts, while population-level impacts are expected from major impacts.

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 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 Section 4.8.1.4.

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; UDNR 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 2010). Barriers to movement that prevent snakes from accessing wintering 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). ROW corridors, especially those with access roads, can promote vehicle access to previously undisturbed areas. This can potentially disturb wildlife. 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, American 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 they 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 collisions 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. In Wyoming, there have been several vehicular incidents where 7 to 21 pronghorn have been killed or injured per incident, and 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 study area (i.e., bald and golden eagles [*Haliaeetus leucocephalus* and *Aquila chrysaetos*]). However, although a rare event, flocks of small birds can be electrocuted when they 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 2002) 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 (BLM 2007b). 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 2007b).

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 2007b). 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 2007b).

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. The 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–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 oil shale development impacts on federally and state-listed threatened and endangered species, BLM-designated sensitive species, and species that are proposed or candidates for listing. 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. 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 expected to be proportional to the amount of land disturbance.

Impacts on threatened, endangered, and sensitive species are 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, but the potential consequence of the impacts may be greater. Because of small population sizes, threatened, endangered, and sensitive species are far more vulnerable to impacts than more common and widespread species. Small population size makes these species more vulnerable than common species 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 specific characteristics 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. Land reclamation activities that would occur after extraction activities are complete would serve to reduce or eliminate ongoing impacts by restoring 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 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.

TABLE 4.8.1-4 Potential Impacts of Commercial Oil Shale Development on Threatened, Endangered, and Sensitive Species

	Potential Magnitude of Impacts According to Species Type[a]					
Impact Category	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) that might be expected from individual development projects 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.

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). In both tables, a determination is made regarding the “potential for negative impact.” Potential for impact or effect was determined on the basis of conservative estimates of species distributions. It is possible that impacts on some species would not occur because suitable habitat may not be present in individual project areas or impacts on those habitats could be avoided.

See Appendix E for the distribution and habitats of endangered, threatened, and sensitive species that may occur in the oil shale basins. Impacts of commercial oil shale development on these species under each of the alternatives analyzed in this PEIS are presented in Sections 6.1.1.7.4, 6.1.2.7.4, 6.1.3.7.4, and 6.1.4.7.4.

