Most of the stone quarries in the planning area are relatively small disposal sites, generally less than 5-10 acres. The disposals from BLM public lands range from a few tons to a few thousand tons per year.

4. Humate

Most humate in Utah is mined from coal beds in the Ferron Sandstone at the Coal Cliffs in southwest Emery County. However, within the eastern part of the planning area, coal beds in the Ferron Sandstone also crop out around the perimeter of the Henry Mountains syncline, west of the Henry Mountains, and three humate mines (two on BLM land and one on state land) are active. These mines are located in north-central Wayne County south of the Emery county line.

The humate mines are generally small operations, and the tonnage produced is relatively small. Thus, the mines are generally active only intermittently, depending on market demand. Most, if not all, of the humate being mined in Utah is used as a nutritional supplement.

5. Other Minerals

In the planning area, mineral materials, mineral specimens, and semiprecious gemstone have included interest in petrified wood, agate, chalcedony, jasper, cryptocrystalline quartz, selenite, alabaster, fluorite, sphalerite, and galena. In the eastern part of the planning area, petrified wood, jasper, agate, and chalcedony are collected primarily from the Morrison Formation, although also found in the Cedar Mountain and Chinle Formations. Gypsum beds in the Jurassic Carmel Formation at some outcrop localities contain selenite and alabaster crystals that are suitable for specimen collecting and carving. Fluorite, sphalerite and galena are mostly associated with the volcanic terrane of the western part of the planning area. Most of the collecting is for personal hobby or recreational rockhounding. However, limited development has occurred for selenite, as previously discussed, at Cathedral Valley.

4. MINERAL OCCURRENCE POTENTIAL AND LIKELIHOOD OF DEVELOPMENT OF MINERAL RESOURCES

In this section, the potential for mineral occurrence, the level of certainty of that occurrence, and the likelihood that these resources will be developed during the expected planning horizon of 15 years are evaluated. This classification is based on BLM Manual 3031. A copy of the BLM mineral potential classification system is provided in Attachment 2. Mineral resources in the planning area that are considered most likely to be developed are oil and gas, gypsum, sand and gravel, and stone. Coal is also likely to be developed, but is not addressed in this report.

A. Leasable Minerals

1. Coal

An evaluation of coal resource potential is not included in this report. Two reports have been completed for the assessment of coal resources.

2. Coal Bed Methane

Coal bed methane (CBM) resources have been extensively explored and developed in the Wasatch Plateau-Emery play in western Carbon and Emery Counties, east of the planning area, and this play is rapidly becoming one of the most productive for CBM in the United States. Recoverable gas resources in the play are estimated to range between 4 and 9 trillion cubic feet with approximately 300 billion cubic feet of gas extracted in Carbon and Emery Counties at the end of 2001 (UDOGM, 2002).

In the planning area on the east side of the Wasatch Plateau, CBM gas is associated with the Ferron Sandstone on the Ferron Trend, which is an extension of the Wasatch Plateau-Emery play. To date there has been limited exploration within the planning area. Because of production in the Wasatch Plateau-Emery play and the continuation of the Ferron Sandstone along strike into the planning area, the Ferron Trend is assigned a high potential with a high degree of certainty (H/D). The potential is shown on Map 20. Development is considered likely in the next 15 years.

West of the high potential area of the Ferron Trend on the the Wasatch Plateau, as shown on Map 20, the Ferron Sandstone, Emery Sandstone, and Blackhawk Formation occur in the subsurface at greater depths than on the Ferron Trend, and less is known about occurrence of coal beds and CBM in this area. The Ferron and Emery Sandstone as well as the Blackhawk Formation have favorability for the deposition of coal and the accumulation of CBM; therefore, moderate potential is assigned with moderate certainty (M/C) in the central Wasatch Plateau. Development is considered unlikely in the next 15 years.

West of the moderate potential area on the Wasatch Plateau, as shown on Map 20, the coal beds are assumed to thin as the depositional environments changed from nearshore and deltaic to the east and highlands to the west. A low potential is assigned with a high degree of certainty (L/D). Development is considered unlikely in the next 15 years.

