3.1.2.6 Mitigation and Residual Impacts

No significant impacts would result from the implementation of the Proposed Action with the actions incorporated to reduce or prevent impacts. No additional measures to mitigate significant impacts have been identified for air resources and there would be no residual significant impacts.

3.2 GEOLOGY/PALEONTOLOGY

This section describes the affected environment and environmental consequences as they apply to geological and paleontological resources in the vicinity of the Proposed Action.

3.2.1 Affected Environment

The following sections describe the current geological and paleontological environment. The description of current conditions represents the baseline for the assessment of impacts and environmental consequences.

3.2.1.1 Region of Influence

The region of influence for assessing impacts on geological and paleontological resources includes the proposed power plant site, well sites, access roads, rights-of-way where ground-disturbing activities could occur, agricultural areas, OPGW installation sites, the proposed or alternative pipeline corridors (R, T, or crossover segment C2), and the adjacent parcels of land.

3.2.1.2 Existing Conditions

The proposed power plant site is located within the southeastern portion of the Big Sandy groundwater basin, which is part of the Basin and Range physiographic province of northwestern Arizona. The Basin and Range physiographic province is characterized by fault block mountain ranges separated by aggraded desert plains (Figure 3.2-1).

The Big Sandy basin generally trends north-south and is bounded by the Hualapai and McCracken mountains to the west; Aquarius Cliffs and Aquarius Mountains to the east; and Cottonwood and Peacock mountains to the north. To the north, a divide in the Peacock Mountains separates the Big Sandy basin from the Hualapai valley to the west. To the south, a granitic gorge separates the Big Sandy basin from the Burro Creek drainage basin.

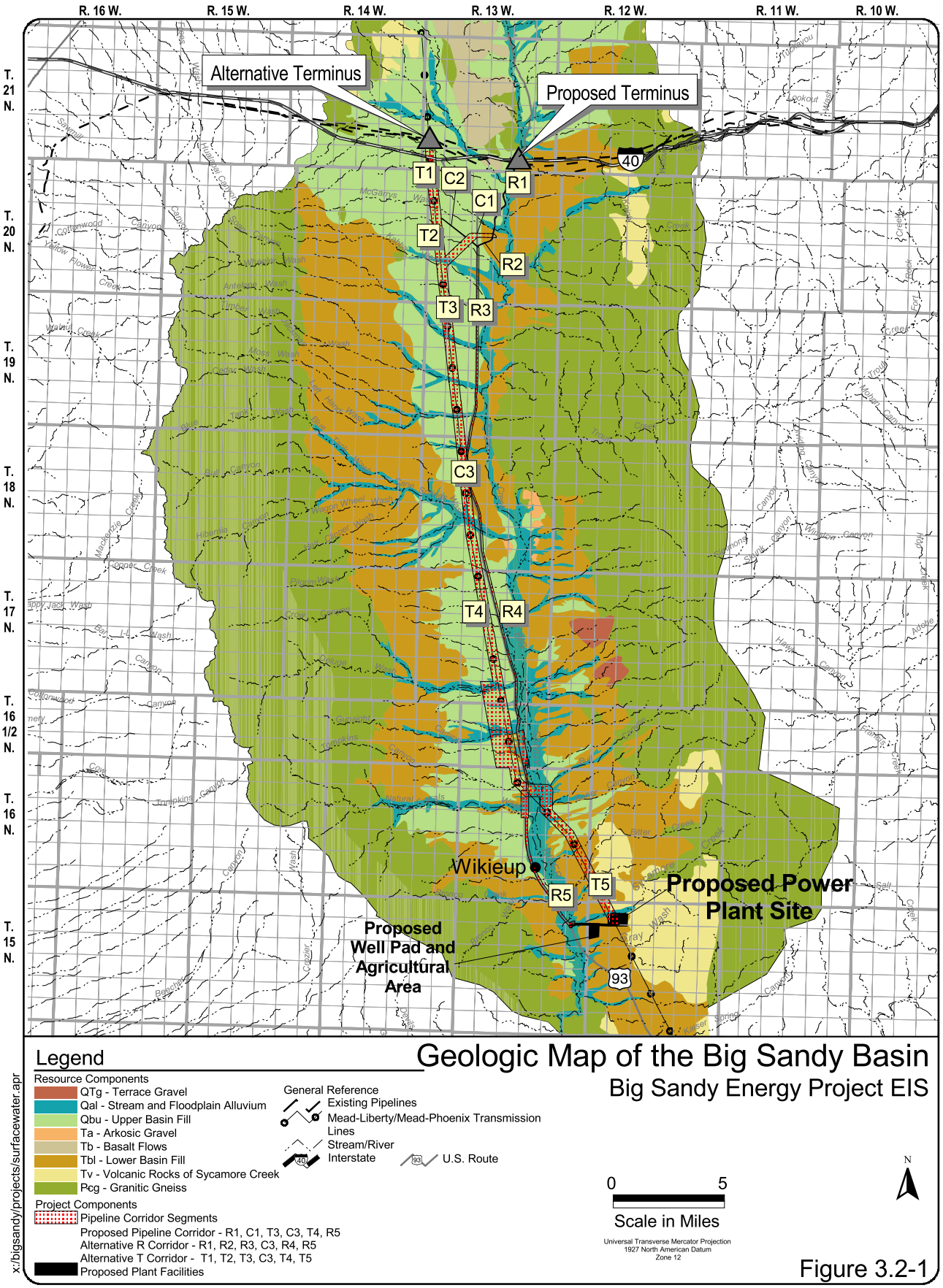
The proposed power plant site is located on a terrace approximately 2 miles east of the Big Sandy River. The elevation of the site ranges from 2,060 to 2,250 feet, and the ground surface generally slopes to the south at between 4 and 40 percent. The site is crossed by several ephemeral drainages that are tributaries to Gray Wash, which is a westerly flowing tributary to the Big Sandy River.