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

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants				
Abies concolor	White fir	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Achnatherum swallenii	Swallen mountain-ricegrass	WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Amsonia jonesii	Jones blue star	BLM-S	UT-Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Androstephium breviflorum	Purple funnel-lily	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Antennaria arcuata	Meadow pussytoes	BLM-S; WY-SC	WY-Sublette	**No impact.** Suitable habitat does not exist in the study area.
Aquilegia scopulorum var. *goodrichii*	Utah columbine	BLM-S	UT-Carbon, Duchesne, Emery, Grand, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Arabis vivariensis	Park rockcress	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Artemisia biennis var. *diffusa*	Mystery wormwood	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus bisulcatus var. *haydenianus*	Hayden's milkvetch	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus calycosus var. *calycosus*	King's milkvetch	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus coltonii var. *moabensis*	Moab milkvetch	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Astragalus debequaeus	Debeque milkvetch	BLM-S	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus detritalis	Debris milkvetch	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus duchesnensis	Duchesne milkvetch	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus equisolensis	Horseshoe milkvetch	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus hamiltonii	Hamilton's milkvetch	BLM-S	UT-Uintah	**Potential for negative impact.** Possible occurrence in upland habitats of Utah study areas.
Astragalus lentiginosus var. *salinus*	Sodaville milkvetch	WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus musiniensis	Ferron milkvetch	BLM-S	CO-Garfield; UT-Emery, Garfield, Grand, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus naturitensis	Naturita milkvetch	BLM-S	CO-Garfield; UT-San Juan	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus paysonii	Payson’s milkvetch	WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus proimanthus	Precocious milkvetch	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Astragalus racemosus var. *treleasei*	Trelease’s racemose milkvetch	BLM-S; WY-SC	WY-Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Atriplex falcata	Sickle saltbush	WY-SC	WY-Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Atriplex wolfii	Wolf's orache	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Boechera crandallii	Crandall's rockcress	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Boechera selbyi	Selby's rockcress	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Bolophyta ligulata	Ligulate feverfew	BLM-S	CO-Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Brickellia microphylla var. *scabra*	Little-leaved brickell-bush	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Ceanothus martinii	Utah mountain lilac	WY-SC	WY-Lincoln, Sweetwater	**No impact.** Suitable habitat does not occur in the study area.
Cercocarpus ledifolius var. *intricatus*	Dwarf mountain mahogany	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Chamaechaen-actis scaposa	Fullstem	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Chrysothamnus greenei	Greene rabbitbrush	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cirsium aridum	Cedar Rim thistle	BLM-S; WY-SC	WY-Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Cirsium ownbeyi	Ownbey's thistle	BLM-S; WY-SC	UT-Uintah; WY Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cirsium perplexans	Adobe thistle	BLM-S	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cleomella palmeriana var. *goodrichii*	Goodrich cleomella	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Collomia grandiflora	Large-flower collomia	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cryptantha barnebyi	Barneby's cat's-eye	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cryptantha caespitosa	Caespitose cat's-eye	BLM-S	CO-Rio Blanco; UT-Carbon, Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cryptantha gracilis	Slender cryptantha	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cryptantha grahamii	Graham's cat's-eye	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cryptantha rollinsii	Rollins' cat's eye	BLM-S; WY-SC	CO-Rio Blanco; UT-Duchesne, San Raphael, Uintah, Wayne; WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cymopterus duchesnensis	Uinta Basin spring-parsley	BLM-S	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Descurainia pinnata var. *paysonii*	Payson's tansy mustard	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Descurainia torulosa	Wyoming tansymustard	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Downingia laeta	Great Basin downingia	WY-SC	WY-Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Draba juniperina	Uinta draba	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Elymus simplex var. *luxurians*	Long-awned alkali wild-rye	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Ephedra viridis var. *viridis*	Green Mormon tea	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Eriastrum wilcoxii	Wilcox eriastrum	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Erigeron compactus var. *consimilis*	San Rafael daisy	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Eriogonum contortum	Grand buckwheat	BLM-S	CO-Garfield; UT-Grand	**Potential for negative impact.** Suitable habitat may occur in the study area.
Eriogonum corymbosum var. *corymbosum*	Crisp-leaf wild buckwheat	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Eriogonum divaricatum	Divergent wild buckwheat	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Eriogonum ephedroides	Ephedra buckwheat	BLM-S	CO-Rio Blanco; UT Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Eriogonum hookeri	Hooker wild buckwheat	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Frasera ackermanae	Ackerman frasera	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Galium coloradoense	Colorado bedstraw	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gentianella tortuosa	Utah gentian	BLM-S	CO-Rio Blanco; UT-Duchesne, Emery, Garfield, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gilia stenothyrsa	Narrow-stem gilia	BLM-S	CO-Rio Blanco; UT Carbon, Duchesne, Emery, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Glossopetalon spinescens var. *meionandrum*	Utah greasebush	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Hymenoxys lapidicola	Rock hymenoxyz	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lathyrus lanszwertii var. *lanszwertii*	Nevada sweetpea	WY-SC	WY-Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lepidium huberi	Huber's pepperplant	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lepidium integrifolium var. *integrifolium*	Entire-leaved peppergrass	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lesquerella macrocarpa	Large-fruited bladderpod	BLM-S; WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Lesquerella multiceps	Western bladderpod	BLM-S; WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lesquerella parviflora	Piceance bladderpod	BLM-S	CO-Garfield, Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lesquerella parvula	Narrow-leaved bladderpod	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lesquerella prostrata	Prostrate bladderpod	WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Listera borealis	Northern twayblade	BLM-S	CO-Garfield; UT- Duchesne, San Juan; WY Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lomatium triternatum var. *anomalum*	Ternate desert-parsley	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Mentzelia goodrichii	Goodrich's blazingstar	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Mentzelia rhizomata	Roan Cliffs blazingstar	BLM-S	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Minuartia nuttallii	Nuttall sandwort	BLM-S	UT Duchesne; WY Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Monolepis pusilla	Red poverty-weed	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Opuntia polyacantha var. *juniperina*	Juniper prickly-pear	WY-SC	WY-Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Opuntia polyacantha var. *rufispina*	Rufous-spine prickly-pear	WY-SC	WY-Lincoln, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Oxytheca dendroidea	Tree-like oxytheca	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Oxytropis besseyi var. *obnapiformis*	Maybell locoweed	WY-SC	WY-Sweetwater, Uinta	**No impact.** Suitable habitat does not occur in the study area.
Packera crocata	Saffron groundsel	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Parthenium ligulatum	Ligulate feverfew	BLM-S	CO-Rio Blanco; UT-Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon acaulis var. *acaulis*	Stemless beardtongue	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon gibbensii	Gibbens' beardtongue	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon harringtonii	Harrington beardtongue	BLM-S	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon laricifolius ssp. *exilifolius*	White beardtongue	WY-SC	WY-Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon scariosus var. *albifluvis*	White River beardtongue	ESA-C;	CO-Rio Blanco; UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon scariosus var. *garrettii*	Garrett's beardtongue	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Phacelia argylensis	Argyle Canyon phacelia	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia demissa	Intermountain phacelia	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia glandulosa var. *deserta*	Desert glandular phacelia	WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia incana	Western phacelia	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia salina	Nelson phacelia	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia tetramera	Tiny phacelia	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Philadelphus microphyllus var. *occidentalis*	Little-leaf mock-orange	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phlox albomarginata	White-margined phlox	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phlox pungens	Beaver Rim phlox	BLM-S; WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Physaria condensata	Tufted twinpod	BLM-S; WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Physaria dornii	Dorn's twinpod	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Physocarpus alternans	Dwarf ninebark	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Populus deltoides var. *wislizeni*	Fremont cottonwood	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Potentilla multisecta	Deep Creek cinquefoil	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Psilocarphus brevissimus	Dwarf woolly-heads	WY-SC	WY-Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Ranunculus flabellaris	Yellow water-crowfoot	WY-SC	WY-Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Rorippa calycina	Persistent sepal yellowcress	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sambucus cerulea	Blue elderberry	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Senecio spartioides var. *multicapitatus*	Many-headed broom groundsel	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Silene douglasii	Douglas' campion	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Thelesperma caespitosum	Green River greenthread	BLM-S; WY-SC	WY-Sweetwater; UT-Duchesne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Thelesperma pubescens	Uinta greenthread	BLM-S; WY-SC	WY-Sweetwater, Uinta; UT-Duchesne	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Townsendia microcephala	Cedar Mountain Easter-daisy	BLM-S; WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Townsendia strigosa	Strigose Easter-daisy	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Yucca sterilis	Spanish bayonet	BLM-S	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Invertebrates				
Speyeria nokomis nokomis	Great Basin silverspot butterfly	BLM-S	UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Fish				
Catostomus discobolus	Bluehead sucker	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.** Suitable habitat may occur in the study area.
Catostomus latipinnis	Flannelmouth sucker	BLM-S; 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.** Suitable habitat may occur in the study area.
Castostomus platyrhynchus	Mountain sucker	BLM-S; CO-SC	CO-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Grand, Uintah; WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gila copei	Leatherside chub	BLM-S; UT-SC; WY-SC	UT-Duchesne, Emery, Garfield, Wayne; WY Lincoln, Uinta	**No impact.** Suitable habitat does not occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Fish (Cont.)				
Gila robusta	Roundtail chub	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.** Suitable habitat may occur in the study area.
Oncorhynchus clarkii pleuriticus	Colorado River cutthroat trout	BLM-S; CO-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Garfield, Uintah, Wayne; WY Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Oncorhynchus clarkii utah	Bonneville cutthroat trout	BLM-S; WY-SC	WY-Lincoln, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Amphibians				
Bufo boreas	Boreal toad	BLM-S; CO-E; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT - Carbon, Duchesne, Emery, Garfield, Uintah, Wayne; WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Rana luteiventris	Columbia spotted frog	BLM-S; WY-SC	UT-Utah, Wasatch; WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Rana pipiens	Northern leopard frog	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.** Suitable habitat may occur in the study area.
Spea intermontana	Great basin spadefoot	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.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Reptiles				
Crotalus oreganus concolor	Midget faded rattlesnake	BLM-S; CO-SC	CO-Garfield, Rio Blanco; WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gambelia wislizenii	Longnose leopard lizard	BLM-S; CO-SC	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Liochlorophis vernalis	Smooth greensnake	BLM-S; UT-SC	UT-Carbon, Duchesne, Grand, San Juan, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Birds				
Accipiter gentilis	Northern goshawk	BLM-S; 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.** Suitable habitat may occur in the study area.
Aechmophorus clarkii	Clark's grebe	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Aegolius funereus	Boreal owl	WY-SC	WY Lincoln, Uinta	**No impact.** Suitable habitat for the species does not occur in the study area.
Ammodramus bairdii	Baird's sparrow	BLM-S; WY-SC	WY-Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Ammodramus savannarum	Grasshopper sparrow	UT-SC	UT-Duchesne, Uintah, Utah, Wasatch	**Potential for negative impact.** Suitable habitat may occur in the study area.
Amphispiza belli	Sage sparrow	BLM-S	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Aphelocoma californica	Western scrub-jay	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Birds (Cont.)				
Asio flammeus	Short-eared owl	BLM-S; UT-SC	UT-Carbon, Duchesne, Emery, Grand, Garfield, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Athene cunicularia	Burrowing owl	BLM-S; CO-T; UT-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.** Suitable habitat may occur in the study area.
Baeolophus ridgwayi	Juniper titmouse	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Botaurus lentiginosus	American bittern	WY-SC	WY-Lincoln, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Bucephala islandica	Barrow's goldeneye	BLM-S	CO-Garfield, Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Buteo regalis	Ferruginous hawk	BLM-S; CO-SC; UT-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.** Suitable habitat may occur in the study area.
Calcarius mccownii	McCown's longspur	WY-SC	WY-Sweetwater	**No impact.** Suitable habitat for the species does not occur in the study area.
Centrocercus urophasianus	Greater sage-grouse	ESA-C; BLM-S; CO-SC; UT-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.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Birds (Cont.)				
Charadrius montanus	Mountain plover	BLM-S; CO-SC; UT-SC; WY-SC	CO-Rio Blanco; WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	ESA-C; BLM-S; WY-SC	UT-Duchesne, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cygnus buccinator	Trumpeter swan	WY-SC	WY-Lincoln, Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cypseloides niger	Black swift	BLM-S; CO-SC; UT-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Dolichonyx oryzivorus	Bobolink	BLM-S; UT-SC	UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Falco peregrinus anatum	American peregrine falcon	BLM-S; CO-SC	CO-Garfield, Rio Blanco; WY-Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gavia immer	Common loon	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Grus canadensis tabida	Greater sandhill crane	CO-SC	CO-Garfield, Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Haliaeetus leucocephalus	Bald eagle	BLM-S; CO-T; 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.** Suitable habitat may occur in the study area.
Icterus parisorum	Scott's oriole	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Birds (Cont.)				
Lanius ludovicianus	Loggerhead shrike	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Melanerpes lewis	Lewis's woodpecker	BLM-S; UT-SC; WY-SC	UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne; WY-Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Numenius americanus	Long-billed curlew	BLM-S; CO-SC; UT-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.** Suitable habitat may occur in the study area.
Oreoscoptes montanus	Sage thrasher	BLM-S; WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Pelecanus erythrorhynchos	American white pelican	BLM-S; UT-SC	CO-Garfield, UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Picoides arcticus	Black-backed woodpecker	WY-SC	WY-Lincoln	**No impact.** Suitable habitat for the species does not occur in the study area.
Picoides tridactylus	Three-toed woodpecker	BLM-S; UT-SC	UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**No impact.** Suitable habitat for the species does not occur in the study area.
Plegadis chihi	White-faced ibis	BLM-S; WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Psaltriparus minimus	Bushtit	WY-SC	WY-Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Birds (Cont.)				
Sitta pygmaea	Pygmy nuthatch	WY-SC	WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sphyrapicus thyroideus	Williamson's sapsucker	WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Spizella breweri	Brewer's sparrow	BLM-S; WY-SC	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sterna caspia	Caspian tern	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sterna forsteri	Forster's tern	WY-SC	WY-Lincoln	**Potential for negative impact.** Suitable habitat may occur in the study area.
Tympanuchus phasianellus columbianus	Columbian sharp-tailed grouse	BLM-S; CO-SC	CO-Garfield, Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Mammals				
Antrozous pallidus	Pallid bat	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Brachylagus idahoensis	Pygmy rabbit	BLM-S; UT-SC; WY-SC	UT-Garfield, Wayne; WY Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Corynorhinus townsendii pallescens	Townsend's big-eared bat	BLM-S; CO-SC; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne; WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Cynomys leucurus	White-tailed prairie dog	BLM-S; UT-SC; WY-SC	UT-Carbon, Duchesne, Emery, Grand, Uintah; WY Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Mammals (Cont.)				
Euderma maculatum	Spotted bat	BLM-S; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Garfield, Grand, San Juan, Uintah, Wayne; WY Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Gulo gulo	Wolverine	CO-E; WY-SC	CO-Garfield, Rio Blanco; WY-Lincoln, Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Lasiurus blossevillii	Western red bat	BLM-S; UT-SC	UT-Carbon, Emery, Grand, Garfield, San Juan, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Microtus richardsoni	Water vole	WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Myotis evotis	Long-eared myotis	BLM-S	WY-Lincoln, Sublette, Sweetwater, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Myotis thysanodes	Fringed myotis	BLM-S; UT-SC; WY-SC	CO-Garfield, Rio Blanco; UT-Duchesne, Garfield, Grand, San Juan, Uintah, Wayne; WY Sublette	**Potential for negative impact.** Suitable habitat may occur in the study area.
Nyctinomops macrotis	Big free-tailed bat	BLM-S; UT-SC	CO-Garfield; UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Peromyscus crinitus	Canyon mouse	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Peromyscus truei	Pinon mouse	WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sorex preblei	Preble's shrew	WY-SC	WY-Lincoln, Uinta	**No impact.** Suitable habitat for the species does not occur in the study area.