In the Henry Mountains coal field, the Ferron Sandstone and Muley Canyon Sandstone Members of the Mancos Shale contain coal-bearing strata. The Henry Mountains coal field lies between the Henry Mountains on the east and Capitol Reef National Park on the west. Other than exploration for coal and conventional oil and gas, these coal beds have not been explored for CBM. Generally, the coal beds in the Ferron Sandstone average of 1-3 ft in thickness, the coal beds are discontinuous, and

most of the coal is less than 1,000 ft in depth (Tabet, 2000). The Muley Canyon Sandstone is distributed more widely in the coal field, the average thickness is 5 to 10 ft of total coal with an aggregate thickness up to 28 ft, and most of the coal is less than 1,000 ft in depth. Generally, this topography is dissected with buttes and mesas, which could be unfavorable for the trapping of CBM. Accordingly, south of Highway 24 and Factory Butte, a moderate occurrence potential with a moderate degree of certainty (M/C) is assigned, as coal beds are present and conditions may be favorable for the accumulation of CBM. North of Highway 24 and near Factory Butte, a low occurrence potential with a high degree of certainty (L/D) is assigned, because the Ferron Sandstone is exposed at the surface or is present at relatively shallow depths and the Muley Canyon is exposed at the surface. The Henry Mountains coal field is not likely to be developed for CBM in the next 15 years.

3. Oil and Gas

As shown on Map 10, most of the planning area is covered by one or more USGS oil and gas plays, except for a small triangular shaped area in northern Wayne County. Hydrocarbon shows have been reported from many formations in the different plays.

A new field is being explored and developed in the Sevier Frontal play in Sevier County. A historic field, Joes Valley, for conventional gas in the Cretaceous Sandstone play is seeing renewed interest for exploration. As shown on Map 21, high potential with a high certainty (H/D) is assigned to the Sevier Frontal and Cretaceous Sandstone plays in the western part of the planning area. The Sevier Frontal play has current production and the Cretaceous Sandstone play has past production. The stratigraphy and structures, that define each of these two plays, are potentially present throughout these two plays and are favorable for the accumulation of hydrocarbons.

Producing or past producing fields are adjacent to the planning area in the Paradox Basin province. As shown on Map 21, high potential with a moderate certainty (H/C) is assigned to the Fractured Interbed, Salt Anticline, Buried Fault Block, and Porous Carbonate Buildup plays of the Paradox Basin province in the eastern part of the planning area (Map 21). The Paradox Basin has established production in the formations and structures associated with the fields in this basin, and similar fields could be present in these plays within the planning area.

The Permo-Triassic Unconformity play is based on stratigraphic sequences in formations and on structural traps below and above this unconformity. Adjacent to the planning area, hydrocarbons are produced at the Upper Valley field in Garfield County near Escalante, and producible gas is also known at the Last Chance field in Emery County. In addition, producible carbon dioxide was discovered in a well north of Loa. A favorable geologic setting is present for trapping hydrocarbons, as well as the carbon dioxide. Wells drilled in the eastern part of this play, generally east of Koosharem and Grass Valley, have reported hydrocarbon shows. Given the known production in close

proximity to the planning area, known producible gas, and hydrocarbon shows in the Kaibab and the Moenkopi, a high potential with a low certainty (H/B) is assigned to the eastern part of the Permo-Triassic Unconformity play. In the western part of the Permo-Triassic Unconformity play, few wells have been drilled and hydrocarbon shows are not reported. Given the sparcity of wells, a moderate potential with low certainty (M/B) is assigned to the western part of the play. Stratigraphic sequences and structure, similar to the producing fields in this play outside the planning area, are inferred to be present and favorable for the accumulation of oil and gas.

The Late Proterozoic (Chuar-sourced) and Lower Paleozoic play is enclosed within the area defined by the Permo-Triassic Unconformity play. As only limited information is known about this hypothetical play, a mineral potential, specifically for this play, is not assigned.

In the western part of the planning area, the Late Paleozoic Play has had very limited exploration. Production is not established within the play; however, the stratigraphy and structure are favorable for oil and gas accumulations. A moderate potential with low certainty (M/B) is assigned to this play. The assignment of moderate potential (M/B) on Map 21 is the combination of the western part of the Permo-Triassic Unconformity and the Paleozoic plays.