Geological Resources

The geology of the Big Sandy groundwater basin within the region of influence can be separated into the following seven units, from youngest to oldest:

- stream and floodplain deposits
- upper basin fill
- lower basin fill (includes the Big Sandy Formation, which constitutes the upper member of this unit)
- basaltic volcanic rocks
- volcanic rocks of Sycamore Creek
- arkosic gravels and conglomerate
- granitic gneiss

Detailed descriptions of these units, their thickness and extent, and their relationships, including geologic cross-sections, are provided in Caithness' water resources (Caithness 2000a)



Legend

Resource Components
- QTg - Terrace Gravel
- Qal - Stream and Floodplain Alluvium
- Qbu - Upper Basin Fill
- Ta - Arkosic Gravel
- Tb - Basalt Flows
- Tbl - Lower Basin Fill
- Tv - Volcanic Rocks of Sycamore Creek
- Pcg - Granitic Gneiss

General Reference
- Existing Pipelines
- Mead-Liberty/Mead-Phoenix Transmission Lines
- Stream/River
- Interstate
- U.S. Route

Project Components
- Pipeline Corridor Segments
- Proposed Pipeline Corridor - R1, C1, T3, C3, T4, R5
- Alternative R Corridor - R1, R2, R3, C3, R4, R5
- Alternative T Corridor - T1, T2, T3, C3, T4, T5
- Proposed Plant Facilities

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Scale in Miles

Universal Transverse Mercator Projection
1927 North American Datum
Zone 12

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Geologic Map of the Big Sandy Basin

Big Sandy Energy Project EIS

Figure 3.2-1

and geology reports (Caithness 2000b); a previous water resources study of the Big Sandy area (Davidson 1973); the *Big Sandy Energy Project Groundwater Technical Report* (Appendix F); and in the Hydrogeologic Units and Model Development discussion in Section 3.4.

The proposed power plant site is situated on lower basin fill just west of the contact with the volcanic rocks of Sycamore Creek. The surface geology of the site consists of a minimum 30-foot-thick layer of silty sand to sandy clay material designated as partially cemented weathered volcanic ash or tuff that likely is derived from volcanic rocks that crop out upgradient of the site (Western Technologies, Inc. [Westech] 2000). These surface deposits likely are underlain by lacustrine clays, which represent the upper member of the lower basin fill unit.

Hard-rock mining for gold, silver, copper, and allied minerals historically has occurred in the Hualapai Mountains to the west and northwest of the proposed power plant site; however, most of these mines are inactive. Arizona Green Sands has an active mining operation in the southeast corner of Section 7, Township 15 North, Range 12 West (T15N, R12W) (Figure 3.2-2). This is a small surface mine that extracts a group of minerals known as zeolites from the surface clays, which are part of the exposed upper member of the lower basin fill. Numerous small sand and gravel operations exist along the Big Sandy River, which exploit the stream and floodplain deposits for construction of roads and other projects. There are no known significant coal, oil, or natural gas resources, or known potential mineral resource development areas of economic importance, within the region of influence.

