DOE/EIS - 0138D
Volume IV Appendix 5a of 16

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

SUPERCONDUCTING SUPER COLLIDER

Volume IV
Appendix 5a

August 1988

U.S. Department of Energy
Washington, DC 20585

218-829 - 88 - 1 (BOOK 3)

VOLUME IV

APPENDIX 5A

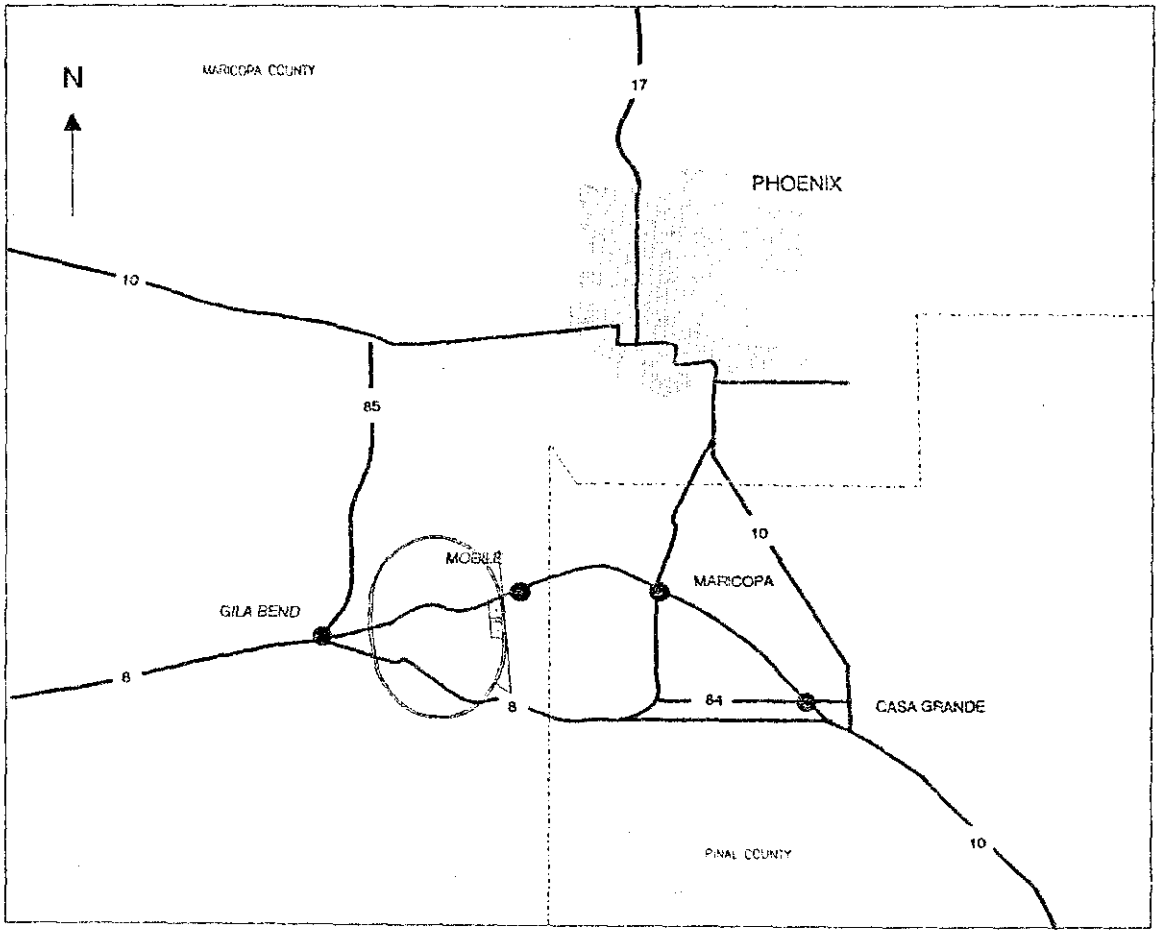
AFFECTED ENVIRONMENTS AT ALTERNATIVE SITES

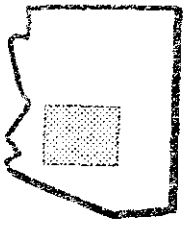
5.1 ARIZONA

5.2 COLORADO

Affected Environments at Site Alternatives

A R I Z O N A





Arizona - The proposed site is located approximately 30 miles southwest of Phoenix, Arizona in the southern portion of Maricopa County. Ninety-two percent of the tunnel would be constructed by tunneling techniques and 8 percent by cut and cover in unsaturated materials (principally fanglomerates, granite, and interbedded volcanic and sedimentary rocks). The entire tunnel would lie completely above the water table.

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5.1 ARIZONA

5.1.1 Earth Resources

5.1.1.1 Physiography and Topography

The Arizona site lies in the Sonoran Desert section of the basin and range physiographic province (Fenneman 1931). Physiography of the site vicinity includes widely separated, discontinuous mountain ranges rising hundreds to thousands of feet above a desert plain (Figure 5.1.1-1). The plain consists of numerous alluvial coalescing fans (the toes of which form bajadas) flanking the mountains. Occasional isolated outlier hills protrude 530 to 570 ft above the alluvial fans. Exposed bedrock on the isolated knobs, and within the Maricopa Mountains, is weathered and provides a supply of new detritus to the surrounding bajada surfaces. Drainage courses intermittently carry water down the fans to major washes that feed into the Gila River. Three major drainages are present in the site area: Waterman Wash, which drains the northeast quadrant into Rainbow Valley; Bender Wash, which receives runoff from the west and southwest portion of the ring; and Vekol Wash, which drains the southwest quadrant into the Vekol Valley.

The site encircles the southern two-thirds of the Maricopa Mountains (U.S.G.S. 1951a,b; 1952b). The collider ring lies mostly on the bajadas at lower elevations (down to 1,160 ft). Mountain peaks within the site range from 2,200 to 3,270 ft in elevation. Only where the ring crosses the mountains does the center-line topography rise to 2,340 ft (U.S.G.S. 1973). The bajada surfaces slope 40 to 70 ft/mi; their surfaces are marked by numerous, parallel, slightly incised dry drainages (U.S.G.S. 1951 a,b,c). The Maricopa Mountains rise 530 to 1,120 ft above the heads of the fans. Fan surfaces sloping westward from the mountains descend to a 840-ft elevation at Gila Bend (U.S.G.S. 1951c); fans draining to the northeast descend into Little Rainbow Valley (Waterman Wash) at an elevation of 1,200 ft (U.S.G.S. 1951b). The head of a third valley, Vekol Valley, lies southeast of the site (U.S.G.S. 1951a; 1963). The Maricopa Mountains are separated from a neighboring range, the Sand Tank Mountains, by a narrow draw named Bender Wash (U.S.G.S. 1951a).

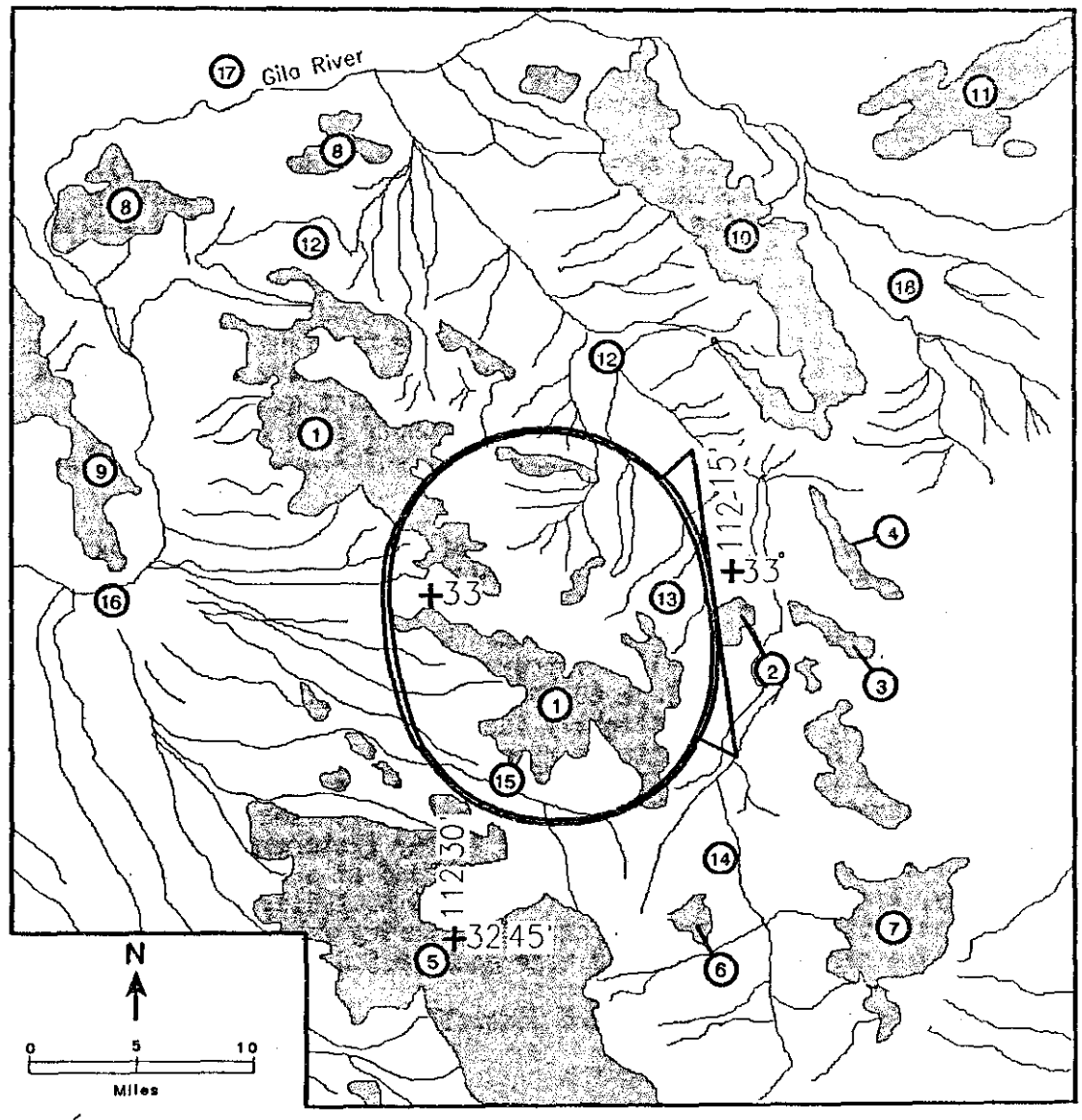
Drainage courses in the mountains are generally incised by 200 to 280 ft.

5.1.1.2 Stratigraphy

The general rock types present within and surrounding the Maricopa Mountains are shown in the stratigraphic column Figure 5.1.1-2. Lithologic descriptions of the units in the column are presented in Table 5.1.1-1. Detailed descriptions and maps of the area are limited prior to 1987; information provided in this section was obtained from Welty et al. (1988) and Cunningham et al. (1987), and site visits. The time scale used to approximate the ages of the rocks units is the "Decade of North American Geology 1983 Geologic Time Scale" (Palmer 1983).

Figure 5.1.1-1

TOPOGRAPHIC SETTING OF ARIZONA SITE

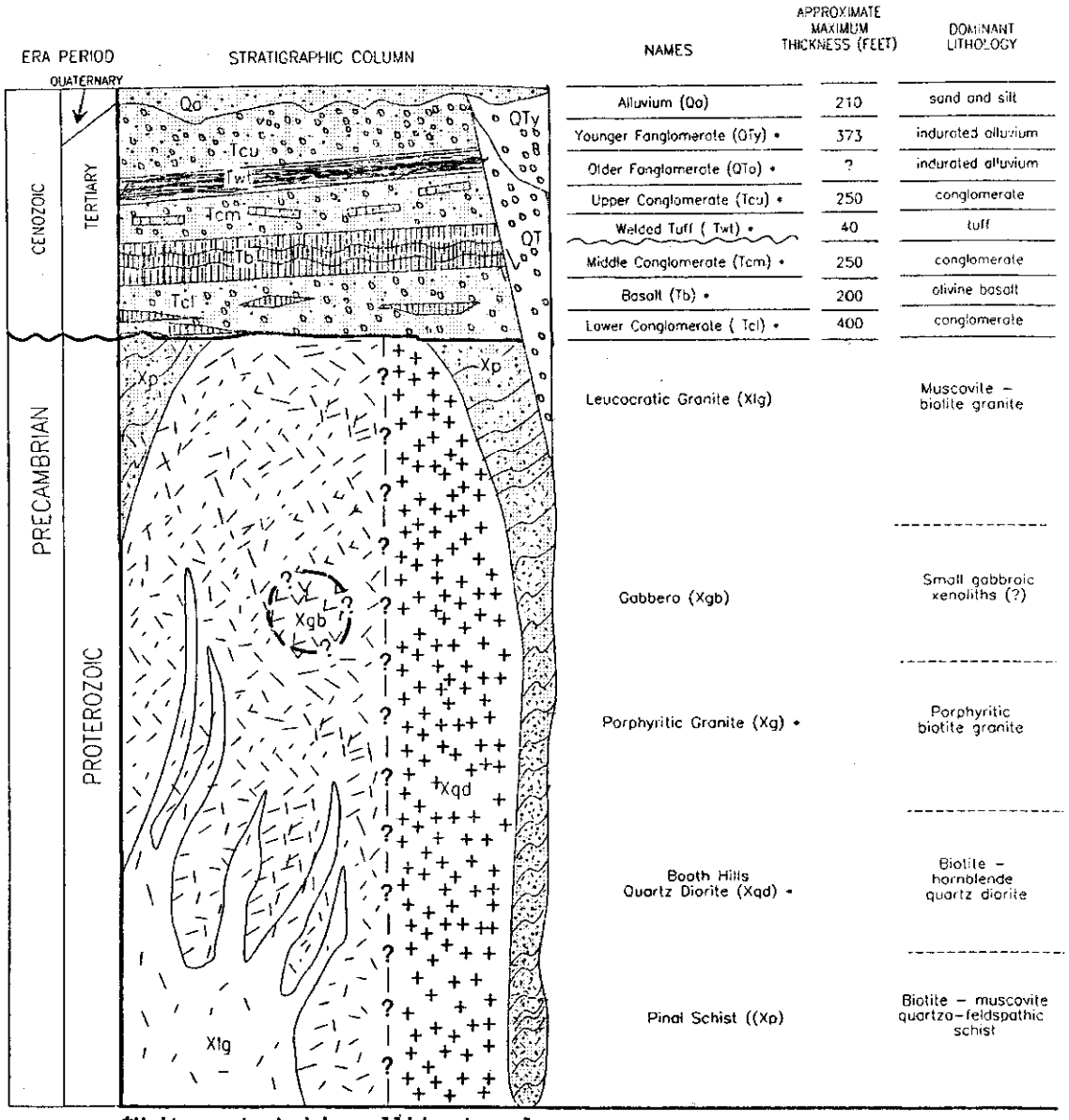


Mountains
1. Maricopa Mts.
2. Both Hills
3. Haley Hills
4. Palo Verde Mts.
5. Sand Tank Mts.
6. White Hills
7. Table Top Mts.
8. Buckeye Hills
9. Gila Bend Mts.
10. Sierra Estrella
11. South Mts.

Valleys
12. Little Rainbow V.
13. Mobile V.
14. Vekol V.
15. Bender Wash
16. Gila Bend
17. Buckeye V.
18. Santa Cruz Wash

Figure 5.1.1-2

STRATIGRAPHIC COLUMN - ARIZONA SSC SITE



***Unit penetrated by collider tunnel.**

Source: Welty et al. 1988.

Table 5.1.1-1

LITHOLOGIC DESCRIPTIONS

Formation	Lithology	Other Characteristics
Alluvium	Thin deposits of sand and silt:	
Basin-Fill (Younger Fanglomerate)	Well to extremely poorly sorted, weakly to moderately cemented silt, sand, and gravel derived from eroded porphyritic granite, quartz diorite, and Pinal schist and, locally, basalt and tuff. Locally dominated by fine sandy or clay-rich silts, or interbedded clayey sands and sandy clays. Unit becomes generally finer basinward, though locally rapid vertical variability in sedimentary texture, unit thickness, and grain size has been observed. Sediments were probably deposited in medial and distal alluvial fan environments as intermittent stream overbank, sheetflood, and channel deposits, and as playa or playa-edge sediments.	Compressional wave velocities vary from 2,000 to 8,500 ft/s.
Basin-Fill (Older Fanglomerate)	Indurated, poorly sorted sandy gravel.	Older Fanglomerate distinguished from Younger Fanglomerate by compressional wave velocities that range from 6,900 to 11,000 ft/s.
Upper Conglomerate (Tertiary)(1)	Polylithologic clasts in a dark red quartzose to calcareous cement. Includes basalt flows and beds of tuffaceous sandstone.	Clasts generally range from 2 to 5 inches, with some up to 20 inches in diameter.
Welded Tuff (Tertiary)(1)	Reddish-gray, massive welded tuff.	Fractured horizontally and vertically.
Middle Conglomerate (Tertiary)(1)	Clasts of granite and schist in quartzose cement. Includes intercalated vesicular basalt flows with a thin, very fine-grained, thinly laminated, lacustrine limestone, and a basal sandstone.	Clasts are smaller than those in upper and lower conglomerates.
Basalt Flows (Tertiary)(1)	Dense to vesicular, black to medium-gray olivine basalts.	Flow foliation is common.

Table 5.1.1-1 (Cont)

Formation	Lithology	Other Characteristics
Lower Conglomerate (Tertiary)[1]	Poorly sorted, subangular to subrounded, granitic clasts cemented by a dark red, locally arkosic, quartzose cement. Local lenses of tuffaceous sandstone.	Clasts are between 1 inch and 3 ft in diameter. Depositional contact with basement.
Porphyritic Granite	Gray to brownish-tan, medium- to very coarse-grained porphyritic biotite granite. Includes intrusive concordant and discordant masses of leucocratic, tan to cream, fine- to medium-grained muscovite-biotite granite (Xlg), and several small gabbroic bodies (Xgb) in the central portion of the range.	Undeformed to well foliated--mostly weakly to moderately foliated. Local mylonitic fabric. Phenocrysts of potassium feldspar are up to 2 inches long.
Booth Hills Quartz Diorite	Mesocratic, fine- to medium-grained, biotite-hornblende quartz diorite.	Epidote along fractures replaces biotite and hornblende, and 0.5 to 0.75 inch quartz augen are common.
Pinal Schist	Fine- to medium-grained biotite-muscovite, quartzofeldspathic schist, characterized by medium gray to brownish gray muscovite up to 0.5 inch long. Intruded by abundant muscovite pegmatites (locally appears migmatitic).	Strong foliation parallel to lithologic layering and penetrative lineation in the plane of foliation. Deformation includes minor folds, fold boudins, intrafolial folds, and sheared-out chevron folds locally.

1. Significant lateral variation in the Tertiary sedimentary and volcanic units, as seen in the poor correlation between borehole logs, merits consideration of a single undifferentiated Tertiary unit. This unit is generally made up of varying thicknesses of the subunits described below. The stratigraphy implied in the following descriptions is present in at least one area but is not considered laterally consistent.

Source: Welty et al. 1988.

Three distinct lithologic groups make up the rock types at the Arizona site. Proterozoic include from oldest to youngest, the pinal schist, dionite and granite, diorite, porphyrite granite, gabbro, and leucocratic granite. These rocks were formed during the early Proterozoic, about 3,400 million years ago. The Proterozoic, metamorphic, and intrusive rocks in the Maricopa Mountains are overlain in the southern portion of the mountains by an interbedded sequence of Tertiary (1.8- to 65-million-year-old) volcanic and sedimentary rocks. The Tertiary units are, from oldest to youngest, felsite dike, mafic dike, lower conglomerate, basalt, middle conglomerate, welded tuff, and upper conglomerate. The ages of the Tertiary units are not well known. The felsite and mafic dike units were intruded some time during the Tertiary (1.8 to 65 million years ago). The lower conglomerate, basalt, middle conglomerate, and welded tuff were deposited during the Mid-Tertiary (sometime between 20 and 40 million years ago). The upper conglomerate was most likely deposited during the late Tertiary (1.8 to 20 million years ago).

The valleys surrounding the mountains are filled with less indurated silt, sand, and gravel composing the older and younger fanglomerates. The fanglomerates were deposited between the Late Tertiary (about 50 million years ago) and the Quaternary (1.8 million years ago to present).

5.1.1.3 Geologic Structure

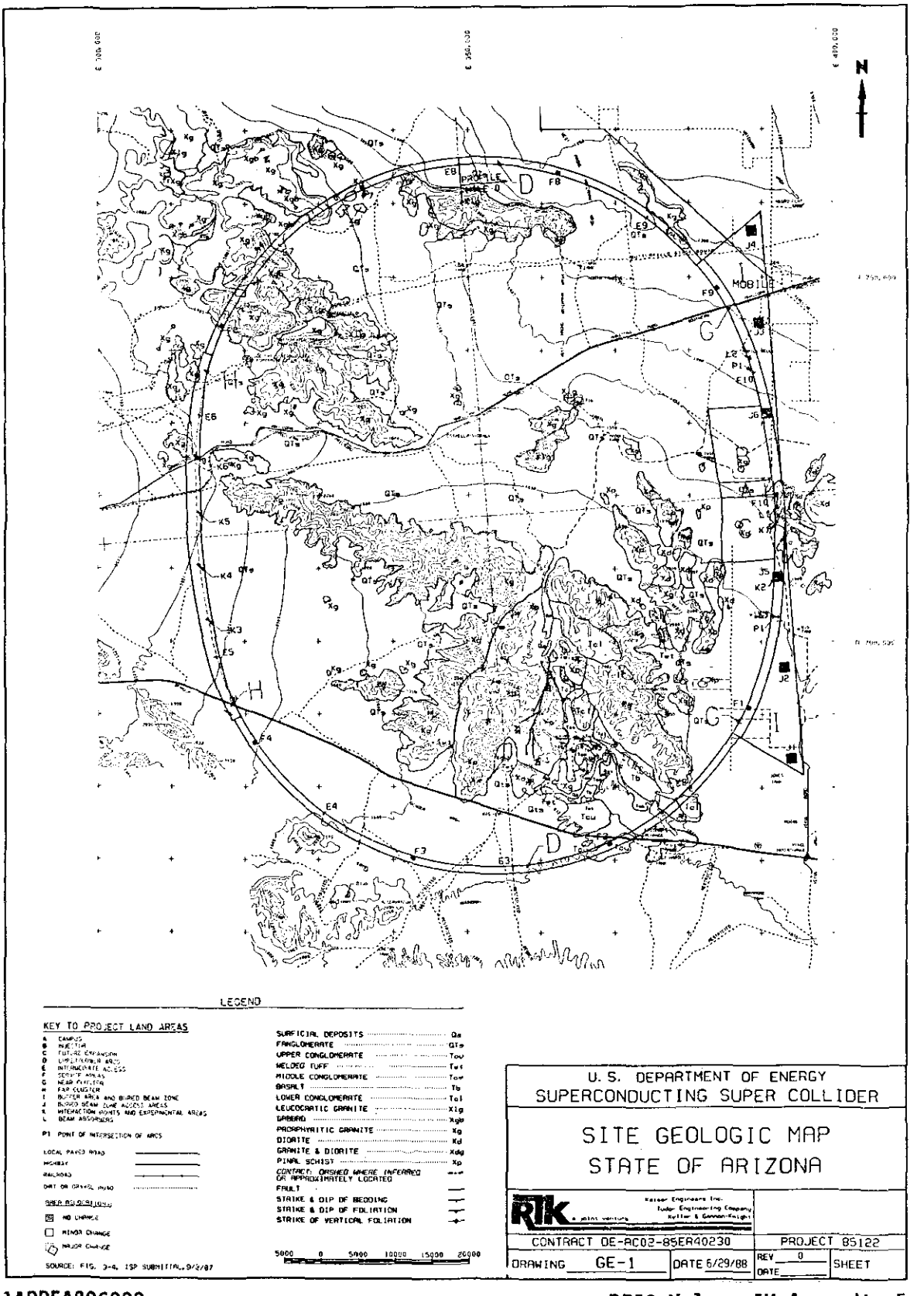
The surficial geology of the Arizona SSC site is shown in Figure 5.1.1-3. A cross section along the SSC ring is presented in Figure 5.1.1-4. The following discussion and the accompanying figures are based on recent information documented by Welty et al. (1988) and site visits.

The geologic setting of the Arizona site comprises two discrete elements, the Maricopa Mountains and the surrounding basins. The Maricopa Mountains are made of Proterozoic (over 570-million-year-old) schists that have been intruded by Proterozoic granitic rocks. These are unconformably overlain in the southeastern portion of the ring by a sequence of Tertiary (between 1.8- and 65-million-year-old) volcanic and sedimentary rocks. Valleys between and around the mountains are filled with younger sediments. Dense, compacted, weakly cemented alluvium (fanglomerate) constitutes most of the material the tunnel will intersect. The lithologies of these rocks were described in Section 5.1.1.2.

The site area is in a basin and range type of structural setting characterized by normal faults along which the basins have been down-dropped relative to the mountains. Erosion since the main period of mountain-building activity some time during Miocene (5-24 million years ago) has reduced the mountains in size and filled the down-faulted basins. The major block-bounding faults are now essentially inactive and buried beneath Quaternary (less than 1.8-million-year-old) alluvium, some distance from the present foot of the mountains. Although no direct evidence for such faults is known in the vicinity of the site, they may be postulated to exist based on the location of the site within the Basin and Range tectonic province.

Figure 5.1.1-3

SURFICIAL GEOLOGY OF ARIZONA SSC SITE



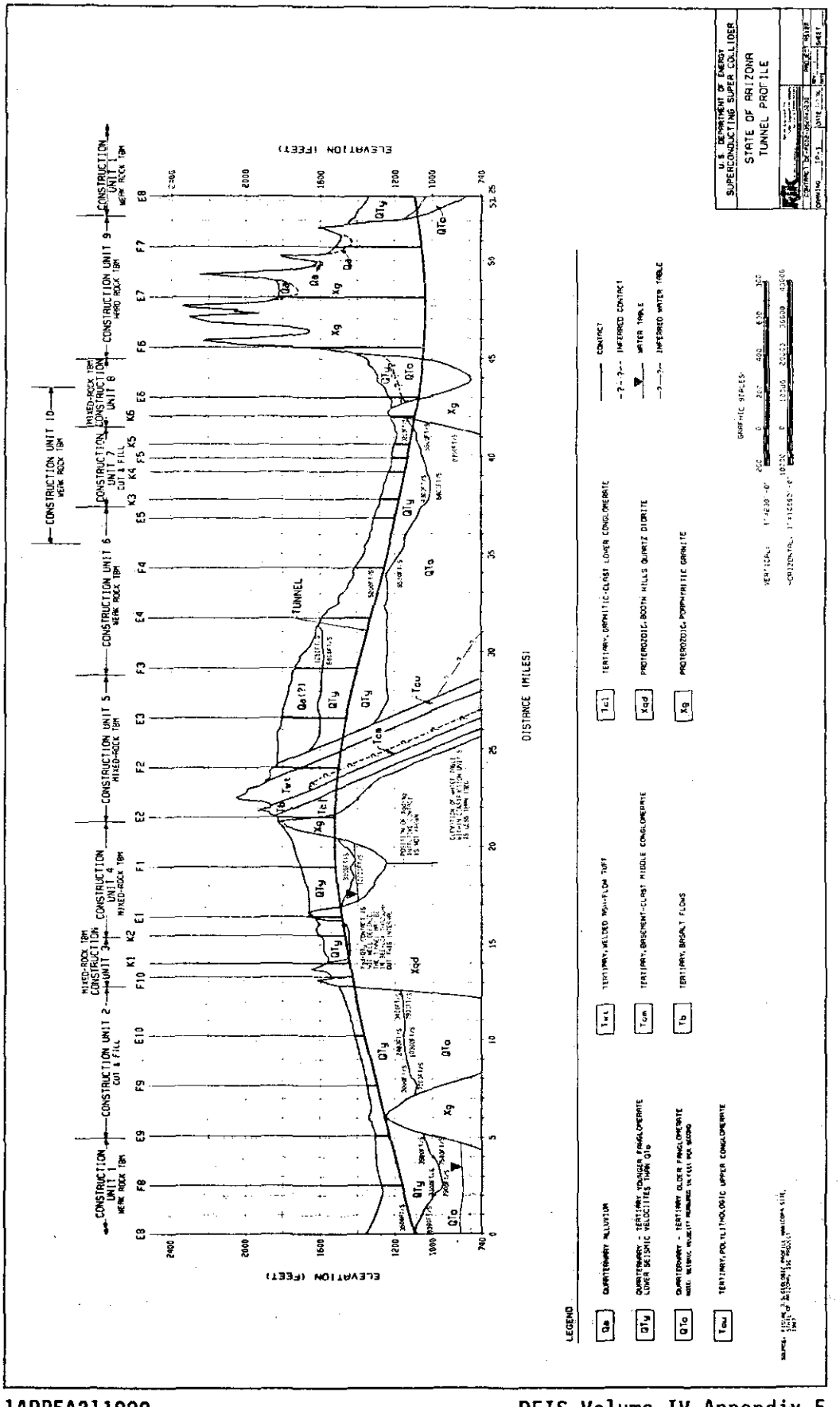


Figure 5.1.1-4

CROSS SECTION ALONG THE SSC RING

The structural complexity of the Maricopa Mountains is not entirely understood. Most of the basement rocks are granitic plutons believed to have intruded the schist about 1.7 billion years ago. The relationship between the two distinct intrusive rock types (the Leucocratic granite and the porphyritic granite) is uncertain as is the nature of mylonitic and cataclastic shear zones within them. However, foliation in all basement rocks generally strikes northeast and dips about 60 degrees (except in areas of localized deformation, as in the center of the range).

The Tertiary sequence of volcanic and sedimentary rocks appears confined to an asymmetric trough that plunges to the southeast. The Tertiary rocks are made up of heterogeneous and laterally discontinuous beds that strike roughly N45°W and dip southwest. An unnamed fault system occurs near the western edge of the trough.

Table 5.1.1-2 describes the characteristics of known faults in the vicinity of the site. The Sand Tank fault, about 6 mi southwest of the ring, is the only known Quaternary fault in the vicinity of the ring alignment. It is a short fault that displaces alluvium covering a pediment at the northwestern end of the Sand Tank Mountains. The surficial fault

Table 5.1.1-2

SUMMARY OF FAULT CHARACTERISTICS

Fault	Location	Strike	Dip	Width	Displacement/Age
Sand Tank	6 mi W-SW	NE	NW	--	6 ft/8000-20,000 yr
Unnamed Complex (7 faults)	3.5 mi inside SE ring	N-NE	Near Vertical	Locally up to 10 ft, more commonly 1 to 2 ft	Tertiary
Unnamed	3.5 mi inside S ring	NE	Near Vertical	Locally up to 10 ft, more commonly 1 to 2 ft	pC mylonite zone with gouge (Tertiary reactivation.)
Unnamed	<1 mi inside NW ring	NW	90°	1 ft	Precambrian

Source: Cunningham et al. 1987; Welty et al. 1988; Welty 1988.

scarp is less than 2 mi long with a maximum scarp height of 5 to 6 ft. Based on the surface morphology and trenching studies, the fault is believed to have ruptured once in late Quaternary time between 8,000 and 20,000 years ago.

There is no good evidence of previous ruptures during the preceding few tens of thousands of years suggesting that surface-rupture recurrence intervals are in the 50,000- to 1-million-year range. The potential seismic hazard associated with this structure is discussed in Section 5.1.1.5. The other unnamed faults within the Proterozoic rocks lack evidence of Quaternary movement and are all considered inactive.

Joints are common throughout all rocks except the alluvium and basin-filling fanglomerate. Joints identified in the volcanic rocks dip about 30 degrees to the southwest and northwest and are spaced one to two per foot. At least five sets of joints with vertical to 30-degree dips were identified in the porphyritic granite. These dip to the northwest, southwest, and southeast and average one and a half to two per foot.

Two of these joint sets persist into the quartz diorite where their density increases to five joints per foot. Jointing varies in density over short distances and appears most concentrated in the vicinity of major structural discontinuities.

5.1.1.4 Geoengineering Conditions

The geoengineering materials at the Arizona site include:

- o Recent alluvium
- o Basin-fill (Younger and Older Fanglomerates)
- o Fanglomerate
- o Granitic rocks
  - quartz diorite
  - porphyritic granite
- o Volcanic assemblage
  - basalt
  - conglomerate
  - welded tuff.

Recent alluvium is found in isolated pockets in the Maricopa Mountains (northwest portion of the site) and in the Bender Wash area (southern portion of the site). Alluvium is expected at four shaft locations. Recent alluvium at the Arizona site was not studied but may contain sands, silts, and clays. Although only clay deposits were reported near the site, soft clays, unconsolidated sands, and collapse-susceptible

soils may be present. These soil conditions are typically found in similar environments (Beckwith and Hansen 1982; Dudley 1970).

Basin-fill sediments (Older and Younger Fanglomerate) cover almost the entire site with the exception of the Maricopa Mountains and the Booth Hills area. Approximately 67% of the collider ring alignment is in the basin-fill sediments and fanglomerate. Basin-fill is found at 13 shaft locations, two experimental halls, and the booster facilities. Fanglomerate is expected at only one shaft location.

Basin-fill sediments (Older and Younger Fanglomerate) cemented alluvium composed of clay to gravel, generally classified as silty sand from site investigations (Nowatzki et al. 1988). Moisture content and plasticity are generally low and strength characteristics good. Seismic velocities indicate moderately dense basin-fill materials and hard, dense fanglomerate. The available geoengineering properties for the basin fill sediments (Older and Younger Fanglomerate) are presented in Table 5.1.1-3. These properties are based on the Unified Soil Classification System (USCS) designation of soils.

Porphyritic granite, quartz diorite, and an assemblage of volcanic rocks with interbedded sedimentary rock are present at the site. Formations at the collider ring alignment include both the granitic rocks and the volcanic assemblage, with granitic rocks also expected at two to three experiment hall locations. Granitic rocks may be found at six shaft locations and the volcanic assemblage at two shaft locations. Minor quartz diorite may be found at the booster/injector facilities area. The rock units generally show fair to good strength characteristics. Granitic materials show medium high to high strength which generally appears to be dependent on weathering. Tests of a diabase dike show moderate strength. The volcanic assemblage contains materials with characteristics varying from weak conglomerate to dense massive basalts and welded tuff. The available geoengineering properties for the granite rocks and volcanic assemblage are presented in Table 5.1.1-4.

Drill hole data, cores, and exposures of the sediments and rock reveal the following:

- There is very good pit-wall stability and excavatability using conventional scrapers in materials similar to the basin fill sediments and the fanglomerate.

- Properties in the granitic rocks are expected to vary rapidly because of intrusions, weathering, fracture intensity, and sheared zones.

- Rapid changes in lithology and mechanical properties may be anticipated in the volcanic assemblage which may contain several conglomerate units, basalt interflows, nonwelded tuffs, sandstone, and limestone.

Table 5.1.1-3

GEOENGINEERING PROPERTIES OF BASIN-FILL (YOUNGER FANGLOMERATE) SEDIMENTS

Unit	Soil Type USCS	Bulk	Density lb/ft^3 Dry	Moisture Content %	Liquid Limit/ Plasticity Index	Unconfined Compressive Strength $lb/inch^2$	Cohesion $lb/inch^2$	Friction Angle	Remarks
Basin-fill various borings*	SM[2],SC[3]	ND[4]	ND	5.1 (0.9-12.6)	31/9 (19-54/1-29)	(15-18)	(7.6-8.7)	(36-40)	
Borehole MA-12		105.7 (100.7-109.8)	96.6 (89.2-104.6)	9.7 (3.4-17.4)	22-37/13	ND	ND 15	32	Direct shear tests
Borehole MD-12		129.8 (117.6-140.0)	116.3 (101.9-120.3)	11.8 (7.2.-28.4)	ND	ND	(62.5)	(27)	Direct shear tests
							(13.9-79.2)	(26-39)	Triaxial tests

Notes:

Data values are averages with ranges shown in parenthesis.

1. LL/PI - Liquid limit/plasticity index.
2. SM - Silty sand
3. SC - Clayey sand
4. ND - No data available

* Five borings drilled and sampled for the SSC proposal preparation.

Sources: Nowatzki et al. 1988; Denatale et al. 1987.

Table 5.1.1-4

GEOENGINEERING CHARACTERISTICS OF THE GRANITIC ROCKS AND VOLCANIC ASSEMBLAGE

Unit	Seismic Velocity Ratio	Unconfined Compressive Strength lb/inch^2	Tensile Strength	Young's Modulus lb/inch^2	Poisson's Ratio	Bulk Density lb/inch^2	Cohesion lb/inch^2	Friction Angle
Granitic Rocks								
Porphyritic granite	ND	12,000 (Mod. Weathered) 17,800 (Fresh)	ND	ND	ND	163-169	3,400-2,800	45-46
Quartz diorite	ND	28,500	ND	ND	ND	169	ND	ND
Diabase dike	ND	4,500	ND	ND	ND	185-187	ND	ND
Granodiorite	ND	ND	ND	ND	ND	ND	5,100	47
Volcanic Assemblage								
Basalt	ND	7,800	ND	ND	ND	158-161	1,200	57
Conglomerate								
Lower	ND	(167-630)	ND	ND	ND	135-140	ND	ND
Middle	ND	(1,646-1,795)	ND	ND	ND	151-152	ND	ND
Upper	ND	(657)	ND	ND	ND	135	ND	ND

Notes: Unconfined compressive strength values are averages derived from confined compression and point load tests. Where available, ranges from confined compression tests are shown in parentheses.
ND - No Data Available.

Source: Cummings et al. 1988.

- Zones of intense fracturing (usually less than 10 ft thick) are found in the granitic materials.

- Based on borehole information, fracture zones occur at vertical intervals of 50 to 100 ft in the porphyritic granites and 25 ft in the quartz diorites in some borehole sections. Boreholes in the porphyritic granites were located in topographic embayments (Engineers International 1988). Therefore, the intensity of fracturing may have been overestimated. Occurrences of intensely fractured zones can be expected to increase under topographic lows and align with the orientation of the surface feature.

- Groundwater inflows should not be present since the entire tunnel would be above the groundwater table.

- Possible perched groundwater of unknown thickness between 150 and 200 ft in depth, was noted in a borehole near the campus area (Nowatzki et al. 1988).

5.1.1.5 Geologic Hazards

Seismic activity in Arizona is generally low, with most of the earthquakes occurring along the southern edge of the Colorado Plateau and in the transition zone between the plateau and the Sonoran Desert. The SSC site is in Zone 2 of the Uniform Building Code (International Conference of Building Officials 1988) seismic risk map. This zone is characterized as an area that can expect moderate earthquake damage, corresponding to modified Mercalli (MM) intensities up to VII. The area surrounding the site is the area of lowest seismicity in the western United States. Seismicity maps of this area show a cluster of small earthquakes near the southwestern corner of the state. Several of the events in the cluster may be poorly located events that were associated with tectonics in the Salton Trough in adjacent California (Arizona Public Service Co. 1978; Mokhtar 1979).

Between 1875 and 1980, 11 earthquakes were reported in the region, all with intensities smaller or equal to V intensity. Four of the events were centered 200 or more mi west of the Arizona site on the San Andreas fault system (Dubois et al. 1982). Isoseismal maps (Dubois et al. 1982) indicate the Arizona site has experienced no earthquake shaking with MM intensities equal to or greater than VI (the lower limit for structural damage).

Microearthquakes (magnitude smaller than 3.0) have been experienced in the region, but there does not appear to be any systematic pattern to the microearthquake seismicity, and it does not appear to be related to any obvious structural feature. On the basis of recurrence of these events, it is reasonable to assume that there will be about one microearthquake per year in the region (Welty et al.). Based on historical seismicity, an acceleration of less than 0.06g has a 90% probability of not being exceeded within 50 years (Algermissen et al. 1982). Potentially active faults that have not generated earthquakes in historical times were not considered in the Algermissen et al. probability analysis.

The nearest potentially active fault is the Sand Tank fault about 6 mi southwest of the SSC site (Pearthree et al. 1983). The fault has ruptured the ground surface at least once in the late Quaternary, possibly as recently as early Holocene (8,000 years ago) (Section 5.1.1.3). Although this fault must be considered to have a seismic potential, the geology indicates that it ruptures infrequently with perhaps as much as 50,000 to 1 million years between events. The magnitude of earthquakes associated with this rupture is not known but can be estimated from geologic data such as length of surface rupture and amount of past displacement. Depending upon the assumptions made and the empirical relationships used (e.g., Slemmons 1977), estimates of a maximum credible earthquake (MCE) range from about magnitude 5.5 to 7.0. Considering the tectonic regime, field data, and assumptions, an MCE for the Sand Tank fault of about magnitude 6.6 seems extremely conservative. Such an event could generate accelerations at the site of about 0.42g, according to the attenuation relations of Joyner and Boore (1981). The probability of the Sand Tank fault generating ground motions greater than those of Algermissen et al. (1982), given a magnitude 6.6 event with a recurrence interval of 50,000 years, is about 0.1000 which is the same value Algermissen et al. arrived at based on historical seismicity.

The occurrence of an earthquake, such as the MCE postulated for the Sand Tank fault, could generate downslope mass movements. In the desert environment, and in primarily granitic rocks such as those at the SSC site, mass movements would most likely consist of rock falls rather than slumps or earth flows. Empirical data of Wilson and Keefer (1985) indicate a magnitude 6.6 earthquake can cause such rock falls up to a distance of about 50 mi. However, the probability analysis indicates that the probability of occurrence of a magnitude 6.6 event, and hence rockfalls, is very remote.

Because alluvial materials at the site are generally not saturated, the seismic liquefaction potential is very low.

Ground subsidence sometimes occurs when excessive pumping causes increased effective stresses initiating consolidation of clay layers; compaction of coarse-grained layers is generally considered to be negligible. Subsidence caused by groundwater withdrawal has occurred near the Maricopa site. Areas of known earth fissures caused by water withdrawal and subsidence are located near Stanfield and Maricopa, approximately 12 and 7 mi, respectively, from the site (Schumman and Genualdi 1986). Subsidence has also been reported in the Gila Bend area west of the site (Schumman and Genualdi 1986). The Stanfield and Maricopa areas are in the Lower Santa Cruz hydrologic basin, while the Gila Bend hydrologic basin is several miles west of the site; none of the areas are hydrologically connected to the site locale (Schumman, Laney, and Cripe 1985). However, materials prone to subsidence, such as the clayey deposits at the Arizona Hazardous Waste Management Facility currently under construction near Mobile (EPA (region 9) 1983), may be present at the SSC location.

These deposits suggest that the interior of the ring may have deposits with susceptibility and the potential for subsidence if groundwater withdrawal is not controlled. Other causes of subsidence, such as dissolution of bedrock (leading to sink holes) and pumping of pressured oil and gas reservoirs are absent at the Maricopa site.

Hazardous excavation conditions, such as gassy ground or high rock stress, are not described in the literature for the region and hence are not expected at the Arizona site. Similarly, there are no hazards caused by volcanism. Debris flows may occur in the major washes on the alluvial fans in association with flash floods.

5.1.1.6 Economic Geologic Resources

Southern Arizona has been known historically for its wealth of geologic resources and there has been substantial regional exploration and development. Recent and ongoing construction of several large-scale engineering projects, including the Central Arizona Project aqueduct system and the Palo Verde Nuclear Generating Station, has required development of abundant aggregate resources.

A. Earthen Construction Materials

Numerous sources of commercial aggregate material for construction are located in the area. The largest of these is a deposit along the Gila River about 20 to 40 mi from the site (Welty 1988). Known reserves along the river conservatively approach 600 million tons and may total 2.9 billion tons if additional extraction is permitted by the Gila River Indian Tribe (Welty 1988). Other commercial sources of aggregate are located in Gila Bend and Casa Grande, as well as throughout the Phoenix area (Welty 1988). The granitic rocks of the Maricopa Mountains have also been considered for their aggregate potential in studies conducted for the U.S. Air Force (Fugro National, Inc. 1978) in which they were described as probably (though possibly marginally) suitable for use as a concrete aggregate. However, the regional abundance of aggregate material from both fluvial and intact sources diminishes the importance of the Maricopa Mountains as a potential additional source.

Cement is available from two plants in Arizona and one in Hermosillo, Mexico. The largest of these has an annual capacity of 1.3 million tons with reserves estimated at 100 years. This plant is located in Rillito near Tucson, about 80 mi from the site (Welty 1988). A plant in Clarkdale, 150 mi from the site, has an annual capacity of 560,000 tons and estimated reserves of 180 years (Welty 1988). The supply of cement in Arizona is supplemented by the 1-million-ton/yr plant in Hermosillo, Mexico, with reserves estimated at 50 years (Welty 1988).

B. Energy Resources

The areas of geothermal potential shown in Figure 5.1.1-5 surround wells or springs in which measured water temperatures range from 30° to 50°C, and temperatures calculated through chalcedony geothermometry range from 30° to 80°C (Witcher 1979). The areas shown in the figure are portions of much larger areas that extend to the north, east, and west of the site.

Heat flow within the entire basin and range province is characteristically high, and the presence of warm groundwater in the area does not represent a resource that is in any way unique to the region (Reed 1983). In addition, no indication of the presence of hydrocarbons or other carbonaceous materials at the site has been documented (Pierce et al. 1970).

The region of uranium potential in the southeastern portion of the ring (Figure 5.1.1-5) is based on thorium and lanthanum anomalies and monazite in stream sediments (Peterson et al. 1985). The presence of uranium in this area is considered possible as a result of sediment influx from surrounding granitic and metamorphic terrain and the incorporation of uranium into monazite. No specific occurrences of uranium ore have been reported (Pierce et al. 1970; Keith et al. 1983; Welty et al. 1985).

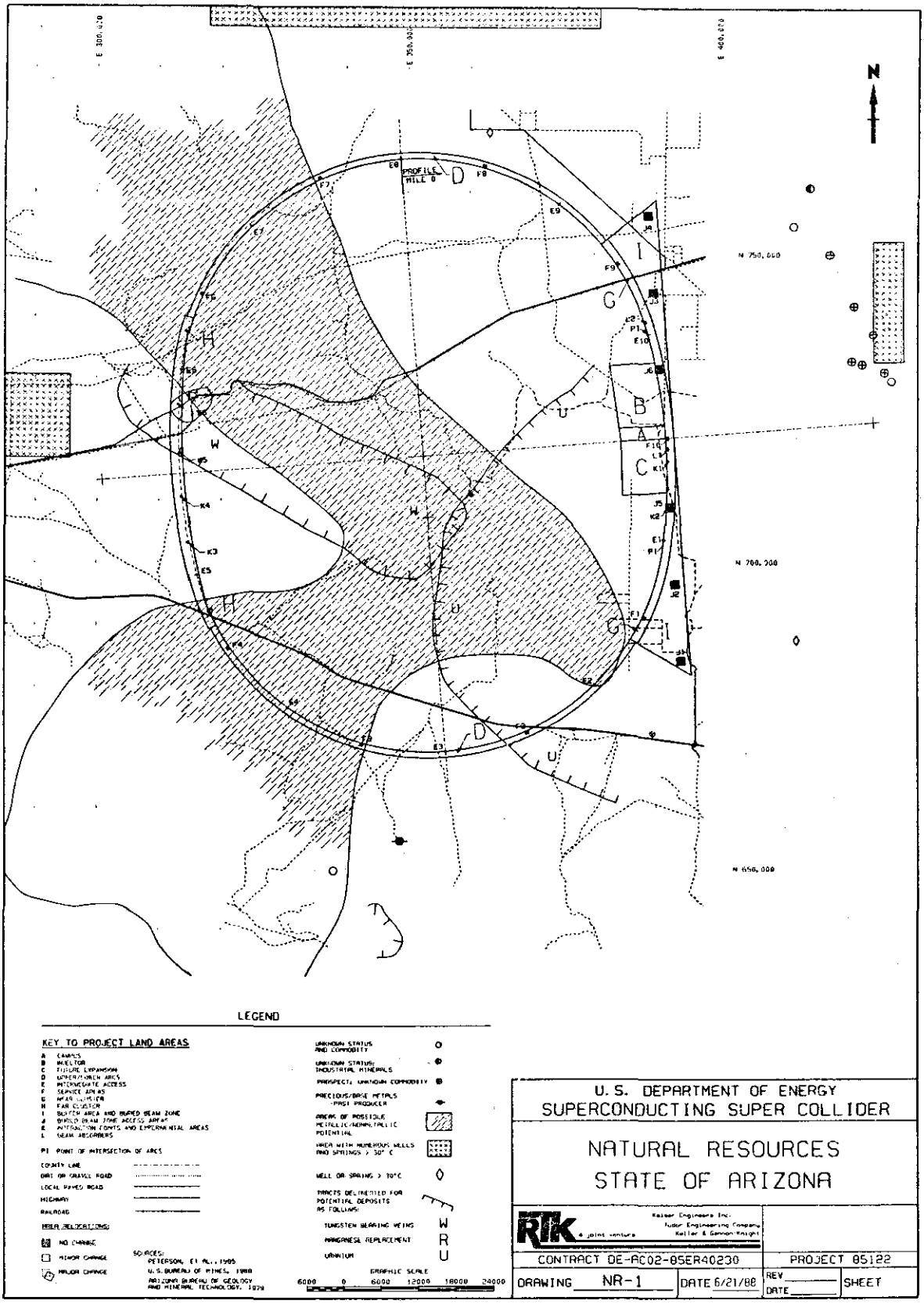
C. Metallic Resources

Despite extensive exploration efforts and the numerous mining districts known throughout the region, no significant metallic deposits have been discovered within the Maricopa Mountains (Pierce et al. 1970; Keith et al. 1983; Welty et al. 1985). However, the large number of mining claims (Bureau of Land Management 1987) and the gross geologic setting suggest that a potential for future discovery of economic deposits should be considered. Mines and prospects in the area listed in the Bureau of Mines' Minerals Industry Location System (MILS) database are shown in Figure 5.1.1-5. These include two sites at which precious and base metals have been mined in the past: the Blasted Cactus deposit near the center of the ring and the Altuda deposit a few miles south of the ring. The Blasted Cactus deposit produced an unknown amount of primary copper with associated gold and silver. The Altuda deposit was mined for gold and also produced iron, silicon, and silver. It is presently owned by the Luke Air Force Range (Bureau of Mines 1988). Prospects to the northeast of the ring are located in the Palo Verde Mountains where no development of metallic or nonmetallic resources has been documented (Bureau of Mines 1988).

The area encompassing the Maricopa Mountains and northern Sand Tank Mountains in Figure 5.1.1-5 has been designated as favorable for the presence of metallic/nonmetallic resources by the Arizona Department of Mines and Mineral Resources (1984). Their assessment was based on file data and a compilation of exploration targets of the mineral industry. The hatched lines outline areas considered permissive for the presence of manganese, tungsten, and uranium deposits by the U.S.G.S. (Peterson et al. 1985). The zone of manganese potential near K6 in the western portion of the

Figure 5.1.1-5

MINES, PROSPECTS, AND REGIONS OF ENERGY RESOURCE POTENTIAL OF THE ARIZONA SSC SITE



ring contains manganese ore in the form of oxides in a breccia within the Proterozoic granite. A small amount of ore at 15 to 20% manganese was produced at this locality (Peterson et al. 1985).

Tungsten-bearing vein deposits are known to exist in districts east of the site in greisen (quartz-mica-topaz alteration) and other forms of alteration typically surrounding small intrusions. The area outlined in Figure 5.1.1-5 was identified on the basis of anomalous amounts of tungsten, beryllium, and lead as a result of geochemical surveys of the regionally metamorphosed rocks of the northern Maricopa Mountains. No tungsten-bearing veins have been identified within the area and the anomalies may represent high background levels in rock that have not developed a greisen assemblage suitable for ore concentration (Peterson et al. 1985).

None of the reported occurrences of metallic ore appears to represent a geologic resource of economic significance. The previously mined deposits of base and precious metals were all of very small size, and it appears unlikely that larger deposits of similar type have yet to be discovered. However, the areas of potential mineralization shown in Figure 5.1.1-5 were defined on the basis of regional geochemical anomalies and data from the mineral industry, and though the presence of economic concentration is not directly implied, a geologic setting potentially amenable to ore deposition appears to be present.

D. Other Resources

Felspar, mica, and silicon ore are reported just north of the Maricopa Mountains (Bureau of Mines 1988). These localities are shown in Figure 5.1.1-5. No other resources have been identified in the vicinity of the site.

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5.1.2 Water Resources

5.1.2.1 Surface Water Hydrology, Quality, and Use

A. Surface Runoff and Flooding

The Arizona site is situated in the Gila River drainage basin. The Gila River extends from the Continental Divide in southwestern New Mexico to the Colorado River and its drainage basin and includes nearly all of the southern half of Arizona. It passes approximately 25 mi north and about 10 mi west of the project site (Figure 5.1.2-1), flowing generally west-southwest to join the Colorado River at Yuma, Arizona, about 30 mi upstream from the Mexican border. At its confluence with the Colorado River, the Gila River has a drainage area of 58,200 mi^2. The Gila River was historically a perennial river; however, because of upstream diversions and reservoir storage, it now flows only intermittently (Corps of Engineers 1982).

The hydrological features of the site are shown in Figure 5.1.2-2. A drainage divide along the crest of the Maricopa Mountains approximately bisects the project site from the northwest to the southeast. The northeasterly portion drains across the ring to Waterman Wash, which flows north and west, and joins the Gila River near Buckeye (Figure 5.1.2-3). The major drainage channel in this portion of the site is the west prong of Waterman Wash, which has a drainage area of 130 mi^2 as it crosses the ring.

The extreme southerly portion of the site drains into Bender Wash, which joins Sand Tank Wash 10 mi west of the ring, and discharges into the Gila River at Gila Bend. The drainage area of Bender Wash at the ring crossing is about 68 mi^2.

The western portion of the project site drains directly into the Gila River through a series of roughly parallel unnamed drainage channels. The project area contained within the collider ring in this drainage system is about 74 mi^2.

A small area of approximately 5 mi^2, located within the collider ring along the east-southeast side, flows to the Vekol Wash, which flows northerly and joins the Santa Cruz Wash south of Phoenix, and then the Gila River southwest of Phoenix. The project area within the Vekol Wash drainage system also includes the southerly buried beam zone access areas (J3 and J4). These areas are located outside of the collider ring. The west prong of Waterman Wash at the ring crossing near F2 has a depth of about 4 ft and a floodplain width of 138 ft. Bender Wash, where it crosses the collider ring near F6, is about 4 ft deep and 60 ft wide.

Elevations within the project site (area contained within the ring, including the buried beam facilities) range from a high of 3,272 ft above mean sea level in the Maricopa Mountains to about 1,160 ft above

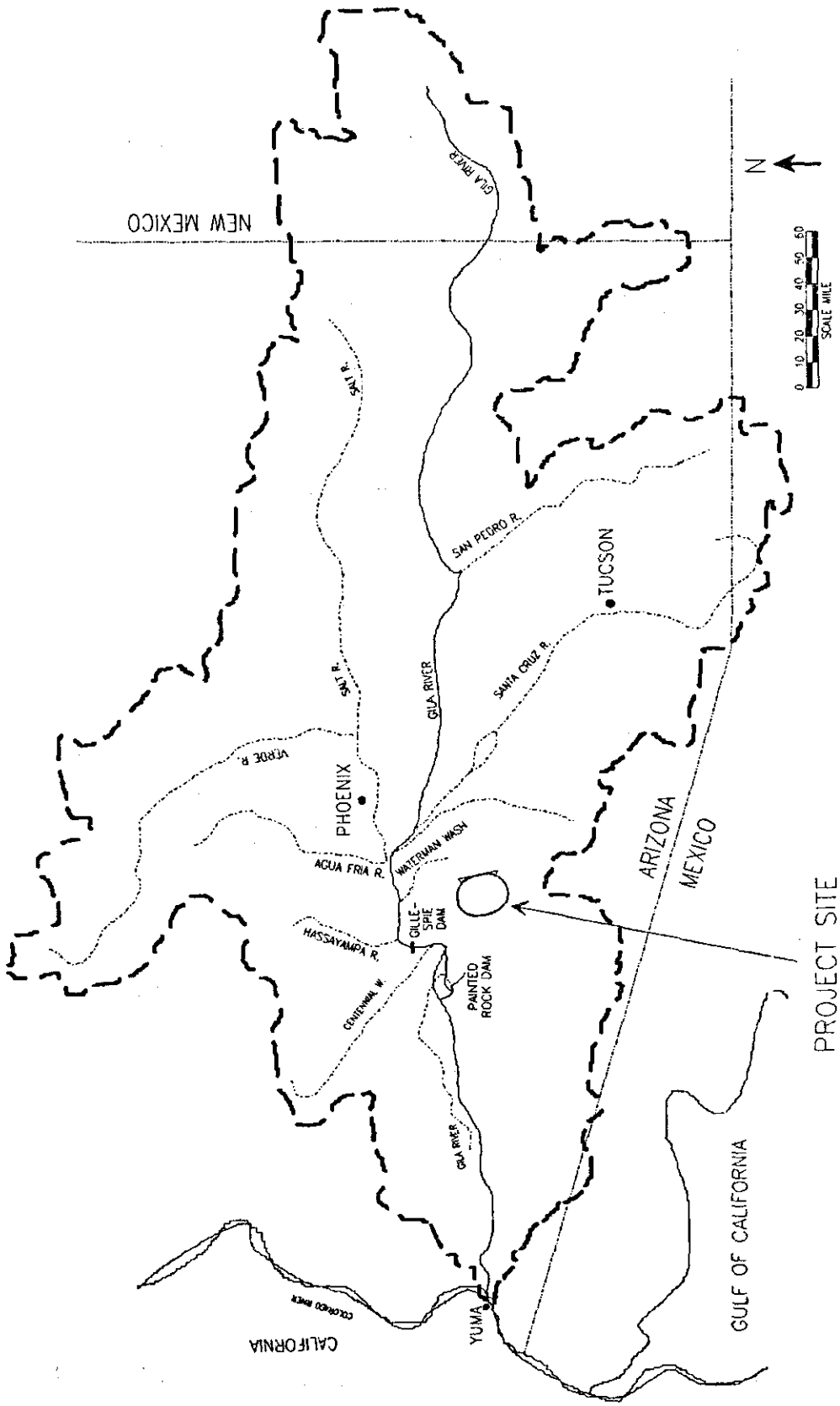
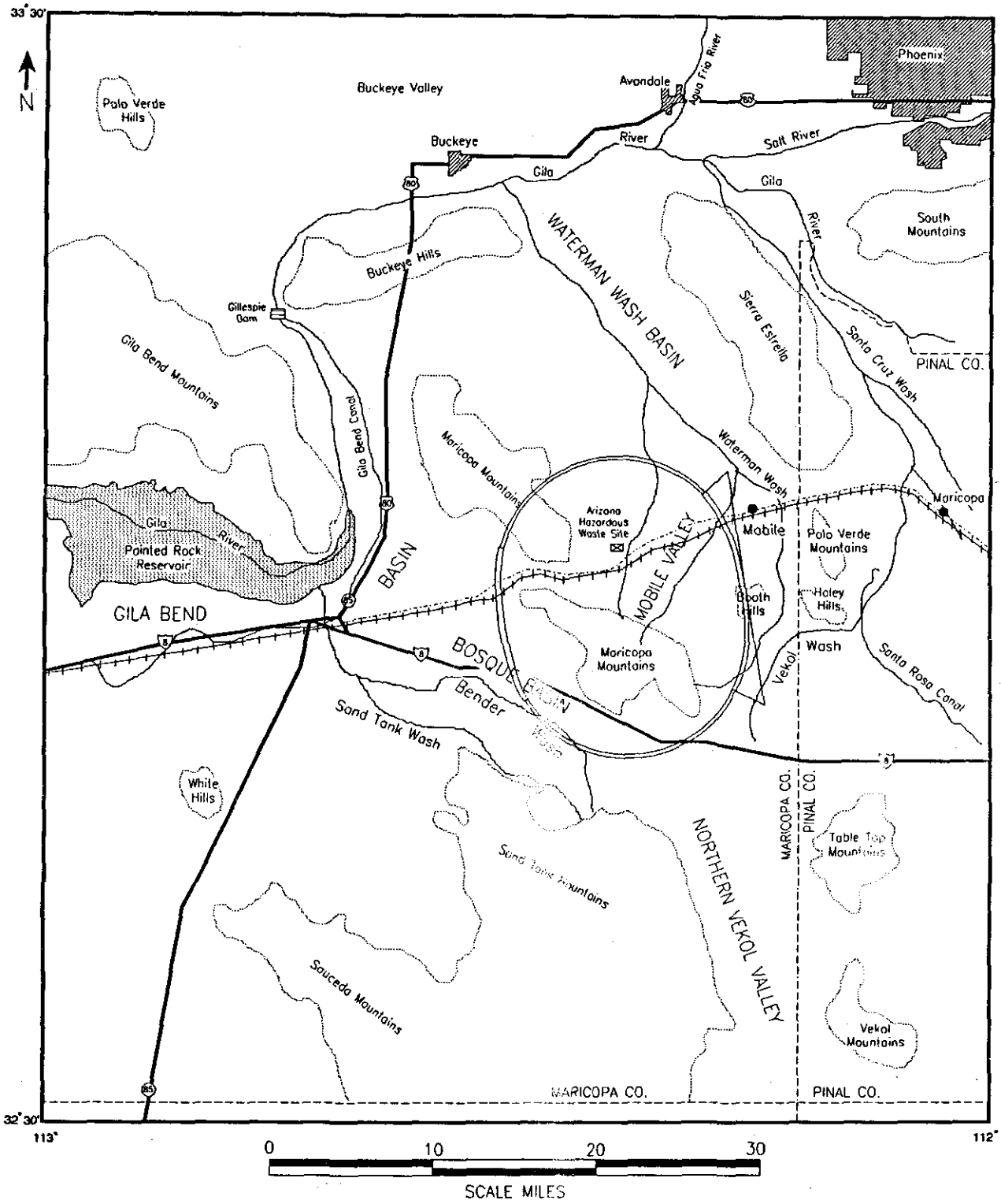


Figure 5.1.2-1

MAJOR WATERSHED IN ARIZONA

Figure 5.1.2-2

HYDROLOGIC FEATURES - ARIZONA SITE



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mean sea level where various unnamed channels cross the western edge of the collider ring.

Throughout the project site, broad alluvial slopes lie between steep mountain areas and major water courses. These slopes are formed by the intermingling of alluvial fans from several drainage channels and they are traversed by many small channels that divide and reconverge at many places in response to intense rainfall events.

Flash floods that originate in the mountains frequently convey substantial amounts of rock debris, which are then deposited on the alluvial slope causing the channels and washes to abruptly change their course. Much of the flood flow on the upland areas is unconfined and flows downslope as sheet flow. This sheet flow generally occurs on ground slopes of 1 to 5%. Slopes of less than 1% are too flat to convey water significant distances. Ponding and infiltration rapidly deplete the flood flows. Slopes of more than 5% usually cause defined channels to form. Defined channels of minor tributaries may extend a considerable distance across slopes that are flatter than 5%, but will seldom reach slopes of less than 2% without forming new channels (Federal Emergency Management Agency 1987).

Continuous records are not available for channels within the project site. However, the U.S.G.S. operated crest-stage gauging stations in Waterman Wash near Buckeye from 1964-1985 and Bender Wash near Gila Bend from 1963-1979 (Table 5.1.2-1). Other estimates of runoff within the project site and vicinity were made by Maricopa County following a major thunderstorm in August 1987; a design flow rate was estimated for a bridge construction crossing at the west prong of Waterman Wash along the highway from Maricopa to Gila Bend. Annual peak flow rates at the crest-stage gauging stations are of significant size most years, with most occurring during the months of August and September (Brooks 1988b).

On August 8, 1987, a thunderstorm centered near the Maricopa Mountains produced substantial runoff in Waterman Wash. High water marks were identified by representatives of the Maricopa County Flood Control District, and peak flow rates were estimated at selected stations using indirect methods. On the west prong of Waterman Wash crossing of the north collider ring, the estimated peak flow rate was 5,349 ft^3/s with a flooded width of 138 ft (Rumann 1987).

B. Surface Water Quality

Surface water within the project site does not constitute a viable water supply source. There are no surface reservoirs close to the site, and surface flows in the stream channels and washes occur only during significant storm events. In addition, storm runoff generally contains substantial quantities of sediment and debris, which would make the use of water retention facilities impracticable. Because of the lack of perennial surface water near the site, no water quality monitoring or

Table 5.1.2-1

GAUGE DATA IN PROJECT VICINITY

U.S.G.S. Gauge	Drainage Area mi^2	Instantaneous Maximum Flow*	Date	Minimum Flow*	Flow Duration* Q5%	Q25%	Q50%	Q75%	Q95%
Waterman Wash near Buckeye (No. 09514200, crest-stage records only)	403	6,300	9/3/67	0	-	-	-	-	-
Bender Wash near Gila Bend (No. 09519750, crest-stage records only)	68	2,670	8/71	0	-	-	-	-	-

*All flow values in cubic feet per second (ft^3/s)

Source: Brooks 1988b.

sampling of any kind has been accomplished. Only Gila River and Colorado River waters have been sampled anywhere near there, but these data are not representative of the surface water at the site, and, therefore, are not included here.

C. Surface Water Use

The only surface waters of recent use within or immediately adjacent to the project site are very small water catchments or "tanks." These are excavated and bermed pits that have been used as supplies for watering livestock. Water may be stored for brief periods following surface runoff from storm events; however, the tanks remain dry most of the time, and even when filled they are not large enough to constitute an important water supply source for the area.

As described in Section 5.1.2.1.A, the Gila River was initially a perennial river; however, because of upstream diversions and reservoir storage, it now flows only intermittently. Upstream from Gillespie Dam, the flow is regulated by numerous reservoirs on the Gila and its major tributaries, including the Salt, Verde, and Agua Fria rivers. The combined storage capacity of these reservoirs is 3,303,900 acre-ft (White and Garrett 1988). At Gillespie Dam the flow is diverted from the river into canals. From 1975-1983 the average annual deliveries in these canals was 46,800 acre-ft/yr (Linkswiler 1988). Water diverted from the Gila River supplies irrigation, municipal, and industrial uses.

The Arizona Department of Transportation is currently constructing a major bridge crossing of the west prong Waterman Wash along the Maricopa-Mobile-Gila Bend Highway (proposed State Route 238). The 50-yr recurrence interval design discharge estimated by the highway department for this bridge crossing was 4,250 ft^3/s. The contributary drainage at the bridge crossing was estimated to be 87 mi^2 (Ross 1988).

5.1.2.2 Groundwater Hydrology, Quality, and Use

A. Groundwater Hydrology

The Arizona site is situated within three hydrologic basins that include Waterman Wash, the northern Vekol Valley basins, and the Bosque Subbasin of the Gila Bend basin (Figure 5.1.2-2). The mountains in the site vicinity and the bedrock beneath the alluvial fill consist of igneous, metamorphic, and sedimentary rocks. Although these consolidated rocks may yield a few gallons per minute of water where fractured, they are not considered to be water bearing and do not constitute a source of water locally. Northern Vekol Valley, Waterman Wash, and Bosque basin are partly filled with unconsolidated to moderately consolidated basin-fill deposits that range in thickness from 1,900 to 3,000 ft and are generally saturated within a few hundred feet of the land surface (Hollett and Marie 1987; Wilson 1979). These alluvial basins are a major source of groundwater and are used for agricultural, industrial, and public water supplies. The potential for overdrafting alluvial

basins is a major water resource issue in Arizona. Table 5.1.2-2 provides a summary of the water-bearing characteristics of the alluvial-fill deposits in the three groundwater basins.

1. Northern Vekol Valley

Northern Vekol Valley is about 90 mi^2 in area. The valley is about 8 mi wide and extends 12 mi south from the Booth Hills to a bedrock ridge that separates Vekol Valley into distinct northern and southern parts. (Hollett and Marie 1987).

Northern Vekol Valley contains at least 1,900 ft of basin-fill deposits that are divided into two hydrogeologic units: a relatively unconsolidated gravelly sand underlain by a moderately to well-consolidated silt, sand, and pebble conglomerate (Brooks 1987). Depth-to-water ranges from about 150 ft below land surface in the northeast part of the basin to about 400 ft in the area just south of Interstate 8 (Wilson 1979). Depth-to-water where the SSC crosses the basin has been estimated to be 240 to 350 ft below land surface, whereas the tunnel in this area is at depths of 150 to 225 ft (Brooks 1987). Recoverable groundwater volume in storage has been estimated to be about 3.1 million acre-ft in the upper 1,500 ft of saturated sediments (Hollett and Marie 1987; Wilson 1979).

Recharge to the groundwater basin occurs as the result of surface flow that infiltrates into the aquifer during runoff and includes infiltration from stream channels, along mountain fronts, and through the valley floor. Some water may enter the aquifer through the bedrock in the mountains; however, the amount is small. Groundwater movement is from south to north, exiting the valley east of the Booth Hills. Average precipitation in northern Vekol Valley is about 8 inches/yr, and it has been estimated that only 5 to 10% recharges to the aquifer system. The annual recharge in northern Vekol Valley is estimated to be 1,200 acre-ft/yr. An estimated 1,200 acre-ft/yr is discharged from the valley through subsurface flow near Booth Hills (Hollett and Marie 1987).

Transmissivity of the aquifer units within the proposed SSC well field in northern Vekol Valley is estimated to range from 10,500 to 15,000 ft^2/d in the upper unconfined unit to 300 to 3,600 ft^2/d in the lower confined units (Brooks 1987). Hydraulic conductivity ranges from 2×10^{-2} to 3.5×10^{-4} cm/s (Hollett and Marie 1987). Well yields are typically a few gal/min, but with favorably located and properly constructed wells, 2,000 gal/min could be obtained (Wilson 1979).

2. Waterman Wash Basin

Waterman Wash basin is approximately 210 mi^2 in area and is about 30 mi long and 10 mi wide. It is bounded on the north by the Buckeye Hills, on the south by the Haley and Booth hills and Palo Verde Mountains, on the east by the Sierra Estrella, and on the west by the Maricopa Mountains (Figure 5.1.2-2). The Waterman Wash basin is underlain by more

Table 5.1.2-2

SUMMARY OF WATER-BEARING CHARACTERISTICS OF ALLUVIAL-FILL DEPOSITS IN VICINITY OF THE ARIZONA SITE

Characteristic	Northern Vekol Valley	Southern Waterman Wash	Bosque Basin
Thickness of alluvial fill	600-3,000 ft	1,000-2,000 ft[a]	3,000 ft
Depth-to-water below land surface	150-400 ft	396-525 ft	500-700 ft
Recoverable groundwater in 1,500 ft of saturated sediments	3.1 million acre-ft	10.3 million acre-ft[a]	3.6 million acre-ft
Hydraulic gradient	2-10 ft/mi	10-30 ft/mi	13 ft/mi
Annual recharge	1,200 acre-ft	2,000 acre-ft[a]	N/A[c]
Well yields	5-2,000 gal/min	0-300 gal/min	0-500 gal/min
Transmissivity	300-15,000 ft^2/d	500-2,000 ft^2/d	800 ft^2/d
Hydraulic conductivity	2×10^{-2} - 3.5×10^{-4} cm/s	1.5×10^{-4} cm/s[b]	N/A
Specific capacity	>15 gal/min/ft drawdown	>15 gal/min/ft drawdown	>3 gal/min/ft drawdown
Specific yield	0.08-0.12	0.1	0.1

Notes: a. Estimate for both Northern and Southern Waterman Wash valley.
b. Unsaturated sample.
c. Data not available.

Sources: Hollett and Marie 1987; Environmental Protection Agency 1983; Wilson 1979.

than 2,000 ft of basin-fill deposits. The deposits have been divided into two distinct units: an upper unit that consists of unconsolidated sandy clay to sand and gravel and a lower unit that consists of poorly to moderately consolidated coarse sandy gravel to sand and gravel that contains small amounts of silt and clay. The upper unit is approximately 800 ft thick in the center of the basin and thickens to the northwest, away from the SSC site. The lower unit is as much as 1,000 ft thick (Wilson 1979).

Depth-to-water ranges from about 100 ft in the northwest portion of the basin to more than 400 ft near Mobile. In the north central portion of the ring at the Arizona Hazardous Waste Facility on Figure 5.1.2-2, depth-to-water is 525 ft. Depth-to-water at a test hole drilled 1 mi north of the ring is 396 ft (Brooks 1987). Groundwater in Waterman Wash is generally under water-table conditions and moves from southeast to northwest toward the cone of depression that has formed in response to groundwater withdrawals north of the SSC site. Recoverable groundwater volume in storage in the Waterman Wash area is about 10.3 million acre-ft in the upper 1,500 ft of saturated sediments (Wilson 1979).

Recharge to the groundwater basin occurs mainly near the mountains as the result of surface flow that infiltrates into the aquifer. The annual recharge to Waterman Wash basin is estimated to be 2,000 acre-ft/yr (Wilson 1977).

Transmissivities of the aquifer units in the northern and central portions of Waterman Wash basin range from 4,500 ft^2/d to 13,000 ft^2/d in the upper unit. The transmissivity of the lower unit in the central portion of the basin was estimated to be about 11,000 ft^2/d. Typical well yields in these areas range from 1,000 to 2,500 gal/min (Wilson 1979).

In the southern portion of Waterman Wash basin, Mobile Valley results of aquifer tests indicated a range of transmissivity of 500 to 2,000 ft^2/d near Mobile. Maximum well yields in and around Mobile are about 300 gal/min. The SSC tunnel is entirely within the unsaturated portion of the upper unit where it traverses the Waterman Wash basin. Permeability tests conducted on an undisturbed sample from a borehole located on the northeast portion of the ring in unsaturated material indicated a permeability on the order of 1.5×10^{-4} cm/s (Brooks 1987).

3. Bosque Basin

The Bosque subbasin area of the larger Gila Bend basin is 15 mi long and from 2 to 10 mi wide and is bounded on the northeast by the Maricopa Mountains and on the south by the Sand Tank Mountains (Figure 5.1.2-2). Existing irrigation activity is extensive to the north and west of the Bosque subbasin area along the Gila River. The SSC would be located in the eastern, undeveloped portion of the Gila Bend basin, referred to as Bosque basin.

Bosque basin is a northwest-trending trough that contains as much as 3,000 ft of basin-fill deposits that can be divided into three units. The upper unit is 700 to 900 ft thick and is composed of unconsolidated coarse to fine gravel, sand, silt, and clay. The middle unit is 800 to 1,450 ft thick and consists of unconsolidated to poorly consolidated fine to very coarse sand and fine to coarse gravel. The thickness of the lower unit is not known but consists of volcanic rocks interbedded with moderately to weakly cemented conglomerates (Wilson 1979).

Depth-to-water in the Bosque area ranges from 200 ft in the west to 700 ft in the southeast (Wilson 1979). Below the SSC alignment, groundwater depths are estimated to be greater than 500 ft (Brooks 1987). Groundwater movement is from the southeast to the northwest toward a cone of depression that has formed in response to groundwater withdrawals along the Gila Bend Canal. Recoverable groundwater volume in storage has been estimated to be 3.6 million acre-ft in the upper and middle units (Wilson 1979).

Very little aquifer recharge occurs from direct precipitation. Most of the annual recharge is from percolation of excess irrigation water. Irregular streamflow in the Gila River, which is totally controlled by upstream diversions, also provides a source of recharge (Wilson 1979).