In the eastern part of the planning area, the area on the flank of the San Rafael Swell, northeast of Hanksville, is not included in a USGS play. Although the dip slope of the Swell, as a regional structure, may not be favorable for the accumulation of hydrocarbons, smaller structures could be favorable. Limited drilling has been completed in this area. A moderate potential with low certainty (M/B) is assigned to this area.

Development is considered likely in the Sevier Frontal and Cretaceous Sandstone plays. The other plays are likely to have exploration activity, but development is not considered likely at this time.

4. Tar Sands

The Tar Sand Triangle in eastern Garfield and Wayne Counties contains an estimated equivalent of 12–16 billion barrels of oil in place. Deposits associated with the Tar Sand Triangle are assigned a high potential with a high degree of certainty (H/D) as shown on Map 22. Most of this area is designated as a Special Tar Sand Area (STSA).

Tar sand deposits and occurrences are also found in the vicinity of Capitol Reef National Park and the Waterpocket Fold. These deposits are included in the Circle Cliffs STSA and are assigned a high potential with a moderate degree of certainty (H/C).

Northwestward of the high potential at the Circle Cliffs, occurrences of tar sands are increasingly discontinuous and isolated. As shows of tar sands are present, a moderate potential with a moderate certainty (M/C) is assigned to these occurrences.

Development of tar sands is considered unlikely in the next 15 years. Tar sand deposits in Alberta are producing and seeing increased development, and recent industry publications indicate interest in unconventional hydrocarbon deposits may increase with the increase in the price for oil and gas. However, the infrastructure for development would take time to put in place and certainly would be 5-10 years if not 15, if the prices for hydrocarbons become favorable for the exploration and development of tar sand deposits in the planning area. If development were to take place, development is most likely at the Tar Sand Triangle. A sizable portion of the tar sand deposits overlap BLM Wilderness Study Areas and lands administered by the National Park Service, and tar sand exploration and development may not be consistent with the policies and management of these lands.

5. Geothermal Resources

The western part of the planning area is characterized by an active seismic belt, range-bounding faults, elevated spring temperatures, high heat flow, and Tertiary and Quarternary igneous features that are indicative of terrains with potential for geothermal resources. These features are associated with the Sevier thermal area and the fault-bounded Sevier and Sanpete Valleys. Past interest in geothermal resource exploration and development was focused at the southern part of the Sevier Valley at the Monroe and Joseph hot springs. A high potential for occurrence with a moderate degree of certainty (H/C) is designated, as shown on Map 23, in the western part of the Transition Zone. The geologic conditions in this high potential area have similarities to conditions at Sulphurdale and Roosevelt Hot Springs to the west of the planning area, where geothermal resources are used for the production of electricity.

In the Transition Zone, east of the high potential as described above, high heat flow, faults, seismic activity, and/or igneous features are present but not to the degree as is present in the area of high potential. The Transition Zone, not designated as high potential, is assigned a moderate potential with a low degree of certainty (M/C) as shown on Map 23.

The eastern part of the planning area does not have the igneous features, the elevated ground water temperatures, and seismic activity that is present in the Transition Zone. The eastern part of the planning area is assigned a low potential with moderate certainty (L/C) as shown on Map 23.

Geothermal resources in the planning area will probably not be developed in the next 15 years. Currently, there is no leasing interest in the planning area; however, geothermal resource production could become more favorable because of market

changes related to energy demands and interest in increasing the use of renewable energy resources.

6. Salt

In the western part of the planning area, salt deposition is associated with the Jurassic Arapien Shale, which crops out in the Sevier Valley. The salt beds in the Arapien Shale are highly contorted and discontinuous. Salt exposed at the surface is easily eroded, and surface deposits are assumed to be largely removed by erosion. However, given the diapirism that is prevalent in the Arapien Shale, the geologic setting is favorable for salt deposits in the subsurface. Some oil and gas exploration wells have penetrated considerable thickness of salt-bearing strata. RCS Salt, near Redmond, is the only operating salt mine in the planning area. Historically, there have been other small prospects in the Sevier and Sanpete Valleys between Glenwood and Manti. In the western part of the planning area in the Sevier and Sanpete Valleys, a high occurrence potential for salt with a high degree of certainty (H/D) is assigned to the Arapien Shale, as shown on Map 25.