Geologic Hazards

Potential geologic hazards that exist within the region of influence include earthquakes, mass movements (e.g., slope failures, slumps, rockfalls), expansive soils, and flash floods. The region of influence lies within seismic risk Zone +2, which is characterized as moderate risk.

A total of 13 earthquakes were reported to have occurred within Mohave County since 1891, with the greatest having a magnitude of approximately 5.75 on the Richter scale. The Richter scale is a common method of classifying earthquake severity, which uses a logarithmic measure of the maximum motions of the seismic waves as recorded by a seismograph. A search of the U.S. Geological Survey (USGS) National Earthquake Information Center (NEIC) database (1999) indicates that two significant earthquake events occurred within a 100-kilometer radius of the proposed power plant site. The largest event had a magnitude of 4.6 on the Richter scale.

The maximum impact that can be expected to occur at the proposed power plant site is moderate damage from an earthquake with an intensity of 7 (scale from 1 to 12) on the Modified Mercalli Intensity (MMI) scale. The MMI scale is the method used most often to classify earthquake intensity. The higher the number, the greater the associated ground-shaking intensity and/or damage. Earthquakes have varying intensities that generally decrease with increasing distance from the source (Bausch and Brumbaugh 1997).

The potential for mass movement is mainly restricted to the steep slopes along the northern margin of the proposed power plant site. In this area, there is a potential for rockfalls and slope failure. Figures 3.3-5, 3.3-6, and 3.3-7 in Section 3.3 show areas of slopes exceeding 20 percent in the vicinity of the proposed power plant site and proposed or alternative pipeline corridors (R, T, or crossover segment C2). Hazards from expansive soils exist in areas where proposed Project-related structures would be constructed on clayey soils, and particularly where these soils are hydrated due to poor drainage or the presence of springs/seeps (Westech 2000). Flash flood hazards exist within the washes that drain the site, with the highest potential to occur

during the monsoon season between July and September.

Paleontological Resources

One of the geological units in the Big Sandy Valley is the Big Sandy Formation, which is a sequence of lake-deposited sediments interbedded with volcanic ash, marginal sandstone, and conglomerate. These deposits are exposed within an area of approximately 20 square miles. The deposits are up to 65 meters thick in the center of the basin, but thin to only a few meters at the basin margins.

Vertebrate fossils have been found at two localities within a 4- to 5-meter-thick horizon of the Big Sandy Formation. These fossils are of Late Miocene to Early Pliocene age (about 5 million years old). A number of research institutions have made collections from these quarries and recovered a diversity of land mammal and bird fossils. The avian fossils are characterized as the most significant pre-Pleistocene bird assemblage in North America.

The two studied fossil quarries at both of these localities are about 3 miles south of the proposed power plant site. The plant site, well field, new access road, plus the southern 6 to 7 miles of the proposed and alternative pipeline corridors (parts of corridor segments T4, T5, R4, and R5) and the route of OPGW installation are within areas where the Big Sandy Formation is exposed or buried at shallow depth. A field survey was conducted in these areas. Although the survey did not encompass the full width of the proposed and alternative pipeline corridors, the results can be interpolated to the entire width of the corridors with two exceptions. The eastern portions of corridor segment T5 at the crossings of Sycamore Creek and Bitter Creek would warrant additional survey if that corridor segment were selected for construction of the pipeline (Archer 2000).

The survey discovered previously unreported plant fossils in the form of root casts (probably of aquatic or semi-aquatic plants) and stromatolites (algal clumps) within the proposed power plant site. These fossils are indicative of a shallow, near-shore lake environment. Further study of the root casts and stromatolite fossils would not yield important information (Archer 2000).

The ancient lake that formed within the Big Sandy Valley apparently had little through-flow or was completely blocked from draining at times and became highly saline. The salty water was unlikely to have supported abundant life. The two known fossil localities apparently represent rare situations where mammals and birds either died near the edge of the lake and were quickly buried, or died along adjacent freshwater streams and their bones were washed into the lake. Potential lake inlets that might represent such rare situations have been noted north of the proposed power plant site and to the east of the Mead-Phoenix Project 500-kV transmission line along Sycamore Creek and Bitter Creek.