Transmissivity of the aquifer units in Bosque basin ranges from 8,000 to 27,000 ft^2/d near the Gila River to 800 ft^2/d near the tunnel alignment. The low yields near the tunnel are thought to be the result of poor sorting of the aquifer material in this area and may not be representative of the entire region. Well yields along the Gila Bend Canal are as high as 2,000 gal/min. Well yields decrease to the southeast where yields of up to 500 gal/min can be expected (Wilson 1979).

B. Groundwater Quality

Groundwater quality is highly variable throughout the three basins. Table 5.1.2-3 summarizes the range of water quality within the three basins.

Chemical quality of the water in northern Vekol Valley is excellent with total dissolved solids ranging from 313 to 544 mg/l in one well and two test holes in the valley. The main ions in solution are sodium, chloride, bicarbonate, and sulfate (Wilson 1979).

Groundwater quality is generally poor in the Waterman Wash area where irrigation is occurring. The main ions are sodium and chloride with smaller concentrations of sulfate, bicarbonate, and calcium. Dissolved solids concentrations in this area range from less than 600 to greater than 1,800 mg/l (Environmental Protection Agency 1983). A water sample taken from the Mobile School well in early 1987 had a total dissolved solids of 464 mg/l (Brooks 1987).

Table 5.1.2-3

APPROXIMATE RANGE OF GROUNDWATER QUALITY IN THE VICINITY OF THE ARIZONA SITE

Source	Range of Chemical Constituents mg/l				
	Total Dissolved Solids	Chloride	Sulfate	Nitrate	Hardness[1] ($Ca\ Co_3$)
National drinking water standards	500	250	250	45	none
Northern Vekol Valley	313-544	4.3-49	8.6-47	3.3-6.2	42-65
Southern Waterman Wash[2]	464	NA[3]	NA	NA	NA
Bosque basin[2]	540	NA	NA	NA	NA

Notes: 1. Typical classifications of the hardness of water are as follows: 0-60 mg/l = soft to slightly hard; 60-120 mg/l = moderately hard; 120-180 mg/l = hard; >180 mg/l = very hard.
2. Limited data is available on chemical constituents in vicinity of SSC site because of minor amount of water use presently occurring.
3. NA = Data not available.

Sources: Brooks 1987; Cuff 1984; Driscoll 1986; Wilson 1979; U.S. Environmental Protection Agency 1977.

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Chemical quality of groundwater in Bosque basin is not well documented because of limited wells in the area. One well in Bosque Basin had a reported total dissolved solids of 540 mg/l (Wilson 1979).

C. Groundwater Use

Since few wells exist within the SSC project area, groundwater use near the SSC site is very limited. Major groundwater pumping centers are located to the north of the site in Waterman Wash basin and to the west of the site along the Gila River. In Waterman Wash, about 10 mi north of the ring, extensive irrigation is occurring. Another smaller area of irrigated land occurs approximately 1 to 4 mi north of the ring. Groundwater use in Waterman Wash for irrigation is about 45,000 acre-ft/yr. Three small wells are located in Mobile and provide approximately 12 acre-ft/yr of domestic water for Mobile Elementary School and nearby homes. The Mobile Water Company has recently sold a well to ENSCO, the operators of the Arizona Hazardous Waste Facility. The system will be expanded to supply the facility's future water needs anticipated to be 500 to 800 acre-ft/yr. Water use at the facility in 1988 is expected to be about 100 acre-ft (Brooks 1988a).

No groundwater use occurs in Bosque basin near the SSC site. A limited amount of groundwater development has occurred in northern Vekol Valley to the southeast of the site. Twenty-two domestic and stock wells exist in northern Vekol Valley; however, only 11 are presently used and withdraw an estimated 50 acre-ft/yr of groundwater (Hollett and Marie 1987).

Future groundwater development in the project area should be limited to domestic and industrial uses because most of the area is within the Phoenix Active Management Area where no new irrigation water rights can be granted. The present trend is away from irrigation using groundwater because of declining water levels and higher pumping costs. Many farmers are instead opting to use water from the Central Arizona Project canal. The Sierra Estrella housing development is projected for the eastern portion on the Waterman Wash basin. In order to obtain water rights for a supply source, AMCOR Development Company has recently purchased 20,000 acres of land in Waterman Wash and retired it from production (Brooks 1988a).

5.1.3 Climate and Meteorology

5.1.3.1 General Description

The climate at the Arizona site is best characterized as Sonoran Desert, with great extremes between day and night temperatures, light annual rainfall, generally clear, dry air, and long periods with little or no precipitation. The climate is also greatly influenced by elevation. The higher elevations experience lower average temperatures and greater precipitation on an annual basis (National Oceanic and Atmospheric Administration 1974).

5.1.3.2 Temperature

Temperatures in the region vary from an average low temperature of 34°F in January to an average high temperature of 101°F in August. The extreme high temperature recorded was 123°F in September; the extreme low temperature recorded was 22°F in January. The temperature drops below freezing, on the average, 17 days per year. Frost penetration, which occurs exclusively at higher elevations, reaches an average of 3 inches and an extreme of 5 inches in depth (U.S. Weather Bureau 1941). Normal and extreme temperature and heating degree-day data for the Arizona site are shown in Table 5.1.3-1.

5.1.3.3 Precipitation

Precipitation patterns in Sonoran Desert climates are strongly dependent on elevational and seasonal factors. The bimodal precipitation pattern produces both winter and summer peaks in rainfall. The November through March peak is caused by Pacific Ocean storm systems; the July through mid-September peak is caused by moisture-bearing winds from the Gulf of Mexico (National Oceanic and Atmospheric Administration 1974).

The south-central Arizona climatic region receives 10.33 inches of precipitation per year. The peak month for precipitation is August with an average of 1.78 inches. The month with the least rainfall is May, with an average of 0.15 inches. The region receives no snowfall during the course of an average year. Mean precipitation and snowfall data are shown in Table 5.1.3-2. Also, 1-, 2-, 5-, 10-, 25-, 50-, and 100-year return period extreme rainfall data are shown in Table 5.1.3-3.

5.1.3.4 Wind

The prevailing wind direction at the Arizona site is toward the west at an annual average speed of 5.0 mi/hr. The monthly average speeds are relatively uniform, ranging from 4.0 mi/hr to 6.0 mi/hr. The highest recorded wind speed was 75 mi/hr, which occurred in September. Average wind speed and direction data are shown, by month, in Table 5.1.3-4.

NORMAL AND EXTREME TEMPERATURE DATA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average maximum temperature, °F	65	65	75	85	92	100	100	107	95	85	74	64
Average minimum temperature, °F	34	40	45	50	55	62	71	71	70	52	45	37
Highest	86	94	100	107	120	120	120	119	123	109	98	86
Lowest	22	25	31	38	39	50	61	60	50	38	29	22
Heating Degree-days	470	330	220	80	0	0	0	0	0	20	230	420

Source: U.S. Environmental Science Services Administration 1968.

Table 5.1.3-2

MEAN PRECIPITATION AND SNOWFALL DATA FOR SOUTH-CENTRAL ARIZONA CLIMATIC REGION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly precipitation, inches	1.11	1.05	0.96	0.49	0.15	0.16	1.27	1.78	0.97	0.47	0.78	1.14
Mean monthly snowfall, inches	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: U.S. Environmental Science Services Administration 1968.

Table 5.1.3-3

MAXIMUM 1-HOUR AND 6-HOUR RAINFALL BY RETURN PERIOD

Return Period Years	Rainfall (inches) 1-Hour	6-Hour
1	0.70	1.10
2	0.90	1.50
5	1.30	2.00
10	1.60	2.50
25	1.80	3.00
50	2.00	3.50
100	2.30	4.00

Source: U.S. Weather Bureau 1961

Table 5.1.3-4

MONTHLY AVERAGE WIND SPEED AND DIRECTION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average wind speed, mi/hr	4.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	5.0	5.0	6.0
Wind blowing toward:	W	W	W	W	W	W	E	W	W	W	W	W

Source: U.S. Environmental Science Services Administration 1968.

5.1.3.5 Humidity

The yearly mean relative humidity in the region of the Arizona site is 40%. The average relative humidity peaks in January at 52% and reaches its lowest values in April, May, and June at 30%. Mean and maximum dew-point and mean relative humidity data are shown in Table 5.1.3-5.

5.1.3.6 Severe Weather

Severe weather in the region of the Arizona site can be best characterized through discussion of tornadoes, extreme winds, thunderstorms, dust storms, and floods.

Tornadoes in the region of the site are relatively rare. The yearly probability of a point being struck by a tornado is approximately 2.12×10^{-3}, which corresponds to a return period of 4,750 years (Thom 1963). For the period of record 1950-1986, 52 tornadoes were observed within a 50-nautical mile radius of Phoenix. Sixty-eight injuries and no deaths resulted from these events (National Severe Storms Forcast Center 1988).

Extreme winds that would accompany severe thunderstorms in the region are shown in Table 5.1.3-6 by maximum wind speed and return period.

Thunderstorms occur in the region on an average of 27 times per year, with peak activity in July, August, and September (National Climatic Center 1981). Dust storms occurring at the Phoenix first order National Weather Service (NWS) station (Sky Harbor Airport) were analyzed (Nickling and Brazel 1984). Nickling and Brazel defined a dust storm as occurring when visibility is reduced to less than 1 mi because of blowing dust. Phoenix experienced a mean of 4.4 dust storms per year (period of record 1965-1980), with the preponderance of events (3.8 per year) occurring in the summer (June-September). Hail greater than .75 inches in diameter is observed, on the average, once every 13 years (Department of Commerce, U.S. Weather Bureau 1969).

Flooding, which is infrequent, occurs primarily as a result of thunderstorm activity in July and August. Heaviest flood runoff generally occurs when hurricanes that dissipate near the west Mexican Coast bring tropical air into the region (National Oceanic and Atmospheric Administration 1974).

Table 5.1.3-5

DEWPOINT AND RELATIVE HUMIDITY DATA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Dewpoint Temperature, °F	33	33	33	35	36	42	58	60	53	44	36	33
Maximum 12-Hour 1,000 mBar dewpoint °F	58	60	62	62	65	70	76	76	74	68	63	60
Mean relative humidity, %	52	50	40	30	30	30	38	45	40	40	40	50

Source: Climatic Atlas of the United States 1968.

Table 5.1.3-6

EXTREME WIND SPEED AND RETURN PERIOD DATA

Return Period years	Wind Speed mi/h
10	60
25	67
50	72
100	77

Source: Thom 1968.

5.1.4 Air Quality

5.1.4.1 Conditions Affecting Air Quality

A. Topographical

The Arizona site is characterized topographically by the southern two-thirds of the Maricopa Mountains. The southern portion of the range is located in the ring's center. The northern portion crosses over the ring between F6 and E7. Both are spatially distinct from other ranges in the area. While these are significant features that undoubtedly influence wind direction locally, their ability to affect regional air movements and patterns is limited by the vastness of the surrounding valley basin. The remainder of the site is very flat. The topography is conducive to good atmospheric dispersion.

B. Meteorological

The ability of the atmosphere to disperse a pollutant is categorized in part by its stability classification. The stability classification, of which six are commonly defined, is a function of incoming solar radiation and wind speed. An A classification means that the atmosphere is extremely unstable and that air pollutants would be dispersed well. Conversely, an F classification means that the atmosphere is extremely stable and that pollutants would be dispersed poorly. The ability of the atmosphere to disperse air pollutants is greater for the larger portion of time for which neutral or unstable stability classes prevail. The site's relative frequency of occurrence of the six stability classes is shown in Table 5.1.4-1.

Table 5.1.4-1

FREQUENCY OF OCCURRENCE OF ATMOSPHERIC STABILITY CLASSES

Class	Definition	% Occurrence
A	Extremely unstable	3
B	Unstable	14
C	Slightly unstable	16
D	Neutral	18
E	Slightly stable	14
F	Stable and extremely stable	35

Source: National Climatic Data Center, Weather Station No. 23183, Phoenix, AZ (Period of Record 1/82-12/86).

The potential of an area to experience high levels of air pollution caused by meteorologic factors was studied by G. C. Holzworth (Holzworth 1972). Holzworth's number is a function of the height of the mixing layer and the average wind speed within the mixing layer. The mixing layer in the atmosphere is the region in which relatively vigorous vertical mixing occurs. Increased height of the mixing layer and increased wind speeds will produce conditions more conducive to air pollutant dispersion. Holzworth estimates between 10 and 20 "forecast days" of high meteorological potential for air pollution in a 5-yr period. The influence of winds on dispersion conditions on an annual basis is demonstrated by Table 5.1.4-2. The table is an annual summary of the frequency of wind speed and direction for the Phoenix first-order National Weather Service Station (National Climatic Data Center (NCDC) 1988).

5.1.4.2 Air Quality

A. Applicable Standards

The National Ambient Air Quality Standards (NAAQS) (40 CFR 50) function as the applicable regulatory levels in the State of Arizona. The primary standards are shown in Table 5.1.4-3.

B. Background Concentrations

A portfolio of values was assembled to quantify ambient air pollutant concentrations in the region. For air pollutant concentrations with averaging times of less than one year, the highest representative regional value is shown. These values are delineated, along with the applicable standard for each pollutant, in Table 5.1.4-3. It should be noted that no data are available for Sierra Estrella sailport after 1978 (Provident Energy Company 1979). Selected ambient air quality monitoring stations are plotted in Figure 5.1.4-1.

C. Compliance Status

The noncompliance or nonattainment status (EPA 1985) for the counties in the region of influence of the Arizona site is as follows:

- Parts of Maricopa County are nonattainment for total suspended particulate (TSP), carbon monoxide (CO), and ozone (O_3).
- Parts of Pinal County are nonattainment for TSP and sulfur dioxide (SO_2).

These nonattainment areas do not cover the portion of Maricopa County within the footprint of the SSC site.

Table 5.1.4-2

ANNUAL FREQUENCY OF WIND SPEED AND DIRECTION ARIZONA SSC SITE

Direction	Speed - Knots 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	.009359	.012970	.003516	.001005	.000160	.000000	.027009
NNE	.005749	.008243	.002169	.000639	.000023	.000046	.016869
NE	.007335	.011303	.003768	.001530	.000160	.000069	.024164
ENE	.016604	.033999	.020253	.005412	.000594	.000137	.076999
E	.044171	.090170	.072794	.006622	.000662	.000069	.214488
ESE	.023438	.047928	.025414	.002786	.000228	.000023	.099816
SE	.016287	.028131	.012513	.002809	.000206	.000046	.059990
SSE	.010179	.017513	.006759	.002009	.000434	.000023	.036916
S	.013574	.018153	.006325	.001713	.000274	.000206	.040244
SSW	.008966	.013495	.004681	.000845	.000183	.000000	.028169
SW	.014039	.021989	.009407	.002809	.000343	.000046	.048632
WSW	.021886	.040187	.027469	.010618	.000982	.000114	.101256
W	.024178	.043338	.041991	.013700	.001461	.000525	.125194
WNW	.013126	.021601	.012148	.003105	.000457	.000069	.050505
NW	.009814	.014134	.006553	.001324	.000114	.000023	.031962
NNW	.006347	.008494	.002169	.000708	.000023	.000046	.017787
Total	.245051	.431647	.257929	.057632	.006302	.001439	

Source: National Climatic Data Center, Weather Station No. 23183, Phoenix, AZ (Period of Record 1/82-12/86).

Table 5.1.4-3

AMBIENT AIR POLLUTANT CONCENTRATIONS AND BACKGROUND LEVELS

Pollutant Averaging Time	NAAQS Standard $\mu g/m^3$	Background Concentration $\mu g/m^3$	Point Measured at
TSP-24 hr	260	91*	Sierra Estrella sailport, 1978
TSP-ann. geo. mean	75	70	Sierra Estrella sailport, 1978
SO_2-3 hr	1300	146	Sierra Estrella sailport, 1978
SO_2-24 hr	365	33	Sierra Estrella sailport, 1978
SO_2-annual	80	2	Sierra Estrella sailport, 1978
NO_2-annual	100	15	Sierra Estrella sailport, 1978
CO-1 hr	40,000	22,900*	Phoenix, 1986
CO-8 hr	10,000	20,600*	Phoenix, 1986
O_3-1 hr	235	154*	Sierra Estrella sailport, 1978
Pb-quarterly	1.5	0.27*	Tucson, 1986

* Highest representative regional value is given.

Sources: 1986 Air Quality Control for Arizona, Arizona Department of Environmental Quality 1987.
PSD Permit Application, Provident Energy Company 1979.

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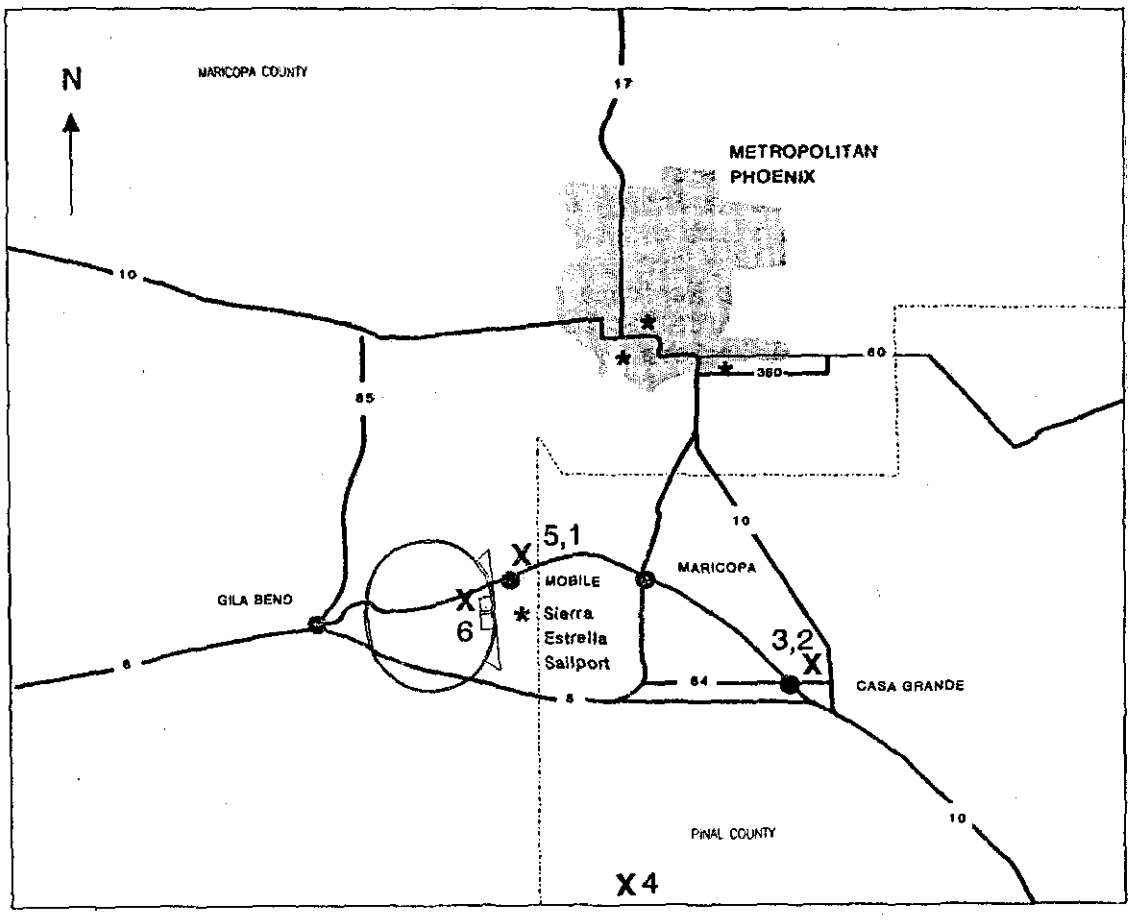
Figure 5.1.4-1

AMBIENT AIR QUALITY MONITORING STATIONS AND REGIONAL AIR POLLUTANT SOURCES ARIZONA SSC SITE



X = Air Pollutant Source

* = Ambient Air Quality Monitoring Station

D. Proximity to Sensitive Areas

The Arizona site is proposed for a Prevention of Significant Air Quality Deterioration (PSD) Class II area, which allows for moderate growth in air pollutant emissions. The closest PSD Class I area that permits minimal air quality deterioration is Superstition Wilderness, 30 mi northwest of the site.

5.1.4.3 Regional Air Pollutant Sources

Potential sources of air pollutants sources in the project vicinity include two proposed oil refineries, a print manufacturing company, a proposed hazardous waste incinerator, an inactive sheetrock manufacturing plant, and an inactive copper roaster/leach/acid plant. The permitted or actual emissions levels (Arizona Department of Environmental Quality 1988) of each of these sources are shown in Table 5.1.4-4. The PSD construction permit for the Provident Energy Company (PEC) refinery was revoked because of failure to start construction. The PEC emissions levels are shown here because they are expected to be representative of those which would result from the Maricopa Refinery Company facility, if built. The American Rockwool source has not operated for the past two years. Also, the Cyprus Lakeshore copper facility is currently undergoing PSD permitting in anticipation of resuming operations (Arizona Department of Environmental Quality 1988). Figure 5.1.4-1 shows the locations of these sources with respect to the Arizona SSC site.

Table 5.1.4-4

REGIONAL AIR POLLUTION SOURCES
ARIZONA SSC SITE

Source Name	Location	Permitted or Actual Emissions				
		SO_2	TSP	NO_2 tons/yr	CO	VOC
Provident Energy Co.	Mobile	1,862	237	1,386	193	325
American Rockwool	Casa Grande	71	56	7	244	0
Meredith Bruder	Casa Grande	1	3	81	24	11,887
Cyprus Casa Grande	Noranda	556	24	0	0	0
Maricopa Refinery Co.	Mobile	TBD	TBD	TBD	TBD	TBD
ENSCO	6 miles west of Mobile	27	196	106	34	79

TBD - Permit application has not specified expected emissions.

Source: Arizona Department of Environmental Quality 1988.

5.1.5 Noise and Vibration

5.1.5.1 Ambient Noise Levels

A. Applicable Standards

Applicable noise abatement criteria in potentially applicable for the region of the Arizona site have been promulgated by the Federal Highway Administration (FHWA) and the Department of Housing and Urban Development (HUD). FHWA noise abatement criteria are delineated in 23 CFR 772 for FHWA funded highway projects, and the allowable hourly A-weighted sound levels (L_{eq}) range from 57 dBA for lands on which serenity and quiet are of extraordinary significance to 72 dBA on developed lands. Table 1 in 23 CFR 772 is reproduced here as Table 5.1.5-1. HUD delineated its criteria in 24 CFR 51 for site acceptability for residential development. A site is acceptable in 24 CFR 51 if the day-night average sound level (L_{dn}) does not exceed 65 dBA. No noise regulations, other than nuisance ordinances, exist in the State of Arizona.

B. Background Levels

Ambient noise levels in the project locale away from significant sources are expected to range from 30 to 48 dBA, which would be typical of rural areas. The day-night average sound level (L_{dn}) would be expected to average to 40 dBA (EPA 1982).

C. Proximity to Sensitive Areas

Sensitive noise receptors in the region include schools and residences. The country school at Mobile is located approximately 1.5 mi away from buried beam zone access area J1 and also 1.7 mi from service area F-9. Approximately 11 residences are located within 2 mi of SSC site facilities. Sensitive noise receptors in the project vicinity are shown in Figure 5.1.5-1. Other sensitive noise receptors include big horn sheep, wilderness study areas, and recreational areas.

5.1.5.2 Other Noise Sources

Sources of noise in the region include railroad and Interstate 8 traffic, and military aircraft overflights.

The Southern Pacific Railroad, which is discussed in further detail in following sections, produced a noise level ranging from 72 to 78 dBA at a location 150 ft from the tracks. Interstate 8 (I-8) produces a 24-h time average sound pressure level (L_{eq}) of 56 dBA. Military aircraft, which use the site as a low-level flight training area for military flights from various bases in Arizona, produce a maximum noise level of 70 dBA at a distance greater than 1,000 ft (Cliff 1988).

Table 5.1.5-1

**NOISE ABATEMENT CRITERIA
23 CFR 772
FEDERAL HIGHWAY ADMINISTRATION**

Activity Category	Hourly A-Weighted Sound Level-decibels (dBA)[1] $L_{eq}(h)$	$L_{10}(h)$	Description of Activity Category
A	57 (exterior)	60 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	70 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (exterior)	75 (exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	[2]	[2]	Undeveloped lands.
E	52 (interior)	55 (interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Notes: 1. Either $L_{10}(h)$ or $L_{eq}(h)$ (but not both) may be used on a project.

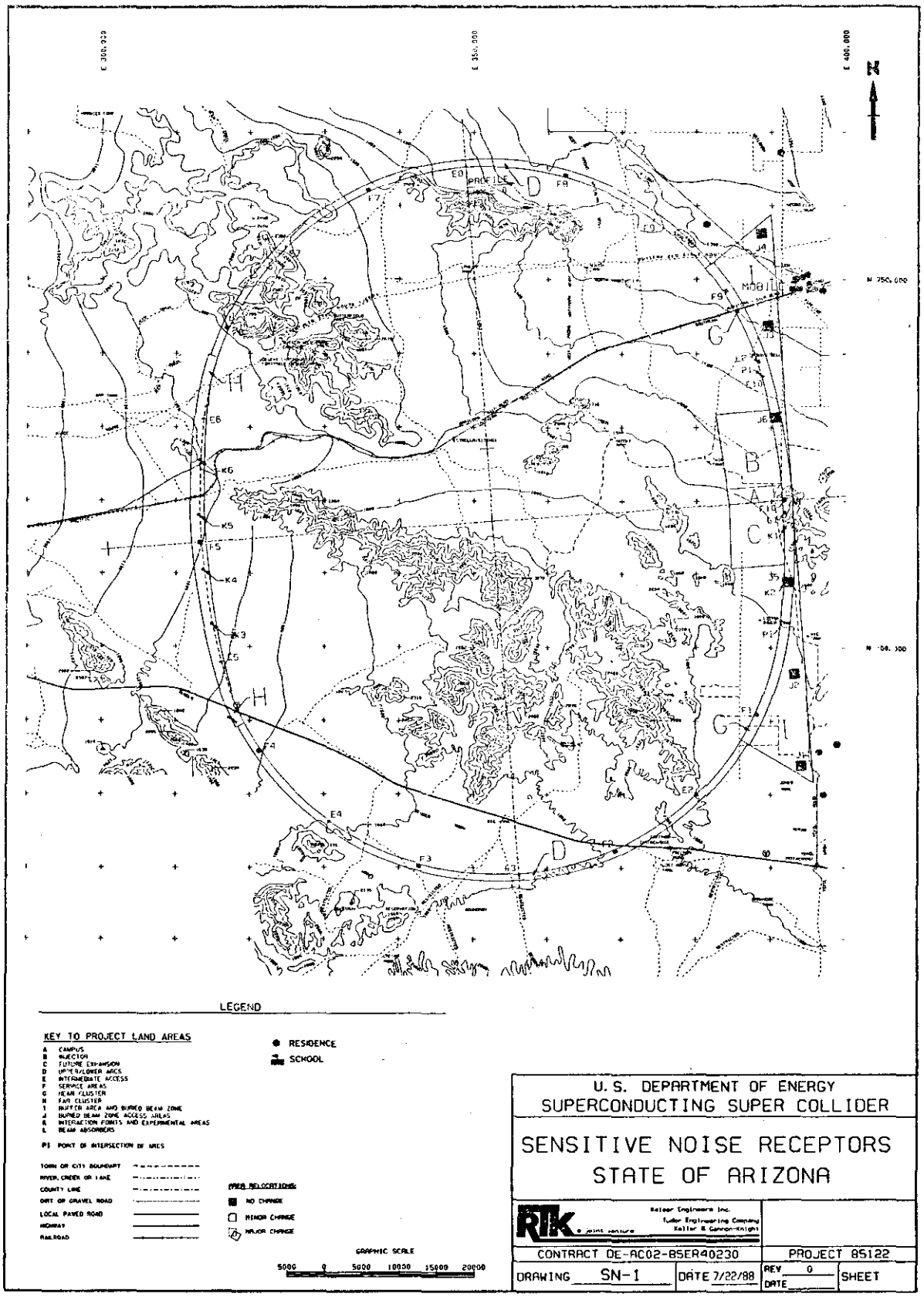
2. No criteria listed in regulation.

Source:

Figure 5.1.5-1

SENSITIVE NOISE RECEPTORS

ARIZONA SSC SITE



5.1.5.3 Ambient Vibration Levels

Ambient vibration levels in the project vicinity are dependent on proximity to human activity. Naturally occurring vibrations, which result from weather phenomena exciting vibrations that can travel long distances in the earth, are low frequency (1 Hz or less). Vibrations from large, distant earthquakes will also produce vibrations at the site. Vibrations caused by human activity are discussed in further detail in the next section.

5.1.5.4 Other Vibration Sources

Vibration sources caused by human activities include I-8 and the Southern Pacific Railroad line traffic. These sources are shown in Figure 5.1.5-2. I-8 crosses the ring at two points. The ring tunnel will be located 100 ft below the railroad on the west crossing and 300 ft below the railroad on the east crossing. Vibrations produced by the highway traffic have not been measured. The Southern Pacific Railroad line crosses the ring at two points. The ring tunnel is located 45 ft and 110 ft below the railroad at the crossing points. The railroad passes within 1/2 mi of interaction points K3 and K4. Vibrations produced by the railroad only are shown in Table 5.1.5-2.

Figure 5.1.5-2

REGIONAL VIBRATION SOURCES
ARIZONA SSC SITE

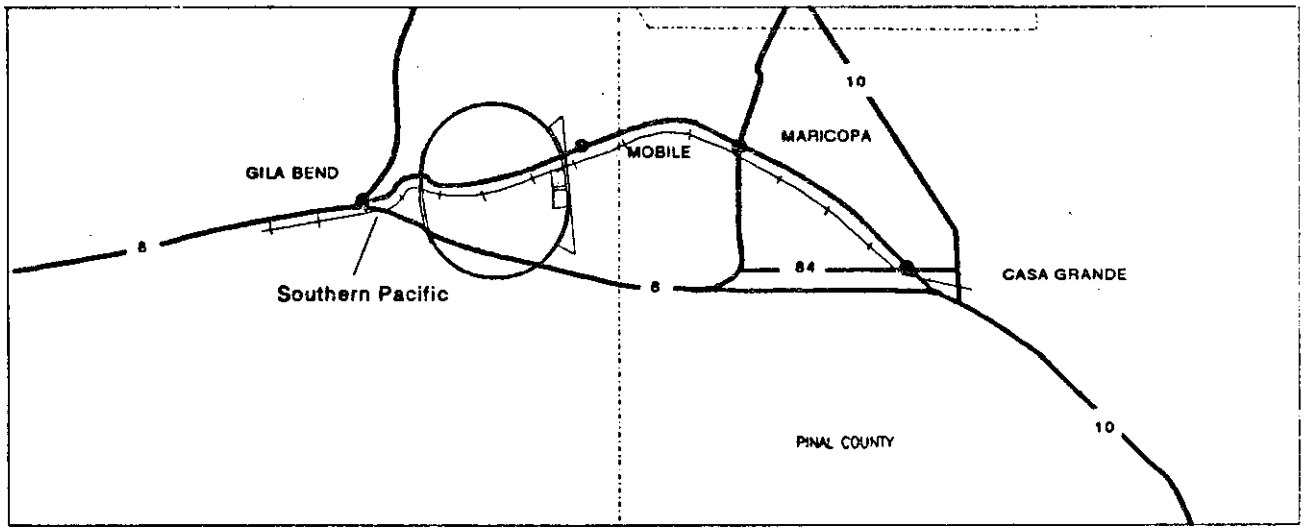


Table 5.1.5-2

RAILROAD PRODUCED VIBRATIONS
ARIZONA SSC SITE

Location of Point Relative to Vibration Source		Measured Vibrations			
		Horizontal		Vertical	
Horizontal ft	Vertical ft*	Displacement in	Frequency Hz	Displacement in	Frequency Hz
70	64	8×10^{-5}	57	5×10^{-4}	28
70	33	1×10^{-4}	43	5×10^{-4}	28
70	10	7×10^{-4}	21	1.2×10^{-3}	21
70	0	1.3×10^{-3}	31	7×10^{-4}	26
50	65	0	N/A	6×10^{-5}	85
50	35	0	N/A	1.7×10^{-4}	28
50	10	8×10^{-5}	57	2×10^{-4}	24
50	0	6×10^{-4}	43	2×10^{-4}	36

* Ft below ground level.

Source: Sergent, Hauskins, and Beckwith 1987.

5.1.6 Environmental Radiation

5.1.6.1 Natural Radioactivity

A. Radon

Indoor radon levels reported by the University of Pittsburgh Radon Project are presented in Table 5.1.6-1. Indoor radon levels in Maricopa County residences averaged 2.50 pCi/l (Cohen 1988).

Radon-222 is a decay product of Ra-226 and U-238, and therefore the concentration of Ra-226 determines the Rn-222 production rate. The Ra-226 concentrations reported by the Arizona State University Radiation Measurements Facility (RMF) were not measured at the proposed SSC tunnel depth, but soil concentrations ranged from less than 0.25 to 2.02 pCi/g with an average of 1.33 pCi/g (RMF 1987). Exposure rates from core samples obtained at the proposed tunnel depth measured 23 μR/hr which is slightly elevated over the background of 20 μR/hr in the core storage building. The maximum exposure rate from these core samples was 27 μR/h. The proposed SSC site contains formations of granite (see Section 5.1.1) which typically contain 1 pCi/g U-238 (NCRP 1975). If Ra-226 is assumed to be in equilibrium with U-238, this would represent a Ra-226 concentration of 1 pCi/g.

B. Soil/Rock

Since 1981, the RMF has routinely monitored natural radioactivity in the surface soil. The following isotopes were reported by the RMF in baseline data from 1985 to 1987 at three different locations in the vicinity of the proposed SSC: Ra-226, U-238, Th-232, K-40, Cs-137, Ac-228, Pb-214, Bi-214 and Sr-90 (RMF 1985-1987). The Ra-226 concentrations ranged from less than 0.25 to 2.02 pCi/g with an average of 1.33 pCi/g. The U-238 concentrations were reported in 1985 and were below the minimum detectable activity (RMF 1985). The Th-232 concentrations ranged from 1.07 pCi/g to 1.64 pCi/g with an average of 1.33 pCi/g. No anomalies were reported.

Core samples from the proposed SSC site were radiometrically surveyed. One core sample from a drill hole located 1 mi east-northeast of milepost 46 on the collider footprint yielded exposure rates on the order of 27 μR/h. All other core samples were 23 μR/h or less. The survey was performed at the core storage area, which had a natural background of approximately 20 μR/h.

The National Uranium Resource Evaluation Data (NURE 1979) did not indicate the presence of uranium ore bodies in the area of the proposed SSC. However, the presence of uranium in this area is considered possible, as a result of sediment influx from surrounding granitic and metamorphic terrains and the incorporation of uranium into monzaite.

Table 5.1.6-1

RADON LEVELS

Location	Number of Samples	Geometric Mean pCi/l	Average pCi/l	Percentage of Homes with Radon Levels <4 pCi/l	4-20 pCi/l	>20 pCi/l
United States						
Living space	49,659	1.76	4.01	80	18	2
Basement	23,984	3.37	7.87	59	34	7
Arizona						
Living space	115	1.95	3.23	83	15	2
Basement	4	6.39	6.83	0	100	0
Maricopa County						
Living space	47	1.76	2.50	94	4	2
Basement	NA					

NA - Not available.
Source: Cohen 1988.

C. Water

Two groundwater samples from locations at the proposed SSC site were analyzed by the RMF (RMF 1988). Gross alpha activities were less than 8.870 pCi/l and 17.100 pCi/l. The values reflect a high minimum detectable level and uncertainty due to nonradioactive impurities and dissolved solids in water. Gross beta activities were reported as 8.220 and 6.170 pCi/L; the Ra-226 concentrations were 0.160 and 0.004 pCi/l. Tritium was reported as less than 471 pCi/l at the campus area and 581 pCi/l at the south location.

D. Measured Considerations

Borehole and water radioactivity levels were based on a limited number of samples. These samples may or may not be representative of the radioactivity expected at the site.

No surface water was found in the vicinity.

5.1.6.2 Man-Made Radiation

Based on the profile of state and local radiation control programs for FY 1985 (CRCPD 1987), the State of Arizona issued 230 medical licenses, 190 industrial licenses, and four academic licenses to authorize the use of radioactive materials (RAM) in the state. Nineteen licenses were granted authorizing the use of RAMs other than the above named categories. Authorization was also awarded to one licensee for use of source materials and to another licensee the use of special nuclear materials. RAMs were used in medical institutions, private clinics, teletherapy, in-vitro laboratory analysis, and nuclear pharmacy by the medical licensees. For the industrial licensees, the RAMs were used for well logging, industrial radiography irradiation, civil defense, research and development, etc. Some licensees were authorized to manage radioactive wastes or to perform leak testing for sealed radioactive sources for their clients. Nuclear reactors and federal facilities, excluding DOE facilities, are currently regulated by the Nuclear Regulatory Commission (NRC). In Arizona, 21 RAM licensees are under the NRC's jurisdiction.

The proposed SSC site is in a rural area that does not contain any of the licensed operations listed above. The site does not encompass any government facilities possessing RAMs nor are there any milling or mining activities that would enhance the natural background levels.

The Palo Verde Nuclear Generating Station (PVNGS) is located approximately 30 mi northwest of the proposed SSC footprint. An extensive environmental sampling program including soil, water, and air monitoring does not indicate any increased radioactivity in the proposed area due to PVNGS operations (McKlveen 1988).

A search was conducted using the Oak Ridge National Laboratory (ORNL) Decommissioning Site Database to identify any decommissioned RAM site in this area. No known decommissioned site is in the proposed SSC area.

5.1.6.3 Background Radiation

A long-term environmental assessment program for the PVNGS includes four monitoring locations in the vicinity of the SSC: Stellar Airpark in Chandler, Estrella Airpark near Mobile, Gila Bend, and the Gila Compressor Station at Gillespie Dam.

The direct radiation monitoring portion of the program consists of monthly and quarterly thermoluminescent dosimetry, monthly scintillator, and annual pressurized ion-chamber measurements of background radiation.

Data obtained in the assessment program in the SSC vicinity since 1984 show measured gamma radiation dose of an equivalent rate of background radiation to be in the range of approximately 100 to 130 mrem/yr (Palo Verde 1984-1987).

5.1.7 Nonradioactive Environmental Hazards

5.1.7.1 Hazardous/Toxic Materials

The proposed Arizona SSC site is in a rural desert region with little or no historical industrial activity. Consequently, no former sources of hazardous/toxic materials have been located. Likewise, no industrial sources of hazardous/toxic materials currently exist in the affected area.

One future potential source of hazardous/toxic materials in the vicinity is a small oil refinery (Maricopa Refinery Co.) proposed for a location near the town of Mobile. It is expected to process about 30,000 bbl/d and will be located about 3 mi from the SSC ring. The owners are presently in the process of obtaining a permit for construction.

An existing natural gas distribution pipeline passes through the town of Mobile and crosses the SSC beam absorber area (between access points J3 and J4). In addition, a crude-oil pipeline, scheduled for construction in 1988-1989 by the Pacific Texas Pipeline Co. of Midland, Texas, will be located along the same right-of-way as the gas pipeline. These pipelines are closed systems that will present no hazard unless subjected to catastrophic failure.

The State of Arizona is constructing its first approved hazardous waste treatment and disposal facility. Located within the bounds of the proposed SSC location, the facility, sited about 6 mi west-southwest of Mobile, is just north of Maricopa Road (inside the SSC ring) on a 1-mi^2 parcel of land. It will include both landfill and incineration capabilities.

5.1.7.2 Biological Hazards

The proposed SSC site is located adjacent to Rainbow Valley, a source of a particular fungal spore, *Coccidioides immitis* that can cause an illness commonly known as Valley Fever (Coccidioidomycosis) (Leathers 1982). This soil fungus thrives in arid and semiarid regions such as southern Arizona and is particularly prevalent in the Phoenix and Tucson areas.

The disease is contracted by inhaling the airborne microorganisms (usually transported by high winds) and most often manifests itself as a bad cold. Most persons infected by the fungus (60 to 70%) do not develop symptoms and are not aware of the infection. It has been estimated that about two-thirds of all residents of Valley Fever areas have been infected with the disease-causing fungus and have thereby acquired an immunity to further infection.

A more serious illness results in about 30 to 40% of all Valley Fever cases. And in rare instances (less than 1% of infections), death has been attributed (at least in part) to this disease (EPA 1983). The known death rate from Valley Fever in Arizona is 25 persons per year, although one scientist estimates that the rate could be as high as 100 because of difficulties in diagnosis and reporting (Leathers 1982).

5.1.8 Existing Waste Management Facilities

5.1.8.1 Sewage Facilities

There are no existing sewage (wastewater) treatment facilities to which the sewage system from the SSC area could be connected. None of the surface drainage systems at the site receive treated sewage inventories. Domestic wastes from ranches near the site are disposed of at their point of origin.

5.1.8.2 Solid Waste Facilities

The three existing landfill facilities in Maricopa County have remaining capacities as shown in Table 5.1.8-1. The approximate locations of these three landfill facilities are shown in Figure 5.1.8-1. The total remaining capacity is 47.5 million yd^3.

Table 5.1.8-1

EXISTING LANDFILLS IN MARICOPA COUNTY

Landfill	Approximate Distance from SSC Site mi	Remaining Capacity million yd^3	Year Maximum Capacity Reached
Glendale	75	12	2012
Chandler	40	1.5	1995
Tri-City	50	34	2015

Source: MAG 1987.

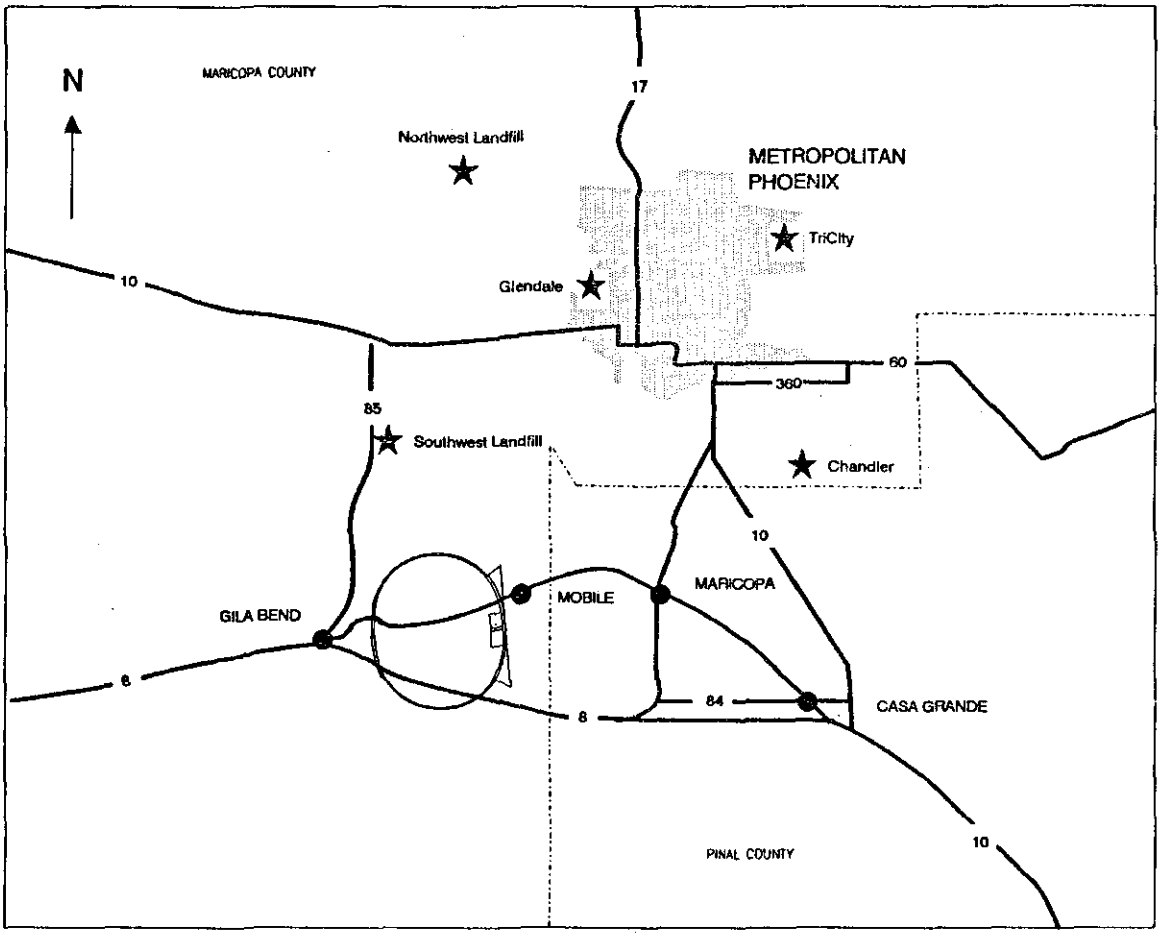
Proposed facilities in the southwest and northwest of Maricopa County will have capacities of 62 million yd^3 and 43 million yd^3 and will reach their maximum capacities by the years 2017 and 2037. The northwest regional landfill will be located at 187th Avenue and Deer Valley Road (about 60 mi north of SSC site). The southwest regional landfill will be located 50 mi northwest of the SSC site, near Buckeye (MAG 1987). The proposed southwest regional landfill will accept nonhazardous liquid industrial waste.

5.1.8.3 Hazardous Waste Disposal Facilities

At present, there are no approved (permitted) off-site hazardous waste disposal facilities in Arizona. Waste generators must ship their hazardous materials to approved facilities out of state unless they have been permitted by the state to store, treat, or dispose of hazardous wastes on site.

Figure 5.1.8-1

APPROXIMATE LOCATION OF EXISTING SOLID WASTE FACILITIES



★ Approximate Location of Existing Solid Waste Facilities in the Arizona SSC Area

Arizona is currently developing a hazardous waste disposal facility to be constructed and operated by a contractor for the state. Construction of this facility was recently begun at a location approximately 6 mi west of the village of Mobile (which places it inside the SSC ring). Operation is anticipated to begin in 1989. The present design of the facility includes an incinerator to burn both PCBs and liquid hazardous wastes, and a landfill for solid wastes. Storage, treatment, and support facilities will complete the site (EPA 1983).

5.1.8.4 Low-Level Radioactive/Mixed Waste Disposal Facilities

Currently there are no commercial low-level radioactive/mixed waste disposal facilities operating in Arizona.

As reported by disposal site operators, 136 m^3 (109 curies) of low-level radioactive waste (LLRW) was generated in Arizona in 1986. Utilities generated 98.3% of the total volume, which consisted of spent resins, filter sludges, and evaporator bottoms. LLRW generated by the industrial generators only accounts for the other 1.7% of the total volume. Only 1% of the volume was class B LLRW, and the other 99% was class A waste (EG&G 1987).

5.1.9 Ecological Resources

5.1.9.1 Regional Ecological Characteristics

A. Definition of Drainage Basins and Boundaries of Ecological Resources Potentially Impacted

The drainage basin potentially hosting the SSC is the Gila River drainage basin which drains the central portion of Arizona (Figure 5.1.9-1). In the area of the proposed site, there is only ephemeral flow in the Gila River because of upstream diversions for earlier developments (Rea 1983).

There are three subdrainage basins of the Gila River within the site. These are:

- Vekol Wash in the east which drains into the Gila River northeast of the site (50% of the basin)
- Waterman Wash which drains into the Gila River due north of the site (40% of the basin)
- Bender Wash in the west which drains into the Gila River west-southwest of the site (10% of the basin).

The ecosystems within this drainage basin are moderately undisturbed desert scrub systems that: 1) are slow to recover from stress; 2) behave as a series of islands of biological productivity in the sea of desert pavement, 3) exhibit stochastic productivity (rapidly growing and reproducing during periods of water availability); and 4) have nutrient cycles that depend on atmosphere/soil (including microbial-invertebrate interactions)/vegetation interactions.

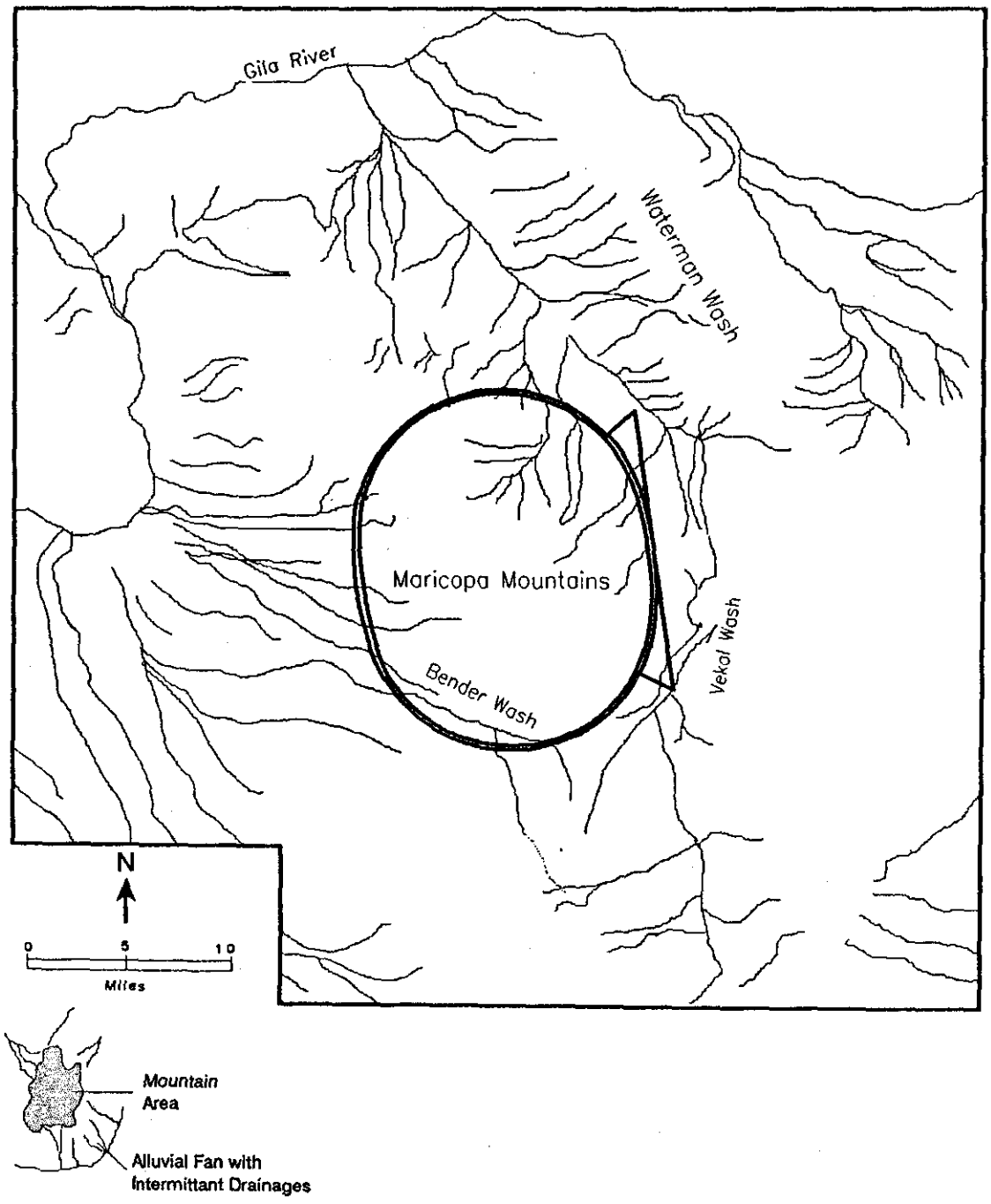
B. Relationship of Ecological Resources with Other Resources

The other resources most closely coupled with the ecological resources are: 1) soil, because of essential element mineralization and soils stabilization (including organic matter accumulation) within vegetation clumps; 2) air, increasing localized water vapor, moderating desert temperatures, and minimizing wind erosion of soil; and 3) water, conserving rare precipitation events within succulent plant parts and in underground caches of organically rich, high-moisture-content fecal materials and detritus.

Ecological communities in the desert environment are affected in the short term by microclimatic conditions and physical disturbances. Once disturbed, these communities have slow reestablishment rates; the costs associated with desert reclamation are high. Ecological communities are affected in the long-term by climate, by the accumulation of organic debris and mineralized nutrients, and perhaps by the action of seed-eating herbivores.

Figure 5.1.9-1

RIVER BASINS OF THE ARIZONA SSC SITE



C. Classification of Ecosystem Types and Their Distribution

The ecotypes within the Arizona site are two forms of desert scrub, the Arizona Upland and Lower Colorado associations. These associations occupy more than 90% of the proposed site (Brown 1982). Figure 5.1.9-2 summarizes the distribution of these desert scrub associations with respect to the proposed SSC features. The subdrainage basins affected can be summarized as:

- Bender Wash, Arizona Upland
- Waterman Wash, mostly Lower Colorado with isolated pockets of Arizona Upland
- Vekol Wash, Lower Colorado.

There are negligible aquatic ecosystems in the region of influence (ROI). Ephemeral associations are especially associated with temporary catchments used for livestock and wildlife watering. There are no permanent ponds or perennial streams in the area. Under the USFWS classification system, there are no Class I wetlands in the area (Cowardin 1979).

The one xeroriparian association in the area is the Sonoran riparian woodlands (Warren and Anderson 1985). The woodland ecotype is limited to the two ephemeral washes traversing the site: Bender Wash in the southwest and Waterman Wash in the northeast. Other small washes are common on the site that may have riparian associations within limited areas.

There are eight stock ponds within the ring, and mesquite is associated with each. In addition, there are numerous concrete-lined water catchments that have enhanced the vegetation on their borders.

5.1.9.2 Terrestrial Ecosystem Characteristics

A. Plant Community Composition

Table 5.1.9-1 summarizes the aerial extent and proportion (%) of the SSC surface features within the Arizona Upland and Lower Colorado associations. In total, the site is approximately 70% Arizona Upland and 30% Lower Colorado. The Sonoran riparian woodland is discussed under the aquatic ecosystems section below.

Figure 5.1.9-2

**DISTRIBUTION OF DESERT SCRUB
ARIZONA SSC SITE**

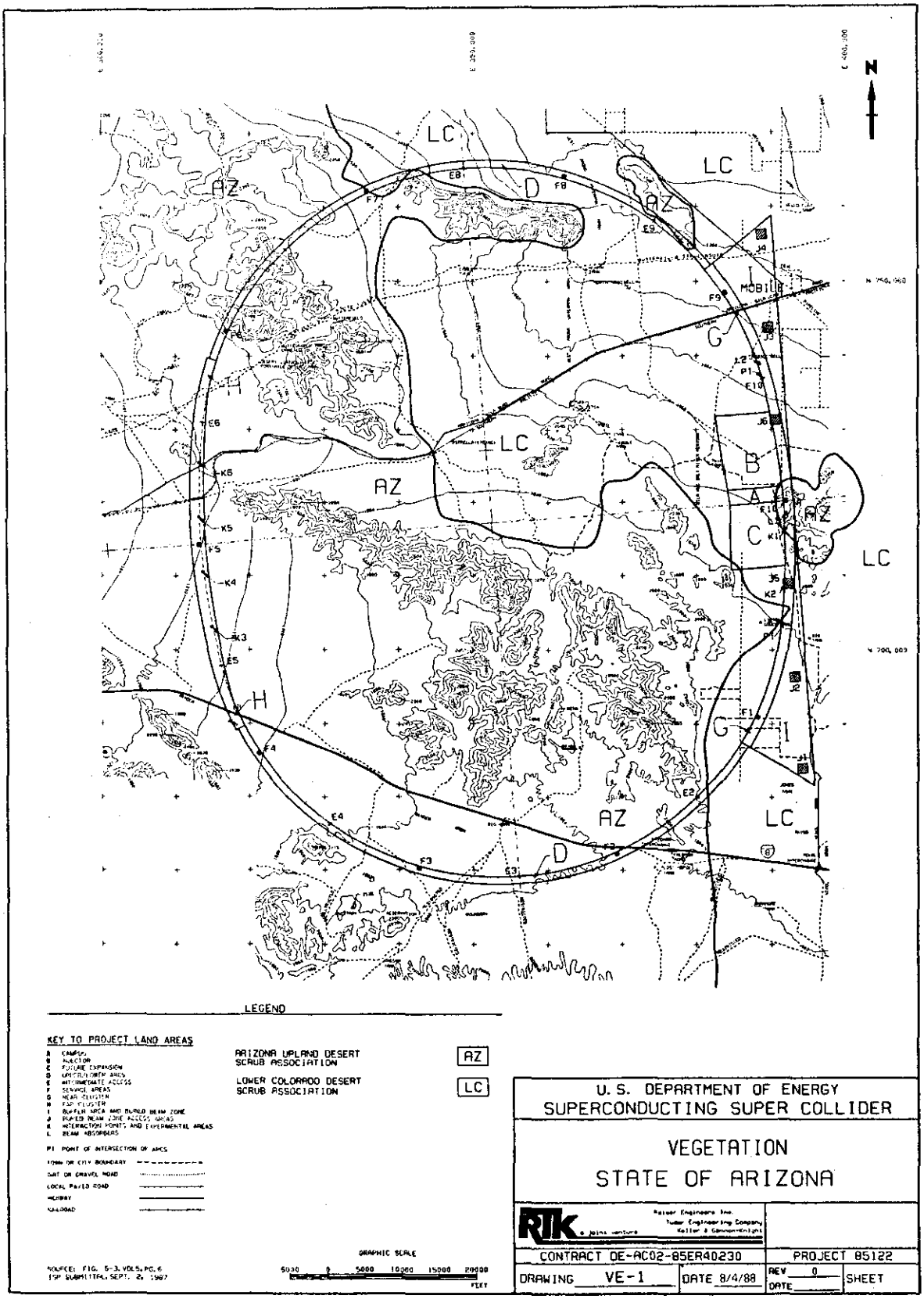


Table 5.1.9-1

DISTRIBUTION OF LANDS
WITHIN 1,000 FT OF THE TUNNEL BY
VEGETATION TYPE

Facility Area	Association Arizona Upland acres (%)	 Lower Colorado acres (%)
A,B,C (campus, injector, expansion)	175 (5)	3,325 (95)
D,E,F (collider ring, service access)	2,274 (60)	1,510 (40)
G,H,K (experimental area clusters)	2,394 (60)	1,596 (40)
I,J (absorber/external beam access)	0 (0)	4,550 (100)
Cut-and-Cover Portion of Collider Ring	490 (34)	952 (66)

Sources: BLM 1987; Brown 1982.

Much of the area can be classified as climax in terms of plant development and maturity of the successional trend. In those areas that have been disturbed the extreme sensitivity of the desert ecosystems is reflected in the presence of a disclimax plant community. Following disturbance such as off-road vehicle traffic and grazing livestock, recolonization by the same species occurs. Certain species, notably bursage and brittle bush, have greater recolonization rates. Cacti and creosote bush are much slower to reestablish in disturbed areas. Recovery rates are very slow, often taking up to 100 years to reach predisturbance levels of productivity, species diversity, and density (Webb and Wilshire 1983). Table 5.1.9-2 summarizes the plant communities, the type of disturbance near proposed SSC facilities, and any noteworthy ecological features at each of these locales.

No formal studies of plant diversity have been conducted in the site area; however, qualitative information presented below is characteristic of the dominant associations. Additional information on the mesa and mountain plant associations is also given in Keil (1970) and Sundell (1974).

Table 5.1.9-2

EXISTING DISTURBANCE OF ECOLOGICAL ASSOCIATIONS IN THE AREAS PROPOSED TO SUPPORT SSC FACILITIES

Proposed SSC Facility	Association	Level of Disturbance: Grazing Cattle	Mesquite Harvest	Mining Claims	Off-Road Vehicles	Biota Collection	Notation
A Campus	Lower CO	Hi	Mod	Neg	Hi	Mod	
B Injector	Lower CO	Mod	Mod	Neg	Mod	Neg	
C Expansion Area	Lower CO	Mod	Neg	Neg	Mod	Neg	
Access Shafts:							
E1	Lower CO	Hi	Neg	Neg	Neg	Neg	
E2	Lower CO	Hi	Neg	Neg	Neg	Neg	Night-blooming cereus present.
E3	Lower CO	Neg	Neg	Mod	Neg	Neg	High diversity in bajadas and washes.
E4	AZ Upland	Neg	Neg	Neg	Lo	Neg	Prime bighorn sheep habitat; North Maricopa Mtns. WSA*
E5	AZ Upland	Neg	Neg	Neg	Lo	Neg	Prime desert tortoise habitat; Butterfield Stage. WSA*
E6	AZ Upland	Neg	Neg	Neg	Lo	Neg	South Maricopa Mtns. WSA*
E7	AZ Upland	Neg	Neg	Neg	Lo	Neg	High bird diversity; adjacent to Bender Wool; Park-lined tinajas
E8	AZ Upland	Neg	Neg	Neg	Neg	Neg	Moderate wash; potential desert tortoise habitat
E9	AZ Upland	Lo	Neg	Neg	Neg	Neg	

Table 5.1.9-2 (Cont)

EXISTING DISTURBANCE OF ECOLOGICAL ASSOCIATIONS IN THE AREAS PROPOSED TO SUPPORT SSC FACILITIES

Proposed SSC Facility	Association	Level of Disturbance: Grazing Cattle	Mesquite Harvest	Mining Claims	Off-Road Vehicles	Biota Collection	Notations
E10	AZ Upland	Lo	Neg	Neg	Neg	Lo	Mammillaria species
Service Areas:							
F1	Lower CO	HI	Neg	Neg	Neg	Neg	
F2	Lower CO	Lo	Neg	Neg	Neg	Neg	Near Waterman Wash; high diversity.
F3	AZ Upland	Neg	Neg	Neg	Neg	Neg	North Maricopa Mtns. WSA*
F4	AZ Upland	Neg	Neg	Neg	Lo	Neg	Prime bighorn sheep habitat; North Maricopa Mtns. WSA*
F5	AZ Upland	Neg	Neg	Neg	Lo	Neg	South Maricopa Mtns. WSA*
F6	AZ Upland	Neg	Neg	Neg	Lo	Neg	Near Bender Wash; increased bird diversity.
F7	AZ Upland	Neg	Neg	Neg	Lo	Neg	
F8	AZ Upland	Neg	Neg	Neg	Lo	Neg	
F9	Lower CO	Lo	Neg	Neg	Neg	Neg	
F10	AZ Upland	Neg	Neg	Neg	Lo	Neg	

Table 5.1.9-2 (Cont)

EXISTING DISTURBANCE OF ECOLOGICAL ASSOCIATIONS IN THE AREAS PROPOSED TO SUPPORT SSC FACILITIES

Proposed SSC Facility	Association	Level of Disturbance: Grazing Cattle	Mesquite Harvest	Mining Claims	Off-Road Vehicles	Biota Collection	Notations
Interaction Areas:							
K2	Lower CO	Mod	Neg	Neg	Lo	Neg	
K3	AZ Upland	Neg	Neg	Neg	Lo	Neg	
K4	AZ Upland	Neg	Neg	Neg	Lo	Neg	South Maricopa Mtns. WSA*
K5	AZ Upland	Neg	Neg	Neg	Lo	Neg	South Maricopa Mtns. WSA*
K6	AZ Upland	Neg	Neg	Neg	Lo	Neg	South Maricopa Mtns. WSA*
External Beam/Absorbers:							
J1	Lower CO	Neg	Mod	Neg	Mod	Mod	Dump site at south edge. Night-blooming cereus in wash.
J2	Lower CO	Mod	Neg	Neg	Mod	Neg	
J3	Lower CO	Lo	Neg	Neg	Neg	Neg	
J4	Lower CO	Neg	Neg	Neg	Lo	Neg	High diversity in wash and hills. Large areas of desert pavement.
J5	Lower CO	Mod	Neg	Neg	Lo	Neg	
J6	Lower CO	Neg	Neg	Neg	Neg	Neg	Night-blooming cereus in wash (East).

Notes:
WSA - Wilderness Study Area. Hi - High Neg - Negligible
Sources: Damneer & Patten 1985; BLM 1987. Mod - Moderate Lo - Low

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1. Arizona Upland Association

The Arizona Upland association is characterized by a relatively high diversity of species found on bajadas, on mountain slopes, and on higher elevation mesas. At lower elevations (approximately 1,600 to 2,000 ft above mean sea level), the association is dominated by leguminous trees, including mesquite, iron wood, and a few palo verde, and by shrubs and cacti. At higher elevations and on the mesas (usually above 2,000 ft above mean sea level), the association is dominated by palo verde, fewer cacti, low stature shrubs, ferns, and perennial herbs.

The productivity of this assemblage is greater than that of the Lower Colorado association. The greater productivity results from favorable microclimatic conditions, particularly with respect to availability of sparse water sources and from the dominance of leguminous trees, allowing more rapid nitrogen incorporation and higher accumulations of organic matter into soils under the canopy.

2. Lower Colorado Association

The Lower Colorado association is dominant below 1,600 ft above mean sea level and is typically creosote bush and bursage. It has a characteristically lower diversity, density, and productivity than the Arizona Upland association. In addition to the dominant creosote bush and bursage, cacti are plentiful. The few annuals are dominated by plantain and Mediterranean grass.

Washes are located throughout the Lower Colorado ecotype but are more characteristic of the Arizona Upland in both species diversity and density. Most noticeable along the washes are increased frequencies of triangle leaf bursage, ratany, and the columnar saguaro cactus. Small washes that occur in the Arizona Uplands exhibit even greater increases in frequencies of bursage, ratany, and saguaro.

B. Animal Community Composition

The discussion of the consumer communities below is organized into that for invertebrates, herpetofauna (amphibians and reptiles), ground-dwelling predator-prey relationships, and avian predator-prey relationships. The discussion of individual populations is limited to those that are economically, recreationally, or culturally important or that are protected by either state or federal statute.

1. Invertebrates

Desert invertebrates are abundant and are dominantly below-ground life-forms, although emergence for feeding is common. Approximately 20 to 30 species of ants may be encountered along a gradient from the Lower Colorado washes to the upper bajadas. Scorpions are also prevalent. Desert spiders include Carolina wolf spider and the tarantula. Common insects include bees, wasps, beetles, centipedes, and termites (MacMahon 1985).

Termites are abundant and play an important role in nutrient cycling (reference). Mechanisms of enhanced nutrient cycling include: increased incorporation of organic matter in sandy soils; greatly enhanced nitrogen accumulation; invasion and channeling of woody debris; and enhanced stabilized microbial production in termite mounds. Each termite colony and its supporting microbial community is responsible for approximately one-third of the nitrogen accumulated in the area annually.

Desert invertebrates are important to ecological processes, including pollination of short-lived blooms of annuals and some cacti.

2. Herpetofauna

The Sonoran Desert is richly populated with reptiles. Species occurrence is dependent on a variety of habitat factors, including:

- Geological characteristics in mineralization zones
- Soil texture and chemical composition (including microsite moisture levels)
- Vegetation types, food preference, and densities of preferred food and shelter plants
- Little under-shrub clusters or "islands" both in quantity and substrate quality
- Above-ground and below-ground spatial diversity of the structural components of the plant communities.

Amphibians are rare, although toads and salamanders can be found in catchments and ephemeral pools in desert washes when water is present. Species of amphibians capable of reproduction in these habitats are Colorado River or spadefoot toad, Great Plains toad, and red-spotted toad. The duration of water availability determines species composition of the catchment or wash. Spadefoot toads have been objects of ecological investigation because they complete their life cycle in the few weeks available in ephemeral pools, spending the balance of the year dormant in underground burrows.

Reptiles are far more abundant than amphibians. Common within the creosote bush (Lower Colorado association) are desert iguana, Sonoran spotted whiptail lizard, and desert horned lizard. Within the bajadas of the Arizona Upland, other reptiles such as chuckwalla and collared lizard are frequent. The Gila monster is closely associated with the Arizona Upland area. The desert tortoise is a dominant inhabitant of the bajadas, especially those areas closely associated with washes, which are required for the tortoise.

Rocky hillsides host snakes, typically the gopher snake, western diamondback rattlesnake, and Mojave rattlesnake. Washes provide habitat for many reptilian species, including the arboreal tree lizard and desert spiny lizard.

3. Ground-Dwelling Prey and Predators

The SSC area is rich in vertebrate species. The Arizona Upland ecotype has 114 known species, while the Lower Colorado ecotype has 87 species.

The predominant prey species are typical Sonoran small mammals, including desert cottontail rabbit, black-tailed jackrabbit, and a myriad of rodent species such as the antelope squirrel, Merriam's kangaroo rat, desert pocket mouse, white-throated wood rat, and cactus mouse (MacMahon 1985; Lowe 1964; Hoffmeister 1985). These animals are almost exclusively burrowing animals, living beneath the canopies of the desert scrub vegetation in the litter or in the soil among woody roots. Small rodents are abundant, feeding on the large volume of seeds produced by desert plant communities. Several, such as the kangaroo rats, excavate extensive burrows under one or more creosote bushes or associated larger shrubs. Others, such as the wood rat, make dens of the surficial litter and debris.

Several large mammals inhabit the site. These are primarily javelina, desert bighorn sheep, and mule deer. These are discussed in detail in Section 5.1.9.5.

Predators include coyote, grey and kit foxes, bobcat, spotted and common skunks, and fewer porcupines and badgers. The kit fox and bobcat have minimally overlapping ranges, with the kit fox dominating the low elevation Lower Colorado association and the bobcat usually confined to the upper bajadas and high mesas. There are more than 20 species of bats which have been identified in the general region of influence of the proposed SSC site. Many are seasonal migrants. Several are important pollinators of the saguaro cactus and other night-blooming plant species. However, no large colonies have been observed. Their distribution is highly skewed toward permanent water sources, e.g., catchments and protected shelter such as old growth trees.

4. Avian Communities

Dummer and Patten (1985) report that more than 30 bird species are likely to breed in the Sonoran desert scrub associations. There are probably more than 120 additional species that are transient to the area (EPA 1983). The creosote-bush-dominated Lower Colorado association supports fewer bird species than the Arizona Upland association. Those nesting in the habitat include the Gambel's quail, black-throated sparrow, and lesser nighthawk.

The Arizona Upland, including the denser vegetation near washes, supports additional avian species, including the cactus-nesting birds such as the cactus wren, Gila woodpecker, elf owl, and screech owl. Quail, roadrunners, curve-billed thrashers, red-tailed hawks, and Harris hawks are also common in the Arizona Upland. Where water is within flight distance, white-wing doves nest in this association.

C. Ecosystem Level Processes

Variation in total productivity of the Sonoran desert ecosystem is high from year to year depending on rainfall and microclimatic patterns. Reclamation of disturbed areas is extremely slow, averaging 30 to 100 years depending on the size of the disturbed area, the microclimate in the area, and seed distribution/establishment rates. Soil stabilization via algal crust formation is a key to enhanced recolonization rates.

5.1.9.3 Aquatic Ecosystems

There are no aquatic ecosystems in the proposed site area. There are no wetlands as defined by the USFWS classification (Cowardin et al. 1979). The discussion of aquatic ecological resources presented below is limited to:

- Sonoran riparian woodlands (Brown 1982)
- Stock ponds
- Water catchments.

There are no fish associated with these aquatic ecosystems and only limited presence of amphibians (as described above) and invertibrates.

The Sonoran riparian woodlands are only associated with the deeper washes in the site. There are no obligate riparian species such as Batamote (*Baccharis* spp.) or Cottonwood (*Populus fremontii*) present in the ROI. These shallow woodlands are dominated by ironwood, blue palo verde, white thorn acacia, and mesquite. Many of these species are also found in the Arizona Upland association. Shrubs that are frequent include cat-claw acacia, wolfberry, and burrobush. Other shrubs present in less density include graythorn, feather duster, desert hackberry, and Mexican jumping bean. Several herbs, grasses, and vines are also riparian species, most notably canyon ragweed.

The eight stock ponds within the ring are sparsely populated, but mesquite and salt cedar (an introduced species) are common around the borders.

Water catchments in the area are typically concrete-lined. The surrounding associations are typical of the dominant Arizona Upland or Lower Colorado ecotypes. The water held in these stock ponds and catchments is essential for some wildlife, e.g., bighorn sheep, and is attractive to other desert dwellers such as quail, roadrunners, coyotes, bobcats, reptiles, and amphibians.

5.1.9.4 Economically, Recreationally, and Culturally Important Species

Species of economic importance in the area include domestic livestock within the three grazing allotments, as well as two furbearers, bobcat and coyote. There are no aquatic species of economic importance.

Recreational hunting use is typical for a few game species, including Gambel's quail, doves, rabbits, mule deer, javelina, coyote, and (traditionally) bighorn sheep.

There are no species within the SSC site vicinity that are of special cultural significance.

Hunting that occurs within the SSC ROI is primarily for javelina and mule deer. Densities of the javelina are low, but not well known (Remington 1987). Densities of mule deer are reported within the ROI as 2 to 5/mi^2 (Werner 1987). Mule deer occur throughout the area, though densities are somewhat higher in the northern Maricopa Mountains and the drainages of the northwest sector of the proposed project. Habitats of each of these species have been reduced because of off-road vehicles and cattle grazing.

5.1.9.5 Threatened and Endangered Species

A. Federally Listed, Proposed, or Candidate Species

There are three plants and three animals federally identified as potentially threatened or endangered. Only one of these is listed as endangered, the Tumamoc globeberry. Neolloydia is a Category 1 species, night-blooming cereus, desert tortoise, Gila monster, and Swainson's hawk are all Category 2 species. Two additional species, the peregrine falcon (*Falco peregrinus*) and the southern bald eagle (*Haliaeetus leucocephalus leucocephalus*), are both classified as endangered species. Although their range includes the SSC ROI, they are not discussed here because they are not known to make sufficient use of the area.

The typical sites of these species are summarized in Table 5.1.9.3. No density or productivity data are available currently for the ROI.

1. Swainson's Hawk

The Swainson's hawk (*Buteo swainsoni*) is a USFWS Category 2 species. It may use the SSC ROI during migration. The hawk is remarkably similar to the red-tailed hawk in appearance and life history. It summers throughout the U.S. and often winters in Argentina. It is a typical raptor, feeding on small mammals, primarily rodents. The Swainson's hawk typically nests in palo verde or mesquite branches using a platform of sticks. The clutch size is typically two to four eggs.

Table 5.1.9-3

THREATENED AND ENDANGERED SPECIES AT THE ARIZONA SITE: FEDERALLY LISTED, PROPOSED, OR CANDIDATE SPECIES

Status Category	Common Name	Scientific Name	Habitat	Sources
1	Neolloydia	Neolloydia erectocentra var acunensis	Lower CO association, well-drained bajadas and slopes	Spiller, 1987 Spiller, 1988
2	Night-blooming cereus	Peniocereus greggii	Lower CO association, understory species	Spiller 1987 Spiller 1988
Endangered	Tumamoc globeberry	Tumamoca macdougalii	AZ Upland association, Vine, between 1,500-2,600 ft	Spiller 1988
2	Desert tortoise	Gopherus agassizi	Washes, rocky bajadas, mostly north Maricopa Mtns.	AG7C 1982 Spiller 1987 Spiller 1988
2	Gila monster	Heloderma suspectum	Lower CO and AZ Upland Associations	AG7C 1982 Spiller 1987 Spiller 1988
2	Swainson's hawk	Buteo Swaninsoni	Throughout site	Spiller 1988

2. Other Animal Species

The desert tortoise, the bighorn sheep, and the Gila monster, all Category 2 species, are discussed under the Arizona protected animal species below.

3. Plant Species

The Tumamoc globeberry (Tumamoca macdougaii) is known to occur in Pima County and in south Pinal County. However, it is not believed to be present in the Maricopa Mountains (BLM 1987).