TABLE 4.8.1-5 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
***Mammals* (*Cont.*)**				
Tamias dorsalis utahensis	Cliff chipmunk	WY-SC	WY-Sweetwater	**No impact.** Suitable habitat for the species does not occur in the study area.
Thomomys clusius	Wyoming pocket gopher	BLM-S	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.
Thomomys idahoensis	Idaho pocket gopher	BLM-S; WY-SC	WY-Lincoln, Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Vulpes macrotis	Kit fox	BLM-S; CO-E; UT-SC	CO-Garfield, Rio Blanco; UT Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Vulpes velox	Swift fox	BLM-S; WY-SC	WY-Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

[a] Status categories: BLM-S = listed by the BLM as sensitive; CO-E = listed as endangered by the state of Colorado; CO-SC = species of special concern in the state of Colorado; CO-T = listed as threatened by the state of Colorado; ESA-C = candidate for listing under the ESA; UT-SC = species of special concern in the state of Utah; WY-SC = species of special concern in the state of Wyoming.

[b] Potential impacts based on general habitat preference and presence of habitat in the study area. Specific habitat preferences are presented in Appendix E

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TABLE 4.8.1-6 Potential Effects of Commercial Tar Sands Development on Federally Listed Threatened, Endangered, and Proposed Species

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants				
Carex specuicola	Navajo sedge	ESA-T	UT-San Juan	**No impact.** Suitable habitat does not occur in the study area. Known distribution is outside of the potential lease areas.
Lepidium barnebyanum	Barneby ridge-cress	ESA-E	UT-Duchesne	**No impact.** Suitable habitat does not occur in the study area. Known distribution is outside of the potential lease areas.
Lesquerella congesta	Dudley Bluffs bladderpod	ESA-T	CO-Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon debilis	Parachute beardtongue	ESA-T	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Penstemon grahamii	Graham's beardtongue	ESA-PT; BLM	CO-Rio Blanco; UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia argillacea	Clay phacelia	ESA-E	UT-Utah, Wasatch	**Potential for negative impact.** Suitable habitat may occur in the study area.
Phacelia scopulina var. *submutica*	Debeque phacelia	ESA-T	CO-Garfield	**Potential for negative impact.** Suitable habitat may occur in the study area.
Physaria obcordata	Dudley Bluffs twinpod	ESA-T	CO-Rio Blanco	**Potential for negative impact.** Suitable habitat may occur in the study area.
Schoenocrambe argillacea	Clay reed-mustard	ESA-T	UT-Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Schoenocrambe suffrutescens	Shrubby reed-mustard	ESA-E	UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.