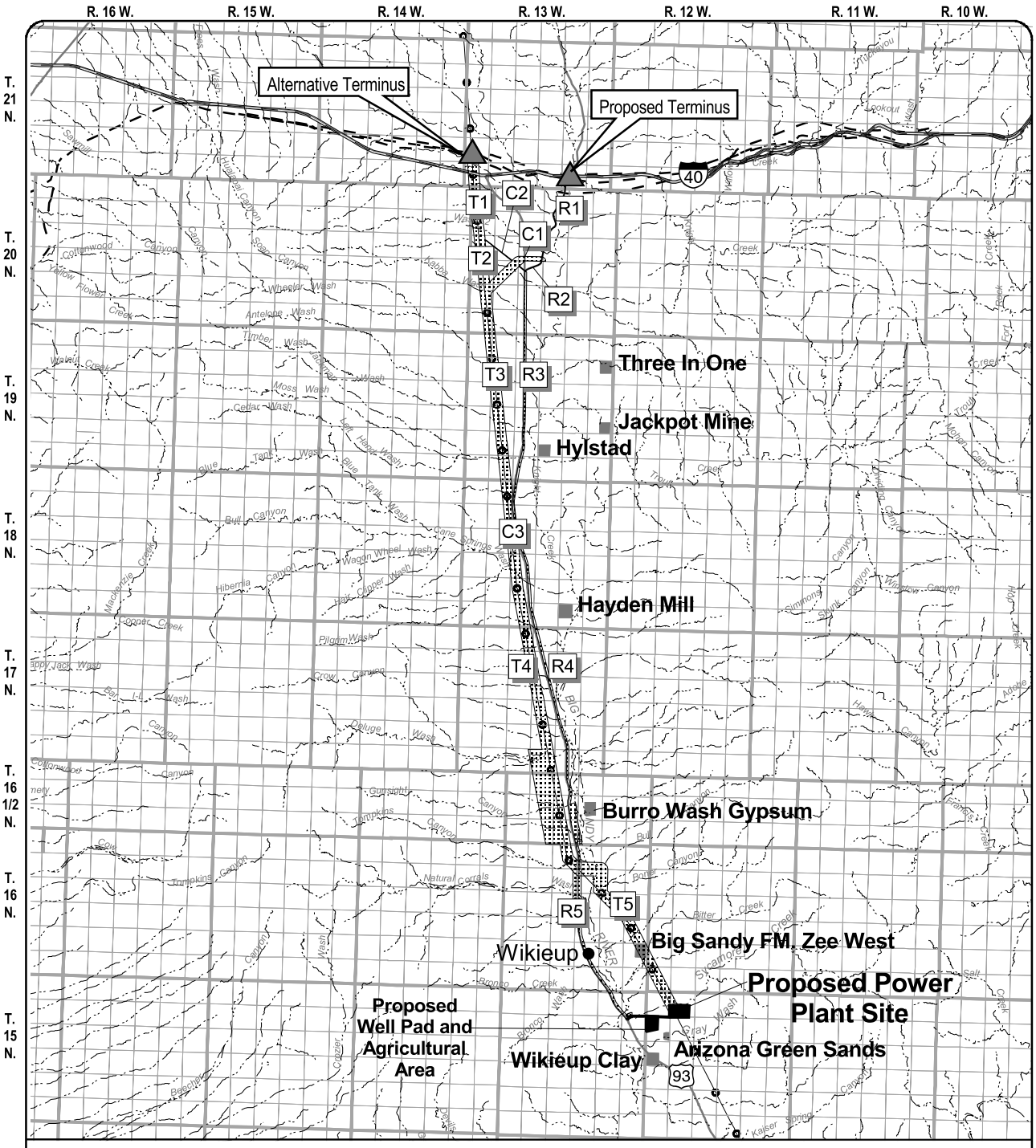
3.2.2 Environmental Consequences

The following sections outline the environmental issues related to geology and paleontology, significance criteria, and methodology and conclusions of the impact assessment. Also described are mitigation measures that could be implemented to prevent significant impacts on geological and/or paleontological resources.