Neolloydia (Neolloydie erectocentra) occurs in the well-drained ridge slopes and knolls in the creosote-bursage association. It is a typical but obscure component of these associations and may have been overlooked in surveys (BLM 1987).

Night-blooming cereus (Periorereus greggii) is known to occur in the Maricopa Mountains. Approximately 45,000 acres of suitable habitat have been identified in the northern Maricopa Mountains for this cactus, approximately 36,000 acres in the southern Maricopas. During the University of Arizona's reconnaissance of the proposed site, four areas were identified within the Lower Colorado association with night-blooming cereus present. The locations are described in Table 5.1.9-4.

Table 5.1.9-4

IDENTIFIED LOCATIONS OF NIGHT-BLOOMING CEREUS IN THE PROPOSED ARIZONA SSC SITE

Location SSC Facility (Parcel Desc)	Associated Species	No. Plants Found	Elev. ft Above Mean Sea Level
Near E2 (R1W T4S,NE1/4 of SW1/4 Sect11)	Creosote, Bursage	1	1,280
J2 (R1E T4S, NW1/4 of SE1/4 Sec 29)	Creosote, Bursage	4	1,340
J6 (R1E T5S, S1/2 of NW1/4 Sec 33)	Mesquite creosote	4	1,560
Milepost 20 (R1E T6S, NE1/4 of NE 1/4 Sec 30)	Creosote	1	1,720

B. Arizona Protected Plant Species

The State of Arizona has not designated state threatened and endangered plant species. The State of Arizona Native Plant Law (AZ Rev. Stat. Chpt 7, Art 1 53-901) protects all cacti, the soap-tree yucca, the ocotillo, the Mexican jumping bean, mesquite, palo verde, and ironwood from collection. Plants occurring in areas of development are removed intact, salvaged, or disposed under state supervision (Arizona Commission of Agriculture and Horticulture 1981).

C. Arizona Protected Animal Species

The Arizona Game and Fish Commission has named threatened native wildlife within the state (Arizona Game and Fish Commission 1982). This list includes those species present in small populations or in threatened habitats. There are four group designations based on the severity of the threat and the probability of extirpation from the state. The groups are:

- Group 1: known or highly probably extirpated in Arizona
- Group 2: present but high probability of extirpation in the near future in Arizona
- Group 3: in jeopardy in foreseeable future in Arizona
- Group 4: moderate threat to critical habitats in Arizona

The southern bald eagle, a federally listed species, is considered a Group 2 species by Arizona. The desert tortoise, desert bighorn sheep, and gila monster are listed as Arizona Group 3 species and are discussed below in some detail as there is a probability they will occur within the SSC Site vicinity.

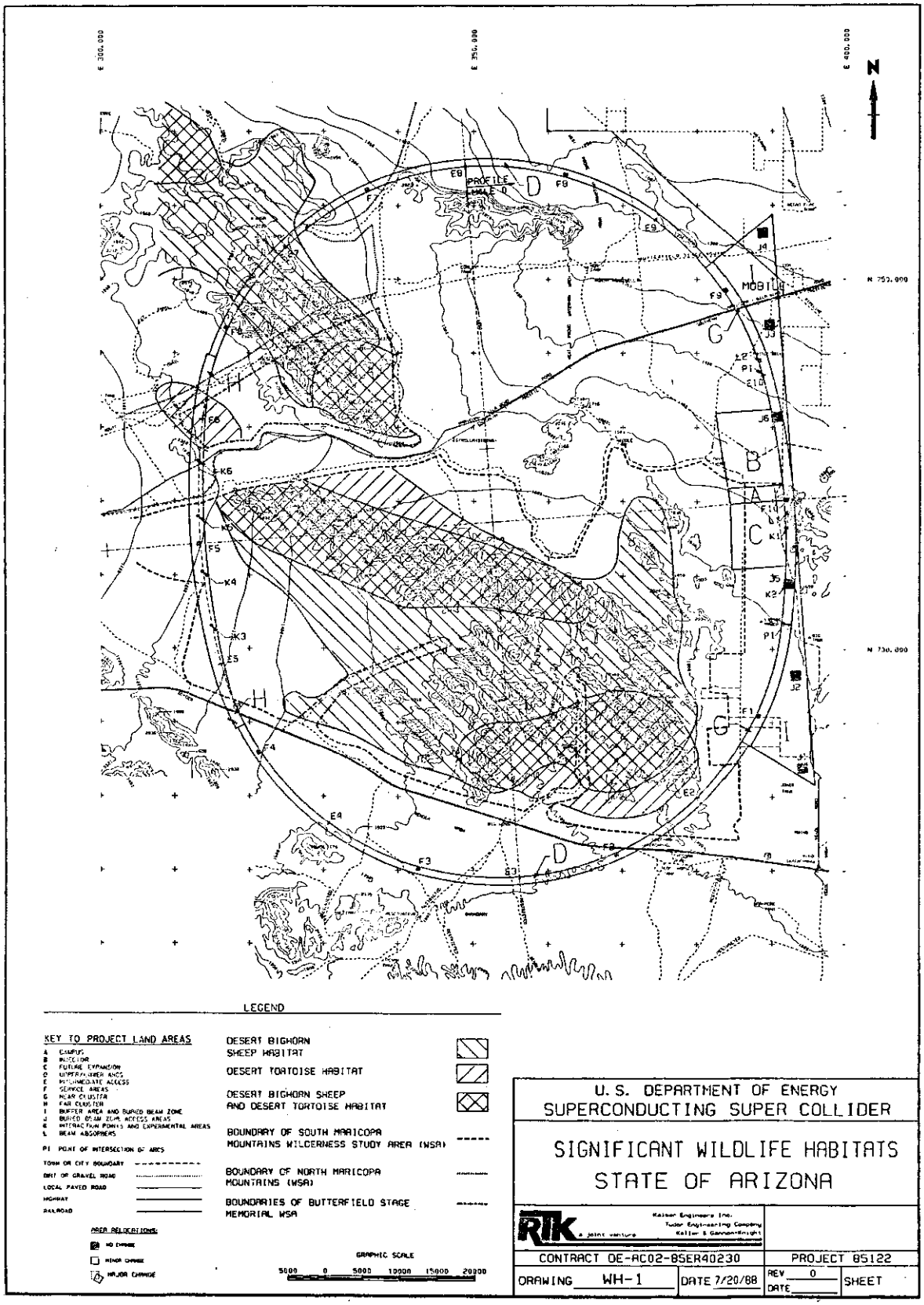
1. Desert Tortoise (*Gopherus Agassizi*)

The desert tortoise is a relatively large (mean adult weight = 5 lbs) reptile inhabiting both the northern and southern Maricopa Mountains (Vaughn 1984). High-density habitats for the desert tortoise in the two mountain ranges are highlighted on Figure 5.1.9-3. The populations typically occur in the mixed cacti/palo verde associations along rocky bajadas and mountain slopes.

Tortoise densities in the northern Maricopa Mountains have been estimated recently as high as 150 individuals/mi^2 based on capture studies measuring 53 tortoises/mi^2 (Cordery 1988). The densities of tortoises in the mountain areas are considered to be highly productive, one of the highest in the southwestern U.S. (Schwalbe 1988). While tortoises are found in the lowlands occasionally, their densities are low.

Figure 5.1.9-3

HIGH-DENSITY HABITATS OF THE DESERT TORTOISE AND BIGHORN SHEEP



Ephemeral washes with their moist soils are essential to tortoise populations in that the moist soil is an essential part of tortoise reproduction. Mating occurs in August to October, and eggs are laid in a shallow nest of moist soil June to August (Burge 1977). The eggs hatch in approximately three months. The tortoise has an extremely slow reproductive rate, not reaching maturity until 15 to 20 years of age. The maximum lifespan of a desert tortoise is approximately 100 years. Tortoises are dormant (a period called brumation) generally from October to February/April, as single or paired tortoises.

Tortoises also spend much of the summer in underground burrows to escape the high temperatures. These summer dens are often communal among the tortoises, rattlesnakes, wood rats, and cottontails. Single tortoises may move among dens during the same year (Cordery 1988).

The diet of the tortoise requires high-protein components; deficient diets appear to be a major cause of mortality (Schwalbe 1988). The active seasons are spring and fall, the foraging times morning and evening. The tortoise will forage an area of 25 to 75 acres. Major forbs include Plantago spp., Erodium spp., and Sphaeralcea spp., although the tortoise will also graze on grasses and flowers of shrubs and cacti.

The tortoise populations may be declining (Arizona Game and Fish Commission 1982). However, the population within the Maricopas is large and may be of special significance (Schwalbe 1988). Stress factors reducing the populations include habitat destruction, off-road vehicle traffic, and collection as pets (BLM 1987). Range degradation via cattle grazing may also reduce available food, especially preferred forbs (Schwalbe 1988).

2. Bighorn Sheep (Ovis canadensis mexicana)

The Mexicana desert bighorn sheep occupy a significant portion of the proposed SSC site (Figure 5.1.9-2). The total population of bighorn sheep in the State of Arizona currently ranges between 2,000 and 3,000 individuals. While they are common in western Arizona, the bighorn sheep are rare or absent from much of their traditional habitat in central and southwestern Arizona (Monson and Sumner 1985).

Over the last decade, the sheep population has been declining in the state. Hunting is severely restricted and probably does not represent the major reason for the decline. Principal threats include encroachment including roads, powerlines, land development, and mineral exploration; competition with the burro and cattle in the areas; disease; and disruption of the migration routes (BLM 1987; Monson and Sumner 1985).

Prime habitat in the project area occurs in the Maricopa Mountains. The density of sheep in the area approximates 1 to 5/10 mi^2 (Werner 1987). The population densities, recruitment rate, and characteristics have not been thoroughly documented.

Bighorn sheep require a sufficient quantity and quality of feed, as well as water, bedding areas, and escape spaces (Monson and Sumner 1980). Food preferences include a diverse array of forbs, shrubs, and grasses. Water is the frequent limiting factor. As with all mammals, a free water source must be within the range for survival after more than a few days.

The home range of the bighorn is approximately 35 km^2 for the ewes and 100 km^2 for rams (Dummer and Patten 1985). The animals usually travel in small matriarchal groups of two to three animals. Lambing occurs January to March, approximately six months following rutting season. During this period, the sheep travel in larger groups containing rams, ewes, and juveniles. Approximately ten days prior to lambing, the ewes become solitary and seek a lambing area that is isolated, protected, and away from view (Monson and Summer 1985). In most cases, the lambing rate is one lamb per ewe per year.

Management is limited in the SSC Site vicinity. Since the population is not considered stable, transfer of bighorn into the area is being considered (Werner 1988).

Bighorns are susceptible to diseases brought on by domestic animals such as sheep and goats or other related species introduced into the area. They are also susceptible to diseases they are normally resistant to because of stress factors such as lack of water, crowding, sharp loud noises, or other forms of human disturbance.

3. Gila Monster (*Heloderma suspectum*)

The Gila monster, a venomous reptile, is probably present in the SSC ROI in stable populations. However, documentation of the populations is minimal and the species is unique to the Sonoran region of the western U.S. and Mexico. The Gila monster is a USFWS Category 2 species, but is not currently classified as threatened under the state program. However, it is "protected", requiring a Scientific Collecting or Management Research Permit for removal or collection.

These venomous lizards inhabit portions of chaparral, desert grassland, and desert scrub. Within the SSC site vicinity, the Gila monsters are more densely distributed in the Arizona Upland than in the creosote bush flats (Lowe et al. 1986). Comparably little is known of the life history of the Gila monster. They weigh about 500 grams at maturity and spend more than 98% of their time underground; from July through February, they aestivate in burrows. In the summer, dens are usually in lower bajadas and alluvial valley sites. Winter dens are often communal among reptiles, e.g., desert tortoises and rattlesnakes, and are generally on rocky uplands.

The period of maximum activity is spring, when food is most available. In the diverse vegetation microsites, the monsters range about 10 acres. On the creosote flats, their range is larger, up to 30 acres. They move along washes and feed largely on eggs of birds and reptiles and on small mammals. The Gila monsters can survive long periods without food and water.

Mating occurs from March to July, resulting in a clutch of from 2 to 13 eggs (averaging five eggs), and are laid in July/August. The nests are in ephemeral washes, usually about 12 cm deep. The eggs incubate over winter and hatch the following May.

No specific information regarding Gila monster population densities and recruitment is available in the SSC site vicinity. The populations are not currently studied or managed at the site.

5.1.9.6 Unique Ecosystems and Communities Potentially Affected

A. Statutorily Protected Areas

Approximately two-thirds of the State of Arizona is held in designated or restricted use. These lands include Indian lands, national and state wilderness and park areas, national monuments, wildlife refuges and forests (Brown 1988). Figure 5.1.9-4 shows the designated areas within the ROI and those proposed as additions to the wilderness and park areas by the Forest Service and/or Arizona Wilderness Coalition (AWC).

The AWC has recommended that the North Maricopa Mountains WSA, the Butterfield Stage Memorial WSA and the South Maricopa Mountain WSA be established as wilderness areas by Congress (Arizona Wilderness-AWC Report, December 1987).

BLM recommended these three WSAs as not suitable for wilderness designation (Lower Gila South Final Wilderness Environmental Impact Statement, August 1987). Instead, BLM believed the Maricopa Mountains area should be managed to maintain the existing variety of dispersed and undeveloped recreation use, in a generally un-roaded and natural setting. The continuation of existing motorized and non-motorized recreation opportunities were considered by BLM the highest and best use of the area. This finding was the primary reason the Maricopa Mountain area WSAs were not recommended for wilderness designation. Moreover, at the time of the EIS, no land uses were identified by BLM that would significantly change the natural appearance of the Maricopa Mountain landscape.

The Maricopa Mountains are popular with organized ORV groups and numerous individual ORV users due to their scenic and accessible valleys and washes. Moreover, hikers, hunters, trappers, backpackers, sightseers and organized youth groups (Boy Scouts) frequent the area. Rather than exclude ORV and vehicle-based recreationists from a popular

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recreation area, BLM proposed to manage the area to allow a diversity of recreation opportunities, both motorized and non-motorized. BLM hoped to enhance and facilitate all recreation uses, rather than exclude the majority of current users-vehicle based recreationists.

The SSC project area includes, in right-of-way areas, portions of three WSAs (Figure 5.1.9-4):

- Northern Maricopa Mountains, 2-157 WSA
- Butterfield Stage Route Memorial, 2-167 WSA
- Southern Maricopa Mountains, 2-163 WSA.

B. Remnant Communities, Virgin Stands, and Unique Assemblages

The SSC proposed site lies within typical Sonoran desert. There are no unique biological assemblages within the Arizona Uplands or Lower Colorado associations. The Maricopa Mountains are covered by terrestrial plant and animal communities which are similar to those in the immediate region; however, the Maricopa Mountains have far less riparian woodland areas. The limited ranges of the desert tortoise, the bighorn sheep, and the Gila monster make the project site unique.

C. Marginal Range Associations and Transition Zones

The transition zones between Arizona Upland and Lower Colorado associations are along topographic features, enhancing density within the washes and at higher elevation. There are no transition zones in the project site that are different from those discussed in the Plant Community Composition section (Section 5.1.9.2.A).

The desert tortoise's requirement for wash areas and easy water availability may limit its distribution in the ROI. The hiding places available for the Gila monster may similarly limit its range. The bighorn sheep migrations within the site and the requirements within lambing season will also continue to limit their range. Each of these is discussed in detail in Section 5.1.9.4 and 5.

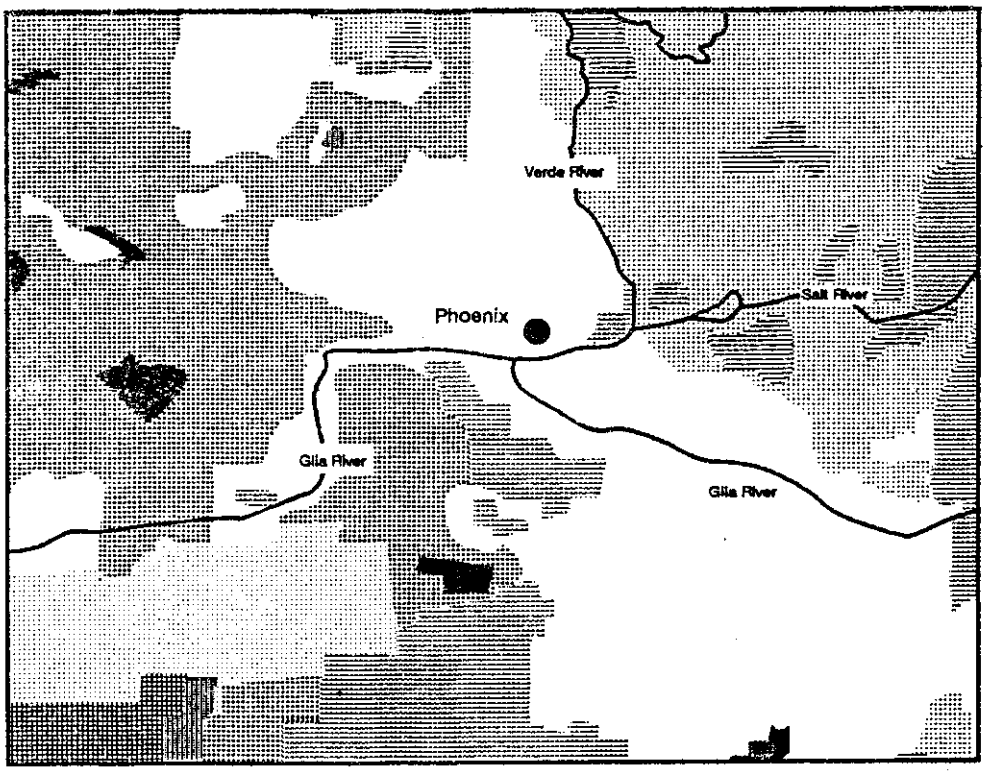
The javelina, mostly located in the bajadas and Maricopa Mountains, are at the northern edge of their range within the ROI (Remington 1987).

D. Implications on Land Use Policy

In order for the SSC to be implemented at the proposed Arizona site, the wilderness issues must be resolved by Congressional Action. BLM has recommended that only the campus and near cluster facilities, the facilities required at the service areas, and the required access roads in the ring perimeter are features in conflict with WSA nonimpairment criteria. A more complete discussion of the land use implications of the BLM lands is given in Section 5.1.10.

Figure 5.1.9-4

DESIGNATED AND PROPOSED WILDERNESS AND PARK AREAS
WITHIN THE ARIZONA SSC SITE VICINITY



- National Parks, National Monuments, and National Recreation Areas
- National Forests
- National Wildlife Refuges
- Indian Reservations
- Military Reservations
- Bureau of Land Management Lands
- Designated National Park, National Monument, and National Recreation Area Wilderness
- Designated National Forest Wilderness
- Wildlife Refuge Wilderness Proposed by U.S. Fish and Wildlife Service
- Additions Proposed by Bureau of Land Management

Revised from Map by Leander Skagg and Cindy Morgan-Jaffe in David Brown's 'A Gift to the Young'. WILDERNESS SPRING 1988, Volume 51 (180); pp 51-60

5.1.10 Land Resources

5.1.10.1 Regional Setting

A. Jurisdictional Setting

The proposed Arizona SSC site is approximately 35 mi southwest of Phoenix in Maricopa County. Maricopa County was established in 1871, with its seat in Phoenix, the state capital (Maricopa County 1988). The county covers an approximate 9,226-mi^2 area, of which roughly 90% is classed as unincorporated territory (Maricopa County 1988). The Arizona site is represented at the federal, state, and local levels of government by the following elected officials (Mountain Bell 1988 and Maricopa County 1988):

- United States Senate
  Dennis DeConcini
  John S. McCain III

- United States House of Representatives
  Morris K. Udall, 2nd District

- State Senate
  Alan Stephens, Minority Leader and Representative, 6th District

- State Assembly
  Henry Evans, 6th District
  Jim Hartdegen, 6th District

- Maricopa County, Board of Supervisors, 5th District

B. Ownership Patterns

Table 5.1.10-1 presents data on land ownership in Maricopa County. Approximately 70% of the county's land area is under either federal, state, or local governmental control (Maricopa County 1988). The largest single land owner/manager in Maricopa County is the Department of the Interior, Bureau of Land Management (BLM), with roughly 28% of the total (Maricopa County 1988). The mix of Maricopa County land ownership is similar to land ownership ratios at the state level, with somewhat less land held under public control, i.e., 83% and slightly more land held privately i.e., 17% than the state average (Valley National Bank of Arizona 1987).

C. Historic Land Use

The growth of Phoenix and other settlements along the Salt River fostered not only the Arizona Territory split away from the Territory of New Mexico in 1863 but also the subsequent creation of Maricopa County in 1871 (Maricopa County 1988). The completion of the Roosevelt Dam in 1911, as the keystone to the entire Salt River Irrigation Project,

Table 5.1.10-1

MARICOPA COUNTY, ARIZONA,
LAND OWNERSHIP DATA

Total Land Area: 5,905,000 Acres	Acres	Percent of County
Federal Control	3,455,000*	55%
Including:		
Bureau of Land Management	1,679,000	
Department of Defense	839,000	
Forest Service	658,000	
Bureau of Indian Affairs	269,000	
Bureau of Reclamation	10,000	
State Control	650,000	11%
Including, but not limited to:		
State Land Department	581,295	
State Highway Department	22,000	
Local Government Control	236,000	4%
Including, but not limited to:		
Maricopa County parks	95,000	
Privately owned	1,772,000	30%

*All figures are approximate.
Sources: Maricopa County, "Maricopa County Arizona Facts and Figures" 1988.

ensured the region use of an adequate and reliable water supply for expansion of economic activities (Maricopa County 1988). The thrust of this growth began with intensive agricultural development, followed by industrial development and its associated urban growth (Maricopa County 1988). This growth concentrated in the central portion of the county with areas at the periphery, including the proposed SSC project site, remaining largely undeveloped as a result of federal land ownership policies.

D. Existing Land Use Plans, Policies, and Controls

Land use planning in Maricopa County is conducted at the following four levels of government: federal, state, regional and local; the latter includes not only county-level activities but also local cities and towns and some Native American communities. Given the high percentage of land in Maricopa County under either federal or state control, several of the major agencies, including the Forest Service, BLM, Department of Defense, Bureau of Reclamation, and the Arizona State Land Department have already or are currently preparing, or revising, land management plans for their respective holdings. Of particular note to the SSC project are the following two BLM plans: Lower Gila South Final Resource Management Plan/Environmental Impact Statement (1985), and the subsequent Lower Gila South Final Wilderness Environmental Impact Statement (1987).

Land use planning at the regional level is conducted by the Maricopa Association of Governments (MAG), which serves as the designated Metropolitan Planning Organization for the urban areas within Maricopa County. The Maricopa Association of Governments was created in 1976 as a voluntary organization and consists of elected representatives from Maricopa County and from each of its 22 cities and towns (Maricopa Association of Governments 1987). In addition, a representative from the Arizona Department of Transportation (ADOT) serves as a member of the governing body (the Regional Council) as transportation-related issues are handled (Maricopa Council of Governments 1987). Key plans prepared by MAG are the Regional Freeway/Expressway Plan (1987) and the Transportation Improvement Plan (1987), which is an annually updated 5-year regional guide to transportation projects throughout Maricopa County. (See Section 5.1.11.2).

Under Arizona state law, long-range comprehensive land use planning is delegated to either the county government for all unincorporated private lands or to municipalities (Maricopa County 1983). Municipal land use plans must include a land use and circulation element as a minimum; large municipalities must also include plans for conservation, public facilities, housing, redevelopment, and safety (Maricopa County 1983). County land use plans must be similarly prepared with the express purpose of guiding, coordinating, and promoting the harmonious development of the area as a whole (Maricopa County 1983). The SSC project is

located entirely on county unincorporated lands; therefore, the key planning documents are the Maricopa County Composite Land Use Plan (1983) and the Maricopa County Composite Future Land Use Plan (1983).

In addition, two metropolitan Phoenix-area Native American communities, the Gila River Indian Community and the Salt River-Pima-Maricopa Indian Community, have prepared their own future land use plans as a means to achieve their development goals and objectives (Maricopa County 1983). Since the locations are well away from the site neither of the two plans affects the SSC project.

E. Existing Land Uses

MAG provides a regional planning perspective to its member agencies primarily through analyses of regional population growth and development projections. The key document is the MAG Regional Development Summary, 1987, from which this and the following section is abstracted.

Figure 5.1.10-1 illustrates their division of the county into five distinctly different regions upon which land use planning and management is based. These five planning units are described briefly below:

- Central region - Downtown Phoenix (core of city's office/ commercial base).

- Northeast region - Northeast Phoenix (metropolitan base), Scottsdale (artistic, recreational, tourism base), Paradise Valley (upscale residential base), Carefree (planned residential community), Cave Creek, and Fountain Hills.

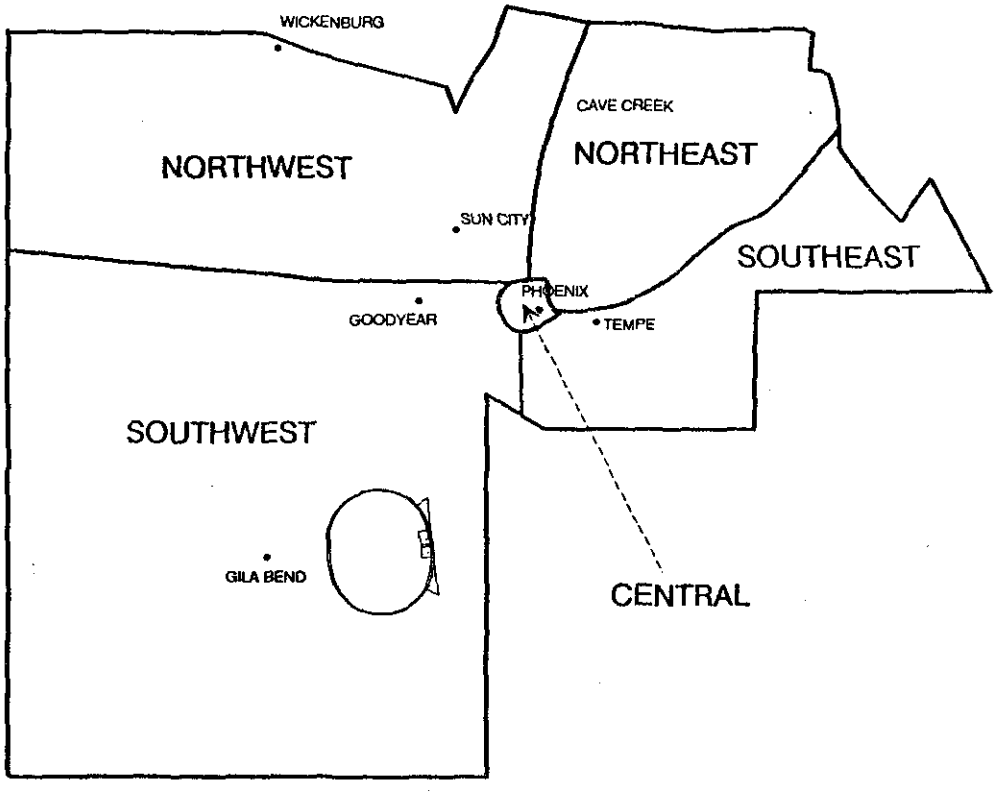
- Northwest region - Northwest Phoenix (metropolitan base), Glendale (agricultural, manufacturing, services base), Peoria (government, retail services, manufacturing base), Youngstown (retirement community), Surprise (agriculture to urban base), El Mirage (agriculture base), Sun City (retirement community), and Wickenburg (tourism, cattle ranching, agriculture base).

- Southwest region - Southwest Phoenix (metropolitan base), Tolleson (agriculture base), Goodyear (agriculture, industry base), Avondale (agriculture and manufacturing base), Buckeye (agriculture, retail trade, services base), and Gila Bend (agriculture, retail trade, services base).

- Southeast region - Southeast Phoenix (metropolitan base), Mesa (manufacturing, high technology, retail, services base), Tempe (university, retail, entertainment base), Chandler (high technology, industrial base), Gilbert (upscale master planned community), and Guadalupe (industrial, retail base).

Figure 5.1.10-1

MARICOPA ASSOCIATION OF
GOVERNMENTS REGIONAL PLANNING UNITS



Reference : Maricopa Association of Governments, 1987. MAG Regional Development Summary 1987.

The SSC project is located on the southeastern fringe of MAG's southwestern region. As such, Gila Bend is the project's closest major population/service support area.

F. Future Planned Land Uses

MAG has developed estimates of both land available for development and population projections for their five study regions to the year 2010. Table 5.1.10-2 shows current available land and the percentage of absorption of residential and commercial land developed through the year 2010. Table 5.1.10-3 shows how this translates into projected population growth. Figure 5.1.10-2 illustrates the changing shares of the county-projected population totals as garnered by each of the five study regions.

The central region is already well developed, with little available land. Population growth, therefore, is less rapid than it is in the other four regions, with growth of less than 9% between 1985 and 2000. The central regional share of the county's total population is projected to consistently decline, dropping from 20% in 1985 to 11% by 2010. The future of this area could change dramatically with access to rapid transit and major redevelopment.

In the northeast region, only 40% of residential land and 20% of commercial land has been developed. With an abundance of available land, a growing employment base, and the expectation created as a result of the planned Pima Freeway, which will link East Valley areas with Scottsdale and north Phoenix, the area is expected to grow quite rapidly - 24% between 1985 and 1990 and over 48% between 1990 and 2000. It consistently has about 13% of the county total over the 25-year period. It is anticipated that by 2010, 70% of residential and 44% of commercial lands will be developed. Although absorption is expected to be rapid, a fair amount of residential and half of the commercial land will still be available by 2010.

In the northwest region, only about 35% of residential land and 22% of commercial land has been developed so far. It is currently the second most populated region and is expected to grow rapidly, adding 22% between 1985 and 1990 and 50% between 1990 and 2000. Factors influencing the growth will be the large amounts of available land, continued major employment along I-17, and improved access from the planned Agua Fria Freeway. The region consistently maintains just over one-quarter of the county's total population. By 2010, about 65% of residential and 31% of commercial land is expected to be developed, with few geographic limits for the future. A significant amount of residential and nearly 70% of commercial land will still be available.

The southwest region, with virtually no geographic restrictions, is the least developed region with only 30% of residential and 19 percent of commercial land absorbed, respectively. The area is largely agricultural at the present time, but with large amounts of available land, few

Table 5.1.10-2

MARICOPA ASSOCIATION OF GOVERNMENTS (MAG) URBAN LAND USE PROJECTIONS FOR THE PERIOD 1985 - 2010, BY REGION

	Square Miles					
	Central	NE	NW	SE	SW	Total
Total area	102.503	413.438	598.458	458.081	344.272	1925.755
Undevelopable*	15.922	122.230	143.803	67.859	90.679	440.493
Total Residential	56.626	220.248	294.562	273.517	152.38	997.333
Percent developed						
1985	95.73%	39.52%	35.28%	40.93%	30.37%	40.45%
1990	96.70%	44.49%	38.59%	47.04%	32.61%	44.59%
2000	97.60%	59.44%	52.14%	59.73%	44.13%	57.19%
2010	97.84%	69.94%	64.83%	68.53%	57.00%	67.65%
Total commercial	29.955	70.96	169.093	116.705	101.216	487.929
Percent developed						
1985	86.98%	19.84%	21.56%	28.33%	19.22%	26.46%
1990	92.18%	26.49%	23.35%	34.23%	20.56%	30.05%
2000	97.84%	35.89%	28.12%	48.76%	23.95%	37.60%
2010	99.96%	44.12%	31.33%	55.78%	29.86%	42.95%

Note:
* Undevelopable includes mountains, parks, washes, and other protected or unbuildable acreage. Does not include Indian reservations and major portions of the county outside of the urban planning area. Total area of Maricopa County is 9,225.4 mi^2.

Sources: Maricopa Association of Governments, 1987. MAG Regional Development Summary 1987.

Table 5.1.10-3

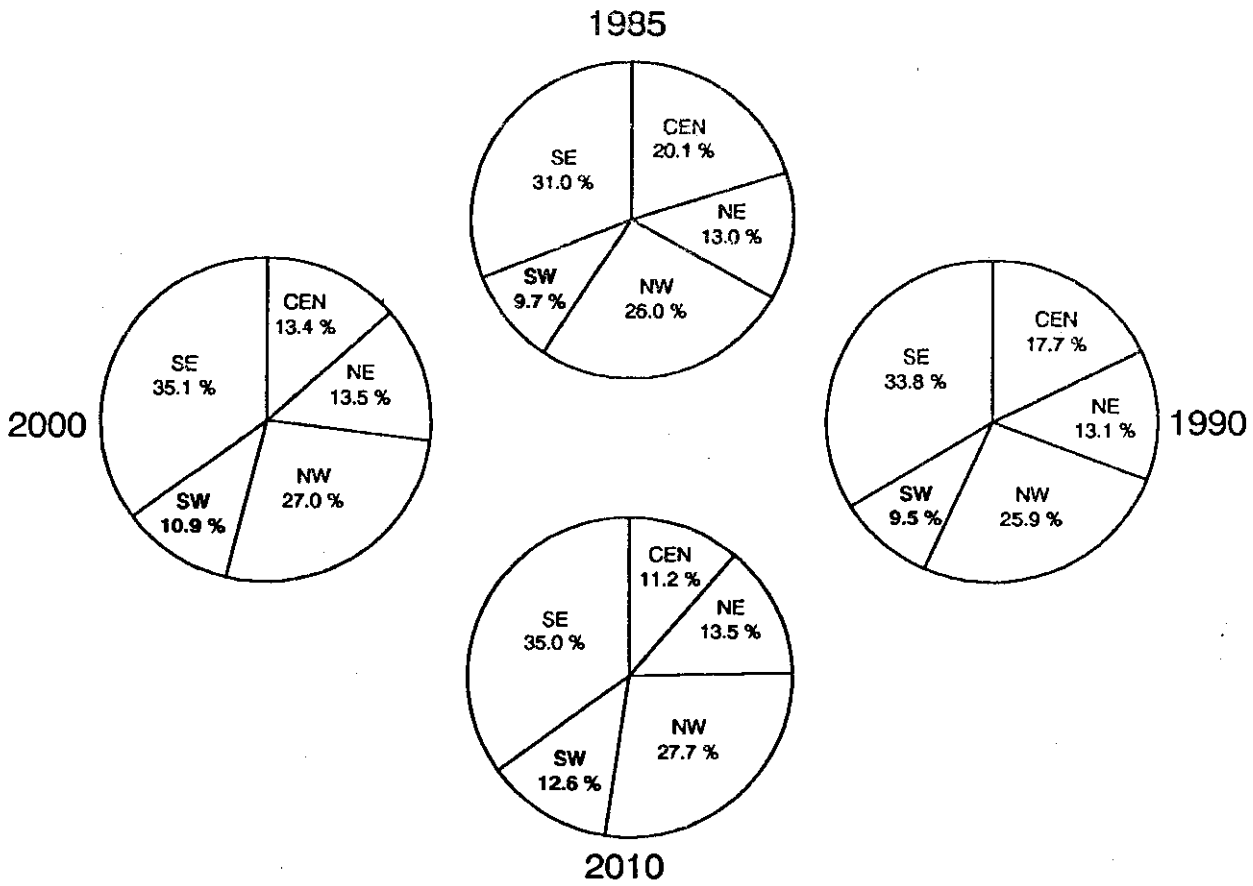
MARICOPA ASSOCIATION OF GOVERNMENTS (MAG) PROJECTED POPULATION GROWTH FOR THE PERIOD 1985 - 2010, BY REGION

	No. of Persons (000)			
	1985	1990	2000	2010
Central	370.1	400.8	436.7	453.0
Percent change		8.3	8.9	3.7
Northeast	239.9	295.6	439.8	542.2
Percent change		23.6	48.3	24.4
Northwest	478.4	585.4	879.1	1123.9
Percent change		22.4	50.2	27.8
Southwest	178.7	215.2	354.5	511.4
Percent change		20.4	64.6	44.3
Southeast	570.8	764.1	1,142.3	1,416.5
Percent change		33.9	49.5	24.0
TOTAL	1,837,900	2,262,100	3,252,400	4,052,000

Source: Maricopa Association of Governments 1987, MAG Regional Development Summary 1987.

Figure 5.1.10-2

MARICOPA ASSOCIATION OF GOVERNMENTS
REGIONAL SHARES OF PROJECTED POPULATION
FOR THE PERIOD 1985-2010



CEN = CENTRAL
NE = NORTHEAST
NW = NORTHWEST
SW = SOUTHWEST
SE = SOUTHEAST

Reference : Maricopa Association of Governments, 1987. MAG Regional Development Summary, 1987.

physical barriers, proximity to Los Angeles for industry, and the completion of I-10, the region is expected to grow very quickly. It is expected to gain about 20% between 1985 and 1990 and nearly 65% between 1990 and 2000. With this rapid growth, it will increase its share of the county total from 9% in 1985 to 12% in 2010. By 2010, absorption levels are expected to be 57% of residential and 30% of commercial property. Despite rapid development, the southwest region will have the most land still available by 2010.

In the southeast region, about 41% of residential and 28% of commercial land has been developed in 1985. The area presently has almost 600,000 people and will add 34% to this already large base between 1985 and 1990 and nearly 50% between 1990 and 2000. The growth will be fueled by the growing employment center along I-10 and improved transportation with the extension of the existing Superstition Freeway, and the planned Santan Freeway, Red Mountain Freeway, South Mountain Parkway, and Price Parkway. The rapid growth is forecasted to give the Southeast Valley an increased share of the county total, from 31% in 1985 to 35% by 2010. By 2010, absorption levels are expected to reach 69% of residential and 56% of commercial land. The region, geographically boxed in by Indian lands and the Salt River, will experience the most intense absorption levels of any of the suburban regions over the next 25 years.

G. Community Values/Attitudes Toward Development

As a result of their analyses, the Maricopa Association of Governments expects that Maricopa County will be one of the fastest growing population centers in the country over the next 25 years. Growth in Maricopa County is expected to continue unabated in the foreseeable future with fully 70% of the countywide population growth to be the result of net immigration (Maricopa Association of Governments 1987).

The Maricopa County Department of Planning and Development well recognizes the challenges associated with providing ordered development. They recognize the need to capitalize on the positive aspects of the region, i.e., the climate, natural environment, housing availability, and a strong, diversified economy, while overcoming obstacles associated with water availability, traffic congestion, air pollution, crime, foreign business competition, and the high cost of infrastructure and attendant financing constraints (Maricopa County 1983).

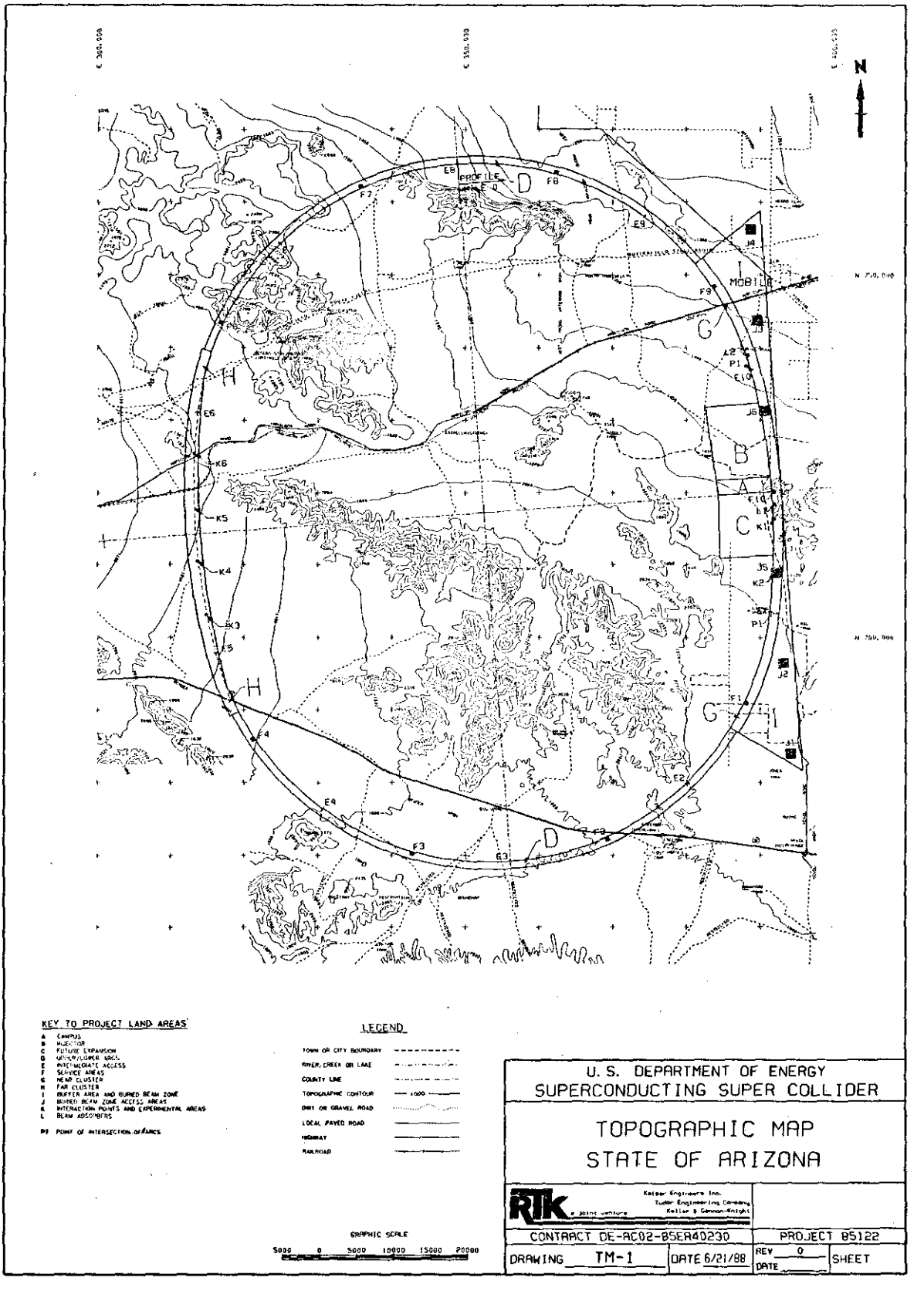
5.1.10.2 Local Setting

A. Project Level

The proposed SSC project site is located entirely in the southwestern portion of Maricopa County on unincorporated land. See Figure 5.1.10-3. The SSC project study area contains no federally designated parklands, such as national parks, monuments, preserves, rivers, scenic and historic trails, historic sites, recreation areas, and parkways. The historic Butterfield Stage Coach Line and the Juan Bautista de Anza Historic Trail are both potentially significant historic resources when

Figure 5.1.10-3

THE PROPOSED ARIZONA SSC SITE REGION



applying the eligibility criteria for the National Register of Historic Places. To date, neither resource has been listed, nor has Congress passed legislation in support of the National Park Service's recent recommendation that de Anza be established as a National Historic Trail (see Section 5.1.12). There are no federal- or state- designated wild and scenic rivers located in the SSC project study area.

The SSC project study area, including much of the actual site, is under BLM jurisdiction and as such is actively managed by them. Four types of land use and associated activity are of particular BLM management concern: wilderness, recreation, grazing, and habitat. The first three land use management issues/concerns are described below; habitat management is discussed in Section 5.1.9.

The BLM is under congressional mandate to provide for orderly use and development of public lands and to preserve the land and its resources from destruction. The Federal Land Policy and Management Act of 1976 (FLPMA) directed the BLM to periodically inventory its lands and project present and future uses in their various plans in order to ensure that public lands are managed on a multiple-use and sustained yield basis and that the quality of natural resources is preserved. Section 603 of FLPMA directed the Secretary of the Interior to review roadless areas of 5,000 acres or more having wilderness characteristics and to recommend to the President the suitability of such areas for preservation as wilderness by 1991. The President subsequently must send his own report to Congress within two years. Congress, however, has no time limit for acting on the President's recommendation.

The BLM, Phoenix District Office has complied by preparing its Lower Gila South Final Resource Management Plan/Environmental Impact Statement (1985) and the subsequent Lower Gila South Final Wilderness Environmental Impact Statement (1987). Upon review, the following three Wilderness Study Areas (WSAs) are located in areas selected for SSC project development: North Maricopa Mountains WSA (AZ-020-157), South Maricopa Mountains WSA (AZ-020-163), and Butterfield Stage Memorial WSA (AZ-020-164)(see Figure 5.1.9-5). Each WSA is described below according to the following four wilderness values: naturalness, solitude, primitive recreation, and special features.

1. <u>The North Maricopa Mountains WSA (75,483 acres)</u>

Naturalness: The WSA includes a 10-mile long portion of the Maricopa Mountains, rising 1,000 to 2,813 feet from the desert floor, as well as extensive portions of the surrounding desert plain. Several wide valleys narrow into canyons from all sides of the WSA toward its center.

The WSA is considered to be predominantly natural in appearance, with minor evidence of human activity. The WSA has 35 miles of jeep trails, several miles of fence, and several rangeland developments. All of these imprints are screened by topography and are widely scattered across a large area. Dead-end roads of 0.125- to 4.5-miles in length extend into the WSA. All roads show signs of continuous use. All of these roads

lie on the level valley floors amidst scattered saguaro cactus and creosotebush; some routes are seen from surrounding higher elevation points.

Solitude: Outstanding opportunities for solitude are created throughout the WSA as a result of its size (10 miles wide by 12 miles long), considerable variation in topography, and variety of access and destination points.

Primitive Recreation: Outstanding opportunities for primitive and unconfined recreation are created in the WSA as a result of its large size, diverse terrain, and scenic vistas. The many peaks in the Maricopa Mountains offer physical challenge and scenic viewpoints. Wildlife observation and photography opportunities are available throughout the WSA.

Special Features: The WSA provides important habitat for desert bighorn sheep and desert tortoise (see Section 5.1.9). Several cultural resource values are present, including portions of the historic Butterfield Stage Route. One prehistoric settlement site present is eligible for the National Register of Historic Places (see Section 5.1.12).

2. South Maricopa Mountains WSA (72,004 acres)

Naturalness: The WSA includes a narrow east-west trending mountain range surrounded by gently rolling desert. The mountains rise 2,000 feet above the desert floor to an elevation of 3,272 feet. Numerous washes originating from the center of the WSA dissect the desert. Valleys are also interspersed throughout the eastern side of the WSA. Vegetation is a creosotebush-bursage community with some saguaro found on the mountain slopes and in the bajadas and valleys.

Although some evidence of human activity is present, the WSA is considered predominantly natural, with human impacts being substantially unnoticeable. The WSA has 9.50 miles of dead-end roads and 35.4 miles of jeep trails. Other imprints include several old car bodies, an earthen dike, an old mine, and an area of numerous compacted trails.

Solitude: Outstanding opportunities for solitude exist throughout the WSA because of its large size, complex topography, and vegetative screening.

Primitive Recreation: Outstanding opportunities for primitive and unconfined recreation exist in the WSA, including hiking, backpacking, sightseeing, and horseback riding.

Special Features: Nearly all the mountainous terrain and the intervening valleys are considered bighorn sheep habitat. The southeastern quarter and north-central portions of the WSA contain desert tortoise habitat (see Section 5.1.9).

3. Butterfield Stage Memorial WSA (9,566 acres)

Naturalness: The WSA has a mountainous center that consists of valleys and steep, highly dissected ridges. A large plain is found on the western side of the WSA. Vegetation is a paloverde-saguaro community with an abundance of saguaro and cholla cacti. Dominant plans found in the valley areas consist of saguaro, cholla, and triangle bursage. Creosotebush prevails on the plains and blue paloverde and ironwood dominate the washes.

The WSA is considered predominantly natural, with human impacts being substantially unnoticeable. There are 8.5 miles of jeep trails, one mile of fence, and several cattle trails. Several of the jeep trails are used frequently.

Solitude: Outstanding opportunities for solitude exist in the WSA because of its small size, diversity and ruggedness of terrain, variety of vegetation, and limited number of visitors to the area. The steep terrain requires visitors to use a few major wash areas to access high ridgelines. This channeling effect, along with the area's small size, could result in increased visitor contacts and a loss of solitude opportunities.

Primitive Recreation: Opportunities for primitive and unconfined recreation are not outstanding because the area's small size precludes extensive backcountry travel.

Special Features: The WSA has crucial bighorn sheep and desert tortoise habitat (see Section 5.1.9). The relatively flat western part of the WSA (4,480 acres) is considered to be culturally sensitive, with prehistoric rockshelters, rock rings, and habitation sites. The historic Butterfield Stage Route forms the northern boundary of the WSA (see Section 5.1.12).

The BLM evaluated these WSAs for wilderness value as part of its Final EIS and has recommended to the Secretary of the Interior as its Proposed Action that none of them be nominated for wilderness designation and subsequent protection. The primary reasons for this position are that given anticipated mineral exploration and rights-of-way construction projects and expected increases in motorized vehicle use, wilderness values would be adversely impacted to the point that its intrinsic character would be lost. This recommendation is not supported by the Arizona Wilderness Coalition, who has published its own report, Arizona Wilderness (1987). The regulatory fate of these three WSAs and the attendant decision as to the appropriateness of siting the SSC project in a federally designated wilderness area is a matter for Congressional action.

The BLM is, nevertheless, concerned about these three WSAs, particularly as part of their recreation resource management planning. It is their opinion that the highest and best use of the Maricopa Mountains area is as a setting for the following two kinds of recreation opportunities: "Semi-primitive, Nonmotorized Recreation" and " Semi-primitive Motorized

Recreation." Recreation opportunities of the first type offered includes settings for hunters, hikers, trappers, campers, and backpackers who frequent the Maricopa Mountain area during the cool-weather season between October and April. These recreationists share many of the same routes and trails used by off-road vehicle (ORV) users, such as those with 4WDs and dirt bikes. However, these visitors have the option of traveling into areas not accessible to vehicles, including many interior canyons and the sides and crests of the Maricopa Range. Recreation opportunities of the second type offered includes settings for many organized ORV groups and individuals. There are many popular jeep trails and washes that provide access into scenic interior areas of the Maricopa Range. Several organized ORV groups use the area for annual treks or safaris; some groups stage occasional weekend encampments as part of their outings. Although ORV use is popular, little surface disturbance is noticeable, since most ORV use is confined to existing trails and desert washes. The Arizona Desert Racing Association, under permit from the BLM, uses portions of the area for organized and competitive ORV racing. Sightseers, including many Boy Scout troops, drive and hike the Butterfield Stage Coach Line, particularly during the winter months. In addition, many of these same troops camp and backpack in the area as part of their conservation and outdoor skills training and historic study programs.

The SSC project study area also includes BLM lands that are managed for grazing purposes, including the following three grazing allotments: Bighorn, Conley, and Lower Vekol. All three allotments are classed as perennial-ephemeral allotments and are generally for cow-calf operations. Additional livestock, i.e., steer grazing for ephemeral forage can be authorized under a supplemental grazing license when sufficient annual forage is present and such use does not conflict with other resources or damage the perennial vegetation base. This situation occurs generally three years out of each decade. Each of the three allotments has one permittee; authorized grazing preferences are assigned as follows:

Allotment	Animal Unit Month (AUM)
Bighorn	6,038
Conley	4,158
Lower Vekol	1,165

As the AUM statistics indicate, the greatest amount of forage is needed in the Bighorn Allotment to sustain one cow or its equivalent for one month than in the other two allotments. Stated another way, the Lower Vekol Allotment offers the best grazing opportunities of the three allotments.

Aside from these uses on BLM-managed lands, the only new additional land use to the SSC project area is the state-legislated Arizona Hazardous Waste Management Facility, which is currently under construction (State of Arizona 1988). The 640-acre site is located in the northwest quadrant of the collider arc region interior, approximately 3,000 ft north of State Route 238 and 6 mi west of the town of Mobile. When completed,

this project will treat, incinerate, and dispose of nonnuclear hazardous waste from commercial, industrial, institutional, and governmental sources, including those from the proposed SSC project (see Section 5.1.7). Service access to the hazardous waste facility will require major improvements to the Maricopa/Gila Bend Road from the plant site to east of Mobile (see Section 5.1.11.2).

The Maricopa County Planning Department has zoned the entire SSC project area, including BLM-managed lands as Rural-190, which allows for 190,000 ft^2 per dwelling unit (Maricopa County 1988). This represents the county's largest minimum-sized lot. There are no other major future land use plans for the SSC project area that would alter its existing character (Maricopa County 1988).

Community values and attitudes toward the SSC project are generally positive, as evidenced by the relative dearth of letters received from the public as part of the DOE public scoping process (see Volume III: Methodology for Site Selection). Of the 28 letters received by the DOE as of mid-May 1988, 10 letters offered no opinion about the project; 9 letters were in favor of the project; and 9 letters were opposed to the project. The types of issues raised in these letters included: road and congestion problems, increased demand for water and electricity, endangered species and critical habitat degradation, changes in scenic and visual resource character,adequacy of geological conditions, and adverse impacts to historic and archaeological sites.

B. Facility Level

Table 5.1.10-4 presents land use data for each of the major SSC project facilities. This includes information on county locations, ownership existing zoning designations, existing land use, and future planned land use. Narrative descriptions are provided below.

Table 5.1.10-4

LAND USE DATA ARIZONA SSC SITE

SSC Project Facility	County Location	Ownership Patterns	Existing Zoning	Existing Land Use	Future Planned Land Use
Near Cluster Quadrant					
Campus area A	Maricopa	Public/private	R-190	Undeveloped	Same
Injector area B	Maricopa	Public/private	R-190	Undeveloped	Same
Future exp. area C	Maricopa	Public/private	R-190	Undeveloped	Same
BABBZ I	Maricopa	Public/private	R-190/R-43	Undeveloped	Same
J1	Maricopa	Private	R-190	Undeveloped	Same
J2	Maricopa	Public	R-190	Undeveloped	Same
J3	Maricopa	Private	R-43	Undeveloped	Same
J4	Maricopa	Private	R-190/R-43	Undeveloped	Landfill
Near Cluster Ring (G)					
E1	Maricopa	Public	R-190	Undeveloped	Same
E10	Maricopa	Private	R-190	Undeveloped	Same
F1	Maricopa	Private	R-190	Undeveloped	Same
F9	Maricopa	Private	R-43	Undeveloped	Same
F10	Maricopa	Public	R-190	Undeveloped	Same
J5	Maricopa	Public	R-190	Undeveloped	Same
J6	Maricopa	Private	R-190	Undeveloped	Same
K1	Maricopa	Public	R-190	Undeveloped	Same
K2	Maricopa	Public	R-190	Undeveloped	Same
Far Cluster Quadrant					
Far Cluster Ring (H)	Maricopa	Public	R-190	Undeveloped	Same
E5	Maricopa	Public	R-190	Undeveloped	Same
E6	Maricopa	Public	R-190	Undeveloped	Same
F5	Maricopa	Public	R-190	Undeveloped	Same
K3	Maricopa	Public	R-190	Undeveloped	Same
K4	Maricopa	Public	R-190	Undeveloped	Same
K5	Maricopa	Public	R-190	Undeveloped	Same
K6	Maricopa	Public	R-190	Undeveloped	Same
Lower Arc Quadrant					
Lower Arc Ring (D)	Maricopa	Public	R-190	Undeveloped	Same
E2	Maricopa	Public	R-190	Undeveloped	Same
E4	Maricopa	Public	R-190	Undeveloped	Same
F2	Maricopa	Public	R-190	Undeveloped	Same
F3	Maricopa	Public	R-190	Undeveloped	Same
F4	Maricopa	Public	R-190	Undeveloped	Same
Upper Arc Quadrant	Maricopa	Public	R-190	Undeveloped	Same
Upper Arc Ring (D)	Maricopa	Public	R-190	Undeveloped	Same
E7	Maricopa	Public	R-190	Undeveloped	Same
E8	Maricopa	Public	R-190	Undeveloped	Same
E9	Maricopa	Public	R-190	Undeveloped	Same
F6	Maricopa	Public	R-190	Undeveloped	Same
F7	Maricopa	Public	R-190	Undeveloped	Same
F8	Maricopa	Public	R-190	Undeveloped	Same
Roads and rail	Maricopa	Public/private	R-190/R-43	Undeveloped	Same
Utilities	Maricopa	Public/private	R-190/R-43	Undeveloped	Same

Source: Maricopa County, Unicorporated Area Zoning District map, 1987; Maricopa County Zoning ordinance 1988; Maricopa County Arizona Generalized Land use 1982; Cella Bar Associates 1988; Maricopa County Highway Map 1988.

B. Facility Level

1. SSC Project Near Cluster Quadrant

The near cluster portion of the proposed SSC site encompasses the majority of the project's surface features and affected lands. This includes campus area A, injector area B, future expansion area and buried beam zone I, buried beam zone and access areas J. Intermediate access areas E-1 and E-10, service areas F-1, F-9, and F-10, and interaction paints and experimental areas K-1 and K-2. Even though this area is presently largely undeveloped and very sparsely populated, it represents the most intensive and diverse existing land use of the entire ring. Nearly all of the privately held property in the project area is clustered near the town of Mobile and includes a concentration of ranching activities toward its southern extension. The near cluster area is zoned almost entirely as Rural-190, except for portions of the north buffer area and buried beam zone, part of the arc that are zoned Rural-43 (1 acre per dwelling unit). The near cluster is also part of the large Bighorn Grazing Allotment, which accounts for low intensity grazing activity. The predominant land use is open space, with some associated low development recreational use. Current and future plans and policies consider this location as acceptable for either open space, extremely low density residential, light grazing, or light industrial uses. There has been little or no pressure to develop the near cluster area; however, the town of Mobile has experienced some interest in industrial and residential development, including a current Waste Management Corporation of America proposal to construct a sanitary landfill at the north tip of area I (see Section 5.1.8).

a. Campus Area A

Approximately 70% of proposed campus area A is privately owned, while the remaining 30% (the most westerly part) is managed by the BLM. The only improvement found here is a tin building and an associated air strip located on the northern edge. Aside from this, the area is undeveloped open space.

b. Injector Area B

Approximately 20% of proposed injector area B is privately owned, while the BLM holds title to the remaining 80%. Two private air strips, one residence, and minor ranching improvements are the only deviation from the open space/light grazing use of this area. Two small dirt roads cross through the site from east to west. Hunting, off-road vehicle use and other open space recreation occur on BLM-administered public land in this area.

c. Future Expansion Area C

Approximately 40% of proposed future expansion area C is privately owned, while the remaining 60% managed by the BLM. Hunting, off-road vehicle use, and other open space recreation occur on BLM-administered public lands in this area. There are no existing structures at this area; ranch fencing exists as the only improvement. As such, this area is of an open space/light ranching character.

d. Buffer Area and Buried Beam Zone I, including Buried Beam Zone Access Areas J1, J2, J3, and J4

The north buffer area and buried beam zone are primarily privately owned, at approximately 85% and the remainding 15% under BLM management. The Southern Pacific Railroad and Maricopa Road run east to west through the area's center, and it is intersected diagonally by the El Paso Natural Gas and All American Pipelines. There are no residences and the only other improvement is an abandoned trailer. The majority of the area (Township 4 South, Range 1 East, Sections 19, 20, 29, 30, 31 and 32) is zoned Rural-43 because of its proximity to Mobile. The only use aside from railroad and utility easements is open space and light ranching, with the Bighorn Grazing Allotment covering Section 32. The historic Butterfield Stage Coach Line crosses the northern section of the near cluster in an east to west direction (see Section 5.1.12).

Two locations of particular concern within the north cluster area are the proposed buried beam zone access areas, J3 and J4. The southern third of J3 intersects an area designated as part of the Bighorn Grazing Allotment, and a minor dirt road crosses the site diagonally. There are no residences or improvements on or within 1,000 ft of the proposed J3 location site. The proposed J4 site, located north of the Butterfield Stage Coach Line, is entirely unimproved open space, as is a 1,000-ft buffer locate zone around it. This J4 location, northwest of Mobile, and its immediate vicinity have been proposed as the aforementioned sanitary landfill site.

The second area of private land concentration is in the southern half of the buffer area, with buried beam zone I, where 40% of the property is privately held and the remainder being BLM-managed land. The only improvements are minor dirt roads and ranching improvements, including a well and some fencing. The Bighorn and Lower Vekol Grazing allotments both occur in this area. One residence is located on the site itself; however, just beyond a 1,000-ft buffer zone, four residences can be found along Vekol Road to the east of a water tank.

The buried beam zone access areas J1 and J2 are both located on lands that abut areas considered as part of the Lower Vekol Grazing Allotment. The character of the area is open space, and no improvements are noted on or within 1,000 ft of either area.

e. Near Cluster - Ring Area G including Intermediate Access E1 and E10 and Service Areas F1, F9, and F10, Buried Beam Access Areas J5 and J6, and Interaction Points and Experimental Areas K1 and K2

The near cluster ring, nearly 50% private property and 50% BLM land, hosts a small scattering of minor ranching improvements. No residences or structures are found on this arc site, with the possible exception of a trailer associated with the air strip located in injector area B. Beginning at the north end of the arc and moving south, the first 3 mi are zoned Rural-43, because of the proximity to the town of Mobile to the east. The remainder of the arc is zoned Rural-190.

Service area F9 is located on private property north of the Maricopa/ Gila Bend Road. There are no existing or planned land uses changes proposed for this proposed F9 site and current use is open space.

Intermediate access location E10 is on private property with no structures on or within a 1,000-ft buffer zone of this site. Current land use is open space, and no proposed land use plans exist for the site.

Buried beam zone access area J6 is located on private property. No structures or improvements exist on the site or within a 1,000-ft buffer zone; however, just beyond this area are two trailers and one of the air strips mentioned in injector area B. The current land use is open space and no proposed plans exist for this area.

Service area F10 and interaction points and experimental areas K1 and K2, buried beam zone access area J5, and intermediate access location E1 are all on BLM property in unimproved areas of open space. These locations fall within the Lower Vekol Grazing Allotment. There are no proposed land use plans affecting these areas.

Service area F1 is on private property; current land use is open space with no improvements or plans affecting it or the 1,000-ft buffer zone.

Hunting, hiking, off-road vehicle use and other open space recreation occur on BLM-administered public lands in this area.

2. SSC Project Far Cluster Quadrant - Far Cluster Ring Area H, including Intermediate Access Areas E5 and E6, Service Area F5, and Interaction Points and Experimental Areas K3, K4, K5, and K6

The entire far cluster quadrant is located on BLM-managed lands, all of which is considered to be part of the Conley Grazing Allotment. The far cluster ring is intersected from north to south by the following lineal land uses: the historic Butterfield Stage Coach Line, Maricopa Road, the Southern Pacific Railroad, and Interstate-8. None of these routes are located in proximity to any of the E,F, or K sites, except Maricopa Road which is situated 400 ft south of site K6. The far cluster quadrant is also intersected from north to south by the following three WSAs: North Maricopa Mountains WSA, Butterfield Stage Memorial WSA (including site

E6), and South Maricopa Mountains WSA (including sites K5, F5, K4, K3,and E5). Recreation opportunities in the area include a variety of non-motorized and motorized activities.

3. SSC Project Lower Arc Quadrant

Lower Arc Quadrant D, including Intermediate Access Areas E2, E3, and E4, and Service Areas F2, F3, F4.

Land use in the lower arc is predominantly unimproved open space, with some low-intensity livestock grazing with minor ranching improvements noted in the eastern portion of the area. A small section of private property is found in the eastern tip, while the remainder is managed by the BLM. The entire lower arc quadrant is considered to be part of the Conley Grazing Allotment. The lower arc is intersected by Interstate-8, just north of site F2, where the highway serves as the southern boundary to the South Maricopa Mountains WSA. Several restricted-travel dirt roads are located south of the freeway and provide access to Luke Air Force Range.

The 1,000 ft buffer zone around site E2 is undeveloped open space, except for fencing and other minor ranching improvements.

Sites E3, E4, F3, and F4 are also located south of Interstate-8. Each of these sites is located in areas that are classed as either undeveloped open space or low intensity grazing areas. Hiking, hunting, ORV use, and other open space recreational opportunities exist in the BLM-managed portions of the quadrant.

4. SSC Project Upper Arc Quadrant

Upper Arc Quadrant Area D, including Intermediate Access Areas E7, E8, and E9, and Service Areas F6, F7, and F8.

Land use in the upper arc quadrant is predominantly unimproved open space with some low-intensity livestock grazing and minor ranching improvements. A small section of private property is found on the extreme eastern tip of the quadrant, while the remainder is managed by the BLM. The quadrant is intersected by two minor dirt roads as well as the historic Butterfield Stage Coach Line. Sites F6, E7, and F7 are located within the North Maricopa Mountains WSA. Sites F6 and E7 are considered to be part of the Conley Grazing Allotment, while sites F7, E8, F8, and E9 are located in the Bighorn Grazing Allotment. Recreational opportunities like the ones discussed above are available, however in diminished form, given the relative lack of access.

5. Planned SSC Project Road and Railroad Networks

Locational descriptions of planned SSC project road and railroad improvements are provided in Section 1.2.1.2.

Adjacent land use patterns for the road network are no different than for what has been generally described for the area. There are no land use plans that constrain these areas from further improvement. The first 0.25 mi (north to south) of the proposed rail spur to the near cluster area is on private property. Land ownership for the next 3 mi is mixed, with private land to the east and BLM-managed land to the west. The remaining portion of the proposed spur is on BLM-managed property. The current land use is unimproved open space with low intensity livestock grazing. It is part of the Bighorn Allotment, and a grazing lease is identified to the east of the area.

6. Planned SSC Project Utility Improvements

Location descriptions of planned SSC project utilities are provided in Section 1.2.1.2. Affected land use is of an open space character.

5.1.10.3 Soil and Prime Farmland Resources

A. Soils and Their Characteristics

The Arizona site has a physiography characterized by broad valleys bordered by generally north-oriented mountain ranges (Soil Survey of Maricopa County 1977). The physiography plays a considerable role in the distribution of soils at the proposed site. As a general rule, soils with similar features are confined to a particular landform.

Irrespective of the position of the surface upon which they developed, Arizona site soils have general characteristics that reflect the dry, hot, and continental character of the climate in which they develop, and thus, soils have a low content of organic matter, often below 0.5%, and many soils are carbonated, partly a reflection of the site dryness.

Eighteen soil series identified at the site belong to the Orthid and 5 belong to the Argid suborders. Argids are soils that have an argillic or a natric horizon. The argillic is the horizon in the profile where clay accumulates. The natric horizon is that part of the soil where, in addition to clay accumulation, the horizon has acquired alcalinity caused by high sodium content that imparts to the whole soil detrimental characteristics. Both horizons, but particularly the natric, limit plant-root development to a shallow depth. Orthids are soils that have a calcic horizon (caliche) or a duripan. The calcic horizon is one in which calcium carbonate accumulates while the duripan is a silica-indurated layer. (Key to Soil Taxonomy 1987)

Table 5.1.10-5 presents the SSC-site soils. The table indicates that

Table 5.1.10-5

SOIL CATEGORIES AT THE ARIZONA SSC SITE

Classification Families	Categories Series
Loamy-skeletal, mixed, hyperthermic Typic Haplargid	Chuckawalla
Loamy-skeletal, mixed, hyperthermic Typic Haplargid	Pinamt
Fine-loamy, mixed, hyperthermic Typic Haplargid	Mohall(PPF)*
Loamy-skeletal, mixed, hyperthermic Petrocalcic Paleargid	Ajo
Loamy-skeletal, mixed, hyperthermic, shallow Typic Durargid	Comobabi
Coarse-loamy, mixed, hyperthermic Typic Camborthid	Dateland(PPF)
Coarse-loamy, mixed, hyperthermic Typic Camborthid	Denure(PPF)
Loamy-skeletal, mixed, calcareous, hypothermic Typic Torriorthent	Momoli
Coarse-loamy, mixed, hyperthermic Fluventic Camborthid	Cuerda(PPF)
Coarse-loamy, mixed, hyperthermic Fluventic Camborthid	Why
Coarse-loamy, mixed, hyperthermic Typic Calciorthid	Coolidge(PPF)
Coarse-loamy, mixed, hyperthermic, Typic Calciorthid	Rillito
Loamy-skeletal, mixed, hyperthermic, Typic Calciorthid	Gunsight
Loamy-skeletal, mixed, hyperthermic, shallow Typic Paleorthid	Pompeii
Loamy-skeletal, mixed, hyperthermic, shallow Typic Durorthid	Cipriano
Sandy-skeletal, mixed, hyperthermic Typic Torriorthent	Carrizo
Loamy-skeletal, mixed calcareous, hyperthermic Lithic Torriorthent	Hyder
Loamy-skeletal, mixed calcareous, hyperthermic Lithic Torriorthent	Quilotosa

Notes:
*PPF means potentially prime farmland
Sources: Classification of Soil Series and Inactive Series 1987.
Soil survey of the Gila Bend/Ajo area, parts of Maricopa and Pina counties, under publication, SCS, U.S.D.A.

most soils belong to a coarse or skeletal particle-size class. The Mohall soil is the only one with a relatively fine mechanical composition; the "fine-loamy" term associated with Mohall, introduces a soil that has more than 65% by weight made up of fines (particles smaller than 2 mm. This characteristic imparts to the Mohall soil good water-retention characteristics. Table 5.1.10-5 also shows that the other four soils that have a good agricultural potential all belong to the suborders Camborthid and Calciorthid. Camborthids are soils that have a rather developed subsurface horizon. Leaching of carbonates below the cambic horizon is an indication of relative maturity of such soils. They have already developed the essential characteristics required to support plant growth.

B. Prime Farmland Inventory

Among prime farmland qualifying criteria (7 CFR Part 657.5), the limited availability of water for plant growth is important at the Arizona site. Since the scarcity of water is determined by the regional climate, all soils at the site are characterized by an aridic (torric) moisture regime (Soil Taxonomy 1987). The soil is dry between the surface and the parent rock more than 50% of time when temperature is above 41°F at a depth of 20 inches. The soil is never moist for 90 consecutive days when the temperature is above 46.4°F at a depth of 20 inches.

In their aridic environment the potential of these soils to produce crops relies totally on the presence of an irrigation system dependable, both in terms of the quantity of water supplied and its quality. Since at the present time very little irrigated agriculture is practiced, one can identify only a small acreage of prime farmlands at the site. The Mohall, Dateland, Denure, Cuerda, and Coolidge soil series (marked in Table 5.1.10-5) can become prime farmlands if irrigated.

The Mohall soil, covering one-third of the fee-simple area is deep and well-drained with abundant lime below a certain depth. It developed in old alluvial fans of diverse geologic origin (granite, rhyolite, schist, basic igneous, limestone). In the Soil Survey of Maricopa County, the Mohall soil is classified under Capability Unit, I-Irrigated. This means that when irrigated, this soil has no special limitations and that it can be farmed to produce most crops adapted locally. The moderately high pH of the deeper horizons, (a lime-induced alcalinity) could be mitigated under controlled irrigation/drainage. Thus, the Mohall soil is a potential prime farmland if irrigated.

Th Coolidge series consists of deep, well-drained soil formed in alluvium of old fans and valley plains. The alluvium is of diverse geologic origin (granite, rhyolite, metamorphics, tuff, basalt, limestone). In a representative profile, the soil is sandy loam to 5+ ft. The calcic horizon appears at 14 to 30 inches. This soil is classified in the Soil Survey of Maricopa County under Capability Unit II - Irrigated, which indicates a good potential for producing crops if irrigated.

The Dateland, Denure, and Cuerda Series have similar characteristics: all have a generally common succession of horizons and all are characterized by the presence of the diagnostic cambic horizon. While Dateland and Denure are found on stream and fan terraces, the Cuerda soil is characteristically associated with floodplains. These soils have a relatively low water holding capacity and thus, even if irrigated, their performance as prime farmlands is questionable. They may be salt-affected, a condition that can be corrected under good irrigation/drainage management practices.

The Soil Survey of the SSC area (Soil Survey of the Gila Bend/Ajo, parts of Maricopa and Pima Counties, under publication, SCS, U.S.D.A.), identifies the soil units that are potentially prime farmland if irrigated. They are presented together with their acreages in the fee-simple region in Table 5.1.10-6. It is estimated that only 10-15% of the potentially prime farmlands at the Arizona site are actually irrigated and performing as prime farmlands.

Table 5.1.10-6

SOIL ASSOCIATIONS AT THE ARIZONA SSC SITE, AND A ROUGH ESTIMATE OF PRIME FARMLANDS IF A DEPENDABLE IRRIGATION SYSTEM IS AVAILABLE

Soil Association	Potential Prime Farmland if Irrigated acres
Carrizo/Dateland, 0-3%*	20
Dateland/Cuerda, 0-3%	85
Denure/Coolidge, 1-3%	779
Denure/Rillito/Why, 1-5%	490
Denure/Why, 1-5%	782
Mohall, 0-1%	1277
TOTAL	3433

Note:

* % slope

5.1.11 Socioeconomics and Infrastructure

5.1.11.1 Socioeconomics

Development and operation at the SSC Arizona site would affect the socioeconomic environments of three Arizona counties: Maricopa, Pima, and Pinal. Communities within these counties, the Phoenix metropolitan area in Maricopa County, Tucson in Pima County, and the Casa Grande area in Pinal County could provide a sizable portion of the project work force. Since these counties include settlement opportunities within approximately one hour's driving time from the site, they most likely would house all relocating workers as well.

The ROI studied for this site consists of this three-county area (Figure 5.1.11-1). Maricopa County is where all SSC facilities would be located, where most project-related workers would probably reside, and where many of the requirements for goods and services would be met. This county comprises the primary impact area for this analysis. Economic issues are addressed for the ROI and the primary impact area of Maricopa County. Demographic characteristics and housing opportunities are evaluated for the ROI and those portions of Maricopa and Pinal counties nearest the site. Maricopa County is the base for analysis of public service and finance, as well as relationships at the ROI and state levels.

A. Economic Activity, Labor Force, and Income

1. Regional Setting

During the past two decades, the economy of the three-county region has been growing steadily (Table 5.1.11-1). Expansion in the employment base in the ROI during this period was nearly triple the national employment growth rate. Total employment growth averaged 5.3% annually between 1969 and 1984. By comparison, the national annual average employment growth rate during that period was 1.9% (U.S. Department of Commerce, Bureau of Economic Analysis 1986).

The agricultural services sector experienced the largest percentage gain in employment in the Arizona ROI during this period, growing at an average annual rate of 9.3%. This sector also had the largest employment increase at the national level between 1969 and 1984; growth nationally averaged less than 6% a year. Other leading sectors in the Arizona ROI in terms of employment growth were the finance, insurance, and real estate sector which grew at an average annual pace of 7.8%, construction which grew at 7.0% annually, and services which posted an average annual gain of 6.9%.

