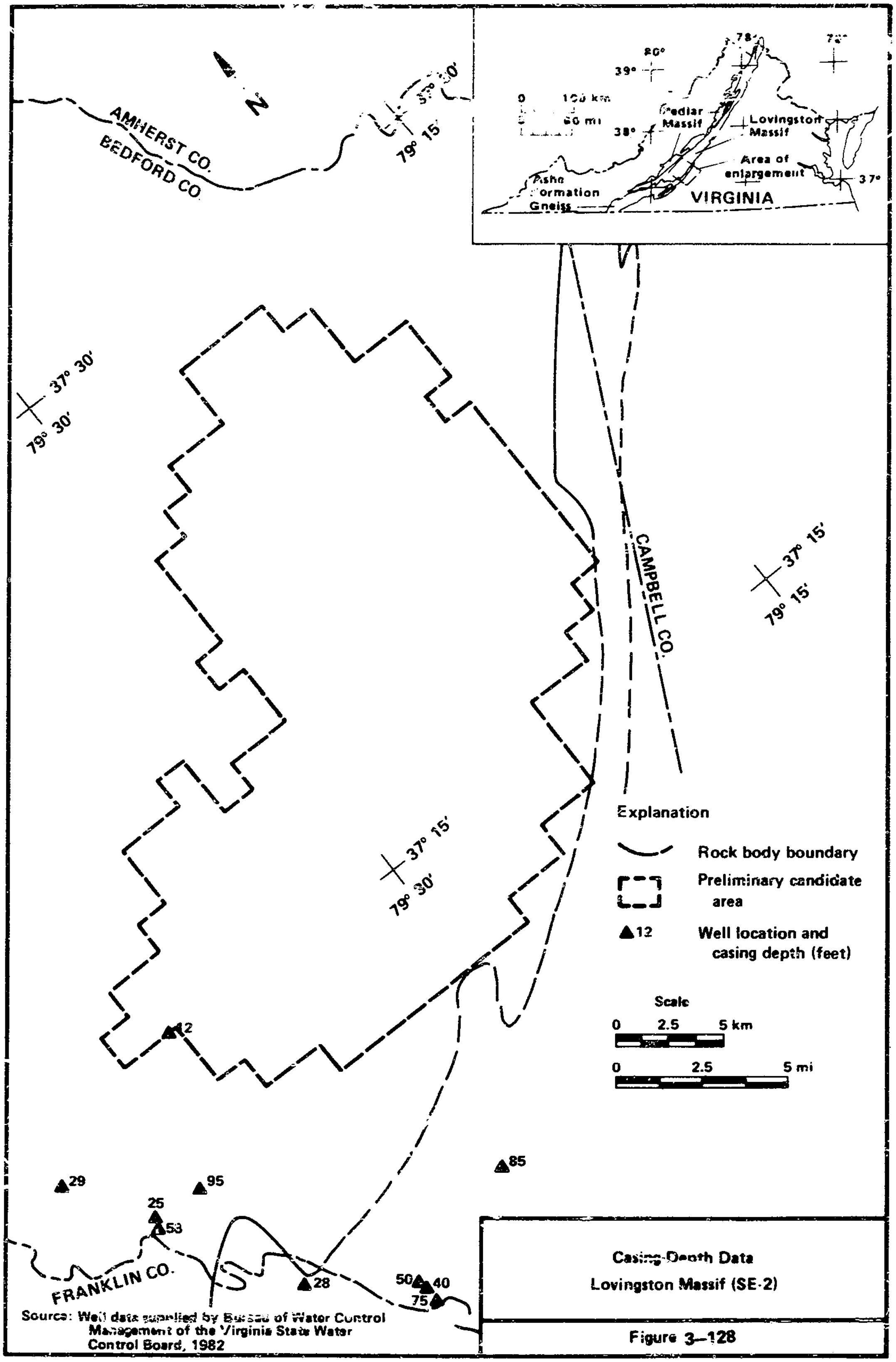


Casing-Depth Data
Lovingston Massif (SE-2)

Figure 3—128

is 13.4 m (43.8 ft). Additionally, based on five nearby data points, the average thickness of saprolite overlying surrounding units is 16.9 m (55.6 ft). Casing-depth data are available for only one well within the preliminary candidate area indicating a saprolite thickness of 3.7 m (12 ft). Well data were provided by the Bureau of Water Control Management of the Virginia State Water Control Board (1982). The location and distribution of areas where rocks crop out is presently unknown; however, mappable exposures are expected to be extensive.

On the basis of the data provided above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock within the preliminary candidate area has sufficient lateral extent and is sufficiently thick to allow significant flexibility in selecting a depth, configuration, and location for the underground facility to ensure isolation.

3.2.3.3.2 <u>Lithology and Tectonics.</u> The preliminary candidate area overlies the Sandy Creek granulite gneiss, Stage Road layered gneiss, Moneta gneiss, Turkey Mountain suite, Horsepen Mountain suite, Ashe Formation-gneiss (Lynchburg gneiss), and unnamed bodies of granulite, gneiss and charnockite (Figure 3-127a).

Bartholomew (1981) described the Sandy Creek granulite as a medium- to coarse-grained, layered quartzo-feldspathic gneiss with well developed segregation and granoblastic texture. This unit is most likely equivalent, in part, to what Hamilton (1964) mapped as Marshall gneiss, which includes fine- to medium-grained sericite-quartz-feldspar gneiss, amphibole-bearing gneiss, and actinolite schist. The Sandy Creek granulite gneiss is intruded by small bodies of pegmatite and felsite (Hamilton, 1964) and dikes of granite (Bartholomew, 1981).

The Stage Road layered gneiss is a well foliated, thickly layered unit of coarse-grained augen gneiss and fine- to medium-grained biotite gneiss (Sinha and Bartholomew, 1984). This unit is cut by numerous small intrusions of granite and dikes of metabasalt, diabase, and amphibolite (Allen, 1963; Nelson, 1962).

The Moneta gneiss consists of interlayered biotite gneiss and hornblende gneiss with a migmatite facies (Brown, 1958; Conley, 1978; Hamilton, 1964). The migmatite facies typically consists of interbedded hornblende gneiss and pegmatite (Brown, 1958). The gneiss is cut by dikes of pegmatite and hornblende gneiss (Brown, 1958; Diggs, 1955).

The Turkey Mountain suite (Bartholomew and Lewis, 1984) consists of charnockitic ferrodiorite and biotite augen gneiss (Herz and Force, 1984). The ferrodiorite has a coarse-grained, hypidiomorphic granular texture which grades into the massive, porphyritic biotite augen gneiss (Herz and Force, 1984).

The Horsepen Mountain suite consists of several varieties of charnockite and norite (Bartholomew, 1981; Hamilton, 1964). These rocks are fine to coarse grained, and massive to slightly foliated, but locally are mylonitic and well foliated (Bartholomew, 1981; Hamilton, 1964). The suite contains abundant gneissic xenoliths (Bartholomew, 1981) and is cut by basalt and diabase dikes (Hamilton, 1964).

The Ashe Formation-gneiss consists of interlayered biotite-muscovite gneiss, hornblende gneiss, and amphibolite (Brown, 1958; Conley, 1978). It is typically strongly layered and foliated and contains large- and small-scale folding (Brown, 1958; Conley, 1978; Rankin et al., 1973).

The crystalline rocks of the Lovingston massif originated as sedimentary and volcanic rocks (Sinha and Bartholomew, 1982). During the Grenville orogeny (culminating about 1,100 to 1,050 million years ago), the rocks of the Lovingston massif were metamorphased to granulite-grade and were probably intruded by anorthosite and charnockite. A period of uplift and erosion followed Grenville's orogeny, exposing the rocks of the Lovingston and Pedlar massifs. The uplift and erosion continued during deposition of the Ashe Formation-gneiss (Lynchburg Formation). From about 800 to 650 million years ago, granitic stocks of the Crossnore plutonic-volcanic group (including the Suck Mountain pluton) intruded the Lovingston massif (Bartholomew et al., 1981). During the Taconic orogeny (about 450 million years ago), the Lovingston massif was subjected to amphibolite facies metamorphism, but the effects of this event are not discernible in the basement rocks and can only be seen in the cover rocks including the Ashe Formation-gneiss (Bartholomew and Lewis, 1984).

During the Acadian orogeny about 400 to 350 million years ago, ductile deformation occurred along the Rockfish Valley fault during greenschist-grade metamorphism and juxtaposed the Lovingston Massif over the Pedlar massif (Bartholomew et al., 1981). Fault systems characterized by brittle deformation formed during the Late Paleozoic Alleghenian event.

The Lovingston massif and adjacent Ashe Formation-gneiss are located in the Blue Ridge anticlinorium (Conley, 1978). The rocks within the preliminary candidate area have undergone multiple episodes of folding and are juxtaposed in a steeply inclined, near-parallel arrangement (Figure 3-127b) (Hamilton, 1964). The Ashe Formation-gneiss is tightly infolded into the Moneta gneiss, forming detached antiformal structures (Brown, 1958; Conley, 1978).

Although no faults have been identified within the preliminary candidate area, there are at least two fault systems and four faults within 10 km (6 mi) of the preliminary candidate area (Figure 3-127a). These include the Rockfish Valley fault and the Peaks of Otter fault to the northwest of the preliminary candidate area, two unnamed faults north of the preliminary candidate area (Calver, 1963), and a system of faults associated with the James River synclinorium to the east.

The Rockfish Valley [illegible] located approximately 5 km (3 mi) from the preliminary candidate area at its nearest point, is a zone of Paleozoic ductile deformation (Sinha and Bartholomew, 1984). It is topographically expressed by a linear, 1.6- to 4.8-km (1- to 3-mi) wide valley (Bartholomew, 1981). The Rockfish Valley fault separates the Lovingston and Pedlar massifs (Sinha and Bartholomew, 1984) and has been interpreted to be a thrust fault (Harris et al., 1982) that truncates the rocks at a depth of about 3 to 4 km (1.8 to 2.4 mi) below the land surface. The Lovingston massif was transported northwestward along the Rockfish Valley fault over parautochthonous granulite basement gneisses of the Pedlar massif (Bartholomew et al., 1981).

The Peaks of Otter fault approximately 5 km (3 mi) west of the preliminary candidate area is marked by a fine-grained schistose zone that is 35 to 762 m (114 to 2,500 ft) wide. Much of the rock in the fault zone has been mylonitized. Hamilton (1964) noted that mineral lineations on foliation surfaces indicate that movement on the faults is mainly dip-slip and suggested that the Peaks of Otter fault may be a minor reverse fault within the Blue Ridge overthrust block (Pedlar massif). There are no descriptions available in the literature of the two faults to the north of preliminary candidate area.

The fault system associated with the James River synclinorium, occurs approximately 8 km (5 mi) east of the preliminary candidate area. These northeast-trending, predominantly high-angle thrust faults are thought to be younger than Paleozoic (Brown, 1958).

Estimates of regional uplift and subsidence are discussed in detail in Section 3.2.3.1.1.3. Regional data indicate recent uplift has occurred but there is a wide range of interpretations on the magnitudes of uplift. No data are available for the preliminary candidate area; therefore, until data are obtained, no conclusions can be drawn concerning effects of uplift. There are no in-situ stress data available for the vicinity of the preliminary candidate area.

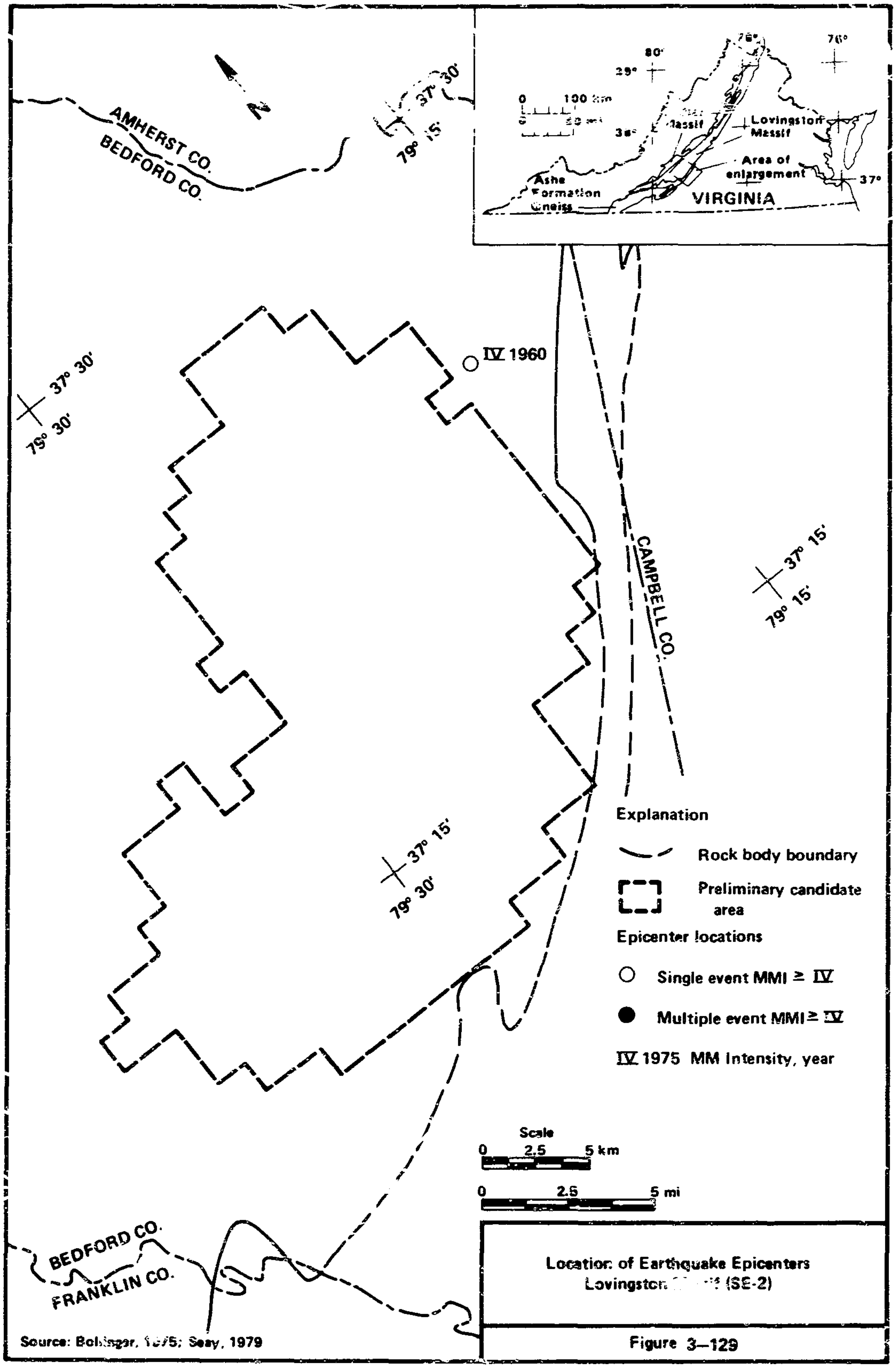
There is no evidence of Quaternary igneous activity, folding, faulting or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process, however, there appears to be no significant potential for tectonic deformations that could affect the regional ground-water flow system.

3.2.3.3.3 Seismicity. One earthquake epicenter with an intensity of MM IV (Bollinger, 1975; Seay, 1979) is located within 3 km (2 mi) of the preliminary candidate area (Figure 3-129). Two other seismic events of MM III are located in or near the preliminary candidate area: one occurred in the south central section of the preliminary candidate area and the other occurred approximately 12 km (7.4 mi) northeast of the preliminary candidate area (see Figure 3-118 in Section 3.2.3.1.1.3). The preliminary candidate area is located within a region of moderate seismic activity (see Figure 3-119). The largest historical earthquake associated with this zone is a MM VIII, which occurred on May 31, 1897 in Giles County, Virginia, approximately 100 km (60 mi) west-southwest of the preliminary candidate area.

The major faults near the preliminary candidate area are discussed in Section 3.2.3.1.1.3. There does not appear to be any strong correlation between the observed seismicity and known faults in the vicinity (less than 10 km [6 mi]) of the preliminary candidate area.

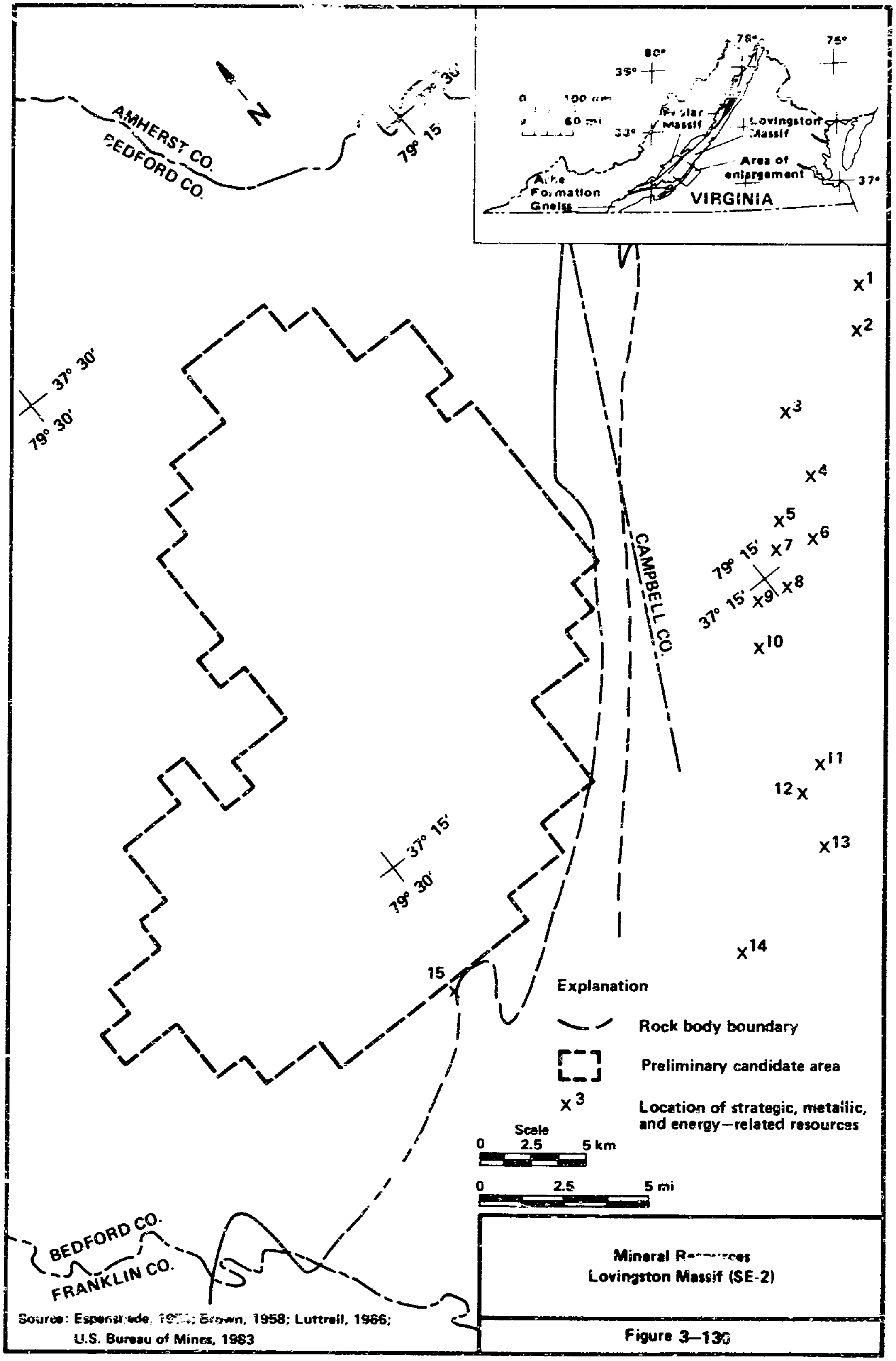
Although the level of seismic activity in the region is moderate, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation, and it is unlikely that the frequency of occurrence of earthquakes in the area will increase in the future.

3.2.3.3.4 Mineral Resources. There are nine mines within 10 km (6 mi) of the preliminary candidate area from which strategic, metallic, or energy-related resources were formerly extracted (Figure 3-130; Table 3-14). In addition, six mines located more than 10 km (6 mi) from



Location of Earthquake Epicenters
Lovingston [illegible] (SE-2)

Figure 3–129



Source: Espenshade, ; Brown, 1958; Luttrell, 1966; U.S. Bureau of Mines, 1983

Mineral Resources
Lovingston Massif (SE-2)

Figure 3–130

Table 3-14. Mineral Resources Near Preliminary Candidate Area SE-2

Map Number (Figure 3-130)	Name	Commodity	Status
1	Neighbors Mine	Manganese	Inactive
2	Dodson Iron Mine	Iron	Unknown
3	Bell Mine	Manganese	Inactive
*	Maddox Mine	Manganese	Inactive
4	McGehee/Arthur Mine	Manganese	Inactive
5	Unnamed	Iron	Inactive
6	Mortimer Mine	Iron, Manganese	Inactive
*	Ward Mine	Manganese	Inactive
7	Pribble Mine	Manganese	Inactive
8	Phillips Mine	Manganese	Inactive
9	Carter Prospect	Manganese	Inactive
10	Russell Den Hollow Mine	Manganese	Inactive
*	Saunders Mine	Manganese	Inactive
*	Teates Mine	Manganese	Inactive
*	Wood Mine	Manganese	Inactive
11	Tardy and Frazier Mine	Manganese	Inactive
*	Theresa Mine	Manganese	Inactive
*	Will F. Tweedy Prospect	Manganese	Inactive
12	Gratsy Mine	Manganese	Inactive
13	Bishop Mine	Manganese, Copper, Sulfur	Inactive
14	Lucas Mine	Manganese	Inactive
15	Overstreet Mine	Iron, Mica	Inactive

Source: Espenshade, 1954; Brown, 1958; U.S. Bureau of Mines, 1983.

* Not shown on map, located off map.

the preliminary candidate area are shown on Figure 3-130 and listed in Table 3-14. None of these mines are located within the boundaries of the preliminary candidate area. The Overstreet mine, located approximately 0.5 km (0.3 mi) south of the preliminary candidate area, is a small, inactive iron mine (U.S. Bureau of Mines, 1983). The remaining 14 mines are located approximately 10 km (6 mi) from the preliminary candidate area, in the James River-Roanoke River manganese district. The deposits, from which manganese and by product iron were mined, are located entirely within the Mt. Athos Formation (Brown, 1958; Espenshade, 1954), and no evidence suggests that manganese could occur in the lithologically distinct Lovingston massif. Therefore, the potential for development of any metallic, strategic, or energy-related resource within the preliminary candidate area is considered very low.

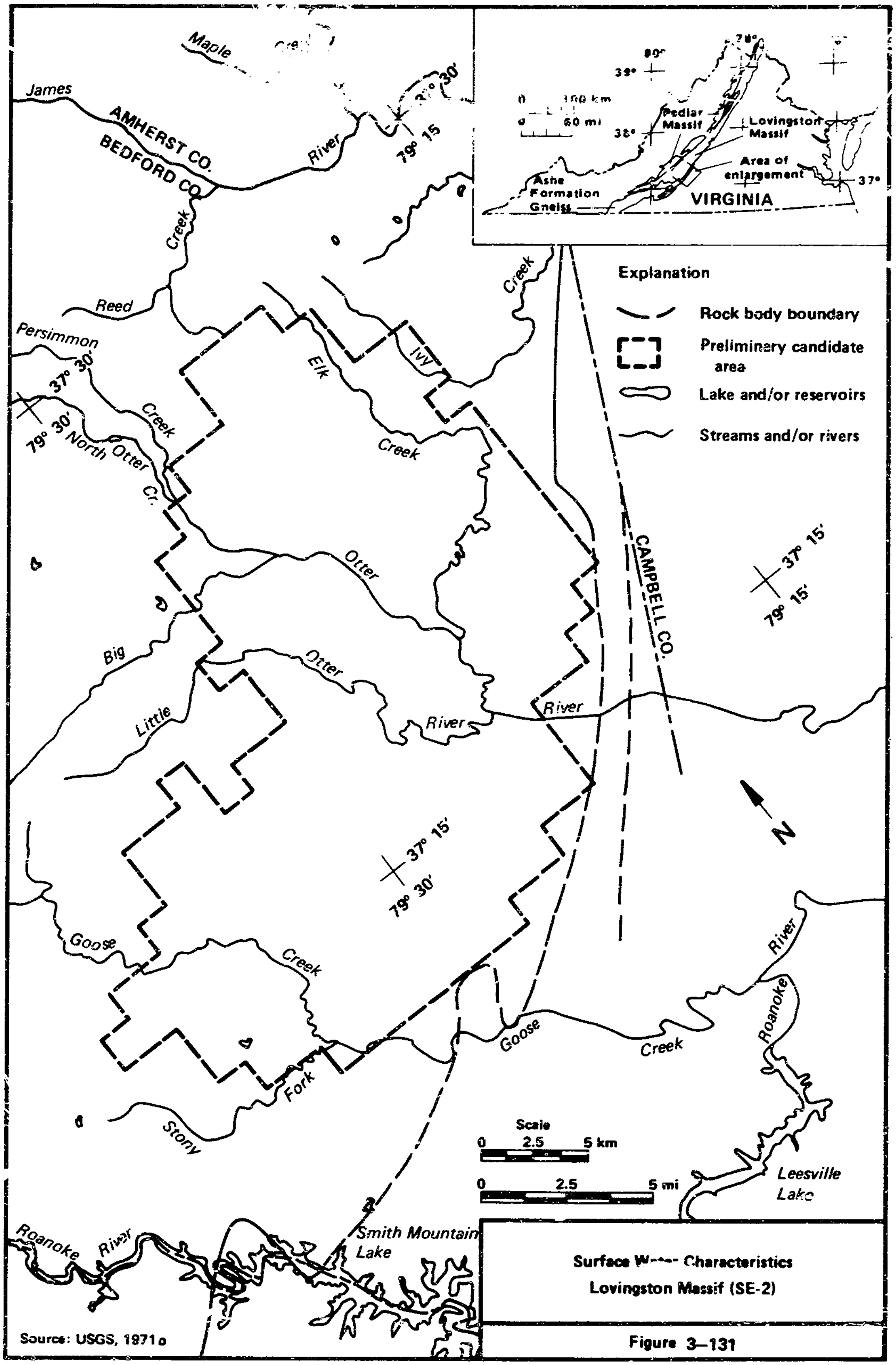
Based on the data presented in this section, there are no known strategic, metallic, or energy-related mineral resources within the preliminary candidate area. There is no evidence for mining to a depth sufficient to affect waste isolation and no information is available to indicate that deep drillholes (greater than 100 m [328 ft] in depth) are present in the preliminary candidate area.

3.2.3.3.5 Topography and Surface-Water Characteristics. The preliminary candidate area is characterized by moderate to highly dissected, relatively flat uplands. In the extreme northern section, No Business Mountain and adjacent high hills, ranging in elevation from 244 to 817 m (800 to 2,680 ft), form local areas of high relief (up to 512 m [1,680 ft]). These areas constitute approximately 5% of the preliminary candidate area (USGS, 1965a; 1965b). Local relief over the remaining 95% of the preliminary candidate area is no more than 84 m (270 ft) (USGS, 1965c; 1966a; 1967a; 1967b; 1967c; 1967e). Floodplains are narrow (less than 31 m [100 ft]) along the majority of stream corridors, but are moderately wide (up to 1[illegible] m [500 ft]) along Big Otter and Little Otter rivers.

The surface-water system within the preliminary candidate area is characterized by a dendritic drainage pattern dominated by the Big Otter and Little Otter Rivers and their tributaries over most of the preliminary candidate area and by Goose Creek and its tributaries in the southernmost part of the preliminary candidate area (Figure 3-131). The Big Otter River generally flows south-southeast and drains into the Roanoke River about 16 km (10 mi) southwest of the preliminary candidate area. Goose Creek flows southeast into the Roanoke River, about 11 km (6.6 mi) southwest of the preliminary candidate area. There are no large lakes or reservoirs within or immediately adjacent (within 10 km [6 mi]) to the preliminary candidate area, although numerous small (less than 4 ha [10 ac]) impoundments occur throughout the preliminary candidate area.

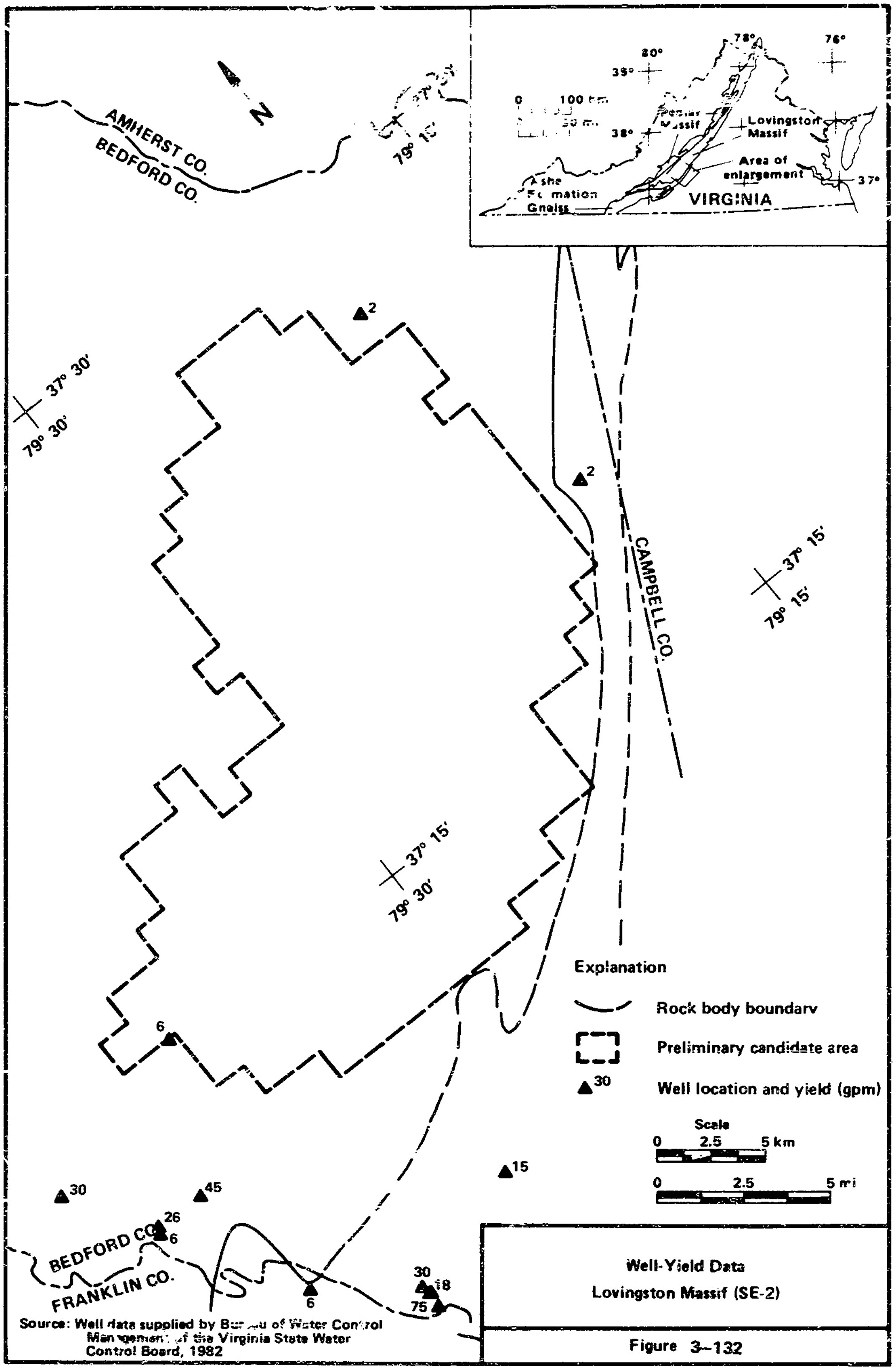
Local relief of no more than 84 m (270 ft) over 95% of the preliminary candidate area, narrow floodplains, and lack of any large lakes, reservoirs, swamps, bogs, or wetlands indicate that the preliminary candidate area is well drained. Consequently, there is an overall low flooding potential. A slightly higher flooding potential exists along the Big Otter and Little Otter River corridors, but these constitute less than 1% of the total preliminary candidate area.