3.2.2.1 Identification of Issues

The following is a list of issues that were identified as relating to geology and paleontology; these issues form the basis for the assessment of potential impacts:

- potential impacts on areas of regional geological importance
- potential impacts on paleontological resources (fossils) of scientific importance



Legend

Resource Components
- Active Mining Operations

Project Components
- Pipeline Corridor Segments
- Proposed Pipeline Corridor - R1, C1, T3, C3, T4,R5
- Alternative R Corridor - R1, R2, R3, C3, R4, R5
- Alternative T Corridro - T1, T2 T3, C3, T4, T5

General Reference
- Existing Pipelines
- Mead-Liberty/Mead-Phoenix Transmission Lines
- Stream/River
- Interstate (40)
- U.S. Route (93)

Map of Active Mining Operations

Big Sandy Energy Project EIS

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0 5 10

Scale in Miles

Universal Transverse Mercator Projection
1927 North American Datum
Zone 12

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Figure 3.2-2

- potential impacts on mining operations or areas of potential mineral resource development of economic importance
- potential impacts on the influences of geologic hazards (e.g., slope failure)
- potential for land subsidence due to groundwater withdrawal

3.2.2.2 Significance Criteria

Listed below are the significance criteria established for the identified issues. Impacts would be considered significant if they would result in the following:

- destruction of or future inaccessibility to areas of regional geological importance
- destruction of or future inaccessibility to scientifically important paleontological resource areas
- destruction of or future inaccessibility to potential mineral resource development areas of economic importance
- adverse impacts on existing mining operations that could not be mitigated
- a substantial increase in the probability or magnitude of mass movements (e.g., slope failures, slumps, rockfalls) or impacts on lands or humans from earthquakes that could be attributed to the Proposed Action.

3.2.2.3 Impact Assessment Methods

In order to assess potential impacts on geological and paleontological resources within the region of influence, available information was compiled related to geological, paleontological, and mineral resources; and geologic hazards. All relevant reports prepared by Caithness and its consultants were reviewed in order to independently evaluate and verify the accuracy and comprehensiveness of information provided by Caithness, and, where necessary, supplement this information.

After data were compiled and reviewed, and the information provided was verified, potential direct and indirect impacts on geological and paleontological resources were assessed. Particular consideration was given to the identified issues, and the significance criteria described in Section 3.2.2.2 were used to assess whether significant impacts potentially could occur.

3.2.2.4 Actions Incorporated Into the Proposed Action to Reduce or Prevent Impacts

The Proposed Action includes the following measures to reduce or prevent potential adverse environmental impacts on geological resources:

- erosion control measures on slopes (waterbars, diversion ditches, riprap, revegetation)
- compliance with UBC Seismic Zone 2b construction practices.

3.2.2.5 Impact Assessment

Proposed Action

The assessment of impacts on geological and paleontological resources is described below in terms of the significance criteria outlined in Section 3.2.2.2.

Geological Resources

There are no areas of geological importance within the region of influence. Therefore, no areas of geological importance would be destroyed or made inaccessible by the Proposed Action.

There are no known potential mineral resource development areas of economic importance within the region of influence of the Proposed

Action. Thus, the Proposed Action would not destroy nor make inaccessible any such areas.

The Proposed Action would not impact any existing mining operations. The active zeolite mine in the southeast corner of Section 7, T15N, R12W, would not be impacted by the Proposed Action, and only a very small portion of the valley's sand and gravel resources would be removed from potential development through construction of the proposed power plant, substation, and evaporation ponds. The potential economic impact of this is insignificant.

The Proposed Action would not cause a substantial increase in the probability or magnitude of mass movements. The Proposed Action requires that areas of substantial cut or fill be engineered to ensure stability, which is a common construction practice. No substantial increase in impacts on lands or humans would occur as a result of the Proposed Action because structures would comply with Uniform Building Code (UBC) Seismic Zone 2b construction practices.