In the eastern part of the planning area, salt beds, which have been penetrated in drill holes, are present in the Paradox Formation that is Pennsylvanian in age. This deposition is part of the Paradox Basin, a structural basin which has thick sequences of cyclic salt deposition. The salt beds in the subsurface in eastern Wayne and Garfield Counties are considered to be the western limit of salt deposition in the Paradox Basin of Pennsylvanian age, and this limit is shown on Map 13. A high occurrence potential for salt with a high degree of certainty (H/D) is assigned to the part of the Paradox Basin as shown on Map 25.

The RCS salt mine on private land is likely to continue to produce; however, development on BLM public land is considered unlikely during the next 15 years. Salt deposits in the Arapien Shale that could be present on public land are most likely to be subsurface deposits and are not considered likely to be competitive with brine extraction at the Great Salt Lake. Similarly, subsurface salt deposits in the Paradox Basin, that are at greater depth than the salt in the Sevier and Sanpete Valleys and may be more distant from market, are also considered unlikely to be developed in the next 15 years.

B. Locatable Minerals

1. Metals

Western Side of the Planning Area

Historically, mineral exploration and development were focused on deposits associated with the organized mining districts near Marysvale in the Tushar Mountains and the Antelope Range. The metals of interest were primarily gold, silver, lead, zinc,

and uranium. The deposits are associated with Tertiary intrusions and volcanic rocks of diverse lithologic assemblages. Since 1981, when BLM began regulating mining operations, most of the exploration on the west side of the field office has occurred in this area. The historical exploration and development primarily focused on surface indications of metallization, such as exposed veins and discolored alteration zones related to the oxidation of metals. Exploration focused on driving adits and trenching favorable zones. Mining was mostly by small-scale, underground methods in relatively small workings. Mines, such as the Annie Laurie, Deer Trail, and VCA, were larger operations.

Metallization is related to an extensive area of Cenozoic igneous emplacement and volcanic ativity, as well as hydrothermal alteration. The Marysvale volcanic field is a large area of igneous intrusive and volcanic rocks that extends from the Tushar Mountains near Marysvale to Thousand Lakes Mountain and Boulder Mountain near Loa. However, most of the known or exposed intrusive rocks, alteration zones, and historical mining occurred near Marysvale. Extensive alteration zones, such as alunitic and kaolinitic zones; relatively small deposits of iron, manganese, and silica related to hot spring activity; and alunite and uranium vein deposits that are related to cupolas of intrusive rocks and hydrothermal systems are known in this area. The deposits are generally polymetallic. A porphyry intrusive body is thought to underlie Alunite Ridge, west of U.S. 89, southwest of Marysvale. The exposed intrusive rocks, polymetallic metallization, extensive alteration, and hot spring activity are favorable for the deposition of mineral deposits, including gold, silver, lead, zinc, molybdenum, and uranium, such as may be present in a porphyry intrusive complex. Potential metallic deposits may not be exposed at the surface but may be present in the subsurface. In addition, many streams have been worked historically for placer gold and have been panned in recent years, mostly as a recreational pursuit. An area of high potential for occurrence with a high degree of certainty (H/D) is assigned to this area as shown on Map 26.

Beyond the described area of high potential, the rest of the Marysvale volcanic field does not have the exposed intrusive centers, zones of alteration, or other mineralization indicators. However, the terrain is volcanic and could have undiscovered mineralization. This portion of the Marysvale Volcanic Field is assigned a moderate potential with a low degree of certainty (M/B).

Along the west side of the Wasatch Plateau, mineralization has been hosted in folded Cretaceous and overyling Tertiary sedimentary rocks. This mineralization is presumably associated with a magmatic source at depth. The prospects, such as those near the mouth of Salina Canyon, are few, and historical production, where reported, is minimal. Any metals deposits in this area are assumed to be relatively small and discontinuous; however, moderate potential with a low degree of certainty (M/B) is assigned to the west front of the Wasatch Plateau near Salina Canyon.

The Sevier and Sanpete Valleys, Wasatch Plateau, Gunnison Plateau, Valley Mountains, and Pahvant Range, except as already mentioned, are assigned a low potential with a moderate degree of certainty (L/C).