TABLE 4.8.1-6 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Plants (Cont.)				
Sclerocactus brevispinus	Pariette cactus	ESA-T	UT-Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sclerocactus glaucus	Colorado hookless cactus	ESA-T	CO-Garfield; UT-Carbon, Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Sclerocactus wetlandicus	Uinta Basin hookless cactus	ESA-T	UT-Carbon, Duchesne, Uintah	**Potential for negative impact.** Suitable habitat may occur in the study area.
Spiranthes diluvialis	Ute ladies'-tresses	ESA-T	UT-Duchesne, Garfield, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Fish				
Gila cypha	Humpback chub	ESA-E; CO-T	UT-Carbon, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area. Designated critical habitat may occur within 5 mi (8 km) downstream from study areas.
Gila elegans	Bonytail	ESA-E	UT-Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area. Designated critical habitat may occur within 5 mi (8 km) downstream from study areas.
Ptychocheilus lucius	Colorado pikeminnow	ESA-E; CO-T	CO-Rio Blanco; UT Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area. Designated critical habitat may occur within 5 mi (8 km) downstream from study areas.
Xyrauchen texanus	Razorback sucker	ESA-E; CO-E	CO-Garfield, Rio Blanco; UT-Carbon, Emery Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area. Designated critical habitat may occur within 5 mi (8 km) downstream from study areas.

TABLE 4.8.1-6 (Cont.)

Scientific Name	Common Name	Status[a]	States and Counties in Which Species May Occur	Potential for Effect[b]
Birds				
Empidonax traillii extimus	Southwestern willow flycatcher	ESA-E	UT Carbon, Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Grus americana	Whooping crane	ESA-XN; CO-E	CO-Garfield, Rio Blanco	**No impact.** Suitable habitat for the species does not occur in the study area. This species may occur only as a rare migrant in the study area.
Strix occidentalis lucida	Mexican spotted owl	ESA-T	UT-Emery, Garfield, Grand, San Juan, Uintah, Wayne	**Potential for negative impact.** Suitable habitat may occur in the study area.
Mammals				
Lynx canadensis	Canada lynx	ESA-T; CO-E; WY-SC	CO-Garfield, Rio Blanco; UT-Emery, Uintah; WY Lincoln, Sublette, Uinta	**Potential for negative impact.** Suitable habitat may occur in the study area.
Mustela nigripes	Black-footed ferret	ESA-XN; CO-E	CO-Rio Blanco; UT Carbon, Duchesne, Emery, Grand, San Juan, Uintah; WY-Sublette, Sweetwater	**Potential for negative impact.** Suitable habitat may occur in the study area.

[a] Status categories: BLM-S = listed by the BLM as sensitive; CO-E = listed as endangered by the state of Colorado; CO-T = listed as threatened by the state of Colorado; ESA-E = listed as endangered under the ESA; ESA-PT = proposed for listing as a threatened species under the ESA; ESA-T = listed as threatened under the ESA; ESA-XN = experimental, nonessential population; WY-SC = species of special concern in the state of Wyoming.

[b] Potential impacts based on general habitat preference and presence of habitat in the study area. Specific habitat preferences are presented in Appendix E.

Federally listed plant plants may be affected by a variety of factors related to oil shale development, including vegetation clearing, habitat fragmentation, dispersal 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. In addition to these listed plant species, the Graham's beardtongue—a species proposed for listing under the ESA—could occur in shale environments and may be affected by oil shale and tar sands activities.

The Ute ladies'-tresses could occur in Utah study 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 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.

In addition to listed bird species mentioned above, the federal candidate greater sage-grouse is a bird species that has the potential to be affected by commercial oil shale development. With the loss of sagebrush and grassland habitats resulting from project developments, greater sage-grouse 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.

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 the Utah study area. The Canada lynx occurs in coniferous forests and potentially occurs in the study area 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

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 2007), 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 (Fogg and Hadley 2007). BLM Manual 6840—*Special Status Species*

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 2011). 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). The BLM is in the process of updating its guidance regarding protection of sage-grouse habitat. It is anticipated that protection measures will be essentially as described above; however, there may be specific differences. The BLM is working with the Utah DWR to refine the delineation of preliminary priority sage-grouse habitats and is in the process of updating its guidance regarding the protection of these habitats. These maps and any updated information will be provided in the Final PEIS.

Management describes BLM policy to protect species identified by the BLM as sensitive (BLM 2008).

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.

- Decontaminate all equipment before arrival at the project site and before leaving the project site, for work occurring near water, to reduce the potential for the transport of aquatic invasive species. Decontamination may consist of draining all water from equipment and compartments, cleaning equipment of all mud, plants, debris, or animals, and then drying the equipment. Another potential decontamination method could be a high-pressure, hot water wash of all equipment and all compartments that may hold water.

- Maintain historic flow regimes in these systems, or in systems that contribute to the support of native fisheries.

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.

- Avoid areas of high habitat value such as the “priority (crucial habitat) areas” and “enhancement areas” identified in the Wyoming Game and Fish Department Strategic Habitat Plan (WGFD 2009), as well as Wyoming pinyon-juniper woodlands, sagebrush steppe, Gardner’s saltbush and barren areas.

- 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 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 2010).

- 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, Endangered, and Sensitive Species

The BLM has determined that the proposed action (amendment of land use plans setting out allocation of areas that will be available for application for leases) would result in no effect on listed species. As a result, the BLM anticipates making a “no effect” determination for listed species in this PEIS. However, the BLM is in the process of reviewing its approach to compliance with Section 7 of the ESA; the results of that review and discussion of the BLM’s approach to ESA Section 7 compliance will be presented in the Final PEIS. Section 6.3 of this PEIS further discusses compliance with the ESA. The conservation measures developed in initial consultation with the 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 conservation 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 developments.

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 2008).

- 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 individual 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.

- Avoid leasing and/or development in sage-grouse habitats.

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 is responsible for ensuring that the scenic values of BLM-administered public lands are considered before allowing uses that may have negative visual impacts. The BLM accomplishes this through its VRM system. The VRM system includes systematic processes for inventorying scenic values on BLM-administered lands, establishing visual resource management objectives for those values through the RMP process, and evaluating proposed activities to determine whether they conform with the management objectives. The primary components of BLM's VRM system include VRI, VRM class designation, and visual contrast rating.

- *VRI.* BLM's VRI process provides BLM managers with a means for determining visual values for a tract of land. The inventory includes the following three components: scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. These inventory components provide systematic processes for rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points. On the basis of the results, BLM-administered lands are placed into one of four VRI classes. These inventory classes represent the relative value of the visual resources. Class I and II are the most valued; Class III represents a moderate value; and Class IV represents the least relative value. Class I is reserved for specially designated areas, such as national wildernesses and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Class II is the highest rating for lands without special designation. The VRI class values may be affected by visual impacts associated with land management activities, such as utility-scale solar energy development. More information about VRI methodology is available in Section 5.7 and in *Visual Resource Inventory*, BLM Manual Handbook 8410-1 (BLM 1986a).

- *VRM class designation.* The results of the VRI become an important component of BLM's RMP for the area. The RMP establishes how the public lands will be used and allocated for different purposes, and the VRI classes provide the basis for considering visual values in the RMP land use allocation process. When a land use allocation is made, the area's visual resources are then assigned to VRM classes with established management objectives, including the degree of contrast resulting from a project or management activity permissible for that VRM classification. BLM activities must conform to the VRM objectives that apply to the individual project area as established in the RMP process. The management objectives for the VRM classes are as follows:

  – Class I objective is 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 is 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 is 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 is 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.