3.2.3.3.6 Ground-Water Resources. Regional ground water data are discussed in Section 3.2.3.1.1.5. Available data in the preliminary candidate area do not allow a differentiation between producing wells in saprolite and crystalline bedrock wells nor are water level contour maps available for the preliminary candidate area. Well data were provided by the Bureau of Water Control Management of the Virginia State Water Control Board. Water well data in the vicinity of the preliminary candidate area are reported by county and is expressed in terms of well yields. Figure 3-132 presents the available well-yield data in the vicinity of the preliminary candidate area. Six wells located within the Lovingston Massif average 1.21 L/s (19.17 gpm). Of these, three yield



Surface Water Characteristics
Lovingston Massif (SE-2)

Figure 3–131



Source: Well data supplied by Bureau of Water Control Management of the Virginia State Water Control Board, 1982

Well-Yield Data
Lovingston Massif (SE-2)

Figure 3–132

less than 1.26 L/s [illegible] these yield from 1.26 to 2.84 L/s (20 to 45 gpm). Only one well with a yield of 0.4 L/s (6 gpm) is located within the preliminary candidate area. Six wells located within surrounding units average 1.54 L/s (24.33 gpm). Of these, four yield less than 1.26 L/s (20 gpm), and the remaining two yield from 1.26 to 4.73 L/s (20 to 75 gpm).

The well yield information indicates the presence of potable ground water in the vicinity of the preliminary candidate area. The yields are generally very low, less than 1.55 L/s (25 gpm) with a few wells yielding up to 4.73 L/s (75 gpm). There are no data to suggest that ground-water conditions in the preliminary candidate area differ significantly from the surrounding area. Specific relationships between lithology, structure, and well yields are not currently available. There are no data on the deep ground-water system within the preliminary candidate area.

3.2.3.3.7 Quaternary Climate. A discussion of Quaternary climatic conditions, including paleoclimatic conditions, vertical crustal movement and changes in sea level, is in Section 3.2.3.1.1.1.

3.2.3.3.8 Federal Lands. There are no Federal lands located within the preliminary candidate area. The Thunder Ridge Wilderness Area and the closest portion of the Blue Ridge Parkway are both located 10 km (6 mi) to the northwest of the preliminary candidate area. The Jefferson National Forest lies 4 km (2.5 mi) to the northwest of the preliminary candidate area. All these features are greater than 130 ha (320 ac) in size and are depicted on Plate 2A of the Southeastern RECR or are listed in Appendix A of that report (DOE, 1985h) (see also Figure 3-133). In addition, there is no evidence in the data base that Federal lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.

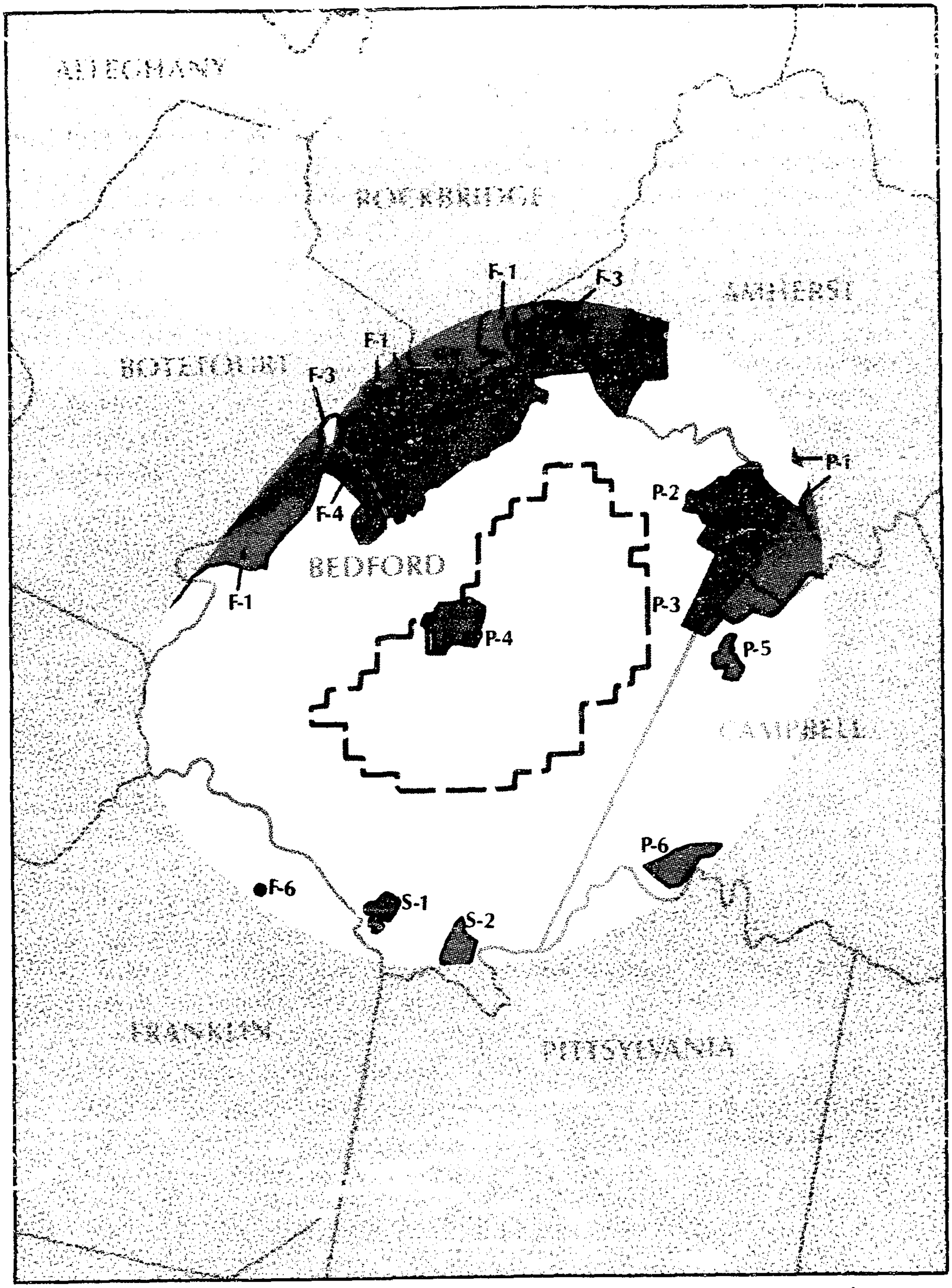


Figure 3-133 Sheet 1 **Environmental Features Lovingston Massif (SE-2)**

Environmental Features Legend

Preliminary Candidate Area

Environmental Features

- **P** Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile
- **F** Federal Lands Greater Than 320 Acres
- **S** State Lands Greater Than 320 Acres
- **I** Federal Indian Reservations
- **●** Federal or State Lands Less Than 320 Acres
- **F-5** Map Alpha-numeric Codes are Keyed to Environmental Features

Rock Bodies

Beyond Ten Miles from Preliminary Candidate Area

State Boundary

County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–133 Sheet 2

ENVIRC"MFN.I FEATURES WITHIN 16 KM (10 MI)
OF ... CANDIDATE AREA SE-2*

Code	Feature
Population Features	
P-1	Madison Heights Highly Populated Area (HPA)
P-2	Lynchburg Minor Civil Division (MCD)
P-3	Tomahawk MCD
P-4	Bedford HPA
P-5	Timberlake HPA
P-6	Altavista HPA
Federal Lands	
F-1	Jefferson National Forest
F-2	James R. Face Wilderness
F-3	Appalachian Trail
F-4	Blue Ridge Parkway
F-5	Thunder Ridge Wilderness
F-6	Booker T. Washington National Monument
State Lands	
S-1	Smith Mountain Lake State Park
S-2	Smith Mountain Wildlife Management Area
Indian Reservations	
None	

* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 3-133, Sheet 3

3.2.3.3.9 State Lands. No State lands lie within the boundary of the preliminary candidate area. Smith Mountain Lake State Park lies approximately 10 km (6 mi) south of the preliminary candidate area. This feature is greater than 130 ha (320 ac) in size and is depicted on Plate 3A of the Southeastern RECR (DOE, 1985h) (see also Figure 3-133). In addition, there is no evidence in the data base that State lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.3.10 Environmental Compliance. No portion of the preliminary candidate area lies within current air quality nonattainment areas. The closest Prevention of Significant Deterioration (PSD) Class I Area is the James River Face National Wilderness Area which lies approximately 11 km (7 mi) to the north of the preliminary candidate area (42 FR 57460, 1977). Two sites on the National Register of Historic Places (NRHP) are located within the preliminary candidate area boundary. These sites are Elk Hill near Forest and Old Rectory near Perrowville (44 FR 7613, 1979). No proposed NRHP sites exist within the preliminary candidate area. In the regional data base there are no known existing archaeological sites or districts or any any proposed for designation within the preliminary candidate area. No National Trails are located within the preliminary candidate area. The Appalachian Trail is 10 km (6 mi) to the northwest of the preliminary candidate area boundary at its closest approach (Alexandria Drafting Company, 1981).

3.2.3.3.11 Population Density and Distribution. The preliminary candidate area contains one highly populated area (Bedford) which has a population of 5,991. There are three other highly populated areas within 16 km (10 mi) of the preliminary candidate area (Altavista, Madison Heights, Timberlake). Altavista is located 11 km (7 mi) southeast of the preliminary candidate area and has a population of 3,849. Madison Heights, with a population of 14,146, and Timberlake, with a population of 9,697, are located 14 km (9 mi) and 4.8 km (3 mi) east of the preliminary candidate area, respectively (see Figure 3-133). The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square mile. There are two areas with population densities greater than or equal to 1,000 persons per square mile (Lynchburg and Tomahawk) within 16 km (10 mi) of the preliminary candidate area (see Figure 3-133). Tomahawk, with a population of 4,204, is located 3.2 km (2 mi) east of the preliminary candidate area. Lynchburg, which is located 3.2 km (2 mi) east-northeast of the preliminary candidate area, has a population of 66,743. The average population density of the preliminary candidate area is approximately 50 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate area is approximately 84 persons per square mile. Low population density is defined as a density in the general region of the site less than the average population density for the conterminous United Staters (76 persons per square mile) based on the 1980 census.

3.2.3.3.12 Site Ownership. There are no Federal or DOE-owned lands located within the preliminary candidate area. The Cherokee Indian Reservation is 370 km (230 mi) southwest of the preliminary candidate area (see Plate SE-1A).

3.2.3.3.13 Offsite Installations. No commercial nuclear reactors are located within the preliminary candidate area. The nearest operating commercial nuclear reactor is North Anna, which is approximately 140 km (85 mi) to the northeast (Dames & Moore, 1972). The nearest commercial nuclear reactor under construction is the Shearon Harris Nuclear Plant which is approximately 265 km (165 mi) to the southwest (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 40 CFR 191, Subpart A, within or in proximity to the preliminary candidate area.

3.2.3.3.14 Transportation. The nearest interstate highway is I81 which is located approximately 24 km (15 mi) northwest of the preliminary candidate area on the west side of the Blue Ridge Mountains. I581 in Roanoke is about 24 km (15 mi) west of the preliminary candidate area. I64 is about 80 km (50 mi) to the northeast. Both U.S. 221 and 460 pass through the middle of the preliminary candidate area. U.S. 460 is a four-lane, divided highway between Roanoke and Lynchburg, Virginia. U.S. 501 is located northeast of the preliminary candidate area. U.S. 501 passes through the James River gap in the Blue Ridge Mountains. State Route 24 runs across the extreme southern edge of the preliminary candidate area roughly paralleling U.S. 460. State Route 122 (not shown on the plot) is the only other State highway which crosses the area. State Route 122 begins at U.S. 501 near the Blue Ridge Parkway and runs along the western edge of the preliminary candidate area. State Route 122 also intersects U.S. 221 and U.S. 460 at Bedford.

A Norfolk and Western mainline railroad crosses through the center of this preliminary candidate area. The Norfolk and Western also has another mainline about 3.2 km (2 mi) south of the preliminary candidate area. The Chesapeake and Ohio has a mainline that travels through the James River valley about 3.2 km (2 mi) to the north of the preliminary candidate area. The Southern Railway's mainline between Washington, D.C., and Atlanta is located about 8 km (5 mi) east of the preliminary candidate area. There are no branchlines in the immediate vicinity of the preliminary candidate area.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.3.15 Preliminary Candidate Area Deferral Analysis. This section identifies significant additional information (specified in Section 3.2) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-2 that could affect DOE's decision to defer further considerations of the area. Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation [960.4-2-3(b)(1), 960.5-2-9(b)(1), 960.5-2-9(c)(1)]
- presence of host rock that permits emplacement of waste at least 300 m (1,000 ft) below ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow systems should not be significantly affected [960.4-2-7(c)(6)]
- absence of active faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]
- no indications, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could produce ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]

- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect waste containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring material that is not widely available from other sources [960.4-2-8-1(c)(4)]
- presence of generally flat terrain [960.5-2-8(b)(1)]
- presence of generally well-drained terrain [960.5-2-8(b)(2)]
- general absence of surface characteristics or surface-water systems that could lead to flooding [960.5-2-8(c), 960.5-2-10(b)(2)]
- located within a geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]
- absence of Federal lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(3)]
- absence of State lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(4)]
- low population density within its boundaries [960.5-2-1(b)(1)]
- absence of nuclear installations [960.5-2-4(b) and (c)(2)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfer of title, or Federal condemnation proceedings [960.4-2-8-2(c), 960.5-2-2(c)]

- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2), 960.5-2-7(b)(3)].

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]
- presence of shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2-8-1(c)(1)(i)]
- a majority of the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile [960.5-2-1(c)(2)].

The results indicate that there are no significant adverse features identified to date that would preclude DOE from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-2 at this time.

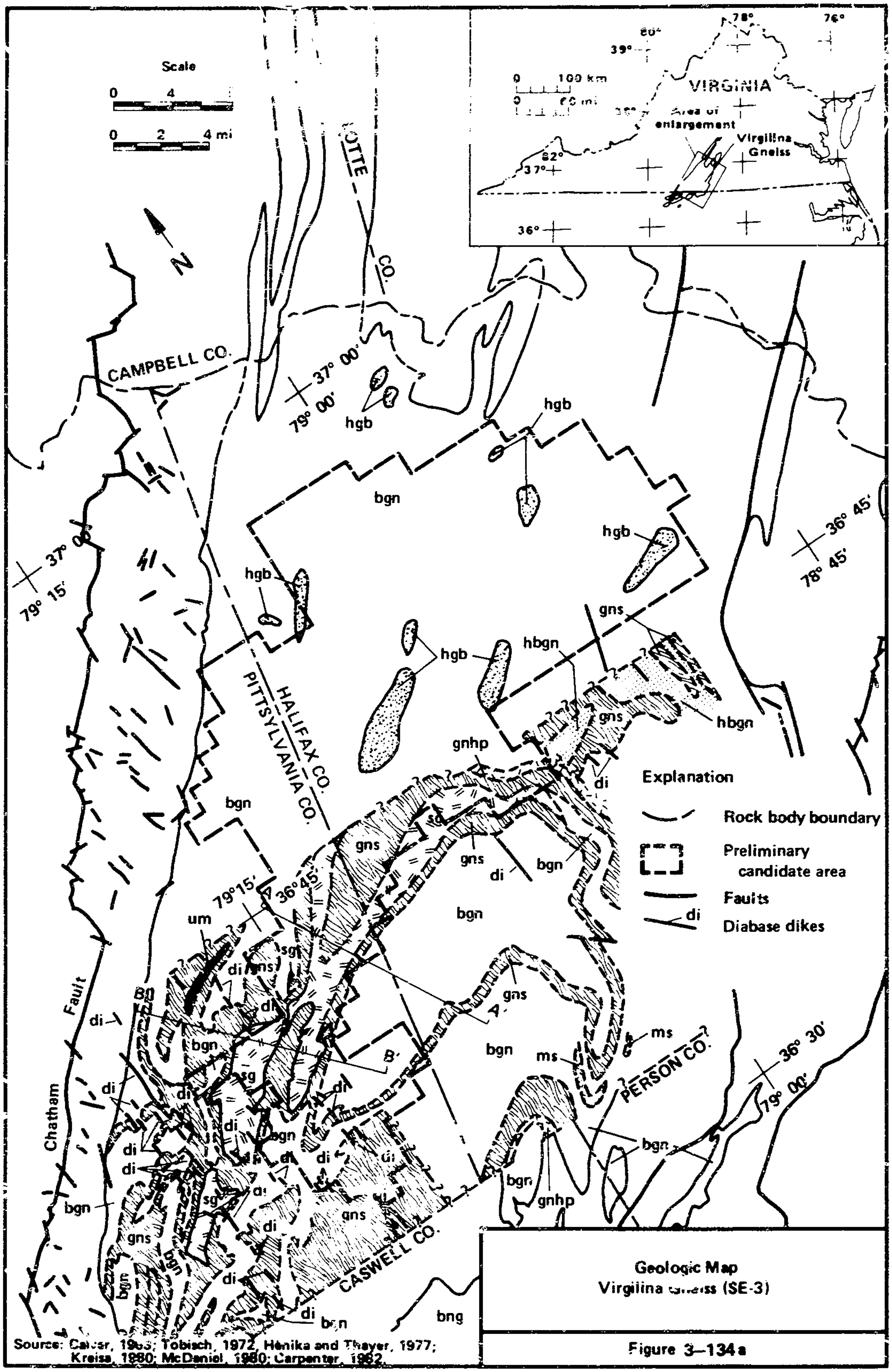
3.2.3.4 Preliminary Candidate Area Description - Virgilina Gneiss (SE-3)

Preliminary candidate area SE-3 is located within the Piedmont physiographic province of south central Virginia in Pittsylvania and Halifax Counties, at approximately 36°45' N latitude, 79°00' W longitude (Figure 3-134a).

3.2.3.4.1 Host Rock Geometry and Overburden Thickness. The preliminary candidate area has an area of 798 km^2 (307 mi^2); with a length of 47.5 km (29.4 mi), a width of 22.8 km (14.2 mi), and overlies the Virgilina gneiss (Figure 3-134a).

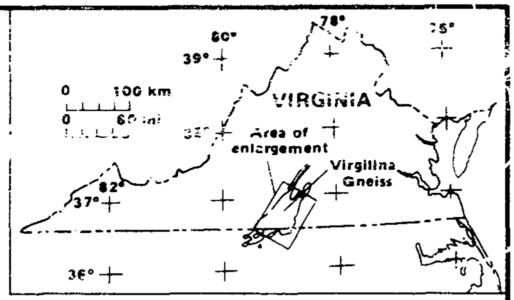
The Virgilina gneiss consists predominantly of an interbedded sequence of paragneisses and a stock of granitic gneiss (Figure 3-134b). There are no direct data concerning the depth of these units, although they are usually shown as persisting with depth in cross section (Calver, 1963; Carpenter, 1982; Kreisa, 1980; McDaniel, 1980; Price et al., 1980a, 1980b; Wilson and Carpenter, 1981). Tobisch (1972), for example, extends these units approximately 2 km (1.2 mi) beneath the land surface without showing any other lithologies deeper in the section (Figure 3-134b).

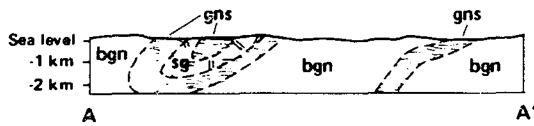
Available water well casing depth data in the vicinity of the preliminary candidate area are given in Figure 3-135. No casing-depth data are available for wells within the preliminary candidate area. However, based on five data points within the Virgilina gneiss, the average thickness of saprolite is 13.4 m (43.8 ft). Based on eight nearby data points, the average thickness of saprolite overlying surrounding units is 13.1 m (43 ft). Well data were provided by the Bureau of Water Control Management of the Virginia State Water Control Board (1982). The location and distribution of areas of rock exposure are presently unknown; however, mappable exposures are expected to be fairly extensive.



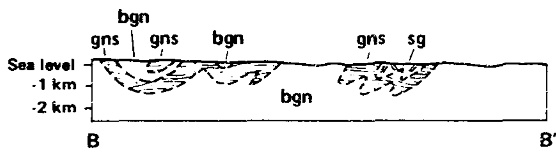
Geologic Map
Virgilina Gneiss (SE-3)

Figure 3–134a





Source: Tobisch (1972)



Source: Henika and Thayer (1977)

Explanation

Lithologic contacts

bgn — Granitic gneiss, local mafic and calcareous gneiss

gns — Granitic gneiss with interlayered mica schist

sg — Shelton Formation (granitic gneiss)

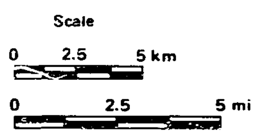
hbgn — Hornblende-biotite gneiss

gnhp — Granite gneiss and interlayered hornblende-plagioclase gneiss

hgb — Hornblende gabbro

um — Ultramafic rocks

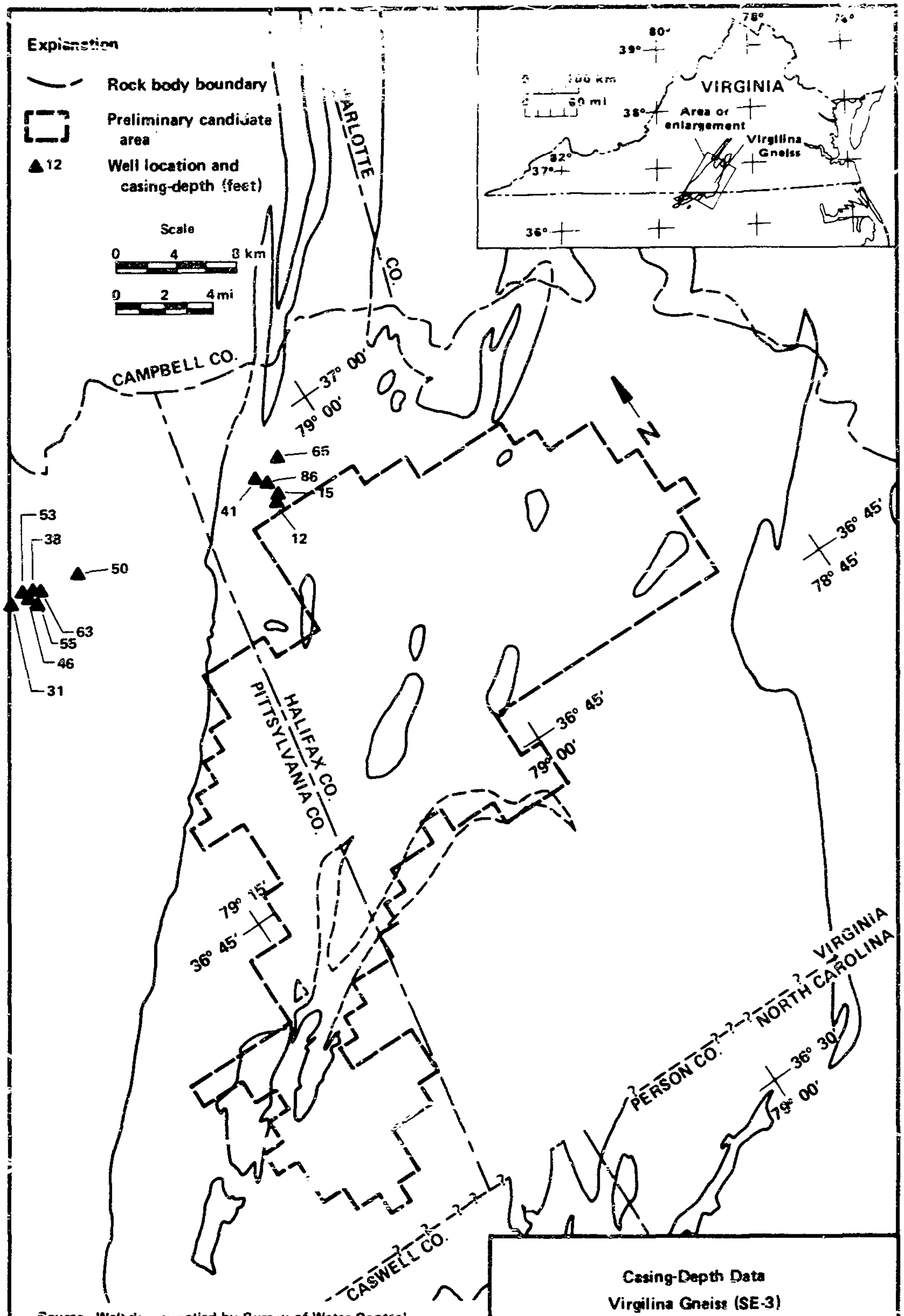
ms — Mica schist and mica quartzite



Note: Scale for cross sections (1: 250,000) is smaller than the scale for the geologic map (1:360,000)

Geologic Cross Section
Virgilina Gneiss (SE-3)

Figure 3–134b



Source: Well data supplied by Bureau of Water Control Management of the Virginia State Water Control Board, 1982

Casing-Depth Data
Virgilina Gneiss (SE-3)

Figure 3–135

On the basis of the data presented above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock underlying the preliminary candidate area is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation.

3.2.3.4.2 Lithology and Tectonics. The Virgilina gneiss consists of volcanic and sedimentary rocks that have been metamorphosed at lower greenschist to amphibolite grade rocks (Henika and Thayer, 1977). Tobisch (1972) places a kyanite-sillimanite isograd immediately southeast of the preliminary candidate area, with sillimanite-grade rocks on the southeast side of the isograd. However, the specific metamorphic grades throughout the preliminary candidate area are unknown. There are at least five major gneissic rock units that have been mapped within the preliminary candidate area (Figure 3-134a). These include the Shelton Formation, granitic gneiss with local occurrences of mafic and calcareous gneiss, granitic gneiss and mica schist, interlayered granitic gneiss and hornblende-plagioclase gneiss, and hornblende gabbro and gneiss, (Calver, 1963; Henika and Thayer, 1977; Tobisch, 1972).

The Shelton Formation consists of medium- to coarse-grained, homogeneous, strongly foliated and lineated gneiss that is typically granitic in composition (Henika and Thayer, 1977; Tobisch, 1972). It is cut by mafic dikes and quartz veins (Henika, 1980).

The granitic gneiss and mica schist unit consists of interlayered granitic gneiss, mafic and felsic metavolcanic rocks, and mica schist (Tobisch, 1972; Henika and Thayer, 1977). The unit may include slaty lithofacies depending on metamorphic grade (Henika and Thayer, 1977). Schist generally occurs in layers that are less than 3.3 m (10 ft) thick, although some layers 66 m (200 ft) thick have been reported (Tobisch, 1972). Thin layers of quartzite occur locally and are associated with pelitic rock (Tobisch, 1972). Tourmaline occurs locally in the schist and quartzite (Tobisch, 1972).

The granitic, and [illegible] calcareous gneiss unit consists of fine- to medium-grained, massive [illegible] layered, foliated granitic gneiss and felsic metatuff (Tobisch, 1972; Henika and Thayer, 1977). The unit may include slaty and schistose lithofacies dependent on metamorphic grade (Henika and Thayer, 1977). Locally, the gneiss contains interlayered, medium-grained, layered hornblende-plagioclase gneiss and rarely calcareous gneiss (Tobisch, 1972).

The granitic and hornblende-plagioclase gneiss unit consists of medium-grained, massive to layered granitic gneiss that is interlayered with fine- to coarse-grained hornblende-plagioclase gneiss (Tobisch, 1972). Locally, medium-grained, layered calcareous gneiss is present (Tobisch and Glover, 1969).

The hornblende gabbro and gneiss unit occurs in the northern part of the preliminary candidate area. These rocks include talc, amphibole-chlorite schist, amphibolite, chloritic diorite, and hornblende diorite (Calver, 1963).

During the Taconic orogeny, the gneisses underwent two episodes of folding. Near the end of the second folding episode, the protolith of the Shelton Formation intruded the gneisses, spreading into the cores of preexisting folds. Two subsequent episodes of folding affected all the rocks. Although the latter two episodes have not been dated, they probably reflect the regional metamorphic and deformational events that occurred during the Acadian (400 to 350 million years ago) and Alleghenian orogenies (330 to 270 million years ago). Deformation during the Alleghenian orogeny was partially brittle in nature, producing faults and fractures (Henika, 1980).