Mining and farming experienced overall declines in employment during the 16-yr period. The 1.5% average annual loss in employment in the farming sector in the Arizona ROI was consistent with the national trend for that period; the U.S. farming sector experienced an average annual loss in employment of 1% between 1969 and 1984. The average annual loss of

Figure 5.1.11-1

COUNTIES FOR SOCIOECONOMIC ANALYSIS - ARIZONA SSC REGION

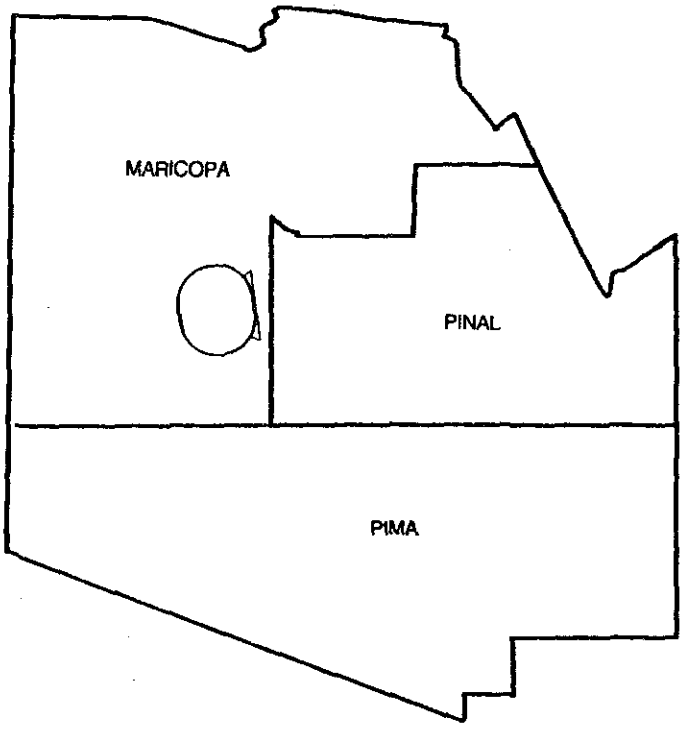


Table 5.1.11-1

HISTORIC ECONOMIC INDICATORS FOR THE UNITED STATES, ARIZONA ROI, AND MARICOPA COUNTY

	1969	1974	1979	1984	1987	Average Annual Growth Rate
UNITED STATES						
Total employment[1]	89,386,600	97,887,400	110,649,200	118,491,900	NA[2]	1.9%
Earnings per worker[3]	$22,102	$22,455	22,041	21,027	NA	-0.3%
Per capita personal income[3]	$12,147	$13,248	$14,292	$14,746	NA	1.3%
Unemployment rate[4]	3.4%	5.5%	5.8%	7.4%	6.1%	NA
ARIZONA ROI						
Total employment	555,319	751,729	982,840	1,208,100	NA	5.3%
Earnings per worker	$25,951	$26,304	$25,155	$23,973	NA	-0.5%
Per capita personal income	$11,854	$13,035	$14,087	$14,847	NA	1.5%
Unemployment rate	NA	6.7%	4.5%	4.1%	5.6%	NA
MARICOPA COUNTY						
Total employment	399,294	542,812	735,103	916,066	NA	5.7%
Earnings per worker	$22,372	$22,692	$21,802	$20,763	NA	-0.5%
Per capita personal income	$11,992	$13,302	$14,476	$15,238	NA	1.6%
Unemployment rate	3.0%	7.1%	4.4%	3.8%	5.5%	NA

Notes:

1. Employment is by place of work.
2. NA - data not available or not applicable.
3. Earnings and income are in constant 1988 dollars.
4. Unemployment rates from 1969 are not necessarily directly comparable to rates from later years because of changes in the method of calculation.

Sources: Department of Commerce, Bureau of Economic Analysis 1986 (employment, earnings, and income); U.S. Council of Economic Advisors 1988 (U.S. unemployment rates); Arizona Department of Economic Security 1988 (ROI and county unemployment rates).

1.2% of mining employment in the Arizona ROI, however, was not consistent with the national trend; the U.S. mining sector experienced an average annual gain of 4.1%, which was the second largest percentage increase of the 11 major industrial sectors.

Figure 5.1.11-2 indicates the distribution of employment among the 11 major industrial sectors in the Arizona ROI in 1984. The most dominant sectors of the Arizona ROI economy in terms of employment are services (with 25.4% of workers in the ROI), retail trade (17.8%), government (14.6%), and manufacturing (13.2%).

Average earnings per worker in the Arizona ROI were higher than the national average in 1984. These earnings were highest in the transportation and public utilities sector at $37,804 (all monetary values in this analysis are reported in 1988 dollars). Average earnings in the governmental sector were $27,812.

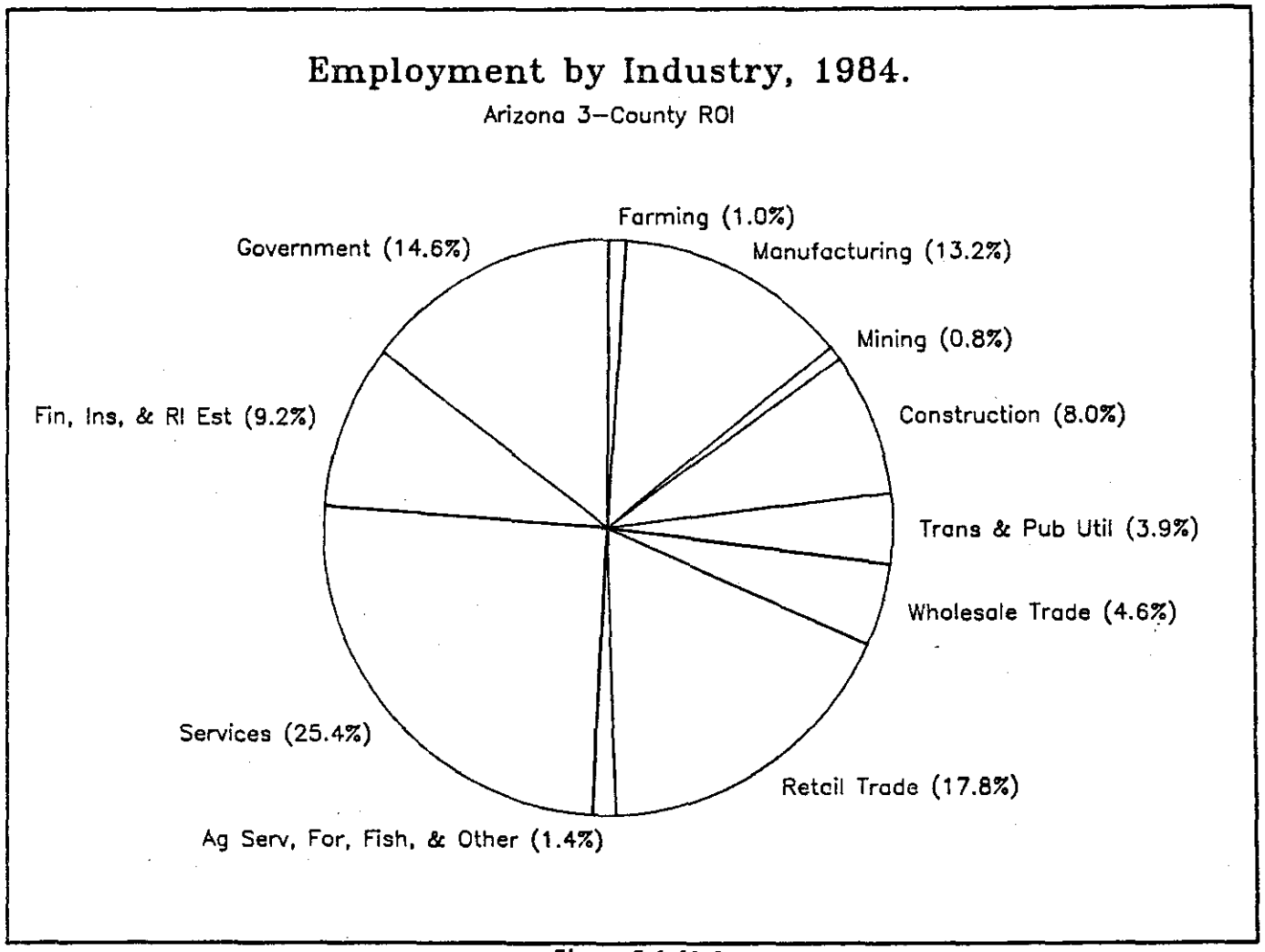


Figure 5.1.11-2

EMPLOYMENT BY INDUSTRY, 1984
ARIZONA ROI MARICOPA, PIMA, AND PINAL COUNTIES

IAPP5A20688130

In recent years, the rate of unemployment in the Arizona ROI has been lower than most of the other ROIs, and lower than the national average; unemployment was 5.3%, 5.8%, and 5.6% in 1985, 1986, and 1987 in Arizona, but 7.1%, 6.9%, and 6.1% during those years nationwide (Arizona Department of Economic Security 1988; U.S. Council of Economic Advisors 1988). The unemployment rate within the Arizona ROI has not been above the national average since the mid-1970s. During the mid-1970s, however, the Arizona ROI did have several years of relatively high unemployment. The ROI labor force has increased even more rapidly than total employment during the last two decades at an annual average rate of 5.6% during that period and included a work force exceeding 1,350,000 in 1987.

In 1984, the Arizona per capita personal income level of $14,495 was slightly lower than the national average of $14,746. Per capita personal income consistently lower than the national average between 1969 and 1984. In the Arizona ROI

Employment in the Arizona ROI is expected to continue to increase at an average annual rate above that of the nation. Between 1988 and 2000, employment by place of work is expected to grow at an average annual rate of 2.5%, from an estimated 1.3 million jobs to almost 1.8 million. This level of job growth is nearly double the 1.3% annual growth projection for employment at the national level between 1988 and 2000 (U.S. Department of Labor, Bureau of Labor Statistics 1987).

2. Maricopa County

Maricopa County is the largest county in Arizona in terms of employment and total income. Between 1969 and 1984, Maricopa County provided nearly 76% of employment and collected more than 62% of personal income within the ROI. Total employment growth in the county averaged more than 5.7% annually.

Although there was an overall decline in mining employment in past years, mining jobs in Maricopa County grew at an average annual rate of 14.1%, from 310 jobs in 1969 to 2,244 in 1984. The agriculture services, forestry, and fishing sector was the second fastest growing industrial section, with an average annual growth rate of 9.7%. Other leading sectors in Maricopa County were construction (which grew at 8.1% annually), the finance, insurance, and real estate sector (which grew at an average annual pace of 7.9%), and services (with an average annual growth rate of 7.4%).

The farming industry was the only sector that experienced an overall decline in employment during the 16-yr period. The 0.6% average annual loss in farming employment in the county was consistent with both the Arizona ROI and national trends for that period.

The distribution of employment among the 11 major industrial sectors in Maricopa County in 1984 is very similar to that of the Arizona ROI. The most dominant sectors of the county's economy are services (25.4%), retail trade (17.9%), manufacturing (13.9%), and government (13.1%).

Average earnings per worker in Maricopa County were $20,763, which was lower than both the average for the Arizona ROI and the national average in 1984. In 1984, the highest average earnings per worker in Maricopa County were paid in the transportation and public utilities sector at $32,125. This industry also reported the highest average earnings per worker for the Arizona ROI, although the level of earnings at the county level is considerably lower than that of the Arizona ROI.

Unemployment in Maricopa County in recent years has consistently been lower than the Arizona ROI and the national unemployment level, averaging 5.1%, 5.6%, and 5.5% during 1985, 1986, and 1987, respectively (Arizona Department of Economic Security 1988). The county's labor force increased at an average annual rate of 6.0% between 1969 and 1987, and exceeded 1 million persons in 1987.

Per capita personal income in Maricopa County was greater than both the Arizona ROI and national averages in 1984. The county typically had a slightly greater per capita personal income level than the Arizona ROI and a slightly lower per capita income level than the United States between 1969 and 1984.

B. Demographics and Housing

1. Regional Setting

The population of the three-county Arizona ROI has increased steadily since the 1940s. This growth trend peaked during the 1970s when the number of inhabitants in the region rose from 1.4 to 2.1 million persons (U.S. Bureau of the Census 1982b). Population growth averaged 4.4% annually between 1970 and 1980, an extremely rapid increase due largely to substantial immigration to Maricopa County (Phoenix) and Pima County (Tucson) (see Table 5.1.11-2). The most recently available systematic population estimates for counties within the Arizona ROI indicate that demographic growth in this region continued until 1985 (U.S. Bureau of the Census 1988), with the average annual change from 1980 decreasing to a rate of 3.5%.

Population projections developed for the Arizona ROI indicate a continuation of the two major trends seen in 1970-1980 and 1980-1985: continued growth, but at continually lessening rates of increase. By 1990, the population of the region is anticipated to exceed 2.9 million persons, representing an average annual increase of 3.3% over the preceding decade. At the turn of the century, ROI population is projected at 3.6 million, the result of 2.1% annual growth during the 1990s. Finally, by 2030 (the last year of the projections prepared for this

present study) the population of the Arizona ROI is projected to exceed 5.4 million persons, having increased at a 1.3% average annual growth rate during the 2020-2030 decade.

In addition to increasing numbers of people in the Arizona ROI, the composition of this population is also expected to change primarily in terms of its age structure (Table 5.11.1-2). Some of the most important aspects of this change are found in the anticipated relative decrease in young people and a corresponding relative increase in older individuals.

With regard to demographics, the number of year-round housing units in the Arizona ROI has increased at a steady, rapid rate since the 1940s (Bureau of the Census 1982a). By 1980 the total number of year-round units in the region had exceeded 840,000, of which 63.8% were occupied (or available for occupancy) by owners, 33.0% were occupied (or available for occupancy) by renters, and the remaining 3.2% were deemed uninhabitable (e.g., because of renovation or condemnation) or considered in transition (e.g., under transfer of ownership).

Of the total year-round housing units in the ROI, 91.2% were occupied in 1980. Considering just year-round units available for occupancy in the ROI, the 1980 vacancy rates were 2.8% for owner units and 11.7% for rental units. Partially because of continued rapid population growth in the region (particularly Maricopa County), building permits were issued for the construction of more than 285,000 new housing units in the Arizona ROI between the years 1981 and 1986, an average of nearly 48,000 units per year (Bureau of the Census 1983, 1985b, 1987a).

2. Maricopa and Pinal Counties

The portions of the Arizona ROI of greatest concern with respect to demographics and housing are Maricopa and Pinal counties. Maricopa County is the proposed location of the SSC. However, historically much of the change in Maricopa County demography and housing has been linked to the growth of metropolitan Phoenix, and this trend is expected to continue. As a result, documented and projected changes in these variables at the county level are not always indicative of local changes in the remote area of the proposed SSC site. These changes are, however, indicative of population and housing trends in the rapidly growing portions of the urbanized area to the south (Chandler, Tempe) and to the west (Goodyear, Buckeye) of Phoenix.

Pinal County lies slightly east of the planned SSC campus site. Several towns within Pinal County, including Casa Grande, Stansfield, and Maricopa, are all quite accessible to the site, with the latter two communities being potentially important local areas of new housing growth. Because change in the demography and housing of Pinal County has been dispersed, county level statistics are more indicative of local changes.

Table 5.1.11-2

KEY DEMOGRAPHIC INDICATORS FOR THE ARIZONA ROI

	1970	1980	1990	2000	2010	2020	2030
Population (millions)	1.39	2.13	2.95	3.64	4.19	4.80	5.46
Avg. ann. chg. from preceding decade	3.4%	4.4%	3.3%	2.1%	1.4%	1.4%	1.3%
			Age Distribution				
≤ 4 Years	8.7%	7.5%	8.7%	7.3%	7.1%	6.9%	6.8%
5-19 Years	30.4%	24.4%	21.8%	22.9%	20.5%	19.8%	19.7%
≥ 65 Years	9.4%	11.6%	12.0%	11.8%	13.0%	16.0%	19.6%

Sources: Historic Data by U.S. Bureau of Census 1982b.

The populations of Maricopa and Pinal counties are expected to grow at approximately the same rates as projected for the ROI as a whole. The population of Maricopa County was 1.5 million in 1980, increasing to slightly more than 1.8 million in 1985 (U.S. Bureau of the Census 1982b 1988). In continuing to account for the majority of the ROI population, Maricopa County is expected to contain 2.1 million persons by 1990 and 2.6 million by the turn of the century, with its population reaching nearly 3.9 million by 2030.

Pinal County had slightly more than 90,000 persons in 1980, increasing to approximately 98,000 by 1985 (U.S. Bureau of the Census 1982b, 1988). Projections for 1990, 2000, and 2030 place its future populations at 129,000, 159,000, and 238,000, respectively. The town of Casa Grande in Pinal County, the closest incorporated place to the proposed SSC campus, had a population of nearly 15,000 in 1980, increasing to an estimated 16,500 by 1986 (Arizona Department of Commerce 1987).

According to the 1980 Census of Housing, Maricopa County contained nearly 600,000 year-round housing units in 1980. Approximately two-thirds were classified as owner units (i.e., occupied or available for occupancy by owners) (U.S. Bureau of the Census 1982a). Vacancy rates in Maricopa County in 1980 were 2.8% for owner units, 11.8% for rental units, and 8.6% for these units combined.

By contrast, Pinal County contained slightly fewer than 31,000 year-round housing units in 1980, although the owner-renter breakdown was approximately the same as that for Maricopa County. Vacancy rates in Pinal County were lower as well, with owner, renter, and total combined vacancy rates reported at 1.6%, 8.9%, and 8.1%. For both Maricopa and Pinal counties, the stocks of year-round units reported in 1980 were relatively new, with 49.9% and 44.4% of the respective inventories having been built in the preceding decade.

The trend toward constructing large numbers of new housing units in the two counties of primary interest has continued into the 1980s. During the years 1981 to 1986, some 225,000 building permits were issued for the construction of housing units in Maricopa County, an average of over 37,000 annually (U.S. Bureau of the Census 1983, 1985b, 1987a). At the end of 1986, the total number of year-round units in Maricopa County was estimated at approximately 900,000, including mobile homes (U.S. Bureau of the Census 1983, 1985a, 1985b, 1987a).

A 1986 housing vacancy survey by the Federal Home Loan Bank of San Francisco (1987) suggests a decrease in the total vacancy rate in the Phoenix Metropolitan Statistical Area from the 1980 Census-derived rate (U.S. Bureau of the Census 1982a). Vacancy data for 1986 for Pinal County are unavailable. Building permits were issued for the construction of more than 4,200 housing units between 1981 and 1986 in Pinal County, an average for this time period of approximately 700 units per year (U.S. Bureau of the Census 1983, 1985b, 1987a).

For purposes of temporary housing, 355 facilities (hotels, motels, and resorts) are currently located within Maricopa County. More than 36,000 rooms are available at these establishments. In addition, some 18 recreational vehicle parks are located within Maricopa County, providing hookups for more than 28,000 vehicles (Arizona Department of Commerce 1987). Pinal County currently contains 38 motels, with more than 1,600 rooms available. An additional 115 recreational vehicle parks (some combined with mobile home parks) are located in Pinal County, with a capacity for more than 14,000 vehicles (Arizona Department of Commerce 1987).

C. Public Services

Public services provided by local governments within the ROI were analyzed using October 1982 employment data (Bureau of the Census 1984) and 1986-87 public school year statistics (Arizona Department of Education 1987).

Local public services include local government administration, operation, and maintenance; transportation; environmental control; housing development; and utilities. The ratio of government employment to area population is used in this analysis as an indicator of local levels of service. Generally speaking, the lower this ratio the lower the level of service to which the regional population is accustomed. These ratios, however, do not reveal varying regional conditions such as differing levels of mechanization by government agencies, out-of-region service provision, concentration of like facilities, or varying levels of crime and health problems. Also, the "per capita" nature of the ratios can misrepresent the actual quality of service in sparsely populated regions. Despite these shortfalls, the ratios are useful indicators of the magnitude by which regional population impacts would increase needs for local government employment to maintain current levels of service.

Police and fire protection, provision of health care, and public educational instruction were examined detail. Levels of general public service were determined generally by the ratio of employees to regional population and, for instruction alone, by student/teacher ratios at the primary and secondary public school levels.

1. Regional Setting

Total local government full-time equivalent (FTE) employees for the ROI (Maricopa, Pima, and Pinal counties combined) was 35.95 per 1,000 population, higher than the national average of 34.35 but slightly lower than the Arizona average of 36.61 (Table 5.1.11-3). The ROI level of service for police protection exceeded the Arizona and U.S. averages, largely because of the inclusion of the large police forces of metropolitan Phoenix in the ROI. Fire protection and health care levels of service for the ROI exceeded the Arizona state averages but fell below the national averages.

FTE employees in education averaged 19.29 per 1,000 population for the ROI, greater than the national average of 18.44 yet less than the state average of 20.76 per 1,000. The average student/teacher ratio for the ROI was 19.3, lower than the state average (19.7) but not as low as the national average (18.0).

Public services in Maricopa County are specifically addressed below, since the county would host the ring and adjacent facilities and most likely would provide most of the necessary public services to the SSC and its employees.

2. Maricopa County

Maricopa County has the highest concentration and some of the most sophisticated public services and facilities in Arizona. These services are concentrated in and around Phoenix, but more than 35 mi northeast of the proposed site of the SSC.

Maricopa County has 35 hospitals providing more than 7,600 beds, as well as 3,000 physicians offering specialization in all medical fields (Arizona Department of Commerce 1987). Nine air ambulance services (public and private) are able to provide access to medical centers from the proposed SSC site. The closest hospital to the proposed site is the Casa Grande Regional Medical Center, a 100-bed level-1 trauma center that has the capability of receiving air ambulance-delivered patients. This center is located in Pinal County approximately 35 mi east of the proposed campus site (Arizona Department of Commerce 1987).

A total of 55 school districts provide the residents of Maricopa County with public school services and facilities (341 elementary and 58 high schools). The county's student/teacher ratio for primary and secondary education (20.0) is slightly higher than the state (19.7) and national (18.0) averages. The proposed site of the campus falls near the border of the Mobile Elementary School District (ESD) and an area not organized for public education. Mobile ESD operates one school (kindergarten through eighth grade) in Mobile with a total enrollment of 17 students. The area falls within no high school district; promoted Mobile ESD students attend high school under a tuition agreement at Casa Grande, 35 mi to the east (Arizona Department of Education 1987).

At this time, there are virtually no public services or facilities provided at the uninhabited site proposed for the SSC. The area falls within the jurisdiction of the Maricopa County Sheriff's Office, but the nearest permanent police substation is approximately 30 mi west of the proposed campus site at Gila Bend. The site is also unorganized for fire protection. Public services necessary for the safe and complete operation of any major development in this area would have to be expanded from surrounding areas (police and fire protection) or created (emergency health care) to suit the needs of the facility.

Table 5.1.11-3

LEVELS OF PUBLIC SERVICE - ARIZONA SSC SITE[1]

Area	Police Protection	Fire Protection	Health and Welfare	Public Education: General Education	Public Education: Student/ Teacher Ratio	All Other	Total
Maricopa County	2.61	0.92	2.45	19.22	20.0	11.28	36.48
Pima County	2.17	0.87	2.47	18.21	20.7	8.61	33.14
Pinal County	3.61	0.18	4.26	26.90	18.4	9.43	43.56
Region of Influence	2.54	0.88	2.53	19.29	19.3	10.71	35.95
Arizona	2.50	0.86	2.36	20.76	19.7	10.13	36.61
United States	2.34	1.02	3.84	18.44	18.0	8.71	34.35

Notes:

1. All table values represent full-time equivalent (FTE) employees per 1,000 except student/teacher ratio.

Source: U.S. Bureau of the Census 1984; Arizona Department of Education 1987; U.S. Department of Education 1987.

D. Public Finance

1. Arizona State Government Finances

a. State Government Taxes

Arizona has several sales and use tax rates under its general transaction tax, several excise taxes on selected items, and an income tax. Motor fuel and motor vehicles produce substantial tax revenues. A brief discussion will indicate the principal features of these taxes. All dollar values in the public finance discussion are current dollars for the fiscal years cited.

Arizona's sales tax is a tax for the privilege of transacting business. The rate ranges from .46875 of 1% (on wholesale feed) to 5% depending on the type of business. Most sales are at a 5% rate. The use tax is levied on all purchases of tangible personal property for which the sales tax is not paid. This source also includes severance taxes on timber and certain minerals. There is also a municipal sales tax. The base is quite broad covering rental occupancy, transporting and towing, utilities and communications, contracting materials, transient lodging, amusements, and retail sales. In FY86, this tax accounted for 45.66% of Arizona tax revenues (Table 5.1.11-4).

Corporations and individuals pay income taxes that are graduated and follow federal taxable income. These sources provided 27.31% of Arizona tax revenues in FY86.

Gasoline and aviation fuel are taxed at 16 cents/gal (17 cents beginning July 1, 1990). Aviation fuel distributors pay an additional 5 cents/gal. Fuel use is similar. These taxes provided 8.06% of Arizona revenues in FY86.

Auto license taxes vary according to the value of the vehicle; motor carrier taxes vary according to weight and Arizona mileage. Property carriers pay 2.5% and passenger carriers 2.25% of their gross intrastate receipts. These sources provided 7.84% of FY86 tax revenues.

Other Arizona taxes contributing to the total tax revenue include alcoholic beverage taxes, general property tax, cigarette and tobacco taxes, and the insurance company tax. The largest such source is the property tax because railroad and airline property is taxed at the state level for 3.59% of FY86 tax revenues.

b. State Revenue and Expenditure

Details of state government general revenues (which exclude insurance funds) and total general expenditures and direct capital outlays are presented in Table 5.1.11-4 for FY86, the latest available. The major source category is taxes followed by intergovernmental (mostly federal)

Table 5.1.11-4

ARIZONA STATE GENERAL REVENUE AND EXPENDITURE

Revenue/Expenditure	Amount (in thousands)	Per Capita
REVENUE		
Total intergovernmental	$ 806,831	$ 243
Federal	733,331	221
Total taxes	3,195,720	963
Sales and gross receipts	1,969,299	594
General sales	1,459,253	440
Selective sales, gross receipts	510,046	154
Alcohol	40,849	12
Insurance	67,936	20
Motor fuels	257,445	78
Public utilities	80,345	24
Tobacco	50,776	15
Individual income	701,998	212
Corporate net income	170,821	51
Licenses	225,714	68
Corporate license tax	3,677	1
Motor vehicle	168,290	51
Occupation and business licenses	16,808	5
Documentary and stock transfer fees	---	---
Property tax	114,719	35
Charges and misc. general revenue	602,378	182
Current charges	327,800	99
Total General Revenue	4,604,929	1,388
EXPENDITURE		
Total General Expenditure	4,688,190	1,413
Direct capital outlay	562,376	170

Notes: Population as of 7-1-86: 3,317,000
Source: U.S. Bureau of the Census, 1987b.

revenues and charges and miscellaneous sources. Expenditures exceeded revenues by less than 2%. Capital outlays were nearly 12% of general expenditures.

c. Local Government Organization and State Payments to Local Governments

There were 14 county, 76 municipal, and 232 school district governments in Arizona at the time of the 1982 Census of Governments. There were several types of school districts, including community college districts, and a few (13) dependent public school systems under county governments in sparsely populated areas.

There were also 130 special district governments including general improvement districts, power districts, sanitary districts, special road districts, fire districts, water conservation districts, and the Salt River Project Agricultural Improvement and Power District, which is part of a joint private-public reclamation and power activity.

School districts may levy property taxes and, with voter approval, may issue general obligation bonds. Other districts may collect rates and charges, accept grants, levy property taxes, and, in some instances, issue revenue or general obligation bonds.

The major expenditure by Arizona is for K-12 education support. The basic entitlement is granted to school districts and, in a few sparsely populated areas, to counties for operations. Other categorical funds are provided.

The sales tax rate at the state level consists of two parts: nonshared and distribution that is shared with counties and cities. Municipal sales taxes are also permitted. The distribution portion of the state sales tax is shared as follows: cities and towns receive 25% based on population; counties receive 38.08% based on assessed valuation and origin factors. The residual is retained by the state.

The state income tax is shared with cities and towns. Each year 15% of net collections from two years prior is distributed as urban revenue sharing in proportion to population.

One-third of the proceeds of the alcoholic beverage license tax is distributed to the county of origin.

Half of the revenue from motor vehicle license and privilege taxes, motor fuel taxes, and the state lottery is distributed as follows: 7% to larger cities; 30% to cities by population and fuel sales factors; and 20% to counties by fuel sales.

2. Maricopa County and Other Local Government Finances

Since the entire proposed site is within Maricopa County and since Maricopa County is such a major force in Arizona, public finance impacts at the local level will be considered only for jurisdictions within it.

Revenue and expenditure data for the latest available year, FY87, are provided in Table 5.1.11-5 for Maricopa County government. The largest revenue source is intergovernmental distributions from federal and state sources. Taxes, in this instance property tax revenues, were the largest strictly local source. Charges were a substantial source while licenses and permits and fines and forfeits were small. Miscellaneous, which includes interest and rental income, was a moderate share of total revenue. Maricopa County operations include expenditures for general government; public safety; roads; health, welfare, and sanitation; and recreation. Capital outlay was about 19% of total expenditure in this fast-growing area. Revenue exceeded expenditure by about 11%.

Maricopa County acted as tax collector for all levels of government levying property taxes within its boundaries. In 1986-87 the following tax levy prevailed:

Jurisdiction	Tax Levy
County government	$ 165,244,468
City government	97,767,795
School districts	513,585,394
Special districts	137,177,238
State government	37,058,981
Total Maricopa County	$ 913,775,876

Total assessed value for the period was $10,963,593,000, while market value was $74,154,746,000 resulting in a ratio of assessed to market value of the taxable property base of 14.8%.

Table 5.1.11-5

MARICOPA COUNTY, ARIZONA
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1987

Revenue/Expenditure	Amount	Per Capita
REVENUE		
Taxes	$ 168,844,289	$ 85
Licenses and permits	11,172,323	6
Intergovernmental	247,937,973	125
Charges for services	50,999,681	26
Fines and forfeits	5,099,137	3
Miscellaneous	21,708,993	11
Total Operating Revenue	$ 505,762,396	$ 254
EXPENDITURE		
Operations	$ 337,851,069	$ 170
Principal retirement	23,711,432	12
Interest charges	7,219,187	4
Capital outlay	85,892,571	43
Total Expenditure	$ 454,674,259	$ 228

Notes: (Population, 1987: 1,990,800)
(Assessed Value: $ 10,963,593,000)
Source: Maricopa County, 1987a.

5.1.11.2 Infrastructure

A. Transportation

1. Roads

Major highways and roads serving the proposed SSC site are shown in Figure 5.1.11-3. Data on those highways and roads are presented in Table 5.1.11-6.

Metropolitan Phoenix 35 mi north-northeast of the proposed site is served by a freeway system that includes I-17 extending to the north and I-10 extending to the west and south from downtown Phoenix. In addition, the Superstition Freeway (State Route 360) extends to the east. The Maricopa Association of Governments (MAG) has prepared a master freeway/expressway plan that calls for development of an extensive system of beltways and arterials to supplement the existing system (Maricopa Association of Governments 1987a).

The proposed SSC site is served by a network of interstate and state highways and county roads. These include I-10 on the north and east and I-8 on the south, State Route 85 on the west and State Route 84 on the south, and Pinal County's Maricopa and Casa Grande roads on the east. The Maricopa-Gila Bend Road is a county-maintained, two-lane dirt road that cuts across the northern half of the site. A portion of this road, extending from 14 mi east of Mobile to the site of the future hazardous waste facility, is currently being upgraded to a two-lane paved state highway and will be designated State Route 238 (Keller 1987).

The site may also be served in the future by a proposed Estrella Freeway Connection between I-10 and I-8 (BRW 1988). This would consist of a four-lane freeway that would extend from I-10 near the City of Goodyear to I-8 east of the proposed SSC site. Completion of the freeway was proposed for some time after the year 2005. The freeway was not included in the MAG freeway/expressway plan.

A limited number of poor quality dirt roads provide access to the location of some of the proposed surface facilities. Most of these are passable only by four-wheel-drive vehicles.

2. Rail

The proposed SSC site is served by a Southern Pacific Transportation Company main line that extends across the entire southern portion of the state as shown in Figure 5.1.11-3. It connects the site with major cities to the east and west along the main line and with most other U.S. cities through connections to other railroads. It crosses the proposed SSC site along the alignment of the Maricopa-Gila Bend Road. Sidings and additional tracks are located at Mobile 5 mi north of the proposed campus location and Estrella. Current traffic on the line averages 26

Figure 5.1.11-3

MAJOR TRANSPORTATION SYSTEMS
SERVING THE ARIZONA SITE

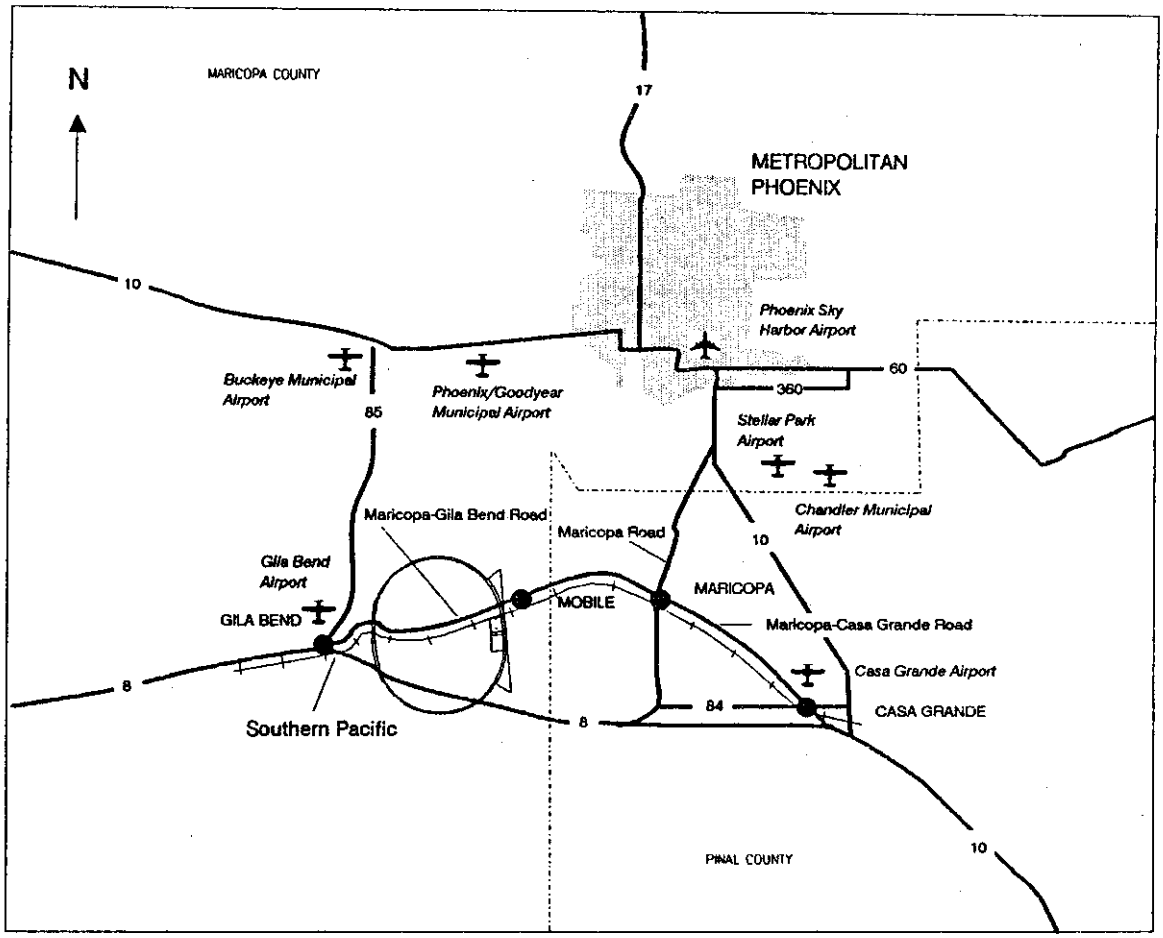


Table 5.1.11-6

PRESENT HIGHWAYS AND ROADS SERVING THE PROPOSED ARIZONA SSC SITE

Road Segment	Length Miles	Lanes	Peak Hour Capacity pcph[1]	Volume pcph	LOS[2]
I-10: State Route S85 to 27th Ave.	30	4	8,000	2,400	A[3]
I-10: State Route 360 to Maricopy Road	7	4	8,000	4,150	B[4]
I-10: Maricopa Road to I-8	37	4	8,000	2,200	A
I-8: State Route 85 to I-10	63	4	8,000	550	A
State Route 85: I-10 to I-8, Including Spur 85	35	2	2,800	800	C
State Route 84: I-10 to I08	28	2	2,800	350	B[5]
Maricopa Road: I-10 to Maricopa	15	2	2,800	350	B
Maricopa Road: Maricopa to State Route 84	13	2	2,800	250	B
Maricopa-Gila Bend Road: (State Route 238)	39	2	N/A	100	N/A[6]
Maricopa-Casa Grande Road:	24	2	2,800	190	B

Notes:
1. PCPH - passenger cars per hour.
2. LOS - Level of service.
   A - Free flow with individual users virtually unaffected by the presence of others in the traffic stream.
   B - Stable flow but the presence of other users in the traffic stream begins to be noticeable.
   C - Stable flow but operations of individual users becomes significantly affected by interactions withh others in the traffic stream.
   D - High density, but stable flow with speed and freedom to maneuver severely restricted and the driver experiences a generally poor level of comfort and convenience.
3. Portions of I-10 close to 27th Ave. experience LOS C.
4. Portions of I-10 close to State Route 360 experience LOS D.
5. Portions of State Route 84 close to State Route 287 and 387 experience LOS C.
6. Currently a 2-lane dirt road. Portions are being upgraded to a 2-lane paved highway.

Sources: Arizona Department Of Transportation 1987-2; Heisinger 1987; Transportation Research Board 1985; ADOT 1986.

trains per day. The maximum capacity of the line is 36 to 42 trains per day (SPTC 1988). AMTRAK line passenger rail service is available at Phoenix (unverified).

3. Air

Airport locations serving the proposed SSC site are shown on Figure 5.1.11-3. The principal airport that would provide passenger and freight service to the proposed SSC site is the Phoenix Sky Harbor Airport. This airport, owned and operated by the City of Phoenix, is located approximately 3 mi east of downtown Phoenix and 35 mi northeast of the proposed campus location. The airport served more than 13 million passengers in 1986 (ADOT 1987a-1).

Airport operations are currently congested with 22,000 hours of delays experienced by scheduled airline operations in 1986. Delays are forecasted to increase to 49,000 hours in 1996. An additional runway is expected to be constructed within the next five years to mitigate delays to airline operations (Yatzeck 1988).

The Arizona Department of Transportation has conducted a preliminary search for a new metropolitan jetport site (Arizona Department Of Transportation 1988). This search is the first step in the development of a major new airport sometime in the 21st century. The search resulted in the recommendation of two potential sites located near Casa Grande and Coolidge. The Casa Grande site would be located south of Maricopa approximately 15 mi east of the proposed campus location. The other site would be located approximately 45 mi east of the proposed campus location.

A number of general aviation fields are also available to provide service to the SSC site. These are located at Buckeye, Goodyear, Stellar, Chandler, Casa Grande, and Gila Bend (Arizona Department Of Transportation 1987a-1). The Casa Grande Municipal Airport located 30 mi east of the proposed campus location is the closest municipal airport to the SSC campus site and is capable of handling corporate jet aircraft. It is significantly underutilized (Sverdrup & Parcel & Associates 1981)

4. Waterways

There are no waterways that serve the SSC site. The closest port is Puerto Penasco at the head of the Gulf of California in Mexico approximately 130 mi to the southwest of the proposed SSC site. The reactor vessels for the Palo Verde Nuclear Generating Station were shipped to this port and then trucked to Arizona.

5. Public Transit

a. Bus Service

The City of Phoenix Transit System provides scheduled bus service in Phoenix, Glendale, Mesa, Scottsdale, and Tempe (Arizona Department Of Transportation 1987). A Regional Public Transit Authority was established in 1986 to prepare a long-range transit plan for the MAG area (Maricopa Association of Governments 1987b). This organization is performing studies to analyze transit system improvements and to evaluate the feasibility of implementing a rapid transit system.

b. Taxi Service

Privately operated taxi, shuttle, and limousine services are provided in the Phoenix metropolitan area.

c. Rental Car Service

Privately operated rental car services are located at the Sky Harbor Airport and other locations in the Phoenix metropolitan area. Additional rental car services are located at general aviation fields in Stellar, Chandler, and Casa Grande (Flight Guide 1986).

d. Para-Transit Services

Phoenix and several surrounding cities operate dial-a-ride systems for the general public in some areas of low population density and during periods of low passenger demand (Arizona Department Of Transportation 1987a). This service is provided by a privately owned taxi system under contract to the cities. Special provisions are made for the elderly, handicapped, and in some cases, low income persons.

A regional ride-sharing program operated by MAG attempts to integrate the use of carpool, vanpool, and bus service (ADOT 1987). MAG provides assistance to employers developing and implementing ride-sharing programs for their employees.

B. Utilities

1. Electricity

a. Ownership

The area in the vicinity of the Arizona site is served mainly by two separate electric utilities: the Arizona Public Service Company (APS) and the Salt River Project (SRP).

Other facilities in the area with electric generating capabilities are: the Western Area Power Administration, Tucson Electric Power Company (TEP), and the Bureau of Indian Affairs (BIA).

APS was incorporated in 1920 under the laws of the State of Arizona, and is engaged principally in the generation and sale of electricity. All shares of common stock in the company are owned by Pinnacle West Capital Corporation (formerly AZP Group, Inc.) (Arizona Public Service Company report 1987).

b. Delineation of Service Territory

The APS interconnected transmission network serves the entire State of Arizona (Arizona Public Service Company 1987b).

The Arizona transmission system is considered to belong to one of the four areas into which the Western Systems Coordinating Council's (WSCC) region is subdivided. The Arizona-New Mexico Power Area consists of Arizona, most of New Mexico, and the westernmost part of Texas (North American Electric Reliability Council 1987).

Local communities served by their electric utilities are shown in Table 5.1.11-7.

c. Interrelationships with Other Electric Utilities

APS power requirements and planning are coordinated with other utilities, primarily through close cooperation with the Salt River Project, Arizona Electric Power Cooperative, Tucson Electric Power Company, Western Area Power Administration, and the Department of Energy. Coordination with utilities outside of Arizona is carried out through joint ownership of certain plants and transmission lines (Arizona Public Service Company 1988).

Arizona's interconnected power system is part of the WSCC, which is one of nine regional councils that make up the North American Electric Reliability Council (NERC). The WSCC, with 60 member systems and four affiliates, encompasses approximately 1.8 million mi^2 of territory in 14 western states, plus parts of two Canadian provinces and the northern portion of Baja California, Mexico (North American Electric Reliability Council 1987).

The Arizona and New Mexico utilities are actively working with California utilities, both directly and through WSCC, to increase assurances that present and proposed interface schemes will not decrease system reliability in the Arizona-New Mexico area (North American Electric Reliability Council 1987).

d. Existing Network

Arizona Public Service Company's electric generating system has a net accredited capacity of approximately 10,400 MW in joint use/ownership with other utilities. The rated capacity available to the APS system is approximately 4,460 MW. These figures include the Palo Verde Nuclear Unit No. 3, which began power operation in January, 1988 (Arizona Public Service Company 1986c; Arizona Public Service 1988).

The Arizona transmission network, in conjunction with the United States portion of the WSCC, has approximately 120,000 MW of installed capability (North American Electric Reliability Council 1987).

e. Planned Future Upgrades/Additions

APS has plans to bring a fifth unit on line at their Cholla steam generating plant in the year 2005. This will increase capacity directly to APS by approximately 340 MW (Arizona Public Service Company 1986c).

APS also plans to construct several 230-kV transmission lines and substations, including a new 230-kV line between the existing Santa Rosa and Gila Bend substations. Construction is scheduled to begin in 1996 with a planned in-service date of 1997. APS has proposed both preferred and alternate routes to situate the new line, and has already filed an environmental assessment report for the proposed construction project (APS 1988, USDOI).

2. Natural Gas

a. Ownership

Natural gas demands for the area in the vicinity of the Arizona site are met by the Southwest Gas Corporation (Southwest), El Paso Natural Gas Company, Arizona Public Service Company, the Salt River Project, and the Black Mountain Gas Company (Arizona Department of Commerce 1987).

Southwest Gas Corporation is a publically held California corporation whose common stock is listed on the New York Stock Exchange. Its principal businesses are natural gas distribution and financial services (Southwest 1987).

In 1984, Southwest Gas Corporation acquired all of the gas utility assets of Arizona Public Service Company (Southwest 1987).

The El Paso Natural Gas Company, a subsidiary of the El Paso Company, was incorporated in 1928 under the laws of the State of Delaware. Principal business activities are the production, sale, and transportation of oil and gas. The El Paso Company is a wholly owned subsidiary of Burlington Northen Inc. (El Paso 1987).

b. Delineation of Service Territory

Southwest Gas Corporation provides natural gas service to southern Nevada, southern California, and southern Arizona, including Maricopa, Yuma, Pima, and Pinal counties (Arizona Department of Commerce 1987; Southwest 1987).

Table 5.1.11-7

EXISTING PUBLIC SERVICE UTILITIES FOR COMMUNITIES IN MARICOPA, PIMA, AND PINAL COUNTIES

Community	Electric Service	Natural Gas	Telephone Service
MARICOPA COUNTY:			
Avondale	APS	Southwest	U.S. West Communications
Buckeye	APS	Southwest	U.S. West Communications, AT&T
Carefree/Cave Creek	APS	Black Mountain Gas	U.S. West Communications
Chandler	APS, SRP	Southwest	U.S. West Communications
El Mirage	APS	Southwest	U.S. West Communications
Fountain Hills	SRP	Fountain Hills L-P Gas	U.S. West Communications, AT&T
Gila Bend	APS	Southwest	U.S. West Communications, AT&T
Gilbert	APS, SRP	Southwest	U.S. West Communications
Glendale	APS, SRP	Southwest	U.S. West Communications, AT&T
Goodyear	APS	Southwest	U.S. West Communications
Greater Paradise Valley Area	APS, SRP	Southwest, SRP	U.S. West Communications, AT&T
Guadalupe	SRP	Southwest	U.S. West Communications
Litchfield Park	APS	Southwest	U.S. West Communications, AT&T
Mesa	Municipal, SRP	Municipal	U.S. West Communications
Peoria	APS, SRP	Southwest	U.S. West Communications
Phoenix	APS, SRP	Southwest	U.S. West Communications
Salt River-Pima Maricopa Indian Comm.	SRP	Southwest, independent cos.	U.S. West Communications
Scottsdale	APS, SRP	Southwest AT&T	U.S. West Communications
Surprise	APS	Southwest	U.S. West Communications
Tempe	APS, SRP		Southwest Mountain Bell, AT&T, Sprint, MCI
Tolleson	SRP	Southwest	U.S. West Communications
Wickenburg	APS, Municipal	Southwest	U.S. West Communications, AT&T
Youngtown	APS	Southwest	U.S. West Communications
PIMA COUNTY:			
Ajo	APS, Ajo Improv	Southwest, Ajo Improve	U.S. West Communications
Green Valley	TEP, Trico Elec	Southwest	U.S. West Communications
Marana	TEP, Trico Elec	Southwest	U.S. West Communications

Table 5.1.11-7 (Cont)

EXISTING PUBLIC SERVICE UTILITIES FOR COMMUNITIES IN MARICOPA, PIMA, AND PINAL COUNTIES

Community	Electric Service	Natural Gas	Telephone Service
Oro Valley	TEP	Southwest	U.S. West Communications
South Tucson	Tucson Gas & Elec	Southwest	U.S. West Communications
Tucson	TEP, Trico Elec Co-op	Southwest	U.S. West Communications AT&T, Sprint
PINAL COUNTY:			
Ak-Chin Indian	APS	Southwest	U.S. West Communications AT&T
Apache Junction	SRP	Southwest	U.S. West Communications
Arizona City	APS	Southwest	U.S. West Communications AT&T
Casa Grande	APS	Southwest	U.S. West Communications
Coolidge	APS, BIA	Southwest	U.S. West Communications
Eloy	APS	Southwest	U.S. West Communications
Florence	APS	Southwest	U.S. West Communications
Kearny	APS	Southwest	U.S. West Communications
Mammoth	BIA	Southwest, El Paso Natural Gas	U.S. West Communications AT&T
Oracle	BIA	Southwest	U.S. West Communications
Picacho/Red Rock/ Picacho Peak	APS	Southwest	U.S. West Communications

Notes:
APS - Arizona Public Service Company.
SRP - Salt River Project.
TEP - Tucson Electric Power Company
BIA - Bureau of Indian Affairs
Southwest - Southwest Gas Corporation
Source: Arizona Department of Commerce 1987.

El Paso Natural Gas Company owns and operates a 22,000-mi interstate natural gas pipeline and gathering system in the southwestern and western United States (El Paso 1987).

Local communities served by their natural gas utilities are shown in Table 5.1.11-7.

c. Interrelationship with Other Natural Gas Utilities

Southwest's pipeline transmission and distribution system has interconnections with Arizona Public Service Company, Southern Union Gas Company, Pacific Gas and Electric Company, and Southern California Gas Company (Southwest 1987).

Southwest's traditional pipeline supplier also include El Paso Natural Gas Company, Northwest Pipeline Corporation, and Pacific Gas & Electric Company (Southwest 1987).

El Paso Natural Gas Company purchases the majority of its natural gas supplies from producers in the Permian basin of west Texas and southeastern New Mexico, the Anadarko basin of western Oklahoma, and the San Juan basin of nothwestern New Mexico (El Paso 1987).

Through its deliveries to Southern California Gas Company, Pacific Gas & Electric Company, and other California customers, El Paso Natural Gas Company supplied approximately 50% of all natural gas consumed, in California in 1987 (amounting to 83% of El Paso's total deliveries) (El Paso 1987).

d. Existing Network

The referenced source details the existing pipeline transmission system in Arizona (Southwest 1987).

e. Planned Future Upgrades/Additions

Three natural gas pipelines traverse the site vicinity from northwest to southeast through Hidden Valley. El Paso Natural Gas Company plans to reroute the existing right-of-way near Mobile to serve the proposed Provident Energy Company oil refinery slated for construction there

3. Telecommunications

a. Ownership

Telecommunications facilities and equipment are owned and operated by Mountain Bell and American Telephone and Telegraph (AT&T).

Mountain Bell (formally the Mountain States Telephone and Telegraph Company) is a publicly held corporation incorporated under the laws of the State of Colorado. The company is a subsidiary of U.S. West

Communications Group, Inc., a telecommunications holding company. U.S. West Communications Group, Inc. is a wholly owned subsidiary of U.S. West, Inc. (U.S. West 1987) (Bell 1987).

b. Delineation of Service Territory

Mountain Bell is engaged in the business of furnishing telecommunications services in Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming (Bell 1987).

Mountain Bell provides service to Maricopa, Yuma, Pima, and Pinal counties. AT&T, Sprint, and MCI provide services to smaller areas within this region.

c. Interrelationship with Other Telecommunications Systems

Mountain Bell is interconnected with U.S. West's other principal subsidiaries, Northwestern Bell and Pacific Northwest Bell. Together they provide telecommunications service to 14 Western states, including over nine million customers (U.S. West 1987).

Mountain Bell provides network access service to interexchange carriers, the largest volume of which is provided to AT&T (U.S. West 1987).

d. Existing Network

About 46% of Mountain Bell's access lines are in the metropolitan areas of Denver, Phoenix, and Salt Lake City, and about 29% in 19 other exchange areas having populations greater than 50,000 (Bell 1987).

e. Planned Future Upgrades/Additions

No information is available to indicate future service upgrades.

5.1.12 Cultural and Paleontological Resources

5.1.12.1 Cultural Resources

A. Cultural History and Scientific Basis/Understanding

People have lived in the southern desert of Arizona for at least the past 12,000 years. Archaeologists divide this time into cultural periods: Paleo-Indian (9000-5000 B.C.), Archaic (5000 B.C.-A.D 500), Hohokam (A.D. 500-1450), Protohistoric (A.D. 1450-1700), and Historic (A.D. 1700-1850-present) periods.

The Paleo-Indian Period represents Late Pleistocene-early Holocene occupations when prehistoric populations hunted now-extinct large game. Paleo-Indian Period sites are rare, so it is difficult to evaluate the lifestyle of the people or the locations of the sites near the proposed SSC. Paleo-Indian finds in Arizona have mostly been confined to the higher desert grasslands of the southeast (Shackley and Rice 1985). However, a Folsom point has been recorded near Gila Bend (Effland et al. 1982).

The Archaic Period is marked by the introduction of seed grinding implements and basketry, indicating changes in technological emphasis. Archaic peoples hunted wild game and gathered native plant resources while moving seasonally from one location to another. Because of their low population density and their nomadic life, Archaic sites tend to be rare and small in size. The Maricopa Mountains include springs and sheltered valleys; ecological diversity that was used by Archaic peoples (Bostwick 1986). Two cultural traditions have been defined in southern Arizona for this period; the Cochise, which occurs in the southeast area; and the Amargosa, which is identified in the southwest area. It has been suggested that these traditions may represent adaptations by the same culture to different environmental zones (McGuire and Schiffer 1982). Populations appear to have increased toward the end of the Archaic Period, which combined with a decrease in precipitation, may have been the impetus for their transition to a farming economy and a settlement shift to more sedentary habitation along major drainages (Wilcox 1979).

The Hohokam tradition became dominant following the Archaic Period and lasted until 1450 A.D. when it abruptly ceased. The Hohokam were farmers who lived in sedentary villages and frequently relied on canal irrigation (Haury 1976). Very large Hohokam villages are found in the Vekol Valley to the southeast of the proposed SSC site and the Gila River Valley to the north and west. A major Hohokam site is located at Painted Rock Reservoir west of Gila Bend, an area that McGuire and Schiffer (1982) believe may have been an important center along the trading path of marine shell from the California coast to the Hohokam settlement. Research in environmental regions similar to the proposed project area (Bostwick 1982) have identified sites that are indicative of the ephemeral camps used by peoples of nearby Hohokam villages.

Chronology for the Hohokam has been based on changes in ceramic design and architecture (Haury 1976). Several phases have been identified, including the Colonial and Sedentary periods, from approximately 700 A.D. to 1100 A.D., when the Hohokam culture expanded along the major drainages and reached its greatest territorial holdings. In the western Arizona region, settlements were established as far as Gila Bend and the Salt-Gila basin, where crops were irrigated by an extensive network of canals.

The Classic phase of the Hohokam Period, from 1100 A.D. to 1400 A.D., is defined on the basis of further changes in ceramic design, architecture, settlement patterns, and burial practices (Shackley and Rice 1985). Exchange systems may have undergone disruption, and the territory around Gila Bend may have been abandoned around this time as the Hohokam retracted into a smaller territory. Patayan migrations from the Lower Colorado River area into the westernmost portion of the area abandoned by the Hohokam may have occurred in the latter part of the Classic Period (Shackley and Rice 1985). It is likely that the Hohokam used trails that crossed the proposed SSC region during their travels between major population centers and probably hunted and gathered in the area. Between 1375 and 1450, there appears to have been a return to less complex architecture settlement and subsistence patterns at sites excavated in the Phoenix basin (Doyel 1988), and possibly throughout the region.

The Pima, Papago, and Maricopa Indians were living in the southern deserts at the time of the first European arrivals. These groups are almost certainly the descendants of the Hohokam, but their numbers were severely reduced compared with the Hohokam population.

Jesuit missionaries reached southern Arizona in 1687 when Father Kino established mission centers. The Spanish introduced domesticated livestock and new crops such as wheat, which thrived in the Arizona winter climate, allowing the Pima to farm in the winter and acquire a surplus of grain. By 1744, the Gila Pima were growing winter wheat irrigated by an extensive system of canals and ditches (Doyel 1988).

Between 1848 and 1854, it is estimated that 60,000 American goldseekers passed through the Pima villages and territory on their way to California. They camped at a site near Maricopa Wells where they traded with the Pima for provisions (Hackenberg 1983).

People of European descent in the Historic Period used the region for cattle grazing and small scale homesteading. Transportation routes, wagon trails, and a railroad system were established. The most famous was the historic Butterfield Stage Line, which crossed the proposed SSC site through the Maricopa Mountains. The Butterfield Stage Line was used by the Butterfield Stage Coach Company between 1846 and 1861 as part of a contract with the federal government to provide mail service from Texas to California.

B. Known National Register Sites/Sacred Sites

No cultural resource properties in the proposed site have yet been listed or determined eligible for inclusion on the National Register of Historic Places. No Native American sacred sites have yet been identified.

C. Previously Recorded Sites and Research in Project Area

Information pertaining to known sites in the proposed project area was obtained from 1) previous surveys within the area and in adjacent regions (Bureau of Land Management 1985, 1987; Bostwick 1982), 2) archival research, and 3) recent field surveys (Bostwick 1986; Butler and Fletcher, n.d.) conducted by the Office of Cultural Resource Management, Department of Anthropology, Arizona State University. For purposes of comparison, an assessment was made of archeological and historical sites previously recorded on lands included on all U.S.G.S 7.5-minute maps within which the proposed sites would be constructed.

The archival research performed by Arizona State University included a records search at the Phoenix District Office of the Bureau of Land Management. General Land Office records were reviewed. Extensive surveys have been conducted in the nearby Vekol Valley to the east (Bostwick 1982).

Major BLM environmental overviews pertaining to the project area involve the Lower Gila South Resource Management Plan (RMP) and Environmental Impact Statement (Bureau of Land Management 1985, 1987). The wilderness-related portions of these documents compare 12 wilderness study areas (WSA), including three that partially coincide with the proposed SSC site: North Maricopa Mountains WSA, Butterfield Stage memorial WSA, and South Maricopa Mountains WSA. As reported in the project documents, about 1.26% of the RMP area had been intensively surveyed for cultural resources; 390 cultural resource sites had been recorded on BLM lands. Projected over the entire study area, over 20,000 sites were estimated to occur. Further, the 1% sample survey of 607,532 acres of the WSAs resulted in designating 218,560 acres as having high probability of yielding cultural resources. Reports describing traditional cultural/ religious sites as identified by Native American interviews are also cited (Cultural Systems Research, Inc. 1978; Westec 1982; Woods 1982). Also noteworthy is Appendix 17 of the RMP, which lists prehistoric and historic archaeological site types in the Lower Gila South Study Area.

Within the North Maricopa Mountain WSA a potentially significant archaeological site was described as a large subsurface site with possible pit-houses, probably containing over 10,000 groundstone, chipped stone, and ceramic artifacts. Few sites of this size or nature have been found in the area. This site, located outside the SSC study area, is probably eligible for the National Register.

Another recent study, pertinent to the project area, is the Environmental Impact Assessment Report prepared for the Santa Rosa to Gila Bend 230 kV Transmission Line Project (Bureau of Land Management n.d.). The proposed route crosses the Maricopa Mountains. Although an actual field survey was not undertaken, assessments were made of the potential impacts to cultural resources along portions of the route. Through the Maricopa Mountains, the potential impact to archaeological and historic sites was rated moderate; no impacts to Native American sacred sites were identified, although a traditional gathering place was nearby.

In addition, several phases of field research were undertaken by Arizona State University to determine the actual cultural resources that could be affected by SSC activities (Schackley and Rice 1985; Bostwick 1986). Portions of the ring to be constructed by cut-and-cover operations were surveyed. These areas include the section designated from mile 2.0 to mile 16.3 and from mile 35.0 to mile 41.6. In addition, prior to several stages of seismic testing, archaeological crews surveyed the testing areas to inventory and mark the boundaries of cultural resources.

Table 5.1.12-1 lists 17 recorded prehistoric and historic sites that are located in construction areas of the proposed project (State of Arizona 1987). Seven of these are prehistoric sites affiliated with the Hohokam Period and probably date between A.D. 700 and 1450. The remaining ten sites are historic or modern sites associated with the Euro-American occupation of Arizona. In addition, 13 sites have been recorded by previous surveys within or near the circumference of the collider ring; these are listed on Table 5.1.12-2 (State of Arizona 1987).

The seven prehistoric sites within construction areas include a lithic quarry, two base camps with multiple categories of artifacts, two sherd scatters, one site of rock piles and an associated scatter of sherds, and one site consisting of two rock piles. One of the two camps includes a roasting pit. Excavations at these two sites could identify additional features and structures. These seven sites appear to have been used by Hohokam populations during intermittent visits to the areas to procure lithic artifacts and to gather local food resources.

Historic sites within the area proposed SSC site include the route of the Butterfield Stage Coach Line, construction camps associated with the Southern Pacific Railroad line in 1880, and a series of homesteads and related sites dating to the 1930s (Schackley and Rice 1985). The Butterfield Stage Line route crosses the proposed buried beam zone access areas J3 and J4 and through the far cluster. A one-room stone and concrete structure, deeded to Clyde Collins in 1932, is still standing in the proposed campus area. At four other locations within the project area, only the foundations and remains of collapsed buildings were found. There are also three scatters of historic artifacts (dating prior to World War II) that appear to be associated with the occupations of the nearby homesteads (State of Arizona 1987).

Table 5.1.12-1

SITES WITHIN DIRECT IMPACT AREAS OF PROPOSED ARIZONA SITE

Site Number	Project Location	Description
ASU FS-1	F9-E10	Historic trash
ASU FS-2	F9-E10	Historic homestead and trash
ASU FS-3	F9-E9	Prehistoric artifact scatter; probable campsite
AZ:Z:3:4(BLM)	Injector	Historic building
AZ:Z:3:1(ASU)	Near E2	Plainware sherd scatter
ASU LM-2	Injector	Two rock features
ASU LM-3	Injector	Historic structure and trash with prehistoric sherds
ASU LM-5	Injector	Prehistoric sherd and lithic scatter
ASU LM-7	Campus	Historic structure
ASU LM-8	Campus	Prehistoric sherd scatter
ASU LM-9	Campus/F10	Prehistoric quarry with lithics
ASU LM-10	Future Expansion	Historic trash scatter
ASU MZ 1	Injector	Historic trash, possible campsite
ASU PM-1	Campus	Historic homestead, foundation and trash
ASU PM-5	Future Expansion	Plainware scatter with possible stone piles
Butterfield Stage Line	Buried beam zone beam (J3-J4); far cluster	Only locations of portions within SSC ring are identified
De Anza Trail	J4; F9-E9 E5-E6, near K6	Only locations of portions within SSC ring are identified.

Source: Bostwick 1986.

Table 5.1.12-2

SITES OUTSIDE OF DIRECT IMPACT AREAS OF PROPOSED ARIZONA SITE

Site Number	Description
ASU FS-5	Desert Well Station of the Butterfield Stage Line
ASU FS-6	Happy Camp Station of the Butterfield Stage Line
AZ:Z:3:3(BLM)	Prehistoric campsite
HW2	Prehistoric campsite
HW3	Prehistoric lithic scatter
AZ:T:15:1(BLM)	Rock pile
AZ:T:15:1(ARS)	Railroad station
AZ:T:15:2(ARS)	Railroad camp
AZ:T:15:3(ARS)	Railroad camp
AZ:T:15:3(BLM)	Historic trash concentration
AZ:T:15:4(BLM)	Historic trash concentration
AZ:T:15:5(BLM)	Historic homestead
AZ:T:15:2(BLM)	Historic can scatter

Sources: Bostwick 1986.

Another historic thoroughfare that crosses the proposed SSC site is the Juan Bautista de Anza Historic Trail (National Park Service 1985). The de Anza Trail extends between Nogales, Mexico, and the San Francisco Bay area. The expedition left Horcasitas (175 mi south of Nogales) on September 28, 1775, with 30 families. After several delays and stopovers, 191 colonists arrived at Mission Dolores on June 27, 1776. On September 17, 1987, the National Park Service recommended to Congress that the de Anza Trail be established as a National Historic Trail. The draft bill has been prepared for Congressional review. A portion of this east-west trail crosses the proposed SSC site near abort/external beam access J4, along the collider ring between service area F9 and intermediate access E9, and between service areas E5 and E6 near interaction point K6.

In addition to these sites, isolated features and artifacts were noted. These kinds of localities range from single historic tin cans to a small scatter of prehistoric sherds, which probably represent the breakage of a single vessel (Bostwick 1986).

D. Characterization of Known Resources and Scientific/Educational Potential and Significance

Seven of the seventeen known sites located in the project area date to the prehistoric period. These include a lithic quarry, two base camps, two sherd scatters, a sherd scatter with associated rock piles, and a site with two rock alignments. These resources have the potential of yielding scientific information about the past and are therefore probably significant cultural resources using National Register criteria.

The significance of the prehistoric resources, both those already identified and those that might be identified in future surveys, can be realized through appropriate data recovery programs. Such programs would include emphasis on the recovery of botanical and faunal data from roasting pits, rock pile features, and buried cultural features in an attempt to document the procurement activities performed at these locations. It is possible that a considerable part of the artifact assemblage at these sites is surficial.

The ten known historic sites, include a portion of the Butterfield Stage Coach Line, portions of the de Anza Trail, the remains of five structures, and three scatters of litter. The stage line is associated with an important event related to Anglo-American settlement of the Southwest and is more than 50 years old. The trail is associated with an important event related to earlier Spanish settlement as well. These are potentially significant historical resources when applying National Register criteria. The five historic structures (of which only one remains standing) and the three scatters of artifacts are slightly more than 50 years old. They reflect attempts made during the 1930s to establish homesteads on the flat plains encircling the Maricopa Mountains. The history of homesteading is an important process in the

Euro-American settlement of the arid Southwest, and these structures might have the potential to provide a local, rather recent perspective on this process. The significance of the historic sites has not been fully established.

E. Unknown but Potential Resources

Additional sites are expected to be found during intensive field surveys, but it is very unlikely that the density or nature of these would differ significantly from those already recorded. Prehistoric and historic sites likely to yield important information are present.

A study is being conducted by Arizona State University to determine if there are Native American religious sites in the study area. Preliminary interviews with elders and religious specialists among the Native American groups residing near the project area suggest that the Maricopa Mountains and surrounding regions are viewed as wilderness (Bahr et al. n.d.). There are native beliefs pertaining to the importance of wilderness portions of the landscape; the proposed project area may fall into this general category. As yet, however, no specific locations of religious significance have been identified.

5.1.12.2 Paleontological Resources

A. Scientific Basis/Understanding

For a description and discussion of the stratigraphy of the project area, reference should be made to Section 5.1.1.2.

The Arizona site is geologically composed of three distinct lithologic groups. Holocene and quaternary silt, sand, and alluvium overlay tertiary and proterozoic strata. The valleys surrounding the Maricopa Mountains are filled with silt, sand, and gravel derived from eroded proterozoic porphyritic granite, quartz diorite, and Pinal schist. The younger and older fanglomerate (quaternary) sediments were probably deposited during intermittent stream overflow, flooding, and channel deposits, and as playa-related processes. The collider tunnel at the Arizona SSC site would largely intersect the fanglomerate deposits.

The tertiary sequence (1.8 to 65 million yr old) includes volcanic and sedimentary rocks made up of varying thicknesses of conglomerates, tuff, and basalt flows. The upper conglomerate involves polylithologic clasts in quartzose to calcareous cement and includes basalt flows and tuffaceous sandstone. The middle conglomerate involves clasts of granite and schist in quartzose cement and includes vesicular basalt flows with limestone and a basal sandstone. The lower conglomerate involves granitic clasts in quartzose cement with local lenses of sandstones.

Proterozoic metamorphic and intrusive rocks are located in the Maricopa Mountains including prophyritic biotite granite, quartz diorite, and Pinal schist.

B. Known Paleontological Localities

No known paleontological localities have been recorded in the proposed Arizona SSC project area. Geologic mapping along the surface of the proposed collider ring and the exposed limits of the middle Tertiary section has not produced any fossil discoveries (State of Arizona 1988).

C. Characterization of Geological Strata and Paleontological Potential

The geological setting of the proposed site is not considered favorable to preservation of fossil remains. Proterozoic granites and schists predate the existence of hard-body parts necessary for fossil preservation, and Precambiran soft-tissue organisms are rarely preserved in igneous and metamorphic rocks.

The middle Tertiary stratigraphic section present at the site is dominated by basaltic volcanism and basement-derived conglomerates indicative of high-energy depositional environments. Fossils are unlikely to be discovered in the pre-Messinian (pre-6.5 million years) rocks given the region's geologic history (State of Arizona 1988).

The late Tertiary-Quaternary stratigraphic section is not sufficiently exposed to fully determine the nature of the potential paleontological resource. These sections have been examined by borehole methods that would largely destroy any fossil remains. The older fanglomerate is characterized by coarse-grained subangular to subrounded clasts in a sand matrix cemented by calcium carbonate. These deposits are also interpreted as high-energy environments of deposition and are thought not to be conducive for fossil preservation. The younger fanglomerates are a sequence of sand-, silt-, and clay-sized particles moderately cemented by lime. Rocks similar to the younger fanglomerates in the San Pedro River Valley of southeastern Arizona, 140 mi southeast of the proposed SSC site, preserve a late Cenozoic terrestrial sequence and have yielded the best record of biotic evolution during this time (Lindsay 1984). It is unlikely that similar fossil remains will be recovered at the proposed SSC site because the younger fanglomerates are not well exposed.

Locally on the desert pavement, particularly from mile 20 to 35 along the proposed SSC collider ring, individual clasts of Paleozoic limestone often contain corals and other fauna indicative of the Paleozoic Era. The closest known Paleozoic outcrops containing such materials are located 10 mi to the south on the south slope of the Sand Tank Mountains (State of Arizona 1988).

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5.1.13 Scenic and Visual Resources

5.1.13.1 Visual Character of the Region

The Arizona site lies within the Sonoran desert section of the basin and range physiographic province. The province is a physiographically similar desert and semi-desert, extending from southern Oregon to western Texas. The dominant visual features are the isolated mountain ranges that rise abruptly above adjacent gentle slopes and flat-floored basins. The mountains tend to be roughly broken and steep-sided, narrow compared to their length, distinctly separate from each other, and arranged in parallel patterns.

Water features are few. Characteristically, the basins have no drainage, resulting in ephemeral lakes and alkali flats or salt pans. The canyons and gullies that drain the mountains are usually dry, their streams being intermittent or ephemeral after rains. At the mouth of these canyons and gullies, deposition of eroded materials has resulted in fan-shaped slopes that grade imperceptibly into the basin floors.

Drought-tolerant plants dominate this arid province, with sagebrush, shadescale, greaseweed, creosote bush, mesquite, and cacti being the most prevalent species (White 1979). Most of these are low growing and sparsely distributed.

The province is a sparsely settled region with few major cities. Historical movement of population has been from east to west across, rather than into, the province (White 1979). Where water is available, there are oases of ordered irrigated fields around associated settlements. Livestock grazing is practiced widely on extensive ranches. Otherwise, there are vast tracts of land with little to no evidence of cultural modifications.

5.1.13.2 Visual Character of the Site

A. Topography

The dominant visual features in or near the Arizona site are the northern and southern Maricopa Mountains. The collider ring would fully encircle the southernmost range, and cross under the northernmost. Of secondary importance are the Sand Tank Mountains along the lower arc and several isolated mountains, hills, and rises including Booth Hills flanking the east side of the campus area and Espanto Mountain bordering the northeast quadrant.

Relief in the site vicinity is substantial; elevations vary from 1,000 ft 2 mi west of the ring, to 3,270 ft at the ring's center. Within the ring, elevational differences between the heads of the alluvial slopes and the immediate mountain ridges vary from 530 to 1,120 ft.

Outlier hills rise up to 570 ft above the alluvial fans. Drainage patterns in the mountains are generally incized by 200 to 280 ft.

Although the ranges in the area are steep, they are not precipitous; there are no noticeable cliffs. Slopes are essentially similar in appearance: featureless granitic rubble, evenly grey-brown in hue, with no obvious strata or variations in outcrops that are inconspicuously incised by drainages. The principal visual feature of the ranges and isolated mountains and hills is the varied relief along the skyline afforded by their rugged crests.

Between the ranges and hills noted are basins, lands that slope imperceptibly away from the alluvial piedmont at the base of the mountains. These outlying lands appear flat, having essentially no relief, even along washes. The latter appear as narrow, sandy, path-like traces that are not visible until one is in proximate range to them. Their courses are noticeably incised only along their upper reaches where they cross the alluvial piedmont.

B. Vegetation

Vegetation within the site is desertscrub which, in foreground views, appears to be discrete, relatively sparse islands of vegetation. Most of the land encircled by the collider ring is Arizona Upland association which is found above 1,600 ft. Vegetation in the uplands is relatively diverse, including several species of trees and cacti (palo verde, mesquite, ironwood, saguaro, ocotillo). Bare, sandy soil separates individual plants; grasses or other groundcover are rare. One third of the encircled area is Lower Colorado association found in the plains below 1,600 ft. Because conditions are more arid than in the uplands, vegetation in the plains is limited in species and is even more widely spaced than in the higher lands. Creosote bush dominates the plains and bursage is found in the washes. The comparatively wide spacing of vegetation in both associations is apparent only in the immediate foreground. Within a few hundred yards or less, the shrubs and low trees appear as a soft, grey-green, solid band concealing the alluvial piedmont of the distant mountains.

Desertscrub systems are slow to recover naturally from disturbance (Section 5.1.9.1). Recovery to predisturbance levels often takes up to 100 years. Visible disturbances of vegetation are not, therefore, readily reversed under natural, unaided conditions.

C. Water Features

There are no perennial streams or lakes on or near the site. All streams are ephemeral (Section 5.1.2.1) and flow is in shallow, sandy washes. These washes are conspicuous only insofar as the vegetation in their immediate vicinity appears denser and taller than in the surrounding areas. The only other surface water features within or near the project site are numerous stock ponds and concrete-lined water catchments for wildlife (Section 5.1.2.2). These are not visible from public travel routes or use areas.

D. Cultural Modifications

The majority of land encircled by the collider ring is owned by the federal government and is administered by the BLM. This land, as well as the balance of land within the encircled areas, is undeveloped, predominantly natural appearing, and sparsely populated; e.g., three BLM wilderness study areas are within the collider ring or nearby. There have been a few cultural modifications, but these are not generally noticeable. The few jeep trails in the site vicinity are not visible unless one is using them; they occur along flat lands or within washes. The All-American Pipeline right-of-way appears similar to a dirt road and is showing signs of revegetation. Although there are mining claims within the area, there is no readily visible evidence of related activity. There are a few residences in the injector, campus, and future use areas, these being mobile homes or small houses; they are widely scattered and inconspicuous.

The one noticeable disturbance of the landscape is the hazardous waste site being constructed in the northeast quadrant north of Maricopa Road. When complete, this site will dominate some views considered sensitive (see below) and will be a substantial deviation from the natural character of the area. Also, a major powerline transmission corridor, in stages of planning, will be parallel to Maricopa Road. Such a structure is among the most prevalent and noticeable kinds of visual intrusions in desert landscapes of the western United States.

E. Viewshed Definition

The northeastern flank of the southern Maricopa Mountains broadly defines the southwestern edge of a vast viewshed. The Sierra Estrella Mountains provide its northeastern boundary about 20 mi away; only a few scattered hills lie to the east. This viewshed includes all of the campus area and most of the upper arc of the collider ring. The southern portion of the Maricopa Mountains defines two other significant viewsheds. One is roughly coincident with the southwest quadrant, the other with the southeast quadrant. A secondary viewshed occurs where the two ranges of the Maricopas overlap to enclose Maricopa Road and the Southern Pacific Railroad. Another borders the Butterfield Stage Route where it follows a pass through the northern Maricopas.

The basin lands surrounding the Maricopas and outlying hills are sufficiently flat so that views from these lands are limited by even the lowest of hills and rises, as well as by creosote bush. However, from the alluvial piedmont slopes, views out to the basin lands are generally unobstructed, extending for several miles.

5.1.13.3 Sensitivity

A. Travel Routes

The site is crossed by few travel routes. Interstate 8 (I-8) passes through the southern third of the proposed ring, the Southern Pacific has railroad tracks traversing the upper half of the ring, and Maricopa Road parallels the rail lines.