  More information about the BLM VRM program is available in Section 5.7 and in *Visual Resource Management*, BLM Manual Handbook 8400 (BLM 1984b).

- *Visual contrast rating.* The BLM's VRM system defines visual impact as the contrast observers perceive between existing landscapes and proposed projects and activities. (See text box for factors that influence an individual's perception of visual impacts and that are considered within the BLM's VRM system.) The BLM's contrast rating system (BLM 1986b) specifies a systematic process for determining the nature and extent of visual contrasts that may result from a proposed land use activity and for determining whether those levels of contrast are consistent with the VRM class destination for the area. Contrasts between an existing landscape and a proposed project or

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.

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.

Continued on next page.

Factors That Influence an Individual's Perception of Visual Impacts (Cont.)

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 (e.g., 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).

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.

Visual impacts can be either positive or negative, depending on the type and degree of visual contrasts introduced into 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 may be 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 expected to 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.

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. Large visual impacts would be expected at night because of facility, vehicular, and activity lighting. 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, as determined by visual contrast rating from nearby observation points with unobstructed views of the facility. VRM Class II or Class III areas in proximity to the major facilities where open lines of sight existed between the Class II or Class III lands and the major facilities could in some cases also be subjected to strong visual contrasts, particularly if the distance was within the foreground-middleground range, but possibly farther in some cases.

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 into 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 struc*tures would be constructed, such as administration buildings, work trailers, guardhouses, storage structures,* and fences. 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

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.)

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, 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.

  Oil shale facilities would include exterior lighting around buildings, parking areas, and other work areas. Security and other lighting around and on support structures (e.g., the control building) could contribute to light pollution. Operations and maintenance activities conducted at night might require vehicle-mounted lights and other activity lighting, which could also contribute to light pollution. Light pollution impacts associated with utility-scale solar facilities include skyglow, light trespass, and glare.

Skyglow is a brightening of the night sky caused by both natural and man-made factors. Skyglow decreases a person's ability to see dark night skies and stars, which is an important recreational activity in many parts of the western United States, including BLM- and non-BLM lands within or near the study area. Skyglow effects can be visible for long distances. Outdoor artificial lighting can contribute to skyglow by directing light directly upwards into the night sky and also through the reflection of light from the ground and other illuminated surfaces.

Light trespass is the casting of light into areas where it is unneeded or unwanted, such as when light designed to illuminate an industrial facility falls into nearby residential areas. Poorly placed and aimed lighting can result in spill light that falls outside the area needing illumination.

Glare is the visual sensation caused by excessive and uncontrolled brightness and, in the context of outdoor lighting, is generally associated with direct views of a strong light source. Poorly placed and aimed lighting can cause glare, as can the use of excessively bright lighting.

These light pollution impacts from oil shale facilities could be reduced somewhat by shielding and/or other mitigation measures; however, any degree of lighting would produce some off-site light pollution, which might be particularly noticeable in dark nighttime sky conditions typical of the rural/natural settings within the study area.

For facilities with tall structures (including electric transmission towers associated with oil shale facilities), Federal Aviation Administration (FAA) guidelines for marking and lighting facilities could require aircraft warning lights that flash white during the day and at twilight and red at night (FAA 2007), or alternatively, red or white strobe lights flashing during the day and/or at night. Daylight lighting might be avoided in some cases by painting the tower orange and white according to FAA guidelines, but this practice could result in large increases in visual contrast for the tower during the day. Terrain, weather, and other location factors allow for adjustments to the manner in which FAA requirements are applied. FAA-compliant aircraft warning lights would be required for power tower receivers (or other structures) 200 ft (61 m) tall or higher and might be required in some circumstances for lower height structures.

The presence of aircraft warning lights could greatly increase visibility of the facilities and associated transmission lines at night in some locations, because the flashing red warning lights or strobes could be visible for long distances. In the dark nighttime sky conditions typical of the predominantly rural/natural settings within the three-state study area, the warning lights could potentially cause large visual impacts, especially if few similar light sources were present in the area. Because of intermittent operation, however, marker beacons would not likely contribute significantly to skyglow. White lights in daylight conditions would likely be less obtrusive.

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 and telephone lines; 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.

- Preparing a lighting plan that documents how lighting will be designed and installed to minimize night-sky impacts during facility construction and operations phases. Lighting for facilities should not exceed the minimum number of lights and brightness required for safety and security and should not cause excessive reflected glare. Low-pressure sodium light sources should be utilized where feasible to reduce light pollution. Full cut-off luminaires should be utilized to minimize uplighting. Lights should be directed downward or toward the area to be illuminated. Light fixtures should not spill light beyond the project boundary. Lights in high-illumination areas not occupied on a continuous basis should have switches, timer switches, or motion detectors so that the lights operate only when the area is occupied. Where feasible, vehicle-mounted lights should be used for night maintenance activities. Wherever feasible, consistent with safety and security, lighting should be kept off when not in use.

- 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.

- No wind rows or large piles should be created. There should be only a 20% ground cover from slash and the minimum amount needed for reclamation should be staged; all other should be removed or spread to 20% ground cover. Staging should be done 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

Cultural resources, listed or eligible for listing on the NRHP, could be affected by future 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, compliance with Section 106 of the NHPA, as well as all other pertinent laws, regulations, and policies will likely result in the addition of stipulations to leases to avoid, minimize, or mitigate adverse impacts on for historic properties present within a lease area or, when warranted, denial of the lease.

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, 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 during the leasing and project-development stages in consultations between the applicant, the BLM, 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 a cultural resources overview were completed for the study area (Bengston 2007 and O'Rourke et al. 2011, 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 analysis did not identify geographical areas that will preclude moving areas forward for leasing. Prior to any lease issuance, or development project approval, the overviews and ongoing tribal consultation will be reviewed for any pertinent information to determine areas of sensitivity and appropriate survey and mitigation needs.

The BLM has initiated the Section 106 process pursuant to Subpart B of the Advisory Council on Historic Preservation (ACHP) regulations at 36 CFR Part 800, and is reviewing existing information regarding historic properties in the area of potential effects for this proposed amendment of land use plans. The BLM is engaging in consultation with the SHPOs, tribes, and other consulting parties. As appropriate to the level of analysis necessary for this PEIS, the BLM identified historic properties and evaluate potential impacts under Section 106 of the NHPA for this proposed undertaking, in part through consultation with the consulting parties. Based on this information, the BLM will make a determination about potential effects on historic properties at the programmatic level.

As discussed in Section 1.1.1, potential oil shale development would require a three-stage decision-making process including this proposed amendment of land use plans. Oil shale leasing may require additional consultation and information gathering (e.g., cultural resource inventories) prior to the lease sale. In addition, the lessee must submit a plan of development for any site-specific project that would require BLM approval. 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 pertinent laws, regulations, and policies. In addition, 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 based on the Section106 and other related reviews and consultations conducted during the leasing phase, in order to avoid, minimize, or mitigate adverse impacts on such resources.