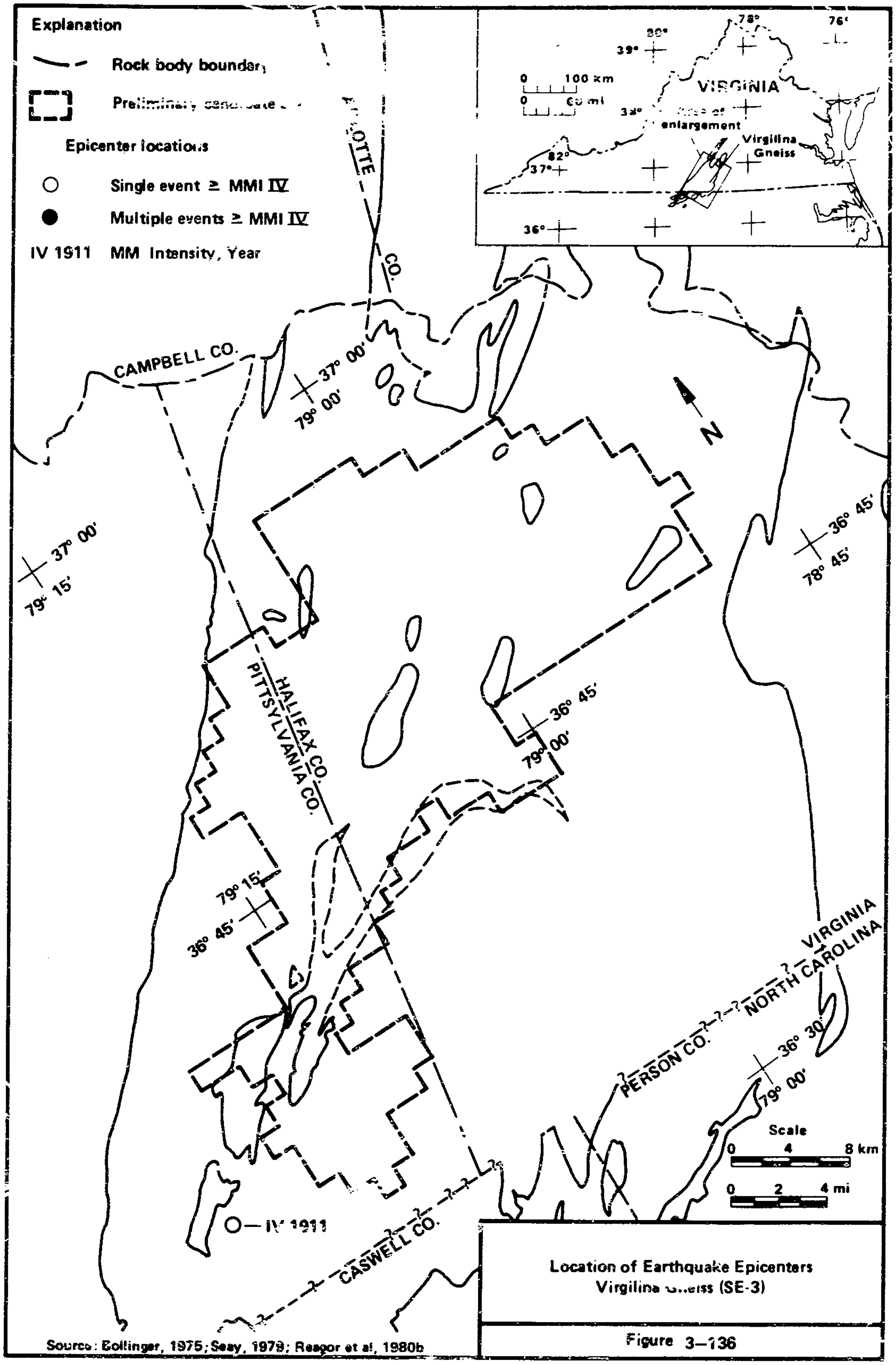
The Virgilina gneiss has been subjected to multiple deformation events. The major structural features within the southwestern section of the preliminary candidate area are a series of refolded, synformal, and antiformal structures overturned to the southeast (Tobisch, 1972).

There are two major fault systems within 10 km (6.2 mi) of the preliminary candidate area (Figure 3-134a) corresponding, in part, to the eastern and western boundaries of the Virgilina gneiss. The Chatham fault system is located about 5 km (3 mi) west of the boundary of the preliminary candidate area. It is a normal fault that bounds Triassic sedimentary rocks and adjacent gneisses and schists. The fault is expressed by numerous fractures and shears, and broad bands of cataclastic rocks (Henika and Thayer, 1977). The most recent movement along this fault is estimated to have occurred during early Jurassic (Henika and Thayer, 1977). The fault located on the eastern boundary of the Virgilina gneiss (Calver, 1963) has not been described in the literature. About eight short faults are located to the north of and at an oblique angle to the trend of the Chatham fault. These faults are approximately 10 km (6 mi) from the preliminary candidate area.

Estimates of regional uplift and subsidence are discussed in detail in Section 3.2.3.1.1.3. Regional data indicate recent uplift has occurred but there is a wide range of interpretations on the magnitudes of uplift. No data are available for the preliminary candidate area; therefore, until data are obtained, no conclusion can be drawn concerning affects of uplift. There are no in situ stress data available for the vicinity of the preliminary candidate area.

There is no evidence of quaternary igneous activity, folding, faulting, or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process, however, there appears to be no significant potential for tectonic deformations that could affect the regional ground-water flow system.

3.2.3.4.3 Seismicity. One earthquake epicenter with an intensity of MM IV (Bollinger, 1975; Seay, 1979; Reagor et al., 1980b; Stover et al., 1984) is located within 10 km (6 mi) of the preliminary candidate area Figure 3-136. One other seismic event of MM III (?) (Stover et al., 1984) is located about 10 km (6 mi) west of the southern section of the



Location of Earthquake Epicenters
Virgilina Gneiss (SE-3)

Figure 3–136

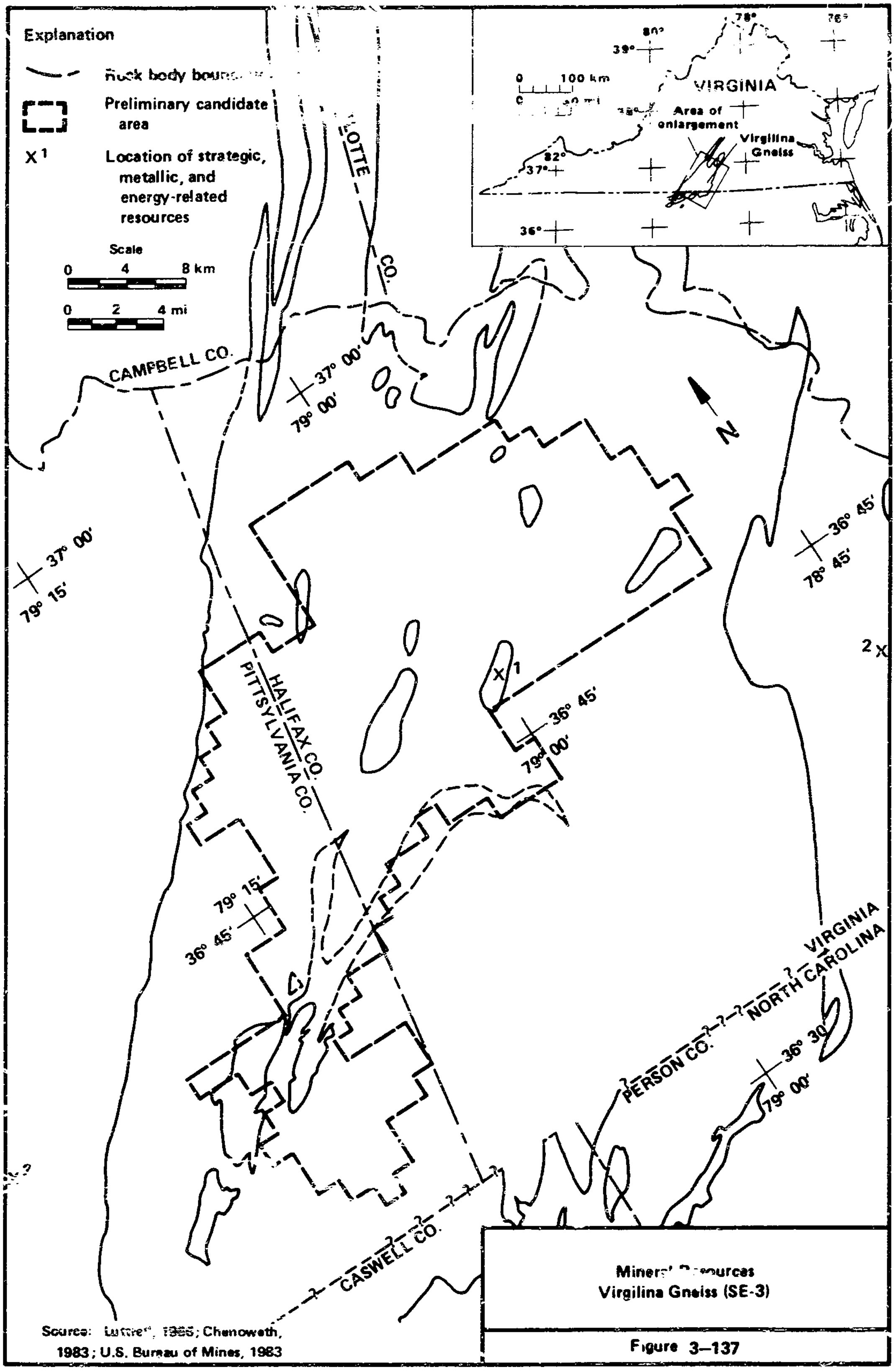
preliminary candid[illegible] Figure 3-118 in Section 3.2.3.1.1.3. The preliminary candidate area [illegible] located [illegible] in a region of little seismic activity (see Figure 3-119 in Section 3.2.3.1.1.3).

The major faults near the preliminary candidate area are discussed in Section 3.2.3.4.2. There is no obvious correlation between the observed seismicity and the faults adjacent to the preliminary candidate area.

The largest historical earthquake associated with this region is a MM VII which occurred December 23, 1875, in Buckingham County, Virginia, approximately 100 km (60 mi) northeast of the preliminary candidate area.

Considering the low level and magnitude of seismic activity in the region and the absence of active tectonic processes within the geologic setting during the Quaternary Period, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation, and it is unlikely that the frequency of occurrence or the magnitude of earthquakes in the area will increase in the future.

3.2.3.4.4 Mineral Resources. One inactive, lead prospect is located in the preliminary candidate area (U.S. Bureau of Mines, 1983) (Table 3-15, Figure 3-137). No other metallic, strategic, or energy-related resources or mining districts (Figure 3-137) are located within 10 km (6 mi) of the preliminary candidate area. Two additional resources, more than 10 km (6 mi) from the preliminary candidate area, consist of an inactive copper and silver mine and a uranium prospect (U.S. Bureau of Mines, 1983; Chenoweth, 1983). The uranium occurrence is an ore body associated with a shear zone adjacent to the Chatham fault (Chenoweth, 1983) which trends northeast-southwest, roughly parallel and outside the western boundary of the Virgilina gneiss (Figure 3-134a).



Mineral Resources
Virgilina Gneiss (SE-3)

Figure 3–137

Therefore, the probability of similar uranium deposits within the preliminary candidate area is very low. In addition, there is no substantial history of mining within or adjacent to the preliminary candidate area and potential for future development of mineral resources is considered very low.

Table 3-15. Mineral Resources Near Preliminary Candidate Area SE-3

Map Number Figure 3-137	Name	Commodity	Status
1	W. C. Powell Prospect	Lead	Inactive
2	High Hill Mine	Copper-Silver	Inactive
3	Unnamed Occurrence	Uranium	Unknown

Source: U.S. Bureau of Mines, 1983; Chenoweth, 1983; Luttrell, 1966.

Based on the data presented in this section, there is one inactive mineral resource within the preliminary candidate area. However, there is no substantial history of mining within or adjacent to the preliminary candidate area and potential for future development of mineral resources is considered very low. There is no evidence for mining to a depth sufficient to affect waste isolation and no information is available to indicate that deep drillholes (greater than 100 m [328 ft] in depth) are present in the preliminary candidate area.

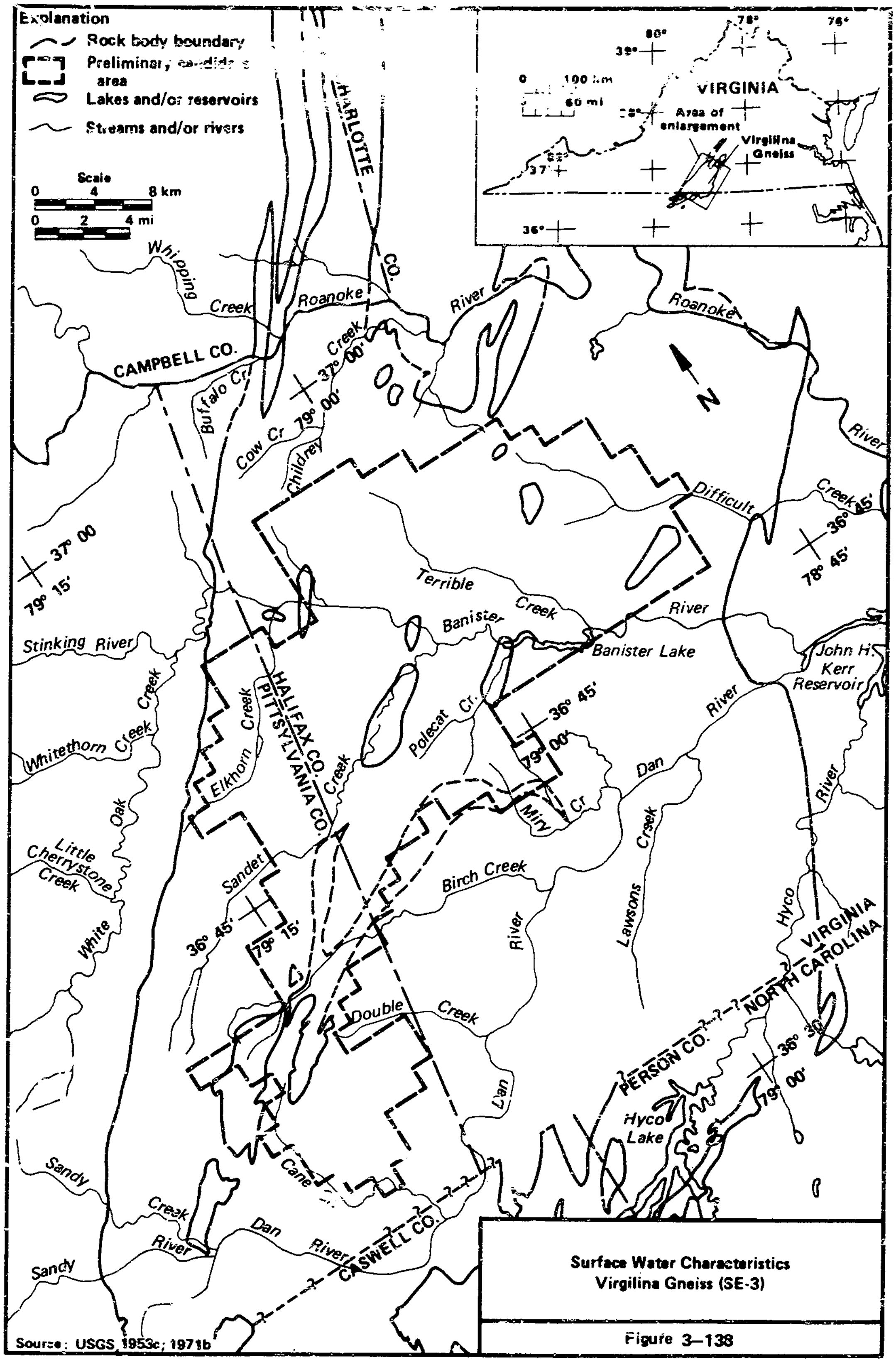
3.2.3.4.5 Topography and Surface-Water Characteristics. The preliminary candidate area is a highly dissected plain. Elevations range from 101 to 244 m (330 to 800 ft) over an area of approximately 799 km^2 (30[illegible] mi^2) (USGS, 1964b, 1965d; 1966b; 1968c; 1968e through 1968k). Local relief averages 27 m ([illegible] ft), but may be as much as 61 m (200 ft).

Floodplain widths range [illegible] than 31 m (100 ft) along upper reaches of the tributaries to as m[illegible] [illegible] m (2,200 ft) along the Banister River.

The surface-water system within the preliminary candidate area is characterized by a well-developed dentritic pattern that is dominated by the Banister River and its tributaries, including Terrible Creek and Sandy Creek (Figure 3-138) (USGS, 1953c). Streams generally flow east-southeast across the preliminary candidate area, and the Banister River drains into the Dan River approximately 9 km (5.4 mi) south of the preliminary candidate area (USGS, 1953c). The easternmost portion of the preliminary candidate area is drained by Difficult Creek, which discharges into the Roanoke River approximately 15 km (9 mi) southeast of the preliminary candidate area. The Roanoke River, in turn, discharges into John H. Kerr Reservoir approximately 2.5 km (1.5 mi) downstream from its confluence with Difficult Creek. The Banister River is impounded just inside the eastern margin of the preliminary candidate area, producing Banister Lake. There are no other large lakes or reservoirs in or within 12.5 km (7.5 mi) the preliminary candidate area, although small impoundments (less than 1.2 ha or [3 ac]) are widely scattered throughout (USGS, 1964b; 1965d; 1966b; 1968c; 1968e through 1968k). The location of surface waters in the preliminary candidate area on Figure 3-138 are based on USGS maps.

The presence of relatively low relief and narrow to moderately wide floodplains indicates localized poor drainage. Flooding from failure of the dam on the Banister River would be concentrated to the east, away from the preliminary candidate area. Therefore, overall flooding potential is low, with localized flooding potential only apparent for less than 3% of the entire preliminary candidate area.

3.2.3.4.6 <u>Ground-Water Resources</u>. Regional ground-water data are discussed in Section 3.2.3.1.1.5. Available data in the preliminary candidate area do not allow differentiation between saprolite producing wells and crystalline bedrock wells nor are water level contour maps



Surface Water Characteristics
Virgilina Gneiss (SE-3)

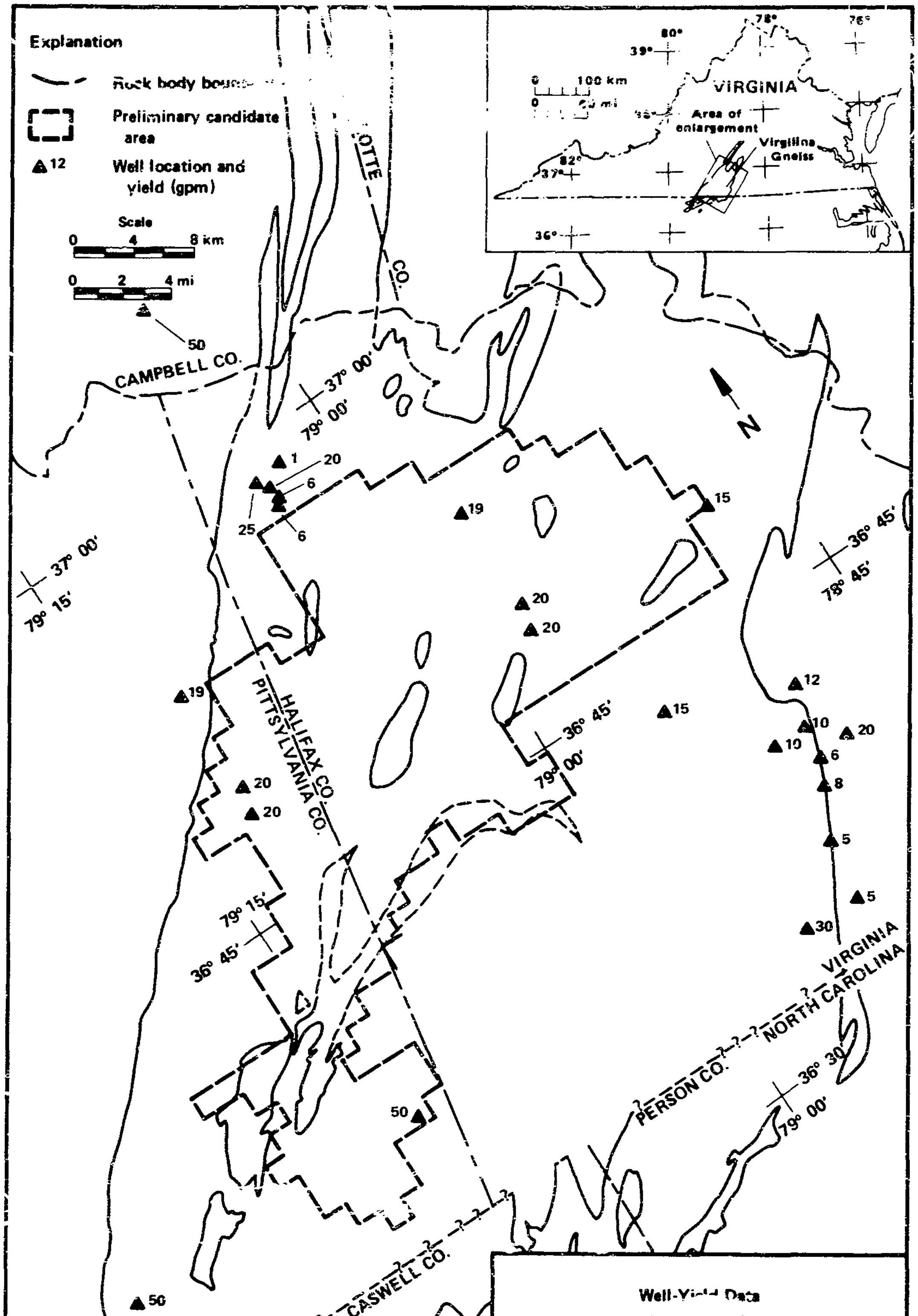
Figure 3–138

available for the preliminary candidate area. Well data were provided by the Virginia Bureau of Water Control Management of the Virginia State Water Control Board. Water well data in the vicinity of the preliminary candidate area is reported by county and is expressed in terms of well yields. Figure 3-139 presents the available well-yield data in the vicinity of the preliminary candidate area. Twenty wells located within the Virgilina gneiss average 1.12 L/s (17.8 gpm). Of these 11 yield less than 1.26 L/s (20 gpm), seven yield from 1.26 to 1.89 L/s (20 to 30 gpm), and two yield 3.15 L/s (50 gpm). Only six wells ranging in yield from 1.2 to 3.15 L/s (19 to 50 gpm) are located within the preliminary candidate area. Five additional wells within the surrounding units yield an average of 1.34 L/s (21.2 gpm). Of these three yield less than 1.26 L/s (20 gpm) one yields 1.26 L/s (20 gpm), and one yields 3.15 L/s (50 gpm).

The well yield information indicates the presence of potable ground water in the vicinity of the preliminary candidate area. The yields are generally very low (less than 1.26 L/s [20 gpm]) with a few wells producing around 3.15 L/s (50 gpm). There are no data to suggest ground-water conditions in the candidate area differ from the surrounding area. Specific relationships between lithology, structure, and well yields are not currently available. There are no data on the deep ground-water system within the candidate area.

3.2.3.4.7 Quaternary Climate. A discussion of Quaternary climatic conditions, including paleoclimatic conditions, vertical crustal movement, and changes in sea level is in Section 3.2.3.1.1.1.

3.2.3.4.8 Federal Lands. There are no Federal lands greater than 130 ha (320 ac) in size located either in or within 10 km (6 mi) of the preliminary candidate area. Federal lands which do occur in Virginia are depicted in Plate 2A of the Southeastern RECR or are listed in Appendix A of that report (DOE, 1985h). There is no evidence in the data base that Federal lands less than 130 ha (320 ac) in size are located either in or within 10 km (6 mi) of the preliminary candidate area.



Source: Well data supplied by Bureau of Water Control Management of the Virginia State Water Control Board, 1982

Well-Yield Data
Virgilina Gneiss (SE-3)

Figure 3–139

3.2.3.4.9 State Lands. There are no State lands within the boundary of the preliminary candidate area. White Oak Mountain Wildlife Management Area is approximately 4 km (2.5 mi) west of the preliminary candidate area. The Staunton River State Park lies approximately 14 km (9 mi) east of the preliminary candidate area, and the Staunton Wild and Scenic River passes within 8 km (5 mi) north of the preliminary candidate area. The features described above are greater than 130 ha (320 ac) in size and are either depicted on Plates 3A or 4A of the Southeastern RECR (DOE, 1985h) (see also Figure 3-140). In addition, there is no evidence in the data base that State lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.4.10 Environmental Compliance. None of the preliminary candidate area lies within current air quality nonattainment areas. There is no Prevention of Significant Deterioration (PSD) Class I Area within 40 km (25 mi) of the preliminary candidate area. One site on the National Register of Historic Places (NRHP) (Carters Tavern near Ingram) is located within the preliminary candidate area (44 FR 7615, 1979). No proposed NRHP sites exist within the preliminary candidate area. In the regional data base there are no known existing archaeological sites or districts or any proposed for designation within the preliminary candidate area. No National Trails are located within 40 km (25 mi) of the preliminary candidate areas.

3.2.3.4.11 Population Density and Distribution. The preliminary candidate area contains no highly populated areas. There are three highly populated areas within 16 km (10 mi) of the preliminary candidate area (Danville, South Boston, Westover). South Boston has a population of 7,093 and is located 4.8 km (3 mi) southeast of the preliminary candidate area. Danville, with a population of 45,642, and Westover, with a population of 3,051, are located 1.6 km (1 mi) and 8 km (5 mi) west-southwest of the preliminary candidate area, respectively (see Figure 3-140). The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square

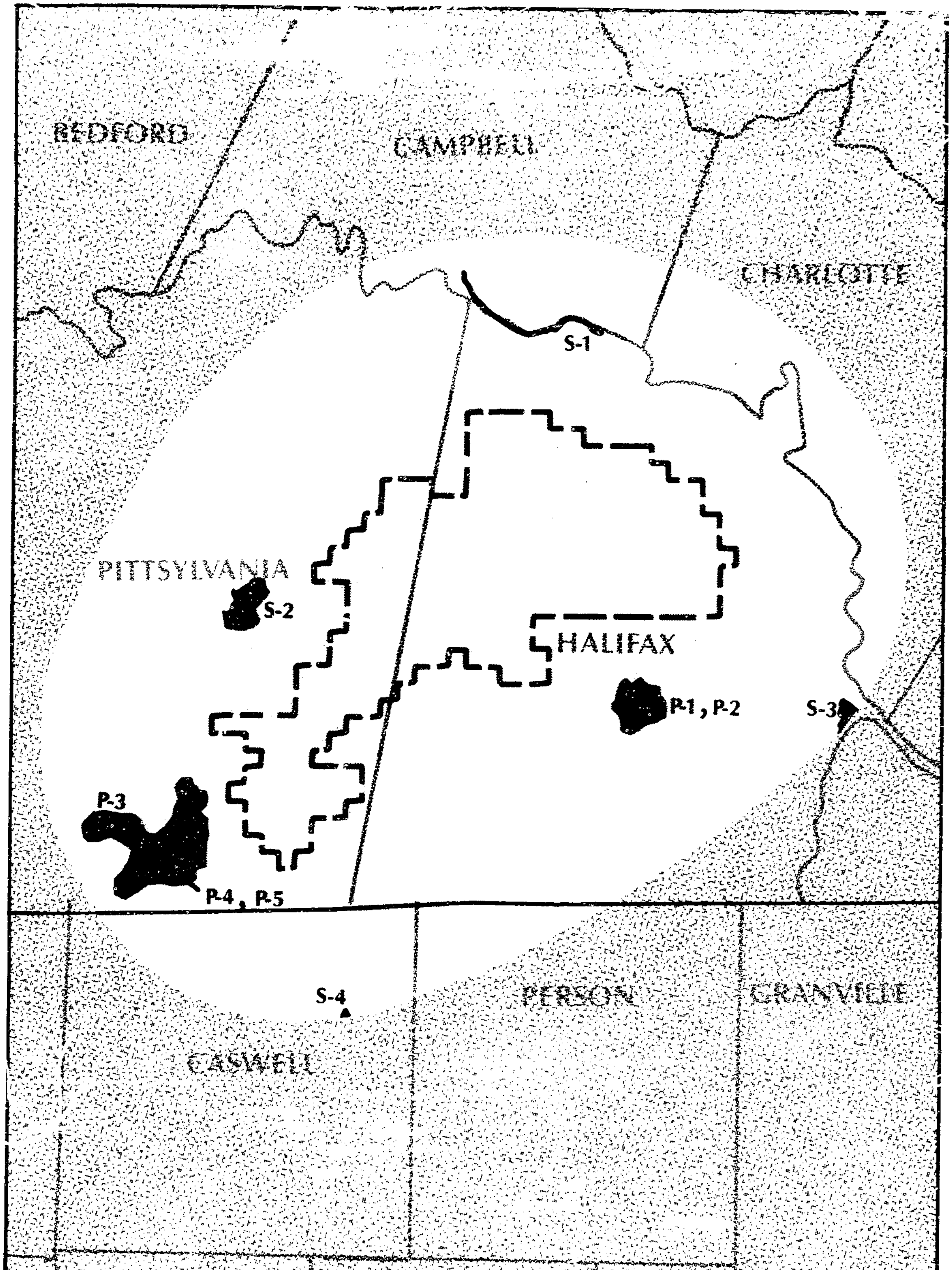


Figure 3–140 Sheet 1

Environmental Features
Virgilina Gneiss (SE-3)

Environmental Features Legend

Preliminary Candidate Area

Environmental Features

- **P** Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile
- **F** Federal Lands Greater Than 320 Acres
- **S** State Lands Greater Than 320 Acres
- **I** Federal Indian Reservations
- **●** Federal or State Lands Less Than 320 Acres
- **F-5** Map Alpha-numeric Codes are Keyed to Environmental Features

Rock Bodies

Beyond Ten Miles from Preliminary Candidate Area

State Boundary

County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–140 Sheet 2

ENVIRONMENTAL FEATURES WITHIN 16 KM (10 MI) OF PRELIMINARY CANDIDATE AREA SE-3*

Code	Feature
Population Features	
P-1	South Boston Highly Populated Area (HPA)
P-2	South Boston Minor Civil Division (MCD)
P-3	Westover HPA
P-4	Danville HPA
P-5	Danville MCD
Federal Lands	
None	
State Lands	
S-1	Staunton Wild and Scenic River
S-2	White Oak Mountain Wildlife Management Area (WMA)
S-3	Staunton River State Park
S-4	Caswell Game Lands WMA
Indian Reservations	
None	

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* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 3-140, Sheet 3

mile. There are [illegible] population greater than or equal to 1,000 persons per square mile within 16 km (10 mi) of the preliminary candidate area; these are also highly populated areas (South Boston and Danville) (see Figure 3-140). The average population density of the preliminary candidate area is approximately 50 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate is approximately 114 persons per square mile. Low population density is defined as a density in the general region of the site less than the average population density for the conterminous United States (76 persons per square mile) based on the 1980 census.