I-8 traverses the two viewsheds south of the southern Maricopa Mountains. Views to the north from this highway extend to the crests of these mountains; to the south, the viewshed is defined by the Sand Tank Mountains. The interstate passes relatively close to several facilities along the southern arc: the road is less than 1,000 ft from F4; 1 mi from E3 and F4; and less than 1-1/2 mi from F3, E4, and E5. I-8 in the site vicinity is not a designated scenic highway, nor is this stretch shown to be a scenic route on local road maps. It serves as access to no designated area of aesthetic, recreational, cultural, or scientific significance in the site vicinity. Views from this road near the site therefore would be considered low in sensitivity. However, it also is near the southern Maricopa Mountains WSAs would this area be designated as a wilderness, views from the highway would become moderately sensitive (the highway would serve secondarily as access to the wilderness).

Maricopa Road is in the viewshed enclosed by the overlap of the northern and southern Maricopas. It is now a graded, unpaved road. However, a portion is currently being paved to serve the hazardous waste site noted. The road connects Gila Bend to the west, and Mobile and Maricopa to the east, passing along the southern edge of the Butterfield Stage WSA. Experimental hall K6 is adjacent to the road; another, K5, is just over a mile to the south, and an exit/vent site, E6, is just under a mile to the north. At the K6 location, the road crosses a cut-and-cover area. Access into the WSA and to several undesignated but popular campsites is via jeep trails that are accessed by Maricopa Road. Maricopa Road does not, itself, serve as access to the WSA or the campsites; it is, therefore, considered low in sensitivity. However, should the Butterfield Stage WSA be designated as a wilderness, Maricopa Road could become moderately sensitive given its proximity to the wilderness.

The jeep trails within the affected viewsheds are the primary access to the WSAs and the undesignated campsites noted; they would therefore have the potential for high sensitivity if the WSAs become designated wildernesses. At this time, sensitivity is considered to be moderate for views from these trails, as is the case for views from the study areas. Upon designation as wilderness, the trails would be considered highly sensitive.

The Butterfield Stage Route/Mormon Battalion Trail, in the northern half of the ring, is considered highly sensitive. This route is apparently important to the public. Boy Scout troops and the Mormon Church maintain signs marking its location and the jeep trails that lead to it. One such jeep trail parallels the route for a considerable distance. The trails serve primarily as access to the historic route and would also be considered highly sensitive. The currently natural-appearing qualities of the route's context, as well as that of the jeep trails accessing the route, are assumed to be important to appreciation of the route's historic significance. The route passes within about a mile south of a service facility F6, and one of the accessing jeep trails along the far cluster would pass near the cut-and-cover area.

B. Public Use Areas

Except for several undesignated campsites, there are no public use areas in the site vicinity that would be considered sensitive. The campsites noted occur along the eastern flank of the northern Maricopas near a jeep trail leading north to the Butterfield Stage Route. There is another along the stage route near the low mountain pass. These are considered moderately sensitive. Also, there is one site along the historic route where there are modest visitor interpretive facilities maintained by the BLM in cooperation with the Boy Scouts of America. These occur at the Happy Camp cistern, about 1.5 mi west of the pass. Sensitivity here is high.

Day and overnight hikes, including hikes sponsored by outdoor interest groups, occur in the three wilderness study areas. Several organized off-road vehicle groups use the Maricopa Mountains for annual encampments and four-wheel-drive safaris. Many of the crests and upper slopes are therefore areas of occasional public use. From many such elevated positions, the near and far clusters would be visible. Sensitivity for views from these crests and slopes could be high. Particularly vulnerable would be views from the northeast slopes of the southern Maricopas.

C. Laws, Plans, Policies, and Regulations

Another indicator of sensitivity is the set of Visual Resource Management (VRM) objectives set out for BLM lands within the project area. Nearly half the area encircled by the collider ring is in VRM Class II, mostly the higher elevations of the Arizona Uplands. Class II lands are managed such that changes in the landscape caused by project activity, although visible, should not attract attention. Such an objective is moderately restrictive. Where there is the potential for inconsistency with local, state, or federal visual resource management objectives, sensitivity is considered to be high (and any substantial adverse visual impact would be significant).

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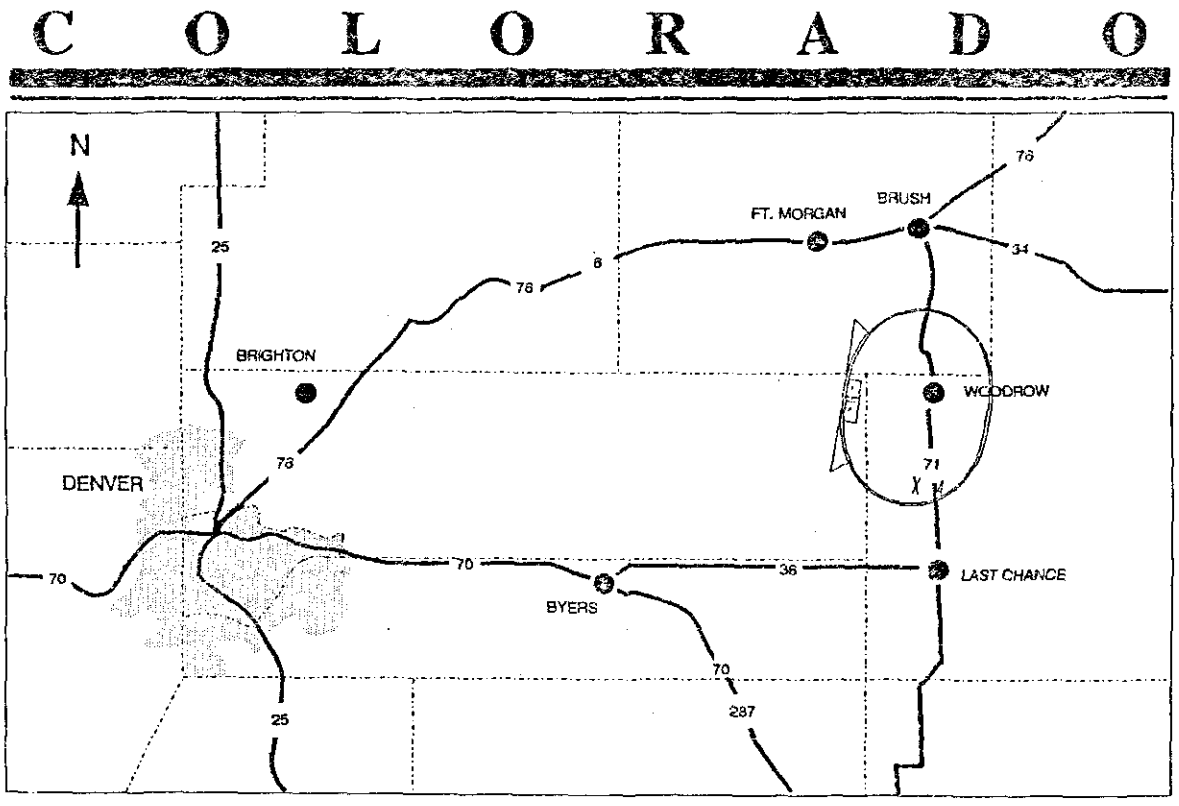

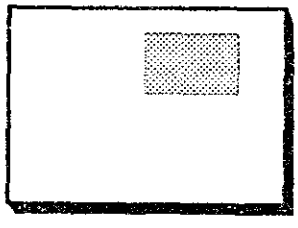

Colorado - The proposed site is located approximately 65 miles northeast of Denver and includes portions of Adams, Morgan and Washington Counties. The entire tunnel would be constructed by tunneling techniques in Pierre shale below the water table.

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5.2 COLORADO

5.2.1 Earth Resources

5.2.1.1 Physiography and Topography

The proposed Colorado SSC site lies in the Colorado Piedmont section of the Great Plains physiographic province, about 8 mi east of the High Plains section (Fenneman, 1931). It is typified by broadly rolling topography. The site is situated on the middle reaches of the Badger and Beaver creek drainages. Both creeks are intermittent tributaries to the South Platte River (Figure 5.2.1-1). Badger and Beaver creeks and several tributaries to Beaver Creek have relatively flat-bottomed valleys (alluvium-filled floodplains), which are 0.25 to 0.5 mi wide (U.S.G.S. 1973a,b,d, and e; U.S.G.S. 1984b). The northnorthwestern, northeastern, and east-southeastern portions of the site include several areas with north-northwest trending sand dunes and sand hills.

Elevations in the site area range from 4,820 ft in the southwestern buffer area and buried beam zone to about 4,320 ft where Beaver Creek exits the vicinity to the north. The majority of the site area is broad upland tracts between the drainages; upland slopes range from 25 to 75 ft/mi (U.S.G.S. 1973c,d,e,f,g,h, and i). Floodplains of Beaver and Badger creeks lie about 50 ft and 100 ft, respectively, below the adjacent uplands. Relief in the sand dune/sand hill areas is on the order of 10 to 20 ft (U.S.G.S. 1975a and b; U.S.G.S. 1984a and b).

The site topography generally mimics the relatively flat top of the underlying bedrock (Pierre Shale); throughout most of the area, this bedrock is overlain by a blanket of loess (Tweto 1979). Beneath the covering soils, the upper 5 to 35 ft of bedrock is moderately weathered. Erosion of the loess and bedrock has produced numerous dendritic tributaries to Beaver and Badger creeks. Sand, in dunes and hills, locally tops both bedrock and loess (the dunes were active in the early Holocene time, 6,000 to 8,000 years ago; Muhs 1985). Drainage in these areas is poorly integrated. The youngest landforms in the site area are modern floodplains with broadly meandering stream channels.

5.2.1.2 Stratigraphy

The general rock types within and surrounding the Colorado site are depicted by the stratigraphic column in Figure 5.2.1-2. The lithologic descriptions of the units in the column are presented in Table 5.2.1-1. Information provided in this section was obtained from geologic maps, including Sharps (1980) and Tweto (1979), and various regional and site-specific references (Rogers et al. 1985; RMAG Research Committee 1977). The time scale used to approximate the ages of the rock units is the "Decade of North American Geology 1983 Geologic Time Scale" (Palmer 1983).

Figure 5.2.1-1

TOPOGRAPHIC SETTING OF THE COLORADO SITE

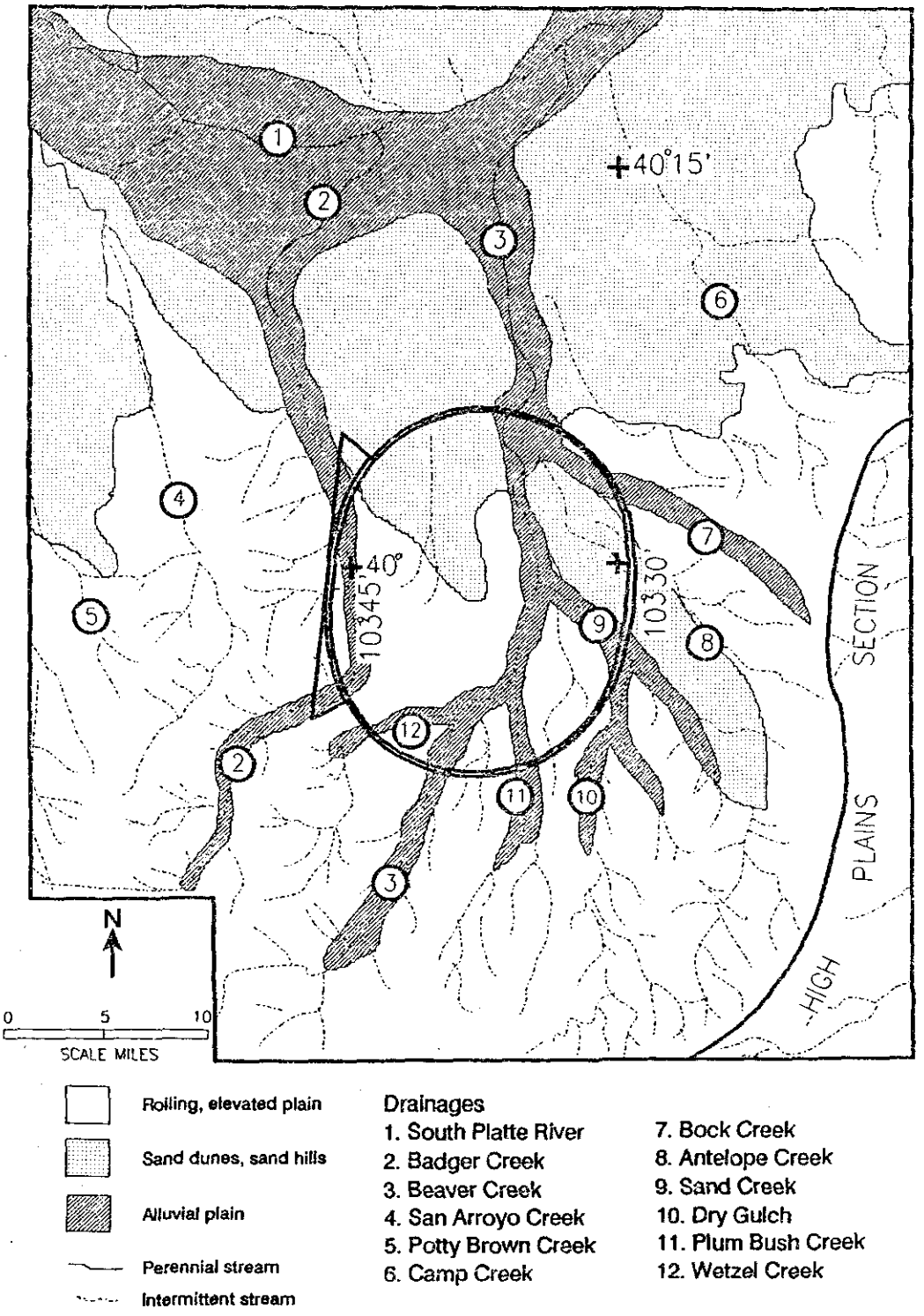
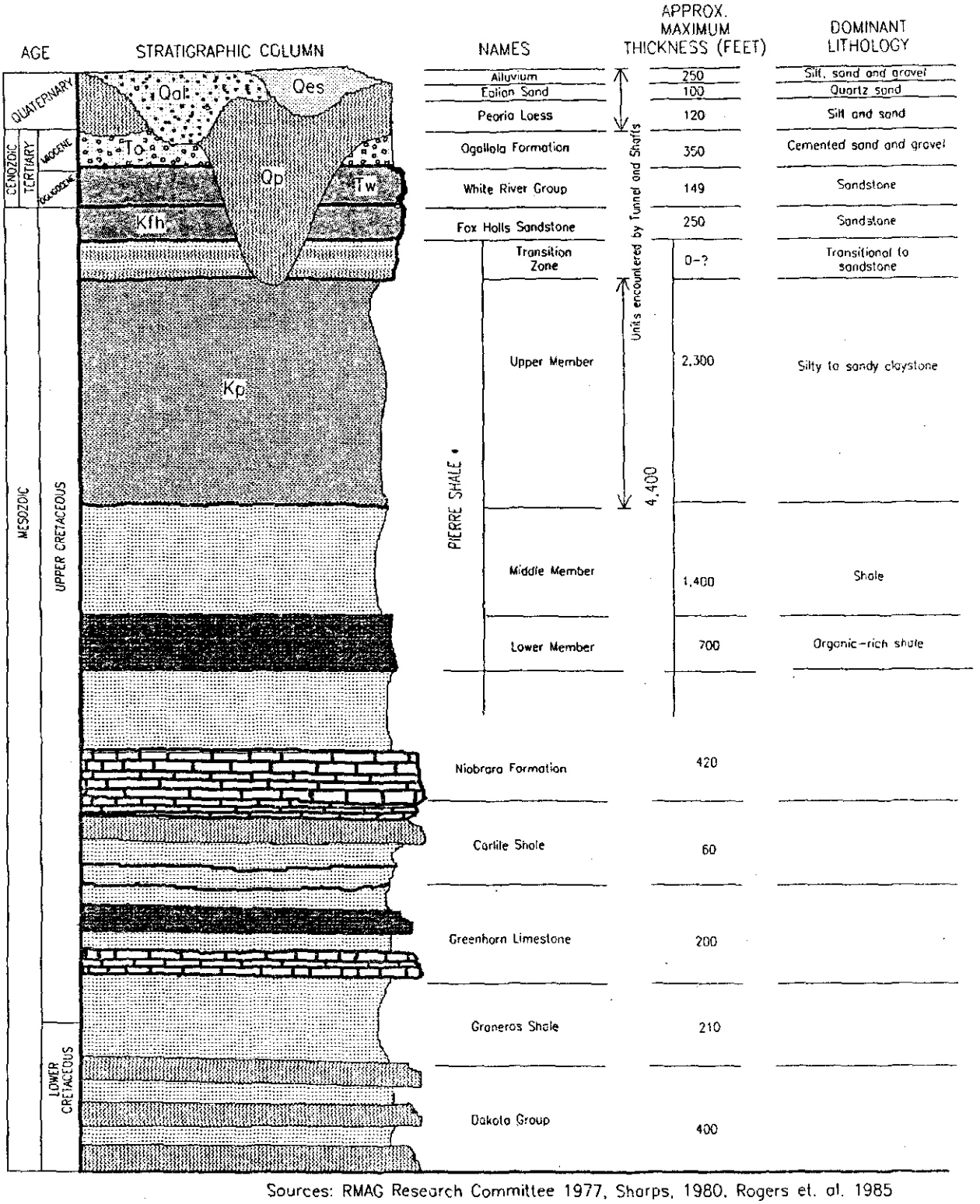


Figure 5.2.1-2

STRATIGRAPHIC COLUMN - COLORADO



Sources: RMAG Research Committee 1977, Sharps, 1980, Rogers et. al. 1985
* Unit penetrated by collider tunnel

Table 5.2.1-1

LITHOLOGIC DESCRIPTIONS

Formation	Lithology	Other Characteristics
Alluvium	Fine-grained deposits of clay in upper part generally overlie a coarser layer of clean to silty sand with fine gravel. These deposits are dark yellowish gray to yellowish tan, cross-bedded, and nonindurated.	Confined to floors of stream valleys, and occasionally beneath loess and eolian sand. Usually 20 to 85 ft thick, but 250-ft thicknesses also reported.
Eolian Sand	Yellowish brown, very fine- to medium-grained silty quartz sand. Sand contents range from 40 to 80%. Dunes are partially stabilized by vegetation.	Generally a thin blanket overlying loess and some alluvium. Five to 30 ft thick.
Peoria Loess	Brown, sandy silt with very fine sand, and about 15% particles less than 15-micron diameter. Includes several 1- to 3-ft-thick carbonate-cemented layers.	Beneath upland surfaces (sand) and overlying bedrock surfaces.
Ogallala Formation	Mostly well-cemented cobble gravel with sandy caliche. Grades east and northeastward to sand, calcareous sandstone, fine gravel, conglomerate, limestone, marl, and clay. Further northeastward marl, clay, partly calcareous fine gravel (covered with a layer of calcrete in some places) and limestone predominate.	Not present at site. Potential source of aggregate, in the region.
White River Formation	Medium to coarse-grained grayish-white to gray, cross-bedded sandstone with some fine gravel.	Not present at site but does occur in the stratigraphic sequence elsewhere in the region.

Table 5.2.1-1 (Cont)
LITHOLOGIC DESCRIPTIONS

Formation	Lithology	Other Characteristics
Fox Hills Sandstone	Fine- to medium-grained, white to yellowish, massive, friable quartz sandstone.	Not present at site. Important regional aquifer and source of uranium.
Pierre Shale Transitional Zone	Transitional to Fox Hills sandstone, completely eroded at site.	Not present at site but does occur in the stratigraphic sequence elsewhere in the region.
Pierre Shale Upper Member	Medium-gray, silty and fine, sandy claystone (45% to 60% clay-size) with thin layers of limestone, calcareous claystone, and minor sandstone beds. Contains hard, dense limestone and dolomite concretions and lenses. Upper zone (0 ft to 40 ft) is typically weathered with oxidized claystone and secondary gypsiferous fracture filling.	Limestone beds are 0.2 to 3 ft thick and are spaced about 40 ft apart. Also some 0.2 to 1-ft thick plastic claystone beds.
Pierre Shale Middle Member	Predominantly dark-gray sandy and silty shale with some soft sandstone.	Sandstone not identified at site but does occur in the stratigraphic sequence elsewhere in the region.
Pierre Shale Lower Member	Organic-rich shale with abundant bentonite beds in lower part.	
Niobrara Formation	Upper portion (Smoky Hill unit) dark gray, speckled, very limey shale. Lower portion (Fort Hays unit) is predominantly limestone.	
Carlile Shale	Shale, limestone, sandstone, and siltstone.	

Table 5.2.1-1 (Cont)
LITHOLOGIC DESCRIPTIONS

Formation	Lithology	Other Characteristics
Greenhorn Limestone	Shale and limestone.	
Graneros Shale	Shaley sandstone and limestone.	
Dakota Group	Sandstone, siltstone, and shale.	Important source of oil and gas.

Sources: Sharps 1980; Rogers et al 1985; Tweto 1979; The RMAG Research Committee 1977.

The stratigraphy at the site is dominated by the Pierre Shale at and immediately surrounding the tunnel horizon. Younger rock units have been eroded at the site but are present to the west and southwest in more central portions of the Denver Basin, where they represent a significant economic resource (see Section 5.2.1.6). Overburden is generally thin; the Ogallala formation, a regionally important aquifer and source of aggregate, is east of the site. Sediments beneath the Pierre Shale include the deep sands of the Dakota group, which contain abundant deposits of oil and gas (Section 5.2.1.6).

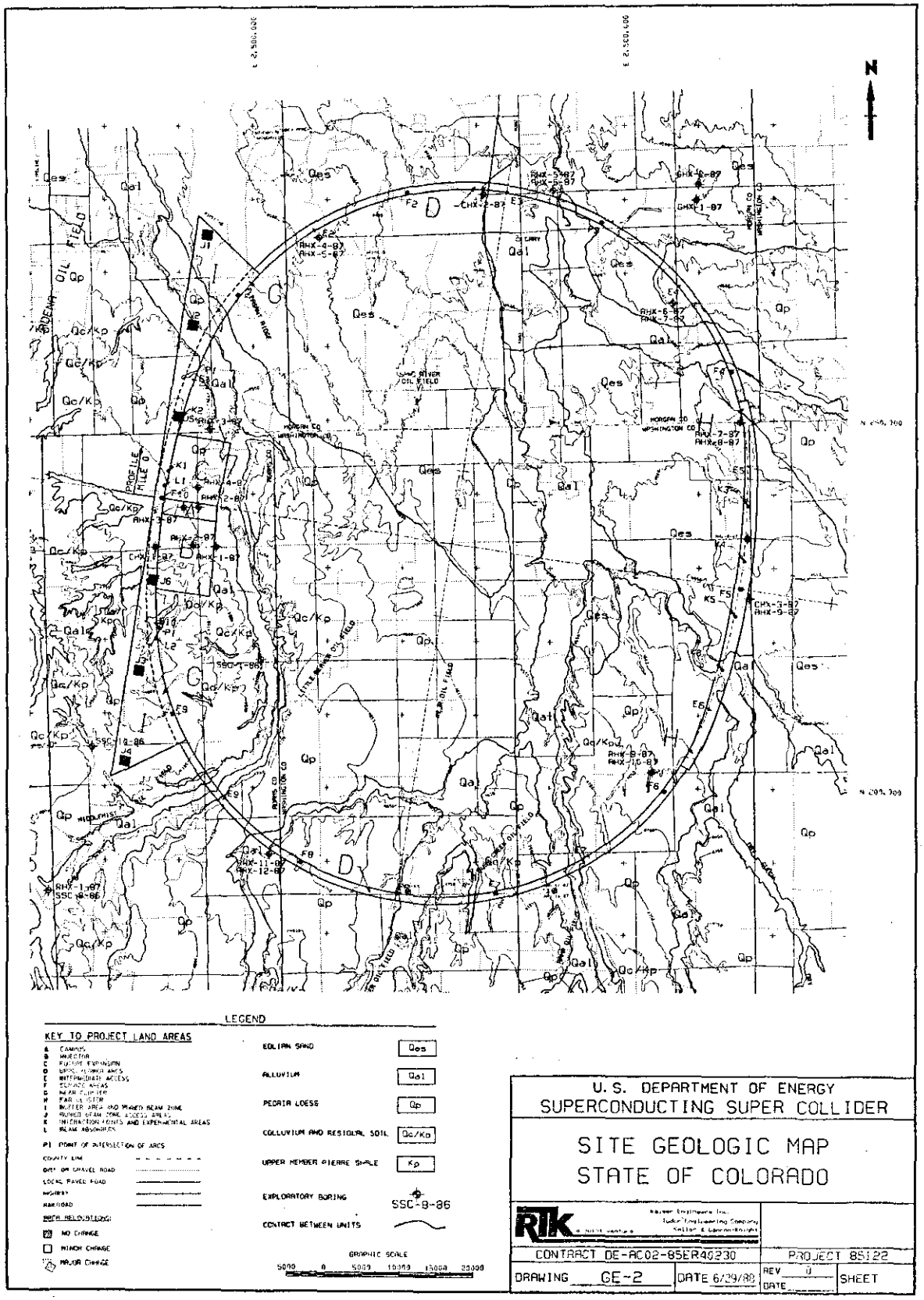
5.2.1.3 Geologic Structure

The surficial geology of the area surrounding the Colorado site is shown in Figure 5.2.1-3. A cross section along the proposed ring is presented in Figure 5.2.1-4. The site is structurally simple with no evidence of significant deformation since initial basin development in Late Cretaceous-early Tertiary time. The site lies near the western margin of the Great Plains on the eastern side of the Denver Structural Basin. The Denver basin is a broad, gentle, structural downwarp (Tweto 1979 and 1983; Kirkham and Rogers 1981). In the site area, the sedimentary units dip toward the center of the basin (northwest of the site) at about 12 ft/mi (Rogers 1988a). The closest mapped faults are at the base of the Front Range, about 90 mi away.

Joints are rare in the Pierre Shale. Very few were encountered in boreholes drilled at the site. However, based on previous experience, widely spaced, steeply dipping joints, spaced 10 ft (or more) apart are expected. Zones of soft sediment deformation may occur at depth (Rogers 1988a).

Figure 5.2.1-3

SURFICIAL GEOLOGY SURROUNDING THE
COLORADO SSC SITE



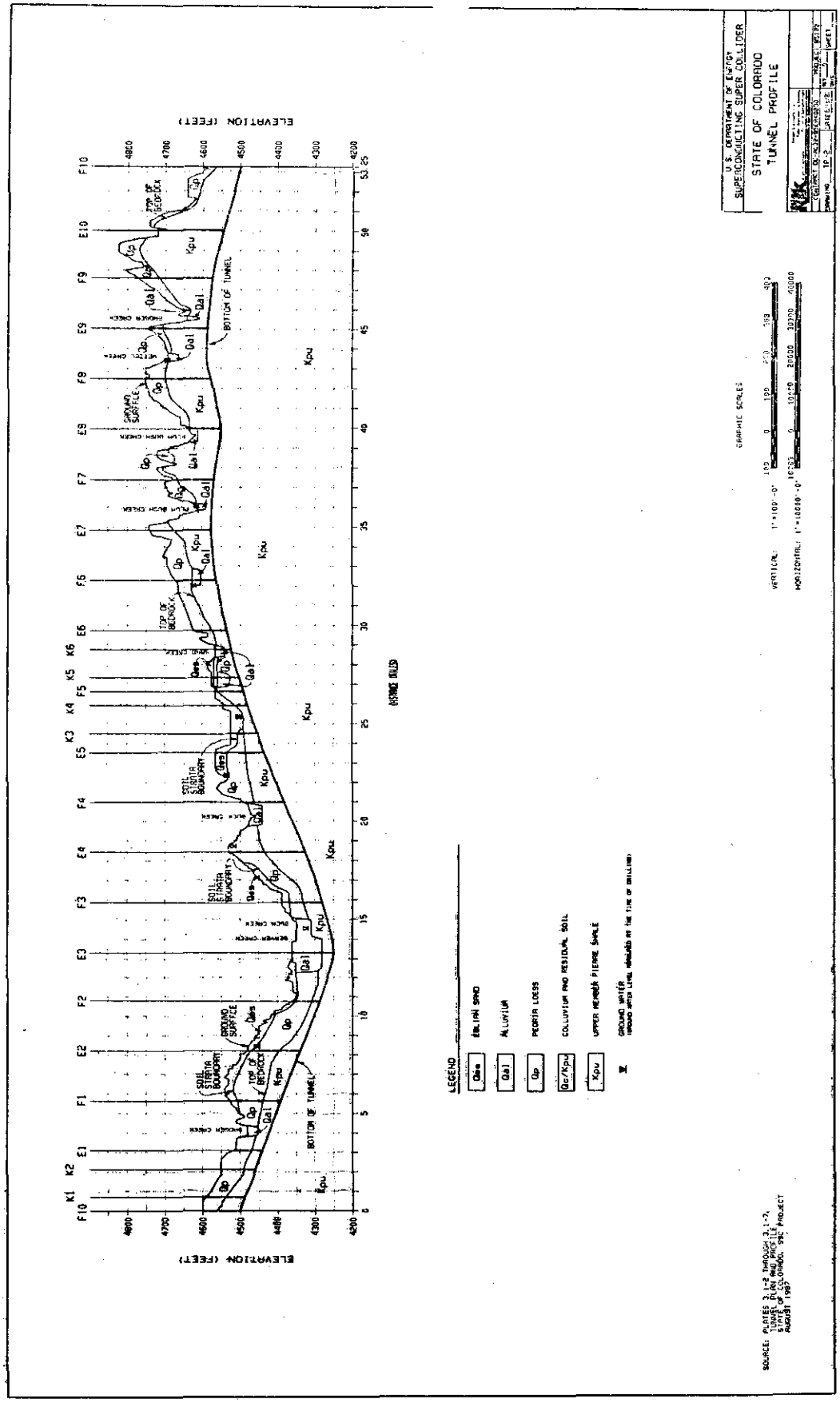


Figure 5.2.1-4

CROSS SECTION ALONG PROPOSED RING

5.2.1.4 Geoengineering Conditions

The geoengineering materials at the Colorado SSC site include:

- o Overburden soils
  - Alluvium
  - Eolian sand
  - Peoria loess
- o Pierre Shale claystone

Overburden soils cover the entire site with Peoria loess at almost all shaft and hall locations. Alluvium and/or eolian sand are present at some shafts and the halls on the eastern portion of the site. The alluvium is expected to be confined to stream channels and floodplains, and eolian sands are only a thin veneer in the northern and eastern portions of the site.

The overburden consists of a variety of soil types and characteristics. Alluvium is typically clay with low-plasticity (CL) or high-plasticity (CH); overlying sands, either poorly graded with minor fines (SP) or silty sand (SM); varying plasticity and moderate densities (Table 5.2.1-2). Some clays may have high swell potential. The eolian sand comprises silty sands of moderate density; although they are generally stabilized, disturbance by overgrazing or vehicle traffic causes high erosion potential (Tabor 1969). The loess deposits are silts and clays of low to moderate density. If they are not vegetated, they are suceptible to erosion. The low-density zones in the loess may be susceptible to collapse under loading and wetting (Tabor 1969). Geoengineering properties of the overburden soils are presented in Table 5.2.1-2.

Pierre Shale claystone is found along the entire collider ring alignment, at all shaft and experiment hall locations, and the booster facilities. The claystone shows very low strength, moderate densities and moisture content, and moderate to high slake potential; typically its mechanical properties are anisotropic. Minor limestone and calcareous claystone interbeds are found in the claystone and have higher strength and hardness than the claystone. The properties of unweathered Pierre Shale are generally comparable for stratigraphic equivalents in other western locations, suggesting very uniform characteristics (Nichols and Collins 1986). Geoengineering properties of the Pierre Shale are presented in Table 5.2.1-3.

TABLE 5.2.1-2

GEOENGINEERING CHARACTERISTICS OF THE OVERBURDEN SOIL

Unit	Soil Description USGS	Dry Density lb/ft^3	Moisture Content %	Liquid Limit/ Plasticity Index	Unconfined Compressive Strength ton/ft^2
Alluvium	SP-SM, SM	(119.4)	(3.3-10.6)	(ND)	ND
	CL, CL-ML	(93.8-102.0)	(18.6-29.3)	36/24 (24-68/6/44)	ND
Eolian Sand	SM, ML	(100.9-111.7)	(6.8-9.8)	(ND)	ND
Peoria Loess	CL, CH, ML-CL, CL-SC	102.6 (87.8-113.7)	15.0 (9.2-20.1)	(27-56/6-36)	ND

Notes: Data are represented as averages with ranges in parenthesis.

ND - No data available
SP - Sand, poorly graded, minor fines
SM - Silty Sand
SC - Clayey Sand
ML - Low-Plasticity Silt
CL - Low-Plasticity Clay
CH - High-Plasticity Clay

Sources: Van Zyl and Javed 1987; Mock 1988.

Table 5.2.1-3

GEOENGINEERING CHARACTERISTICS OF PIERRE SHALE

Unit	Seismic Velocity Ratio	Unconfined Compressive Strength lb/inch^2	Tensile Strength lb/inch^2	Young's Modulus lb/inch^2	Poisson's Ratio	Bulk Density lb/inch^2	Moisture Content %	Porosity %
Unweathered Pierre Shale Claystone	ND	640 (400-970)	(108-119)	50000 (27000-89000)	0.42 (0.21-0.71)	134.8 (122.3-139.2)	16 (14.8-17.3)	31 (30-33)
Weathered Pierre Shale Claystone	ND	ND	ND	ND	ND	129.2 (126.6-130.5)	20.3 (18.8-21.2)	ND
Limestone Interbeds	ND	(3640-11600)	ND	(680000-1740000)	(0.23-0.36)			

Notes: Data are presented as averages with ranges in parenthesis.
ND - No data available

Source: Amadei 1986; Mock 1988.

Drill hole data and cores reveal the following:

- The weathered claystone may be encountered at the depth of the collider ring under stream channels. The weathered claystone shows varying plasticity, generally high swell potential, and common occurrences of secondary gypsum.

- Joints in drill cores are tight; these joints are not expected to produce water.

- Bedding planes are not visible in fresh unweathered Pierre Shale cores; the material displays bonding across bedding. However, this bonding breaks down upon drying.

- Groundwater inflows are expected from the saturated alluvium overlying the claystone and may occur from the weathered claystone.

5.2.1.5 Geologic Hazards

The Colorado site is located in the western portion of the tectonically inactive central interior of the United States (Howard et al 1978). Seismic activity is very low, with only a few widely scattered events (Kirkham and Rogers 1981). The site area is in Zone 1 of the Uniform Building Code seismic risk map (International Conference of Building Officials 1988). Zone 1 has a potential for only minor damage from earthquakes with Modified Mercalli intensities (MMI) up to V and VI. The nearest zone of seismic activity is in the Rocky Mountains, about 60 mi to the west of the site, but even this activity is low. Earthquake intensities reported for the entire State of Colorado during the 117-year historical record have not exceeded MMI VII (Kirkham and Rogers 1981).

A swarm of small-magnitude earthquakes occurred in the Derby seismic zone about 35 mi west of the site between 1962 and 1967. These events are generally considered to have been induced by injection of fluid wastes into fractured Precambriam crystalline bedrock beneath the Rocky Mountain Arsenal (Healy et al. 1965; Hsieh and Bredehoeft 1981). The largest event in this swarm was a magnitude 5.3 (m_b), which occurred in 1967; in the SSC site area the intensity ranged from MMI II to IV.

Based on the historical seismicity record, Algermissen et al. (1982) estimated that earthquake-caused ground accelerations with a 90% probability of not being exceeded in 50 years should be less than 0.04g.

There are no potentially active faults in proximity to the SSC site (Howard et al. 1978).

Although loose, nonindurated sediments in modern stream valleys crossing the site might be susceptible to seismic liquefaction if saturated with water, the intensity of shaking from the nearest known seismic zones

will probably not be strong enough to cause liquefaction (Youd and Perkins 1978; Youd and Wieczorek 1982).

Problems of ground subsidence related to oil and gas production have not been observed in the Denver basin, although a large number of oil and gas wells have been drilled in the site area (Section 5.2.1.6). Subsidence associated with oil and gas extraction at the site should not be a potential problem. Instances of large-scale subsidence elsewhere in the world are related to large pressure declines in shallow, thick, highly compressible reservoirs. In contrast, the reservoirs beneath the Colorado site are thin (20 to 90 ft), deep (about 5,200 ft), and not highly compressible (cemented sandstone) (Figure 5.2.1-2).

The large number of hydrocarbon wells in the site area (Oil and Gas Conservation Commission 1986) indicates some potential, albeit low, of inadvertently encountering either an unrecorded well or a poorly plugged, abandoned well during tunnel excavation.

Other characteristics at the site pose little or no geologic hazard. Sand dunes appear to be stabilized by vegetation, although occasional blow-outs occur where the vegetation has been disturbed (Muhs 1985). There is no volcanic activity in the region. Topography at the site is gentle (Section 5.1.1.1) and should not give rise to landslides or rockslides. Site rocks are not subject to dissolution and are not known to contain gas.

5.2.1.6 Economic Geologic Resources

Industrial geologic resources, particularly those required for construction of SSC facilities, are available from a number of sources. The principal natural resources in the vicinity of the proposed site are oil and gas that have been the focus of intense exploration and production for over 30 years. Uranium and coal, the only other significant resources of the region, appear confined to portions of the Denver basin west of the site location.

A. Earthen Construction Materials

The availability of cement and aggregate in the Denver area has been the subject of several studies, the most recent of which was the Strategic Resource Assessment Study (SRAS) in 1987. The SRAS was initiated to assess the availability of construction resources for six major projects proposed for the Denver area in the next decade. These projects include a new airport, a beltway around Denver, cleanup of the Rocky Mountain Arsenal, rapid transit lines, a dam, and the SSC. The SRAS evaluated the strain these projects would add to the existing (baseline) demand in the Denver area. Projected demand will deplete the remaining permitted aggregate reserves by the year 2001 (SRAS 1987).

The local availability and production capacity of cement is expected to be adequate (SRAS 1987) to meet local baseline construction needs and other major proposed projects. Three cement plants in the region are capable of producing from 1,775,000 ton/yr (Schwochow 1981) to as much as 3,115,000 ton/yr (SRAS 1987). Projected needs for all proposed major projects (other than baseline needs) is 257,000 ton/yr; total needs with current Denver baseline consumption added is 1,200,000 ton/yr.

A large portion of the alluvial gravel reserves in the Denver area have become inaccessible as a result of urbanization. The only significant remaining reserves of high-quality alluvial gravel occur in a few areas along the South Platte River and Clear Creek north of Denver (Schwochow 1980). Alluvium in the South Platte River in the site vicinity consists mostly of sand. Sand and gravel in the Ogallala formation east of the site has been exploited for use in the eastern plains (Schwochow 1980) and may provide an alternate source.

Baseline demand for aggregate has ranged from 11 to 17 million ton/yr over the past 10 years (SRAS 1987). The combined requirements for the proposed major projects are 13.2 million tons, causing projected total demand to peak at 21 to 26 million ton/yr in 1992 if all projects proceed on schedule. The permitted aggregate reserves for the Denver area total 315 million tons, including sand, gravel, and crushed stone. Hence, projections indicate that all permitted aggregate will be consumed by the year 2001 (SRAS 1987). Abundant rock is available in the front ranges near Denver to produce crushed stone, but permitting of new quarries has been difficult because of environmental concerns (Schwochow 1980).

B. Energy Resources

Exploration for oil and gas in eastern Colorado began in the 1920s and 1930s after over 60 years of activity in western Colorado. Initial discoveries in western Colorado were the result of wildcatting in areas of surface seepage; the first fields produced oil from fractures in the Pierre Shale (Brainard and Van Tuyl 1954; Hinson 1954). Exploration in eastern Colorado was prompted by discoveries in the Lakota and Dakota groups in Wyoming, northwestern Colorado, and on the western rim of the Denver basin in the early 1920s. Advances in geophysical exploration techniques led to initial drilling in Morgan County in the late 1920s and early 1930s. Drilling was intensified in the site vicinity in the 1950s with production from the Dakota D and J sands (Brainard and Van Tuyl 1954). Production from these principally stratigraphic traps has continued at a significant level since that time (Scanlon 1982; Oil and Gas Conservation Commission 1986).

The known producing horizons near the site are confined to Cretaceous sandstones over 5,000 ft below the surface. Production from fractured zones within the Pierre Shale has been proven economical only in structurally deformed areas west of the site (Hinson 1954; Scanlon 1982). No economic accumulations of oil or gas have been identified within the Pierre Shale in the vicinity of the site.

Abandoned and producing oil and gas wells in the vicinity of the ring are abundant (Figure 5.2.1-5). Because permitting of wells has been required only since the early 1950s, it is possible that older abandoned wells may exist; the presence and location of these wells can only be determined by examining additional records such as local newspapers from the 1930s and 1940s. A preliminary review of published information contains no reference to such wells (Rogers 1988a).

Oil and gas production in the site area appear to have decreased in the 1960s through the 1980s. This is evident from the number of new fields discovered per decade:

Decade	Fields Discovered	Fields Abandoned
1950s	41	1
1960s	17	11
1970s	8	6
1980s	5	4

The high density of existing low production and abandoned wells suggests that the likelihood of discovering new fields in the future is declining. Many of the older wells are producing through the use of enhanced recovery techniques. Only one of the fields discovered in this decade intersects the footprint of the SSC facilities (Scanlon 1982; Oil and Gas Conservation Commission 1986; Rogers 1988b).

The coal beds of the Laramie and Denver formations, the uranium of the Fox Hills sandstone, the Laramie formation, the Arapahoe formation, and Dawson Arkose are confined to the western portions of the Denver basin. These beds stratigraphically overlie the Pierre Shale in deeper portions of the basin (Kirkham and Ladwig 1979 and 1980; U.S.G.S. and Colorado Geological Survey 1977). No potential for geothermal resources has been identified in the area (U.S.G.S. 1978).

C. Metallic Resources

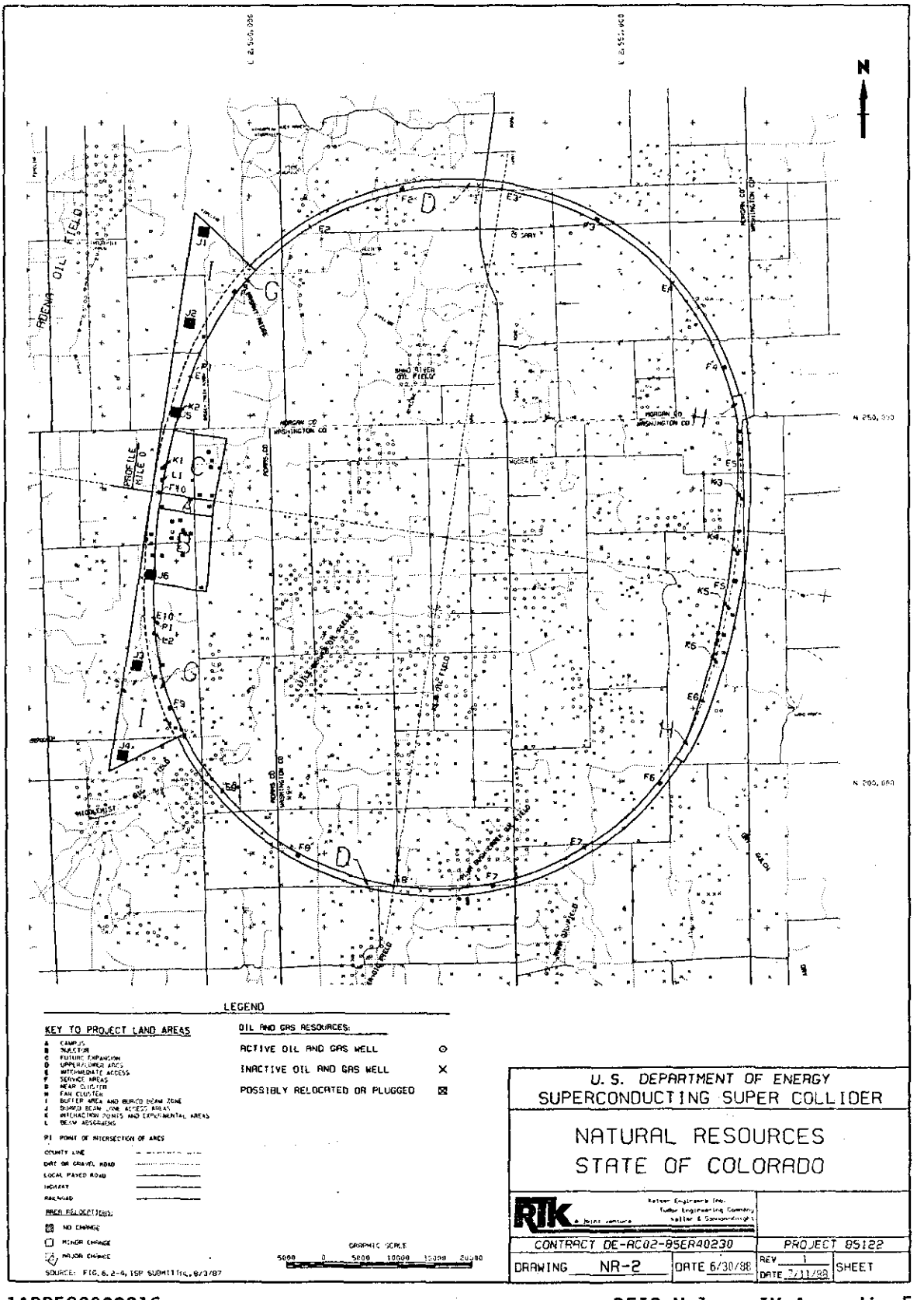
No evidence of metallic resources has been identified in the vicinity of the site.

D. Other Resources

The Bureau of Mines' Minerals Industry Location System (MILS) database contains no reference to mines or prospects in the vicinity of the proposed site. In addition, none of the known characteristics of the geologic setting suggest a high potential for resources other than oil, gas, and minor aggregate at the surface.

Figure 5.2.1-5

OIL AND GAS WELLS IN VICINITY



5.2.2 Water Resources

5.2.2.1 Surface Water Hydrology, Quality, and Use

A. Surface Runoff and Flooding

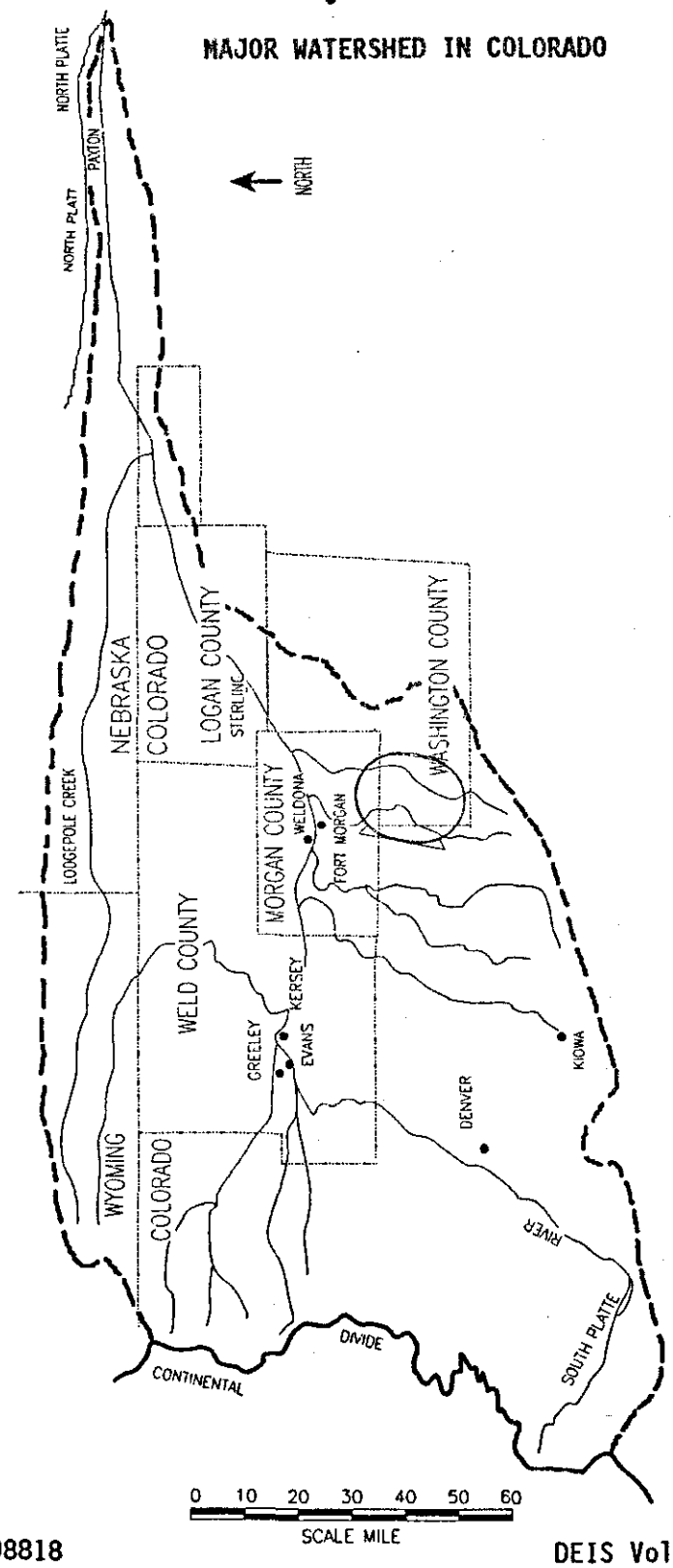
The project site is situated in the South Platte River Drainage Basin. The South Platte originates along the eastern slope of the Continental Divide in the Rocky Mountain Range of north-central Colorado (Figure 5.2.2-1). It passes approximately 15 mi north of the project site (Figure 5.2.2-2). From the project site, it flows generally northeast and east across the Colorado-Nebraska state line to its confluence with the North Platte River in southeastern Nebraska. Elevations in the basin range from about 14,200 ft above mean sea level along the Continental Divide (Corps of Engineers 1977a) to 3,400 ft above mean sea level at the Colorado-Nebraska state line. The drainage area of the basin at the state line is about 23,000 mi^2 (Corps of Engineers 1977b); the drainage area at Fort Morgan is about 14,810 mi^2 (Corps of Engineers 1977a).

The project site is located in the lower reaches of two right-bank tributaries to the South Platte River: Beaver and Badger creeks. Beaver Creek is the largest of the two drainage basins. It originates in the High Plains Region south of the project site near Limon, flows north and approximately bisects the site from south to north, and joins the South Platte River northeast of Brush. Elevations range from 5,890 ft above mean sea level near Limon to about 4,350 ft above mean sea level where it crosses the north collider ring. The drainage area at the south ring crossing is 313 mi^2; at the north ring crossing, the drainage area is 814 mi^2 (URS Corporation 1988). Channel and floodplain dimensions for Beaver Creek near the collider ring are given in Table 5.2.2.1.

Badger Creek is the other major drainage basin tributary to the South Platte that flows through the project site. It originates in the high plains southwest from the site, flows generally parallel to Beaver Creek along its westerly side, and joins the South Platte between Fort Morgan and Brush. It enters the project site just south of the injector complex near intermediate access E9, flows along the eastern edge of the injector/campus/future expansion areas, and crosses the collider ring north of the future expansion area adjacent to abort/external beam access J2. Elevations in Badger Creek range from 5,270 ft above mean sea level in its headwaters to about 4,480 ft above mean sea level where it crosses the collider ring near J2. The drainage area of Badger Creek at the campus is 114 mi^2 (URS Corporation 1988). Its channel and floodplain dimensions at the campus area are given in Table 5.2.2-1. The channels are shown on Figure 5.2.2-2.

Figure 5.2.2-1

MAJOR WATERSHED IN COLORADO



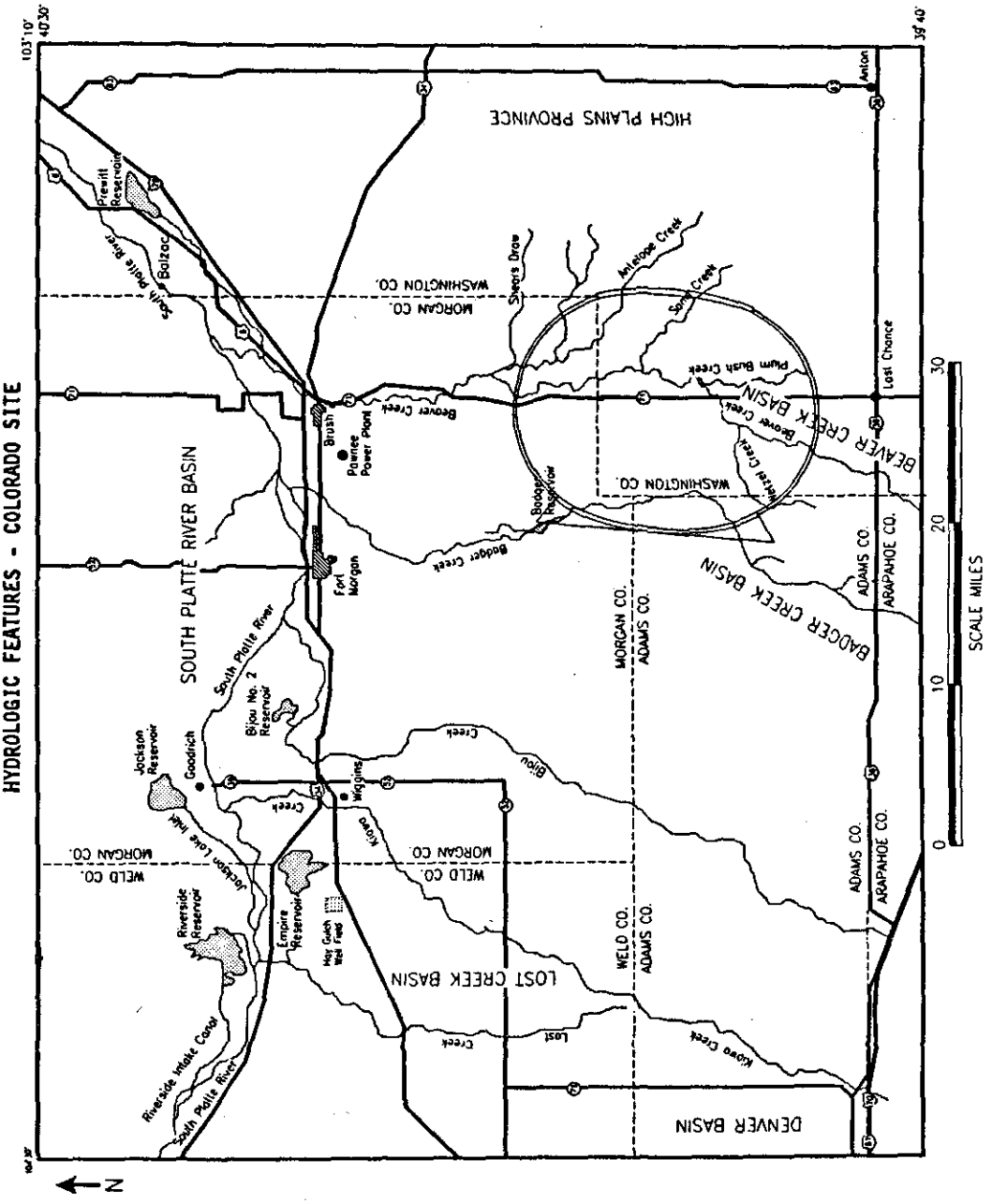


Figure 5.2.2-2
HYDROLOGIC FEATURES - COLORADO SITE

TABLE 5.2.2-1

CHANNEL AND FLOODPLAIN CHARACTERISTICS AT THE COLORADO COLLIDER RING

Drainage Channel	Drainage Area mi^2	Bankfull Channel Width ft	Bankfull Channel Depth ft	Floodplain Width ft
Beaver Creek near E3	814	60	8	10,000
Shears Draw near F3	32	50	4	3,000
Antelope Creek near K3	24	50	5	4,000
Sand Creek near K6	229	60	8	5,000
Plum Bush Creek between E7 & F7	68	30	8	3,000
Wetzel Creek between F8 & E9	42	50	5	1,500
Beaver Creek near E8	313	60	8	3,500
Badger Creek near J2	114	60	8	3,000

Source: URS Corporation, 1988

Beaver and Badger creeks and their tributaries are intermittent streams that generally flow only during precipitation and snowmelt events. In general, their stream channels are stable and well vegetated and characterized by frequent meanders and oxbows. Except during major flood events, their streamflow seldom reaches the South Platte River.

Flooding along the South Platte River and its major tributaries in Morgan and Washington counties normally occurs from May through September with the most frequent flooding occurring during June. However, maximum discharges for the year have been recorded from February through October (Corps of Engineers 1977a). Flooding can result from intense, localized rainfall or general rains, either of which may be augmented by snowmelt. Most of the disastrous flood experience in the project vicinity has been caused by intense convective thunderstorm rainfall in tributaries, producing high peak discharges that rapidly attenuate in the lower reaches of the tributary floodplains or in the South Platte River channel. Snowmelt augmented by general spring rains can also produce severe flooding from the high volume of runoff.

Runoff records are not available for Beaver and Badger creeks. However, streamflow were recorded for Kiowa Creek, located west from the project

site, from 1956 to 1965, in the South Platte River both upstream and downstream from its confluence with Beaver Creek and for Bijou Creek. Mean annual discharge in Kiowa Creek, for its period of record was 3.8 ft^3/s. Historic instantaneous maximum flow rates for these stations, are shown in Table 5.2.2-2, along with flow-duration data for the South Platte River at Kersey and Balzac (McDanold 1988).

Historic records indicate that major floods occurred in Beaver Creek and adjacent watersheds to the west (Badger, Kiowa, and Bijou creeks) in 1935, 1955, and 1965. The 1935 flood in Kiowa and Beaver creeks caused the second largest flood ever recorded in the South Platte River. The flood washed out many bridges and railroad crossings and flow from Beaver Creek flooded the community of Brush with depths up to 4 ft (Gingery Associates 1976). Peak flow estimates were not available for Beaver Creek; however, in Bijou Creek, the flood crest at Fort Morgan was estimated to be 10 ft above flood stage, with a discharge of 84,300 ft^3/s (Corps of Engineers 1977a). The maximum in Bijou Creek was reported near Wiggins with a peak flow rate of 282,900 ft^3/s; in Kiowa Creek, maximum discharge was 110,000 ft^3/s north of Kiowa (Matthai 1969).

The flood of June, 1965, produced the highest known discharge in Bijou Creek and major flood stages in other nearby drainage systems. Peak flood stages occurred following four consecutive days with one or more intense storms. On the final day, the average depth of six-hour rainfall over a 1,000-mi^2 area was 7.8 inches (Corps of Engineers 1977b). Peak flow rates as high as 466,000 ft^3/s were recorded in Bijou Creek near Wiggins (Matthai 1969). This discharge was the largest recorded peak flow in Colorado.

By 1965, the city of Brush had constructed a 5-ft-high dike around the southeast side of the city. This dike held during the flood of June 1965 that washed out numerous bridges and highways in Beaver Creek and the vicinity. The U.S.G.S. estimated the peak discharge at the State Highway 71 crossing south of Brush to be 24,300 ft^3/s. The flood was considered comparable to a 25-year event (Gingery Associates 1976).

Flood flows for the 100-year recurrence interval storm event were computed for Beaver and Badger creeks and their major tributaries at the project site,using the Corps of Engineers HEC 1 flood hydrograph computer model. Runoff hydrographs at major stream channel confluences were combined and routed downstream (URS Corporation 1988). Normal depths were computed for appropriate channel reaches, superimposed on topographic maps, and the extent of flooding near project facilities was estimated. These maps were then field checked by representatives of the Colorado Water Conservation Board and verified during the site visit. Flooding widths are tabulated in Table 5.2.2-1.

Table 5.2.2-2

GAUGE DATA IN PROJECT VICINITY

U.S.G.S. Gauge	Drainage Area mi^2	Instantaneous Maximum Flow*	Date	Minimum Flow*	Average Flow*	Flow Duration* Q5%	Q20%	Q50%	Q80%	Q95%
South Platte River near Kersey (No. 06754000)	9,598	31,500	1973	28	777	3,000	1,000	800	400	150
South Platte River near Weldona (No. 06758500)	13,245	26,800	1973	39	572	---	---	---	---	---
South Platte River at Balzac (No. 06760000)	16,852	123,000	1965	1.3	426	1,000	400	95	50	15
Bijou Creek near Wiggins (No. 7590)	1,314	466,000	1965	0	9.2	---	---	---	---	---
Kiowa Creek at Kiowa (No. 6-7582)	111	19,700	1965	0	3.8	---	---	---	---	---

* All flow values in cubic feet per second (ft^3/s)
Sources: McDanold 1988; Matthai 1969.

B. Surface Water Quality

The Colorado Water Quality Control Commission has the responsibility for classifying the waters of the state. Waters of the South Platte River and its tributaries have been classified to protect secondary body contact for boating, warm water fisheries, and agricultural water supply. For Jackson, Prewitt, and Riverside reservoirs adjacent to the South Platte River, the classification includes body contact recreation, warm water fisheries, and agricultural water supply (Colorado Department of Health 1987). Standards have been adapted for these sources and they are shown on Table 5.2.2-3 for selected parameters.

Table 5.2.2-3

SURFACE WATER QUALITY DATA IN PROJECT VICINITY

Parameter	Units	Standard	Maximum*	Minimum*	Average
Stream: South Platte River near Kersey, 1968 to 1988					
Flow	cfs				
Fecal Coliform	#/100ml				
pH					
Temperature	°C				
Dissolved oxygen	mg/l	5.0	11.00	0.05	9.14
Dissolved solids	mg/l		1,105	652	983
Turbidity	FTU				
Chloride	mg/l				
Sulfate	mg/l		965	276	496
Nitrate (N)	mg/l	0.1	5.94	1.84	4.36
Lead	µg/l	0.05	20.88	6.42	12.24
Mercury	mg/l				

* Mean monthly concentrations

Source: McDamold 1988.

Beaver and Badger creeks have no water quality monitoring records. The South Platte River is monitored at various locations in the vicinity of Beaver and Badger creeks. A summary of the data from the South Platte River near Kersey for selected parameters during the period from 1968 to 1988 is shown in Table 5.2.2-3 (McDanold 1988).

Much of the area adjacent to the lower South Platte is devoted to irrigated agriculture. Some areas of the plains not reached by irrigation are dry farmed and other areas are devoted to grazing. Industrial activities in the area that impact water quality are sugar beet processing, feed lots, power generation, food processing, meat packaging, and oil drilling. Major domestic wastewater facilities that discharge to the South Platte are at Fort Morgan and Brush (Colorado Department of Health 1987). These activities and effluent discharges combine to produce elevated levels of dissolved solids, hardness, suspended sediments, and sulfates in the South Platte.

The most significant water quality concern in the area is the elevated concentrations of total dissolved solids (TDS). Irrigated crops have differing tolerances for salinity; however, when tolerance levels are approached, yield reductions can be expected. At present, the tolerance levels for crops such as beans, onions, and lettuce are exceeded.

Currently, during certain periods of the year, the sulfate concentrations exceed the recommended limit of 250 mg/l for drinking water by two times. In addition, the nitrate levels are the highest of any stream in Colorado; however, they do not exceed the drinking water standards (Colorado Department of Health 1987).

In general, the concentrations of total dissolved solids tend to increase during the low-flow period of the year when irrigation return flows, municipal wastewater discharges, and groundwater inflows compose most of the stream discharge. During the primary storm season, surface runoff predominates. The concentration of TDS becomes diluted by the relatively clean storm runoff, and the concentrations decline.

There are 14 NPDES permits issued by the Colorado Department of Health for surface discharges to waters in the project vicinity. Of the 14 permits, 5 regulate discharges directly to the South Platte River; the remaining permits regulate discharges to tributaries of the South Platte. In the immediate project vicinity, a construction dewatering permit regulates discharge to an unnamed tributary to Beaver Creek and an unnamed tributary to Wetzel Creek. An agricultural permit regulates discharge to Beaver Creek from a feedlot operation (Colorado Department of Health 1987).

C. Surface Water Use

The only surface waters within and immediately adjacent to the project site are occasional and short-term storm and snowmelt flows in the drainage channels, and various natural and constructed ponds and

reservoirs. The natural ponds are located in surface depressions, and they usually dry up each year. Constructed reservoirs are located in stream channels and most may store water throughout the year. These reservoirs are used for stock watering and recreational purposes, but they do not constitute an important water supply source for the area.

The South Platte River supplies water for irrigation, municipal, industrial, and recreational purposes, and for replacement or augmentation of water extracted from groundwater basins in regulated areas. Its waters have been allocated through a series of court decrees.

Numerous off-channel reservoirs have been constructed adjacent to the South Platte River. They are used principally for irrigation and groundwater basin augmentation. They receive their water from a relatively small tributary drainage basin, from diversions from the South Platte River, and by transbasin diversion from the western slopes of the Rockies in the Colorado Big Thompson project. The major reservoirs in the project area are Riverside, Jackson, Empire, Bijou and Prewitt. They have a combined storage capacity of 172,850 acre-ft (Corps of Engineers 1977b). Waters in these reservoirs have also been allocated by court decree. The reservoirs are shown in Figure 5.2.2-2.

5.2.2.2 Groundwater Hydrology, Quality, and Use

A. Groundwater Hydrology

The SSC site in Colorado is located in the South Platte River basin between the Denver Basin and the High Plains Province (Figure 5.2.2-2). The major aquifers of the Denver Basin (Laramie-Fox Hills aquifer) and the High Plain Province (Ogallala aquifer) have been completely eroded from the project area, leaving the relatively impermeable Pierre Shale as the predominant geologic unit. The principal water-bearing sediments in the SSC project area are the alluvial deposits found along and adjacent to major streams in the area and the alluvial terrace deposits bordering, at a slight elevation above, the South Platte River. The alluvial aquifers are restricted to the stream valleys with some upland buried channel aquifers. The Pierre Shale that underlies the surficial deposits is approximately 4,300 ft thick and is generally not a water-bearing unit except in weathered zones. Table 5.2.2-4 provides a summary description of the hydrogeologic units in the vicinity of the SSC site.

The surficial units that overlay the Pierre Shale consist of dune sands, loess, and alluvial deposits. The dune sand deposits predominantly consist of very fine to medium sand up to 60 ft thick and occur in the northeast portion of the project area. The areas of dune sand deposits are good infiltration areas for recharge to the underlying alluvial material. In areas where a small saturated thickness of sand is underlain by impermeable material, small reservoirs of accumulated water yield water to wells. Hydraulic conductivity is reported to range from 10^{-3} to 10^{-4} cm/s (Colorado Geological Survey 1988). The loess deposits are

Table 5.2.2-4

SUMMARY DESCRIPTION OF HYDROGEOLOGIC UNITS IN VICINITY OF SSC SITE, COLORADO

Hydrogeologic Unit	Approximate Thickness ft	Physical Description	Hydraulic Properties	Water-Bearing Characteristics
Dune sand	60	Very fine to medium sand with some coarse sand with silt and clay	$K=10^{-3}$ to 10^{-4} cm/s	Not known to yield water to wells. Serves as an infiltration area for recharge.
Loess deposits	<1-120	Massive, well-sorted silt	$K=10^{-5}$ to 10^{-6} cm/s	Generally lies above water table and not a source of water.
Alluvial deposits	1-85	Uncemented, interbedded gravels, sands, silts, and clays	T = 6,000 to 45,000 ft^2/d $K = 2.3x10^{-2}$ to $1.5x10^{-1}$cm/s S = 0.2 to 0.0001	Most important aquifers in the area. Used extensively for water supplies near major streams and along creeks. Well yields 40 to 1,300 gal/min.
Pierre Shale	4,300	Marine shale and silt interbedded with sand and sandy shale in upper zone; predominantly claystone in project area	$K = 10^{-4}$ to 10^{-10} cm/s	Few wells are completed in Pierre Shale. Not normally used as supply source except to northeast of project where a few 500-foot deep wells are completed in weathered zone.

Notes: T = Transmissivity
K = Hydraulic Conductivity
S = Storativity

Sources: Bjorklund and Brown 1957; Colorado GeoLogic, Inc. 1986; Colorado Geological Survey 1988; McGovern 1964.

composed of up to 120 ft of massive, well-sorted silt that is highly uniform in grain size. The loess generally lies above the water table in most places but in some areas the lower part of the loess deposits may be water saturated (McGovern 1964). Hydraulic conductivity of the loess deposits is estimated to be 10^{-5} to 10^{-6} cm/s (Colorado GeoLogic, Inc. 1986).

The most important aquifers in the South Platte River basin are the alluvial deposits found along and immediately adjacent to the major streams and the alluvial terrace deposits bordering at a slight elevation above the major streams in the area (Pearl 1980). The deposits range in thickness from less than 1 ft up to 85 ft along Beaver and Badger creeks Figure 5.2.2-2). The proposed potable water supply source for the SSC project is groundwater from the Hay Gulch aquifer located in the Lost Creek basin. Alluvial deposits in this area are up to 70 ft thick (Nelson, Haley, Patterson & Quirk, Inc. 1967).

The hydraulic properties of the alluvial deposits vary widely because of the lateral and vertical gradation of the alluvial material from area to area. Well yields are reported to range from 40 to 1,300 gal/min (McGovern 1964). Estimated transmissivity of the alluvial deposits ranges from about 6,000 to 45,000 ft^2/d based on results of pumping tests. Hydraulic conductivity ranges from 10^{-1} to 10^{-2} cm/s. Estimates of storage coefficient ranged from 0.2 to 0.0001, indicating both water table and confined conditions (Bjorklund and Brown 1957). Saturated thickness of the alluvial sediments in the Hay Gulch well field area, approximately 35 mi northeast of the site is, about 70 ft. The annual recharge to the Hay Gulch aquifer is estimated to be 7,000 acre-ft (Norton, Underwood and Lamb, Inc. 1988).

The Pierre Shale underlies the surficial deposits in the area and consists of up to 4,300 ft of relatively impermeable marine shale and silt. A weathered zone up to 70 ft thick at the top of the Pierre Shale is typically fractured and contains water where it is below the water table. Few wells are completed in the Pierre Shale in the project area. Hydraulic conductivity of the Pierre Shale is reported to range from 10^{-4} to 10^{-9} cm/s in the weathered zone to 10^{-7} to 10^{-10} cm/s in the unweathered zone (Colorado GeoLogic, Inc. 1986).

B. Groundwater Quality

Groundwater quality in the project area varies considerably from source to source. Table 5.2.2-5 is a summary of the available groundwater quality data in the site vicinity. Alluvial deposits yield hard water of moderate to high concentrations of dissolved solids, much of which is calcium sulfate. Average concentrations of dissolved solids for the alluvial deposits is about 1,100 mg/l. Groundwater from the alluvial deposits overlain by dune sands is generally softer and contains less dissolved solids. Groundwater from this source is of calcium bicarbonate type and contains moderate concentrations of dissolved solids.

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Table 5.2.2-5

RANGE OF GROUNDWATER QUALITY IN COLORADO SITE VICINITY

	Range of Chemical Constituents (mg/l)				
Source	Total Dissolved Solids	Chloride	Sulfate	Nitrate NO_3	Hardness $CaCO_3$
National drinking water standards	500	250	250	45	None
Alluvium/Dune sand	122-3,730	<1-66	<4-2,480	3-64	44-1,870
Pierre Shale	708-1,740	60-658	6-256	----	10-128

Sources: Bjorklund and Brown 1957; McGovern 1964; Morgan County Quality Water District 1987; Wm. Curtis Wells and Co. 1978; Repplier et al. 1981; U.S. Environmental Protection Agency, 1977.

Water quality of the alluvial wells in the Hay Gulch well field is excellent with total dissolved solids reported to be less than 250 mg/l. The water is of the calcium-sodium bicarbonate type and is soft to moderately hard. One of the proposed industrial supply wells for SSC in Goodrich has poorer water quality with a reported total dissolved solids of 1,820 mg/l. Groundwater from this well is very hard. The second well located east of Wiggins has a reported total dissolved solids of 495 mg/l and the water is also hard (Morgan County Quality Water District 1987).

Groundwater from wells tapping the Pierre Shale is generally soft and of the sodium bicarbonate type with chloride also present in appreciable concentrations. Reported total dissolved solids ranges from 708 to 1,740 mg/l from wells that are 220 to 650 ft in depth (Bjorklund and Brown 1957; Repplier et al. 1981).

C. Groundwater Use

Table 5.2.2-6 summarizes the present grounwater use in the SSC site vicinity in Colorado. Nearly all of the groundwater use in the area occurs along the South Platte River and its major tributaries such as Beaver Creek. Within the immediate project area, the predominant groundwater use from the alluvial sediments along Beaver Creek is for irrigation and domestic/stock watering purposes. A small amount of domestic/stock watering use also occurs along Badger Creek in the western portion of the proposed site. To the northeast of the site a few wells provide irrigation and domestic water from the upper weathered zone of the Pierre Shale.

The estimated irrigated land within the Beaver Creek Basin in 1985 was approximately 16,300 acres, nearly all located at the downstream end of Beaver Creek. The amount of groundwater used for irrigation within Beaver Creek basin in 1986 is estimated to be 16,300 acre-ft. Municipal use in the basin by the city of Brush from 6 wells 4 mi south of the city was approximately 1,230 acre-ft in 1987 (McClary 1988). Domestic and stock wells in the basin use approximately 520 acre-ft/yr and an additional 130 acre-ft/yr is used for commercial purposes. Based on these estimates, total water use within the Beaver Creek Basin is approximately 18,180 acre-ft/yr (HRS Water Consultants, Inc. 1986).

Other water use within the project area occurs along Badger Creek in the west. No estimates are available for the amount of water used; however, only small capacity domestic and stock wells are in the Badger Creek area. Groundwater use from these wells would be expected to be minor.

Two other significant water users in the immediate vicinity of the project are Fort Morgan and the Public Service Company's Pawnee Power Plant. Fort Morgan has 14 wells constructed in the South Platte River alluvium within the city limits just south of the river. Present water use is

Table 5.2.2-6

RECENT GROUNDWATER USE IN VICINITY OF SSC SITE - COLORADO

Source	Recent Water Use acre-ft/yr
Irrigation wells	16,300
Municipal (Brush and Fort Morgan)	4,630
Domestic and stock wells	520
Commercial/Industrial	6,130

Sources: Engineering Professionals, Inc. 1987; HRS Water Consultants, Inc. 1986; McClary 1988; Norton, Underwood and Lamb, Inc. 1988; Halffield 1988; Simpson 1988.

3,400 acre-ft (Simpson 1988). Public Service Company presently has several large-capacity wells located on the banks of the South Platte River about 5 mi north of the Pawnee Power Plant. They presently use approximately 6,000 acre-ft/yr of treated water for cooling at the facility (Halffield 1988).

Morgan County Quality Water District (MCQWD) provides about 800 acre-ft/yr of potable water from its five alluvial wells in the Hay Gulch well field. The District presently has an appropriation granted by the state to 2,130 acre-ft/yr of groundwater from the Hay Gulch aquifer.

Groundwater use in the area is expected to increase through the 1990s. Projected water use in Brush has been estimated at 1,620 acre-ft/yr by the year 2000, based on a conservative 2% population growth rate (Engineering Professionals, Inc. 1987). It is projected that Fort Morgan will use about 3,800 acre-ft/yr by the year 2000 (Simpson 1988). MCQWD has projected that by the year 1993, water use within their district will increase by 100 acre-ft/yr to of 900 acre-ft/yr (Norton, Underwood and Lamb, Inc. 1988).