There would be no potential for land subsidence as a result of groundwater withdrawal for the Proposed Action. Groundwater would be pumped solely from the volcanic aquifer, from a depth of approximately 1,000 to 1,500 feet below ground surface. The volcanic aquifer is confined, and relatively isolated from overlying aquifers. It has been estimated that groundwater levels in the volcanic aquifer may decline by as much as 85 feet as a result of groundwater pumping, and that groundwater levels in the overlying middle aquifer may decline by as much as 12 feet (refer to Section 3.4). Because the volcanic and middle aquifers are confined and have high confining pressures, these impacts would be expressed as a decrease in confining pressure. Since the aquifers would not be dewatered and become unconfined, subsidence would not occur. Furthermore, the volcanic and middle aquifers both consist of relatively incompressable materials. Pulling and tensioning sites for the OPGW would not impact any geologic resources. The sites would not impact any existing mining operations, or substantially increase the probability or magnitude of mass movements. Similarly, the installation of the microwave dishes on existing structures would have an insignificant effect on geologic resources.

Paleontological Resources

Although significant vertebrate fossils have been found within portions of the Big Sandy Formation, no significant fossils have been found or would be expected within the areas to be disturbed based on the surveys conducted. Pulling and tensioning sites for the installation of the OPGW may be located in areas not surveyed. If scientifically important paleontological resources were found there, their destruction as a result of the construction of the OPGW would be considered a significant impact. The microwave dishes would be installed on existing towers and would have no impact on paleontological resources.

Alternative R Gas Pipeline Corridor

Potential impacts resulting from the Alternative R gas pipeline corridor would be the same as those described for the Proposed Action.

Alternative T Gas Pipeline Corridor

Potential impacts resulting from the Alternative T gas pipeline corridor would be the same as those described for the Proposed Action except that the pipeline may be located in areas not surveyed. If scientifically important paleontological resources were found there, their destruction as a result of the construction of the transmission line would be considered a significant impact.

No-Action Alternative

Under the No-Action Alternative, the Project would not be constructed and there would be no change or disturbance of geological or

paleontological resources within the Big Sandy Valley.

3.2.2.6 Mitigation and Residual Impacts

If adopted, the following measures would be implemented to avoid or reduce significant impacts:

- If unknown invertebrate fossils (or suspected invertebrate fossils) are encountered, construction activities in the immediate area would cease and a qualified paleontologist would be contacted. Construction activities would not re-commence until the area is cleared, or the area is avoided.

- If the eastern portion of corridor segment T5 more than 100 feet east of the Mead-Phoenix Project 500-kV transmission line right-of-way is selected for construction, a paleontological field survey would be conducted at the crossings of Sycamore Creek and Bitter Creek. If significant fossil localities are found in these areas, construction activities would not re-commence until the area is cleared, or the area avoided.

With the implementation of these measures, there would be no residual significant impacts.

3.3 SOILS

This section describes the affected environment and environmental consequences as they relate to soils in the vicinity of the Proposed Action.

3.3.1 Affected Environment

The following sections describe the various soils in the vicinity of the Proposed Action. The location and description of each soil type serves as a baseline for the assessment of environmental consequences, and assists in determining appropriate mitigation measures.

3.3.1.1 Region of Influence

The region of influence for assessing impacts on soils includes the power plant site and ancillary facilities, access roads, rights-of-way where ground-disturbing activities (e.g., water pipelines) could occur, the proposed gas pipeline corridor, the alternate gas pipeline corridors, and the areas of disturbance associated with the potential installation of the OPGW. The region of influence also is considered to be all surface areas that could be impacted by soil erosion.

3.3.1.2 Existing Conditions

Soils in the region of influence were surveyed and mapped by the Natural Resources Conservation Service (NRCS) in 1974. The survey is described by the NRCS as "tentative and subject to revision, correction, or completion," and has not yet been published. The soils survey data were compiled onto a map and described in the *Big Sandy Energy Project Soils Report* (Caithness 2000).

Figures 3.3-1 through 3.3-4 (taken from the above-named soils report) show 36 soil map units in the region of influence, based on the soils survey data provided by the NRCS. These figures also show locations of steep slopes (greater than 20 percent) and identify four areas along the corridors where steep slopes coincide with soil types that have severe or very severe erosion potential. Mapping of potential pulling and tensioning sites for the OPGW installation was not done, since these have not yet been located.

- The 36 soil map units presented on Figures 3.3-1 through 3.3-4 represent 25 soil types or associations, which are listed in Table 3.3-1 by soil name and associated map unit number(s). Table 3.3-1 includes the description, setting, and parent material of each soil type/association, range in slope, percentage rock fragments, permeability, runoff, depth, drainage, pH, water erosion hazard, wind erosion hazard, and shrink-