The market for uranium has been depressed since the early 1980s; however, prices have increased somewhat recently. Also, markets related to energy resources, including oil, gas, coal, and other sources such as geothermal and wind resources are in a state of change, because of varied socioeconomic and political conditions, nationally and worldwide. At this time, uranium resource development is not in the forecast and is not considered likely during the planning horizon.

Gold, silver, lead, and zinc, if found in economic quantities, would likely be developed. Except for the Deer Trail Mine on private and National Forest lands, no metal development or significant exploration is under way. Exploration is likely to continue, especially in the area near Marysvale. If economic deposits are discovered, development is likely to involve larger mines than the historical prospecting and mining in this region. Development is not predicted during the planning horizon.

Eastern Side of the Planning Area

Metallization on the east side of the field office is related to distinct sedimentary and igneous processes. The principal metals are uranium, vanadium, and gold.

Uranium and vanadium mineralization, as well as subordinate copper, is hosted in Mesozoic sedimentary formations, principally the Chinle and Morrison Formations. The minerals are predominately hosted in porous, permeable sandstone that was deposited in fluvial environments. The metals are associated with abundant carbonaceous debris and were deposited under reducing conditions.

Gold, copper, and subordinate metals are associated with igneous rocks in the Henry Mountains, proper. Gold mineralization in the Henry Mountains is hosted in shatter and contact zones in diorite porphyry rocks and in placer deposits, primarily along the Crescent Creek drainage.

The east side of the planning area is assigned a high potential for uranium, vanadium, gold, and other metals with a high degree of certainty (H/D). This potential is based on the widespread occurrence of the Chinle and Morrison Formations at the surface and in the subsurface. Although uranium, vanadium, and copper would not be present in economic quantities at all locations, the potential for occurrence is high, because these minerals are ubiquitously associated with the two formations. Gold and copper are commonly associated with the intrusive stocks on the Henry Mountains. These intrusive zones are considered favorable for mineralization, although not all locations would be mineralized.

As previously stated, the market for uranium has been depressed since the early 1980s; however, prices have increased somewhat recently. Also, markets related to energy resources, including oil, gas, coal, and other sources such as geothermal and wind resources are in a state of change, because of varied socioeconomic and political conditions, nationally and worldwide. At this time, developing a uranium resource is not readily in the forecast and development is not considered likely during the planning horizon.

Also, as previously stated, gold and copper, if found in economic quantities, would be developed. Prospecting and exploration are likely to continue in the Henry Mountains, though probably on a small scale.

2. Non-Metals

Gypsum beds of minable thickness occur in the Arapien Shale in the Sanpete and Sevier Valleys. The Arapien Shale is assigned a high occurrence potential for gypsum with a high degree of certainty (H/D) as shown on Map 25. This potential for gypsum coincides with the potential for salt, as both resources are deposits associated with the Arapien Shale. Gypsum mining is currently active in the vicinity of Sigurd, and development of gypsum deposits in the Sanpete and Sevier Valleys is considered likely during the next 15 years.

Gypsum beds also occur in the eastern portion of the planning area in the Carmel Summerville Formations. Areas where these rock units crop out have a high gypsum occurrence potential with a high degree of certainty (H/D). These resources will probably not be developed in the next 15 years because of the relative thinness and discontinuity of the gypsum beds and the remote location of most occurrences.

However, where the Carmel Formation crops out in northern Wayne County in vicinity of Cathedral Valley, selenite crystals are exposed or are at shallow depths. These crystals have been extensively collected by rock hounds in the past and their collection will continue during the next 15 years.

Although scattered, minor gypsum beds and lenses also occur in other sedimentary units across the planning area, these resources are not economic and the remaining portions of the planning area are considered to have low occurrence potential for gypsum with a high level of certainty (L/D).

C. Salable Minerals

1. Sand and Gravel

Quaternary and Tertiary alluvial, alluvial fan, pediments, slope wash, and colluvial debris are deposits in the valleys and stream courses and along mountain fronts in the planning area as shown on Map 17. Most development has occurred near

population centers and along the larger valleys. On Map 27, high potential with a high level of certainty (H/D) is assigned to sand and gravel deposits along the more prominent valleys and mountain fronts. Development is considered likely in the high potential areas but will be on a small scale.