5.2.3 Climate and Meteorology

5.2.3.1 General Description

The climate at the Colorado SSC site is best characterized as continental highland, with abundant sunshine, wide daily ranges in temperature, light rainfall, and moderate to high wind movement. Winters tend to be cold, with typical daily lows reaching 0°F to -15°F. Summers are hot, with daily highs exceeding 95°F (National Oceanic and Atmospheric Administration 1974).

5.2.3.2 Temperature

Temperatures in the region vary from an average low of 10°F in January to an average high of 90°F in July. The extreme high temperature recorded was 105°F, which was in August; the extreme low temperature recorded was -30°F, which was in February. The temperature drops below freezing, on the average, 139 days per year. Frost penetration reaches an average of 25 inches and an extreme of 42 inches in depth (U.S. Weather Bureau 1941). Normal and extreme temperature and heating degree-day data are shown in Table 5.2.3-1.

5.2.3.3 Precipitation

The precipitation pattern at the Colorado site is unimodal, with 70 to 80% of rainfall occurring between April and December. Storms moving from the north predominate in fall and winter, and carry little moisture. Warm, moist air from the south moves into Colorado during the spring and summer. Summer precipitation is largely in the form of thunderstorms, which are sometimes extremely heavy (National Oceanic and Atmospheric Administration 1974).

The Colorado Platte drainage climatic region receives a mean of 15.62 inches of precipitation per year. The peak month for precipitation is May, with a mean of 2.39 inches. The month with the least precipitation is December, with a mean of 0.53 inches. The region receives a mean of 36 inches of snowfall per year. Mean precipitation and snowfall data are shown in Table 5.2.3-2. Also, 1-, 2-, 5-, 10-, 25-, 50-, and 100-year return period extreme rainfall data are shown in Table 5.2.3-3.

Table 5.2.3-1

NORMAL AND EXTREME TEMPERATURE DATA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average maximum temperature, °F	40	43	52	62	72	82	90	87	78	65	52	43
Average minimum temperature, °F	10	15	22	32	43	53	60	55	48	35	22	15
Highest	76	77	82	86	96	104	104	105	97	90	79	79
Lowest	-29	-30	-11	4	19	30	42	40	31	-2	-18	-25
Heating degree-days	1130	940	890	560	290	70	10	10	120	430	820	1040

Source: U.S. Environmental Science Services Administration 1968.

Table 5.2.3-2

**MEAN PRECIPITATION AND SNOWFALL DATA
FOR THE COLORADO PLATTE DRAINAGE CLIMATIC REGION**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly precipitation, inches	0.60	0.55	1.36	2.00	2.39	1.86	1.81	1.69	1.20	1.00	0.74	0.53
Mean monthly snowfall, inches	8.5	7.0	12.5	10.5	1.5	0.0	0.0	0.0	1.5	2.8	8.0	5.5

Source: U.S. Environmental Science Services Administration 1968.

Table 5.2.3-3

MAXIMUM 1-HOUR AND 6-HOUR RAINFALL BY RETURN PERIOD

Return Period Years	Rainfall (inches) 1-Hour	6-Hour
1	0.8	1.2
2	0.9	1.6
5	1.6	2.1
10	1.9	2.5
25	2.2	3.0
50	2.6	3.2
100	3.0	3.9

Source: U.S. Weather Bureau 1961.

5.2.3.4 Wind

The prevailing wind direction at the Colorado site is toward the southwest at an annual average speed of 11 mi/h. The wind direction varies by month and is toward the north during the months of June through October. The average wind speed varies from 10 mi/h to 14 mi/h. The highest recorded wind speed was 65 mi/h, which occurred in May. Average wind speed and direction data are shown, by month, in Table 5.2.3-4.

Strong winds occur frequently during winter and spring. During periods of drought, these winds give rise to duststorms. Occasionally, when the area is covered by a cold, shallow layer of air, strong westerly winds aloft work their way to the surface and cause rapid warming. This phenomenon, known also as the Chinook, is more common in areas closer to the Rocky Mountains (National Oceanic and Atmospheric Administration 1974).

5.2.3.5 Humidity

The mean relative humidity in the region of the Colorado SSC site is 60% and is relatively constant through the course of a year. Mean and maximum dewpoint and mean relative humidity data are shown in Table 5.2.3-5.

Table 5.2.3-4

MONTHLY AVERAGE WIND SPEED AND DIRECTION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average wind speed, mi/hr	10	12	12	14	13	11	10	11	11	11	10	11
Wind blowing toward	SW	SE	SW	SSE	NNW	N	N	N	N	N	SW	E

Source: U.S. Environmental Science Services Administration 1968.

Table 5.2.3-5

DEWPOINT AND RELATIVE HUMIDITY DATA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean dewpoint temperature, °F	11	17	19	27	40	45	50	50	40	30	21	16
Maximum 12-hour 1000 mbar dewpoint, °F	53	55	57	65	69	74	76	74	73	67	59	54
Mean relative humidity, %	60	60	60	60	60	60	50	60	50	60	60	60

Source: U.S. Environmental Science Services Administration 1968.

5.2.3.6 Severe Weather

Severe weather in the Colorado SSC region can be best characterized as tornadoes, extreme winds, thunderstorms, hail, and blizzards.

Tornadoes are relatively rare. Fatality rates and property loss rates are much less in Colorado than in states farther east (National Oceanic and Atmospheric Administration 1974). The yearly probability of a point being struck by a tornado is 1.04×10^{-3}, which corresponds to a return period of 960 years (Thom 1963). For the period of record 1950-1986, 241 tornadoes were observed within a 50-nautical mile radius of Denver. These events caused no deaths and 10 injuries (National Severe Storms Forecast Center 1988).

Extreme expected winds in the region are shown in Table 5.2.3-6 by maximum wind speed and return period.

Table 5.2.3-6

EXTREME WIND SPEED AND RETURN PERIOD DATA

Return Period Years	Wind Speed* mi/h
10	69
25	77
50	80
100	89

* Maximum wind speed.

Source: Thom 1968.

Thunderstorms are prevalent and occur in the region on an average of 50/yr, with peak activity in May, June, July, and August (National Climatic Center, 1981). Hail greater than .75 inches in diameter is observed on the average 2.4 times per year (U.S. Weather Bureau 1969).

Blizzards are also less frequent in Colorado than in other great plains states and also tend to be less severe (National Oceanic and Atmospheric Administration 1988).

5.2.4 Air Quality

5.2.4.1 Conditions Affecting Air Quality

A. Topographical

Although Colorado is generally considered a mountainous state, the specific location chosen for the SSC is more than 60 mi from the closest mountains (the Front Range of the Rocky Mountains). Denver's air quality is strongly influenced by the Front Range, resulting in frequent stagnation periods with poor visibility and a condition called a "brown cloud." This condition, results from stagnation on the lee side of the Rocky Mountains. This influence is, however, attenuated significantly at the SSC site by its distance from the range and the site topography, which is extremely flat and treeless for great distances in all directions, resulting in good conditions for pollutant dispersion.

B. Meteorological

The ability of the atmosphere to disperse a pollutant is categorized by stability classification. The site's relative frequency of occurrence of the six stability classes is shown in Table 5.2.4-1. The lower number classes have the highest degree of dispersion, as noted in Appendix 5, Section 5.1.4. The surface meteorological data in this format is only reported at Denver's Stapleton International Airport. This is definitely within the area of the meteorological influences on the "brown cloud." Although the meteorological influences at the site are more favorable than those at Stapleton Airport, using this meteorological data will result in conservative estimates of air pollutant dispersion activity. G. C. Holzworth's estimate of the number of "forecast days" of high meteorological potential for air pollution over a 5-year period was between zero and ten (Holzworth 1972).

Table 5.2.4-1

FREQUENCY OF OCCURRENCE OF ATMOSPHERIC STABILITY CLASSES

Class	Definition	% Occurrence
A	Extremely unstable	2
B	Unstable	9
C	Slightly unstable	14
D	Neutral	37
E	Slightly stable	16
F	Stable and extremely stable	22

Source: National Climatic Data Center, 1988

The influence of winds on dispersion conditions on an annual basis is shown in Table 5.2.4-2. The table is an annual summary of the frequency of wind speed and direction for the Denver first-order National Weather Service Station (National Climatic Data Center (NCDC) 1988).

5.2.4.2 Air Quality

A. Applicable Standards

The National Ambient Air Quality Standards (NAAQS) (40 CFR 50) function as the applicable regulatory levels in the State of Colorado. The primary standards are shown in Table 5.2.4-3.

B. Background Concentrations

A portfolio of values was assembled to quantify ambient air pollutant concentrations in the region of the SSC site. For air pollutants with averaging times of less than 1 year, the highest representative regional value is shown. These values are delineated, along with the applicable standard for each pollutant, in Table 5.2.4-3. The Pawnee ambient air quality monitoring station is plotted on Figure 5.2.4-1.

C. Compliance Status

The noncompliance or nonattainment status of air pollutants for the counties in the region of influence of the Colorado SSC site is as follows (EPA 1985). Parts of Adams, Arapahoe, Boulder, and Jefferson counties and all of Denver County are nonattainment for ozone (O_3). Parts of Adams, Arapahoe, Boulder, Jefferson, and Weld counties, and all of Denver County, are nonattainment for carbon monoxide (CO). Parts of Adams, Arapahoe, and Jefferson counties, and all of Denver County, are nonattainment for total suspended particulate (TSP). In addition, parts of Boulder and Weld counties are in violation of the secondary TSP Standard. None of these nonattainment areas cover the footprint of the Colorado SSC site.

D. Proximity to Sensitive Areas

The Colorado SSC site is proposed for a PSD Class II area that allows for moderate growth in air pollutant emissions. The closest PSD Class I area that permits minimal air quality deterioration is Rocky Mountains National Park, located 125 mi northwest of the site.

Table 5.2.4-2

ANNUAL FREQUENCY OF WIND SPEED AND DIRECTION

COLORADO SSC SITE

	Speed-Knots						
DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	.012429	.033132	.033772	.019158	.003631	.001667	.103789
NNE	.004704	.011029	.014020	.005937	.001096	.000274	.037060
NE	.004889	.013107	.014180	.005480	.000502	.000069	.038227
ENE	.005310	.014454	.013609	.004681	.000548	.000023	.038625
E	.009074	.024707	.023200	.005891	.000297	.000046	.063214
ESE	.011417	.030529	.021989	.005161	.000365	.000023	.069485
SE	.013039	.031534	.017126	.005115	.000365	.000069	.067248
SSE	.014266	.034000	.016463	.007056	.001324	.000206	.073315
S	.030175	.083573	.056860	.015071	.001644	.000183	.187525
SSW	.017285	.046376	.030689	.005960	.000731	.000023	.101064
SW	.008983	.020300	.009111	.002352	.000982	.000206	.041932
WSW	.004772	.007581	.005161	.002466	.000411	.000160	.020550
W	.005039	.009134	.008220	.008723	.002831	.001256	.035203
WNW	.004886	.010093	.008243	.007809	.003562	.002032	.036626
NW	.005777	.012947	.011212	.008471	.002283	.000617	.041307
NNW	.005556	.014911	.014888	.007558	.001347	.000571	.044830
TOTAL	.157601	.397406	.298762	.116888	.021921	.007421	

Sources: National Climatic Data Center, Weather Station No. 23062, Denver, Colorado, Period of Record 1/82-12/86

Table 5.2.4-3

AMBIENT AIR POLLUTANT ALLOWABLE CONCENTRATIONS AND BACKGROUND LEVELS

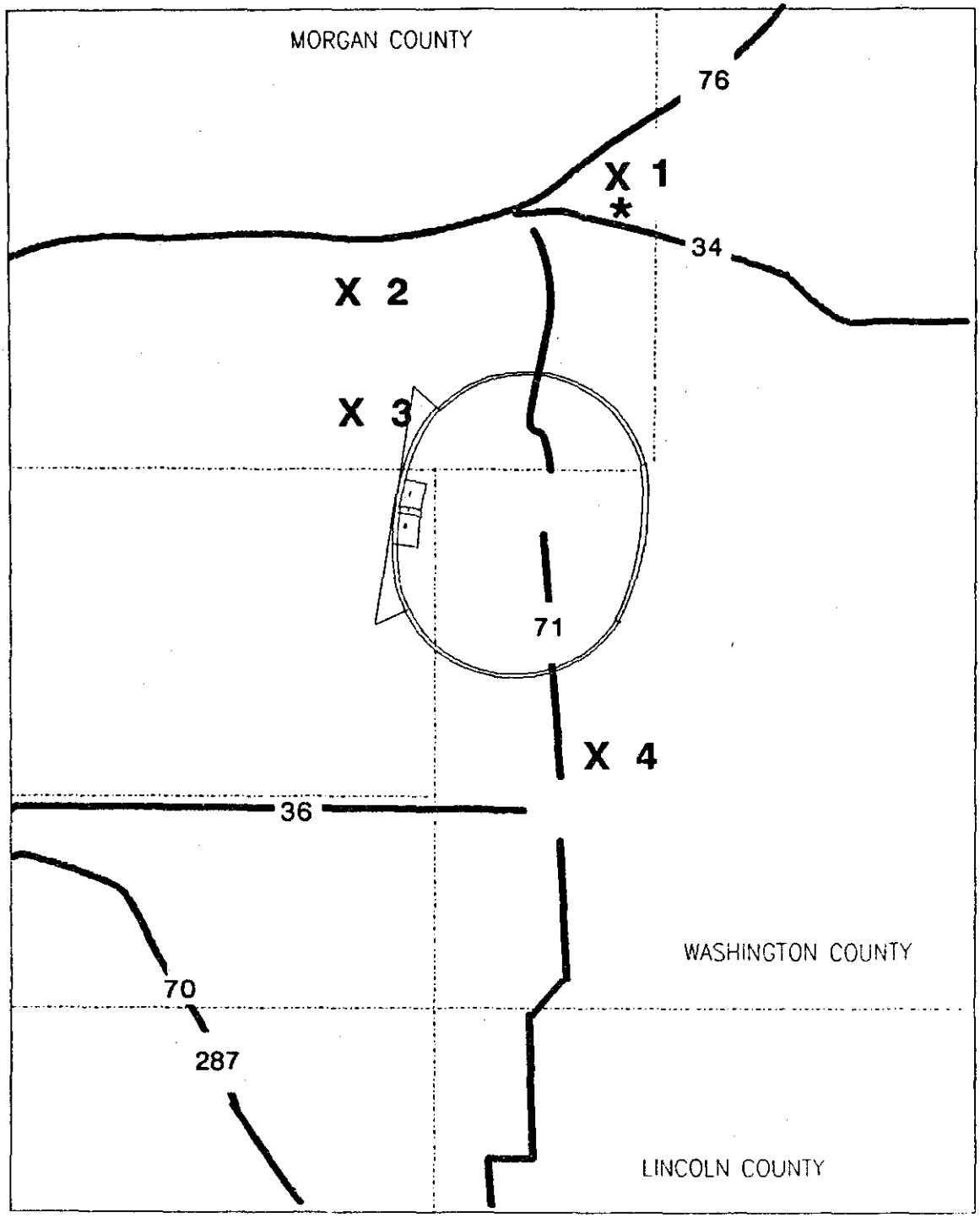
Pollutant Averaging Time	NAAQS Standard $\mu g/m^3$	Background Concentration $\mu g/m^3$	Point Measured at
TSP-24-h	260	160*	Pawnee Generating Station, 1985
TSP-annual geo. mean	75	58	Pawnee Generating Station, 1985
SO_2-3-h	1,300	115*	Pawnee Generating Station, 1985
SO_2-24-h	365	21*	Pawnee Generating Station, 1985
SO_2-annual	80	3	Pawnee Generating Station, 1985
NO_2-annual	100	4	Pawnee Generating Station, 1985
CO-1-h	40,000	2,292*	Pawnee Generating Station, 1985
CO-8-h	10,000	1,146*	Pawnee Generating Station, 1985
O_3-1-h	235	183*	Pawnee Generating Station, 1985
Pb-calendar quarter	1.5	0.35*	Denver, CAMP, 1986

*The highest representative regional value is shown.

Source: Colorado Air Quality Data Report 1986, Colorado Department of Health and Environment, Air Pollution Control Division, 1987.

Figure 5.2.4-1

AMBIENT AIR QUALITY MONITORING STATIONS AND REGIONAL AIR POLLUTANT SOURCES COLORADO SSC SITE



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X = Air Pollutant Source

* = Ambient Air Quality Monitoring Station

5.2.4.3 Regional Air Pollution Sources

Major sources of air pollutant emissions in the project locale include a coal-fired power plant, a sugar beet refinery, and a proposed hazardous waste treatment and disposal facility and are plotted on Figure 5.2.4-1. The permitted or actual emissions for these sources are shown in Table 5.2.4-4. Other sources of air pollutants include fugitive dust generated by vehicles and agricultural activities.

Table 5.2.4-4

REGIONAL AIR POLLUTION SOURCES
COLORADO SSC SITE

Source Name	Location	Permitted or Actual Emissions (ton/yr)				
		SO_2	TSP	NO_2	CO	VOC
1. Pawnee generating station	Brush	14,892	304	23,572	674	79
2. Western sugar company	Fort Morgan	350.7	95.7	369.8	128.1	2.1
3. Colorado interstate gas company	Fort Morgan	0	0	130	17	3
4. Hazardous waste* t/s/d facility	Last Chance	TBD	TBD	TBD	TBD	TBD

Note: Expected air pollutant emissions not available.
* Permit is in review.

Source: Colorado Department of Health, Air Pollution Control Division, 1988

5.2.5 Noise and Vibration

This section describes background noise and vibration conditions in the region of the Colorado SSC site.

5.2.5.1 Ambient Noise Levels

A. Applicable Standards

Applicable noise abatement criteria in the region of the Colorado SSC site have been promulgated by the State of Colorado, the Federal Highway Administration (FHWA), and the Department of Housing and Urban Development (HUD). FHWA and HUD noise abatement criteria are discussed in Section 5.1.5.1. The State of Colorado considers an L_{eq} of 70 dBA acceptable for light industrial uses between the hours of 7:00 a.m. and 7:00 p.m. and 65 dBA as the acceptable level for the remainder of the 24-hour period. Maximum permissible noise levels for all four zones delineated are shown in Table 5.2.5-1.

B. Background Levels

Existing noise levels in the vicinity of the site are typical of areas under agricultural use, and day-night average sound levels (L_{dn}) are expected to range from 35 to 45 dBA, whith a mean of 40 dBA. (EPA 1982).

Table 5.2.5-1

STATE OF COLORADO MAXIMUM PERMISSIBLE NOISE LEVELS

Zone	7:00 a.m. to next 7:00 p.m. dBA	7:00 p.m. to next 7:00 a.m. dBA
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

Source: Colorado State Code, Article 12.

C. Proximity to Sensitive Areas

The primary source of sensitive noise receptors in the region is residences. Approximately 50 residences are located within 1 mi of the collider ring. Three of these are located within 1/2 mi of a service area, two within 1/2 mi of intermediate access area E, and one within 1/2 mi of a buried beam zone access area. Sensitive receptors in the project vicinity are shown in Figure 5.2.5-1.

5.2.5.2 Other Noise Sources

Primary sources of noise in the region include farm equipment, crop-dusting airplanes, oil well pumps, and road traffic. State Highway 71, which crosses the site in the north to south direction, is the most constant noise source. Its noise level has been estimated at 67 dBA (L_{eq}) (Howard, Tammen, Needles, and Bergendoff 1982). The motors that operate oil well pumps produce an estimated sound level ranging from 93 to 120 dBA. (Maione 1987)

5.2.5.3 Ambient Vibration Levels

Ambient vibration levels in the project vicinity are highly dependent on proximity to human activity. Naturally occurring vibrations, which result from weather phenomena, can travel long distances in the earth and are low frequency (1 Hz or less). Vibrations from large, distant earthquakes will also produce vibrations at the site.

5.2.5.4 Other Vibration Sources

Vibration sources in the region include railroads, roads, oil production, oil exploration, and explosive metal bonding. These sources are shown in Figure 5.2.5-2. The Burlington Northern Railroad is located 10 mi from the collider ring and 14 mi from the nearest interaction point (K3). State Highway 71 crosses the ring at two points. The collider tunnel is 100 ft below the road at these crossings. The road passes within 27,000 ft of K6. Vibrations produced by Interstate 36, which is similar to State Highway 71 in traffic load, are shown in Table 5.2.5-2 (Butler 1986).

Oil well drilling and production activities are another source of vibration. The closest wells are within several hundred feet of the collider tunnel but greater than 2,000 ft from any interaction points. Vibrations produced by oil well pumping and drilling operations are also shown in Table 5.2.5-2 (Butler 1986; Butler 1987).

Explosive Fabricators, Inc., bonds metal sheets by the use of explosives. The facility is located 19 mi from the collider ring and 28 mi from the nearest interaction point K6. Vibrations produced by this facility are also shown in Table 5.2.5-2 (Butler 1986).

Figure 5.2.5-1

SENSITIVE NOISE RECEPTORS
COLORADO SSC SITE

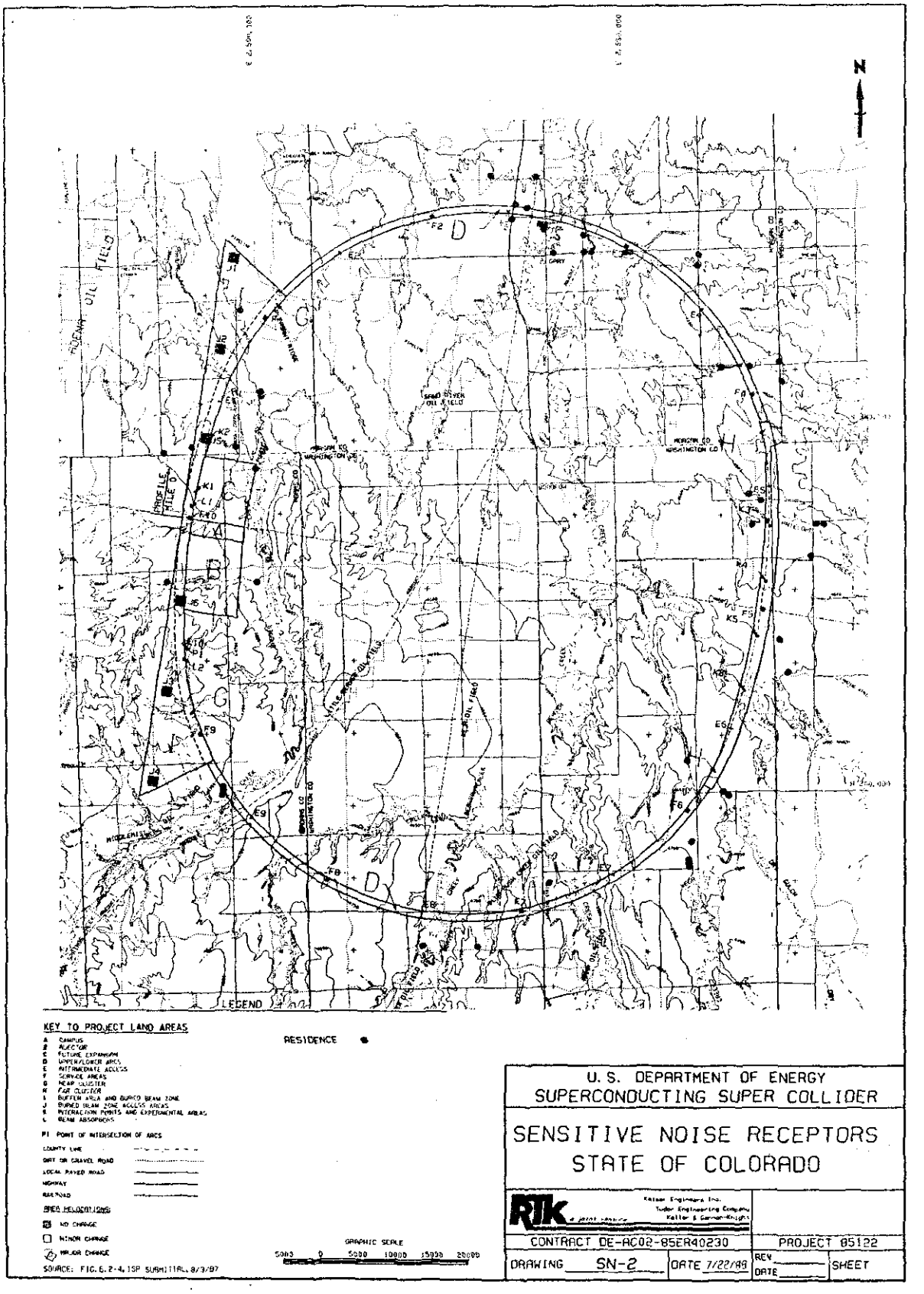


Figure 5.2.5-2

REGIONAL VIBRATION SOURCES
COLORADO SSC SITE

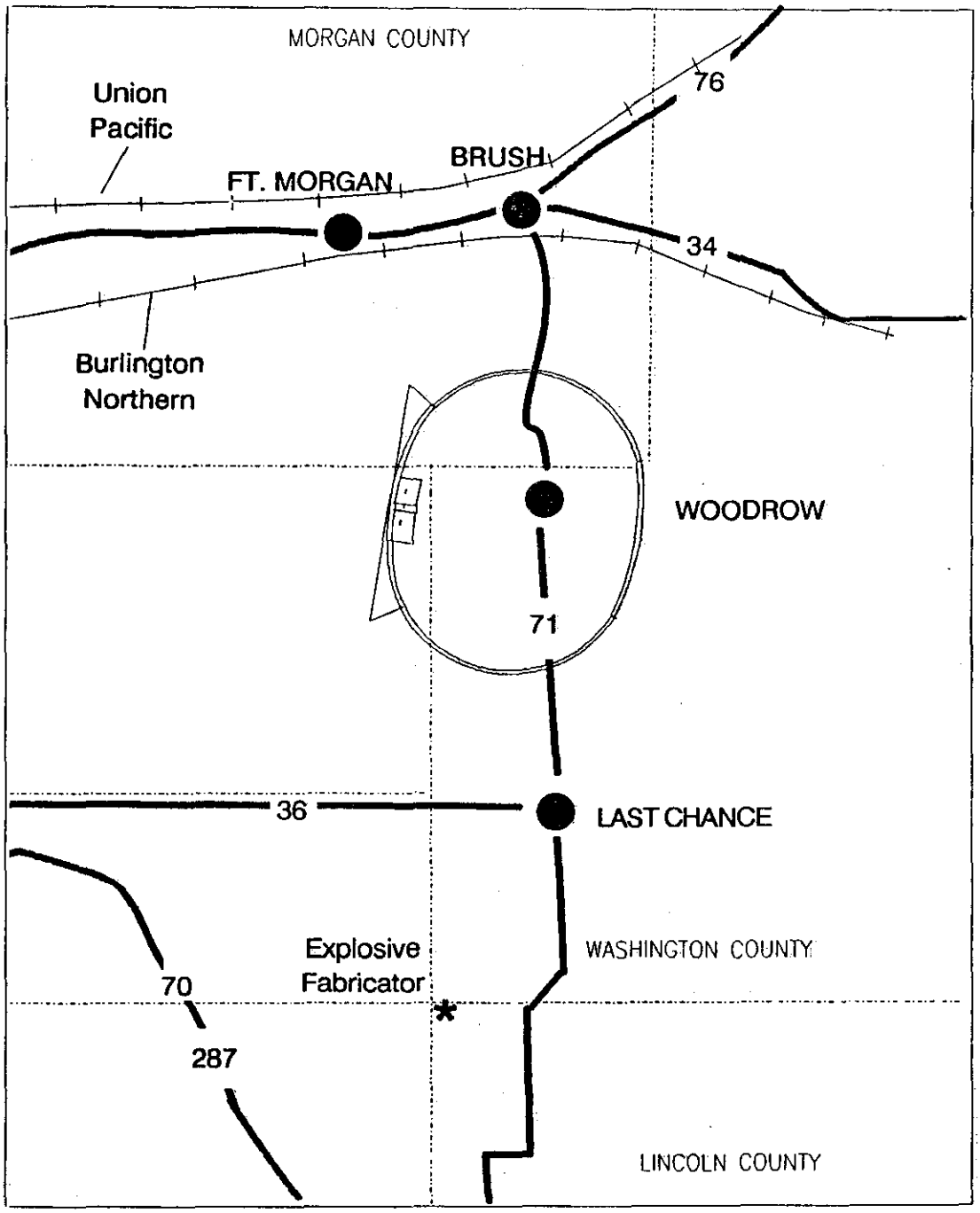


Table 5.2.5-2

REGIONAL VIBRATIONS
COLORADO SSC SITE

Source	Location of Measurement Point Relative to Source Horizontal ft	Vertical ft*	Measured Vibrations Horizontal Displacement in	Horizontal Frequency Hz	Vertical Displacement in	Vertical Frequency Hz
Road (US-36)	100	62	N/A	N/A	3×10^{-6}	10
Oil well (production)	100	85*	N/A	N/A	4×10^{-8}	13
Oil well325 (drilling)	90*	N/A	N/A	8×10^{-8}	6	
Explosive fabrication	36,680	0	N/A	N/A	5×10^{-5}	5

N/A - Not Available; was not measured

* Feet below ground level.

Source: Butler 1986; Butler 1987.

5.2.6 Environmental Radiation

5.2.6.1 Natural Radioactivity

A. Radon

Colorado recently participated in the EPA national survey of radon levels in residential structures. The results of that survey and the University of Pittsburgh radon project are presented in Table 5.2.6-1. Indoor radon levels in Adams County residences averaged 3.25 pCi/l (Cohen 1988).

The Colorado SSC tunnel is proposed for construction in Pierre Shale, which has Ra-226 concentrations measured between 1.2 to 1.9 pCi/g with an average concentration of 1.5 pCi/g (Borak 1987).

Uranium possesses an affinity for crude oil and is frequently associated with oil and gas fields. The radon contained in natural gas is of significance in calculations of radiation exposure estimates (NCRP 45). The proposed site contains oil and gas fields.

B. Soil/Rock

Five boreholes were made adjacent to the proposed SSC ring. (Borak 1987). Two to three samples were analyzed from extracted core of each borehole for natural uranium, Ra-226, gross alpha activity, gross beta activity, and the spectrum of gamma-emitting isotopes. Six samples of unconsolidated soil from depths to 35 ft had natural uranium concentrations ranging from 2.3 μg/g to 4.8 μg/g with an average of 3.1 μg/g. The Ra-226 concentrations ranged from 0.8 pCi/g to 1.8 pCi/g with an average of 1.3 pCi/g. The gross alpha and beta concentrations ranged from 8.6 pCi/g to 17 pCi/g and 26 to 34 pCi/g with an average of 14 pCi/g and 32 pCi/g.

Four radionuclides, Pa-234m, Bi-214, Ac-228, and K-40 were reported from the gamma spectrum analysis. The Ac-228 concentrations, which should reflect the concentration of Th-232 (Ac-228 is in the Th-232 decay chain), were reported as ranging from 0.89 to 1.6 pCi/g in the soil with an average concentration of 1.2 pCi/g.

Five samples from the Pierre Shale at the proposed depth of the SSC were analyzed as stated above. The natural uranium concentrations varied from 1.8 μg/g to 2.7 μg/g averaging 2.2 μg/g. The average Ra-226 concentration was 1.5 pCi/g with a range of 1.2 to 1.9 pCi/g. The Th-232 concentration was reported as varying from 1.1 to 1.5 pCi/g with an average of 1.3 pCi/g. The gross alpha and gross beta concentrations ranged from 16 to 22 pCi/g and 33 to 39 pCi/g with averages of 19 and 37 pCi/g, respectively.

No anomalies were reported and there are no identified uranium deposits at the proposed site.

Table 5.2.6-1

RADON LEVELS

Location	Number of Samples	Geometric Mean pCi/l	Average pCi/l	Percentage of Homes with Radon Levels <4 pCi/l	4-20 pCi/l	>20 pCi/l
United States						
Living space	49,659	1.76	4.01	80	18	2
Basement	23,984	3.37	7.87	59	34	7
Colorado						
Living Space	1,319	3.33	5.44	60	37	3
Basemens	455	6.09	9.44	30	63	7
Basement/living	900	---	4.6	61	37	2
Adams County						
Living space	28	2.70	3.24	61	29	0
Basement	14	5.06	5.20	14	86	0
Morgan County	NA					
Washington County	NA					

NA Not available)
Source: Cohen 1988; EPA 1987.

C. Water

Four water samples, three from deep wells and a surface water sample, were collected and analyzed for natural uranium, Ra-226, gross alpha, and gross beta (Borak 1987). The wellwater samples ranged from less than 0.0003 to 0.0140 mg/l natural uranium with an average of 0.011 μg/l. The Ra-226 concentration ranged from 0.3 to 0.9 pCi/l, averaging 1.5 pCi/l. Gross alpha and gross beta concentrations ranged from 1.5 to 5 pCi/l and 2.7 to 26 pCi/l with averages of 2.6 and 13.2 pCi/l, respectively. The reported concentrations in the surface water were: natural uranium, less than 0.0003 mg/l; Ra-226, 0.7 pCi/l; gross alpha, 1 pCi/l; and gross beta, 26 pCi/l.

D. Measurement Considerations

Borehole and water radioactivity levels were based on a limited number of samples. These samples may or may not be representative of the radioactivity expected at this site.

5.2.6.2 Man-Made Radiation

In Colorado, 461 valid radioactive material (RAM) licenses were issued to authorize the use of RAM, including 67 medical licenses, 360 industrial licenses, 20 academic licenses, 10 source material licenses, and 4 special nuclear material licenses at the end of FY85 by the Conference of Radiation Control Program Directors (CRCPD 1987). Medical users of RAM include medical institutions, private clinics, mobile nuclear medicine facilities, nuclear pharmacies, and medical product distributors. RAMs were also used in well logging, gauging, radiography, irradiation, civil defense, or industrial research and development. Authorization was awarded to three licensees to provide leak testing for radioactive sealed sources and managing radioactive waste for their clients. In Colorado, 45 RAM licensees are regulated by the Nuclear Regulatory Commission, including 3 reactors and 42 federally operated/owned facilities.

The proposed SSC site does not contain any of the licensed facilities listed above. The site does not encompass any government facilities possessing RAMs. There are no mining or milling activities that would enhance the natural background radiation levels.

5.2.6.3 Background Radiation

Measurements (Borak 1987) to estimate the annual average dose equivalent rate were made at 33 locations at the proposed SSC site with a passive integrating system using CaF_2 thermoluminescent dosimeters (TLD).

For each location, two TLDs were placed in a plastic container into which CaF^2 was inserted into an envelope with a layer of black paper to reduce ambient light. The envelope was then sealed in a polyethylene

pouch and the containers attached to the north side of posts or trees at 1 m above the ground. The TLDs were distributed in May 1987, and data were collected every 3 months for four consecutive integration periods.

The measured values range from 120 to 190 mrem/yr with a geometric mean of 150 mrem/yr and a geometric standard deviation of 1.1. The dispersion of data around the mean shows no evidence of hot spots in the proposed SSC area.

5.2.7 Nonradioactive Environmental Hazards

5.2.7.1 Hazardous/Toxic Materials

The proposed Colorado SSC site is located in a region that is sparsely populated and used almost exclusively for homesites, dryland farming, and livestock grazing. No hazardous/toxic materials are known to exist in the region of influence. There is no evidence of former industrial or commercial activity.

The site contains a number of existing and former oil or gas wells at various locations. Four oil-producing wells are located within the footprint. Two of these oil wells lie in the proposed campus area and the other two lie along the ring. At some of the active or recently active well locations, there is a possibility of encountering potentially hazardous/toxic residues in the soil around brine disposal pits. Although no data are available to define the types and concentrations of residues at a typical brine pit, the amount of contaminated soil is expected to be small at each location (McHugh 1988).

5.2.7.2 Biological Hazards

No biological hazards are known to exist within the proposed SSC site area.

5.2.8 Existing Waste Management Facilities

5.2.8.1 Sewage Facilities

Figure 5.2.8-1 shows the approximate location of the existing sewage (wastewater) treatment facilities in the region. Their location, approximate distance to the SSC site, daily capacity, and average demand, are shown in Table 5.2.8-1.

Table 5.2.8-1

EXISTING SEWAGE TREATMENT PLANT CAPACITIES

Treatment System Location	Approximate Distance From SSC Site mi	Design Capacity million gal/d	Average Inflow million gal/d	Excess Capacity million gal/d)
Bennett	40	0.42	0.11[1]	0.31
Brighton	60	2.63	1.88[1]	0.75
Brush	20	1.90	1.41[1]	0.49
Fort Morgan	20	3.60	2.5[1]	1.6
Wiggins	25	2.0	0.15	1.85
Log lane village	25	0.05	0.03	0.02
Hillrose	30	0.1	0.06	0.04
Otis	45	0.01	0.001	0.009
Limon	50	0.44	0.23[1]	0.21

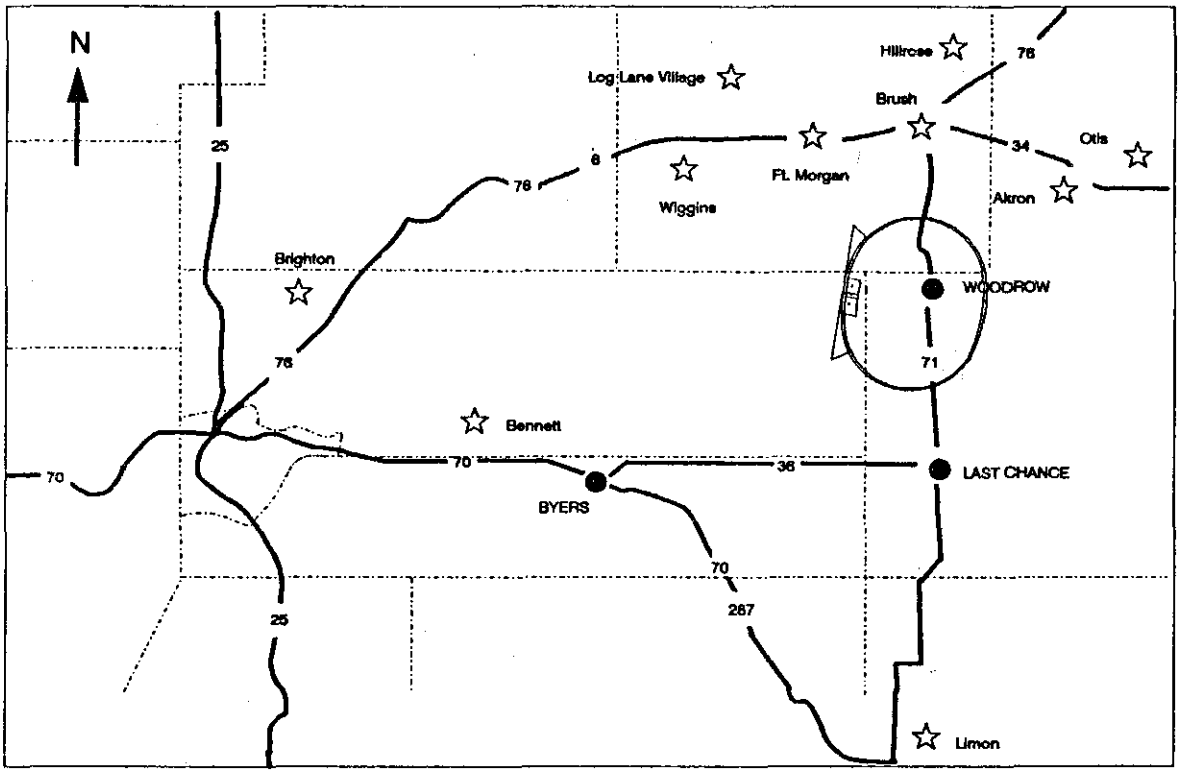
Note: 1. Peak Demand
Source: State of Colorado, Department of Natural Resources

Since wastewater generated at the SSC is estimated to be 0.15 million gal/d, treatment facilities at Brighton, Brush, Fort Morgan, and Wiggins have ample excess capacities to handle this volume.

Wastewater treatment facilities at Brush (20 mi) and Fort Morgan (20 mi) are closer to the SSC site than those at Brighton (60 mi) and Wiggins (25 mi). The wastewater treatment facilities at Brush and Fort Morgan have primary and secondary systems. The wastewater treatment facility at Brush has an excess capacity of 0.49 million gal/d over peak demand. The excess capacity of the Fort Morgan treatment facility would be about 1.6 million gal/d based on the peak demand.

Figure 5.2.8-1

APPROXIMATE LOCATION OF SEWAGE TREATMENT FACILITIES IN THE COLORADO SSC REGION



☆ Approximate Location of Existing Sewage Treatment Plants for Colorado SSC Site

Sewer service in the rural areas of Morgan County is provided onsite in the form of septic fields.

5.2.8.2 Solid Waste Facilities

The sanitary landfills in Adams, Arapahoe, Morgan, and Washington counties are shown in Figure 5.2.8-2. These counties are within 50 mi of the SSC site. Approximate distance from SSC site, initial landfill capacity, remaining life, and annual usage are shown in Table 5.2.8-2. Adams, Morgan, and Washington (Akron landfill) county landfills have excess capacity for 10 to 50 yr based on the current incoming flowrate.

Table 5.2.8-2

SANITARY LANDFILLS IN ADAMS, ARAPAHOE, MORGAN, AND WASHINGTON COUNTIES

County	Approximate Distance From the SSC Site mi	Landfill Name/Operation	Initial Capacity	Remaining Life Capacity (yrs)	Annual Usage yd^3
Adams	40	Tower Road Landfill/ Browning Ferris industries	23×10^6 cubic yards (320 acres)	10-15	0.9×10^6
Arapahoe	70	Denver Arapahoe Disposal Site/ Waste Management Inc.	--	1-2[1]	1.8×10^6
Morgan	25	Morgan County Landfill/County Commissioners	160 acres	25-50	100,000
Washington	40	Akron Landfill/ Town of Akron	200 acres	50	15,000
Washington	50	Otis Landfill/ Town of Otis	15 acres	10-15	6,000

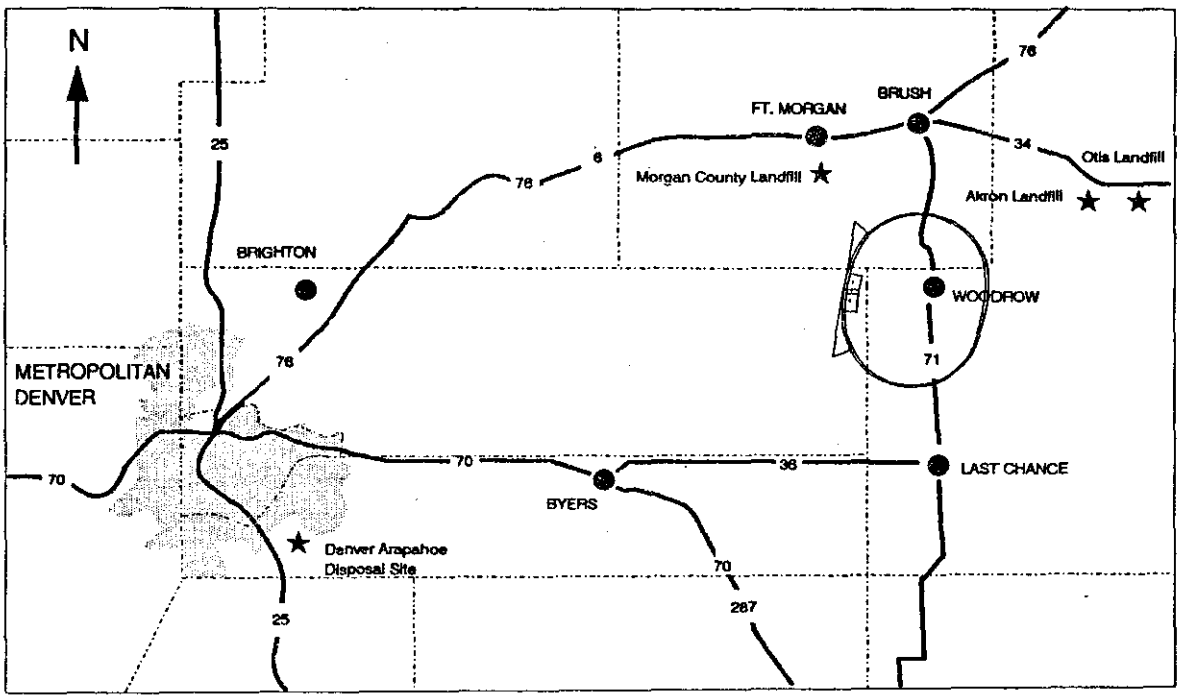
Notes: Waste Management Inc. has applied to expand its landfill area. If the expansion is approved the landfill life will be extended between 5 and 10 years.

All of these landfills will accept construction debris.

Source: Colorado Department of Health.

Figure 5.2.8-2

SANITARY LANDFILL LOCATIONS IN ADAMS, ARAPAHOE, MORGAN, AND WASHINGTON COUNTIES - COLORADO



★ Approximate Location of Existing Solid Waste Facilities for Colorado SSC Site

5.2.8.3 Hazardous Waste Disposal Facilities

No approved facility currently exists in the State of Colorado for the disposal of hazardous wastes. Colorado generators must ship their waste products to out-of-state disposal sites.

Construction is about to begin on a hazardous waste disposal facility in Adams County on State Highway 36 about 7 mi west of Last Chance, Colorado. This 325-acre facility will be approximately 5 mi from the southern radius of the SSC ring. It has been permitted for 16 secure landfill cells and capacities, including 2.5 million yd^3 of hazardous solids, 224,000 gal of liquid hazardous wastes, 1.5 million gal of tank liquid storage, and 600 drums for interim storage. It is claimed to be the first hazardous waste disposal facility in the U.S. to complete the permitting process under RCRA regulations. Operation of this state-of-the-art facility is expected to begin in late 1989. (Richard 1987)

5.2.8.4 Low-Level Radioactive/Mixed Waste Disposal Facilities

Currently, there is no commercial low-level radioactive/mixed waste disposal facility in Colorado.

In 1986, the total volume of LLRW disposed of in commercial disposal sites generated from Colorado was 30 m^3 (3 curies). All of these wastes were generated by the industrial generator and they are class A LLRW. A high-temperature, gas-cooled commercial nuclear power reactor also generated LLRW.

5.2.9 Ecological Resources

5.2.9.1 Regional Ecological Characteristics

A. Definition of Drainage Basins and Boundaries of Ecological Resources Potentially Impacted

The drainage basin potentially hosting the SSC, is the Colorado Piedmont on the lower reaches of the Badger and Beaver creek drainages, intermittent tributaries to the South Platte River. The subdrainages of the South Platte basin are in gently rolling grasslands, typical of the Great Plains (Figure 5.2.9-1). The two potentially affected subdrainages are:

- Beaver Creek, the largest, originates in the high plains to the south near Limon and drains approximately 60% of the site.
- Badger Creek, also originates in the high plains, but to the southwest, and flows to the north paralleling Beaver Creek on the west; it drains approximately 40% of the site.

The ecosystems within the drainage basin are high plains mixed and short-grass prairie, modified by dryland cropping and some irrigated agricultural areas. These ecosystems are water limited but are productive and recover from stresses rapidly. Nutrient cycling of the prairie is dependent on atmosphere/soil/vegetation interactions.

B. Relationship of Ecological Resources with Other Resources

The other resources most closely coupled with ecological resources are: 1) soil, because of mineralization and stabilization of soils by prairie grasslands and for support of agricultural production, 2) land, because of the economics of dryland farming economy, and 3) water, the limiting factor to both natural and managed ecosystem production.

Development in the high plains is affected in the short term because of water limitations and the possibility of sand dune and soil destabilization from wind erosion. Long term implications stem from the limitation of water for revegetation.

C. Classification of Ecosystem Types and Their Distribution

The Soil Conservation Service (SCS) (1986) identifies four natural systems and two managed (Figure 5.2.9-2). These are:

- Natural--short-grass prairie and mixed grass prairie, swales, floodplains (wetlands), and alkali range.
- Managed--irrigated cropland and nonirrigated cropland.

Figure 5.2.9-1

DRAINAGE BASINS OF THE COLORADO SSC SITE

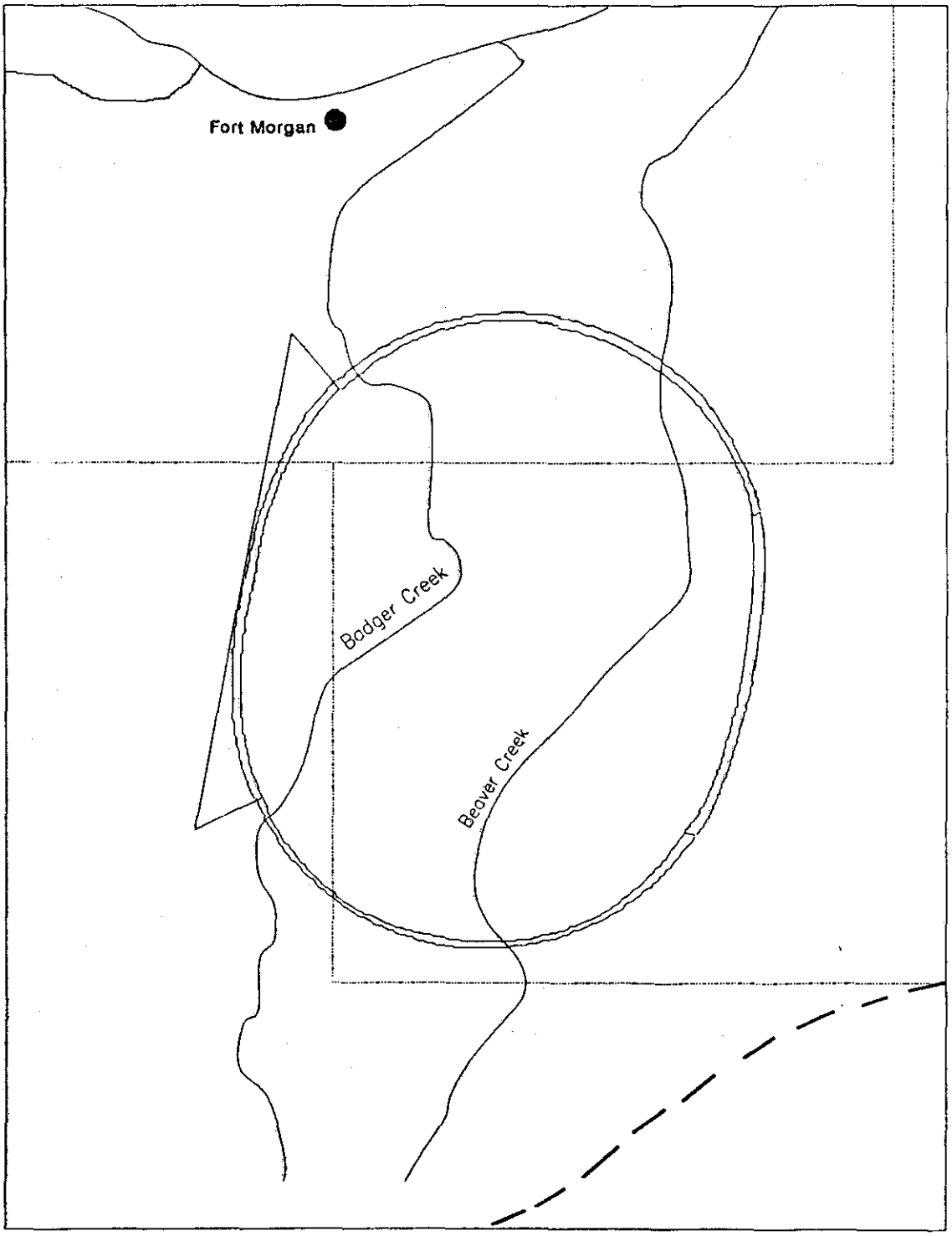
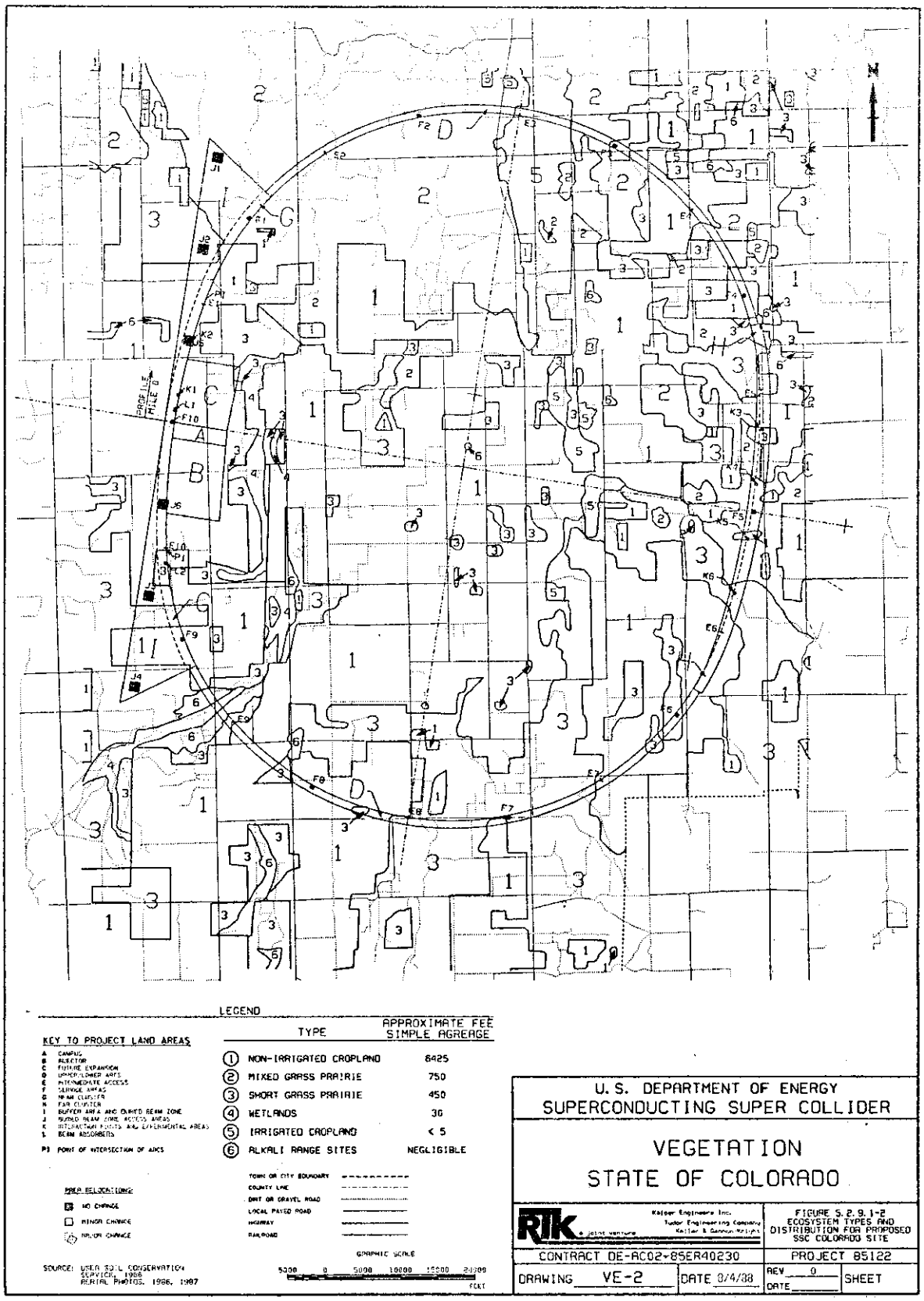


Figure 5.2.9-2

ECOSYSTEM TYPES AND DISTRIBUTION FOR PROPOSED SSC SITE



Within the region of influence (ROI), the distribution of ecotypes is approximately:

- o Nonirrigated cropland 89%
- o Mixed-grass prairie 4%
- o Short-grass prairie 3%
- o Irrigated cropland 2%
- o Swales, floodplains 1%
- o Alkali range 1%

These are discussed in Section 5.2.9.2.

Aquatic ecosystems include both lentic (ponds, lakes, reservoirs) and lotic (streams and rivers) aquatic systems in the ROI. These are summarized below:

- o Lentic systems include Riverside, Empire, Jackson, Prewitt, Barr, and Horse Creek reservoirs and the Mile-High Lakes area, which is a series of small ponds and reservoirs north of Bromley Lake managed primarily as a waterfowl hunting area.

- o Lotic systems include a series of intermittent and perennial streams within the South Platte River drainage from its confluence with the Cache La Poudre River to Sterling. There are numerous small streams that are tributaries of Beaver and Badger creeks.

These are discussed in Section 5.2.9.3.

5.2.9.2 Terrestrial Ecosystem Characteristics

The eastern plains of Colorado are rolling, rising from 4,500 ft above mean sea level to 5,000 ft, east to west. The area is dominated by short-grass prairie, much of which has been converted to croplands, especially dryland farming. The area is dissected by streams, largely intermittent, as well as by temporary and permanent wetlands. Some riparian woodlands occur along intermittent waterways.

The Great Plains short-grass prairie has been extensively studied under the International Biological Program sponsored by the National Science Foundation (Bailey 1978).

A. Plant Community Composition

1. Natural Terrestrial Ecosystems

The mixed grass prairie-type is dominant in the sandy portions of the high plains. Sand bluestem (Table 5.2.9-1), switchgrass, prairie sandreed and blue grama dominate these sites. In some disturbed areas, crested wheatgrass and thistle, both introduced species, have become dominant.

Table 5.2.9-1

DOMINANT PRAIRIE AND ALKALI RANGE VEGETATION OF THE PROPOSED COLORADO SSC SITE

Ecotype	Species Scientific Name	Common Name
Mixed-grass prairie	Andropogon hallii	Sand bluestem
	Panicum virgatum	Switchgrass
	Calamovilfa longifolia	Prairie sandreed
	Bouteloua gracilis	Blue grama
	Andropyron sp.	Wheatgrass*
	Cirsium sp.	Thistle*
Short-grass prairie	Bouteloua gracilis	Blue grama
	Buchloe dactylaches	Buffalo grass
	Andropyron smithii	Western wheat-grass
Alkali range	Distichlis stricta	Salt grass
	Sprorbolus airoides	Alkali sacaton
	Bouteloua gracilis	Blue grama
	Hilaria jamesii	Galleta

*Introduced species, often present on disturbed sites.

Sources: Soil Conservation Service 1986.
CSU NREL Reports 1970-1985.

The short-grass prairie-type is dominated by blue grama and buffalo grass (Table 5.2.9-1). The short-grass prairie is typically associated with loamy soils on slopes and plains and more clayey soils in the bottoms of the rolling topography. In some of the more poorly drained depressions, and in floodplains, western wheatgrass dominates.

The alkali range consists of saline meadows found on very clayey soils. These soils are seasonally saturated and have permanent high water tables. The dominant vegetation includes salt grass and alkali sacaton. The most well-drained areas also include blue grama and galleta.

The swale and floodplains are permanent wetlands, including marshes, shrub, and wetland forest areas. The marshes are dominated by bullrushes, and cattails and are located in permanently saturated soils. Sedges are dominant in seasonal marshes, along with species of rushes. The shrub

wetlands are affected by foraging cattle and are dominated by snowberry and wild roses. The forests, called gallery forests, are dominated by plains cottonwood, peachleaf willow, and interior willow. The shrubs are often the understory in the gallery forest areas (Table 5.2.9-2). (Costello and Harrington 1964)

Table 5.2.9-2

SWALE AND FLOODPLAIN VEGETATION OF PROPOSED COLORADO SSC SITE

Ecotype	Species: Scientific Name	Species: Common Name
Marshes	Scirpus spp.	Bullrushes
	Typha spp.	Cattails
	Carex spp.	Sedges
	Juncus spp.	Rushes
Shrubs	Symphoricarpos spp.	Snowberry
	Rosa spp.	Wild rose
Gallery forests	Populus deltoides	Plains cottonwood
	Salix amygdaloides	Peachleaf willow
	Salix interior	Interior willow

Sources: Colorado Division of Wildlife 1987; National Wetlands Inventory 1987.

2. Managed Terrestrial Ecosystems

Managed ecosystems, primarily croplands, dominate the SSC project ROI. Nonirrigated cropland, primarily dryland wheat, occupies approximately 50% of the actual project site. Irrigation of crops is used, primarily for corn and sugarbeet production. However, some irrigation is used to increase production of other crops. Dominant crops are: winter wheat, spring wheat, corn, grain sorghum, barley, and sugarbeets. Production of these crops is summarized in Table 5.2.9-3.

Table 5.2.9-3

PRODUCTION OF MAJOR CROPS IN THE COLORADO SITE VICINITY AVERAGE 1984-1986

Crop	County	1984-1986 Total Production bushels	1984-1986 Acreage acres	% Acreage Irrigated
Winter wheat	Adams	8,370,000	227,300	4%
	Morgan	3,630,000	86,600	19%
	Washington	14,165,000	345,000	3%
Barley	Adams	555,000	13,500	24%
	Morgan	386,000	9,000	29%
	Washington	321,000	5,000	5%
Spring wheat	Adams	12,300	400	64%
	Morgan	9,200	200	85%
	Washington	5,500	200	30%
Sorghum (grain)	Adams	217,000	6,400	29%
	Morgan	127,000	3,400	29%
	Washington	207,000	6,900	13%
Corn (grain)	Adams	504,000	4,000	100%
	Morgan	11,426,500	76,930	>99%
	Washington	2,333,000	17,970	97%
Sugarbeets		(tons)	(1984, 1986 only)	
	Adams	11,450	730	not given
	Morgan	175,200	7,600	not given
	Washington	585	11,850	not given

Source: Colorado Division of Wildlife 1987.

Within the footprint of the SSC, both managed and nonirrigated systems are found. However, the large portion of the footprint is currently in non-irrigated cropland, approximately 84% of the acreage. The near cluster, including campus, injector, and future expansion areas is currently in nonirrigated cropland, with minimal areas within short-grass and mixed-grass prairie. The far cluster area is currently dominated by mixed-grass prairie, with smaller portions of short-grass prairie and nonirrigated croplands. The south arc is totally in short-grass prairie and dry

croplands currently. The north arc is predominantly mixed-grass prairie with some irrigated cropland near the arc's center. Figure 5.2.9-1 shows the associations in the immediate region of the site.

B. Animal Community Composition

Both livestock and wildlife are plentiful at the proposed Colorado site. These are separately discussed below.

1. Livestock

The dominant livestock includes dairy/beef cattle, sheep, and hogs/pigs. The feedstock requirements in the area, defined as the acreage required for a 1,000-lb cow with 6-mo calf, (animal unit) vary between 20 and 25 acres/animal unit.

Table 5.2.9-4 summarizes the 1984-1986 production of livestock in the ROI (Colorado Department of Agriculture Annual Report 1984-1986). There was a 15% reduction in cattle production between 1984 and 1986. This was caused by changes in federal farm policy as well as market conditions. Sheep production was reduced in the same period by 26%, and hog production by 17%.

Table 5.2.9-4

LIVESTOCK PRODUCTION IN THE COLORADO SSC SITE VICINITY
1984-1986

	No. Head/Yr 1984-1986		
Livestock Group	Adams Co.	Morgan Co.	Washington Co.
Cattle calves	51,300	86,200	84,700
Stock sheep	1,030	1,000	1,300
Hogs/pigs	14,400	36,200	10,600

Source: Colorado Division of Wildlife 1987.

2. Wildlife

More than 300 vertebrate species alone have been identified within the ROI. The wildlife of the area is discussed within the six dominant associations that form their habitats. Table 5.2.9-5 summarizes the

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common wildlife by habitat. Actual population estimates of these birds and mammals are not available within the project site except under the Cooperative Habitat Improvement Projects (CHIP) of approximately 100 acres within the ROI and the Conservation Reserve Program (CRP) of approximately 120 acres. The CHIP has as its goal the enhancement of habitat for pheasant by perennial herbaceous plantings and woody plantings. The CHIP is a cooperative program between the landowners and Colorado Division of Wildlife. The CRP is sponsored by the Division of Wildlife and consists of areas planted to accommodate perennial wildlife.

Table 5.2.9-5

COMMON TERRESTRIAL WILDLIFE IN THE COLORADO SSC SITE VICINITY

Common Name	Breeding Habitat	Nonbreeding Habitat	Migration Route Habitat	Winter Habitat
Mule deer	2,3,4	2,3,4	NA	2,3,4
Pronghorn	2,3	2,3	2,3	2,3
Red fox	1,4	1,2,3,4	NA	1,2,3,4
Swift fox	1	1,2,3	NA	1,2,3
White-tailed deer	1,3,4	1,3,4	NA	1,3,4
Canadian goose	1,4	1,4	1,4	1,4
Ferruginous hawk	1,2,3,4	2,3,4	1,2,3	1,2,3,4
Mallard	1,4	1,4	1,4	1,4
Mourning Dove	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Bullsnake	1,3,4	1,3,4	NA	1,3,4
Ring-necked pheasant	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Ornate box turtle	2,4	2,4	NA	2,4
Great plains toad	4	1,3,4	NA	1,3

Notes: 1 = Croplands
2 = Short-grass prairie
3 = Mixed-grass prairie
4 = Wetlands

Source: Colorado Division of Wildlife 1987.

Herbivores are dominantly rodents that are prey to predatory birds, foxes, and coyotes. There are sufficient populations of antelope and deer to allow recreational hunting.

Herpetiles living in the ROI are typically associated with the short-grass prairie. These include the Great Plains toad and the Plains Spadefoot toad.

3. Wildlife Management Practices

The State of Colorado's Department of Natural Resources, Division of Wildlife (DOW) manages wildlife under a variety of programs. CRP both beneficiates habitat and monitors wildlife populations. Under CRP, several populations are monitored annually to determine density and reproductive successes. These include:

- Pronghorn antelope (aerial surveys)
- Deer (aerial surveys)
- Pheasants (coo count surveys and annual brook count surveys)
- Bobwhite quail (whistle count surveys)
- Mourning dove (coo count surveys)
- Waterfowl (winter aerial surveys and annual nesting aerial surveys)
- Shorebirds (informal siting surveys)
- Bald and golden eagles (winter surveys)
- Greater prairie chicken (lek surveys).

Management practices emphasize the establishment of feeding plots, nesting cover, winter cover, prescribed burns, tillage practices, water diversions, and refuge areas. In addition, the DOW establishes hunting limits and seasons based on the population densities of the various game species in the CRP and other areas of the ROI.

4. Wildlife Migration Corridors

Table 5.2.9-5 summarizes the seasonal habitats of dominant populations within the ROI. There are no distinct migration corridors for big game in the ROI; however, since the proposed site lies in the central flyway, a great variety of shorebirds and waterfowl use this flyway in the summer and fall migration. The reservoirs and the South Platte River and its few perennial tributaries are prime roosting, nesting, and seasonal habitat for many of these birds.

C. Ecosystem Level Processes

Total annual productivity of the Great Plains mixed and short-grass prairie is affected by year-to-year variances in precipitation and its distribution through the year. The nutrient cycling processes of these prairie systems are "external," that is, highly mediated by atmospheric plant interactions.

Reclamation is fairly rapid except in the sand dune areas. The soils are relatively rich (see soils discussion, Section 5.2.10.4). Irrigation increases the rate of reclamation and can be accomplished using irrigation reservoirs in the area. A stable, productive prairie can be established within 5 years using some irrigation during the initial years.

5.2.9.3 Aquatic Ecosystems

While the Great Plains ecotypes are largely terrestrial, there are significant lentic (ponds, lakes) and lotic (streams and rivers) ecosystems in the Colorado proposed site ROI. Lentic ecosystems within the ROI will not be directly affected by the construction and operations of the SSC. However, increased population and the use of lakes, reservoirs, and ponds for fishing and recreation will have an indirect impact on the regional resources. Lotic stream systems will be directly affected by SSC site construction. The current conditions of aquatic resources in the ROI are summarized below.

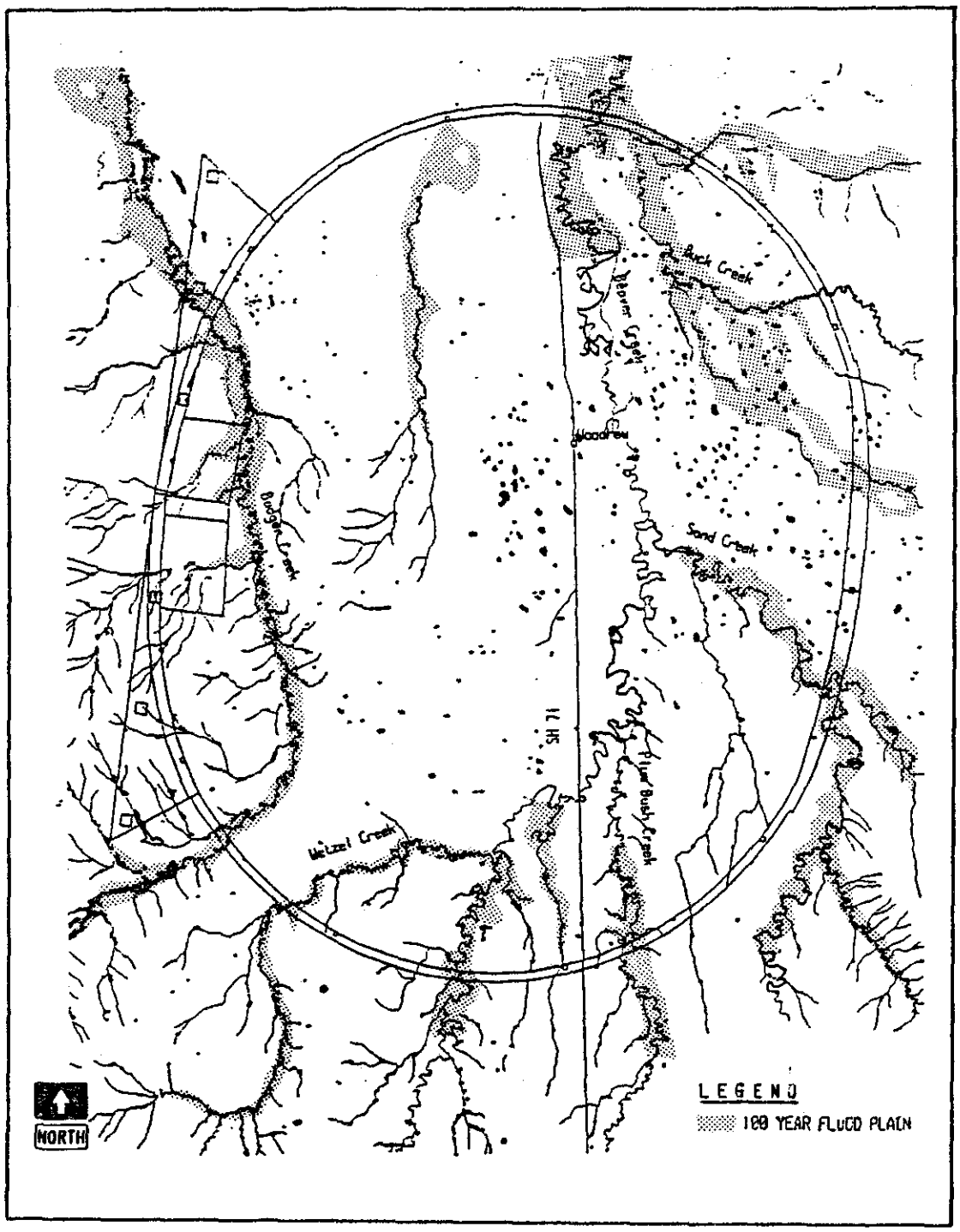
The Colorado ROI for the EIS has been defined as the South Platte River drainage from its confluence with the Cache La Poudre River to Sterling. The ROI includes reservoir systems bounded by the Riverside Reservoir (approximately 40 mi northeast) and Sterling Reservoir (approximately 60 mi northeast). Figure 5.2.9-3 graphically depicts the aquatic ecosystems in the ROI.

A. Lotic Systems

The South Platte River, from its source in the intermountain central Colorado basin traverses the SSC northeasterly. Near Greeley, the system has anastomosed, leaving only intermittent plains tributaries in the ROI. The South Platte River within the ROI can be characterized as a broad, shallow stream alternating from single channel to braided networks through the plains. The riparian zone is therefore relatively wide and shrub/tree canopy shading over portions of the main channel is common. The South Platte River is affected by erosion and drainage from agricultural activities and serves as a source of irrigation waters under tight water rights controls.

Figure 5.2.9-3

WETLANDS IN THE IMMEDIATE VICINITY OF
THE PROPOSED SSC IN COLORADO



The South Platte River is not highly vegetated because of the shifting sand substrate and the constantly changing course of water currents within the variable channels. Occasionally, buttercup, pondweed, and many species of filamentous algae are established in specific areas of the river (Table 5.2.9-6). The adjacent oxbow lakes, sloughs, and marshes, by contrast, support diverse aquatic plant communities. High densities of smartweed, cattail, bullrushes as well as emergent rushes, sedges, and wetlands grasses are found in these areas. In addition, many pockets of standing water support various varieties of pondweed, duckweed, and mats of filamentous algae developed through the growing season. Spirogyra (a filamentous algae) establishes high densities during winter and spring. Table 5.2.9-6 summarizes the floating and emergent vegetation for the South Platte River, the oxbows, and marsh areas. Productivity estimates are not available for the South Platte area in the Colorado SSC vicinity.

Table 5.2.9-6

VEGETATION IN THE LOTIC SYSTEMS OF THE COLORADO SITE

Lotic Systems	Scientific Name	Common Name
Intermittent Streams	*Typha latifolia*	Cattail
	Scirpus americana	Bullrush
	Spirogyra	Filamentous algae
		Various sedges
Small Creeks	*Ranunculus aquatilis*	Buttercup
	Potamogeton filiformes	Pondweed
	Cladophora spp.	Filamentous algae
	Typha spp.	Cattail
	Carex spp.	Sedges
	Scirpus spp.	Bullrush
	Polygonum spp.	Smartweed
South Platte River	*Ranunculus aquatilis*	Buttercup
	Potamogeton filiformes	Pondweed
	Spirogyra, *Claophora*	Filamentous algae
Sloughs, oxbows, and marshes	*Lemna minor* in addition to all of the above species	Duckweed grasses

Source: Colorado Division of Wildlife 1987.

Within the ROI, the South Platte River contains a variety of fish, mostly nongame species, although technically included as sportfish by the Colorado Division of Wildlife. Table 5.2.9-7 summarizes data from the ROI South Platte River for 1978-1980 (Probst 1982). Population densities are not available for these sections of the South Platte River.

Table 5.2.9-7

FISH SPECIES FOUND IN THE SOUTH PLATTE RIVER DRAINAGE, COLORADO 1978-1980

Scientific Name	Common Name
Calaea inconstans	Brook stickleback
Campostoma anomalum	Central stoneroller
Carpoides carpio	River carpsucker
Catostomus catostomus	Longnose sucker
Catostomus commersoni	White sucker
Cyprinus carpio*	Carp
Dorosoma cepedianum	Gizzard shad
Fundulus sciadicus	Plains topminnow
Fundulus zebrinus	Plains killfish
Hybognathus hankinsoni	Brassy minnow
Hybognathus placitus	Plains minnow
Ictalurus nebulosus*	Brown bullhead
Ictalurus punctatus	Channel catfish
Lepomis cyanellus	Green sunfish
Lepomis humilis	Orangespotted sunfish
Micropterus salmoides*	Largemouth bass
Notropis dorsalis	Bigmouth shiner
Notropis lutrensis	Red shiner
Notropis stramineus	Sand shiner
Perca flavescens*	Yellow perch
Phenacobius mirabilis	Suckermouth minnow
Pimephales promelas	Fathead minnow
Promixis nigromaculatus*	Black crappie
Rhinichthys cataractae	Longnose dace
Semotilus atromaculatus	Creek chub

*Introduced species

Source: Probst 1982.