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 INDIAN TRIBAL CONCERNS

Resources important to Native Americans could be affected by commercial oil shale leasing and development in and around the areas where development takes place.

4.11.1 Common Impacts

Native American concerns include traditional cultural properties, burial remains, sacred sites or landscapes, culturally important wild plants and animals, ecological balance and environmental protection, water quality and use, human health and safety, economic development and employment, and access to energy resources. Other Native American concerns could include the potential effects on Indian trust assets, to the extent such assets are present. Native Americans may view these resources as interconnected, such that effects on one resource affect all. The potential for impacts on resources of significance to Native Americans from oil shale leasing and development, including ancillary facilities, such as access roads and transmission lines, is directly related to the amount of land disturbance and the location of the project. Indirect effects—for example, impacts on water quality and use, the ecosystem in general, and the cultural landscape resulting from the erosion of disturbed land surfaces—are also possible.

Impacts on Native American resources could result in several ways, as described below.

- *Complete destruction of an important location or resource* could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if archaeological sites, sacred sites, burials, traditional cultural properties, specific habitat for culturally important plants and wildlife species, and the like are located within the footprint of the project.

- *Degradation and/or destruction of an important resource* 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 important sites or habitats are located on or near the project area. Such degradation could occur both within the lease parcel and in areas downslope or downstream. While the erosion of soils could negatively affect areas downstream of the project area by potentially eroding materials and portions of archaeological sites, the accumulation of sediment could serve to protect some archaeological sites by increasing the amount of protective cover.

- *Increases in human access* and subsequent disturbance (e.g., looting, vandalism, and trampling) of resources of significance to Native Americans could result from the establishment of roads or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes plants, animals, archaeological sites, historic structures and features, and other culturally significant natural features to greater probability of impact from a variety of stressors.

- *Visual degradation of settings* associated with significant cultural resources and sacred landscapes could result from the presence of a commercial oil shale facility and associated land disturbances and ancillary facilities. This could affect important resources for which visual integrity is a component of the sites' significance to the tribes, such as sacred sites, landscapes, and trails.

- *Noise degradation of settings* associated with significant cultural resources and sacred landscapes also could result from the presence of oil shale extraction and processing facilities. This could affect the pristine nature and peacefulness of a culturally significant location.

The difference in surface disturbance is one technology-specific factor that could have a possible impact on resources of concern to Native Americans. However, because all potential impacts on tribally sensitive resources would be determined by site-specific conditions, differences in surface disturbance would not necessarily directly correspond to differences in impacts on these resources at the programmatic level. The magnitude or level of impact would depend on whether the specific location of a proposed oil shale facility contains significant resources, or degrades an important viewshed regardless of the overall size of the facility. Differences in water requirements of various technologies also could be a factor as water use, quality, and availability are important issues of Native American concern.

4.11.2 Mitigation Measures

Government-to-government consultations between the BLM and the directly and substantially affected tribes is required under E.O. 13175 (U.S. President 2000). In addition, Section 106 of the NHPA requires federal agencies to consult with Indian tribes for undertakings on tribal lands and for historic properties of significance to the tribes that may be affected by an undertaking (CFR 36 800.2 (c)(2)). BLM Manual 8120 provides guidance for government-to-government consultations. For impacts on resources of interest to Indian tribes and their members, such as traditional cultural properties, that constitute historic properties under the NHPA, the application of mitigation measures developed in consultation under Section 106 of the NHPA would avoid, reduce, or mitigate the potential for adverse impacts. The use of management practices such as training/education programs for workers and the public could reduce occurrences of human-related disturbances to resources important to tribes. The details of these management practices should be established in project-specific consultations among the applicant and the BLM, tribes, and SHPOs, 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.

For those resources not considered historic properties under the NHPA, ongoing government-to-government consultation would help determine other issues of concern, including but not limited to access rights, disruption of cultural practices, impacts on visual resources important to the tribes, and impacts on subsistence resources. Ecological issues and potential mitigation measures are discussed in Section 4.8. Impacts on water use and quality and potential mitigation measures are discussed in Section 4.5. It should be noted that even when consultation and an extensive inventory or data collection occur, not all impacts on tribally sensitive resources can be fully mitigated.

Some specific mitigation measures are listed below (all mitigation measures listed in Section 4.11.2 for cultural resources would also apply to historic properties of concern to Indian tribes and their members):

- *The BLM will consult with Indian tribal governments* early in the planning process to identify issues and areas of concern for any proposed oil shale project. Such consultation is required by the NHPA and other authorities and is necessary to determine whether construction and operation of the project are likely to disturb tribally sensitive resources, impede access to culturally important locations, disrupt traditional cultural practices, affect movements of animals important to tribes, or visually affect culturally important landscapes. It may be possible to negotiate a mutually acceptable means of minimizing adverse effects on resources important to tribes.

- *Visual intrusion on sacred areas should be avoided to the extent practical* through the selection of location and technology. When avoidance is not possible, timely and meaningful consultation with the affected tribe(s) should be conducted to formulate a mutually acceptable plan to mitigate or reduce the adverse effect.

- *Rock art (panels of petroglyphs and/or pictographs) should be avoided whenever possible*. These panels may be just one component of a larger sacred landscape, in which avoidance of all impacts may not be possible. Mitigation plans for eliminating or reducing (minimizing) potential impacts on rock art should be formulated in consultation with the appropriate tribal cultural authorities.

- *Tribal burial sites should be avoided*. A contingency plan for encountering unanticipated burials and funerary goods during construction, maintenance, or operation of an oil shale facility should be developed as part of a formalized agreement to address management and mitigation options for significant cultural resources in consultation with the appropriate tribal governments and cultural authorities well in advance of any ground disturbances. The contingency plan should include consultation with the lineal descendants or tribal affiliates of the deceased, and human remains and objects of cultural patrimony should be protected and repatriated according to the statutory procedures and regulations of NAGPRA.

- *Springs and other water sources that are or may be sacred or culturally important should be avoided whenever possible*. If construction, maintenance, or operational activities must occur in proximity to springs or other water sources, appropriate measures, such as the use of geotextiles or silt fencing, should be taken to prevent silt from degrading water sources. The effectiveness of these mitigating barriers should be monitored. Measures for preventing water depletion impacts on spring flows should also be employed. Particular mitigations should be determined in consultation with the appropriate Indian tribe(s).

- *Culturally important plant species should be avoided when possible*. Facilities should be designed to minimize impacts on game trails, migration routes, and nesting and breeding areas of tribally important species. Mitigation and monitoring procedures should be developed in consultation with the affected tribe(s).When it is not possible to avoid these plant resources, consultations should be undertaken with the affected tribe(s). If the species is available elsewhere on BLM-managed lands, guaranteeing access may suffice. For rare or less common species, establishing (transplanting) an equal amount of the plant resource elsewhere on BLM-managed land accessible to the affected tribe may be acceptable.