3.2.3.4.12 <u>Site Ownership</u>. There are no Federal or DOE-owned lands located within the preliminary candidate area. The Cherokee Indian reservation is located approximately 352 km (220 mi) southwest of the preliminary candidate area (see Plate SE-1A).

3.2.3.4.13 <u>Offsite Installations</u>. No commercial nuclear reactors are located within the preliminary candidate area. The nearest operating commercial nuclear reactor is North Anna which is approximately 160 km (100 mi) to the northeast (Dames & Moore, 1972). The nearest commercial nuclear reactor under construction is the Shearon Harris Nuclear Plant which is approximately 110 km (70 mi) to the south (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 40 CFR 191, Subpart A, within or in proximity to the preliminary candidate area.

3.2.3.4.14 <u>Transportation</u>. Interstate highway I85 is located approximately 56 km (35 mi) southeast of this preliminary candidate area. I40 is also situated about 35 mi (56 km) to the south. U.S. 501 crosses over the eastern portion of the preliminary candidate area. This highway extends from Durham, North Carolina, to Lynchburg, Virginia. U.S. 29, which is a four-lane highway, passes within 1.6 km (1 mi) of the western edge of the preliminary candidate area. To the south, U.S. 58, a four-lane highway, crosses the extreme southern portion of the preliminary candidate area. State Route 360, which also is a four-lane highway east of South Boston, comes within 1.6 km (1 mi) of the eastern edge of the preliminary candidate area. State Route 360, a principal through highway, is the only State highway that crosses the preliminary candidate area, running through the southern portion. State Route 40 is very close to the northwest corner of the preliminary candidate area. In addition, there are numerous county and local roads in the area.

The Norfolk and Western is the only mainline railroad that crosses over the preliminary candidate area. This line connects with another mainline about 10 km (6 mi) north of the preliminary candidate area. The Southern Railway's mainline between Washington, D.C., and Atlanta passes within a few kilometers (miles) of the western edge of the preliminary candidate area near Danville. The only branchline which crosses the preliminary candidate area is the Southern Railway's line between Danville and Richmond. This is the only branchline railroad in the vicinity.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.4.15 Preliminary Candidate Area Deferral Analysis. This section identifies significant additional information (specified in Section 3.2) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-3 that could affect DOE's decision to defer further consideration of the area. Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation [960.4-2-3(b)(1), 960.5-2-9(b)(1), 960.5-2-9(c)(1)]

- prese[illegible] [illegible] ..ock that permits emplacement of waste at least 300 m ([illegible] 000 ft) b[illegible] ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow systems should not be significantly affected [960.4-2-7(c)(6)]
- absence of active faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]
- no indications, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could produce ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]
- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect waste containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring material that is not widely available from other sources [960.4-2-8-1(c)(4)]
- presence of generally flat terrain [960.5-2-8(b)(1)]

- prese[illegible] [illegible] well-drained terrain [960.5 2-8(b)(2)]
- general absen[illegible] [illegible] characteristics or surface-water systems that could lead to flooding [960.5-2-8(c), 960.5-2-10(b)(2)]
- located within a geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]
- absence of Federal lands less than 130 ha (320 ac) within and in proximity to (i.e., 10 km [6 mi]) the preliminary candidate area [960.5-2-5(c)(3)]
- absence of State lands less than 130 ha (320 ac) in proximity (i.e., 10 km [6 mi]) to the prelimiary candidate area [96-5-2-5(c)(4)]
- low population density within its boundaries [960.5-2-1(b)(1)]
- absence of nuclear installations [960.5-2-4(b) and (c)(2)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfer of title, or Federal condemnation proceedings [960.4-2-8-2(c) and 960.5-2-2(c)]
- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2) and (b)(3)].

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]

- presence of a shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2 8-1(c)(1)i].

- a majority (approximately 50%) of the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile [960.5-2-1(c)(2)].

The results indicate that there are no significant adverse features identified to date that would preclude DOE from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-3 at this time.

3.2.3.5 Preliminary Candidate Area Description - Rolesville (SE-4)

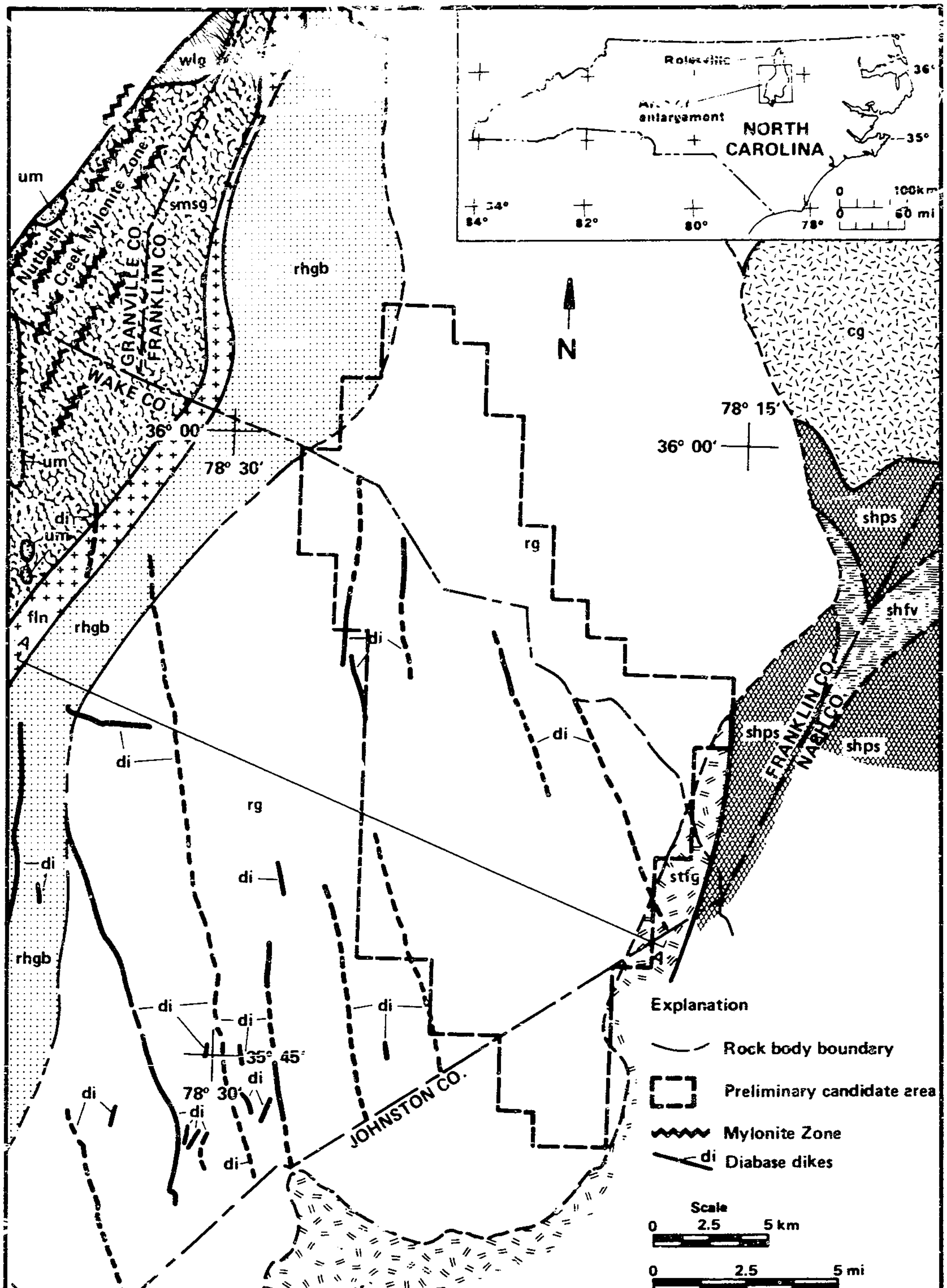
Preliminary candidate area SE-4 is located within the Piedmont province of northeastern North Carolina in Wake, Johnson, and Franklin Counties, at approximately 35°50' N latitude and 78°20' W longitude (Figure 3-141a).

3.2.3.5.1 Host Rock Geometry and Overburden Thickness. The preliminary candidate area overlies the Rolesville pluton and covers an area of 369 km^2 (142 mi^2) with a length of 38 km (23.6 mi) and a width of 17 km (10.5 mi) (Farrar, 1980; McDaniel, 1980) (Figure 3-141a).

Gravity information indicates that the Rolesville pluton has a maximum depth of 13.6 to 15.2 km (8.5 to 9.4 mi) (Glover, 1963). A cross section derived from Farrar (1985b) and Parker (1979) is shown on Figure 3-141b.

Available water well casing-depth data in the vicinity of the preliminary candidate area are given in Figure 3-142. Casing-depth data are available for only four wells within the preliminary candidate area, with saprolite thickness ranging from 6.4 to 22.8 m (21 to 75 ft). Based on 46 data points, the average thickness of saprolite within the Rolesville pluton is 16.05 m (52.65 ft). Based on 27 nearby data points, the average thickness of saprolite overlying surrounding units is 19.95 m (65.44 ft). Well data were supplied by the Division of Environmental Management of the North Carolina Department of Natural Resources and Community Development (1982). The location and distribution of rock exposures are presently unknown; however, mappable exposures are expected to be fairly extensive.

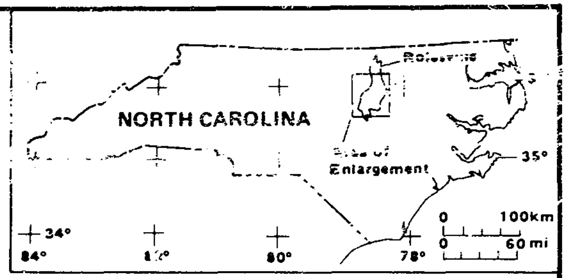
On the basis of the data presented above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock underlying the preliminary candidate area is sufficiently thick and

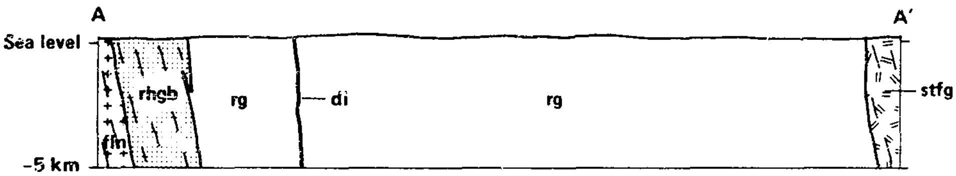


Geologic Map
Rolesville (SE-4)

Figure 3–141a

Source: Parker, 1979; Farrar, 1980; 1985b





Explanation

- Lithologic contacts
- di — Triassic diabase dikes

Late Paleozoic
- rg — Rolesville biotite granite
- cg — Castalia granite
- wlg — Wilton granite

Late Precambrian/ Early Paleozoic
- smsg — Smithfield formation-mica schist and gneiss
- um — Ultramafic rock
- stfg — Stanhope formation-felsic gneiss
- shps — Spring hope formation-phyllite and metasiltstone
- shfv — Spring hope formation-felsic metavolcanics
- fln — Falls leucogneiss

Precambrian?
- rhgb — Raleigh gneiss-hornblende-biotite gneiss

Scale

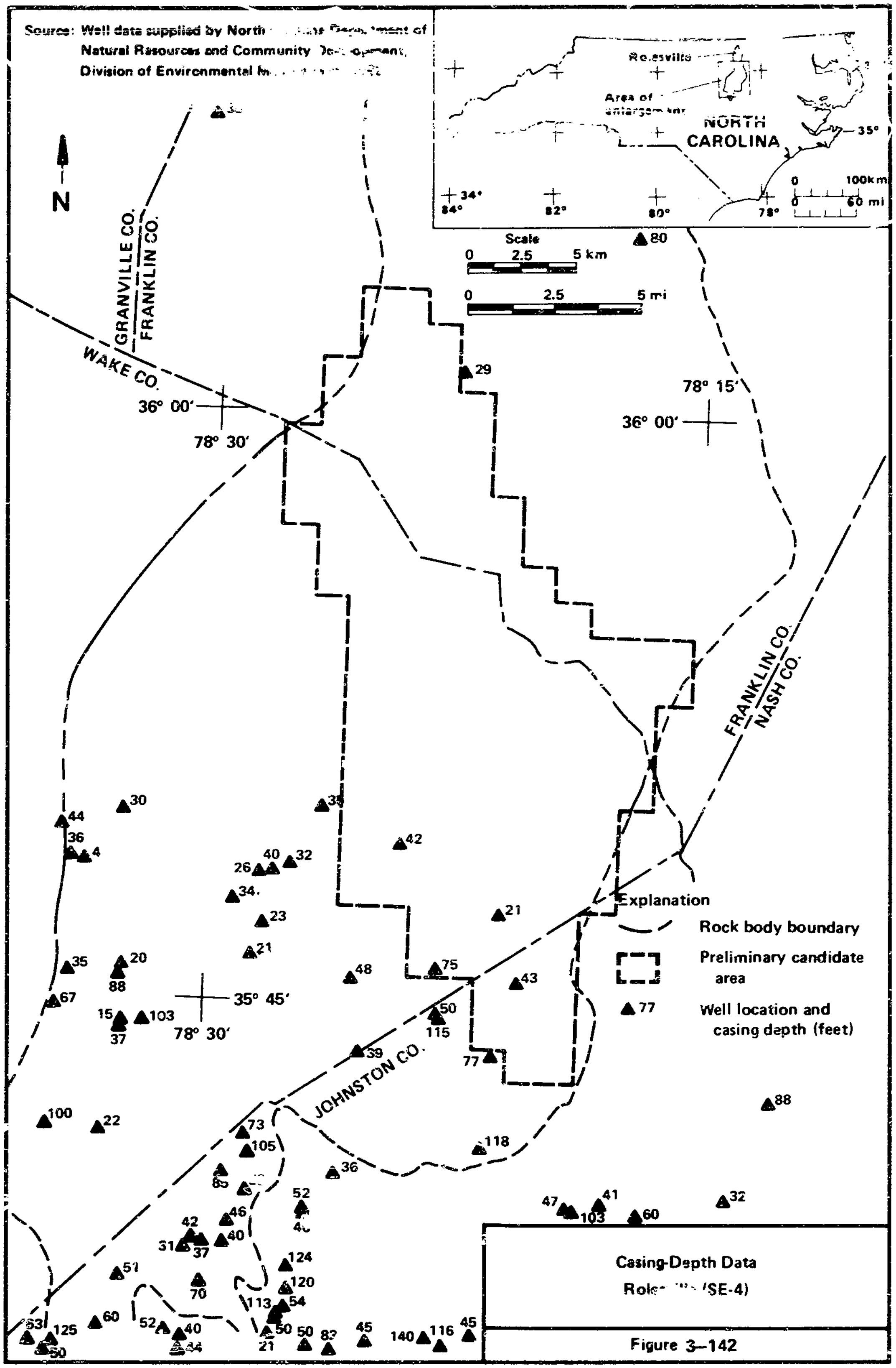
0 2.5 5 km

0 2.5 5 mi

Source: Farrar, 1985b; Parker, 1979

Geologic Cross Section
Rolesville (SE-4)

Figure 3–141b



Casing-Depth Data

Role... (SE-4)

Figure 3–142

laterally extensive to allow sufficient flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation.

3.2.3.5.2 Lithology and Tectonics. The preliminary candidate area is contained entirely within the Rolesville pluton. Four boreholes drilled within the preliminary candidate area indicate that the Rolesville pluton consists of medium- to coarse-grained biotite granite (Farrar, 1977, 1985a; Parker, 1979) (Figure 3-141a). The granite consists of three textural facies: (1) medium- to coarse-grained with weak compositional layering; (2) porphyritic; and (3) fine- to medium-grained, foliated (Farrar, 1985a). The biotite granite is cut by pegmatite and aplite dikes that range from a few to tens of centimeters (inches) thick (Farrar, 1985a). The granite is also cut by diabase dikes that range from about 0.3 to 33 m (1 to 100 ft) thick (Parker, 1979).

The rocks surrounding the Rolesville pluton consist of gneisses and metavolcanic rocks, ranging in age from Precambrian to early Paleozoic (Farrar, 1985b). The Rolesville pluton intruded the country rock during the latest episode of regional metamorphism (Alleghenian, about 330 to 250 million years ago) (Farrar, 1985a). The granite shows a weak, compositional layering that is overprinted by weak to moderate biotite foliation that parallels the foliation in the county rock (Farrar, 1985a). The most recent deformational event occurred during the early Mesozoic (Triassic?), was brittle in nature, and created fractures along which diabase dikes were intruded (Farrar, 1985b; Parker, 1979).

No folds have been observed in the Rolesville pluton (Parker, 1979). One fault located approximately 8 km (5 mi) northwest of the preliminary candidate area, the Nutbush Creek mylonite zone (Figure 3-141a), ranges from relatively narrow to a few hundred meters (feet) in width with a moderate- to near-vertical dip (Farrar, 1985b). The Nutbush Creek mylonite zone was probably formed during late- to post-Alleghenian metamorphism (Farrar, 198[illegible]). Regional relationships suggest that the eastern side of the Nutbush Creek mylonite zone has moved upward with respect to the western side and that there is some componert of right lateral movement (Farrar, 1985b).

Estimates of regional uplift and subsidence are discussed in Section 3.2.3.1.1.3. Regional data indicate that uplift has occurred but there is a wide range of interpretation on the magnitude of uplift. No data are available for the preliminary candidate area; therefore, until data are obtained, no conclusion can be drawn concerning affects of uplift.

A measurement taken at a location 7.2 km (3.5 mi) from the preliminary candidate area indicated a maximum horizontal stress direction of N 83° W (Zoback and Zoback, 1980; Zoback et al., 1984).

There is no evidence of Quaternary igneous activity, folding, faulting, or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process, however, there appears to be no significant potential for tectonic deformations that could affect the regional ground water flow system.

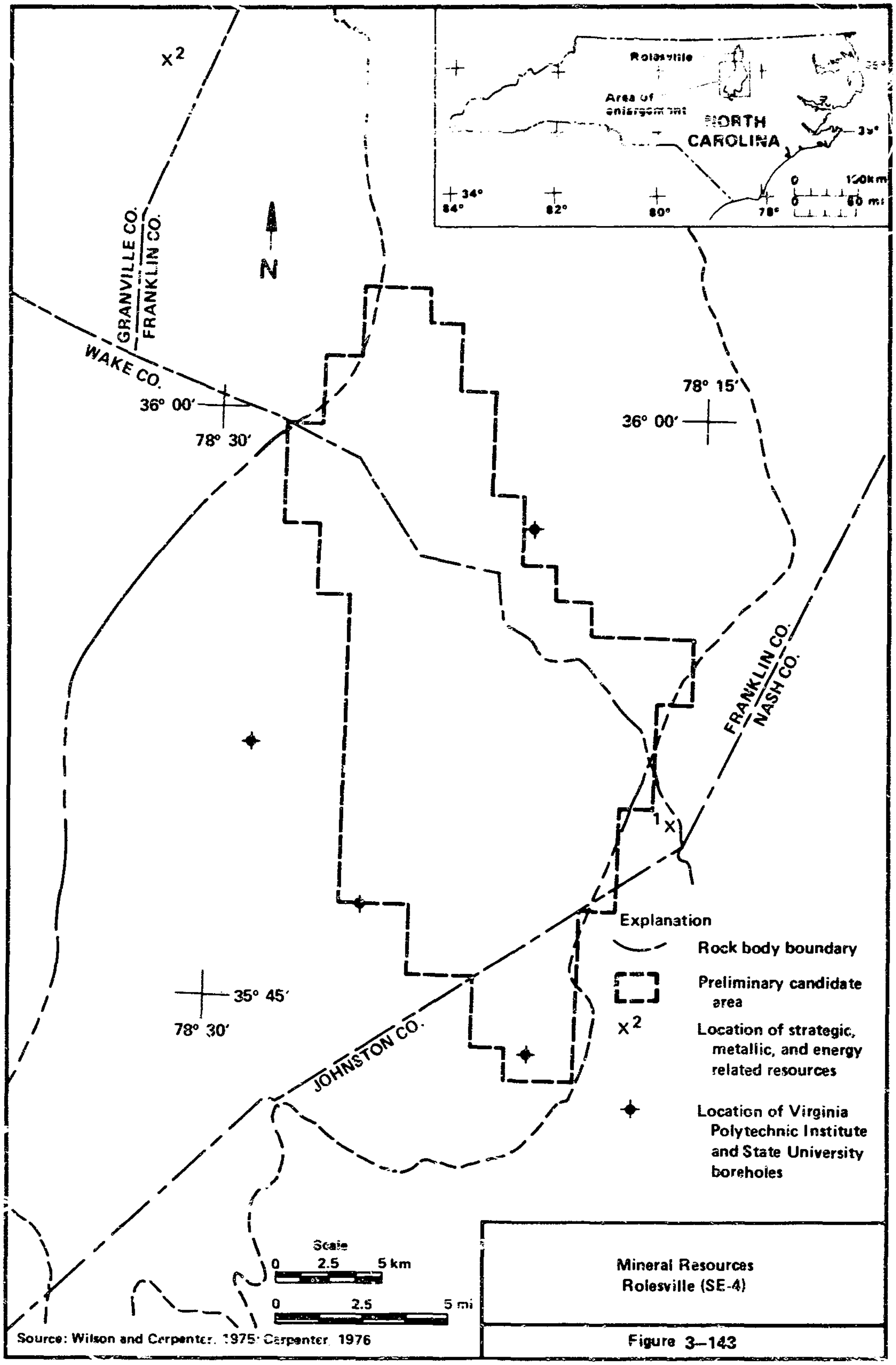
3.2.3.5.3 Seismicity. There are no earthquake epicenters for seismic events of MM IV or greater within 10 km (6 mi) of the preliminary candidate area (Bollinger, 1975; Stover et al., 1984). Two seismic events of MM III (Stover et al., 1984) are located approximately 14 km (8.7 mi) from the southwestern boundary of the preliminary candidate area (see Figure 3-118 in Section 3.2.3.1.1.3). The preliminary candidate area is located within a region of low seismic activity (see Figure 3-119 in Section 3.2.3.1.1.3). The largest historical earthquake associated with this region is an MM V which occurred on March 30, 1850, in Wayne County approximately 45 km (28 mi) southeast of the preliminary candidate area.

Major faults near the preliminary candidate area are discussed in Section 3.2.3.5.2. There is no known correlation between these features and seismic activity.

Considering the low level and magnitude of seismic activity in the region and the absence of active tectonic processes within the geologic setting during the Quaternary Period, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation and it is unlikely that the frequency of occurrence of earthquakes in the area will increase in the future.

3.2.3.5.4 Mineral Resources. One strategic mineral deposit has been identified within 10 km (6 mi) of the preliminary candidate area (Figure 3-143; Table 3-16). A manganese deposit occurs 2.5 km (1.6 mi) southeast of the preliminary candidate area, within a dike in the mica schist (Thompson, 1950) that forms the country rock surrounding the Rolesville pluton. A chromite prospect occurs 18 km (11.2 mi) northeast of the preliminary candidate area in a small ultramafic body. Carpenter (1976) reported that a 165-m (265-ft) core of the ultramafic body encountered only a small amount of chromite. Similar ultramafic bodies have not been mapped within the Rolesville pluton. Therefore, it is unlikely that strategic, metallic, or energy-related mineral resources will be found within the preliminary candidate area.

Four boreholes were drilled in the Rolesville pluton for scientific purposes by Virginia Polytechnic Institute and State University (Figure 3-143). Two of these boreholes are within the preliminary candidate area near the southern border; they range in depth from approximately 198 to 213 m (650 to 700 ft).



Source: Wilson and Carpenter, 1975; Carpenter, 1976

Mineral Resources
Rolesville (SE-4)

Figure 3–143

Table 3-16. Mine[illegible] Near Preliminary Candidate Area SE-4

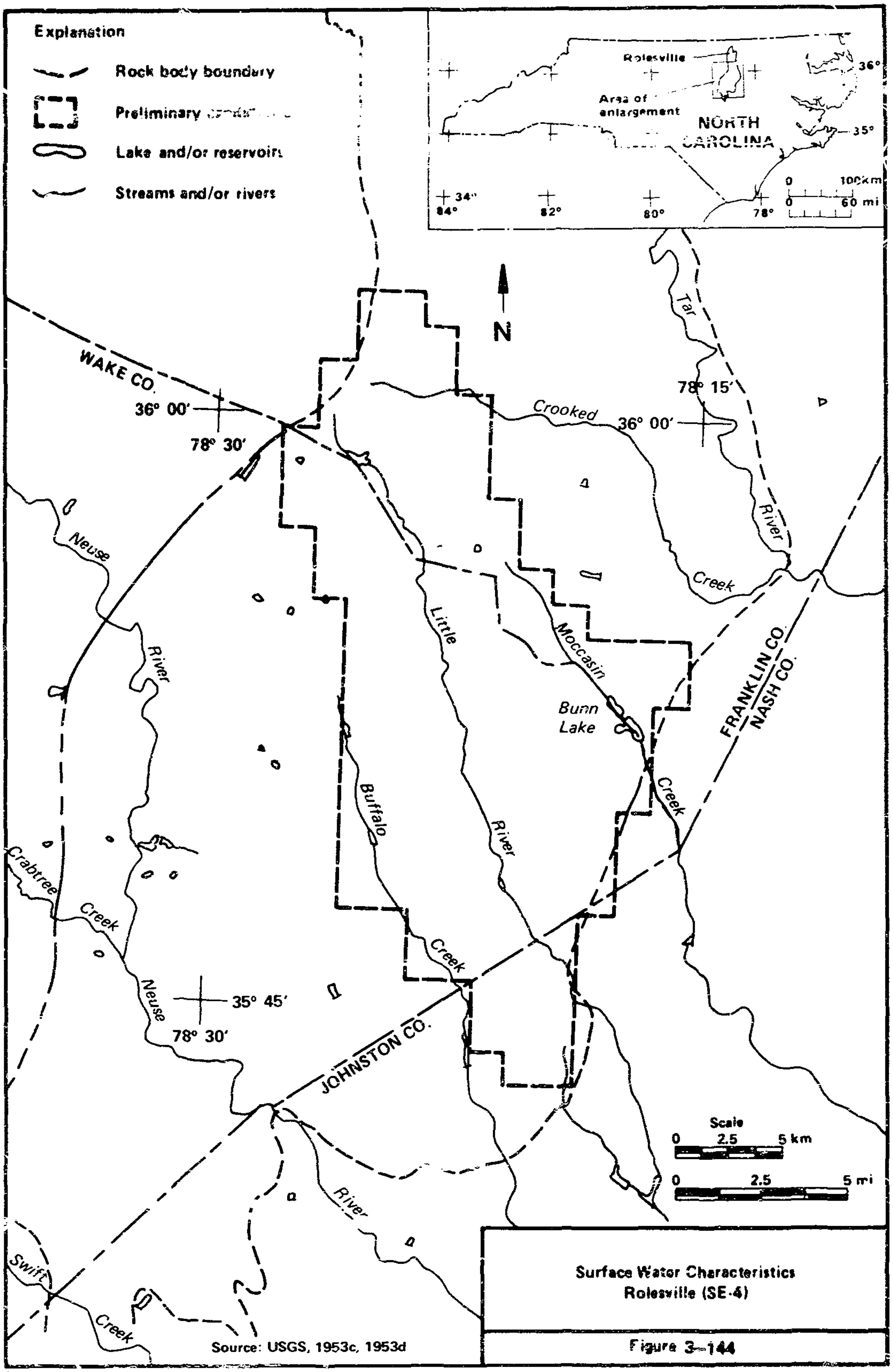
Map Number (Fig. 3-143)	Name	Commodity	Status
1	Avon Privett Property Mine	Manganese	Inactive
2	Leonard Perry Prospect	Chromite	Inactive

Source: Thompson, 1950; Carpenter, 1976

Based on the data presented in this section, no known strategic, metallic, or energy-related mineral resources occur within the preliminary candidate area. Two deep (greater than 100 m [328 ft] in depth) drillholes are known to exist within the preliminary candidate area.

3.2.3.5.5 <u>Topography and Surface-Water Characteristics</u>. The preliminary candidate area is characterized by a moderately dissected, wide, gently sloping or rolling plain. Elevations range from 61 to 143 m (200 to 470 ft) within the preliminary candidate area (USGS, 1964d; 1967d; 1967f; 1968b; 1968m; 1978a; 1978b). Relief averages about 18 m (60 ft) along stream corridors, with a maximum local relief of about 31 m (100 ft) (USGS, 1964d; 1967d; 1967f; 1968b; 1968m; 1978a; 1978b). Floodplains range in width from less than 31 m (100 ft) along tributaries and upper reaches of major streams to approximately 435 m (1,400 ft) further downstream. Relief generally does not exceed 61 m (200 ft) over the entire preliminary candidate area.

The surface-water system within the preliminary candidate area is characterized by a dendritic stream pattern dominated by Buffalo Creek, the Little River, Moccasin Creek, and their tributaries (Figure 3-144) (USGS, 1953c,d). These streams generally flow south-southeast across the preliminary candidate area. Buffalo Creek merges with the Little River approximately 16 km (10 mi) southeast of the preliminary candidate area



Surface Water Characteristics
Rolesville (SE-4)

Figure 3-144

(USGS, 1953d). The Little River drains into the Neuse River approximately 31 km (18.6 mi) downstream from the confluence of Buffalo Creek and Little River and approximately 4 km (2.4 mi) southwest of the city of Goldsboro, North Carolina. The northernmost section of the preliminary candidate area is drained to the east-southeast by Crooked Creek, which drains into the Tar River approximately 15.6 km (9.4 mi) downstream from the preliminary candidate area (USGS, 1953c; 1953d). Impoundments occur along major streams and their tributaries. The largest of these impoundments (Bunn Lake) occurs near the eastern boundary of the preliminary candidate area and is approximately 47 ha (115 ac) in area (USGS, 1968m). The remaining impoundments range from less than 4 ha (10 ac) to 38 ha (94 ac). Marshes and swamps occur locally along Buffalo Creek and Moccasin Creek, but these constitute much less than 1% of the entire preliminary candidate area.

The presence of relatively low relief, moderately wide floodplains, and marshes/swamps indicates locally poor drainage. Consequently, these conditions, coupled with the large number of impoundments and the possibility of impoundment failure, indicate that there is a potential for localized flooding along streams; however, this potential is limited to no more than 2% of the entire preliminary candidate area.