Dominant fish species are the Cyprindae family, principally carp and minnows. White suckers, carp, fathead minnows, sand shiners, and creek chub are the most abundant. More desirable game fish, including yellow perch, largemouth bass, green sunfish and catfish are not abundant (Table 5.2.9-7).

Canals and ditch systems in the area are not considered to be of fishery value because of their intermittent flow and seasonality. Fish do gain access to the canals and ditches from perennial flow areas of the river but are usually left stranded in the fields at the end of an irrigation season.

There are numerous intermittent streams in the immediate area of the ring (Figure 5.2.9-3). Those directly in the site ring area include:

- Badger Creek
- Beaver Creek
- Sand Creek
- Antelope Creek
- Buck Creek
- Wetzel Creek.

Along the Colorado state highway corridor, there are numerous canals and ditches as well as a few creeks that have intermittent flow. These include: Speer Canal, West Burlington Extension Ditch, Beebe Seep Canal, Denver Hudson Canal, Box Elder Creek, Horse Creek, Lost Creek, Sand Creek, Long Draw, Kiowa Creek, Commanche Creek, Mule Creek, Rock Creek, Antelope Creek, Little Antelope Creek, Bijou Creek, Moore Ditch, Muddy Creek, Little Muddy Creek, Potty Brown Creek, Hoffman Creek, San Arroyo Creek, West, and Fork San Arroyo Creek.

Along the access corridor from Fort Morgan, there are three intermittent streams: Fort Morgan Canal, Bijou Creek, and Badger Creek. Both Badger Creek and Fort Morgan Canal flow along the railroad spur.

The Colorado DOW conducted surveys at specific points in Bijou, Box Elder, Commanche, and Sand creeks during 1980 (Table 5.2.9-8).

Table 5.2.9-8

FISH COLLECTED IN FOUR COLORADO STREAMS DURING 1980

Stream Sample Coordinates	Fish Collected Scientific Name	Common Name
Bijou Creek (58W4N28)	Cyprinus carpio	Carp
	Pimephales promelas	Fathead minnow
	Notropis dorsalis	Bigmouth shiner
	Carpoides carpio	River carpsucker
	Fundulus zerbrinus	Plains killifish
	Fundulus sciadicus	Plains topminnow
	Culaea inconstans	Brook stickleback
Box Elder Creek (64W2N31)	Pimephales promelas	Fathead minnow
	Fundulus zebrinus	Plains killifish
	Lepomis cyanellus	Green sunfish
Commanche Creek (63W9S29)	Pimephales promelas	Fathead minnow
Sand Creek (55W1S17)	Pimephales promelas	Fathead minnow
	Lepomis cyanellus	Green sunfish
	Catostomus commersoni	White sucker

Source: Colorado Division of Wildlife 1980.

Box Elder Creek is a small intermittent stream upstream from the South Platte River. Sampling was conducted in 1980 downstream of Klug Lake. Only three fish species were detected, all capable of migration and survival for short time periods in intermittent waterways: fathead minnow, green sunfish, and plains killifish.

Bijou Creek is an intermittent tributary of the Bijou Canal. The 1980 survey identified cyprinids as the most common fish family, including fathead minnow, carp, bigmouth shiner, river carpsucker, plains killifish, and plains topminnow. The only nonminnow species found was the brook stickleback, which was present in very low densities.

Sand Creek was sampled near its confluence with Plum Brush Creek. Species collected were those tolerant of farm runoff and included fathead minnow, green sunfish, and white sucker.

Very few fish were found in Kiowa Creek or Commanche Creek. Those species found were cyprinids, specifically fathead minnow.

B. Lentic Ecosystems

There are no lentic ecosystems within the immediate footprint of the SSC or within the site except for very small farm ponds (Figure 5.2.9-3). Seven reservoir areas within the ROI (Figure 5.2.9-1) are briefly described here because of the increased use expected if the SSC is sited in the Colorado high plains. Vegetative density and composition is quite dependent upon water fluctuations both in terms of frequency and volumes of drawdown. Typically, curly-leafed pondweed forms large mats in the water and the shoreline is dense with cattails. The diversity of vegetation in the wetlands around reservoirs is minimal compared with that around the streams and South Platte River.

When long periods of time, a full season, or even several seasons pass with minimal water fluctuations, milfoil, coontail, narrow-leafed pondweed, horned pondweed, and buttercups form heavy growth in the littoral zones. Spike rush and muckgrass (a filamentous algae) may form extensive mats on the substrate of the reservoir.

C. Other Wetlands

Including the riparian zones around the streams and floodplains, there are approximately 100 acres of wetlands within the boundaries of the proposed SSC ring (USFWS National Wetlands Inventory 1979). Figure 5.2.9-3 shows the palustrine, riverine, farmed palustrine, and stream channel wetlands. The 100-year floodplain is also indicated. Riverine wetlands are within channels but not dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens. While the main channel of the South Platte River is also a riverine system, the sand gravel bars, sand bars, oxbow pools, and sloughs are riverine wetlands.

Palustrine wetlands, frequent in the ROI, are numerous small ponds, marshes, swamps, and bogs. The small ones lack extensive emergent vegetation because of their shallowness and seasonality. These palustrine wetlands dominate much of the floodplain south of the South Platte River north of the ring. Smaller canals, ponds, and swales comprise the remainder of the wetlands. The national inventory lists many of these areas as "flats" since they lack the characteristic vegetation. Other areas that would be palustrine if undisturbed are identified as "farmed" indicating the current land use.

5.2.9.4 Economically, Recreationally, and Culturally Important Species

There are no culturally unique or important species in the ROI. Economic value of individual species is derived from their recreational potential except for livestock.

The following species have recreational hunting value in the area: mule deer, pronghorn antelope, white-tailed deer, rabbits, mallards, mourning dove, ring-necked pheasant, and bobwhite quail. Hunting and trapping records for 1985-1986 are summarized for the ROI and adjacent South Platte River bottomlands (Table 5.2.9-9) (CO Division of Wildlife 1987).

Sportfishing is primarily focused on the reservoirs northwest of the site. Recreation fish include: largemouth bass, yellow perch, walleye, black crappie, and green sunfish.

Table 5.2.9-9

1985-1986 HUNTING AND TRAPPING RECORDS FOR COLORADO SITE*

Game and Furbearer Hunting

Species	Total Number of Hunters for each species	Total Harvest of each species
Bobwhite quail	424	986
Pheasant	1,478	2,628
Cottontail	1,352	2,438
Jackrabbit	849	9,460
Fox squirrel	227	906
Badger	165	114
Kit fox	103	103
Red fox	165	290
Raccoon	118	115
Coyote	686	1,034
Skunk	117	230
Prairie dog	707	9,178

Furbearer Trapping

Species	Total Number of Trappers for each species	Total Harvest of each species
Badger	8	8
Beaver	16	128
Coyote	27	93
Red Fox	4	4

* Colorado Division of Wildlife Unit 36
Source: Colorado Division of Wildlife 1987.

5.2.9.5 Threatened and Endangered Species

A. Federally Listed, Proposed, or Candidate Species

1. Plants

There are no federally protected plant species in the Colorado ROI. There are two federal candidate plant species that may be present in the ROI. These are streaked ragweed (*Ambrosia linearis*), a USFWS neomexicana Category 2 species, and Colorado butterfly plant (*Guara neomexicana* ssp. *coloradoensis*), a USFWS Category 1 species.

Showy prairie gentian (*Eustoma grandflorum*) is rare in Colorado as a whole and may find suitable sites within the ROI. No surveys of these species are available within the ROI.

2. Wildlife

Federally, listed threatened and endangered species in the general vicinity are migratory and typically associated with the wetlands and reservoir/riverine areas north and west of the site (Opdycke, HSFS 1988). These species include:

- Piping plover, *Charadrius melodus* (threatened)
- Whooping crane, *Grus americana* (endangered)
- Bald eagle, *Haliaeetus leucococephalus* (endangered)
- Peregrine falcon, *Falco peregrinus* (endangered)
- Least tern, *Sterna antillarum* (endangered).

The black-footed ferret (*Mustela nigripes*), which is endangered is associated with larger prairie dog towns. While prairie dog towns are present throughout the ROI, there are no data on the proximity and size of the towns or on the presence or absence of the black-footed ferret.

The greater prairie chicken (*Tympanuchus pallidicinctus*) is monitored in the CRP northwest of the site; however, there is no evidence that it is present at the site.

3. Bald and Golden Eagles

The DOW has been collecting data for mid-winter counts of bald eagles since 1980 in the northeast region of the state. The areas surveyed are the reservoirs, South Platte River, and selected tributaries in the area northeast of Denver to the state lines. Table 5.2.9-10 summarizes the mid-winter counts for the region, 1980 to 1988, compared to the state totals.

Table 5.2.9-10

SUMMARY OF MID-WINTER BALD EAGLE COUNTS 1980-1988

Region	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Number of Birds								
South Platte NE region	51	83	105	82	54	60	74	127	91
Other areas in NE region	9	13	10	3	4	0	0	0	21
NE regional total		96	115	85	58	60	74	127	112
State total	595	538	557	468	535	534	463	556	500

*The survey was incomplete, lacking count data from other than South Platte and Crow Creek (near Briggsdale) areas.

Source: State of Colorado Division of Wildlife 1987.

Table 5.2.9-11 summarizes the recent 1988 mid-winter counts for both bald and golden eagles in the northeast region and compares these with the state totals. In general, there are no known golden eagle populations in the SSC ROI.

Table 5.2.9-11

BALD AND GOLDEN EAGLE COUNTS WINTER, 1988

Surveyed Populations	Northeast	Statewide
	Number of Birds	
Adult bald eagles	65	291
Immature bald eagles	47	156
Unidentified bald eagles	0	53
Total bald eagles	112	500
Adult golden eagles	0	29
Immature golden eagles	0	18
Unidentified golden eagles	0	1
Total golden eagles	0	48

Source: State of Colorado Division of Wildlife 1987.

4. Other Federally Protected Species

The following species are federal candidate species and may be present in the area:

- Swift fox, *Vulpes velox*
- Preble's jumping mouse, *Zapus hudsonius preblei*
- Ferruginous hawk, *Buteo regalist*
- Swainson's hawk, *Buteo swainsoni*
- Long-billed curlew, *Numenius americanus*
- Western snowy plover, *Charadrius alexandrinus nivosus*
- Mountain plover, *Charadrius montanus*
- Streaked ragweed, *Ambrosia linearis*
- Colorado butterfly plant, *Gaura neomexicana* sp. *coloradensis*.

B. State-Protected Species

The State of Colorado does not list plants as endangered or threatened. The only state-protected species is the Colorado (blue) columbine, the state flower, which is found in the Rocky Mountains and is absent in the prairie areas.

State-listed wildlife includes five species, all with endangered status. The two species known to have overlapping ranges with portions of the ROI include:

- Bald eagle, *Haliaeetus leucocephalus*
- Plains sharp-tailed grouse, *Tympanuchus phasianellus jamesi*.

The three other listed species may, from time to time, be sited in the ROI but are largely found in adjacent areas, especially the reservoir and South Platte River and tributaries. These are:

- Peregrine falcon, *Falco peregrinus*
- Sandhill crane, *Grus candensis*
- Whooping crane, *Grus americana*.

5.2.9.6 Unique Ecosystems and Communities Potentially Affected

A. Statutorily Protected Areas

There are no protected areas in the immediate site area. The Pawnee National Grasslands, Jackson Lake, and Barr Lake State Recreation areas are to the north and northwest of the site within the general ROI.

B. Remnant Communities, Virgin Stands, or Unique Areas

There are no communities and associations in the ROI that are remnant, virgin, or unique.

C. Marginal Range Association and Transition Zones

The site is in the middle of the Great Plains ecological region. It has no unique transitional or marginal range features among its biota.

D. Implications on Land Use Policy

There are no ecological resource consequences on land use policy at the proposed site.

E. Implications on Prime Farmlands, Wildlife Refuges, and Other Management Areas

There are no direct ecological resource implications resulting from the development of the proposed Colorado site. The prime farmlands are discussed in Section 5.2.10.3. There are a few refuges in the general ROI, as summarized in Section 5.2.9.2 and 5.2.9.3; however, there are none directly within the proposed site. There are no management areas at the proposed site.

5.2.9.7 Ecological Factors Along Proposed Access Road

The planned alignment of the east/west access road from the new Denver airport to the proposed site will traverse a progression from urban encroachment near its western end, the interchange with I-76, to cultivated fields (wheat and barley) interspersed with wetlands. Native vegetation along the proposed alignment is mostly short-grass prairie with small stands of willow and cottonwood lining major drainages. This diverse habitat also contains a prairie dog town, numerous waterfowl, bald eagles and other raptors, and several other threatened and endangered species. Wetlands are a feature of both of the potential alignments of this major access road. Although slightly less acreage is involved with one alignment, higher quality appears to be present at the other. The Colorado Department of Highways estimates approximately 300 wetlands along the alignment. Consultation with the U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers will be undertaken upon selection of the preferred route. Wildlife is common along the undeveloped portions of the planned alignment, including antelope, mule deer, jackrabbits, cottontails, prairie dogs, doves, quail, pheasants, and several species of resident waterfowl. (Colorado Department of Highways 1988).

The Colorado Department of Highways estimates that a number of species listed as threatened and endangered under the Endangered Species Act may utilize habitat along the proposed alignment. These include the bald eagle, black-footed ferret, and whooping crane. Bald eagles make use of the resources of Barr Lake and the Rocky Mountain Arsenal. A communal roost is present at the Rocky Mountain Arsenal and a nesting pair of bald eagles is present at the wildlife refuge on Barr Lake. A survey of prairie dog towns has not been conducted of the area; however, sufficient numbers of prairie dogs are present to trigger such a survey for the

possible presence of the black-footed ferret prior to construction or final alignment of the major access road. The whooping crane is known to use the South Platte Basin and a single sighting has been made in the Barr Lake area. Federal-candidate species that may utilize habitat along the alignment include: Colorado butterfly plant, ferruginous hawk, long-billed curlew, Swainson's hawk, swift fox, western snowy plover, white-faced ibis, mountain plover, and Preble's jumping mouse.

5.2.10 Land Resources

5.2.10.1 Regional Setting

A. Jurisdictional Setting

The proposed Colorado site is located approximately 65 mi east/northeast of Denver in unincorporated northeastern Adams County, southeastern Morgan County, and western Washington County. The county seats of each jurisdiction and the year of respective establishment are as follows: Brighton, Adams County (1901); Fort Morgan, Morgan County (1899); and Akron, Washington County (1887) (Kane 1972). The areal extent of each jurisdiction is listed below:

County	Areal Extent mi^2
Adams	1,241
Morgan	1,296
Washington	2,526
Total:	5,063

The SSC project is situated in areas that are represented by the following federal, state, and local elected officials (Colorado Reapportionment Commission 1982):

- United States Senate
  William L. Armstrong
  Timothy E. Wirth
- United States House of Representatives
  Hank Brown, 4th District
- State Senate
  Jim Brandon, 1st District
  Bob Martinez, 25th District
- State Assembly
  Carl Bledsoe, Speaker, and Representative, 64th District
- Adams County Board of Supervisors
- Morgan County Board of Supervisors
- Washington County Board of Supervisors

B. Ownership Patterns

Land ownership in the SSC project three-county area is predominantly private, with scattered parcels under either Department of Interior, Bureau of Land Management (BLM), or State of Colorado Land Board jurisdiction (McHugh 1988).

This is consistent with land ownership patterns in eastern Colorado where lands are suitable for agricultural production.

C. Historic Land Use

The growth of northeastern Colorado has been dependent on the utilization of the South Platte River as a major water source for developing an agriculturally based economy (Morgan County 1988; Adams County 1987). As the ancient river was formed, three terraces were created, each suitable to a different type of agricultural production (Morgan County 1988). The lowest terrace was enhanced by early settlers who created elaborate ditch and irrigation systems. These enhancements helped to create the area's prime agricultural farmland, which has become the largest and most stable source of farm income. Primary irrigated crops are alfalfa, sugarbeets, onions, beans, corn, potatoes, small grains, and sorghum. The middle-terrace lands are well suited to dryland farming, such as wheat and sorghum production. The highest terrace is used primarily as rangeland for cattle and sheep.

The proposed SSC area has remained predominantly agricultural, even though there is significant oil and gas production activity in the area, especially in Morgan County (Morgan County 1988). Both commodities were discovered during the 1920s, with the Adena Oil Field opening in the 1950s. This oil field was at one time the second-largest producing field in the state, with peak production reached in the early 1980s (Morgan County 1988). Population growth in the SSC project area has been centered historically in and around the small towns that were originally established to service the agrarian economy (Morgan County 1988; Adams County 1987).

D. Existing Land Use Plans, Policies, and Controls

Land use planning in eastern Colorado is conducted at the following three levels of government: state, regional, and local; the latter includes not only county-level activities but also municipalities. Land use planning at the state level is conducted by the Colorado Land Use Commission, whose responsibilities include: 1) invoking temporary emergency power authority when a land development activity poses serious and major threats to the public's health, welfare, and safety, 2) directing matters of state interest, 3) monitoring county subdivision regulations and major activities of municipalities, and 4) completing guidelines related to county subdivision regulations, 100-year floodplain areas, matters of state interest, and a final land use planning program. (Colorado Division of Local Government 1988).

Land use planning at the regional level is conducted by two regional planning commissions: one is the Denver Regional Council of Governments (DRCOG), which covers the eight-county Denver Metropolitan Region, including Adams County; the other is the Northeastern Colorado Association of Local Governments, which includes Morgan and Washington counties. According to state law it is the duty of a regional planning commission to make and adopt a regional plan for the physical development of the territory within the bounds of the region (Denver Regional Council of Government 1988). The Denver Regional Council of Governments (DRCOG) was created in 1955 as a voluntary association of 43 local governments and is chartered with the promotion of regional cooperation and coordination among local governments and between levels of government and the performance of regional planning for the eight-county area as authorized by statute (Denver Regional Council of Government 1988; 1986). Through the years DRCOG has developed a planning process that meets a broad range of areawide planning needs, including areawide development planning, issues-focused strategic planning, and guidance for regional infrastructure. Key plans prepared by DRCOG include the Regional Development Framework (RDF) and Regional Issues Analysis (RIA), each of which complements the other, the 2010 Regional Transportation Plan, the 1981 updated Clean Water Plan, and the Regional Acquisition Systems Plan (Denver Regional Council of Government 1988).

The Northeastern Colorado Association of Local Governments (NCALG) is the successor organization to the Northeastern Colorado Council of Governments that was formed in 1972 (Northeastern Colorado Association of Local Governments 1988). NCALG is a voluntary association of 27 local governments whose purpose is to contribute to the orderly physical, social, and economic development of northeastern Colorado and all of the municipalities and counties therein, in accordance with the expressed wishes of the area's county commissioners, mayors, town trustees, and city council persons. NCALG provides technical assistance, including enterprise zone administration to its members and is also involved in the provision of health and social service delivery programs. The association's key planning document is the recent Region One - Northeastern Colorado Overall Economic Development Plan (1988).

Under Colorado State Law, the majority of land use responsibility and control is placed at the local level of government (Colorado Division of Local Government 1988). Counties and municipalities have the duty to prepare and adopt comprehensive plans for the physical development of their respective jurisdictions although the General Assembly set no deadline for the preparation of such plans. Establishment of county planning commissions who, in turn, have adopted subdivision regulations that have been required since 1972, and establishment of municipal planning commissions and their attendant regulation of subdivisions is optional.

Both Morgan and Adams counties have comprehensive plans for their respective jurisdictions; Washington County does not, given its predominantly low growth and rural character. All three counties rely on zoning and subdivision regulations as a way to guide growth and development. The SSC project area is zoned as "agricultural" in all three counties.

Morgan County has recently prepared its Comprehensive Plan (1988) in anticipation of future growth spurred not only by the SSC project, but also other proposed developments. The Morgan County Comprehensive Plan consists of the following six elements: 1) Environmental Resources and Hazards Plan, 2) Future Land Use Plan, 3) Parks, Recreation, and Open Space Plan, 4) Utilities Plan, 5) Public Facilities and Services Plan, and 6) Circulation and Transportation Plan. Of particular note is the creation of three supplements to the Future Land Use Plan that are patterned after three distinct types of areas where growth occurs in the county: 1) the unincorporated rural areas, 2) the South Platte River/Interstate 76 corridor with its urbanizing characteristics, and 3) the activity center areas of Fort Morgan/Log Lane Village, Brush, and Wiggins.

The Adams County Comprehensive Plan (1987) consists of the following five elements: 1) Future Land Use Plan, 2) Waste Management Plan, 3) Parks, Open Space and Trails Plan, 4) Mineral Extraction Plan, and 5) Transportation Plan. Of particular note is the Future Land Use Plan for the area affected by the SSC project.

E. Existing Land Use

Existing land uses in the three-county SSC project area have not changed appreciably over the years (Morgan County 1988; Adams County 1988). The 11-mi-wide, 31-mi-long South Platte River/Interstate 76 corridor contains most of the area's developed land uses, including the population centers/service support areas of Wiggins (on the west) and Fort Morgan/Log Lane Village, Brush, and Hillrose (on the east) (Morgan County 1988). Of the four towns, Fort Morgan is the largest and is the area's governmental and industrial center, with a modular home manufacturing facility, a beef slaughterhouse, a sugarbeet processing plant, and a raceway in the vicinity. In addition, the Pawnee Generating Station, located between Fort Morgan and Brush, is approximately 3 mi south of U.S. Highway 34/6. Brush is the next largest community with major uses such as a livestock exchange, a bean factory, an industrial park, and a hospital. Wiggins and Hillrose are both agricultural/agribusiness support communities.

The planning corridor also includes several major reservoirs, state and private wildlife refuge areas, and sand and gravel operations along the South Platte River (Morgan County 1988). The Union Pacific/Burlington Northern Railroad extends the length of the corridor (Morgan County 1988). Outside this corridor, primary land uses continue to be either agricultural (dryland farming) or ranching (open space/grazing) related, with oil fields and associated drilling operations scattered throughout the area (Morgan County 1988; Adams County 1987).

F. Planned Future Land Use

The Morgan County Comprehensive Plan (1988) recognizes three major developments besides the SSC project that have the potential for significant impact. They are: 1) construction of the BFI hazardous waste disposal site near Last Chance in neighboring Washington County, 2) construction of Narrows Dam located northeast of Fort Morgan, and 3) construction of Pawnee Generating Station Unit II. The first project is under construction, with a completion date set for early 1989. The latter two projects, while slated for future development, are contingent on a variety of conditions being met; hence, construction start dates are not yet known.

The Adams County Comprehensive Plan (1987) calls for the SSC project area to continue under an "Agriculture-Production" use where neither urbanization nor rural subdivisions will be permitted. This policy is meant to preserve the eastern portion of the county for long-term agricultural production and to prevent police, fire, and school service demands from increasing in areas where they would be difficult and costly to provide.

G. Community Values/Attitudes

The Morgan County Board of County Commissioners and the Planning and Zoning Commission recognize the need for providing ordered development (Morgan County 1988). They also recognize the need to preserve the natural features associated with the South Platte River, including prime agriculture production lands and cultural resources such as archaeological and historic sites. At the same time they need to encourage a diversified economic base that enhances the socioeconomic life of its residents.

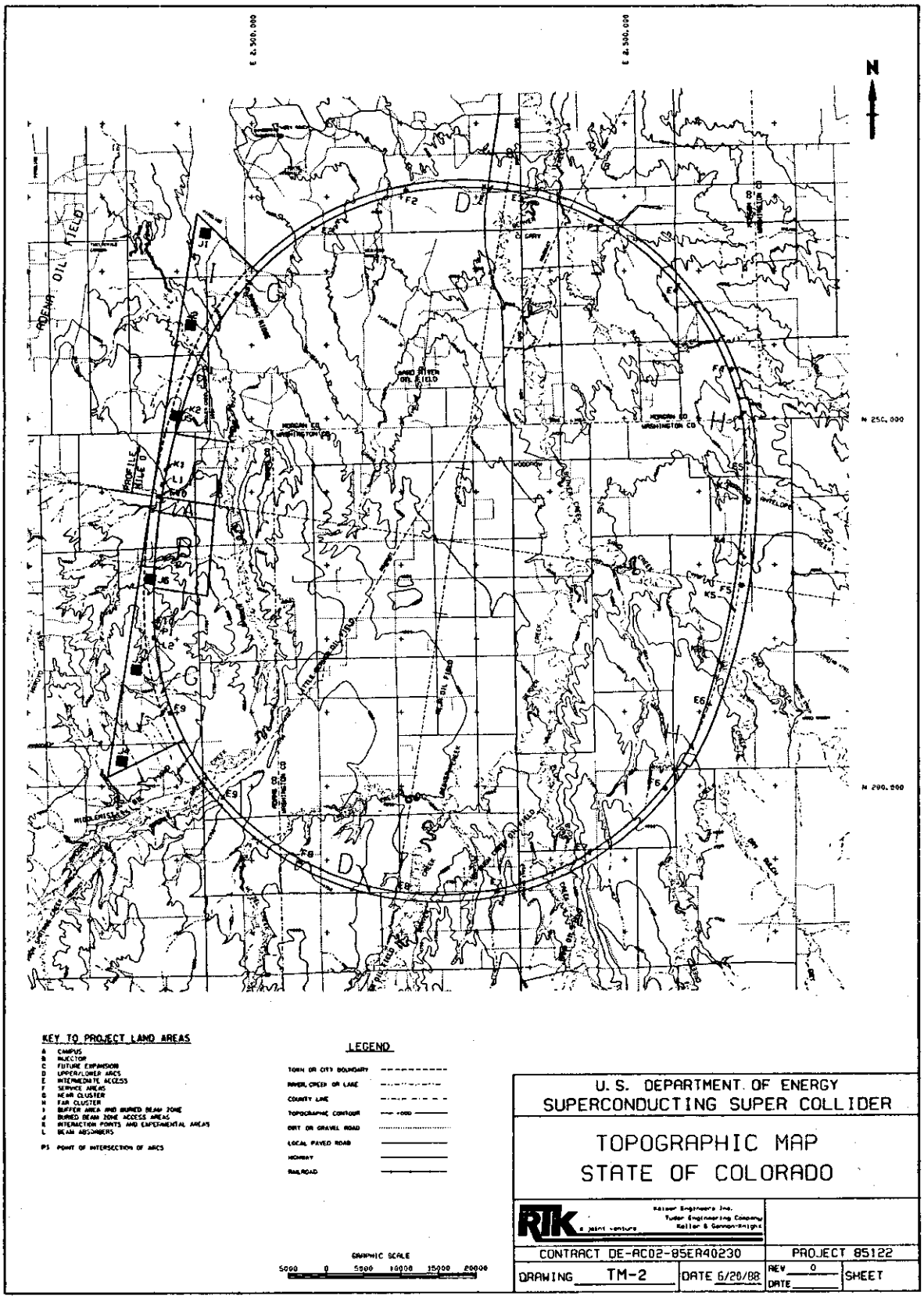
5.2.10.2 Local Setting

A. Project Level

The proposed SSC site is located in northeastern Adams County, southeastern Morgan County, and western Washington County on unincorporated land (see Figure 5.2.10-1). The SSC project study area contains no federal parklands, such as national parks, monuments, preserves, rivers, scenic and historic trails, national historic sites, national recreation areas, or parkways; no federal or state-designated wilderness areas; and no federal or state-designated wild and scenic rivers. Community values and attitudes toward the SSC project are generally positive, as evidenced by the relative dearth of letters received from the public as part of the DOE public scoping process (see Volume III: Methodology for Site Selection). Of the 22 letters received by the DOE as of mid-May, 1988, ten letters were in favor of the project; eight letters offered no opinion about the project; and four letters were opposed to the project. The types of issues raised in these letters included: labor supply changes, disruption to agriculture, road and congestion problems, state and local

Figure 5.2.10-1

THE PROPOSED COLORADO SSC SITE REGION



tax base changes, air pollution, effects on endangered species, effects on surface waters and wetlands, and impacts to archaeological and historical resources.

B. Facility Level

Table 5.2.10-1 presents land use data for each of the major SSC project facilities. This includes information on county locations, ownership, existing zoning designations, existing land use, and future planned land use. Narrative descriptions are provided below.

1. SSC Project Near Cluster Quadrant

Land use of the near cluster is characterized by a mixture of dryland farming, grassland range, and oil and gas extraction. A scattering of active and inactive oil and gas wells is the only deviation from a homogeneous pattern of agricultural/rangeland, with associated residential uses. The site lies in unincorporated areas of Morgan and Adams counties and is zoned for agricultural use A-2 and A-3 respectively. The Morgan County Comprehensive Plan (1988) and the Adams County Comprehensive Plan (1987) call for a continuation of the area's existing agricultural character. The quadrant is almost entirely privately owned as large farm parcels, excluding a portion of state property in the southern buffer area and buried beam zone I. There are no future planned land use changes or project proposals affecting the site.

a. Campus Area A

Campus area A consists of nonirrigated cropland within Adams County. There are four inactive oil wells (on the site), and the area is bisected by a north-south running section line road. No residences, structures, or other improvements exist on this privately owned farmland. The eastern half is designated as a high-potential dry cropland of statewide importance (see Section 5.2.8.3), while the western portion is crossed by minor stream channels. Zoning is A-3 (agricultural) and the Adams County Comprehensive Plan has no plan to change the area's agricultural use.

b. Injector Area B

Injector area B is also entirely private, nonirrigated cropland in Adams County similar in character to that of area A. Approximately 50% of the area is classified in high-potential dry cropland of statewide importance, while the remainder is affected by tributaries to Badger Creek. Two minor section line roads cross the site, as well as overhead transmission lines. A natural gas line runs across the southwest corner. There is one active oil well in the area, as well as 12 dry and abandoned wells. In the surrounding areas to the south and east are three more dry and abandoned oil wells within 1,000 ft of the area. No residences, structures or other improvements are found; however, two residences are located within 0.5 mi to the east and west of the site, respectively. Zoning is A-3 and there are no plans to change the existing land use.

Table 5.2.10-1

LAND USE DATA - SSC PROJECT COLORADO SITE FACILITY

SSC Project Facility	County Location	Ownership Patterns	Existing Zoning	Existing Land Use	Future Planned Land Use
Near Cluster Quadrant					
Campus area A	Adams	Private	A-3	Cropland	Same
Injector area B	Adams	Private	A-3	Cropland	Same
Future exp. area C	Adams	Private	A-3	Cropland/rural	Same
BABBZ area I	Adams/Morgan	Private/public	A-3/A-2	Agr/rural	Same
J1	Morgan	Private	A-2	Range	Same
J2	Morgan	Private	A-2	Range	Same
J3	Adams	Private	A-3	Cropland	Same
J4	Adams	Private	A-3	Range	Same
Near Cluster Ring G	Adams/Morgan	Private	A-3/A-2	Agr/rural	Same
E1	Morgan	Private	A-2	Agr	Same
E10	Adams	Private	A-3	Agr	Same
F1	Morgan	Private	A-2	Agr	Same
F9	Adams	Private	A-3	Cropland	Same
F10	Adams	Private	A-3	Agr	Same
J5	Morgan	Private	A-2	Rural	Same
J6	Adams	Private	A-3	Cropland	Same
K1	Adams	Private	A-3	Cropland	Same
K2	Morgan	Private	A-2	Cropland	Same
Far Cluster Quadrant					
Far Cluster Ring H	Washington/Morgan	Private/public	AG/A-2	Cropland/range	None/same
E5	Washington	Private	AG	Cropland	None
E6	Washington	Private	AG	Range	None
F5	Washington	Private	AG	Cropland	None
K3	Washington	Private	AG	Range	None
K4	Washington	Private	AG	Range	None
K5	Washington	Private	AG	Cropland	None
K6	Washington	Private	AG	Range	None
Lower Arc Quadrant					
Lower Arc Ring D	Adams/Washington	Public/public	AG/A-3	Agr	None/same
E7	Washington	Private	AG	Agr	None
E8	Washington	Private	AG	Agr	None
E9	Adams	Private	A-3	Agr	Same
F6	Washington	Private	AG	Agr	None
F7	Washington	Public	AG	Agr	None
F8	Washington	Private	AG	Agr	None
Upper Arc Quadrant					
Upper Arc Ring D	Morgan	Private/public	A-2	Agr/rural	Same
E2	Morgan	Private	A-2	Range	Same
E3	Morgan	Private	A-2	Cropland	Same
E4	Morgan	Private	A-2	Range	Same
F2	Morgan	Private	A-2	Range	Same
F3	Morgan	Private	A-2	Range	Same
F4	Morgan	Private	A-2	Range	Same
Roads and rail	Adams/Morgan/ Washington	Private	A-2/A-3/AG	Agr/rural	Same/none
Utilities	Adams/Morgan/ Washington	Private	A-2/A-3/AG	Agr/rural	Same/none

Sources: Adams County 1988; Adams County Revisions to 1987; 1988; Morgan County 1981; Morgan County Revisions 1981; Morgan County 1988; Washington County 1983.

c. Future Expansion Area C

Future expansion area C is also private nonirrigated cropland, with a small drainage running diagonally between two areas designated as high potential dry cropland of statewide importance. One active oil well is found here, as well as six dry and abandoned wells. Just beyond the site, within 1,000 ft to the north and east, are one active and three dry oil wells. A farm complex consisting of two residences, six barns, 20 silos, four water wells, and utility and road access is located within and just beyond the northeast corner of the site. A section line road running north to south bisects the area. Approximately 0.5 mi north of this lies another residence within the Morgan County portion of area C. Zoning here is also A-3 and there are no proposed land use changes.

d. Buffer Area and Buried Beam Zone I

1) North Buffer Area and Buried Beam Zone I, including Buried Beam Zone Access Areas J1 and J2

The north buffer area and buried beam zone I is also privately owned, nonirrigated cropland and range; the southern 30% being cropland, the northern 70% is rangeland. Excluding the extreme southern tip in Washington County, nearly all of this area lies in Morgan County. Approximately 15% of the site is designated as high potential dry cropland of statewide importance. The area is traversed by a few minor roads, overhead transmission lines, an oil line in the northern tip, and Badger Creek through the center. Five inactive oil wells, a water well, and a residence are found in the area, while within 1,000 ft to the west is one inactive oil well. Zoning is agricultural (A-2, A-3) and there are no changes planned for the entire area.

Site J1 is rangeland in Morgan county, containing no residences or structural improvements. A 230-kV transmission line enters the site from the west, turns 90 degrees, and exits to the north. An inactive oil or gas well is located on the northwest corner, and just beyond 1,000 ft to the north is an oil pipeline running east to west.

Site J2 is also rangeland within Morgan County; however, the northern 80% has been designated as high-potential dry cropland of statewide importance. No residences, structures or other improvements are within this area, or the 1,000-ft buffer zone. A minor drainage does cross the site, and Badger Creek is located approximately 1,000 ft to the southwest.

2) South Buffer Area and Buried Beam Zone I, Including Buried Beam Zone Access Areas J3 and J4

The south buffer area and buried beam zone I is located entirely within Adams County, with agricultural land use of 40% range and 60% nonirrigated cropland. Approximately 30% of the area, designated as high-potential dry cropland of statewide importance, is found in several large scattered patches. The bulk of the land is privately owned;

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however, there is a section of state property on the southern edge accounting for about 15% of the area. There are no residences or other structural improvements on the site; one residence with a water well is located to the west within 1,000 ft. Several infrastructure improvements are found, including a 10-inch natural gas pipeline, some minor electrical transmission lines, and a section line road. Several minor drainages are also encountered. There are 24 inactive oil or gas wells in the area, as well as one active and six inactive wells within 1,000 ft to the west and south. Zoning for the entire area is A-3 (agricultural) and there are no changes in land use planned for the existing agricultural/rural use.

Land use at site J3 is nonirrigated cropland with no residences, structures, or other improvements. Four inactive oil or gas wells are found outside the site within a 1,000-ft buffer zone, and areas designated as high-potential dry cropland of statewide importance are to the south and northeast.

Site J4 lies almost entirely within state-owned property, and consists mainly of ranchland in an area designated as high-potential dry cropland of statewide importance. There are three inactive petroleum wells outside the site, within 1,000 ft, and a 10-inch natural gas pipeline runs across the northwest corner. There are no residences, structures, or other improvements on or near the area.

e. Near Cluster Ring G, Including Intermediate Access Areas E1, and E10, Service Areas F1, F9, and F10, Buried Beam Access Areas J5, and J6, and Interaction Points and Experimental Areas K1 and K2.

Land use of the near cluster ring is approximately 80% nonirrigated cropland and 20% rangeland. Combined sections of high-potential dry cropland of statewide importance account for about 50% of the area, and the arc is entirely privately owned. The arc is crossed by minor roads, overhead transmission lines, 10-inch natural gas pipelines, and Badger Creek. The area also hosts a number of farm structures, three possible residences, and a number of active and inactive gas and oil wells. The area, zoned "agricultural," includes parts of both Adams and Morgan counties. There are no changes planned for the existing land use.

Sites E1, E10, F1, F9, F10 J5, J6, K1, and K2 all consist of privately-owned unimproved farmland or rangeland with few exceptions. Site F9 is located within 1,000 ft of a 10-inch natural gas pipeline, as is J6, which also includes an inactive petroleum well. Site J5 contains a vacant house and barn. Sites F9, J5, J6, K1, and K2 are in areas designated as high-potential dry cropland of statewide importance. Sites E1, F1, J5, and K2 are located in Morgan County and zoned A-2. The remainder are in Adams County and zoned A-3. Both designations are agricultural and there are no land use changes planned for either.

2. SSC Project Far Cluster Quadrant, Including Far Cluster Ring H, Including Intermediate Access Areas E5 and E6, Service Area F5, and Interaction Points and Experimental Areas K3, K4, K5, and K6.

The far cluster quadrant is located in Washington and Morgan counties, and consists largely of nonirrigated agriculture and rangeland uses. Approximately 60% of the arc is designated as high-potential dry cropland of statewide importance. About 15% of the total area is state owned, the remainder is private property. One residence and associated farm structures lie within the site, and at least two more are within 1,000 ft. Several more residence/farm complexes can be found within 1 mi to the east and west. One oil well and eight dry and abandoned wells are within the area; two active and 10 inactive petroleum wells are within 1,000 ft. The site is also crossed at various points by minor roads, overhead transmission lines, a 10-inch natural gas pipeline, and the Sand Creek drainage. Zoning is agricultural in both counties and there are no land use changes to the agricultural/rural use in Morgan County. (No plans exist for Washington County).

Sites E5, E6, and F5 are all on private property in Washington County. E5 and F5 are unimproved rangeland; E6 is located on unimproved dry cropland. A portion of F5 is designated as high-potential dry cropland of statewide importance. Excluding an overhead transmission line to the east of F5 and an inactive petroleum well near E5, there are no residences, structures, or improvements on or within 1,000 ft of E5, E6, or F5. Beyond this buffer zone, there are two residences and several farm structures of significance about 0.5 mi southwest of E5 near Antelope Creek.

Sites K3, K4, K5 and K6 are all located on private property in Washington County, which is zoned agricultural. No future land use plans are in effect for the area. All four of the sites are considered to be high potential dry cropland of statewide importance with K5 being under nonirrigated cropland use; the remaining three sites are rangeland. An inactive petroleum well is found northeast of K4 and an overhead electrical line and section line road runs along its east edge. Site K3 is bounded to the north by nonirrigated cropland, no improvements are within 1,000 ft. A section of state-owned property lies to the south of K5, and improvements within 1,000 ft include an inactive oil well to the southeast and a residence and farm structures to the north. While K5 is under cropland use, surrounding areas to the north and south are largely rangeland. One inactive oil well approximately 1,000 ft north of K6 represents the only improvement near that site.

3. SSC Project Upper Arc Quadrant

Upper Quadrant D, Including Intermediate Access Areas E2, E3, and E4, and Service Areas F2, F3, and F4.

The upper arc consists of rangeland, and irrigated and nonirrigated cropland as well as several residences, and petroleum extraction uses (oil wells) characteristic of the region. Approximately 15% of this

area is irrigated cropland, which tends to be clustered in the central sections near State Highway 71 and Beaver and Badger creeks; the remainder is largely rangeland. Of the irrigated lands, 60% is considered prime farmland and of federal importance. Less than 5% of this arc is farmland of statewide importance, and about the same percentage is state property, the rest being privately owned. Within the arc and 1,000-ft buffer zone are roughly ten residences, associated farm structures, and water wells concentrated mostly in the central irrigated areas. Other improvements include one natural gas and two oil pipelines, minor farm roads, State Highway 71, and a 115-kV and several smaller overhead transmission lines. Eight inactive oils wells are located in the arc area while within a 1,000 ft buffer zone are one active and twenty-seven inactive wells. The upper arc quadrant is located entirely within Morgan County and is zoned A-Z (agricultural). According to the Morgan County Comprehensive Plan, there are no changes planned in land use.

E2, E3, E4, F2, F3, and F4 are all on private property, with improvements concentrated near E3 and F3. Excluding minor roads, E2, E4, F3, and F4 consist of unimproved rangeland, and there are no structures, residences, or improvements in or around these four sites. E3 is considered prime farmland of national importance, and there is one residence and several farm structures within 1,000 ft, as well as an overhead transmission line. F3 is located on irrigated cropland and, within 1,000 ft of this are one residence and several farm structures, one active oil well, one inactive well, a 4-inch natural gas pipeline, an overhead transmission line, and an area of designated prime farmland. One dry and abandoned oil well is located within 1,000 ft to the northeast of site F2.

5. Planned SSC Project Road and Railroad Networks

Location descriptions of planned SSC project road and rail improvements are provided in Section 1.2.1.2. Adjacent land use patterns for the road and railroad network are no different than for what has been generally described for the area. An environmental assessment of the proposed major campus access roads is provided in a separate study prepared by the Colorado Department of Highways (1988). No future plans constrain these areas from further improvement.

6. Planned SSC Project Utility Improvements

Location descriptions of planned SSC utilities are provided in Section 1.2.1.2. Adjacent land use patterns for the road network are no different than for what has been generally described for the area. There are no future plans that constrain these areas from further improvement.

5.2.10.3 Prime Agricultural and Other Economically Important Soils

A. Soil Conditions at the Proposed Colorado SSC Site

The intersection of the three counties, Adams, Morgan and Washington, hosting the proposed site is within the Colorado Piedmont section of the Great Plains physiographic province. This region is characterized by soils that formed in wind-blown deposits, in alluvium on terraces, and floodplains. It predominantly calcareous and of variable mechanical composition. The characteristic soils belong to the suborder Argis with Orthids, Orthents, Psamments and Ustolls as frequent contributors to the regional soil cover. As a suborder of Mollisols, Ustolls are in general the most fertile of all these categories, if subjected to comparable agrimanagement practices.

Lack of water is of paramount importance in understanding soil conditions at the SSC site. The continental, semiarid climate of the region allows only limited leaching of sparingly soluble constituents from the soil. Thus, calcium carbonate accumulated in the lower soil horizons of many soils. The low precipitation of the area (approximately 14 inches) coupled with specific temperature conditions, results in soils that manifest either an aridic or an ustic (bordering to aridic) moisture regime. This means that the soil is dry and does not contain water that can be extruded at pressures lower than 1.5 MPa, at some depth between 1 and 2 ft below surface for more than 90 days in most years. The aridic moisture regime is generally characterized by dryness during the period when the soil temperature is in excess of 41°F. The ustic soil moisture regime is not as drastic and restrictive to plant growth as the aridic one; the dry period lasts less than 50% of the time when the temperature is over 41°F. The area is covered by soils with a range of moisture conditions between restrictively dry and marginally moist. The total precipitation indicates that without irrigation only a limited number of crops can be grown. Wheat in a fallow rotation, grain, forage sorghum, and corn are a few of the crops that can be produced on some of the good soils of the site.

B. Soil Units and Estimated Prime Farmlands

Soil units that correspond to the fee simple area are considered in this section. This includes areas A, B, C, E (2,3,4,7,8, and 9), F (2,3, 4,6,7, and 8), G, H (including the bypass) and J (1,2,3, and 4). Table 5.2.10-2 presents soil units for each of the three counties.

Table 5.2.10-2 also shows that almost two-thirds of the affected land is Adams County. Moreover, one particular soil unit, Weld loam, with a 1 to 3% slope, is present in all three counties, and covers 45% of all affected soil acreages.

Many of the soils introduced in Table 5.2.10-2 have fair to good intrinsic characteristics for producing crops. However, the lack of water restricts their use. The limited precipitation and the relatively high evaporativity leave barely enough water in the ground for plant growth and development.

Table 5.2.10-2

SOIL UNITS AND ACREAGES OF AFFECTED LANDS AT THE COLORADO SSC PROPOSED SITE

Soil Name	Affected Acreage
Adams County	
Adena-Colby association, gently sloping	446.4
Adena-Colby association, moderately sloping	429.2
Arvada loam, 0-3% slope	60.0
Colby loam, 5-20% slope	290.0
Gullied land	49.5
Loamy alluvial land	441.9
Satanta loam, 1-3% slope	21.0
Shingle-Renohill loams, 5-25% slope	76.5
Weld loam, 1-3% slope	2,842.9
Weld-Deertrail complex, 0-3% slope	33.7
Wiley-Adena-Renohill complex, 3-20% slope	186.2
Total in Adams County	4,877.3
Morgan County	
Ascalon sandy loam, 1-3% slope	33.3
Ascalon sandy loam, 3-5% slope	24.8
Ascalon sandy loam, 5-9% slope	18.3
Colby-Adena loams, 3-5% slope	30.1
Colby-Adena loams, 5-9% slope	20.8
Fort Collins loam, 1-3% slope	77.9
Haverson loam, 1-3% slope	38.4
Limon clay, 0-1% slope	0.9
Nunn loam, 1-3% slope	22.7
Truckton loamy sand, 1-3% slope	49.7
Valentine sand, hilly	38.7
Vona loamy sand, 0-3% slope	106.4
Vona loamy sand, 5-9% slope	101.8
Vona sandy loam, 1-3% slope	7.4
Vona sandy loam, 5-9% slope	9.5
Weld loam, 1-3% slope	309.5
Total in Morgan County	890.2
Washington County	
Ascalon Fine sandy loam, 0-3% slope	396.2
Ascalon Fine sandy loam, 3-9% slope	239.7
Colby loam, 6-12% slope	1.3
Colby-Norka loams, 5-9% slope	8.5
Colby-Ustic torriorthents complex, 9-30% slope	15.7
Haverson loam	97.9
Haverson silty clay loam	88.3
Haxtun loamy sand	4.4
Haxtun sandy loam	68.8
Keith-Kuma very fine sandy loams	77.8
Keith-Kuma complex	17.6
Nunn clay loam	0.5
Rago silt loam	11.1
Sampson loam	118.9
Stoneham loam, 6-9% slope	3.4
Table Mountain loam	34.6
Vona loamy sand, 3-9% slope	29.6
Vona Sandy Loam, 3-9% slope	323.3
Weld silt loam	385.0
Total in Washington County	1,922.6
Total General	7,690.1

When the precipitation in two consecutive years is below 11 inches per year, which happens on average once in a decade, most dryland crops fail. Another group of soils in Table 5.2.10-2, the Colby loam and Wiley-Adena-Renohill complex units in Adams County and Vona loam in Washington County, has considerable limitations that prevent them from being categorized as fair to good quality. These soils developed primarily on hilly topography, thus the erosion hazard is substantial. The same is true for the Aryda loam and Weld-Deertrail Complex in Adams County for which the main limitation is the presence of an alkali condition evidenced both by high Sodium Absorption Ratio (SAR) or Exchangeable Sodium Percentage (ESP) values and also by physical (morphological) features. Some other soils are so coarse that even if water were available they could not hold enough of it for efficient plant growth.

Table 5.2.10-3 presents a compilation of fair to good soils from Table 5.2.10-2. Although related to the issue of prime farmlands, soils listed in this table do not represent, as a block, prime farmlands.

Table 5.2.10-3 indicates that roughly two-thirds of the total affected lands (5,181 of 7,690 acres) are at least of fair farming quality and consequently of significance to the agricultural industry of the state.

Considering the prime farmland characteristics of these soils and using soil information pertinent to the prime farmland criteria (7 CFR Section 657.5, 1986), approximately 90% of the acreage included in Table 5.2.10-3 would be intrinsically prime farmlands if a dependable irrigation system were available. Since this is not the case, prime farmland at the Colorado site is approximately 2,000 acres.

In terms of soil classification at the Great Group taxonomic level, it is of interest that 87% of lands qualified as fair to good quality are Argiustolls, Haplustolls, or Paleustolls, subdivisions of Ustolls (Mollisols).

5.2.10.4 Other Pertinent Soil Characteristics

A. Soil Wind Erosion Hazard

The soil cover at the proposed Colorado SSC site is made up of units developed predominantly in wind-blown parent materials. The effect of wind-generated erosion/sedimentation episodes is felt even today. Thus many areas are vulnerable to soil erosion by wind.

A useful measure of the vulnerability of a soil to wind action at a particular location is the product "I x C", where I is the soil erodibility and C is a climatic factor. The hazard of wind erosion is considerable when this product takes values in excess of 60. Although monthly C values are available, an annual average C value for the SSC area can be estimated as being equal to 85 (Hayes Dye P.C.). Thus any soil that is characterized by an I value in excess of 0.7 would be vulnerable to wind erosion; these would be soils for which the percentage of wind-stable aggregates (soil aggregates larger than 0.84 mm) would be at most equal

to 30. The Soil Conservation Service in Denver, Colorado, has developed I values for each soil type of the state based on textural classes, organic matter content, prevailing moisture conditions at the soil surface, aggregate characteristics, etc. In terms of the effect of these variables on I, the textural characteristics are of primary importance; in general, soils texturally classified as sandy loams or coarser have an I value equal to or in excess of 0.86; soils texturally classified as loams or finer have an I value equal to or smaller than 0.56.

B. Wind Erosion Vulnerability of Fair to Good Soils

Table 5.2.10-3 has introduced valuable farmlands in the area of the proposed SSC. Although valuable, these are not outstanding agricultural lands. Most of them are classified as Capability Class III, comprising soils with severe limitations for farming (when the limitation is mitigated they become Class II soils, i.e., only moderately limited). At the SSC site, quite often the limitation of the soil when not irrigated is its susceptibility for wind erosion. Such is the case with the Ascalon, Haverson, and Keith-Kuma soil series.

The wind erosion hazard is partially mitigated when the soil is irrigated, a management practice that has the indirect effect of modifying the climatic parameter at a submacroscale level. Irrigation enhances production of biomass. This retards wind erosion.

Without irrigation, soil blowing is a problem of considerable magnitude in the SSC area, despite the fact that improved soil conservation measures have been implemented in the last several decades. Many techniques used by farmers to minimize wind blowing on their farmlands rely on the gained experience that minimal land disturbance results in minimal wind erosion, all other factors being kept unchanged. One such technique is minimum tillage, keeping the soil covered as long as possible and using only subsurface implements that maintain crop residues on the soil surface.

C. Identification of Soils with High Susceptibility to Wind Erosion at the SSC Site

The search for wind-erodible soils (soils with an I value over 0.7-0.8 but below approximately 1.2) and highly wind-erodible soils (soils with an I value over approximately 1.2), lead to the following findings:

The mapping units in the Near Cluster G area (equal to 2,010.2 acres) have an average I value equal to 0.672, practically the same as for the whole fee simple area (7,690.1 acres) equal to 0.652. However, large discrepancies between different sections of region G exist. Starting with the uppermost extremity of the G area and following southwest along it for 2 mi, the area is covered by highly wind-erodible soils of the Vona and Truckton soil series. South of this region of high vulnerability there is an island (31 acres) of erodible Colby soil which overlaps the service area F10.

Table 5.2.10-3

FARMLANDS OF FAIR TO GOOD QUALITY AT THE COLORADO SSC SITE

Soil Type or Phases/Soil Families	Acreage
Adena-Colby association, gently sloping/fine-loamy, mixed, mesic Ustollic Paleargids, and fine-silty, mixed (calcareous) Ustic Torriorthents	446.4
Ascalon sandy loam, 0-3% slope/fine-loamy, mixed, mesic Aridic Argiustolls	429.5
Ascalon sandy loam, 3-5% slope/fine-loamy, mixed, mesic Aridic Argiustolls	24.8
Ascalon fine sandy loam, 3-6% slope/fine-loamy, mixed, mesic Aridic Argiustolls	120
Colby-Adena loams, 3-5% slope/fine-silty, mixed (calcareous) Ustic Torriorthents, and fine-loamy, mixed, mesic Ustollic Paleargids	30.1
Fort Collins Loam, 1-3% slope/fine-loamy, mixed, mesic Ustollic Haplargids	77.9
Haverson loam to silty clay loam, 0-3% slope/fine-loamy, mixed (calcareous), mesic Ustic Torrifluvents	130
Haxtun loamy sand to sandy loam/fine-loamy, mixed, mesic Pachic Argiustolls	73.2
Keith-Kuma Complex, loam to silt loam/fine-silty, mixed, mesic Aridic Argiustolls, and fine-silty, mixed, mesic Pachic Argiustolls	17.6
Keith-Kuma, very fine sandy loam/fine-silty, mixed, mesic Aridic Argiustolls, and fine-silty, mixed, mesic Pachic Argiustolls	77.8
Nunn loam to clay loam/fine, Montmorillonitic, mesic Aridic Argiustolls	23.2
Rago silt loam/fine, Montmorillonitic, mesic Pachic Argiustolls	11.1
Sampson loam/fine-loamy, mixed, mesic Pachic Argiustolls	118.9
Satanta loam, 1-3% slope/fine-loamy, mixed, mesic Aridic Argiustolls	21.0
Table Mountain loam/fine-loamy, mixed, mesic Pachic Haplustolls	34.6
Vona sandy loam, 1-3% slope/coarse-loamy, mixed, mesic Ustollic Haplargids	7.4
Weld loam to silt loam, 1-3% slope/fine, montmorillonitic, mesic Aridic Palenustolls	3,537.4
TOTAL ACREAGE	5,180.3

The mapping units in the Far Cluster H area (equal to 1,980.1 acres) have an average I value equal to 0.757, in excess of 0.7, the breakthrough value above which soils in the SSC area can be subjected to wind erosion. There is little variability of wind erosion hazard among different soil mapping units that comprise the H area. The soil cover in the central and upper two-thirds of the H area is dominated by Ascalon soil series with an I value of 0.8 to 0.9, thus making this whole subarea of H a wind-erodible zone. Just northeast of the service area F5 there is a 30-acre unit of Vona loamy sand of high wind erosion hazard.

The mapping units in the Injector B area (equal to 1,700.2 acres) have an average I value equal to 0.591. Less than 7% of the B area is covered with soils that have I values slightly in excess of 0.7.

The mapping units in the Campus A area (equal to 349.9 acres) have an average I value equal to 0.574; 15% of the area is covered with soils that have I values of 0.8 to 0.9. These are the Colby loams.

The mapping units in the Future Expansion C area (equal to 1,450.1 acres) have an average I value equal to 0.528. Only 2% of the area is made up of soils classified as wind erodible.

Among the abort/external beam accesses (J1, J2, J3, and J4; J5 and J6 have been included in G), J1 is covered by Valentine and partially by Vona soils with a weighed I value of around 2.0. The six service and intermediate access areas (F and E respectively) located in the upper arc are part of the larger area of wind blown sands. E2, F2, F3, and E4 are located over the highly erosive Valentine, Vona, and Truckton soil series.

5.2.11 Socioeconomics and Infrastructure

5.2.11.1 Socioeconomics

SSC development and operation in eastern Colorado is likely to affect socioeconomic conditions in as many as 14 counties, which for this analysis are considered the region of influence (ROI) (Figure 5.2.11-1). Communities within these counties, especially those around Denver, may provide a sizable portion of the SSC work force and since they are within an hour's drive of the site, would likely house most relocating workers.

Adams, Morgan, and Washington counties, where the SSC facilities would be located and where a large portion of relocating workers would probably choose to reside, compose the primary impact area. Socioeconomic relationships are discussed for both the ROI and the primary impact area. Treatment of public service and finance issues is focused most closely on the primary impact area, with additional discussion at the state level as required to interpret fiscal relationships between the state and local governments.

A. Economic Activity, Labor Force, and Income

1. Regional Setting

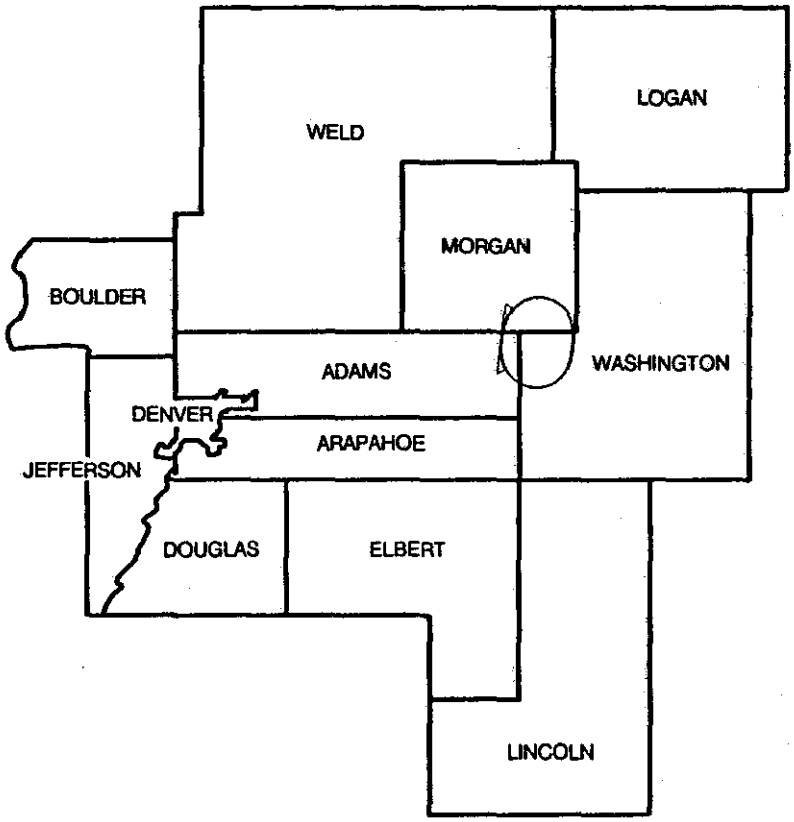
The economy of the Colorado ROI has grown steadily for the past two decades (Table 5.2.11-1). Expansion in the employment base was more than double the national growth rate. Total employment growth in the ROI averaged 4.4% annually between 1969 and 1984, compared with the U.S. annual average of 1.9% (U.S. Department of Commerce, Bureau of Economic Analysis 1986).

Annual employment growth in the Colorado ROI exceeded the average national employment growth rate in every industrial sector from 1969 to 1984 . The mining sector experienced the largest growth with an average annual rate of 10.7%, far greater than the national average of 4.1%. Other leading sectors in ROI employment growth were finance, insurance, and real estate, which grew at a 6.6% annual rate, and services, which posted a 6.0% rate.

Farming was the only ROI sector to experience an overall decline in employment during the 16-yr period. With a 0.9% average annual loss in employment, this decline was consistent with the national trend, which experienced an average annual loss of 1.0%. The manufacturing sector, on the other hand, experienced a national average annual loss of 0.2% but grew in the Colorado ROI at a 3.4% annual rate. Figure 5.2.11-2 shows the distribution of employment in the 11 major industrial sectors in 1984. The dominant sectors of the ROI economy, in terms of employment, were services (with 24.6% of the ROI work force), retail trade (16.3%), government (14.3%), and manufacturing (12.0%).

Figure 5.2.11-1

COUNTIES FOR SOCIOECONOMIC ANALYSIS IN THE COLORADO ROI



Colorado Area Mapped

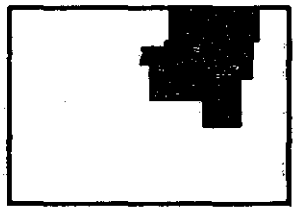


Table 5.2.11-1

HISTORIC ECONOMIC INDICATORS FOR THE COLORADO ROI AND ADAMS, MORGAN AND WASHINGTON COUNTIES

	1969	1974	1979	1984	1987	Average Annual Growth Rate
COLORADO ROI						
Total employment[1]	638,770	820,209	1,030,516	1,220,834	NA[2]	4.4%
Earnings per worker[3]	$22,312	$23,648	$23,006	$22,720	NA	0.1%
Labor force	NA	NA	938,828	1,144,354	1,130,651	3.4%[4]
Per capita personal income[3]	$12,749	$14,900	$16,379	$17,696	NA	2.2%
Unemployment rate	NA	NA	4.3%	4.8%	7.1%	NA
ADAMS COUNTY						
Total employment	46,221	68,550	89,502	104,587	NA	5.6%
Earnings per worker	$21,014	$21,555	$21,298	$20,483	NA	-0.2%
Labor force	NA	NA	132,207	157,310	153,147	3.3%[4]
Per capita personal income	$11,230	$13,314	$13,541	$14,826	NA	1.9%
Unemployment rate	NA	NA	5.0%	5.8%	8.9%	NA
MORGAN COUNTY						
Total employment	8,083	9,646	10,615	12,172	NA	2.8%
Earnings per worker	$18,915	$24,946	$18,739	$15,952	NA	-1.1%
Labor force	NA	NA	10,855	10,589	9,232	-0.5%[4]
Per capita personal income	$10,484	$14,449	$13,600	$14,096	NA	2.0%
Unemployment rate	NA	NA	4.9%	6.8%	9.6%	NA
WASHINGTON COUNTY						
Total employment	2,717	2,660	2,727	3,020	NA	0.7%
Earnings per worker	$16,003	$31,914	$19,509	$17,374	NA	0.5%
Labor force	NA	NA	2,275	2,671	2,512	0.2%[4]
Per capita personal income	$10,844	$20,436	$16,306	$16,238	NA	2.7%
Unemployment rate	NA	NA	2.4%	5.2%	7.1%	NA

Notes: 1. Employment is by place of work.
2. NA - data not available or not applicable.
3. Earnings and income are in constant 1988 dollars.
4. Labor force average annual growth rates are for 1975-1987.

Sources: Department of Commerce, Bureau of Economic Analysis 1986 (employment, earnings, and income); Colorado Department of Labor and Employment 1988, (unemployment rates).

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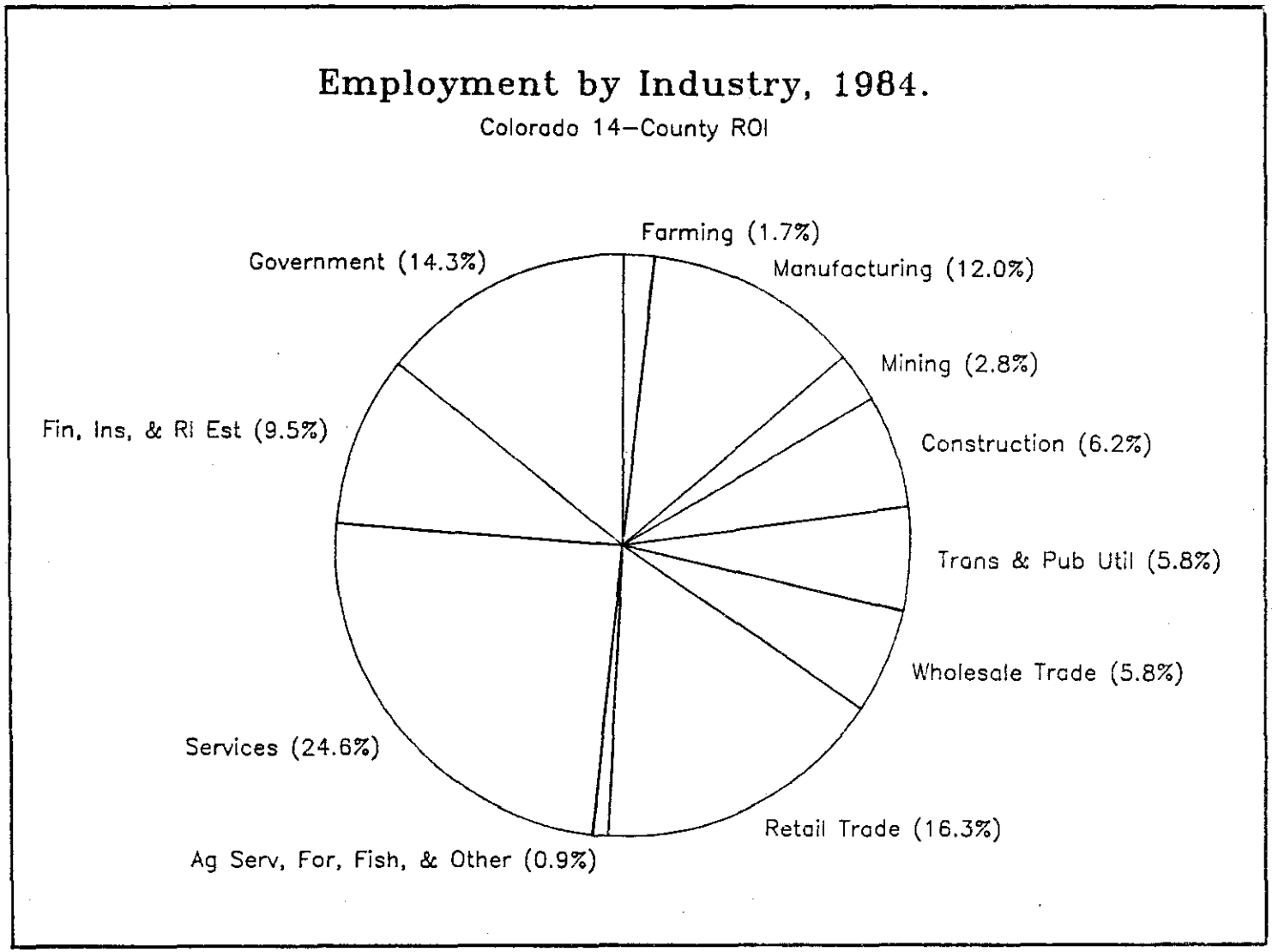

Figure 5.2.11-2
EMPLOYMENT BY INDUSTRY, 1984
COLORADO ROI

Average earnings per worker exceeded the national average in 1984. Average earnings per worker in 1984 were greatest in mining ($37,335) and in and transportation and public utilities ($36,891). All values represent FY 1988 dollars.

During the past decade, unemployment rates in the Colorado ROI consistently remained below the national average; however, in 1987, the unemployment rate of 7.1% surpassed the national average of 6.1% (Colorado Department of Labor and Employment 1988; U.S. Council of Economic Advisors 1988). The labor force in the ROI was 1,130,000 in 1987, down slightly from 1,145,000 in 1984 but has grown since 1975 at an annual rate of 3.4%.

Per capita personal income in the Colorado ROI has exceeded the national average every year since 1969. In 1984 it was $17,696.

Between 1988 and 2000, employment in the ROI by place of work is expected to grow at an average annual rate of 2.2%, from an estimated 1.34 million jobs to 1.73 million. This level of growth is well above the 1.3% national annual growth projection for employment between 1988 and 2000 (U.S. Department of Labor, Bureau of Labor Statistics 1987).

2. Primary Impact Counties

a. Adams County

Adams County has the largest employment and total incomes of the three primary impact counties, although it plays a relatively small role in the ROI because of the economic dominance of Denver and Boulder counties. In 1984, Adams County provided 8.6% of ROI employment and 87.3% of total employment for the three impact counties. The county also collected 11.4% of total personal income in the ROI and 90.6% of total personal income among the primary impact counties. Total employment growth in the county averaged 5.6% annually between 1969 and 1984.

Average annual employment in Adams County grew at rates exceeding the average ROI and national rates in ten of the eleven industrial sectors; only the government sector employment lagged behind the ROI and U.S. average rates. Employment in mining grew fastest from 1969 to 1984 at a rate of 15.3%, followed closely by transportation and public utilities (13.5%), wholesale trade (11.1%), and agricultural services, forestry, and fishing (10.9%). Only employment in the farming sector posted a loss. The rate was 0.3% and not as severe as the ROI (0.9%) or the national (1.0%) average rates of loss. The distribution of employment in the 11 major industrial sectors in Adams County in 1984 was similar to that of the Colorado ROI, though not identical. The strongest sectors were identical to the ROI but ranked differently: retail trade (with 20.5% of the total county work force), services (18.3%), government (14.2%), and manufacturing (13.4%).

Average 1984 earnings per worker in Adams County were $20,483, which were lower than both the national and ROI averages. The highest average earnings per worker were paid in the manufacturing sector at $33,466.

For the past 12 years, unemployment rates in Adams County have been consistently greater than those for the Colorado ROI. Until 1985, however, these rates were lower than the national average; since then the average unemployment rates in the county (8.4 and 8.9% in 1986 and 1987, respectively) surpassed those nationwide (Colorado Department of Labor and Employment 1988). The labor force in the county has grown at an annual rate of 3.3% since 1975. It reached more than 150,000 in 1987.

Per capita personal income in the county typically hovered around the national average and remained well below the ROI average between 1969 and 1984. In 1984, per capita personal income in Adams County ($14,826) was below the ROI average ($17,696) and only slightly greater than the national average ($14,746).

b. Morgan County

Morgan County is the second largest of the three primary impact counties but is not significant in terms of employment or total income. In 1984, the county provided only 1% of ROI employment and 10.2% of total employment in the three impact counties. The county also received only 0.9% of total personal income in the ROI and just 7.4% of total personal income in the primary impact counties. Total employment growth in the county averaged 2.8% annually between 1969 and 1984.

From 1969 to 1984, average annual employment growth was measured at rates slower than the average ROI rates in nine of eleven industrial sectors; only the wholesale trade and manufacturing sectors grew at faster rates. Employment in wholesale trade grew fastest from 1969 to 1984 (12.6%), followed by mining (9.7%) and manufacturing (8.7%). Employment in farming and agricultural services, forestry, and fishing sectors posted losses, at rates of 1.6% and 1.8%, respectively. Because the county is predominantly rural, the distribution of employment in its eleven major industrial sectors in 1984 was less than that of the ROI. The most dominant sectors in county employment were services (with 18.1% of the total county work force), retail trade (14.9%), farming (14.4%), and manufacturing (13.7%).

Average earnings per worker in Morgan County in 1984 were $15,952, the lowest of the primary impact counties and lower than both the national and ROI averages. The highest average earnings per worker in Morgan County were paid in the mining sector ($26,469).

From 1975 to 1985, unemployment rates in Morgan County remained consistently below those for the nation and fluctuated around those for the Colorado ROI. However, in 1985, these county rates surpassed the

national average unemployment rate and peaked in 1986 at 11.5% (Colorado Department of Labor and Employment 1988). Morgan County's labor force decreased over that period by 0.5% annually, and hovered slightly above 9,200 persons in 1984.

Between 1969 and 1984, per capita personal income in the county typically remained below the national average (rising above it only in 1974 and 1981) and remained well below the ROI average. In 1984, per capita personal income in Morgan County was $14,096, below both the Colorado ROI and national averages.

c. Washington County

Washington County has both the lowest employment rate and lowest total income of the three primary impact counties and plays a minor role in the ROI economy. In 1984, Washington County provided merely 0.2% of the employment in the ROI and just 2.5% of total employment in the three impact counties. The county also received only 0.3% of total personal income in the ROI and only 2.0% of total personal income in the primary impact counties. Total employment growth in the county averaged 0.7% annually between 1969 and 1984.

Although average annual employment in Washington County exceeded the average ROI and national rates of growth in five of the eleven industrial sectors, the actual number of jobs created was relatively small. Unlike the nation, which posted negative employment growth in the manufacturing sector from 1969 to 1984, employment in manufacturing grew the fastest of Washington County's industrial sectors, at a rate of 8.8%, followed closely by wholesale trade (7.9%) and construction (7.4%). The farming, retail trade, and government sectors all posted losses for that period. Consistent with the predominantly rural nature of the Washington County, the distribution of employment in the 11 major industrial sectors in 1984 differed substantially from that of the Colorado ROI. The most dominant sectors in terms of employment were farming (with 42.4% of the total county work force), government (14.3%), and services (11.1%).

Average earnings per worker in 1984 were $17,374, lower than both the national and ROI averages. The highest average earnings per worker were paid in the transportation and public utilities sector at $44,550; jobs in farming followed a distant second, paying less than $22,000 each on average. From 1975 to 1983, unemployment rates in Washington County had been consistently lower than those for the Colorado ROI and the U.S. However, county unemployment rates surpassed those of the ROI in 1984 and those of the nation in 1986 (Colorado Department of Labor and Employment 1988). Barely growing over the previous decade (0.2% annually), Washington County's labor force included only about 2,500 persons in 1987.

In 1984, per capita personal income in Washington County was $16,238, the highest of the primary impact counties. This fell below the ROI average ($17,696) but exceeded the national average ($14,746). From 1969 to 1984, per capita personal income in the county had been erratic, with a high of $20,436 in 1974 and a low of $10,073 in 1976.

B. Demographics and Housing

1. Regional Setting

The population of the Colorado ROI has increased steadily since 1940 (U.S. Bureau of the Census 1982b). This general trend reflects population growth in counties near the Denver-Boulder Metropolitan Statistical Area but masks subregional differences that include constant or decreasing numbers of people in many of the ROI eastern plains counties (Elbert, Kit Carson, Lincoln, Logan, Morgan, Washington, and Yuma counties).

Between 1970 and 1980, the population of the Colorado ROI grew from 1.4 million to 1.8 million, at a relatively rapid average annual growth rate of 2.7% (Table 5.2.11-2). The most recent estimate for the region indicates a population of slightly more than 2.0 million in 1985 (U.S. Bureau of the Census 1987a), indicating a slowing average annual growth of 2.3% since 1980.

Table 5.2.11-2

KEY DEMOGRAPHIC INDICATORS FOR THE COLORADO ROI

	1970	1980	1990	2000	2010	2020	2030
Population (millions)	1.40	1.82	2.17	2.41	2.59	2.73	2.82
Avg. ann. chg. from preceding decade	2.6%	2.7%	1.6%	1.1%	0.7%	0.5%	0.4%
			Age Distribution				
≤ 4 years	8.6%	7.3%	7.8%	6.1%	6.1%	5.8%	5.6%
5 - 19 years	30.5%	24.2%	21.0%	21.3%	18.6%	17.5%	16.8%
≥ 65 years	8.0%	8.1%	9.0%	9.8%	11.3%	15.8%	19.4%

Source: U.S. Bureau of Census 1982b.

Population projections suggest that demographic growth will continue in the ROI through the year 2030, though at gradually lessening rates. ROI population is projected at 2.2 million for 1990 since the region has been growing 1.8% annually during the 1980s. Between 1990 and 2000, annual growth is anticipated to slow to 1.1%, with regional population increasing to 2.4 million. By the year 2030, the population is projected at slightly more than 2.8 million, the result of 0.4% average annual growth over the preceding decade.

The evolving age structure of the population is expected in general to parallel that projected for the rest of the United States, with fewer young persons and greater numbers of older persons. In 1980, U.S. Census figures indicated that 7.3% of Colorado ROI residents were less than 5 years of age, 24.2% were 5 to 19, and 8.1% were older than 64 (U.S. Bureau of the Census 1982b). By the year 2000, these percentages are expected to change to 6.1%, 21.3%, and 9.8%, respectively. By 2030, only 5.6% and 16.8% of the regional population are expected to represent the two younger age groups, while 19.4% will be 65 or older.

Regional housing statistics indicate there were more than 726,000 U.S. year-round units in 1980, with an overall vacancy rate of 6.6% (Bureau of the Census 1982a). Of this number, more than 440,000 (60.9% of the total) were owner occupied or available for owner occupancy, with 2.9% vacant. There were more than 270,000 year-round units that were renter occupied (or available for renter occupancy) in 1980 of which 7.7% were vacant. More than half of the year-round units were in Arapahoe, Denver, and Jefferson counties.