However, sand and gravel deposits are found outside of the areas that are delineated as high potential on Map 27. Although sand and gravel are present, these areas are generally located further from markets. Because transportation is a factor in the development of sand and gravel, these areas have been rated as a moderate potential with a moderate certainty (M/C).

2. Clay Including Alunite

Clay occurrence potential is shown on Map 24. Distinguishing between different clay commodities was not considered necessary for planning purposes; thus, clay potential is inclusive of all clay commodities.

Alunitic deposits in the Marysvale volcanic field were developed during World War I as a potash alum and were prospected during World War II and in subsequent years as a source of alumina and fertilizer. Kaolonitic clays are now mined at Box Creek on the Sevier Plateau. Bentonitic clays are currently mined in the Sevier Valley and have been mined on a small scale in Wayne County.

In the western part of the planning area, clay deposits are mostly associated with alteration zones in the Marysvale volcanic field. Clay is also found in the Sevier and Sanpete Valleys and mostly appears to be related to the volcanic sequences. In the vicinity of Marysvale in association with dispersed alteration zones, clay is assigned a high potential with a moderate degree of certainty (H/C). In addition, the Sevier and Sanpete Valleys, where clay deposits and occurrences are also known, are also assigned a high potential with a moderate degree of certainty (H/C).

In the western part of the planning area, in association with the Marysvale volcanic field, but not within the high potential area, as described above, clay alteration is not known, but the geologic setting may be favorable for such. In this area, clay potential is rated as moderate with a low degree of certainty (M/B).

In the eastern part of the field office, clay is associated with the Dakota Sandstone and the Morrison Formation. Where these formations crop out, the potential is rated as high with a moderate degree of certainty (H/C).

Elsewhere in the planning area, clay is assigned a low potential with a moderate degree of certainty (L/C). However, clay may occur in many geologic settings, and clay deposits, probably in small, isolated occurrences, could be present. The Arapien Shale and Mancos Shale crop out in this low potential area, however economic interest in these shales as a clay resource is unknown.

Clay is likely to be developed on BLM land during the planning horizon of 15 years. However, such development is likely to be relatively small scale.

3. Stone and Industrial Minerals

As described in Section 3, the following rock units have all been quarried for various purposes in the planning area:

- Crazy Hollow Formation
- Green River Formation
- Flagstaff Formation
- Tertiary volcanic rocks (undivided)
- Joe Lott Tuff
- Moenkopi Formation
- Navajo Sandstone

In addition, areas with current interest for gathering of pick-up boulders and decorative stone have been delineated on Map 19.

High potential for the occurrence of stone with a high degree of certainty (H/D), as shown on Map 28, is based on formations and locations from which stone has been disposed. Moderate potential with a confidence rating (M/C) is assigned elsewhere as stone is almost ubiquitous in the planning area. Quarries have been relatively small-scale with most of the recent development on sandstone of the Moenkopi Formation and limestone of the Green River Formation. Development on a small-scale at many quarries is considered likely in planning area.

4. Humate

Humate deposits are associated with weathered horizons of coal-bearing beds, mostly in the Ferron Sandstone Member of the Mancos Shale. Commercial development in Utah has been relatively small scale in surface pits.

The only development in the planning area has been on weathered coal beds in the Ferron Sandstone in the vicinity of Factory Butte. Where the Ferron Sandstone crops out, a high potential with a moderate degree of certainty (H/C) is assigned as shown on Map 29. This high potential area is north of Highway 24.

South of Highway 24, the Ferron Sandstone crops out as well. Humates may be associated with these coal beds, but most of the Ferron coal is subsurface. This area is assigned a moderate potential with a low degree of certainty (M/B).

On the east side of the Wasatch Plateau, the Ferron Sandstone crops out and is assigned a high potential with moderate certainty (H/C). To the west, the Ferron

Sandstone and the Emery Sandstone are not exposed at the surface. Low potential with a moderate degree of certainty (L/C) is assigned to this area. The coals are generally deeper in this area, and humates, if present in the subsurface, would most likely not be economic to develop.

Development is likely to continue at Factory Butte on a small scale. Development is not considered likely elsewhere the planning area.