3.2.3.5.6 Ground-Water Resources. Regional ground-water data are discussed in Section 3.2.3.1.1.5. Available data in the preliminary candidate area do not allow a differentiation between saprolite-producing wells and crystalline bedrock wells nor are water-level contour maps available for the preliminary candidate area. Well data were provided by the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management (1982). Figure 3-145 presents the available well-yield data in the vicinity of the preliminary candidate area. Yields for 47 wells located within the Rolesville pluton average 1.74 L/s (27.57 gpm). Of these, 22 yield less than 1.26 L/s (20 gpm), 20 yield from 1.26 to 3.15 L/s (20 to 50 gpm), and five yield from 3.15 to 6.31 L/s (51 to 100 gpm). Only four wells, ranging in yield from 0.5 to 3.15 L/s (8 to 50 gpm) are located within the preliminary

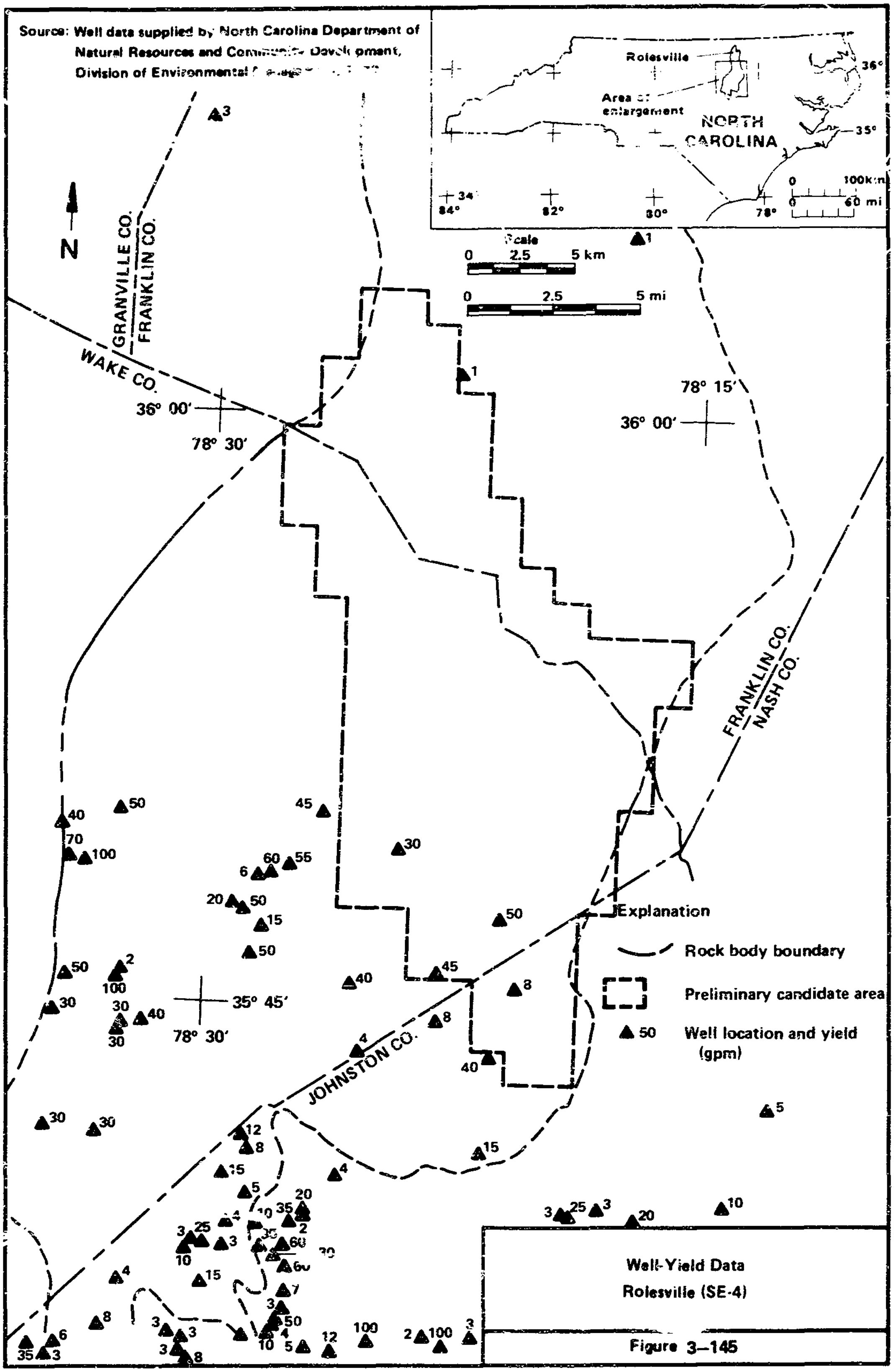

Source: Well data supplied by North Carolina Department of Natural Resources and Community Development, Division of Environmental Management
N
GRANVILLE CO.
FRANKLIN CO.
WAKE CO.
36° 00′
78° 30′
78° 15′
36° 00′
Scale
0 2.5 5 km
0 2.5 5 mi
Rolesville
Area of enlargement
NORTH CAROLINA
36°
35°
34°
84°
82°
80°
78°
0 100km
0 60 mi
FRANKLIN CO.
NASH CO.
JOHNSTON CO.
35° 45′
78° 30′
Explanation
Rock body boundary
Preliminary candidate area
▲ 50 Well location and yield (gpm)
Well-Yield Data
Rolesville (SE-4)

Figure 3–145

candidate area. Thir[illegible] [illegible]tional wells located in the vicinity of the preliminary candidate area average [illegible] L/s (21.03 gpm). Of these, 20 yield less than 1.26 L/s (20 gpm), eight yield from 1.26 to 3.15 L/s (20 to 50 gpm), and four yield from 3.22 to 6.31 L/s (51 to 100 gpm).

The well yield information indicates the presence of potable ground-water aquifers in the vicinity of the preliminary candidate area. The yields are generally low (1.26 L/s [less than 20 gpm]) with a few wells producing up to 6.31 L/s (100 gpm). There are no data to suggest ground-water conditions in the preliminary candidate area differ from the surrounding area. Specific relationships between lithology, structure, and well yields are not currently available. Four deep wells were drilled into the Rolesville pluton (Section 3.2.3.5.4), however, they were not drilled to obtain hydrologic data, consequently, deep ground-water conditions in the preliminary candidate area are unknown.

3.2.3.5.7 Quaternary Climate. A discussion of Quaternary climatic conditions, including paleoclimatic conditions, vertical crustal movement and changes in sea level, is in Section 3.2.3.1.1.1.

3.2.3.5.8 Federal Lands. There are no Federal lands greater than 130 ha (320 ac) in size located either in or within 10 km (6 mi) of the preliminary candidate area. Federal lands which do occur in North Carolina are depicted in Plate 2A of the Southeastern RECR or are listed in Appendix A of that report (DOE, 1985h). In addition, there is no evidence in the data base that Federal lands less than 130 ha (320 ac) in size are located either in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.5.9 State Lands. Two State lands, both of which are less than 130 ha (320 ac) in size, lie within the boundary of the preliminary candidate area; Mitchell's Mill Pond is both a State park and a State Natural Heritage Area which covers approximately 27 ha (67 ac) or less than 0.1% of the preliminary candidate area, in the northwest portion. Robertson's Pond Natural Heritage Area covers 24 ha (60 ac), which is also less than 0.1% of the preliminary candidate area, along the west central edge. Falls [illegible] Recreation Area, which is greater than 130 ha (320 ac) in size, lies approximately 10 km (6 mi) west of the preliminary candidate area, while the Flower Hill Natural Heritage Area, which is less than 130 ha (320 ac) in size, is 8 km (5 mi) east of the preliminary candidate area*. All the features described above are either depicted on Plates 3A or 4A of the Southeastern RECR or are listed in Appendix B of that report (DOE, 1985h).

In summary, two State lands, each of which is less than 130 ha (320 ac), cover a total of 51 ha (127 ac) or less than 0.2% of the preliminary candidate area; and two State lands (one of which is less than 130 ha [320 ac]) are located within 10 km (6 mi) of it (see Figure 3-146).

3.2.3.5.10 <u>Environmental Compliance</u>. No portion of the preliminary candidate area lies within a current air quality nonattainment area. There are no Prevention of Significant Deterioration (PSD) Class I Areas within 40 km (25 mi) of the preliminary candidate area. Four sites on the National Register of Historic Places (NRHP) are located within the preliminary candidate area boundary. These sites are the Cooke House near Louisburg, the William A. Jeffreys House near Youngsville (44 FR 7547, 1979), the Wakelon School (Zebulon Elementary School) in Zebulon and the Midway Plantation near Raleigh (44 FR 7550, 1979). No proposed NRHP sites exist within the preliminary candidate area. One archaeological district which has been proposed for designation (Rolling View Archaeological District in Wake County) may be within the preliminary candidate area (49 FR 4680, 1984); however, the exact location is not specified in the data base. No National Trails are within 40 km (25 mi) of the preliminary candidate area.

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* Overton Rock Natural Heritage Area lies within the counties containing the preliminary candidate area; however, there is no location map for this small State land in the regional data base.

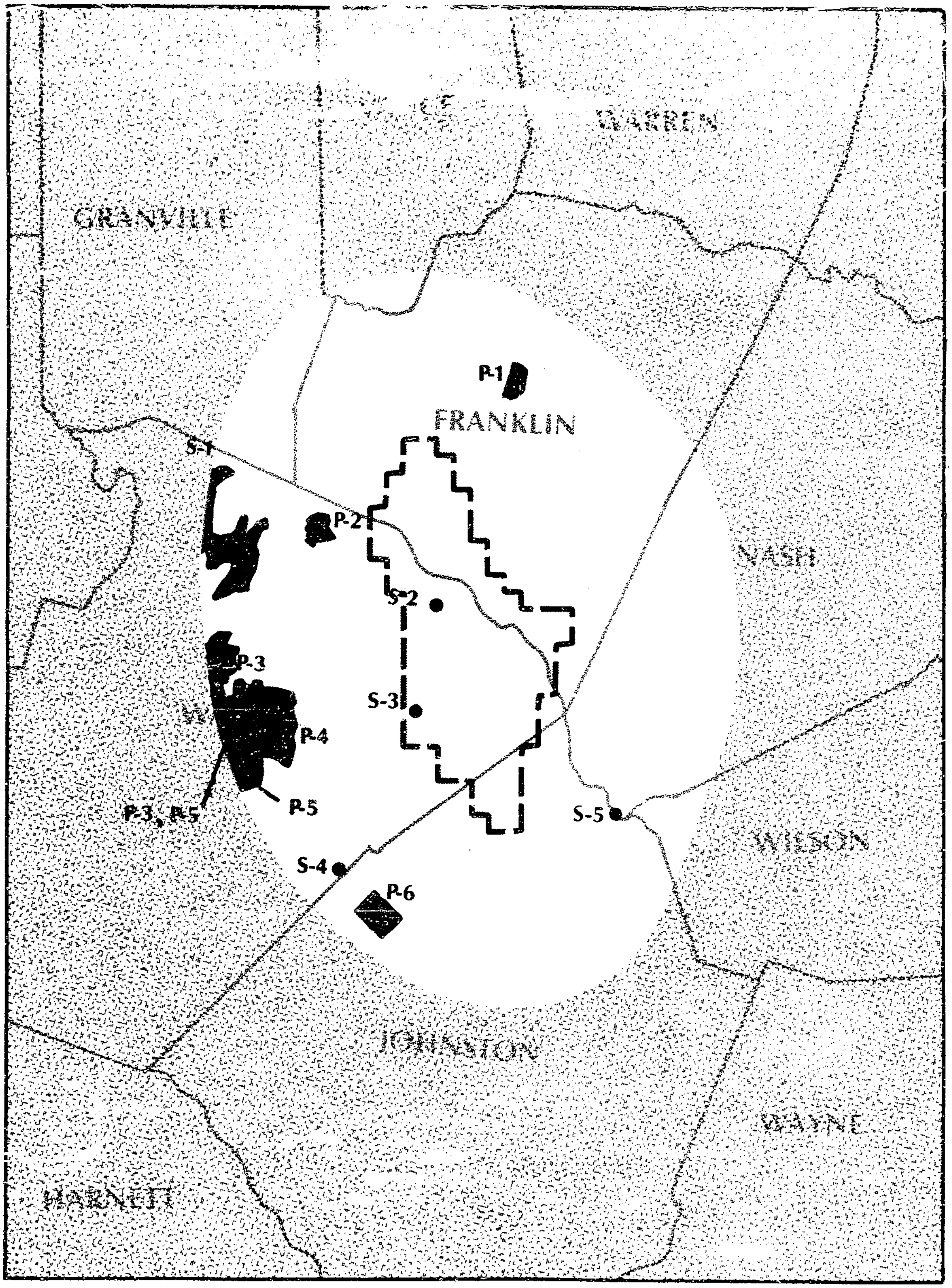

Figure 3–146 Sheet 1

Environmental Features
Rolesville (SE-4)

Environmental Features Legend

Preliminary Candidate Area

Environmental Features

P Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile

F Federal Lands Greater Than 320 Acres

S State Lands Greater Than 320 Acres

I Federal Indian Reservations

● Federal or State Lands Less Than 320 Acres

F-5 Map Alpha-numeric Codes are Keyed to Environmental Features

Rock Bodies

Beyond Ten Miles from Preliminary Candidate Area

State Boundary

County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–148 Sheet 2

ENVIRONMENTAL FEATURES WITHIN 16 KM (10 MI)
OF PRELIMINARY CANDIDATE AREA SE-4*

Code	Feature
Population Features	
P-1	Louisburg Highly Populated Area (HPA)
P-2	Wake Forest HPA
P-3	Raleigh HPA
P-4	New Hope HPA
P-5	Raleigh Minor Civil Division
P-6	Clayton HPA
Federal Lands	
None	
State Lands	
S-1	Falls Lake State Recreation Area
S-2	Mitchell's Mill Pond Natural Area State Park
S-2	Mitchell's Mill Pond Natural Heritage Area
S-3	Robertson's Pond Natural Heritage Area
S-4	Clemmons State Forest
S-5	Flower Hill Natural Heritage Area
Indian Reservations	
None	

* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 3-146, Sheet 3

3.2.3.5.11 Population Density and Distribution. The preliminary candidate area contains no highly populated areas. There are five highly populated areas within 16 km (10 mi) of the preliminary candidate area (Clayton, Louisburg, New Hope, Raleigh, and Wake Forest). Clayton is located 11 km (7 mi) southwest of the preliminary candidate area and has a population of 4,091. Louisburg, with a population of 3,238, is located 8 km (5 mi) northeast of the preliminary candidate area. Wake Forest with a population of 3,780, New Hope with a population of 6,745, and Raleigh with a population of 150,255* are located 3.2 km (2 mi), 11 km (7 mi), and 14 km (9 mi) west of the preliminary candidate area, respectively (see Figure 3-146). The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square mile. There is one area of population density greater than or equal to 1,000 persons per square mile within 16 km (10 mi) of the preliminary candidate area (see Figure 3-146). This area is Raleigh, with a population of 101,909*; Raleigh is also a highly populated area. The average population density of the preliminary candidate area is approximately 103 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate area is approximately 129 persons per square mile. Low population density is defined as a density in the general region of the site less than the average population density for the conterminous United States (76 persons per square mile) based on the 1980 census.

3.2.3.5.12 Site Ownership. There are no Federal or DOE-owned lands within the preliminary candidate area. The Cherokee Indian Reservation is 408 km (255 mi) west of the preliminary candidate area (see Plate SE-1A).

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* The difference in population figures is due to the fact that the geographic extent of the highly populated area of Raleigh is different than the area defined by a density of 1,000 persons per square mile.

3.2.3.5.13 Offsite Installations. No commercial nuclear reactors are located within [illegible] candidate area. The nearest operating commercial nuclear reactor [illegible] Surry, [illegible] is approximately 194 km (120 mi) to the northeast (Wamsley, 1985). The nearest commercial nuclear reactor under construction is the Shearon Harris Nuclear Plant which is approximately 47 km (29 mi) to the southwest (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 10 CFR 191, Subpart A, within or near the preliminary candidate area.

3.2.3.5.14 Transportation. The nearest interstate highway (I40) at Raleigh, North Carolina, is approximately 16 km (10 mi) west of the preliminary candidate area. I95 is located about 24 km (15 mi) east. I85 also passes about 32 km (20 mi) north and northwest of the preliminary candidate area. The U.S. highways which cross the southern portion of the preliminary candidate area are U.S. 64 and 264. Between Raleigh and the western edge of the preliminary candidate area are U.S. 64 and 264. Between Raleigh and the western edge of the preliminary candidate area, these highways run concurrently as a four-lane divided highway. Both of these highways are four-lane, limited-access roads across the preliminary candidate area and between the preliminary candidate area and I95. U.S. 401 crosses the northern portion of the preliminary candidate area. U.S. 1 is located 8 km (5 mi) west of the preliminary candidate area. Although not shown on the transportation network map, a number of State highways (39, 96, and 98) are in the preliminary candidate area. None of these roads are principal highways.

The Southern Railway has a mainline crossing the southern portion of the preliminary candidate area. This line is the main connection between Raleigh and Norfolk, Virginia. The Seaboard mainline parallels U.S. 1 about 8 km (5 mi) west of the preliminary candidate area. Another Seaboard mainline is located 16 to 32 km (10 to 20 mi) to the east and southeast. Both of the Seaboard mainlines are north and south routes. A Southern branchline is located about 13 km (8 mi) south of the preliminary candidate are[illegible] has two branchlines in the vicinity, but like the Sou[illegible], neither of these cross over the preliminary candidate area. One of the Seaboard branchlines is about 3.2 km (2 mi) north while the other terminates about 11 km (7 mi) from the eastern edge of the preliminary candidate area.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.5.15. Preliminary Candidate Area Deferral Analysis. This section identifies significant additional information (specified in Section 3.1) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-4 that could affect DOE's decision to defer further consideration of the area. Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuration, and location of the underground facility [960.4-2-3(b)(1), 960.5-2-9(b)(1), 960.5-2-9(c)(1)]
- presence of host rock that permits emplacement of waste at least 300 m (1,000 ft) below ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow systems should not be significantly affected [960.4-2-7(c)(6)]
- absence of active faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]

- no indication, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could provide ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]
- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring material that is not widely available from other sources [960.4-2-8-1(c)(4)]
- presence of generally flat terrain [960.5-2-8(b)(1)]
- presence of generally well-drained terrain [960.5-2-8(b)(2)]
- general absence of surface characteristics or surface-water systems that could lead to flooding [960.5-2-8(c)(2), 960.5-2-10(b)(2)]
- located within a geologic setting in which climatic changes have had little affect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]
- absence of Federal lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(3)]

- limited [illegible] State lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km or 6 mi of) the preliminary candidate area (960.5-2-5(c)(4)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfers of title, or Federal condemnation proceedings [960.4-2-8-2(c), 960.5-2-2(c)]
- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2) and (b)(3)]

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]
- presence of shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2-8-1(c)(1)(i)]
- a majority of the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile) [960.5-2-1(c)(2)].

The results indicate that there are no significant adverse features identified to date that would preclude DOE from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-4 at this time.

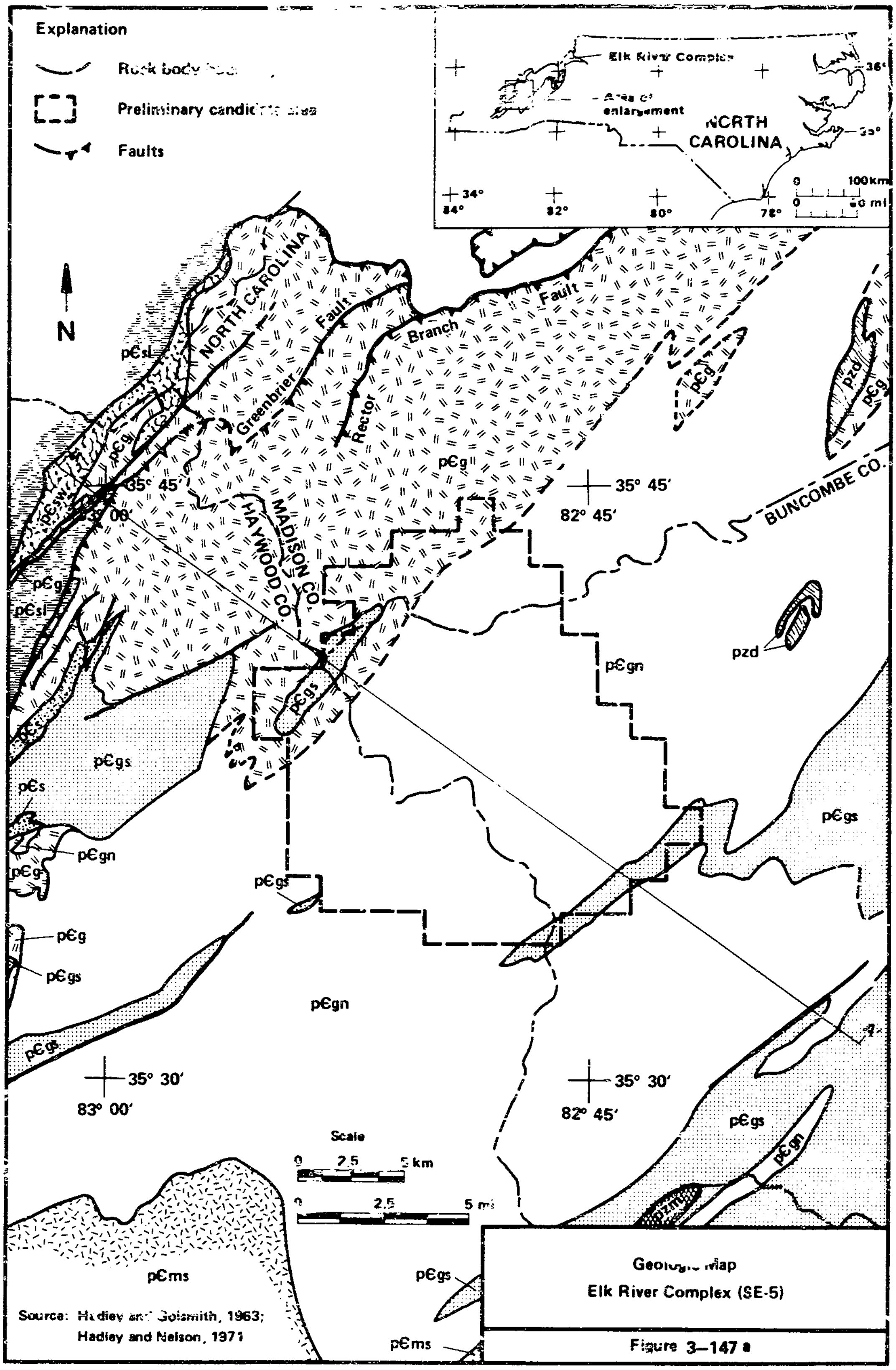
3.2.3.6 Preliminary Candidate Area Description - Elk River Complex (SE-5)

Preliminary candidate area SE-5 is located within the Blue Ridge physiographic province of south western North Carolina in Madison, Buncombe, and Haywood Counties at approximately 35°40' N latitude, 82°50' W longitude (Figure 3-147a).

3.2.3.6.1 Host Rock Geometry and Overburden Thickness. The preliminary candidate area overlies the Elk River complex and has an area of 273 km^2 (105 mi^2) with a mapped length of 21 km (13 mi) and a width of 19.5 km (12.1 mi) (Figure 3-147a).

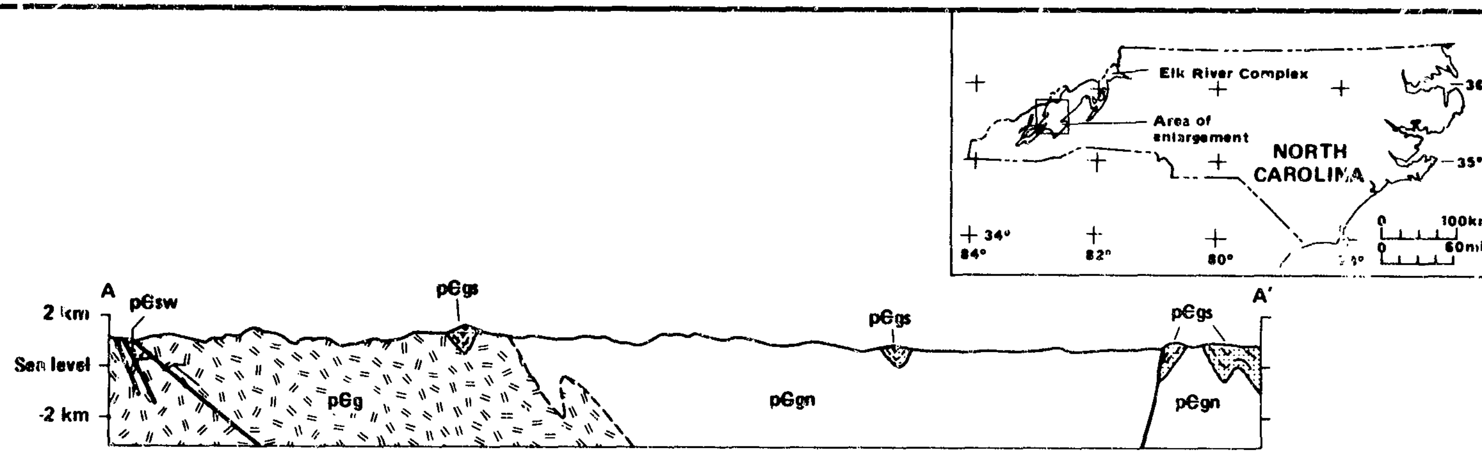
The Elk River complex has been extensively mapped (Bryant and Reed, 1970; Hadley and Goldsmith, 1963; Hadley and Nelson, 1971; Rankin et al., 1972). Each of these authors has provided interpretive cross sections in which the complex is projected to extend from a minimum depth of 630 m (2,080 ft) in the area of the Grandfather Mountain Window (Bryant and Reed, 1970) to more than 4,900 m (16,000 ft) (Hadley and Nelson, 1971). Rankin et al. (1972) disputed the interpretations made by Bryant and Reed (1970), projecting the rocks in the same area to 2,500 m (8,000 ft) below the surface. Within the preliminary candidate area, Hadley and Nelson's (1971) cross section projects the complex to a minimum depth of approximately 4 km (2.4 mi) (Figure 3-147b).

Available water well casing-depth data in the vicinity of the preliminary candidate area are given in Figure 3-148. Based on 68 data points, the average thickness of saprolite within the Elk River complex is 20.4 m (66.9 ft). Based on 11 nearby data points, the average thickness for saprolite overlying surrounding units is 16.3 m (53.4 ft). Casing-depth data are presently available for only five wells within the preliminary candidate area with saprolite thickness ranging from 11 to 28 m (35 to 92 ft). Well data were provided by the Division of Environmental Management of the North Carolina Department of Natural



Geologic Map
Elk River Complex (SE-5)

Figure 3–147 a



Explanation

Lithologic contacts

Fault

pzm Migmatite

pzd Amphibolite, metadiabase, metagabbro, and related mafic intrusive rocks

p€gs Great Smoky Group: metasandstone, schist, phyllite, metaconglomerate

p€s Snowbird Group: quartzite, schist, phyllite

p€sl Longarm Quartzite

p€sw Wading Branch ormation: metagraywacke, schist

p€ms Muscovite schist and gneiss

Elk River Complex:

p€g Biotite augen gneiss and gneissic granite

p€gn Layered gneiss and migmatite

Scale

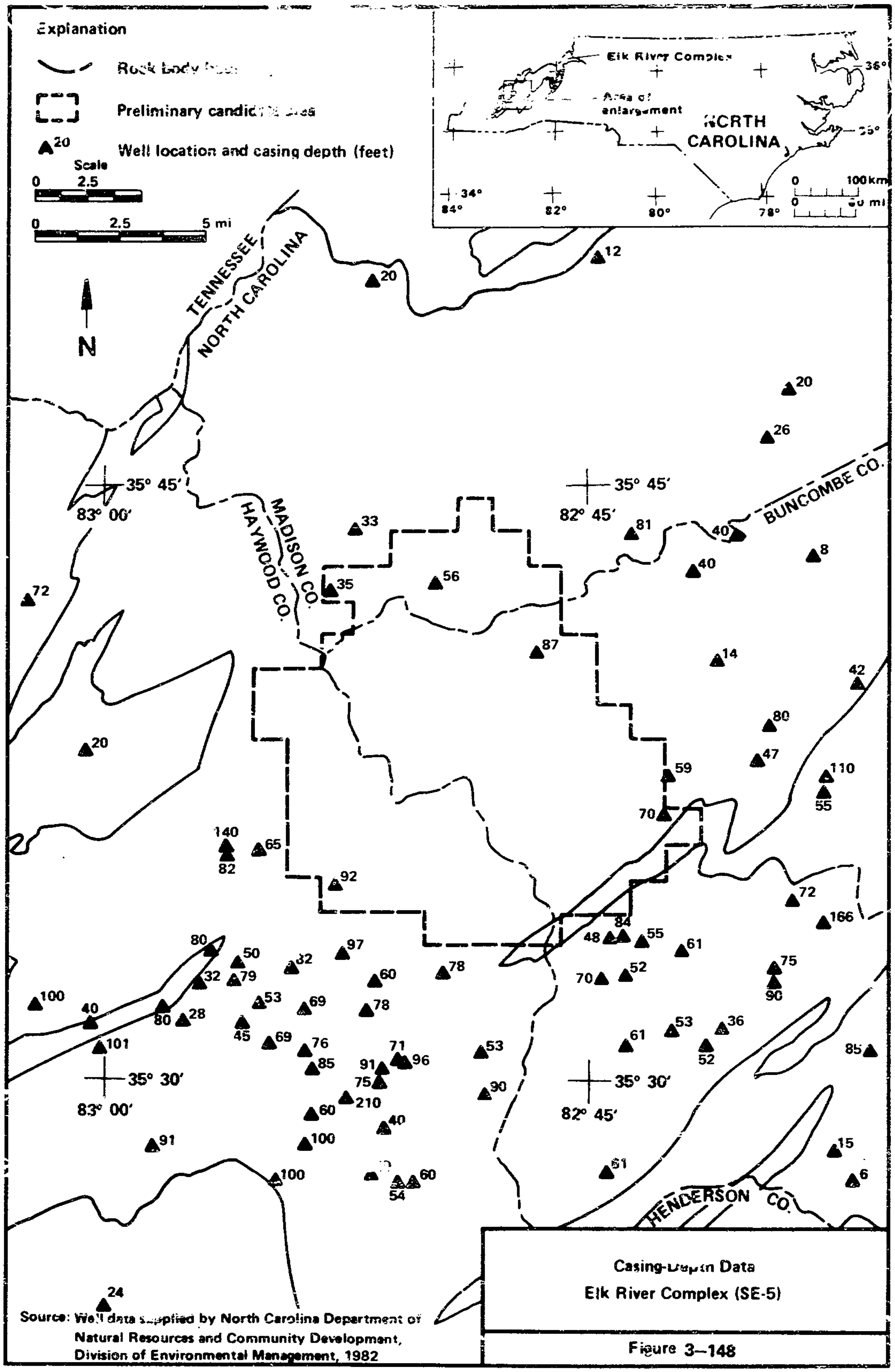
0 2.5 5 km

0 2.5 5 mi

Source: Hadley and Nelson, 1971

Geologic Cross Section
Elk River Complex (SE-5)

Figure 3-147b



Casing-Depth Data
Elk River Complex (SE-5)

Figure 3–148

Source: Well data supplied by North Carolina Department of Natural Resources and Community Development, Division of Environmental Management, 1982

Resources and Comm[illegible] (1982). The location and distribution of areas of ro[illegible] exposure [illegible] presently unknown, however, mappable exposures are expected to be extensive.