More than 131,000 building permits were issued for the ROI from 1981 through 1986. The numbers increased until 1983-84 and decreased slightly after, producing an annual average of nearly 22,000 building permits. (U.S. Bureau of the Census 1983, 1985, 1987b). Adams, Arapahoe, and Jefferson counties were leaders in housing construction. Based upon construction permits and demolitions, the Colorado ROI was estimated to contain 870,000 total housing units (year-round and seasonal units) in 1987 (Colorado Division of Local Government 1988a). Of this total, an estimated 9.6% were vacant.

2. Primary Impact Counties

Adams, Morgan, and Washington counties are the primary impact counties with respect to demographics and housing. These counties are located in the immediate vicinity of the proposed SSC site, and their resident populations and housing stocks are expected to be most immediately affected by the project. Although Denver County lies more than a 1-h drive to the west of the proposed site, the metropolitan area is expected to attract a number of people associated with the SSC. Because its size, however, effects on the demography and housing of this county are expected to be minimal.

With its western portion composing part of Denver's expanding suburbs, Adams County grew by 2.8% annually between 1970 and 1980 when its population increased from 186,000 to 246,000 (U.S. Bureau of the Census 1982b). Adams County population growth slowed slightly to a 2.3% average annual increase between 1980 and 1985, reaching a total of 276,000 inhabitants (U.S. Bureau of the Census 1987a).

The populations of both Morgan and Washington counties changed little over the same time period. Morgan County grew from slightly more than 20,000 people in 1970 to 22,500 in 1980 (an average annual increase of 1.1% throughout the 1970s), reaching an estimated 23,300 by 1985 (increasing by 0.7% annually since 1980). The population of Washington County actually decreased during the 1970s at an average annual rate of 0.3% (from 5,500 to 5,300) before beginning a slow 0.7% annual growth during the first half of the 1980s (to an estimated 5,500 once again by 1985).

Future changes in all these counties are expected to continue these trends, with the population of Adams County increasing steadily as its suburban role grows and the population of the two eastern plains counties remaining roughly constant or growing slowly.

The communities closest to the proposed SSC site are Brush (approximately 30 mi to the northeast) and Fort Morgan (approximately 20 mi to the north), both located in Morgan County. Brush had a population of slightly more than 4,000 in 1980 increasing to approximately 4,300 in 1987 (U.S. Bureau of the Census and increased 1982b; Colorado Division of Local Government 1988b). Fort Morgan is slightly larger, though its population of nearly 8,800 in 1980 appears to have decreased to approximately 8,600 in 1987. Other communities within a 1-h commute to the SSC site are Akron and Brighton. Akron, a town of approximately 1,700 persons (in both 1980 and 1987), lies about 50 mi to the east of the proposed SSC campus site. The City of Brighton is situated on the northeastern edge of the present Denver suburbs, about 60 mi west of the proposed SSC location; its population of approximately 13,000 in 1980 is estimated to reach nearly 14,000 by 1987.

According to the Bureau of the Census (1982a), Adams County contained nearly 90,000 year-round housing units in 1980. Of these units, 67.3% were owner occupied (or available for owner occupancy), 31.4% were renter occupied (or available for renter occupancy), and 1.3% were considered unavailable for occupancy. Of the total year-round units in the county, 94.4% were occupied. Considering just the year-round units available for occupancy, 1980 vacancy rates were 2.8% for owner units and 7.7% for renter units.

Nearly 8,900 year-round housing units were located in Morgan County in 1980, with 60.6% owner units, 34.6% renter units, and 4.8% unavailable for occupancy at the time. Of the total year-round units in Morgan County, 89.9% were occupied. Of all year-round units available for occupancy, 1980 vacancy rates were 1.9% for owner units and 12.2% for rental units.

Washington County contained about 2,400 year-round housing units in 1980; 63.6% owner occupied (or available), 23.9% renter occupied (or available), and 2.5% were unavailable for occupancy at the time. Of all the year-round units in the county, 84.7% were occupied in 1980; considering only those available for occupancy, 1980 vacancy rates were 2.0% for owner units and 23.9% for rental units.

Nearly 18,000 permits were issued in Adams County between 1980 and 1987 for the construction of housing units, an average of approximately 3,000 annually (U.S. Bureau of the Census 1983, 1985, 1987b). These figures contrast sharply with the roughly 350 permits issued for Morgan County and the 50 issued for Washington County over the same time period.

Estimates of the 1987 housing stock show increases in both the total number of units and in vacancy rates for Adams, Morgan, and Washington counties. (Colorado Division of Local Government 1988a). The higher vacancy rates can be attributed in part to differences in methodology between the 1980 census and the 1987 survey and in part to actual softening in the local housing market. A 1986 housing vacancy survey by the Federal Home Loan Bank of Topeka (1986) similarly indicated a higher vacancy rate for Adams County than the 1980 Census estimate.

The 1987 survey by the Colorado Division of Local Government (1988a) estimated the total housing stocks and total vacancy rates of communities within the primary impact counties: 1,845 units in Brush (with 11.3% total vacancy), 3,836 units in Fort Morgan (9.9% total vacancy), 878 units in Akron (13.3% total vacancy), and 5,289 units in Brighton (10.7% total vacancy).

Brighton is the future location of two major housing developments with construction slated to begin in 1988. This expansion is the result of growth in suburban Denver and the anticipated expansion of this area resulting from construction of the proposed Denver Worldport, an air transportation facility envisioned to complement and expand international air service to and from Denver. Once completed, these housing developments will add nearly 20,000 units to the current stock in Brighton.

Temporary housing opportunities are limited in the communities nearest the SSC. Brush currently contains three motels with a total of 73 units. Fort Morgan has nine hotels and motels with approximately 230 total units.

C. Public Services

Public services provided by local governments within the ROI were analyzed using October 1982 employment data (U.S. Bureau of the Census 1984) and 1986-87 school-year statistics (Colorado Department of Education 1987).

Police and fire protection, provision of health care, and public educational instruction were examined in detail. The level of general public service for education was determined by the ratio of employees to

regional population and by student/teacher ratios at the primary and secondary public school levels.

1. Regional Setting

Table 5.2.11-3 shows level of service for key public services for each ROI county, the ROI as a whole, the state, and the nation. Total local government full-time equivalent (FTE) employees for the ROI was 35.43 per 1,000 population, which falls between the Colorado average of 36.83 and the national average of 34.35. The ROI levels of service for police and fire protection exceeded the Colorado and U.S. averages while health care fell below those averages.

Within the primary impact counties, routine medical services and emergency care are provided by local physicians and three local hospitals (located in Fort Morgan, Brush, and Akron). Advanced health care facilities in the ROI are concentrated in the Denver metropolitan area. Thirty-six health care and medical research facilities, including 22 general hospitals, are within either conventional or airborne ambulance reach from the site and provide care in all medical fields.

2. Primary Impact Counties

a. Adams County

Adams County, with a 1980 population of 245,944, supports local public services with 29.82 local government employees per 1,000 population, well below the ROI, Colorado, and national averages of 35.38, 36.83, and 34.35 employees per 1,000 population, respectively. The county provides fire and police protection, health services, and education services at levels of service lower than either the ROI as a whole or the State of Colorado.

The majority of Adams County's population is located in the county's urbanized western quarter near the Front Range; unincorporated and less populated eastern Adams County, on the other hand, is the area proposed to host the campus and injector facilities of the SSC. Local public services related to welfare of employees and safe operation and maintenance of the campus and injector facilities (particularly health services and police and fire protection) would be supplied by Adams County.

The closest community to the proposed site of the campus within the county is Strasburg, approximately 30 mi southeast of the site. Strasburg is the main source of public services and facilities for the far eastern, unincorporated portions of the county. The Adams County Sheriff's Office, operating from the East Strasburg substation, provides law enforcement services to the unincorporated areas within the county. This substation currently maintains four sworn officers and three patrol vehicles. Volunteer fire protection for the site is also headquartered in Strasburg.

Table 5.2.11-3

LEVELS OF PUBLIC SERVICE FOR COLORADO SSC SITE[1]

Area	Police Protection	Fire Protection*	Health and Welfare	Public Education General Education	Public Education Student/ Teacher Ratio	All Other	Total
Adams County	2.05	0.74	1.76	19.20	18.5	6.07	29.82
Arapahoe County	3.09	1.91	0.80	23.80	18.5	6.77	36.36
Boulder County	2.13	0.67	1.55	19.38	18.8	8.79	32.52
Denver County	3.69	2.00	6.52	15.15	17.7	15.64	42.99
Douglas County	1.63	0.20	0.48	22.62	18.0	7.00	31.92
Elbert County	1.17	0.00	0.48	30.95	14.7	10.22	43.50
Jefferson County	2.06	0.56	0.90	19.64	21.9	5.46	28.68
Kit Carson County	2.90	0.00	11.58	27.24	12.4	14.74	56.45
Lincoln County	2.14	0.00	13.94	28.95	13.1	8.79	53.83
Logan County	2.32	0.51	1.36	31.62	14.4	10.86	46.67
Morgan County	2.35	0.27	1.87	23.94	16.8	11.06	39.49
Washington County	2.64	0.00	1.51	27.34	11.1	13.57	45.06
Weld County	2.39	0.59	2.36	19.92	18.5	7.53	32.79
Yuma County	2.58	0.00	6.09	29.64	13.2	10.84	49.16
Region of Influence	2.70	1.18	2.81	19.43	18.8	9.27	35.38
Colorado	2.66	1.03	3.47	19.79	16.2	9.88	36.83
United States	2.34	1.02	3.84	18.44	18.0	8.71	34.35

Notes: 1. All table values represent full-time equivalent (FTE) employees per 1,000 population except student/teacher ratio.

* Zero (0.00) values indicate rural counties served solely by volunteer fire departments.

Sources: U.S. Bureau of the Census 1984; Colorado Department of Education 1987; U.S. Department of Education 1987.

Public education levels supplied by the seven school districts within the county approximate the ROI, state, and national averages for employees per 1,000 population and student/teacher ratio.

b. Morgan County

Although predominantly rural, Morgan County contains the largest communities near the proposed Colorado SSC site: Fort Morgan (1980 population of 8,768) and Brush (1980 population of 4,082). These communities are currently regional centers and could serve a much larger population if they experienced rapid growth with the development of the SSC.

Police and volunteer fire protection and health care services provided within the county are based in Fort Morgan and Brush and have levels of service lower than ROI, state, and national averages. Public education levels of service provided by the four school districts within the county are better than those averages, with higher ratios of employees in education per 1,000 population and lower student/teacher ratios.

c. Washington County

Washington County, with the smallest population of the primary impact counties, is proposed to host approximately one-third of the SSC ring, including the far experiment areas, in its sparsely populated western half. The Washington County Sheriff's Department provides law enforcement services for all residents of the county with a total of seven sworn officers and seven patrol vehicles from Akron, the county seat. Fire protection is provided by volunteer fire departments. Public education is provided by the three school districts in the county at levels of service better than the ROI, state, or nation, based on employees per 1,000 population and student/teacher ratios.

D. Public Finance

1. Colorado State Government Finances

a. State Government Taxes

Colorado has a general income tax covering individuals and corporations, a sales and use tax, and motor fuel and motor vehicle taxes as major sources of revenue. All dollar values in the public finance discussion are current dollars for the fiscal years cited.

Individuals are taxed 5% of federal taxable income plus an alternative minimum tax. Corporations and financial institutions are taxed at a rate of 5 to 6% depending on income level and year over the years 1986 to 1993. This tax provided 45.76% of Colorado tax revenues in fiscal 1986 (Table 5.2.11-4).

Table 5.2.11-4

COLORADO STATE GENERAL REVENUE AND EXPENDITURE - 1986

Revenue/Expenditure	Amount in thousands	Per Capita
REVENUE		
Total intergovernmental	$ 1,192,455	$ 365
Federal	1,173,849	359
Total taxes	$ 2,344,375	$ 718
Sales and gross receipts	1,075,062	329
General sales	736,649	225
Selective sales, gross receipts	338,413	104
Alcohol	23,830	7
Insurance	52,997	16
Motor fuels	194,444	60
Public utilities	3,636	1
Tobacco	50,930	16
Individual income	955,931	293
Corporation net income	116,937	36
Licenses	142,817	44
Corporate license tax	2,424	1
Motor vehicle	72,935	22
Occupation and business licenses	23,886	7
Documentary and Stock Transfer Fees	---	---
Property Tax	9,052	3
Charges and misc. general revenue	1,012,809	310
Current charges	571,917	175
Total General Revenue	$ 4,549,639	$ 1,393
EXPENDITURE		
Total General Expenditure	$ 4,375,554	$ 1,339
Direct Capital Outlay	403,899	124

Notes: Population 7-1-86, 3,267,000

Source: U.S. Bureau of the Census 1987c.

A tax of 3% of gross receipts from retail sales of tangible personal property, telephone, telegraph, gas, and electric services, transient rentals, and meals furnished to the public is levied. This tax provided 31.42% of Colorado tax revenues in fiscal 1986.

Motor gasoline is taxed at 18 cents/gal while special fuel is at 20.5 cents. These produced 8.29% of Colorado tax revenues in fiscal 1986.

The motor vehicle tax is levied in two parts and for passenger vehicles and trucks and tractors separately. Part of the tax is weight based and part is on taxable value. There are also motor carrier mileage charges. These items accounted for 3.39% of fiscal 1986 Colorado tax revenues.

Colorado has other tax sources including an insurance companies tax, tobacco taxes, and alcohol taxes which provided 1.12 to 2.13% of state revenues in fiscal 1986.

b. State Revenue and Expenditure

State government general revenues and expenditures are given in Table 5.2.11-4 for fiscal 1986. Taxes, intergovernmental revenues, and charges are the major categories. Taxes have been discussed previously; the major items are general sales and income taxes. General revenues exceeded general expenditures by about 4%; direct capital outlays were about 9% of general expenditures.

c. Local Government Organization and State Payments to Local Governments

There were 62 county, 267 municipal, and 185 school district governments in Colorado at the time of the 1982 Census of Governments. The City and County of Denver is consolidated but is considered a municipality. There are no dependent public school systems.

There were also 1,030 special district governments. Important entities include fire protection districts, metropolitan districts, water and sewer districts, power authorities, and water conservation districts. Other districts are organized as subordinate agencies to the state, counties, or cities. Rates and charges, property tax levies, and bonding are employed in certain circumstances.

Colorado has a minimum equalization program to provide operations support for common schools. Other aid is provided to school districts under categorical programs.

Cities and counties are provided 46% of the cigarette tax yield in shares based on state sales tax revenues collected. There is an oil shale severance tax fund of which 85% is distributed to political subdivisions socially or economically affected by fuel development and 15% to counties and cities affected by location of employees in mines or related facilities, by relative shares of such employees.

Highway users sales and use taxes on vehicles are distributed in part to counties and cities, 22% to counties and 18% to cities. Taxes on fuel are also partly distributed to cities and counties, in part on the basis of registrations and road mileage.

2. Colorado Local Government Finances

Three counties, Adams, Morgan, and Washington, and two municipalities, Brush and Fort Morgan, both in Morgan County, are included in this public finance analysis.

a. Adams County

Revenues obtained by Adams County in fiscal 1986 are indicated in detail in Table 5.2.11-5. Tax sources include general property, local option general sales, and use and specific ownership property taxes on certain mobile equipment, vehicles, and mobile homes. Most intergovernmental revenues are from the State of Colorado. The largest share of these are earmarked for welfare. Other distributions are from highway user taxes, the cigarette tax, and motor vehicle registration fees. Charges and miscellaneous, which include interest and rent revenue, are the major remaining sources. In FY 1986, operating revenues exceeded total expenditures by about 5% while capital projects were about 2% of total expenditures. Other reference data, including per capita figures, population, and the taxable property base, are included in the table.

Adams County collected property taxes for all local governments, levying them within its boundaries. In 1987 the following levy prevailed:

Jurisdiction	Tax Levy
County government	$ 38,161,945
Cities and towns	7,432,778
School districts	86,276,380
Special districts	8,987,862
Total Adams County	$140,858,966

Total assessed value in 1987 was $1,205,634,394.

b. Morgan County

Morgan County revenues and expenditures are given in Table 5.2.11-6 for fiscal year 1986. With no sales tax levy, property taxes predominate. Welfare funds are the major intergovernmental revenue. Charges, licenses, fines, and miscellaneous revenues round out revenues. Total operating revenues fell short of total operating expenditures by about 9%, but these were mostly from to capital projects, which were 36% of total expenditures. Other reference information is included in the table.

Table 5.2.11-5

ADAMS COUNTY, COLORADO
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1986

Revenue/Expenditure	Amount	Per Capita
REVENUE		
Tax revenues		
General property	$ 33,522,317	$ 120
Specific ownership	2,865,001	10
General sales and use	201,574	1
Total taxes	$ 36,588,892	$ 131
Licenses and permits	406,154	1
Intergovernmental revenues		
Total federal	$ 4,277,120	$ 15
Total state	$ 24,592,265	$ 88
Highway users tax	2,384,999	9
Cigarette tax	493,013	2
Motor vehicle reg. fees	330,406	1
Conservation trust	216,937	1
Social services	20,789,780	75
Other	377,130	1
Total other units	$ 129,002	$ 0
Total intergovernmental revenue	$ 28,998,387	$ 104
Charges for services	7,240,907	26
Fines and forfeits	0	0
Miscellaneous revenues	4,599,216	17
Total Operating Revenue	$ 77,833,556	$ 280
EXPENDITURE		
Total operating expenditure	$ 72,209,352	$ 259
Capital projects	1,644,280	6
Total op. expend. & cap. projects	$ 73,853,632	$ 265
Intergovernmental Expenditure	1,823,872	7

Notes: Population, 1986: 278,300
Assessed Valuation: $ 1,174,358,000

Sources: Colorado Division of Local Government 1988c; U.S. Bureau of the Census 1988.

Table 5.2.11-6

MORGAN COUNTY, COLORADO
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1986

Revenue/Expenditure	Amount	Per Capita
REVENUE		
Tax revenues		
General property	5,196,812	231
Specific ownership	315,364	14
Total taxes	$ 5,512,176	$ 245
Licenses and permits	2,953	0
Intergovernmental revenues		
Total federal	$ 231,424	$ 10
Total state	$ 4,212,803	$ 187
Highway users tax	768,490	34
Cigarette tax	22,369	1
Motor vehicle reg. fees	45,075	2
Conservation trust	29,435	1
Welfare	2,890,210	128
Other	457,224	20
Total other units	$ 254,846	$ 11
Total intergovernmental revenue	$ 4,699,073	$ 209
Charges for services	463,353	21
Fines and forfeits	11,129	0
Miscellaneous revenues	680,061	30
Total Operating Revenue	$ 11,368,745	$ 505
EXPENDITURE		
Total operating expenditure	$ 7,976,979	$ 355
Capital projects	4,467,712	199
Total op. expend. & cap. projects	$ 12,444,691	$ 553
Intergovernmental Expenditure	449,669	20

Notes: Population 1986: 22,500
Assessed Valuation: $ 200,510,000

Sources: Colorado Division of Local Government 1988c. U.S. Bureau of the Census 1988.

Morgan County was the tax collector for all property taxing jurisdictions within the county. The 1987 tax levy was:

Jurisdiction	Tax Levy
County government	$ 5,745,834
Cities and towns	815,144
School districts	8,659,385
Special districts	1,158,159
Total Morgan County	$16,378,523

Total Morgan County assessed value was $ 197,315,740 in 1987.

1) City of Fort Morgan

In Fort Morgan (Table 5.2.11-7), the major local tax is the sales and use tax since the local option rate is 3.0%. Intergovernmental revenue, charges, fines, licenses, miscellaneous, and enterprise fund transfers comprise the rest of the revenues. Operating revenue exceeded total expenditure by less than 1%; capital projects accounted for 18% of total expenditure. Per capita financial figures are included in the table.

2) City of Brush

For Brush, sales and use tax revenues slightly exceeded property tax revenues in fiscal 1986, as shown in Table 5.2.11-8. Franchise taxes also provided a modest share of local source funding. Licenses, intergovernmental revenues, charges, fines, transfers from enterprise activities, and miscellaneous sources provided the balance of operating revenue. A small deficit of about 3% was largely the result of capital projects, which represented about 7% of total expenditures. Per capita fiscal data are included in the table.

c. Washington County

Property taxes are the main tax source for Washington County, as shown in Table 5.2.11-9. Most intergovernmental revenues are highway users tax subventions from the state. Welfare program pass-troughs are quite small in Washington County. Other small sources include charges and miscellaneous. Operating revenue exceeded total expenditures by 9%; however, capital projects were 25% of total expenditures. Per capita financial data and other figures of interest are included in the table.

Table 5.2.11-7

FORT MORGAN (MORGAN COUNTY), COLORADO
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1986

Revenue/Expenditure	Amount	Per Capita
REVENUE		
Tax revenues		
General property	282,947	32
Specific ownership	17,234	2
General sales and use	1,762,114	200
Franchise	33,910	4
Employment occupation	0	0
Other	0	0
Total taxes	$ 2,096,205	$ 238
Licenses and permits	25,828	3
Intergovernmental revenues		
Total federal	$ 129,348	$ 15
Total state	$ 299,632	$ 34
Highway users tax	145,868	17
Cigarette tax	50,711	6
Motor vehicle reg. fees	29,757	3
Conservation trust	33,462	4
Other	39,834	5
Total other units	119,976	$ 14
Total intergovernmental revenue	548,956	$ 62
Charges for services	516,101	59
Fines and forfeits	53,240	6
Miscellaneous revenues	207,411	24
Transfers from enterprise activities	766,742	87
Total Operating Revenue	$ 4,214,483	$ 479
EXPENDITURE		
Total operating expenditure	$ 3,433,962	$ 391
Capital projects	758,899	86
Total op. expend. & cap. projects	$ 4,192,861	$ 477
Intergovernmental expenditure	0	0

Note: Population, 1986: 8,790

Sources: Colorado Division of Local Government 1988c; U.S. Bureau of the Census 1988.

Table 5.2.11-8

BRUSH (MORGAN COUNTY), COLORADO
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1986

Revenue/Expenditure	Amount	Per Capita
REVENUE		
Tax revenues		
General property	353,671	90
Specific ownership	36,096	9
General sales and use	476,521	121
Franchise	77,125	20
Employment occupation	0	0
Other	0	0
Total taxes	$ 943,413	$ 239
Licenses and permits	54,717	14
Intergovernmental revenues		
Total federal	$ 50,762	$ 13
Total state	$ 109,175	$ 28
Highway users tax	63,073	16
Cigarette tax	11,899	3
Motor vehicle reg. fees	0	0
Conservation trust	15,757	4
Other	18,446	5
Total other units	$ 37,745	$ 10
Total intergovernmental revenue	$ 197,682	$ 50
Charges for services	241,911	61
Fines and forfeits	12,516	3
Miscellaneous revenues	78,196	20
Transfers from enterprise activities	13,489	3
Total Operating Revenue	$ 1,541,924	$ 391
EXPENDITURE		
Total operating expenditure	$ 1,477,391	$ 375
Capital projects	112,719	29
Total op. expend. & cap. projects	$ 1,590,110	$ 404
Intergovernmental expenditure	0	0

Note: Population, 1986: 3,940

Sources: Colorado Division of Local Government 1988c; U.S. Bureau of the Census 1988.

Table 5.2.11-9

WASHINGTON COUNTY, COLORADO
COUNTY REVENUE BY SOURCE AND TOTAL EXPENDITURE - 1986

Revenue/Expenditure		Amount		Per Capita
REVENUE				
Tax revenues				
General property		1,586,938		299
Specific ownership		104,925		20
Other		9,213		
Total taxes	$	1,701,076	$	321
Licenses and permits		0		0
Intergovernmental revenues				
Total federal	$	104,131	$	20
Total state	$	2,048,325	$	386
Highway users tax		1,285,113		242
Cigarette tax		4,588		1
Motor vehicle reg. fees		27,853		5
Conservation trust		10,848		2
Social services		318,295		60
Other		401,628		76
Total other units	$	44,342	$	8
Total intergovernmental revenue	$	2,196,798	$	414
Charges for services		113,046		21
Fines and forfeits		0		0
Miscellaneous revenues		199,607		38
Total Operating Revenue	$	4,210,527	$	794
EXPENDITURE				
Total operating expenditure	$	2,891,811	$	546
Capital projects		968,335		183
Total op. expend. & cap. projects	$	3,860,146	$	728
Intergovernmental expenditure	$	279,363	$	53

Notes: Population, 1986: 5,300
Assessed Valuation: $ 106,654,000

Sources: Colorado Division of Local Government 1988c; U.S. Bureau of the Census 1988.

Washington County collected the following property taxes for all jurisdictions within the county in 1987:

Jurisdiction	Tax Levy
County government	$1,619,157
Cities and towns	292,648
School districts	3,643,331
Special districts	162,627
Total Washington County	$5,717,765

Total assessed value in 1987 was $95,255,740.

5.2.11.2 Infrastructure

A. Transportation

1. Roads

Major highways and roads serving the proposed SSC site are shown in Figures 5.2.11-3. Data on these highways and roads are presented in Table 5.2.11-10. Metropolitan Denver 65 mi west-southwest of the proposed site is served by a freeway system that includes Interstate 25 (I-25) extending to the north and south, I-70 extending to the east and west and I-76 extending to the northeast from Denver. In addition there is an extensive system of arterial and bypass freeways and highways.

The proposed site is served by a network of interstate and state highways and county roads. These include I-76 on the north and I-70 on the south. State Route 71 extends south from I-76 at Brush through the proposed SSC site to Last Chance. U.S. Route 36 extends from I-70 at Byers to Last Chance. A system of roads maintained by Adams, Morgan, and Washington counties provides access to most of the proposed locations for surface facilities. The most notable of these is partially paved Sherman Road, County Road 19, which provides access between Fort Morgan and the proposed campus location. County Road 20 to the east of Sherman Road also provides access to the proposed campus location. Most of these county roads are not paved, have narrow widths, and are in constant need of maintenance because of heavy truck traffic (Morgan County 1988).

2. Rail

The proposed SSC site area is served by two main line railroads shown on Figure 5.2.11-3. The first is the Union Pacific which generally follows the north bank of the South Platte River to the north of Fort Morgan and Brush. The second is the Burlington Northern, which runs south of I-76 and passes through Fort Morgan. Both rail lines provide side tracks for the loading of agricultural goods (U.S. Bureau of Reclamation 1983). The closest siding is located in Fort Morgan, 19 mi to the north of the

Figure 5.2.11-3

MAJOR TRANSPORTATION SYSTEMS
SERVING THE COLORADO SITE

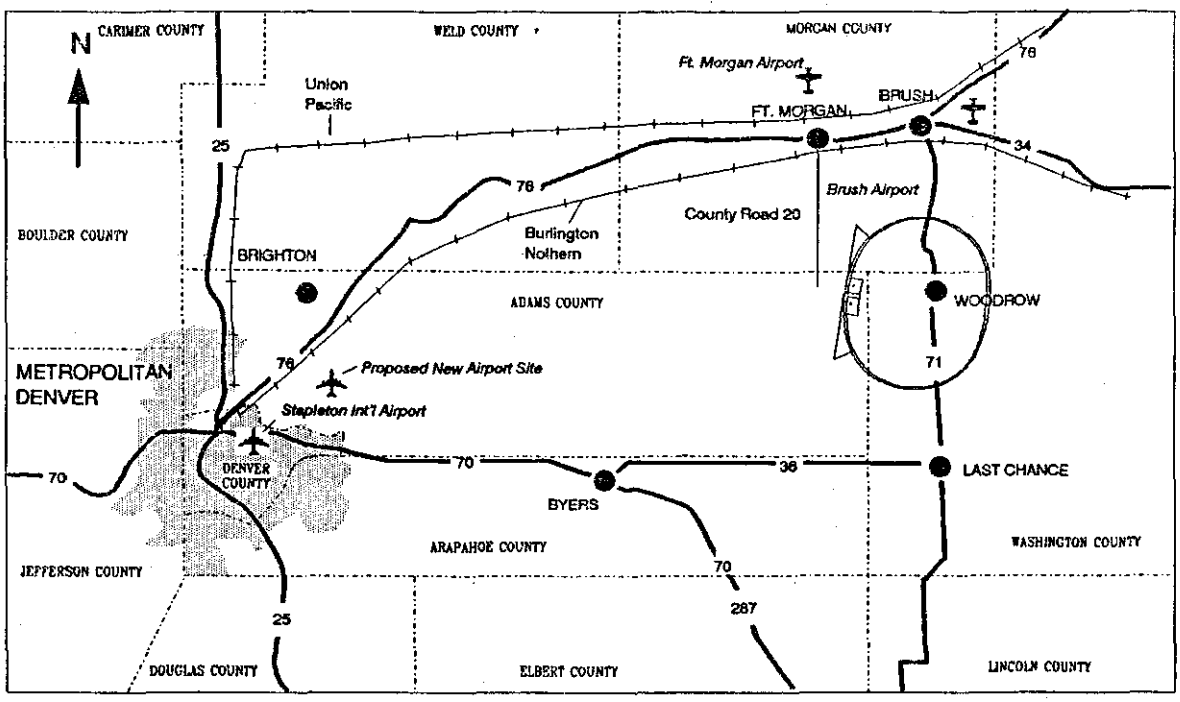

Table 5.2.11-10

PRESENT HIGHWAYS AND ROADS SERVING THE PROPOSED COLORADO SSC SITE

Road Segment	Length mi	Lanes	Capacity pcph[1]	Peak Hour Volume pcph	LOS[2]
I-76: I-270 (Denver) to Fort Morgan	70	4	8,000	800	A
I-76: Fort Morgan to State Route 71 (Brush)	11	4	8,000	850	A
I-70: I-225 (Denver) to U.S. Route 36	33	4	8,000	950	A
U.S.Route 36: I-70 to Last Chance	35	2	2,800	100	A
State Route 71: I-76 to Woodrow	20	2	2,800	100	A
State Route 71: Woodrow to Last Chance	17	2	2,800	100	A
Sherman Road (County Road 19): Ft. Morgan to 40th Parallel (Near Campus Area)	17	2	N/A	200[3]	N/A[4]
County Road 20: South of Ft. Morgan to 40th Parallel (Near Campus Area)	12	2	N/A	200[3]	N/A[4]

Notes: 1. PCPH: Passenger Cars Per Hour
2. LOS: Level of Service
3. Average daily traffic instead of peak hour volume.
4. Small county roads.

A: Free flow with individual users virtually unaffected by the presence of others in the traffic stream.
B: Stable flow but the presence of other users in the traffic stream begins to be noticeable.
C: Stable flow but operations of individual users become significantly affected by interactions with others in the traffic stream.
D: High density, but stable flow with speed and freedom to maneuver severely restricted, and the driver experiences a generally poor level of comfort and convenience.
E: Unstable flow at near capacity level with speeds reduced, maneuvering difficult, and extremely poor level of comfort and convenience.
F: Forced or breakdown flow with traffic demand exceeding the capacity, unstable stop and go traffic.

Sources: Transportation Research Board 1985; Atencio 1988.

proposed campus location. These railroads connect the proposed site area with major cities to the east and west along the main lines and with most other major U.S. cities through connections to other railroads.

AMTRAK provides passenger rail service to the proposed SSC site area using the Burlington Northern tracks. One train heading east and one train heading west stop daily in Fort Morgan (Morgan County League of Women Voters 1985).

3. Air

The locations of airports serving the proposed SSC site are shown on Figure 5.2.11-3. The principal airport that would provide passenger and freight service to the proposed SSC site is the Stapleton International Airport. This airport, owned and operated by the City and County of Denver, is located 7 mi east of downtown Denver and approximately 60 mi west-southwest of the proposed campus location. The airport served more than 34 million passengers in 1986, making it the fifth busiest airport in the U.S. (Morgan County 1988). It is a major hub in the U.S. air transportation system. During the past few years, $275 million of improvements have been made to the airport. These have included the addition of a new north-south runway and two new concourses and the upgrading of existing facilities (Doughty 1987). Airport operations are currently congested with 58,000 hours of delays by scheduled airline operations in 1986. Delays are forecasted to increase to 158,000 hours in 1996 (Yatzeck 1988).

Because of forecasts of significantly increased passenger use, Denver is planning to build another airport (City and County of Denver 1987). On January 28, 1985, Adams County and the City and County of Denver signed an agreement for the construction of a new regional airport in Adams County. The airport will be approximately 10 mi northeast of Stapleton Airport. Construction is projected to begin in 1989, with completion scheduled for 1995 (Adams County 1987). Construction of the airport and the resulting airport access roads will reduce the travel time between the proposed SSC site and the airport.

Two general aviation fields are also available to provide service to the SSC site. The first is the Fort Morgan Municipal Airport located to the north of Fort Morgan, 25 mi north of the porposed campus location. This airport underwent a major rehabilitation during 1985, and currently has the capacity to serve small corporate jets (McCloud 1987). The other is the Brush Municipal Airport (Morgan County League of Women Voters 1985). Both of these are underutilized.

4. Waterways

There are no waterways that serve the SSC site.

5. Public Transit

a. Bus Service

The Denver Regional Transit District provides regularly scheduled and chartered bus service in the Denver metropolitan area. The proposed SSC site is outside of the current service area (Cracraft 1987). Continental Trailways and Greyhound provide bus service to Fort Morgan and Brush three times and once daily, respectively (Morgan County League of Women Voters 1985).

b. Taxi Service

Privately-operated taxi, shuttle, and limousine service is provided in the Denver metropolitan area. One privately owned taxi service is located in Fort Morgan (Morgan County League of Women Voters 1985).

c. Rental Car Service

Privately-operated rental car services are located at Stapleton International Airport and other locations in the Denver metropolitan area. Cars can be rented from auto dealers in Fort Morgan and Brush (Morgan County League of Women Voters 1985).

d. Para-Transit Services

The Northeast Colorado Transportation system provides two vans in Fort Morgan and one van in Brush for the transportation of seniors and disabled persons. This service is financed by donations and federal and state aid (Morgan County League of Women Voters 1985).

B. Utilities

1. Electricity

a. Ownership

Electric service for the area in the vicinity of the Colorado site is provided mainly by Public Service Company of Colorado (PSCo), Tri-State Generation and Transmission Association, Inc. (Tri-State), and the Morgan County Rural Electric Association, Inc. (MCREA). Other utilities in the area with electric generating capabilities or transmission networks are the Western Area Power Administration (WAPA), the Basin Electric Power Cooperative, and the City of Fort Morgan.

PSCo is a publicly held corporation whose principal business is the gas and electric utility industry (Public Service Company of Colorado 1987).

Tri-State is a consumer-owned, nonprofit electrical cooperative that supplies wholesale electricity to rural utility members. (Tri-State 1987a).

MCREA is a rural electric cooperative that provides electric power to rural consumers via their transmission network (Morgan County Rural Electric Association 1986).

b. Delineation of Service Territory

Tri-State, headquartered in the Denver area, provides electricity to 11 member utilities in Wyoming, eight in Colorado, and six in Nebraska. Combined, the member systems deliver service to more than 140,000 customers throughout a 100,000-mi² area (Tri-State 1986).

The Tri-State 1987 annual report delineates its service territory in Wyoming, Colorado, and Nebraska and its interconnections with other electric service utilities (Tri-State 1987a).

PSCo serves approximately 950,000 electric utility customers in a T-shaped area extending from Grand Junction on the west to Sterling on the east, and from Cheyenne, Wyoming, on the north to Alamosa on the south. PSCo provides gas and electric service to approximately 70% of the residents of Colorado as well as to residents of the Cheyenne area of Wyoming (Public Service Company of Colorado 1986, 1983).

The Colorado transmission network belongs to one of the four areas into which the Western Systems Coordinating Council's region is subdivided. The Rocky Mountain Power Area consists of Colorado, eastern Wyoming, and a small portion of South Dakota (North America Electric Reliability Council 1987).

c. Interrelationship with Other Electric Utilities

MCREA distributes electric power purchased from independent sources. These sources include Basin Electric Power Cooperative, Bureau of Reclamation, and Tri-State Generation and Transmission Association, Inc. (Morgan County Rural Electric Association 1986).

Tri-State's power is produced from its 24% ownership of the Laramie River Station near Wheatland, Wyoming, and its 24% ownership in Craig Station in northwest Colorado. Tri-State also purchases power for resale from the Western Area Power Administration and Basin Electric Power Cooperative (Tri-State 1986).

Colorado's interconnected power system is part of the WSCC, which is one of nine regional councils that make up the North American Electric Reliability Council (NERC). The WSCC, with 60 member systems and 4 affiliates, encompasses approximately 1.8 million mi² of territory in 14 western states, plus parts of 2 Canadian provinces and the northern portion of Baja California, Mexico (North American Electric Reliability Council 1987).

The Western Area Power Administration interconnected power system switching diagrams detail Tri-State's existing transmission facilities in the general vicinity of the proposed Colorado site and their interconnections with WAPA's network (Western Area Power Administration 1987).

d. Existing Network

Public utilities of Fort Morgan are self-supporting and are owned by the City of Fort Morgan. Currently, the city purchases electric power from WAPA and services Fort Morgan with 48.5 mi of distribution lines and three substations with 37.8 MW of total capacity (Morgan County League of Women Voters 1985; Calvert 1988). The PSCo transmission system map dated April 26, 1974, delineates PSCo's existing transmission network for the region surrounding the proposed site (PSCo map 1974).

Specifically PSCo serves the city of Brush and the towns of Weldona, Snyder, and Hillrose. In addition, they serve areas north and east of Fort Morgan and north and east of Brush.

MCREA services the remainder of Morgan County, including the town of Wiggins (Morgan 1985).

Table 5.2.11-11 shows the system capability and peak-demand profiles for PSCo and Tri-State electric service utilities from 1982 to 1987.

e. Planned Future Upgrades/Additions

Future system upgrades are two planned coal-fired projects to be located as second units at existing sites. PSCo's Pawnee Generating Station II (485 MW) at Brush, Colorado, is presently being engineered. Preliminary engineering has already begun on the Nixon Generating Station Unit 2 (210 MW) at Colorado Springs, belonging to the city of Colorado Springs. The Nixon unit is planned for operation in the mid-1990s. The PSCo unit was originally scheduled to go on-line in 1994, but construction has been delayed indefinitely.

Also planned for the early 1990s, are two major transmission line upgrades: an additional 230/345-kV transmission line connecting Pawnee to Story substations and a 230-kV transmission line from Sidney to North Yuma.

Figure 5.2.11-4 incorporates this additional generating and transmission capability and shows the planned transmission system for northeast Colorado in the mid-1990s.

Table 5.2.11-11

SYSTEM CAPABILITY/PEAK DEMAND PROFILES FOR ELECTRIC SERVICE UTILITIES

	1987	1986	1985	1984	1983	1982
PSCo						
System Generating Capability (MW)	3,672	3,641	3,952	3,790	3,512	3,401
Peak Demand (MW)	3,298	3,237	3,024	2,948	2,968	2,892
Reserve Capacity	374	404	928	842	544	509
Tri-State						
System Generating Capability (MW)	899	893	893	893	893	893
Peak Demand (MW)	962	922	1,017	968	871	955
Reserve Capacity	-63	-29	-124	-75	-22	-62

Sources: Public Service Company of Colorado 1987; Tri-State 1987.

2. Natural Gas

a. Ownership

The Colorado Interstate Gas Company (CIG) provides natural gas service to the area in the vicinity of the Colorado site. CIG was incorporated in Delaware in 1927 and is a wholly owned subsidiary of The Coastal Corporation (Moris 1987; Colorado Interstate Gas Company 1987).

Public Service Company of Colorado (PSCo) and its interstate gas transmission subsidiary WestGas, also provide natural gas service to the area. (Public Service Company of Colorado 1986; 1987).

b. Delineation of Service Territory

CIG's interstate gas system consists of field-gathering and transmission systems extending from gas supply areas in the Texas Panhandle and in western Oklahoma and Kansas, northwest through eastern Colorado to Denver, and from pipelines and other supply sources in Wyoming, southeast to Denver. CIG also has various gas processing facilities within its transmission and field-gathering systems in Utah and New Mexico (Morris 1987).

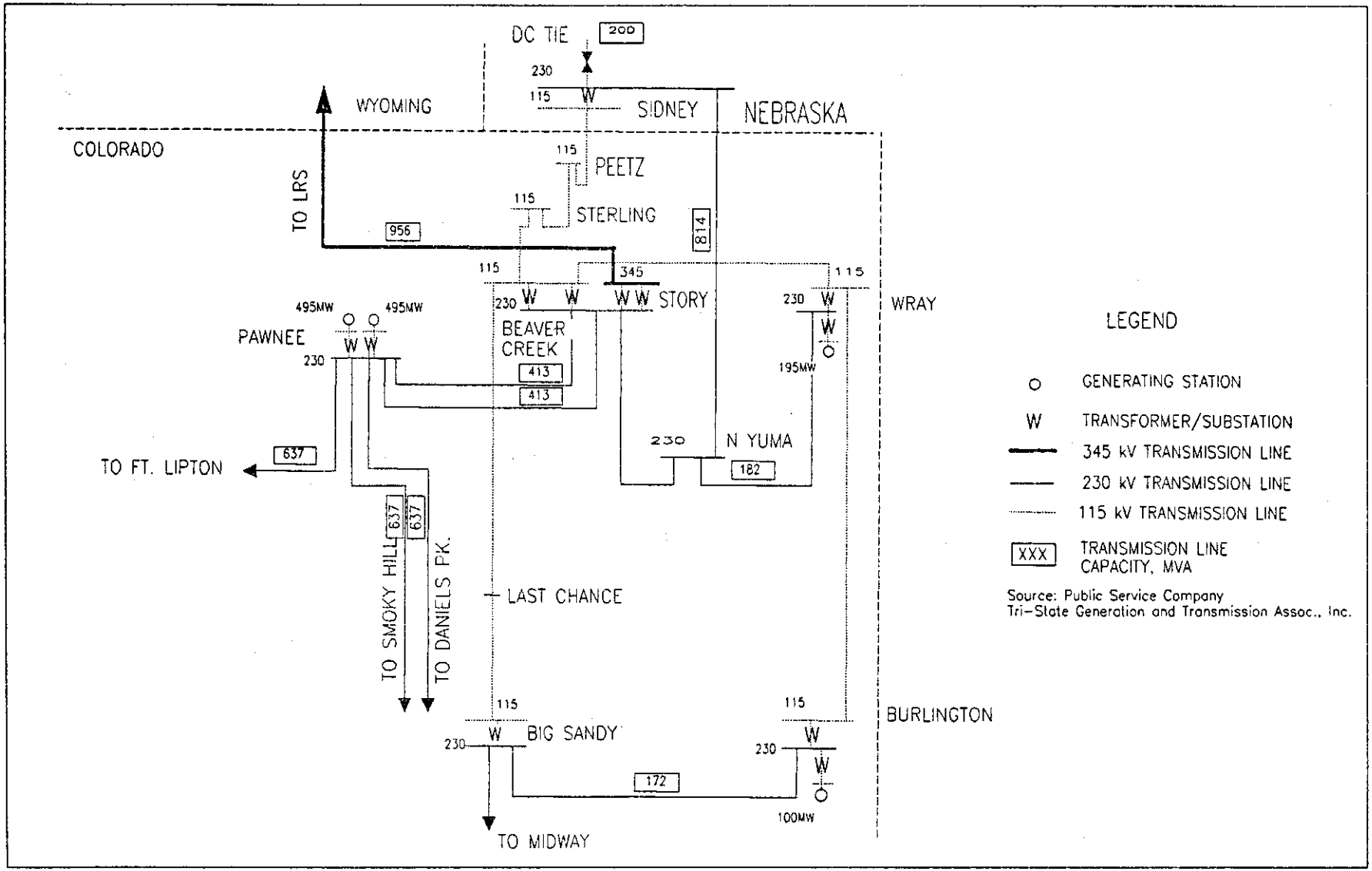

Figure 5.2.11-4

NORTHEAST COLORADO TRANSMISSION SYSTEM (PLANNED)

CIG carries about 70% of the natural gas needs of its home state and Colorado and serves utilities and other customers in Kansas, Oklahoma, Texas, and Wyoming (Coastal 1987).

PSCo serves approximately 820,000 gas customers in a T-shaped area extending from Grand Junction on the west to Sterling on the east and from Cheyenne, Wyoming, on the north to Alamosa on the south. PSCo provides gas and electric service to approximately 70% of the residents of Colorado and to residents of the Cheyenne area of Wyoming (Public Service Company of Colorado 1986, 1983).

WestGas serves PSCo, other distribution utilities, and various directorate industrial customers. WestGas purchases gas in all the major producing areas of the state, including the Wattenburg Field in the Denver-Julesburg basin.

c. Interrelationship with Other Natural Gas Utilities

CIG produces, purchases from others, and transports natural gas through pipelines for sale to utilities, industries, and other natural gas customers. In addition, CIG transports gas, for a fee, for other pipelines, distributors, and end-users (Morris 1987).

PSCo transports and delivers natural gas through CIG's pipeline network. PSCo has purchase agreements in place with K-N Energy, Inc. and CIG (Public Service Company of Colorado 1986).

d. Existing Network

PSCo can provide service to the SSC site and surrounding area through existing pipelines owned and operated by CIG. Currently, PSCo provides service to approximately 820,000 gas customers, including the towns of Sterling, Atwood, Wiggins, and Brush (Public Service Company of Colorado 1986; Morgan County League of Women Voters 1985).

Table 5.2.11-12 provides statistics on PSCo's natural gas service capabilities for a recent 5-yr period.

In 1986, CIG had in operation a total of 6,094 mi of pipeline, consisting of 2,728 mi of transmission lines and 3,366 mi of gathering and storage system lines. Gas system facilities include underground storage, compressor stations, dehydration and treatment plants, and measuring and regulating stations (Morris 1987).

CIG operates four underground gas storage facilities: the Fort Morgan and Latigo fields in northeastern Colorado, the Boehm Field in southwestern Kansas, and the Flank Field in southeastern Colorado. The peak day design delivery capacity of these installations is approximately 551,000 million ft^3 of gas daily and 28 billion ft^3 annually (Morris 1987).

Table 5.2.11-12

PUBLIC SERVICE COMPANY OF COLORADO (PSCo)
NATURAL GAS SERVICE STATISTICS

	1986	1985	1984	1983	1982
Natural gas deliveries (billion ft^3)	176.3	191.4	198.5	177.6	189.8
Average annual residential usage (thousand ft^3)	105.6	120.4	129.2	120.2	125.0
Daily availability (million ft^3)	1,461	1,457	1,464	1,459	1,462
Maximum peak-day sendout (million ft^3)	1,080	1,258	1,284	1,356	1,302

Source: PSCo 1986.

Table 5.2.11-13 provides a view of CIG's transmission system capability for a recent 3-yr period.

e. Planned Future Upgrades/Additions

Insufficient information presently available for upgrade and additions of natural gas service in the Colorado SSC vicinity.

Table 5.2.11-13

CIG INTERSTATE TRANSMISSION SYSTEM CAPABILITY

Year	Sales Volumes Mm ft^3	Transportation Volumes Mm ft^3	Total System Throughput Mm ft^3
1986	138,200	91,800	230,000
1985	204,300	87,800	292,100
1984	258,200	71,200	329,400

Source: Morris 1987.

3. Telecommunications

a. Ownership

Telecommunications service within the vicinity of the Colorado site is provided by Mountain Bell, AT&T, and the Wiggins Telephone Association (Morgan County 1988).

Mountain Bell (formally the Mountain States Telephone and Telegraph Company) is a publicly held corporation incorporated under the laws of the State of Colorado. The company is a subsidiary of U.S. West Communications Group, Inc., a telecommunications holding company. U.S. West Communications Group, Inc. is a wholly owned subsidiary of U.S. West, Inc. (U.S. West 1987) (Mountain Bell 1987).

b. Delineation of Service Territory

Mountain Bell is engaged in the business of furnishing telecommunications services in Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming (Mountain Bell 1987).

The Mountain Bell communications service area encompasses the western United States, including the remainder of Morgan County, the Jackson Lake area, and the Platte River corridor between Orchard and Hillrose, which is the majority of the county's area and population (Morgan County 1988).

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The service area for the Wiggins Telephone Association includes two separate areas that generally encompass the southwest and northwest corners of Morgan County. This service area includes the towns of Wiggins and Hoyt (Morgan County 1988).

c. Interrelationship with Other Telecommunications Systems

Mountain Bell is interconnected with U.S. West's other principal subsidiaries, Northwestern Bell and Pacific Northwest Bell. Together they provide telecommunications service to 14 Western states including more than nine million customers (U.S. West 1987).

Mountain Bell provides network access service to interexchange carriers, the largest volume of which is provided to AT&T (U.S. West 1987).

Communications extend worldwide from Mountain Bell's service area by means of links to existing facilities in the Denver area, including Denver Teleport, commercial satellite facilities, and interconnections to ITT, RCA, and other international interexchange carriers.

d. Existing Network

About 46% of Mountain Bell's access lines are in the metropolitan areas of Denver, Phoenix and Salt Lake City, and about 29% in 19 other exchange areas having populations greater than 50,000 (Mountain Bell 1987).

Fiber optic lightguides, already installed or authorized for construction, link Aurora, Colorado, to the Denver metropolitan area and Front Range Lightguide Networks. These high-speed digital networks interconnect several research and development centers and universities.

Mountain Bell's Limon office is presently served by an intra LATA link to Colorado Springs. This office is equipped with a step-by-step electromechanical switch having a capacity of 4,000 lines and 200 trunks that can support a wide range of telecommunications equipment, including multiple Private Automatic Business Exchanges (PABX) and multiplexed video, voice, and high-speed data communications.

e. Planned Future Upgrades/Additions

Mountain Bell plans for large capital expenditures in maintaining the current infrastructure and upgrading to advanced electronic and digital switching systems, digital transmission systems, and additional fiber optic lightguides.

A planned eastern terminus of the Aurora link to the Limon office is being considered.

WESTNET, a rapidly developing regional network, will extend high-speed digital communication capability to the remainder of the United States via connections to national networks such as NSF Net, ARPANET (Advanced Research Projects Agency Network) and DOE's MFENET.

5.2.12 Cultural and Paleontological Resources

5.2.12.1 Cultural Resources

A. Cultural History and Scientific Basis

The prehistory of Colorado (Greiser 1980) is generally divided into temporal periods based largely on changes in projectile point forms correlated with radiocarbon and stratigraphic dating methods. Evidence of the earliest Paleo-Indian occupation (9500 to 6000 B.C.) is represented by the presence of Clovis projectile points that are often found associated with mammoth kill and processing sites dating to the Late Pleistocene (Eighmy 1984). Clovis points are frequently located in sand dune fields in the eastern Colorado region; two stratified sites containing Clovis points are located close to the proposed SSC project area. These sites contain components from later Paleo-Indian phases, Folsom and Late Paleo-Indian, and from the Middle Plain Archaic.

The Folsom-Midland phase, from 8500 to 7000 B.C., is considered a transitional period between the Late Pleistocene and the Holocene climatic change. Prehistoric sites dating to this time period are marked by the presence of Folsom and Midland projectile points and a more varied tool assemblage than that of the Clovis period. Midland sites also include evidence of circular structures. The Agate Basin/Hell Gap occupation (8500 to 7400 B.C.) overlaps the Folsom-Midland and exhibits evidence of structures but contains a wider variety of chipped stone tools and milling stones. Sites are associated with pond or stream environments.

The Late Paleo-Indian Period occurs during the climatic changes that marked the end of the Pleistocene. Sites are more numerous and exhibit a number of projectile point styles representing local variations within the same cultural complex. Many sites contain milling stones for processing plant foods. Numerous bone tools are found and the spear thrower makes its first appearance. Settlement patterns include base camp sites in rock shelters and open locations, kill sites in deep arroyos or traps in sand dunes, and associated small short-term sites. In eastern Colorado groups often moved to sheltered mountain sites in the winter.

The Early Plains Archaic (5700 to 2700 B.C.) is less well known than other time periods in the region. This may reflect a hiatus of occupation because of deteriorating carrying capacity for big game. Site locations are restricted to mountains, foothills, and ecotonal situations of the plains. During the Middle Plains Archaic (2700 to 900 B.C.), a greater number of sites and site types are reported, indicating a population increase. The first evidence of stone corral traps for bison and the use of acorns as a food source is documented. Food storage pits and caches indicate increased seasonal sedentism with resource procurement scheduling a determining factor in settlement patterns. Late Plains Archaic (900 to 500 A.D.) complexes exhibit a shift toward increased regional variability. Artifact assemblages remain essentially

the same as those of the previous period but bison hunting strategies become a more communal effort (Eighmy 1984; State of Colorado 1987). The Archaic stage is represented in the South Platte drainage system as described by Morris, et al. (1975).

The Late Prehistoric (Greiser 1980) or Formative (Eighmy 1984) covers the period from circa 500 to 1750 A.D. and is subdivided according to the spatial and temporal differences of styles in pottery. It is characterized by the introduction of the bow and arrow and ceramics, and by the large-scale migrations of groups from the north (Athabaskans), the Mississippi Valley and the eastern prairies.

The Early Ceramic Period/Woodland (circa 500 to 1000 A.D.) is represented by the introduction of pottery similar to those types found to the east; the introduction of maize cultivation may also be indicated. Concentrations of sites are located adjacent to major streams and on high ridges. The Middle Ceramic Period (1000 to 1500 A.D.) is characterized by sedentary communities filtering into the region bringing subterranean earth lodges, cultivation of maize, beans and squash, as well as distinctive pottery. The Late Ceramic Period (1500 A.D. to 1725 A.D.) witnesses the expansion of Shoshonean and Apache groups into the area. A mixed hunting and gathering economy continued as the primary subsistence pattern.

Plains Indian culture continues until the early 1800s when the area was opened to Euro-American trappers and settlers after the Lewis and Clark expedition. The local ethnohistorically known Indian groups include the Cheyenne, Arapahoe, Kiowa, Apache, and the Commanche. The horse had been introduced by this time; the economy was based on bison hunting supplemented by farming. The Plains Apache were probably the earliest historic inhabitants of the proposed SSC project area, although many other groups may have passed through or briefly occupied the area during the extensive tribal migrations that took place throughout the period. By the middle 1700s, the Cheyenne had pushed south and established themselves on the North and South Platte rivers. By 1820, the Commanche occupied most of the Colorado area west of the Rocky Mountains, but by 1830 they were supplanted by the Arapahoe and Cheyenne (Cassells 1983).

Spanish exploration of southern Colorado was accomplished by the mid-1600s. In 1720, the Villasur expedition was sent north from Santa Fe, through the project area to the South Platte River, to reconnoiter French presence in the northern plains. The expedition was eventually wiped out by the Pawnee in western Nebraska. The Spanish gained rights to the territory from France in 1763 but ceded it back to the French in 1803. It was later sold to the United States as part of the Louisiana Purchase. American exploration by Pike in 1806, the Long Party in 1820 and others, began soon after. The fur trade flourished in the early 1800s and the South Platte River became a major corridor to the west, eventually developing into part of the Overland Trail. Forts were established at various points for protection. The Overland Trail

diverged from the Oregon Trail, the major route to Fort Laramie established by Fremont and others, and was heavily used by immigrants and gold seekers heading west. Portions of the trail and the Fort Morgan cut-off are close to the SSC project area (Mehls 1984).

The Fort Morgan Canal, completed in 1884 by Homesteaders who worked on the Canal in exchange for water rights, was instrumental in the settlement of Fort Morgan. Other irrigation companies and districts built a large network of ditches and reservoirs.

The region was given impetus to develop a cattle industry between 1840 and 1870 because of the huge surplus of cattle in Texas at that time. Herds were driven along the Texas Trail, north to Kit Carson, across the SSC project area to Brush and then further north, eventually to Montana.

Homesteading began in 1862 with passage of the Homestead Act. Eastern Colorado remained the domain of the cattle ranchers until around 1870 when agricultural colonies based on communal irrigation development were established (Mehls 1984). This was followed closely by an increase in homesteading in more marginal areas, where dryland farming techniques were utilized. This technique of farming the drier plains continued through the 1930s and is still used today in eastern Colorado.

B. Known National Register Sites/Sacred Sites

Two cultural resource properties, the Fort Morgan Post Office and the Rainbow Arch Bridge, located near the proposed project area, are currently listed on the National Register of Historic Places; other sites will require National Register evaluations prior to project implementation. No Native American sacred sites have yet been identified.

C. Previously Recorded Sites and Research in the Project Area

Thirty-eight historic and archaeological properties are currently recorded within the project region of influence (ROI) (State of Colorado 1987). These sites are listed on Table 5.2.12-1 (State of Colorado 1987).

One of the properties, the Fort Morgan Post Office, is listed on the National Register (Colorado Historical Society 1987); the remainder have not been evaluated for National Register eligibility. The 38 known properties include 22 prehistoric archaeological sites, three historic archaeological sites, nine sites with historic standing structures, three historic cemeteries, and an archeological site with both prehistoric and historic components. The prehistoric sites consist of open lithic sites and open campsites, dating from the Paleo-Indian through the Historic period; two prehistoric sites include human burials. Only one previously recorded prehistoric archaeological, WN10, site is recorded within the proposed collider ring. This is a campsite containing hearths, ground stone tools, projectile points, and pottery. However, its exact location is not recorded precisely.

Table 5.2.12-1

PREVIOUSLY RECORDED CULTURAL RESOURCES IN THE VICINITY OF PROPOSED COLORADO SSC SITE

Site Number	Site Type	Period
AH-19	Open camp	Prehistoric
AH-65	Open camp	Prehistoric
AH-125	Open camp	Prehistoric
AH-194	Byers railroad station; Vernacular frame house	Historic
AH-229	Byers Presbyterian church	1910
AH-230	Snow Geo house	1910
AH-231	Byers cemetery	1900s
AH-257	Open lithic; historic Foundation, debris	Prehistoric/ Historic
AH-259	Byers depot site	1890s
AM-1	Open lithic	Prehistoric
AM-4	Open camp; burial	Prehistoric
AM-5	Open camp	Prehistoric (Woodland)
AM-6	Open lithic	Prehistoric
AM-7	Open lithic	Prehistoric
AM-8	Open lithic	Prehistoric
AM-9	Open lithic	Prehistoric
AM-10	Open lithic	Prehistoric
AM-11	Open lithic	Prehistoric
AM-119	Noonen ranch	1880s
AM-147	Ft. Morgan cut-off	Historic Trail
AM-153	Perks sod house	Historic
AM-156	Open lithic	Prehistoric
AM-157	Isolated lithics	Prehistoric
WN-8	Open camp	Prehistoric
WN-9	Open lithic	Prehistoric
WN-10	Open camp	Prehistoric
WN-49	Pinneo depot site	Historic
MR-96	Open camp	Paleo-Indian
MR-278	Debris scatter	1860s
MR-286	Cemetery	1860s
MR-327	Open camp	Prehistoric
MR-338	Open camp	Paleo-Indian, Archaic, Historic
MR-335	Open lithic	Paleo-Indian
MR-378	Open camp; burial	Prehistoric (Woodland)
MR-468	Hoyt cemetery	1910s
MR-469	Ft. Morgan Post Office	1910s
MR-470	Brush Central School	1920
MR-474	Town of Hoyt	1880s

Source: State of Colorado 1987.

The recorded historic archaeological sites include structural foundations, scatters of historic debris, and a historic trail. The cemeteries include Byers Cemetery dating to the 1900s and Hoyt Cemetery dating to the 1910s.

Although a complete historic building survey has not been conducted, local residents and amateur archaeologists report the existence of several historic sites in the project area (State of Colorado 1988). These sites, although not officially recorded, are reported to be of local significance; however they have not been evaluated using National Register criteria. Within the proposed SSC ring, six potentially significant historic sites were identified, including Frost Ranch Cemetery, located 9 mi east of Adena (the original ranch was an historic mail route stop); Swan Cemetery, which dates to 1888; Gary, SW Gary, and SE Gary schools; and an area referred to as God's Half Acre.

According to this report, three known historic sites are located within the limits of the proposed project facility: Steyaert Ranch near E4, which is said to include 12 to 15 Indian sites; the graves of John Pflager and 5 others located on the Hough Farm, which is part of the proposed campus area; and Pleasant Ridge School, located on the proposed collider ring between F1 and E2.

Outside the proposed ring, in addition to the previously mentioned Hoyt Cemetery, the Adena Union Church Cemetery is located west of the proposed SSC facility; Fort Hall (Hall Ranch) is located west of Hoyt; and Glendale School is located near the northern boundary of the campus facility.

An archaeological survey of proposed access roads to the proposed SSC site (Joyner 1988) involved inspection of approximately 20% of two linear alignments, a 63-mi-long by 1,000-ft-wide, east-west corridor in Adams County, and a 18.5-mi-long by 60-ft-wide, north-south corridor in Morgan County. Seven prehistoric sites and ten prehistoric isolated finds were identified in potentially affected areas: six of the sites are open lithic scatters one is an open lithic/ceramic scatter; two of the sites (AM504 and MR478) could be significant and would require further evaluation; the other sites are considered ineligible for inclusion in the National Register. MR478 dates between approximately A.D. 1550 and 1750. The other sites could not be temporally placed.

A corresponding historic survey was undertaken (Pearce and Whitacre 1988) involving a 0.5-mi-wide corridor on either side of the centerline of the proposed access road alignments. The majority of historic sites in the region were farm complexes and irrigation ditches or canals. Ten sites were recorded, including six irrigation ditches and canals, two schools, one grange hall, and one barn. In consultation with the Colorado Office of Archaeology and Historic Preservation, six of these sites were considered eligible to the National Register: Speer Canal, Neres Canal, Fort Morgan Canal, Denver Hudson Canal, Sunnyvale School, and the Work Family Barn.

D. Characterization of Known Resources and Scientific/Educational Potential and Significance

In northeastern Colorado, known archaeological sites date from 9250 B.C. to recent prehistoric times. Most archaeological sites correspond to drainages and their associated ridge systems (Kvamme 1979; Morris et al. 1975). According to Greiser (1980) several primary environmental factors influenced prehistoric settlement locations, including water, fuel, shelter, and area overviews.

Paleo-Indian sites are rare but are found in sand dunes and blow-outs, and on first and second terraces along major drainages. Precise correlations between Paleo-Indian sites and soil horizons are lacking (Wedel 1961). Although most information pertaining to Archaic sites derives from surface data, it has been suggested (Kvamme 1979) that flat terraces associated with drainage confluences and divides were preferred settlement locations. Formative stage sites are often found on second terraces removed from the drainages; these may, however, be buried and identifiable by inspection of bank erosion.

Morris et al. (1975) conducted an archaeological survey of over 36,000 acres for the U.S. Department of Reclamation's Narrows Dam project on the South Platte River in Morgan and Weld counties. This area is 15 to 20 mi north of the proposed SSC project area. Over 300 sites dating from Paleo-Indian to Late Prehistoric cultural periods were recorded; the majority were Archaic sites. Recent Indian groups represented by these occupations include Kiowa, Cheyenne, and Shoshone.

Joyner (1987) surveyed portions of a proposed SSC access roadway within areas of Adams and Arapahoe counties, which are environmentally similar to the SSC study area. One prehistoric site and ten isolated finds were recorded. Activities such as farming, ranching, nonprofessional collecting of artifacts, energy development, and transportation have substantially affected many cultural resources (Joyner 1988).

An archaeological survey of the proposed new airport site in western Adams County (Burney 1987) recorded two lithic scatters and 27 isolated finds. This study includes a description of a local resident's artifact collection, which consists of Paleo-Indian to recent prehistoric materials from western Adams County. Thus, the most likely sites to be found in the proposed SSC project area are open lithic scatters with earlier sites associated more frequently with drainage systems. Sites are most likely to date from Late Archaic to Late Prehistoric times (Joyner 1988).

Early historic settlement patterns in the region are best evidenced by farming and homesteading, and the corresponding development of irrigation systems involving reservoirs, canals, and ditches. Increasing population created the demands for schools, stores, and meeting places.

Historic resources can be expected relating to the development of farming settlements, communities, and transportation and communication with other areas (Pearce and Whitacre 1988).

E. Unknown but Potential Resources

It is anticipated that future archaeological and historical surveys will locate additional archaeological sites within the project area. Prehistoric sites are particularly likely along drainages such as Badger, Beaver, and Bijou creeks. Additional archaeological sites containing burials may be located. In addition, some of the ranch buildings in the area may be historically or architecturally significant.

Although no other Indian sacred sites have been identified, interviews with Native American representatives with ties to the area could reveal localities of significance. The majority of Arapahoe and Cheyenne who occupied the project area at the time of Euro-American contact were relocated to Oklahoma after the Sand Creek Massacre, which took place east of the proposed SSC site in 1868. The Colorado Native American Heritage Council was notified about the proposed SSC project and requested to provide information concerning known sacred sites. Recommendations on possible action were also requested should Native American burials be discovered during construction activities.

5.2.12.2 Paleontological Resources

A. Scientific Basis

For a description and discussion of the geological stratigraphy in the proposed Colorado SSC site, reference should be made to Section 5.2.1.2.

The surface geology within the proposed project area primarily consists of Late Pleistocene and Holocene eolian and alluvial deposits (Bryant et al. 1981; Scott 1978; Sharps 1980; Trimble and Machette 1979). In addition, there are smaller amounts of Cretaceous marine shales, terrestrial sands, and Early Tertiary terrestrial deposits.

There are several identified Quaternary units. From oldest to youngest, these are Slocum alluvium, Louviers alluvium, Peoria loess, Broadway alluvium, and Late Pleistocene aeolian sand (Hunt 1954; Scott 1962; Inbeck 1988) as well as other unnamed and Holocene deposits within and surrounding the proposed project area.

Based on the presence of bison in the Slocum alluvium, these deposits are probably no older than 500,000 years. The Slocum alluvium, Louviers alluvium and Broadway alluvium have produced large mammal fauna from the Denver area (Hunt 1954; Scott 1962, 1963), including mammoth, camel, extinct horse, buffalo, and small ground mammals. The Peoria loess in Yuma County has produced fossil remains, including giant ground sloth, peccary, camel, horse, and badger as well as other small mammals (Graham 1981). Holocene deposits, such as the Piney Creek alluvium, have also

produced faunal material in archeological contexts. In addition, petrified wood and isolated bone fragments were recovered from stream deposits near the project area, but their contexts were such that they could have been transported from their original province (Indeck 1988).

The Cretaceous Pierre Shale in the proposed project area is composed of two primary units, described in Section 5.2.1.2. According to Sharps (1980), U.S.G.S. Mesozoic invertebrate fossil locality No. 15874 is located nearby in the Pierre Shale in Section 7, T1S, R57W, on a tributary drainage to Badger Creek. This was inspected during a paleontological reconnaissance for proposed SSC-related roads (Inbeck 1988), but additional fossils were not located. Fossils such as Sphenodiscus and Baculites clinolobatus are diagnostic of the Upper Transition Member of the Pierre Shale in northeastern Colorado (Scott 1978).

The Pierre Shale fauna and flora are well known; scientifically important fossils have been found in northeastern and east-central Colorado. The University of Colorado Museum has recovered fish and marine reptile remains; part of a mosasaur was recovered from near Flagler, south of the study area (Lee 1987). Core samples taken recently from five areas in the vicinity of the proposed SSC site revealed Upper Cretaceous trace fossils, including gastropods, brachiopod, pelecypod, and ammonites (Kauffman and Batt 1987).

The Late Cretaceous Fox Hills sandstone is not present in the area of the collider ring but is discontinuous nearby and potentially affected by SSC-related access road construction (Indeck 1988). According to Sharps (1980), U.S.G.S. Mesozoic invertebrate fossil locality No. 15866 is near the proposed project area in the Fox Hills on a tributary drainage to Badger Creek. The area was inspected during the paleontological reconnaissance for proposed project-related roads (Indeck 1988) and no additional fossils were located.

Fossil plants, invertebrates (marine mollusks), fish-scales, and vertebrate, sharks' teeth, and an insect have been identified in the Fox Hills sandstone in eastern Colorado. Ophiomorpha is present differentiating it from the overlying Laramie formation (Scott 1978). The type locality for a fossil leafhopper Mesojassoides gigantea is south of the study corridor. (Oman 1937).

The Late Cretaceous Laramie formation and the Denver formation (Late Cretaceous to Paleocene) also occur only in limited areas across the area of the proposed SSC-related access roads (Indeck 1988). Fish, amphibians, reptiles, mammals, and dinosaurs have been recovered from the Laramie formation in Weld County (Carpenter 1979) as well as plant and invertebrate fossils. The Denver formation paleontological localities in the Denver area have produced late Cretaceous leaves and dinosaur bones and Early Paleocene leaves and mammal, reptile, and amphibian bones and teeth (Brown 1962; Middleton 1983).

B. Known Paleontological Localities

According to Sharps (1980), two localities occur in areas potentially affected by SSC-related road construction. U.S.G.S. Invertebrate Fossil Locality No. 15874 is nearby in Pierre Shale in Section 7, T1S, R57W, on a tributary drainage to Badger Creek. U.S.G.S. Mesozoic invertebrate fossil locality No. 15866 is near the proposed project area in the Fox Hills, on a tributary drainage to Badger Creek.

A series of five cores that were drilled at the Last Chance drilling site near the proposed project area (Kauffman and Batt 1987) produced Upper Cretaceous trace fossils, including gastropods, brachiopods (i.e., Lingula), pelecypods, and ammonites (i.e., Baculites). No other known fossil localities are in the proposed SSC collider ring area.

C. Characterization of Geological Strata and Paleontological Potential

Stratigraphic levels that potentially contain fossil materials include the recent alluvium, eolian sands, and the Peoria loess. The Upper Cretaceous Pierre Shales may also be fossiliferous. Outside the area of the collider ring, project activities could uncover paleontological resources in the Laramie formation, Denver formation, and Fox Hill sandstone formations.

Areas associated with alluvial stream or terrace deposits could potentially yield fossils. These include areas around Badger, Lost, and Box Elder creeks (Indeck 1988).

5.2.13 Scenic and Visual Resources

5.2.13.1. Visual Character of the Region

The proposed Colorado SSC site lies within the Piedmont section of the Great Plains physiographic province (Hunt 1967). The Great Plains, an extensive, nearly flat region that slopes gradually to the east, cover 12% of the United States. The western margin exceeds 6,000 ft in elevation, declining gradually to less than 1,500 ft. The average regional slope is 10 ft/mi (White 1979), but slopes can be locally steep at valley margins. However, few valleys are deeper than 150 ft. Between the valleys, the plains are nearly flat. The Colorado Piedmont section is fundamentally a basin, lower than the High Plains to the east. Topography here is strongly controlled by stream dissection.

Trees are mostly confined to valleys and the uplands are nearly treeless. The uplands originally were grasslands but now are cultivated fields, rangeland, or pasture. The region is semiarid. There are few major rivers, and smaller streams are usually intermittent to ephemeral.

Crop production is the most conspicuous use of the land, often expressed as largescale geometric layouts of fields (strip-cropped wheat and center-pivot irrigation of cultivated circles). There are few Settlements and other cultural modifications. The region is a "transit" land, serving east-west highways, railways, and airways (White 1979).

5.2.13.2 Visual Character of the Site

A. Topography

Most of the site terrain is gently rolling and unvaried. It has little spatial definition and few landmarks. The horizon appears flat, though the terrain dips slightly to the north. The highest point is just over 4,900 ft, 5 mi southwest of the campus. The lowest point is about 4,400 ft near the upper arc. The Beaver Creek and Badger Creek drainages run north to the South Platte River and dissect the site slightly. The greatest relief occurs along Badger Creek, near E9, where there is about 100 ft of rise across 1,500 ft (about 7% slope). There is also perceptible relief near E8 across Beaver Creek and near E7 across Plum Bush Creek. Generally, the terrain slopes at 1.5% or less, which is barely perceptible.

There are no gulleys or rock outcrops, and there is only one eroded stream bank within or near the site. Near Beaver Creek, there are old stream terraces, but these are minimally evident. Otherwise, all drainages are smoothly defined as grassy swales.

In the northern and western portions of the upper arc, there are sand dunes. These are vegetated with grasses and are hummocky in appearance.

These dunes are stable unless disturbed but are susceptible to wind erosion if not, resulting in "blow-outs." Only the occasional blow-outs readily indicate the occurrence of the dunes.

B. Vegetation

The site vegetation has little variation. Little if any of the original short-grass prairie remains, having been replaced by annual dryland grain crops and pasture. For much of the year, the fields are brown to gray-brown. There are some riparian habitats along stream channels, but these primarily support low-stature shrubs. A few large trees are found along Beaver Creek. Most, however, occur around a few isolated farmhouses.

C. Water Features

Because of the semiarid climate and rapid rates of infiltration, streams in the area are few. Most streams have courses that are indistinguishable when seen from several hundred yards, the bank's being gentle swales. There are no lakes on the site; the nearest is about 30 mi to the northwest.

D. Cultural Modifications

The nearest communities are Fort Morgan (population 8,700) and Brush (population 4,100). Woodrow, along State Highway 71, consists of a store and gas station. The site is sparsely populated rolling ranchland and farmland. The relatively isolated farm structures are not commonly visible at appreciable distances within or near the site. Several are within shallow valleys flanking the major drainages and tend not to be seen until one is close to them. Also, many ranches are holdings, with few or no structures.

The most pervasive evidence of agriculture is the replacement of native prairie grasslands with crops. However, the most visible agricultural feature within the site vicinity is the Hough Farm grain elevator, located about 1.5 mi southeast of J5 along the near cluster. Tall structures are visible for great distances in the rolling landscape. The Pawnee Generating Station to the north of the site is another major landmark easily seen from the distance.

There are several pipelines and oil and gas fields in the area, with 48 oil wells inside the SSC footprint. Nine of these are active. The pumps are inconspicuous and scattered. The most visible oil facility is the Adena gasoline plant, 1.5 mi west of Twelve-Mile Corner. Other cultural modifications include occasional dirt landing strips serving individual ranches in the area. A hazardous waste facility is now under construction to the south of the SSC site.

E. Viewshed Definition

Because of the relatively flat terrain and low-growing vegetation, there are no major, defined viewsheds. There is some spatial definition caused by the shallow valleys around the major drainages, but the dominant impression is of an uninterrupted horizon extending in all directions. Areas of minimal viewshed definition occur just south of the campus area around the tributaries to Badger Creek and in Badger Creek itself. Also Beaver and Plum Bush creeks define shallow viewsheds. Although the land appears flat in the vicinity of the site, for much of the area views do not extend many miles. The subtle roll of the land abbreviates views to 1 or 2 mi from most of the roads.

5.2.13.3 Sensitivity

A. Travel Routes

Major transportation routes in the vicinity include I-76, 20 min to the north (four-lane); I-70, 55 min to the south (four-lane); and State Highway 71, traversing the site north-south, connecting into I-76 at Brush and I-70 at Limon. A network of county roads provides access within the collider ring. None of these transportation routes is designated as a scenic highway nor are any shown to be scenic routes on maps or the Rand-McNally Road Atlas. State Highway 71 and the county roads noted do not serve residential areas or sites otherwise considered sensitive. Therefore, these roads are considered to be low in sensitivity.

B. Public Use Areas

No designated areas of aesthetic, recreational, cultural, or scientific significance occur within or near the site. The Pawnee National Grasslands, Jackson Lake State Recreation Area, Barr Lake State Recreation Area, and several reservoirs lie well to the northwest and northeast of the site.

C. Laws, Plans, Policies, and Regulations

There are no land use plans, zoning regulations, or regulations that indicate a sensitivity for scenic or visual resource protection in the site vicinity.

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