Government-to-government consultation has been initiated to identify further significant cultural resources. This phase of analysis is ongoing but has yet to identify geographical areas that will preclude allocating these lands as available for lease application. During the leasing phase, tribal consultation will be continued to help determine areas of tribal concern and appropriate means to avoid, minimize, or mitigate impacts on areas of tribal concern, and may attach stipulations to any lease to ensure these measures. Oil shale leasing may require additional consultation and information gathering (e.g., cultural resource inventories) prior to the lease sale. 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, 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.

4.12 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)[13] on employment and personal income in an ROI in which oil shale resources are located in each 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

13 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.

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. Census Bureau 2007) 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 (e.g., rental housing, hotels, and campsites).

- *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 4.12-1). 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 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 4.12-1). 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.

TABLE 4.12-1 Temporary Housing Assumptions

Workers	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).

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 presented in Table 4.1.6-1, employment in a 600-MW power plant would range from 480 to 600 during construction, with 60 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 188 workers during construction and between 132 and 159 workers during operations. If a power plant were needed in Wyoming, it was assumed to be fueled by coal from a surface mine in Wyoming, which would employ 34 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 to 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.

4.12.1 Common Impacts

4.12.1.1 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–d), from DOE (EIA 2007a–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 centered 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 between 1,084 and 1,339 total (direct plus indirect) jobs in the three ROIs in the peak year of construction and between $56 million and $80 million in income (Table 4.12.1-1). Project operations would produce between 1,449 and 1,777 jobs and between $74 million and $105 million in income. Underground mining would create between 1,104 and 1,532 jobs and between $57 million and $97 million in personal income, with between 1,440 and 1,981 jobs created during the operating

TABLE 4.12.1-1 ROI Economic Impacts of Oil Shale Development[a]

			Oil Shale Development			
	Housing Construction		Construction		Operation	
	Employment	Income (2010 $ million)	Employment	Income (2010 $ million)	Employment	Income (2010 $ million)
Surface mining with surface retorting						
Direct	234–298	4.2–5.1	722–866	48.2–69.6	962–1154	64.2–92.9
Indirect	56–67	1.3–1.5	362–473	7.4–9.8	488–623	9.4–12.1
Total	290–365	5.4–6.6	1,084–1,339	55.7–79.5	1,449–1,776	73.6–104.9
Underground mining with surface retorting						
Direct	220–303	4.2–6.3	735–882	49.1–79.4	955–1146	63.8–103.2
Indirect	57–87	1.3–2.5	369–650	7.6–17.3	485–835	9.3–21.1
Total	292–371[b]	5.5–8.8	1,104–1,532	56.7–96.7	1,440–1,981	73.1–124.3
In situ processing						
Direct	71–132	1.3–2.9	225–375	15.0–33.8	75–125	5.0–11.3
Indirect	18–39	0.4–1.1	122–340	2.5–9.0	41–112	0.8–2.9
Total	94–161	1.7–4.0	347–715	17.5–42.8	116–237	5.8–14.1

[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 to 25,000 to 30,000 bbl/day, and from a surface mine with a capacity of 100,000 bbl/day to 25,000 to 30,000 bbl/day. In situ facility data are from Thompson (2006b), with data for Colorado multiplicative of a single facility with a capacity of 30,000 to 50,000 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.

period. Construction of an in situ processing facility would create between 347 and 715 jobs and between $18 million and $43 million in personal income, producing between 116 and 237 jobs and between $6 million and $14 million in income during the operating period. Construction employment for each facility would represent an increase of between 0.2% and 1.9% over the projected employment baseline in the three ROIs in the peak construction year. Enefit Energy alone is projecting around 2,000 direct employees for their 50,000 bpd plant at full production, by about 2024 (Enefit 2011).

Construction of power plants in association with in situ facilities would produce between 696 and 770 total jobs in the three ROIs during the peak construction year and between $39 million and $55 million in income (Table 4.12.1-2). During plant operations, between 75 and 83 employees would be required in the ROIs, producing between $4 million and $6 million in income. Construction employment for the power plants would represent an increase of between 0.5 and 1.3% over the projected employment baseline in the three ROIs in the peak year. Coal mine development in each ROI would produce between 52 and 337 jobs in the ROI during construction and between $3 million and $21 million in income in the ROIs (Table 4.12.1-2). Plant operations would require between 52 and 239 employees in the ROIs, producing between $3 million and $14 million in income. Construction employment for the coal mines would represent an increase of between 0.1% and 0.4% over the projected peak year employment baseline in the three ROIs.

TABLE 4.12.1-2 ROI Economic Impacts of Power Plant and Coal Mine Development[a]

	Housing Construction		Construction		Operation	
	Employment	Income (2010 $ million)	Employment	Income (2010 $ million)	Employment	Income ($ million)
Power plant						
Direct	143–167	2.7–3.4	538	35.9–48.4	60	4.0–5.4
Indirect	37–47	0.8–1.3	158–232	3.1–6.3	15–23	0.3–0.6
Total	190–204[b]	3.6–4.8	696–770	39.2–54.7	75–83	4.3–6.0
Coal mine						
Direct	11–65	0.2–1.4	34–188	2.7–16.9	34–159	2.7–11.9
Indirect	3–19	0.1–0.5	19–139	0.4–3.7	18–96	0.4–2.4
Total	14–79	0.3–1.9	52–327	3.1–20.6	51–235	3.1–1430

[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.

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 290 and 365 jobs and approximately $7 million in income in the ROIs (Table 4.12.1-1). Construction of housing for underground mine workers and families would produce between 290 and 371 jobs and between $6 million and $9 million in income in the ROIs. Construction of housing for in situ project workers and their families would produce employment of between 94 and 161 jobs and between $2 million and $4 million in income in the ROIs. Construction of temporary housing for power plant workers and families in the ROI would create between 190 and 204 jobs, while housing for mine workers would produce between 14 and 79 jobs. Between $4 million and $5 million in income would be produced during construction of housing for power plant workers and between $0.3 million and $2 million during construction of coal mine worker housing (Table 4.12.1-2).

4.12.1.2 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 579 and 901 new residents are expected in the ROIs, with between 1,291 and 2,038 relocating to the ROIs during operations (Table 4.12.1-3). Construction of an underground mine would mean between 590 and 1,430 new residents in the ROI during the peak construction year, with between 1,282 and 2,456 expected during operations. Construction of an in situ facility would mean between 190 and 695 new residents during the peak construction year, with between 104 and 297 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 0.3% and 0.8% over the baseline population in the three ROIs during construction and between 0.5% and 1.9% during operations, with similar increases expected for a surface mine.

Construction of a power plant would bring between 321 and 647 new residents to the ROIs during the peak construction year, with between 63 and 100 workers and their families required during facility operations (Table 4.12.1-4). Coal mine construction would mean between 35 and 305 new residents during construction and between 60 and 283 in-migrants during operations. Population increases associated with the construction of power plants would represent increases of between 0.2% and 0.4% in the population baseline in the three ROIs during construction and between 0.02% and 0.08% during operations. Coal mine construction

TABLE 4.12.1-3 ROI Demographic and Housing Impacts of Oil Shale Development

Type of Development	In-Migration to Local Communities		Housing Demand in Local Communities	
	Construction	Operation	Number of Units	Percent Vacant
Surface mining with surface retorting	579–901	1,291–2,038	167–260	1.5–3.2
Underground mining with surface retorting	590–1,430	1,282–2,456	170–412	1.5–3.2
In situ processing	190–695	104–297	55–201	0.5–1.5

would increase baseline populations in the three ROIs by between 0.02% and 0.1%, with operations adding between 0.05% and 0.08% to the baseline populations in the three ROIs.