On the basis of the data presented above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock within the preliminary candidate area is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation.

3.2.3.6.2 Lithology and Tectonics. The preliminary candidate area includes layered gneiss and migmatite, the Max Patch granite and Cranberry gneiss, and the Great Smoky Group (Figure 3-147a).

The layered gneiss and migmatite in the southernmost portion of the preliminary candidate area includes layered quartz-feldspar gneiss, muscovite gneiss, and biotite gneiss, with minor amounts of mica schist (Hadley and Goldsmith, 1963). In the vicinity of the preliminary candidate area, the rocks include mafic and calc-alkaline migmatite gneiss, with rare muscovite schist or gneiss and very rare marble (Hadley and Nelson, 1971). These rocks range from medium to coarse grained and are variably foliated and locally blastomylonitic (Hadley and Goldsmith, 1963; Hadley and Nelson, 1971).

The Max Patch granite and Cranberry gneiss form the plutonic rocks of the basement complex and include augen and flaser gneiss of granitic to granodioritic composition, with minor amounts of amphibolite and layered gneiss (Hadley and Goldsmith, 1963). Small areas of mafic or calc-alkaline migmatite gneiss are also present (Hadley and Nelson, 1971). All of these rocks are variably foliated or blastomylonitic (Hadley and Nelson, 1971).

The rocks of the [illegible] Group are primarily medium- to thick-bedded feldspathic metasandstones that are commonly interbedded with feldspathic quartz-mica schist and gray phyllite (Hadley and Nelson, 1971).

The Elk River complex consists of metavolcanic and metasedimentary rocks (Hadley and Goldsmith, 1963) that were first metamorphosed during the Grenville orogeny (about 1,100 million years ago) to at least upper amphibolite grade and locally to granulite grade (Bartholomew and Lewis, 1984). To the northwest, these rocks become migmatitic and pass gradually into more uniform granitic rocks, probably representing partial melting during metamorphism (Hadley and Goldsmith, 1963). The peak of Paleozoic metamorphism was reached during the Taconic orogeny (about 450 to 350 million years ago) when rocks of the Elk River complex were folded and transported northwestward along the Greenbrier thrust faults (Bartholomew and Lewis, 1984; Hadley and Goldsmith, 1963). Early folding was followed by greenschist- to amphibolite-grade metamorphism that produced detectable changes in the basement complex, especially in shear zones, which were then recrystallized (Hadley and Goldsmith, 1963). The final stages of the Acadian orogeny were characterized by later folding and formation of mylonite zones in the basement rocks (Hadley and Goldsmith, 1963). The final episode of deformation in the Elk River complex occurred during the Alleghenian orogeny in the late Paleozoic and was characterized by brittle faulting and folding of older thrust faults (Bartholomew and Lewis, 1984).

The Elk River Complex is highly deformed and has a minimum of two principal sets of folds (Hadley and Goldsmith, 1963). To the south of the preliminary candidate area, joints occur in steep, northeast-trending sets that are spaced less than 0.3 m (1 ft) apart (Hadley and Goldsmith, 1963).

At least eight faults associated with the Greenbrier and Reactor Branch fault systems occur within 10 km (6 mi) of the preliminary candidate area to the northwest. Two [illegible] faults occur within 10 km (6 mi) west and southwest of the candidate area (Hadley and Nelson, 1971) (Figure 3-147b). Hadley and Nelson (1971) interpret the fault that is located to the southwest as a high-angle reverse fault that is along the contact of the Great Smoky Group and the basement complex. The fault immediately west of the preliminary candidate area also occurs along the contact between the Great Smoky Group rocks and the basement complex and, therefore, probably shares the same geometry as the previously discussed fault. The Greenbrier fault is a folded, low-angle thrust fault that probably formed about 450 million years ago during the Taconic orogeny (Hadley and Goldsmith, 1963). The Greenbrier fault internally offsets the basement complex and is part of a series of thrusts along which the Elk River complex and its cover rocks were thrust to the northwest. The Reactor Branch fault is part of this series of thrusts and, therefore, is probably similar to the Greenbrier fault.

Estimates of regional uplift and subsidence are discussed in detail in Section 3.2.3.1.1.3. Regional data indicate recent uplift has occurred but there is a wide range of interpretations on the magnitudes of uplift. No data are available for the preliminary candidate area; therefore, until data are obtained, no conclusions can be drawn concerning effects of uplift. There are in-situ stress data available for the vicinity of the preliminary candidate area.

There is no evidence of Quaternary igneous activity, folding, faulting or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process, however, there appears to be no significant potential for tectonic deformations that could affect the regional ground water flow system.

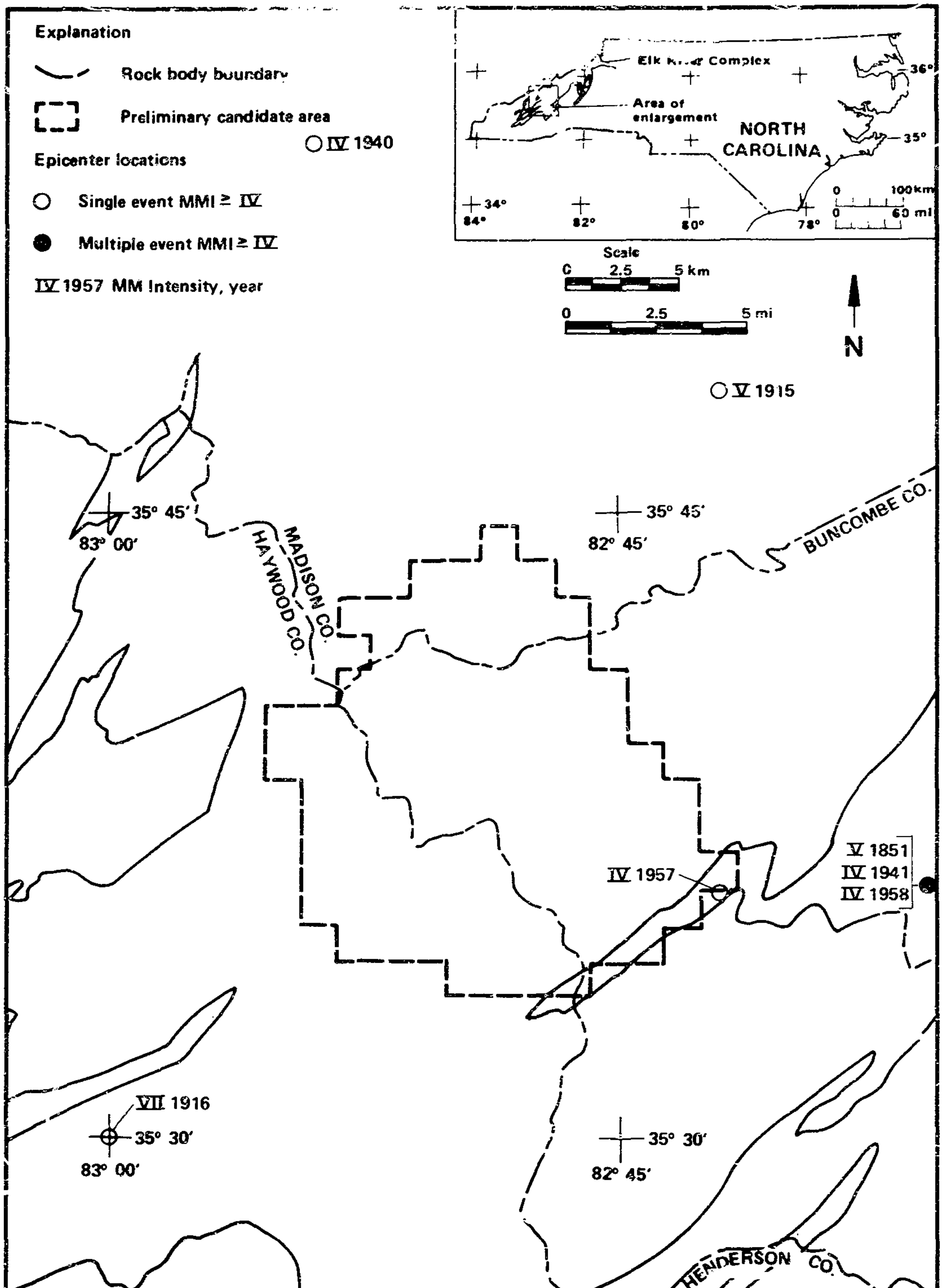
3.2.3.6.3 Seismicity. One earthquake epicenter with an intensity of MM IV (Bollinger, 1975; Reagor et al., 1980a; Seay, 1979; Stover et al., 1984) is located within 10 km (6 mi) of the preliminary candidate area

(Figure 3-149). Six seismic events of MM IV or greater and seven events of MM III or less (Stover et al., 1984) are located within approximately 30 km (18.6 mi) of the preliminary candidate area (see Figure 3-118 in Section 3.2.3.1.1.3). The preliminary candidate area is located within a region of relatively high seismicity which (see Figure 3-119 in Section 3.2.3.1.1.3) appears to be similar to that of adjacent areas. The largest historical earthquake associated with this zone is an MM VII which occurred on February 21, 1916, approximately 30 km (19 mi) southeast of the preliminary candidate area near Skyland, North Carolina.

The major faults near the preliminary candidate area are discussed in Section 3.2.3.6.2. There is no apparent relationship between the observed seismicity and the known faults within or surrounding the preliminary candidate area.

Although the level of seismic activity in the region is relatively high, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation, and it is unlikely that the frequency of occurrence of earthquakes in the area will increase in the future.

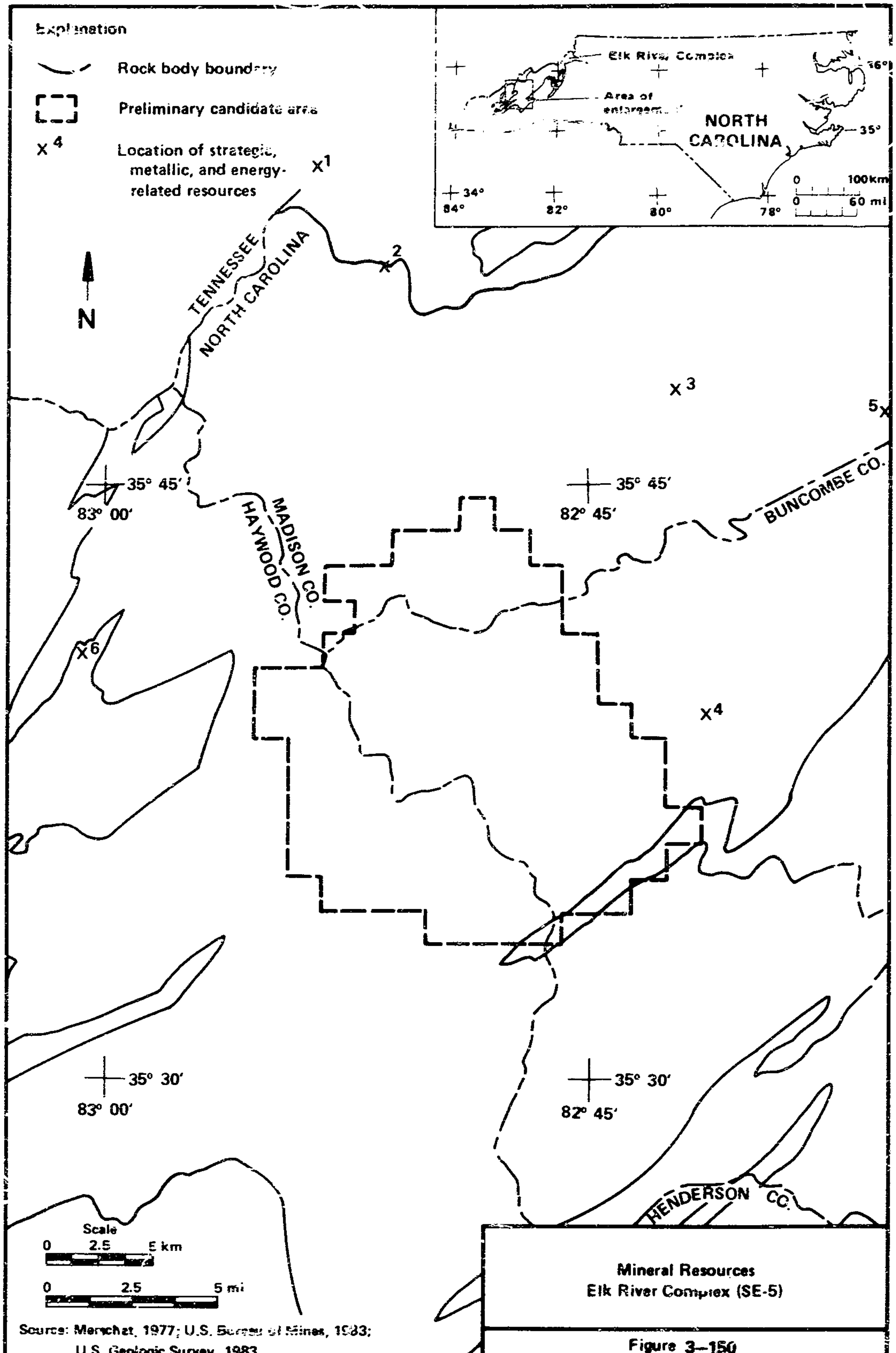
3.2.3.6.4 Mineral Resources. There are five known mines of strategic/metallic resources within 10 km (6 mi) of the preliminary candidate area (Figure 3-150; Table 3-17). Two of these are inactive lead-zinc and iron mines located about 8 km (5 mi) west of the preliminary candidate area in close proximity to each other (U.S. Bureau of Mines, 1983). One is a chromite and iron prospect of unknown status that is located 2 km (1.2 mi) east of the preliminary candidate area and the others are an inactive soapstone-tungsten mine and an iron prospect, both located 10 km (6 mi) northeast of the preliminary candidate area (U.S. Bureau of Mines, 1983). There is no indication that these resources are present within the preliminary candidate area, although their location in a very similar geologic setting, in close proximity to the preliminary candidate area, suggests the possibility that



Source: Bollinger, 1975; Seay, 1979; Templeton and Spencer, 1980; Reagor et al, 1980; Coffman et al, 1982; Stover et al, 1984

Location of Earthquake Epicenters
Elk River Complex (SE-5)

Figure 3–149



Mineral Resources
Elk River Complex (SE-5)

Figure 3–150

mineralization may be prese . Three o r mines, located more than 10 km (6 mi) from the preliminary candidate area, were formerly the sites for the recovery of manganese, barium, lead, silver, and iron ore (Merschat, 1977; U.S. Bureau of Mines, 1983) (Figure 3-150, Table 3-17).

Based on the data presented in this section, no strategic, energy or metallic, or energy-related resources are known to exist within the preliminary candidate area. Numerous resources exist near the preliminary candidate area and the geologic conditions of the preliminary candidate area are similar to the surrounding area. There is no evidence for mining to a depth sufficient to affect waste isolation and no information is available to indicate that deep drillholes (greater than 100 m [328 ft] in depth) are present in the preliminary candidate area.

Table 3-17. Mineral Resources Near Preliminary Candidate Area SE-5

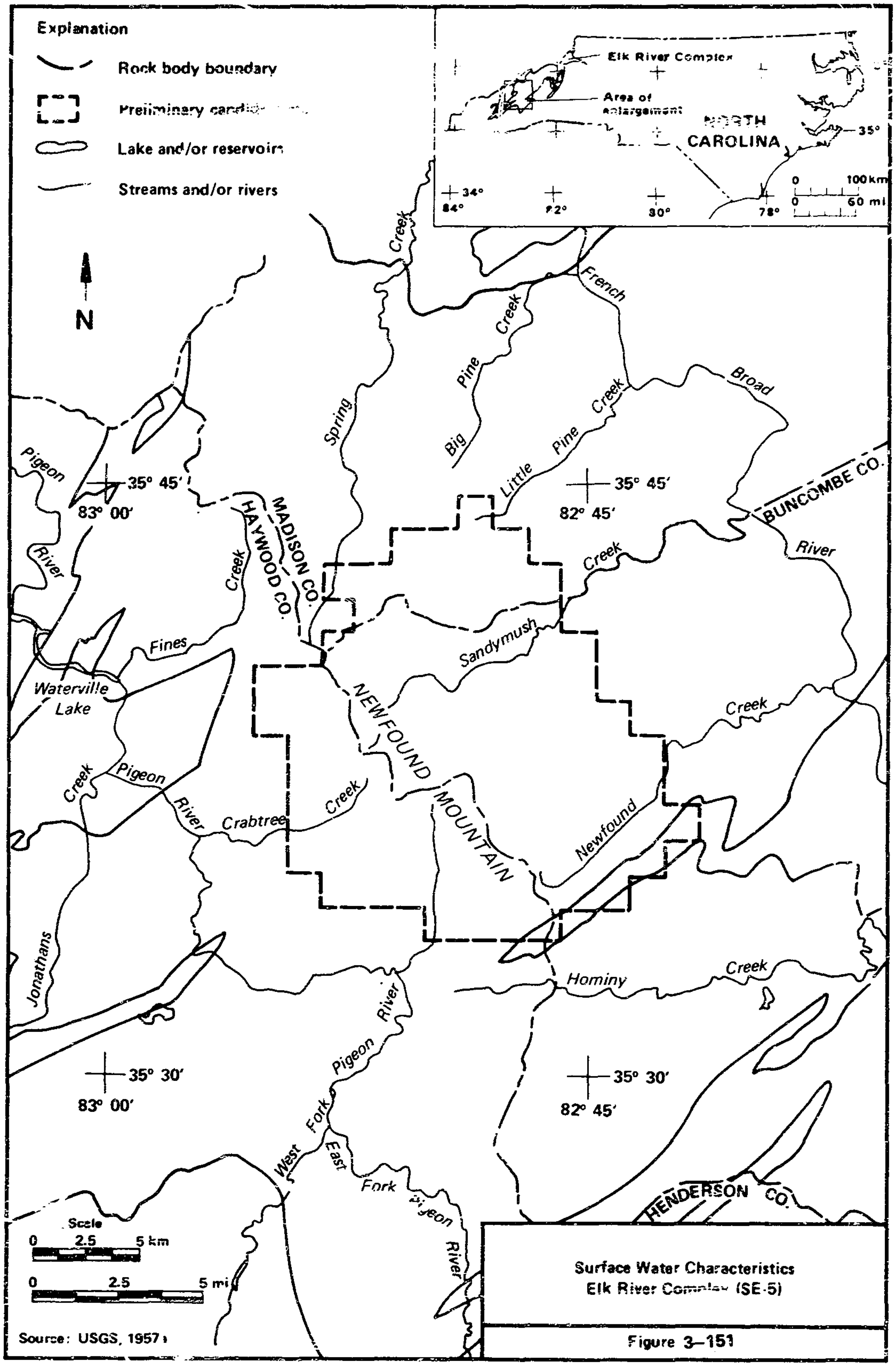
Map Number (Figure 3-150)	Name	Commodity	Status
1	Unnamed	Manganese	Inactive
2	Long Mountain Barite Mine	Barium, Lead, Silver	Inactive
3	Go forth Soapstone Mine	Tungsten, Soapstone	Inactive
*	Joe Ball Prospect	Iron	Inactive
4	Leicester Chromite Prospect	Chromite, Iron	Unknown
5	Big Ivy Mine	Iron	Inactive
6	Redmond Mine	Lead, Zinc	Inactive
*	Carpenter Bank Mine	Iron	Inactive

Source: Merschat, 1977; U.S. Bureau of Mines, 1983

*Not located on map.

3.2.3.6.5 Topography and Surface-water Characteristics. The preliminary candidate area is characterized by linear ridges with sharp crests and steep slopes, alternating with low, relatively narrow intermontane areas of rolling hills and stretches of bottomland along principal rivers. The preliminary candidate area is approximately centered on Newfound Mountain, which trends northwest-southeast. Elevations within the preliminary candidate area range from 634 to 1,571 m (2,080 to 5,152 ft) (U.S. Tennessee Valley Authority, 1941; 1967c). Local relief is as much as 748 m (2,454 ft) over a distance of about 4.8 km (3 mi) (U.S. Tennessee Valley Authority, 1967a). Relief averages about 519 m (1,700 ft) over an average distance of about 0.6 km (1 mi) (U.S. Tennessee Valley Authority, 1941; 1942; 1961; 1967a; 1967b; 1967c). Floodplain widths range from less than 31 m (100 ft) along the upper reaches of the streams to approximately 244 m (800 ft) near the margins of the preliminary candidate area. Floodplains are generally confined to V-shaped valleys.

The surface-water system within the preliminary candidate area is characterized by a parallel drainage pattern that consists of several creeks flowing northeast and southwest away from a central ridge (Newfound Mountain) (USGS, 1957a). Northeast-flowing streams drain into the French Broad River approximately 9 km (5.4 mi) downstream from the preliminary candidate area. Southwest-flowing streams converge in the southwesternmost portion of the preliminary candidate area and flow into the Pigeon River downstream (less than 1 km or 0.6 mi) from the preliminary candidate area (Figure 3-151). The Pigeon River flows northwest to eventually merge with the French Broad River at a backwater of Douglas Lake Reservoir, approximately 38 km (22.8 mi) northeast of the preliminary candidate area. Creeks in the northwestern section drain into Watersville Lake, approximately 6 km (3.6 mi) east of the preliminary candidate area. There are no other large lakes or reservoirs within or near (within 6 km [3.6 mi]) the preliminary candidate area.



Surface Water Characteristics
Elk River Complex (SE-5)

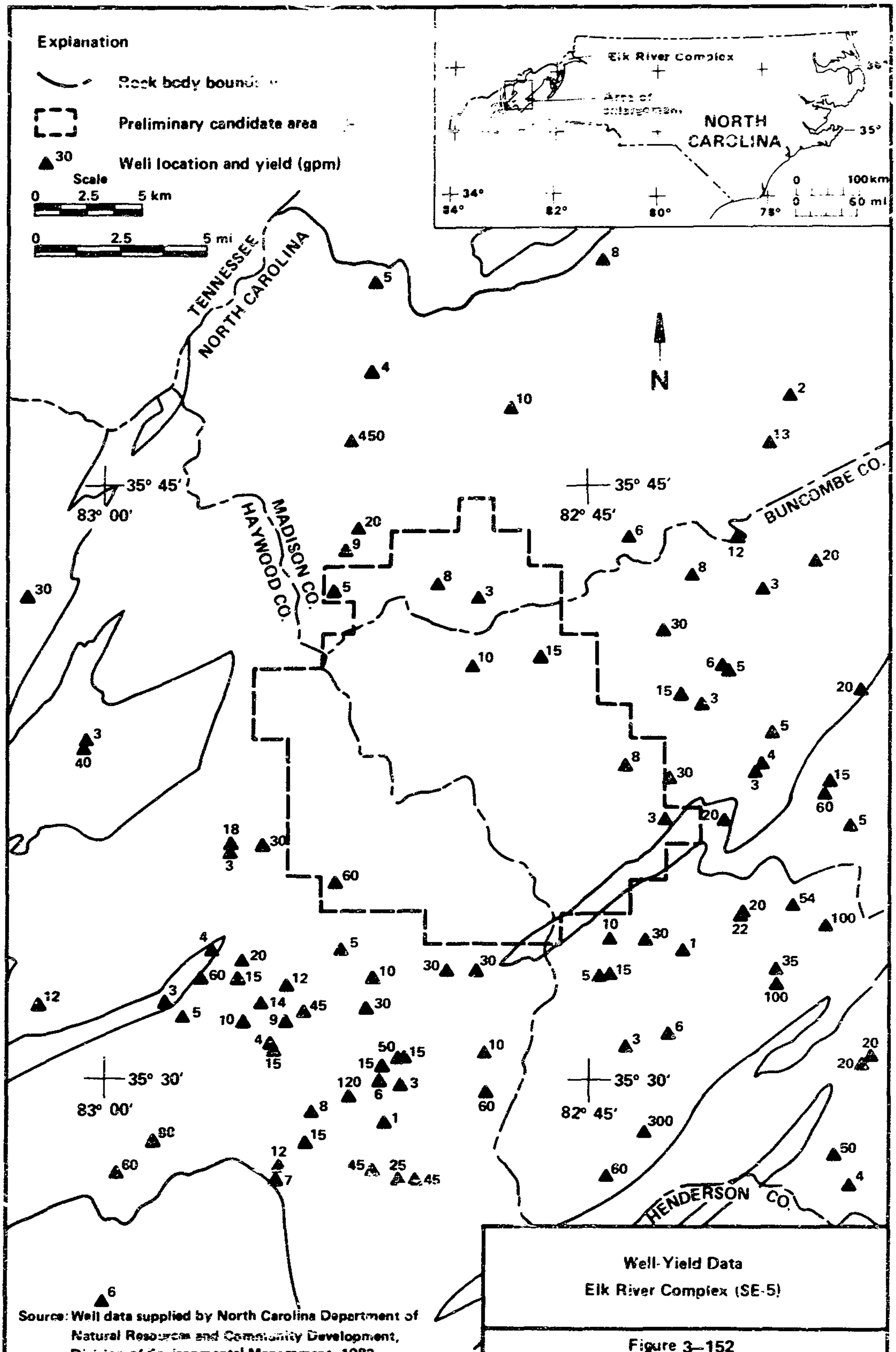
Figure 3–151

High topographic relief, generally narrow floodplains, V-shaped valleys, and lack of any natural lakes/reservoirs or swamps/marshes indicate that the preliminary candidate area is very well drained. Consequently, there is a very low flooding potential.

3.2.3.6.6 Ground-Water Resources. Regional ground-water data in the Southeastern Region are discussed in Section 3.2.3.1.1.5. Available data in the preliminary candidate area do not allow differentiation between producing wells in saprolite and crystalline bedrock wells nor are water level contour maps available for the preliminary candidate area. Water well data were provided by the Division of Environmental Management of the North Carolina Department of Natural Resources and Community Development and are in the form of well yields. Figure 3-152 presents the available well-yield data in the vicinity of the preliminary candidate area. Eighty-five wells located within the Elk River complex average 1.87 L/s (29.6 gpm). Of these, 54 yield less than 1.26 L/s (20 gpm), 19 yield from 1.26 to 3.15 L/s (20 to 50 gpm), and 12 yield from 3.22 to 28.39 L/s (51 to 450 gpm). Only eight wells ranging in yield from 0.2 to 3.8 L/s (3 to 60 gpm) are located within the preliminary candidate area. Fifteen additional wells located within surrounding units average 1.23 L/s (19.5 gpm). Of these eight yield less than 1.26 L/s (20 gpm), six yield from 1.26 to 3.15 L/s (20 to 50 gpm), and one yields 3.79 L/s (60 gpm).

The well yield information indicates the presence of potable ground water in the vicinity of the preliminary candidate area. The yields are generally 1.26 to 3.15 L/s (20 to 50 gpm) with one well producing around 28.39 L/s (450 gpm). Specific relationships between lithology, structure and well yields are not currently available. There are no data on the deep ground-water system within the preliminary candidate area.

3.2.3.6.7 Quaternary Climate. A discussion of Quaternary climatic conditions, including paleoclimatic conditions, vertical crustal movement, and changes in sea level, is in Section 3.2.3.1.1.1.



Well-Yield Data
Elk River Complex (SE-5)

Figure 3–152

Source: Well data supplied by North Carolina Department of Natural Resources and Community Development, Division of Environmental Management, 1982

3.2.3.6.8. Federal Lands. No disqualified Federal lands are located in or within 10 km (6 mi) of the preliminary candidate area. However, approximately 384 ha (960 ac) or less than 1% of the preliminary candidate area lies within the Pisgah National Forest. A separate segment of the Pisgah National Forest is located 5 km (3 mi) to the south of the preliminary candidate area. The Great Smoky Mountain National Park is 11 km (7 mi) west of the preliminary candidate area, while the Blue Ridge Parkway is 13 km (8 mi) to the south at its closest approach. The Shining Rock Wilderness also lies 13 km (8 mi) south of the preliminary candidate area. All of these features are greater than 130 ha (320 ac) in size and are depicted in Plate 2A of the Southeastern RECR (DOE, 1985h) (see also Figure 3-153). There is no evidence in the data base that Federal lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.6.9 State Lands. No State lands greater than 130 ha (320 ac) in size lie within the boundary of the preliminary candidate area. The Great Smoky Mountain Natural Heritage Area is 13 km (8 mi) west of the preliminary candidate area. This feature and other State lands which occur in North Carolina are depicted on Plates 3A or 4A of the Southeastern RECR (DOE, 1985h) (see also Figure 3-153). There is no evidence in the data base of State lands less than 130 ha (320 ac) in size located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.6.10 Environmental Compliance. No portion of the preliminary candidate area lies within current air quality nonattainment areas. The closest Prevention of Significant Deterioration (PSD) Class I Area is the Great Smoky Mountain National Park which lies approximately 11 km (7 mi) to the west of the preliminary candidate area. The Shining Rock Wilderness, another existing PSD Class I Area, lies approximately 13 km (8 mi) to the south (42 FR 57460). One site on the National Register of Historic Places (NRHP) (No. 213 Metal Truss Bridge) may be located within

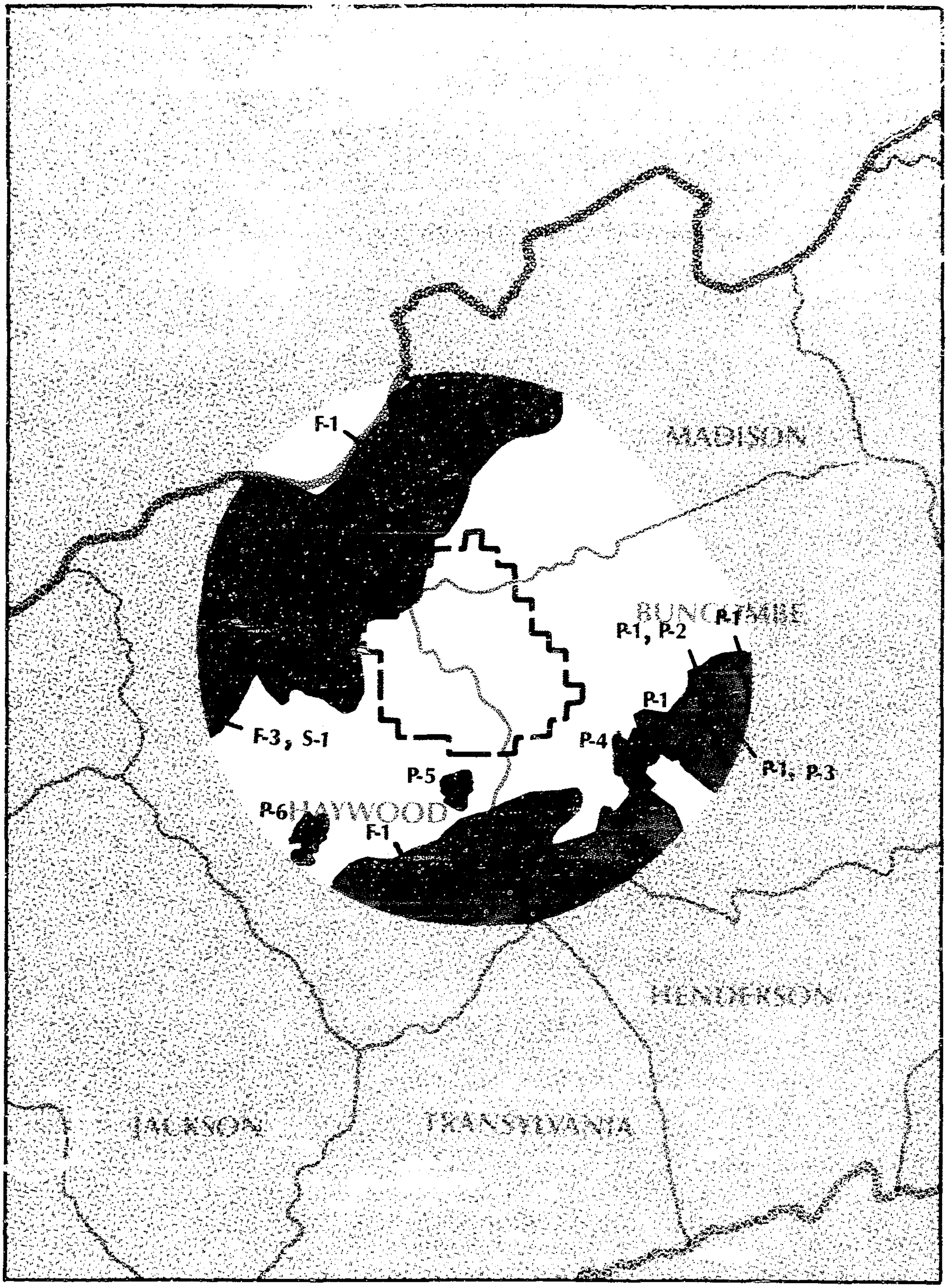


Figure 3–153 Sheet 1

Environmental Features
Elk River Complex (SE-5)

Environmental Features Legend

- Preliminary Candidate Area (dashed line)
- Environmental Features (dark box)

P	Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile
F	Federal Lands Greater Than 320 Acres
S	State Lands Greater Than 320 Acres
I	Federal Indian Reservations
●	Federal or State Lands Less Than 320 Acres
F-5	Map Alpha-numeric Codes are Keyed to Environmental Features

- Rock Bodies
- Beyond Ten Miles from Preliminary Candidate Area
- State Boundary
- County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–153 Sheet 2

ENVIRONMENTAL FEATURES WITHIN 16 KM (10 MI) OF PRELIMINARY CANDIDATE AREA SE-5*

Code	Feature
Population Features	
P-1	Ashville Minor Civil Division
P-2	Woodfin Highly Populated Area (HPA)
P-3	Asheville HPA
P-4	Enka HPA
P-5	Canton HPA
P-6	Waynesville HPA
Federal Lands	
F-1	Pisgah National Forest
F-2	Appalachian Trail
F-3	Great Smoky Mountains National Park
F-4	Shining Rock Wilderness
F-5	Blue Ridge Parkway
State Lands	
S-1	Great Smoky Mountains Natural Heritage Area
Indian Reservations	
None	

* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 3-153, Sheet 3

the preliminary [illegible] boundary in Buncombe County (45 FR 17509, 1980). No proposed NRHP [illegible] within the preliminary candidate areas. In the regional data base there are no known existing archaeological sites or districts or any proposed for designation within the preliminary candidate area. No National Trails are within the preliminary candidate area. The Appalachian Trail is 10 km (6 mi) to the northwest of the preliminary candidate area (NPS, n.d.).

3.2.3.6.11 Population Density and Distribution. The preliminary candidate area contains no highly populated areas. There are five highly populated areas within 16 km (10 mi) of the preliminary candidate area (Asheville, Canton, Enka, Waynesville, Woodfin). Asheville, with a population of 53,583, and Woodfin, with a population of 3,260, are located 11 km (7 mi) and 10 km (6 mi) east of the preliminary candidate area, respectively. Canton is located 1.6 km (1 mi) south of the preliminary candidate area and has a population of 4,631. Enka is located 4.8 km (3 mi) southeast and Waynesville is located 11 km (7 mi) southwest of the preliminary candidate area, respectively. The population of Enka is 5,567, while Waynesville has a population of 6,765 (see Figure 3-153). The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square mile. There is one area (Asheville) of population density greater than or equal to 1,000 persons per square mile within 16 km (10 mi) of the preliminary candidate area (see Figure 3-153). Asheville is located 4.8 km (3 mi)* east-southeast of the preliminary candidate area and has a population of 70,889*; it is also a highly populated area. The average population density of the preliminary candidate area is approximately 76 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate area is approximately 89 persons per

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* The difference in population figures and in distance and direction from the preliminary candidate area is due to the fact that the geographic location and extent of the highly populated area of Asheville is different than the area defined by a density of 1,000 persons per square mile.

square mile. Low [illegible] density is defined as a density in the general region of the site less than [illegible] average population density for the conterminous United States (76 persons per square mile) based on the 1980 census.

3.2.3.6.12 Site Ownership. There are no DOE-owned lands located within the preliminary candidate area, but less than 2% of the preliminary candidate area lies within the Pisgah National Forest. The Cherokee Indian Reservation is approximately 24 km (15 mi) to the west of the preliminary candidate area (see Plate SE-1A).

3.2.3.6.13 Offsite Installations. No commercial nuclear reactors are located within the preliminary candidate area. The nearest operating commercial nuclear reactor is Oconee Station which is approximately 97 km (60 mi) to the south (Wamsley, 1985; Electrical World Directory of Electric Utilities, n.d.). The nearest commercial nuclear reactor under construction is McGuire Unit No 2 which is approximately 161 km (100 mi) to the east in Tennessee (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 40 CFR 191, Subpart A, within or in proximity to the preliminary candidate area.

3.2.3.6.14 Transportation. I40 is the nearest interstate highway and is located from 1.6 to 6 km (1 to 4 mi) away from the southern and western sides of this preliminary candidate area. This interstate is a major east-west highway across the United States. I26, which connects Asheville, North Carolina, with Charleston, South Carolina, is within 13 km (8 mi) of the southeastern edge of the preliminary candidate area. A number of U.S. highways (U.S. 19, 23, 25, 70, and 276) are located within 16 km (10 mi) of the preliminary candidate area. U.S. 25/70 is north and east of the preliminary candidate area, U.S. 19/23 is east and south of the preliminary candidate area, and U.S. 276 is southwest of the preliminary candidate area. Two State highways cross the mountains over this preliminary candidate area. State Route 209 (shown as a straight line) runs north and south through the western portion of the preliminary candidate area. State Route 63 (not shown on the plot) traverses the preliminary candidate area diagonally, between Asheville and State Route 209 in the northwestern portion of the preliminary candidate area.

The nearest mainline railroad is the Southern line that follows the French Broad River between Asheville, North Carolina, and the Tennessee state line. This railroad is from 8 to 13 km (5 to 8 mi) northeast of the preliminary candidate area. The nearest branchline is a Southern line between Asheville and the southwestern part of North Carolina. This line is located from 3.2 to 8 km (2 to 5 mi) to the south of the preliminary candidate area.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.6.15 Preliminary Candidate Area Deferral Analysis. This section identifies significant additional information (specified in Section 3.2) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-5 that could affect DOE's decision to defer further consideration of the area. Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation [960.4-2-3(b)(1), 960.5-2-9(b)(1), 960.5-2-9(c)(1)]
- presence of host rock that permits emplacement of waste at least 300 m (1,000 ft) below ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow system should not be significantly affected [960.4-2-7(c)(6)]

- absence of ac[illegible] faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]
- no indications, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could produce ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]
- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect waste containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring material that is not widely available from other sources [960.4-2-8-1(c)(4)]
- presence of generally well-drained terrain [960.5-2-8(b)(2)]
- general absence of surface characteristics or surface-water systems that could lead to flooding [960.5-2-8(c), 960.5-2-10(b)(2)]
- located within a geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]

- absence of Federal lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km or 6 mi of) the preliminary candidate area [960.5-2-5(c)(3)]
- absence of State lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(4)]
- absence of nuclear installations [960.5-2-4(b) and (c)(2)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfer of title, or Federal condemnation proceedings [960.4-2-8-2(c), 960.5-2-2(c)]
- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2), 960.5-2-7(b)(3)].

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]
- presence of shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2-8-1(c)(1)(i)]
- steep, rugged terrain within the preliminary candidate area and between the preliminary candidate area and existing local highways and railroads [960.5-2-7(c)(2)]
- proximity to two PSD Class I Areas [960.5-2-5(c)(1)]
- a majority of the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile [960.5-2-1(c)(2)]

The results indicate that there are no significant adverse features identified to date that would preclude DOE from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-5 at this time.

3.2.3.7 Preliminary Candidate Area Description - Lithonia Gneiss (SE-6)

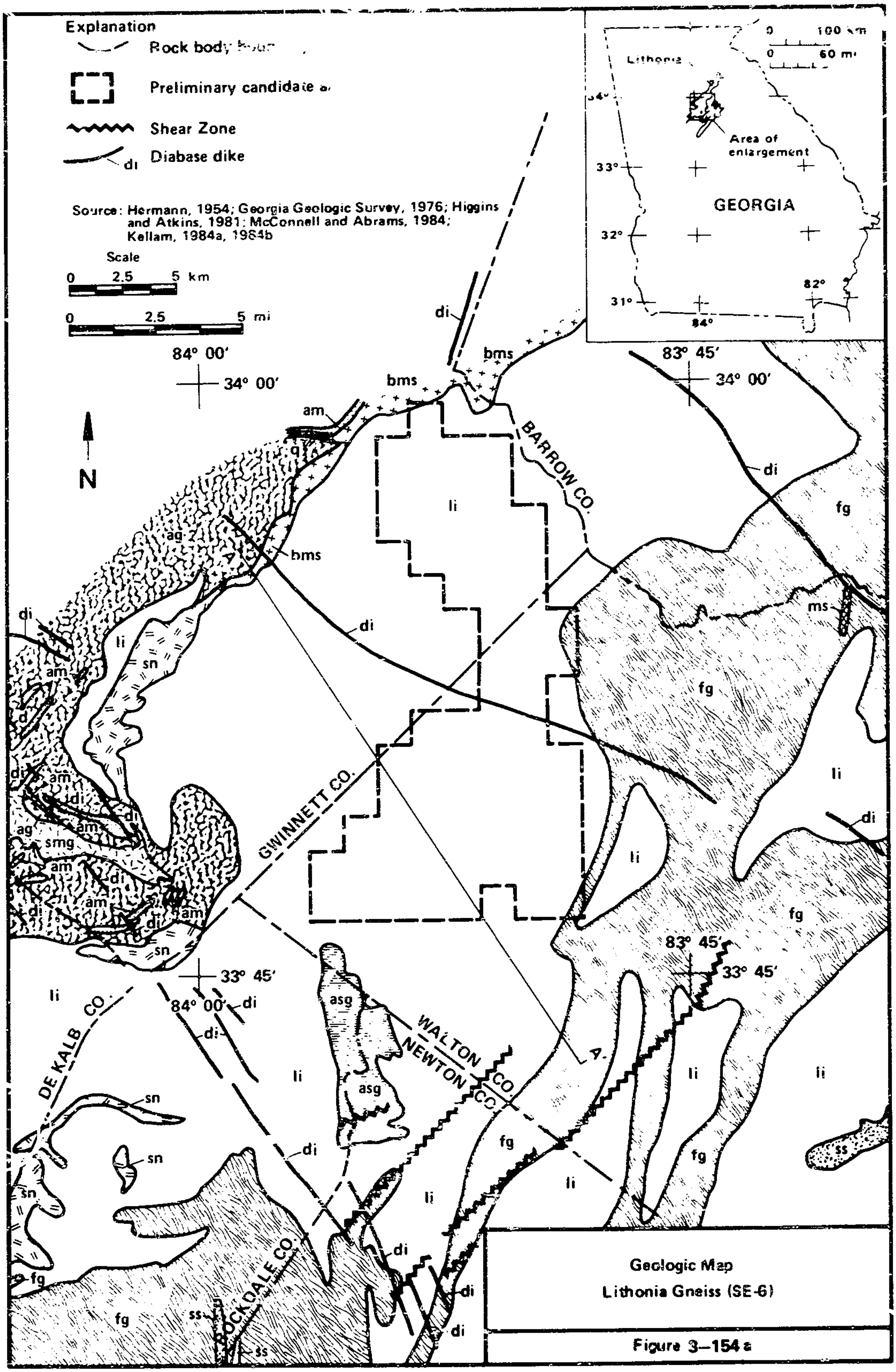
Preliminary candidate area SE-6 is located within the Piedmont physiographic province of central Georgia in Gwinnett and Walton Counties, at approximately 33°50' N latitude, 83°55' W longitude (Figure 3-154a).

3.2.3.7.1 Host Rock Geometry and Overburden Thickness. The preliminary candidate area has an area of approximately 174 km^2 (67 mi^2) with a mapped length of 19 km (11.8 mi) and a width of 12 km (7.4 mi) and overlies the Lithonia gneiss (Figure 3-154a).

Detailed information on the thickness of the Lithonia gneiss is lacking. Herrmann (1954) illustrates the Lithonia gneiss on his cross section as extending to at least 366 m (1,200 ft) below land surface (Figure 3-154b) with no other lithologies beneath it.

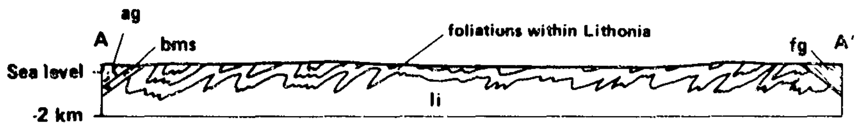
Available water well casing-depth data in the vicinity of the preliminary candidate area are given in Figure 3-155. No casing-depth data are presently available within the preliminary candidate area. Based on three data points, the average thickness of saprolite within the Lithonia gneiss is 9.75 m (32 ft). Well data were supplied by the Georgia Department of Natural Resources (1982). The specific location and distribution of areas of rock exposure are presently unknown; however, mappable exposures are fairly extensive (Higgins and Atkins, 1981).

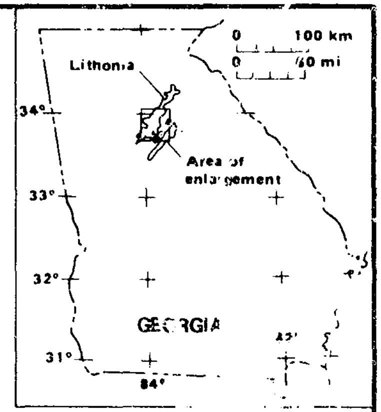
On the basis of the limited data presented above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock underlying the preliminary candidate area is sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location for the underground facility to ensure waste isolation.



Geologic Map
Lithonia Gneiss (SE-6)

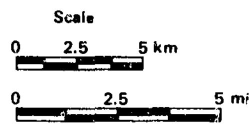
Figure 3–154a





Explanation

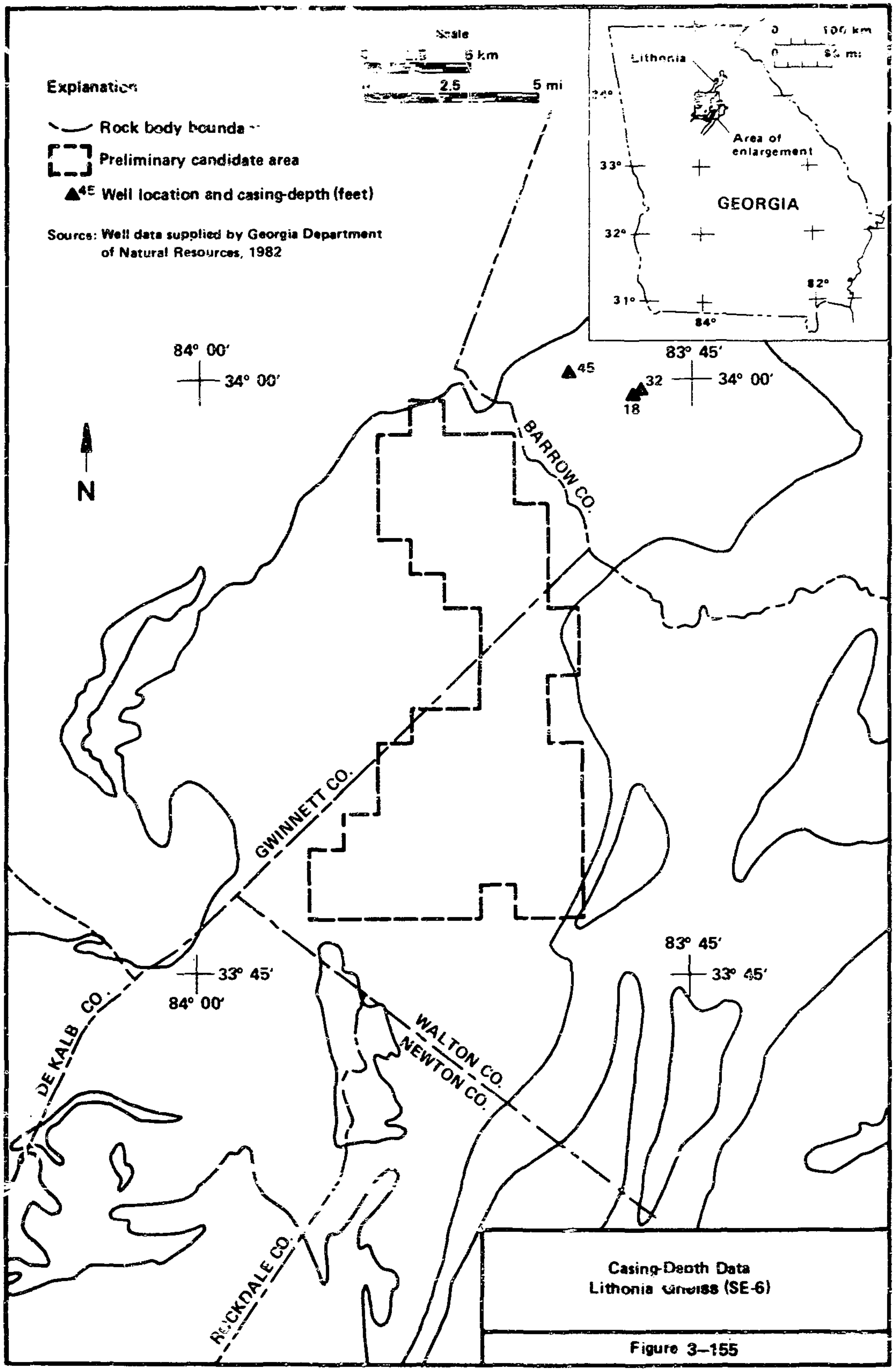
li	Lithonia Gneiss
smg	Stone Mountain gneiss
fg	Biotite gneiss, mica schist and amphibolite
bsg	Amphibolite, mica schist and biotite gneiss
ss	Sillimanite schist, gneiss and amphibolite
ms	Mica schist
am	Amphibolite
	Quartzite
bms	Biotite muscovite schist and other unassigned rocks
ag	Rocks of the Atlanta Group
sn	Snellville Formation



Source: Hermann, 1954

Geologic Cross Section
Lithonia Gneiss (SE-6)

Figure 3-154b



Casing-Depth Data
Lithonia Gneiss (SE-6)

Figure 3–155

3.2.3.7.2 Lithology and Tectonics. The preliminary candidate area overlies the Lithonia gneiss, a fine-to medium-grained, biotite-microcline-oligoclase-quartz gneiss with a well-developed, commonly contorted foliation (Higgins and Atkins, 1981). The gneiss commonly exhibits pronounced compositional banding defined by granoblastic quartz-feldspar layers alternating with open, discontinuous, mica-rich zones (Grant et al., 1980). Coexisting with the banded gneiss are areas of granitic rock and migmatite. The granitic rocks exhibit varying degrees of discontinuity with the gneiss and exist in both flow-like structures parallel to the foliation of the gneiss and in cross-cutting, vein-like patterns (Grant et al., 1980).

The Lithonia gneiss crops out of the southeast flank of the Newnan-Tucker synform (Higgins and Atkins, 1981). Surrounding rocks include gneisses and schists of the Atlanta Group (Higgins and Atkins, 1981) and unnamed gneisses and schists. Hermann (1954) interpreted the Lithonia gneiss as a metasedimentary rock whose original character had been obliterated by subsequent metasomatisn. Higgins and Atkins (1981) offered no interpretation but stated that the Lithonia gneiss may be a metaplutonic intrusive. Grant et al. (1980) interpreted the granitic and migmatitic phases of the gneiss as zones of metamorphic anatexis and metatexis, respectively, of the parent banded gneiss.

Folds in the Lithonia gneiss range from slight undulations in the banded gneiss to complexly contorted flow folds (Hermann, 1954). These variations commonly occur over distances of only a few meters (feet). Axes within the flow folds vary greatly in trend but generally plunge gently to the northeast or southwest (Herrmann, 1954). Because the complex structures in the Lithonia gneiss are not observed in surrounding rocks, the nature and significance of these folds remain controversial.

Higgins et al. (1984) interpreted the Lithonia gneiss and surrounding lithologic units as individual thrust sheets constituting a regional thrust stack that represe... ...llochthonous mass tectonically transported to its present position.

A series of en echelon shear zones is located south-southeast and within 10 km (6 mi) of the preliminary candidate area (Figure 3-154a). The age of last movement for the shear zone is not known. The Brevard zone occurs approximately 15 km (9 mi) to the northwest of the preliminary candidate area. The time of the last movement along the Brevard zone occurred prior to the postmetamorphic period (McConnell and Abrams, 1984) and is interpreted to have occurred prior to the Mesozoic Period (Bryant and Reed, 1970).

Small-scale ductile shearing is ubiquitous in the Lithonia gneiss. The shear zones extend up to 3.05 m (10 ft) in length and are generally no more than 5.1 cm (2 in) in width (Herrmann, 1954). The shear zones are late deformational features (Herrmann, 1954).

Although compositional banding and foliation are well developed in the Lithonia gneiss, they are commonly so contorted that no overall trend is discernible (Higgins and Atkins, 1981).

Jointing does not appear to be well developed in the Lithonia gneiss, which may explain the abundance of pavement exposures. Data supplied in Herrmann's (1954) paper suggest no definite trend to the jointing that is present.

Estimates of regional uplift and subsidence are discussed in detail in Sections 3.2.3.1.1.3. Regional data indicate recent uplift has occurred, but there is a wide range of interpretations on the magnitudes of uplift. No data are available for the preliminary candidate area; therefore, until data are obtained, no conclusions can be drawn concerning effects of uplift. There are no in situ stress data available for the vicinity of the preliminary candidate area.

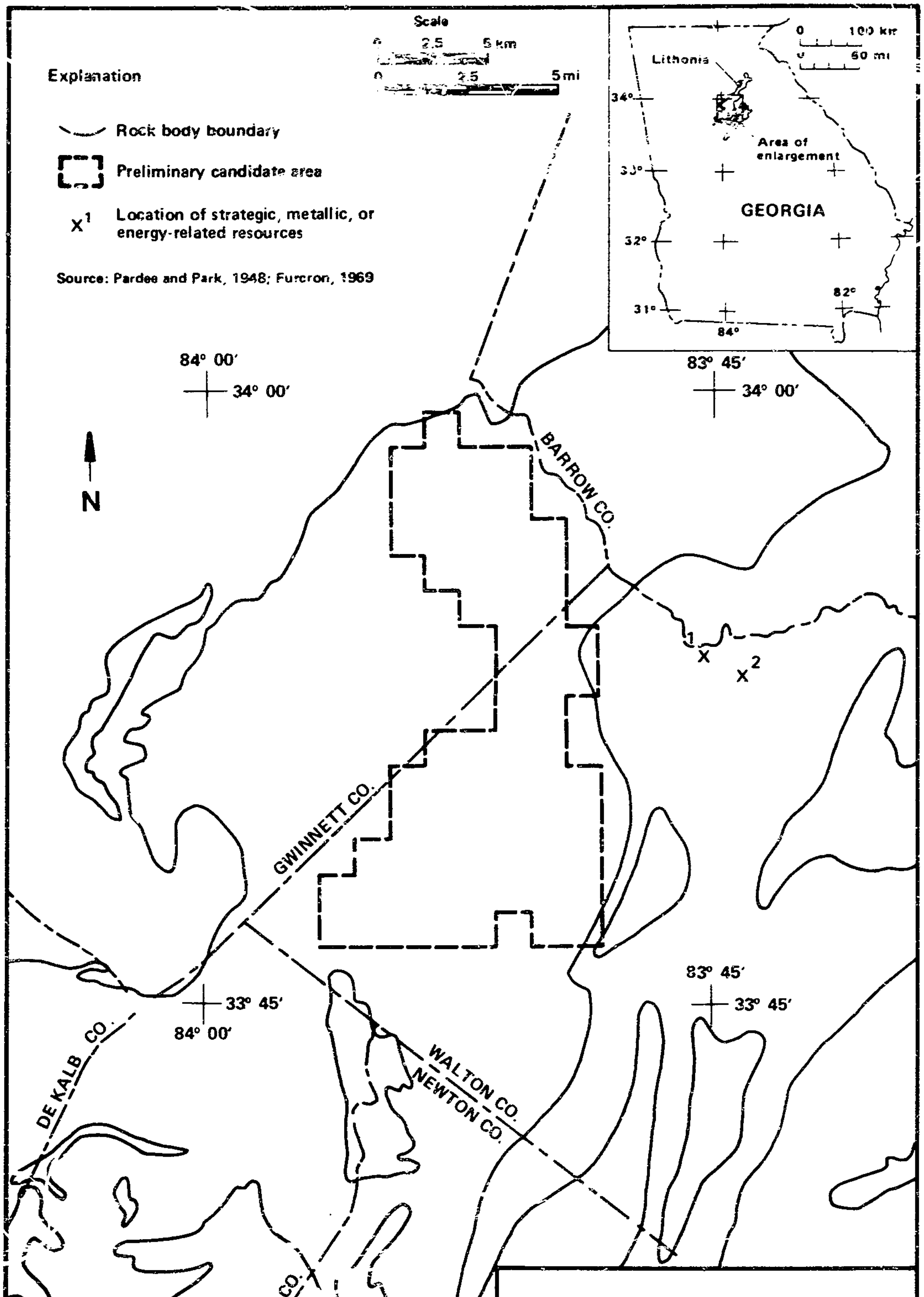
There is no evidence of Quaternary igneous activity, folding, faulting, or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process; however, there appears to be no significant potential for tectonic deformations that could affect the regional ground water flow system.

3.2.3.7.3 Seismicity. The preliminary candidate area is located within a region of relatively low seismicity (see Figures 3-118 and 3-119a in Section 3.2.3.1.1.3). No earthquakes have been reported within 30 km (18.6 mi) of the preliminary candidate area. The largest historical earthquake associated with this region is an MM VI which occurred March 5, 1914, in Morgan County, approximately 60 km (37 mi) southeast of the preliminary candidate area.

Major faults are discussed in Section 3.2.3.7.2, Lithology and Tectonics. There does not appear to be any seismicity associated with these structures.

Considering the low level and magnitude of seismic activity in the region and the absence of active tectonic processes within the geologic setting during the Quaternary Period, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation, and it is unlikely that the frequency of occurrence of earthquakes in the area will increase in the future.

3.2.3.7.4 Mineral Resources. No strategic, metallic, or energy-related resources occur within the preliminary candidate area. Two gold mines occur within 10 km (6 mi) of the candidate area (Table 3-18 and Figure 3-156). Both of these deposits are confined to rocks outside of the Lithonia gneiss; therefore, the potential for discovery and development of these types of deposits within the preliminary candidate area is extremely low.



Mineral Resources
Lithonia Gneiss (SE-6)

Figure 3–156

Table 3-18. Mineral Resources in Candidate Area SE-6

Map Number (Fig. 3-156)	Name	Commodity	Status
1	Unnamed	Gold	Unknown
2	Thompson Placer	Gold	Inactive

Source: Pardee and Park, 1984: Furcron, 1969.