Population increases associated with construction of a surface mine project would require between 167 and 266 housing units in the ROIs, absorbing between 1.5% and 3.2% of vacant housing units (Table 4.12.1-3). For an underground mine, between 170 and 412 housing units, or between 1.5% and 3.2% 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 55 and 200 housing units, or between 0.5% and 1.5% of the vacant housing stock in the three ROIs. For a power plant, population increases associated with project construction would require between 92 and 186 housing units, or between 1.0% and 1.6% of the vacant housing stock in the three ROIs, while coal mine development would require between 10 and 88 housing units, or between 0.1% and 0.7% of vacant units in the ROIs (Table 4.12.1-4).

Construction of a surface mine facility would require between 14 and 29 new local government employees in the three ROIs during construction and between 31 and 65 employees during operations (Table 4.12.1-5). The additional local public service provision during the peak construction year would require an increase of between 0.5% and 1.0% in local expenditures in the three ROIs, with increases of between 1.2% and 2.3% during operations. Construction of an underground mine would require between 14 and 36 local government employees during construction, and between 31 and 66 during operations. The increase in local public service provision would represent an increase of between 0.5% and 1.0% in expenditures in the three ROIs during construction and between 0.9% and 2.3% during operations. Construction of an in situ facility would require between 5 and 18 local government employees during construction and between 3 and 8 during operations, with the increase in local public service provision requiring an increase of between 0.2% and 0.5% in expenditures during construction and between 0.1% and 0.3% during operations. Construction of a power plant would require between 6 and 18 local government employees in the three ROIs during construction and between 1 and 3 during operations, with the increase in local public service provision requiring an increase of

TABLE 4.12.1-4 ROI Demographic and Housing Impacts of Power Plant and Coal Mine Development

Type of Development	In-Migration to Local Communities		Housing Demand in Local Communities	
	Construction	Operation	Number of Units	Percent Vacant
Power plant	320–647	63–100	93–187	1.0–1.6
Coal mine	35–305	60–283	10–88	0.1–0.7

TABLE 4.12.1-5 ROI Community Impacts of Oil Shale Development

Mining Process	Government Employees		Change in Local Government Expenditures (%)	
	Construction	Operation	Construction	Operation
Surface mining with surface retorting (one 25,000–30,000-bbl/day project)	14–29	32–65	0.6–1.0	1.3–2.3
Underground mining with surface retorting (one 25,000–30,000-bbl/day project)	15–36	32–66	0.5–1.0	0.9–2.3
In situ processing (one 30,000–50,000-bbl/day project)	5–18	3–8	0.2–0.5	0.1–0.3

between 0.3% and 0.5% in expenditures in the three ROIs during construction and between 0.05% and 0.1% during operations (Table 4.12.1-6). Coal mine development would require between 1 and 8 local government employees in the three ROIs during construction, requiring an increase of between 0.05% and 0.15% in local government expenditures in the three ROIs, and between 1 and 8 during operations, which would necessitate an increase in local government expenditures of between 0.08% and 0.13%.

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 shale 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, 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

TABLE 4.12.1-6 ROI Community Impacts of Power Plant and Coal Mine Development

Type of Development	Government Employees		Change in Local Government Expenditures (%)	
	Construction	Operation	Construction	Operation
Power plant	6–18	1–3	0.3–0.5	0.05–0.1
Coal mine	1–8	1–8	0.05–0.15	0.08–0.13

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 3.11.2). 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 made by federal agencies as required by law and may be used 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.

4.12.1.3 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).

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.

4.12.1.4 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. In the oil and gas industry, to facilitate new oil and gas development, water rights have often been purchased from agricultural landowners, primarily ranchers (see Section 3.11.2.2). 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 3.11.2.2.1). 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 3.11.2.1.2), 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.

4.12.1.5 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 4.12.1-7). 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.

4.12.1.6 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

TABLE 4.12.1-7 Total ROI[a] Impacts of Reductions in Recreation Sector[b] Employment Resulting from Oil Shale Development

	10% Reduction		20% Reduction	
ROI	Employment	Income ($ million)	Employment	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.

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.

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; 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).

4.12.1.7 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, and skiing. 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.

4.12.1.8 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.

4.12.2 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 2007), including road maintenance requirements.

4.13 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.

4.13.1 Common Impacts

4.13.1.1 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 4.12.1.3).

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.

4.13.1.2 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 3.11.2.2), 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, and drug use. 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.

4.13.1.3 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.

4.13.2 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, and drug use. 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.

4.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

4.14.1 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 are 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.

4.14.1.1 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, Stormwater Pollution Prevention Plans (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). Sanitary wastewater is likely to be treated and disposed of on-site according to permits issued by state or local regulatory authorities.

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.

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.

4.14.1.2 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.

4.14.1.3 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 4.14.1.2 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.

4.14.1.4 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 (now AMSO) 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.[14]

Some of the in situ technologies in the RD&D phase propose using some form of formation fracturing, as described in Appendix A. The means of fracturing would include thermal and hydraulic fracturing, as well as dissolution and recovery of embedded sodium minerals, to open pathways for the recovery of converted kerogen. It is not clear at the current stage of development that chemical additives that would pose groundwater contamination concerns will be used in fracturing process in future commercial operations, but such use is possible. The oil and gas industry has historically used a large number of different chemical additives to enhance the fracturing process, as discussed in Section 6.1.6.3.12. The use of what are often proprietary chemicals for fracturing in the oil and gas industry has been the focus of some public concern in recent years. The EPA is currently considering regulations for chemicals used in fracturing in the oil and gas industry. Thus, it is possible that some future commercial in situ oil shale technologies could use chemical additives in fracturing processes, but it is not known at this time whether oil shale will be subject to regulations formulated for oil and gas fracturing.

Field data on observed impacts of in situ retorting on groundwater quality are limited, 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 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

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[14] 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.

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.

4.14.2 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.

4.15 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 4.15-1.

TABLE 4.15-1 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.[15]

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 4.15-2 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,

TABLE 4.15-2 Estimated Health Effects Associated with a Hypothetical 1,000,000-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 = data not available.

Source: IWG Corp. (1984).

[15] 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.

which represented 50% of the assumed workforce but accounted for 70% of the expected fatalities (Gratt et al. 1984).

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 polycyclic aromatic hydrocarbons (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.

4.15.1 Common Impacts

4.15.1.1 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 PAHs,[16] a carcinogenic component of the shale (further discussed in Section 4.15.1.2 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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[16] Also known as polynuclear aromatic hydrocarbons or polynuclear aromatic compounds.

4.15.1.2 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 CH_4, 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.

4.15.1.3 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., CH_4) 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 4.15.1.1, 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).

4.15.1.4 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 4.15.1.1. 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.

4.15.2 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).

4.16 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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