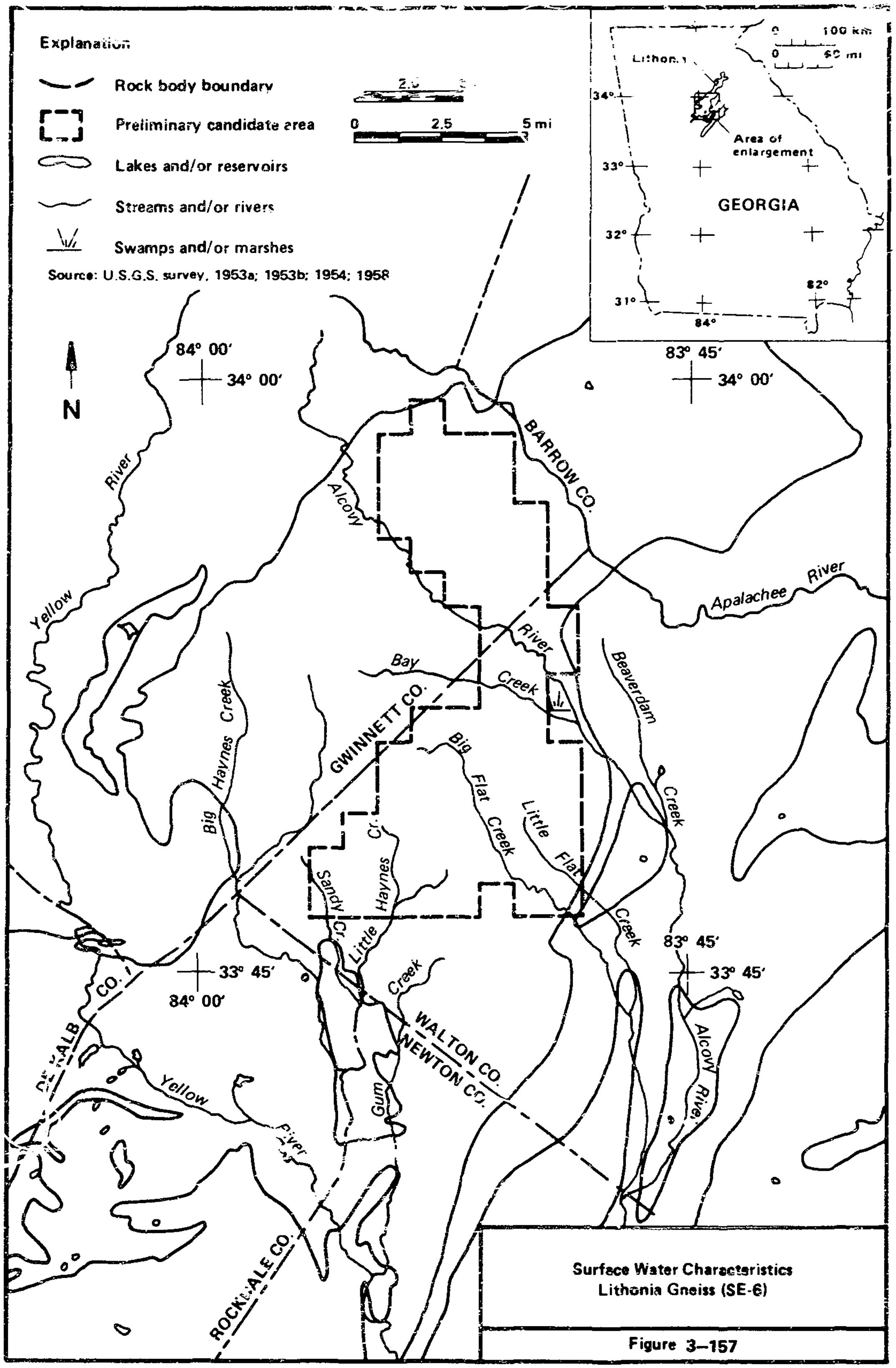
Based on the data presented in this section, there are no known strategic, metallic, or energy-related mineral resources within the preliminary candidate area. There is no evidence for mining to a depth sufficient to affect waste isolation and no information is available to indicate that deep drillholes (greater than 100 m [328 ft] in depth) are present in the preliminary candidate area.

3.2.3.7.5 Topography and Surface Water Characteristics. The preliminary candidate area is characterized by broad, flat areas of gently rolling or sloping topography, dissected by stream valleys creating areas of locally high relief. Elevations within the preliminary candidate area range from 226 to 354 m (740 to 1,160 ft) over an area of 174 km^2 (67 mi^2) (USGS, 1964a; 1964c; 1964e; 1964f). Locally, relief ranges up to 73 m (240 ft) (USGS, 1953a). The average relief is about 45 m (150 ft) and is concentrated along the stream valleys. Floodplains are typically moderately wide, with an average width of 153 m (500 ft); however, the Alcovy River has a wide floodplain (up to 397 m [1,300 ft]) in the area where Bay Creek joins it, and marshes have developed along both bodies of water in this area (USGS, 1964a).

The surface-water system within the preliminary candidate area is a characterized by a dendritic drainage pattern that is dominated by the Alcovy River and its tributaries in the northern part and by Big Haynes Creek and its tributaries in the southern part (Figure 3-157). The principal surface drainage is to the southeast. Big Haynes Creek drains into the Yellow River about 14 km (8.4 mi) south of the preliminary candidate area (USGS, 1953a). There are no large lakes or reservoirs within or near the preliminary candidate area (USGS, 1953a; 1953b; 1954; 1958). The nearest large lake or reservoir is Jackson Lake, which is about 36 km (22 mi) to the south of the preliminary candidate area. Small (about 6 ha [15 ac] or less) impoundments are present throughout the preliminary candidate area (USGS, 1964a; 1964c; 1964e; 1967f).

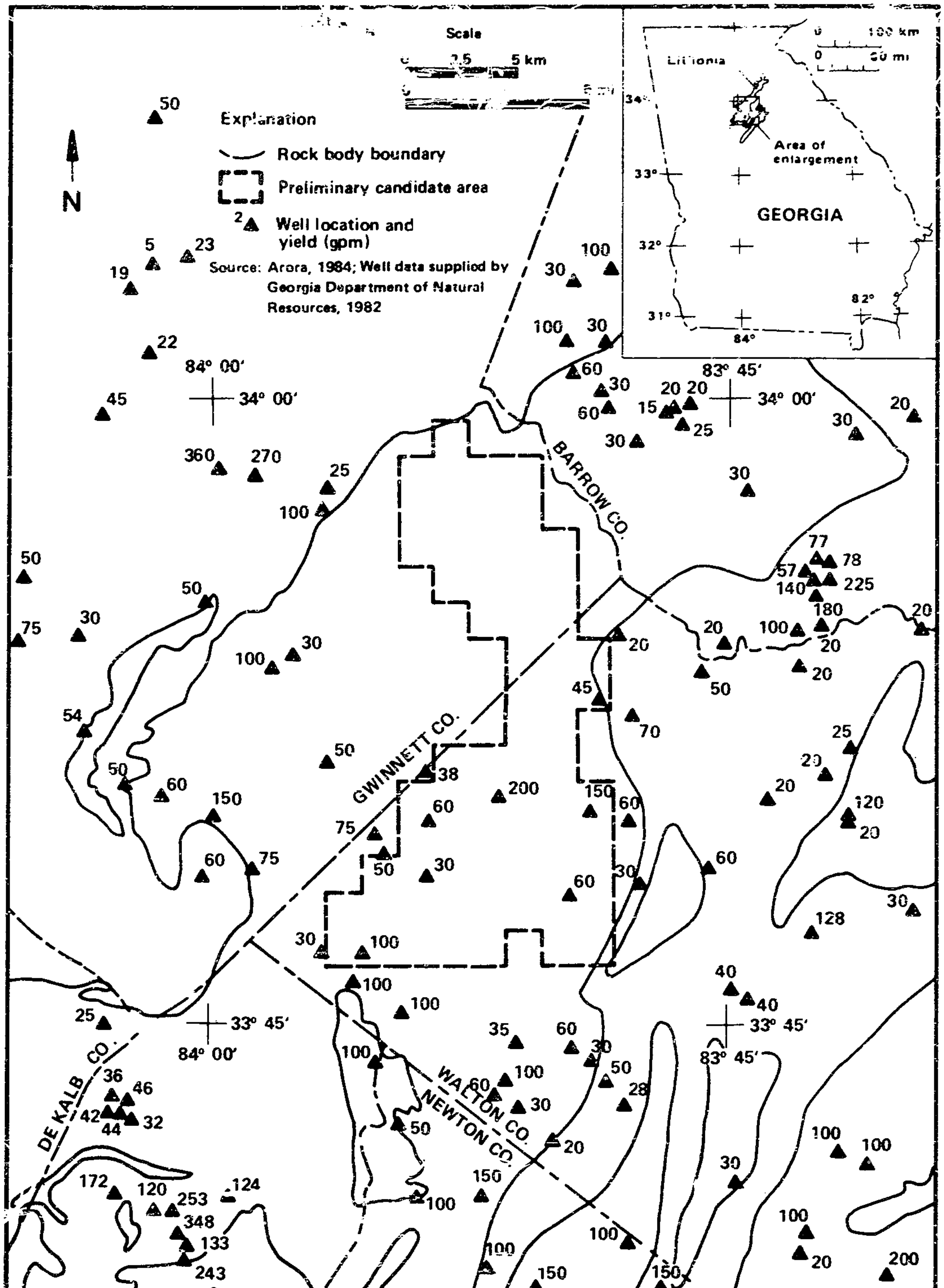
The data in this section indicate that the preliminary candidate area has locally high relief and moderately wide floodplains. The absence of wetlands along all rivers except the Alcovy River indicate that the candidiate area is predominately well drained and the flooding potential is low.

3.2.3.7.6 <u>Ground Water Resources</u>. Regional ground-water data available in the Southeastern Region are discussed in Section 3.2.3.1.1.5. Available data for the preliminary candidate area does not allow differentiation between saprolite-producing wells and crystalline bedrock wells nor are water level contour maps available for the preliminary candidate area. Well data were supplied by the Georgia Department of Natural Resources (1982) and compiled from Hydrologic Atlas 12 (Arora, 1984). Figure 3-158 presents the available well-yield data in the vicinity of the preliminary candidate area. Sixty-six wells located within the Lithonia gneiss average 5.03 L/s (79.7 gpm). Of these, five yield less than 1.58 L/s (25 gpm), 26 yield from 1.58 to 3.15 L/s (25 to 50 gpm), and 35 yield from 3.22 to 21.96 L/s (51 to 348 gpm). Only eight wells ranging in yield from 1.9 to 12.6 L/s (30 to 200 gpm) occur within preliminary candidate area. Sixty additional wells located within



Surface Water Characteristics
Lithonia Gneiss (SE-6)

Figure 3–157



Well-Yield Data
Lithonia Gneiss (SE-6)

Figure 3–158

surrounding units average 3.90 L/s (61.80 gpm). Of these, 19 yield less than 1.58 L/s (25 gpm), 20 yield from 1.58 to 3.15 L/s (25 to 50 gpm), and 20 yield from 3.22 to 22.71 L/s (51 to 360 gpm).

The well yield information indicates the presence of potable ground water within the preliminary candidate area. Specific relationships between lithology, structure and well yields are not currently available. There are no data on the deep ground water system within the preliminary candidate area.

3.2.3.7.7 Quaternary Climate. A discussion of Quaternary climatic conditions, including paleoclimatic conditions, vertical crustal movement, and changes in sea level, is in Section 3.2.3.1.1.1.

3.2.3.7.8 Federal Lands. There are no Federal lands greater than 130 ha (320 ac) in size located either in or within 10 km (6 mi) of the preliminary candidate area. Federal lands which do occur in Georgia are depicted in Plate 2B of the Southeastern RECR and Appendix A of that report (DOE 1985h). There is no evidence in the data base of any Federal lands less than 130 ha (320 ac) in size located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.7.9 State Lands. There are no State lands within the boundary of the preliminary candidate area. Fort Yargo State Park lies approximately 8 km (5 mi) east of the preliminary candidate area. The Rockdale County Natural Area is approximately 2 km (1 mi) south of the preliminary candidate area. These features are greater than 130 ha (320 ac) in size and are either depicted on Plates 3B or 4B of the Southeastern RECR (DOE, 1985h). There is no evidence in the data base of any State lands less than 130 ha (320 ac) in size located in or within 10 km (6 mi) of the preliminary candidate area.

In summary, two State areas (both of which are greater than 130 ha [320 ac] are within 10 km (6 mi) of the preliminary candidate area, and no State lands are located within the preliminary candidate area (see Figure 3-159).

3.2.3.7.10 Environmental Compliance. Part of the preliminary candidate area lies within current air quality nonattainment areas. Gwinnet County is a nonattainment area for ozone and covers approximately 30% of the preliminary candidate area (EPA, 1984). Mobile sources such as automobiles, trucks, and buses are the primary contributors to the nonattainment status for some. There is no Prevention of Significant Deterioration (PSD) Class I Area within 40 km (25 mi) of the preliminary candidate area. Two sites on the National Register of Historic Places (NRHP) are located within the preliminary candidate area boundary near the town of Between. These sites are Briscoe's Store (49 FR 4677, 1984) and James Berrier Upshaw Homeplace (50 FR 8904, 1985). No proposed NRHP exist within the preliminary candidate area. In the regional data base, there are no known existing archaeological sites or districts or any proposed for designation within the preliminary candidate area. No National Trails are within 40 km (25 mi) of the preliminary candidate area.

3.2.3.7.11 Population Density and Distribution. The preliminary candidate area contains no highly populated areas. There are nine highly populated areas within 16 km (10 mi) of the preliminary candidate area (Buford, Conyers, Lawrenceville, Lilburn, Monroe, Mountain Park, Snellville, Social Circle, and Winder) (see Figure 3-159). Monroe, with a population of 8,854, and Winder, with a population of 6,705, are located 5 km (3 mi) and 10 km (6 mi) east of the preliminary candidate area, respectively. Lawrenceville and Snellville are both located 2 km (1 mi) west of the preliminary candidate area and have populations of 8,928 and 8,514, respectively. Lilburn and Mountain Park, with populations of 3,765 and 9,425, respectively, are both located 14 km (9 mi) west of the preliminary candidate area. Buford, with a population of 6,697, is located 10 km (6 mi) northwest of the preliminary candidate

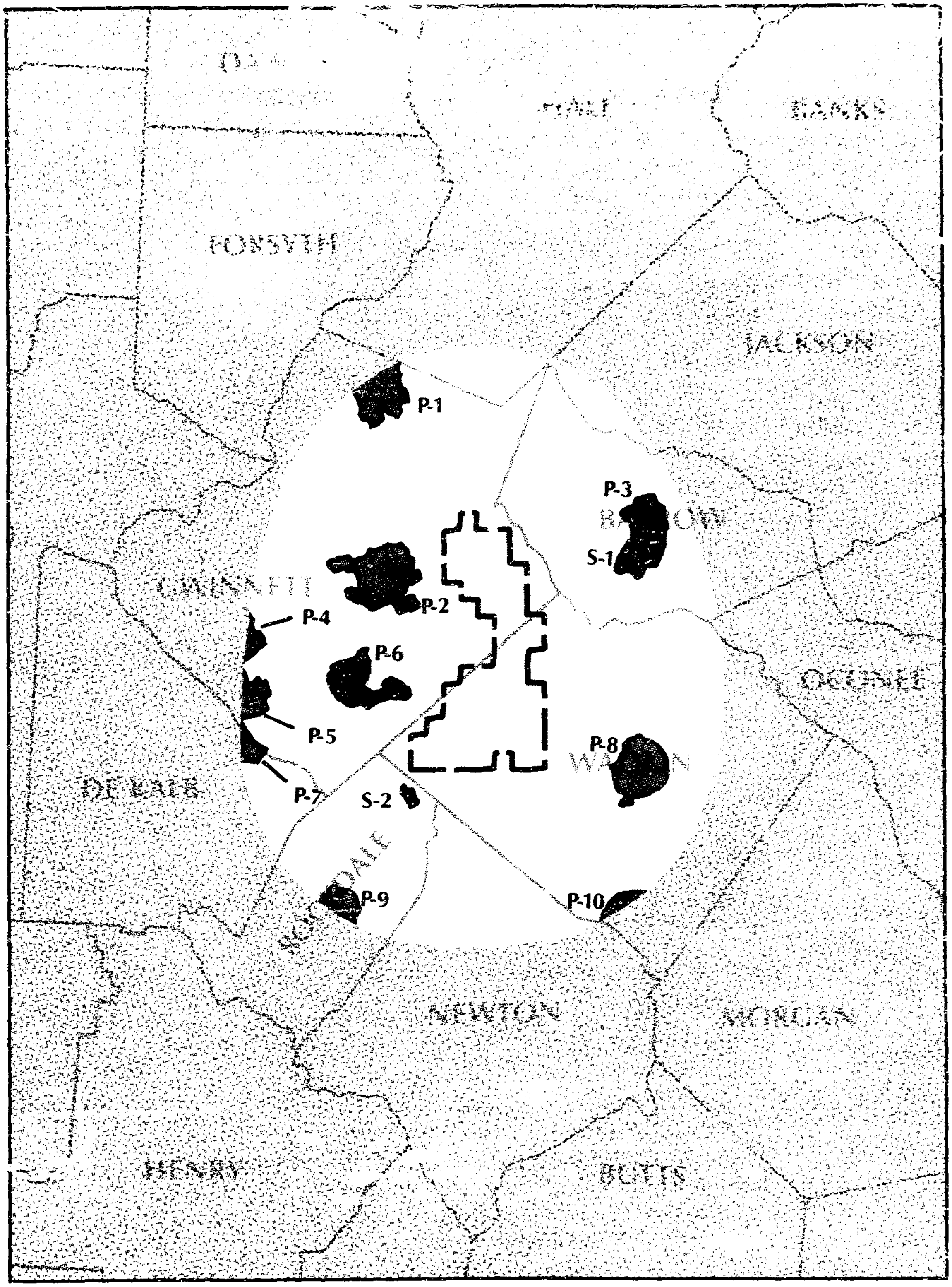


Figure 3—159 Sheet 1

Environmental Features
Lithonia Gneiss (SE-6)

Environmental Features Legend

Preliminary Candidate Area

Environmental Features

P Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile

F Federal Lands Greater Than 320 Acres

S State Lands Greater Than 320 Acres

I Federal Indian Reservations

● Federal or State Lands Less Than 320 Acres

F-5 Map Alpha-numeric Codes are Keyed to Environmental Features

Rock Bodies

Beyond Ten Miles from Preliminary Candidate Area

State Boundary

County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–159 Sheet 2

ENVIRONMENTAL FEATURES WITHIN 16 KM (10 MI)
OF PRELIMINARY CANDIDATE AREA SR-6*

Code	Feature
Population Features	
P-1	Buford Highly Populated Area (HPA)
P-2	Lawrenceville HPA
P-3	Winder HPA
P-4	Lilburn HPA
P-5	Mountain Park HPA
P-6	Snellville HPA
P-7	Stone Mountain Minor Civil Division
P-8	Monroe HPA
P-9	Conyers HPA
P-10	Social Circle HPA
Federal Lands	
None	
State Lands	
S-1	Fort Yargo State Park
S-2	Rockdale County Natural Area
Indian Reservations	
None	

* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 159, Sheet 3

area; Conyers is located 13 km (8 mi) southwest of the preliminary candidate area and has a population of 6,567. Social Circle, which is located 14 km (9 mi) southeast of the preliminary candidate area, has a population of 2,591. The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square mile. There is one area of population density greater than or equal to 1,000 persons per square mile within 16 km (10 mi) of the preliminary candidate area (see Figure 3-159). Stone Mountain (which is on the eastern fringe of the greater Atlanta Metropolitan Area) has a population of 22,611 and is located 14 km (9 mi) west of the preliminary candidate area. The average population density of the preliminary candidate area is approximately 108 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate area is approximately 261 persons per square mile. Low population density is defined as a density in the general region of the site less than the average population density for the conterminous United States (76 persons per square mile) based on the 1980 census.

3.2.3.7.12 Site Ownership. There are no Federal or DOE-owned lands located within the preliminary candidate area. The Cherokee Indian Reservation is located approximately 120 km (75 mi) north of the preliminary candidate area (see Plate SE-1B).

3.2.3.7.13 Offsite Installations. No commercial nuclear reactors are located within the preliminary candidate area. The nearest operating commercial nuclear reactors is Oconee Station which is approximately 113 km (70 mi) to the northeast (Wamsley, 1985; Electrical World Directory of Electric Utilities, n.d.). The nearest commercial nuclear reactor under construction is the Alvin W. Vogtle Electric Generating Plant which is approximately 194 km (120 mi) to the southeast (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 40 CFR 191, Subpart A, within or in proximity to the preliminary candidate area.

3.2.3.7.14 <u>Transpo[illegible]</u> [illegible]85, which is located 9.6 km (6 mi) north of the area, i[illegible] the [illegible]est Interstate highway. I20 is 17.6 km (11 mi) south of the area. U.S. 78 passe[illegible] through the central portion of the preliminary candidate area. U.S. 29 is located within 1.6 km (1 mi) of the northern edge. Only one State highway is shown on the map. This is State Route 138 which runs between Monroe, Georgia (near the eastern side of the area) and I20. State Routes 20 and 81, which are not shown on the map, also traverse the area.

Two mainline railroads are near this area and both are part of the Seaboard System. The main route between Atlanta and Richmond, Virginia, is located within 3.2 km (2 mi) of the northern edge of the preliminary candidate area. Another mainline between Atlanta and Augusta is 14.4 km (9 mi) southwest of the preliminary candidate area. The only branchline near this area is the line connecting Monroe, Georgia, with the Atlanta-Augusta mainline. This line terminates about 8 km (5 mi) east of the preliminary candidate area.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.7.15 <u>Preliminary Candidate Area Deferral Analysis</u>. This section identifies significant additional information (specified in Section 3.2) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-6 that could affect DOE's decision to defer further considerations of the area.

Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuratio[illegible] and location of the underground facility [illegible] [illegible]ation [960.4-2-3(b)(1); 960.5-2-9(b)(1); [illegible]0.5-2-9[illegible]]

- presence of host rock that permits emplacement of waste at least 300 m (1,000 ft) below ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow system should not be significantly affected [960.4-2-7(c)(6)]
- absence of active faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]
- no indications, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could produce ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]
- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect waste containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring mate[illegible]al that is not widely available from other sources [960.4-2-8-1(c)(4)]

- presence of [illegible] flat terrain [960.5-2-8(b)(1)]
- presence of generally well-drained terrain [960.5-2-8(b)(2)]
- general absence of surface characteristics or surface-water systems that could lead to flooding [960.5-2-8(c), 960.5-2-10(b)(2)]
- located within a geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]
- absence of Federal lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(3)]
- absence of State lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(4)]
- absence of nuclear installations [960.5-2-4(b) and (c)(2)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfer of title, or Federal condemnation proceedings [960.4-2-8-2(c), 960.5-2-2(c)]
- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2), 960.5-2-7(b)(3)].

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]
- presence of shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2-8-1(c)(1)(i)]

- the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile [960.5-2-1(b)(2) and (c)(2)].

The results indicate that there are no significant adverse features identified to date that would preclude DOE from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-6 at this time.

3.2.3.8 Preliminary Candidate Area Description - Woodland Gneiss Complex (SE-7)

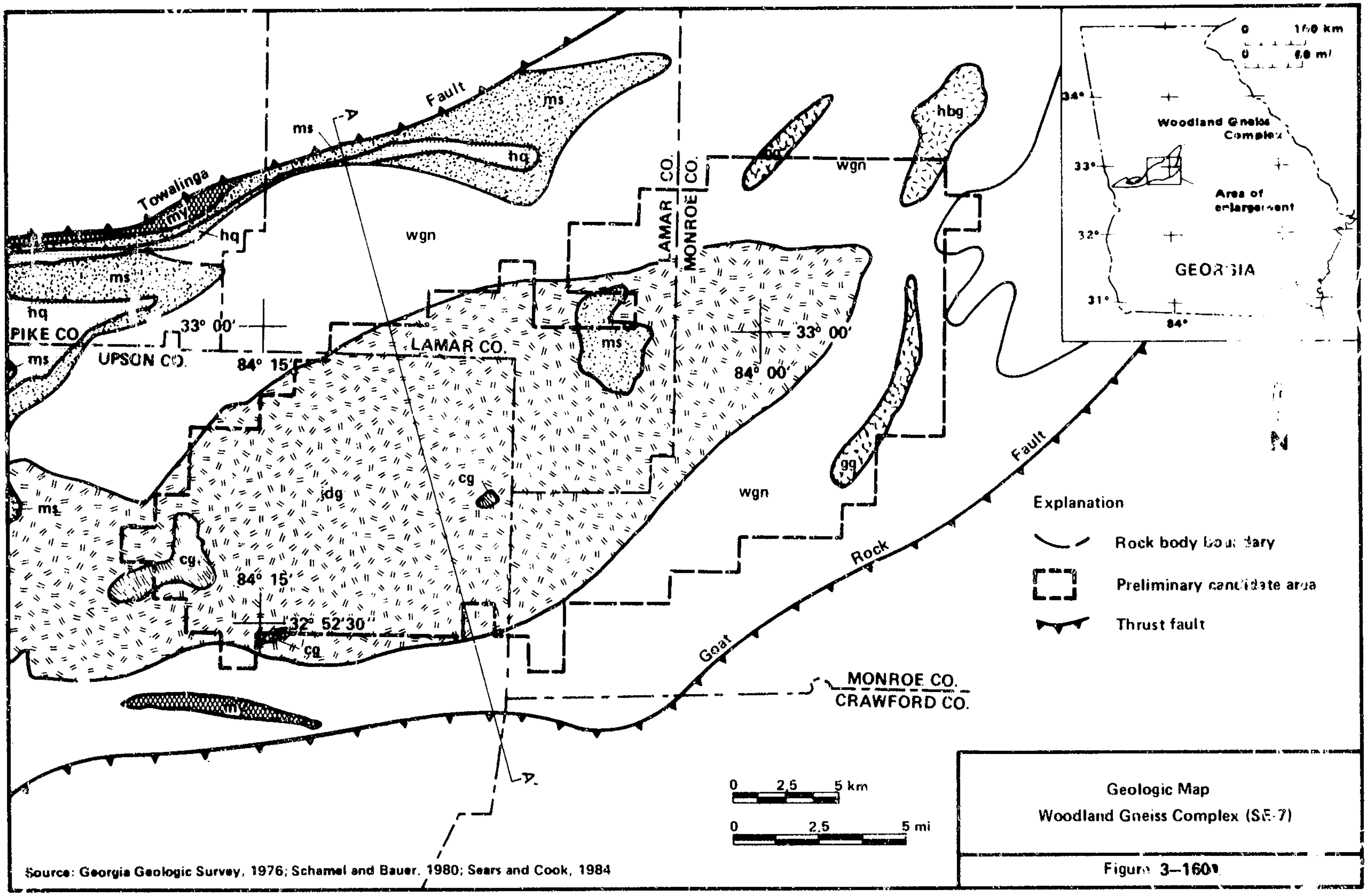
Preliminary candidate area SE-7 is located within the Piedmont physiographic province of southwestern Georgia in Upson, Monroe, and Lamar Counties, at approximately 33° N latitude, 84° W longitude (see Figure 3-160a).

3.2.3.8.1 Host Rock Geometry and Overburden Thickness. The preliminary candidate area overlies the Woodland gneiss and has an area of 556 km^2 (214 mi^2) with a mapped length of 43 km (26.7 mi) and a width of 18 km (11.2 mi) (Figure 3-160a).

The lithologic units that make up the Woodland gneiss are all part of a Grenville-age basement complex that is exposed within an erosional window bounded by the Towaliga and Goat Rock faults (Figure 3-160a) (Georgia Geologic Survey, 1976; Schamel and Bauer, 1980; Sears and Cook, 1984). Interpretations regarding the structural configuration of rocks within this erosional exposure vary, but cross sections show gneissic rocks extending at least 5 km (3.1 mi) beneath the surface (Figure 3-160b) (Schmael and Bauer, 1980; Sears and Cook, 1984).

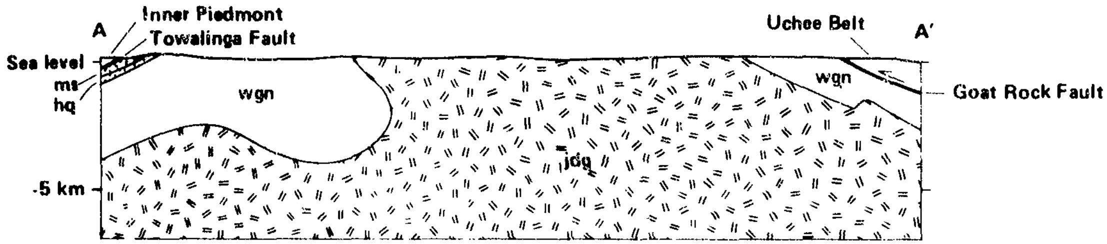
Water well casing depth data, from which overburden thickness is estimated, are presently unavailable for the preliminary candidate area. The location and distribution of areas of direct rock exposure are presently unknown; however, mappable exposures are expected to be fairly extensive (e.g., Higgins & Atkins, 1981).

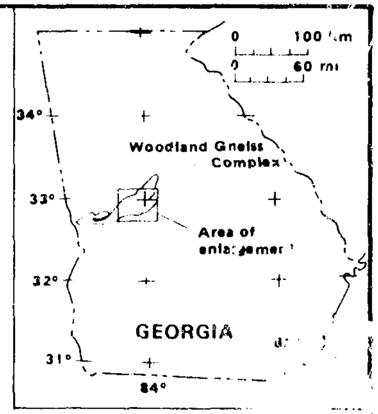
On the basis of the data presented above and the assumed depth and size of a repository in crystalline rock (see Section 1.5), the host rock underlying the preliminary candidate area is assumed to be sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation.



Geologic Map
Woodland Gneiss Complex (SE-7)

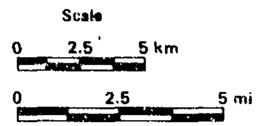
Figure 3–160





Explanation

- Lithologic contacts
- Fault
- wgn — Woodland Gneiss
- jdg — Jeff Davis Granite
- cg — Cunningham Granite
- hbg — Hornblende gneiss
- gg — Granitic gneiss
- ms — Manchester Schist, Sparks Schist
- hq — Hollis Quartzite
- my — Mylonite and ultramylonite



Source: Extrapolated from Schamel and Bauer (1980)

Geologic Cross Section
Woodland Gneiss Complex (SE-7)

Figure 3-160b

3.2.3.8.2 Lithology and Tectonics. The rocks underlying the preliminary candidate area include the Woodland gneiss, Jeff Davis granite, Cunningham granite, undifferentiated Manchester and Sparks schists, undifferentiated granitic gneiss, and hornblende gneiss (Figure 3-160a).

The Woodland gneiss consists predominantly of biotite-garnet orthogneiss and feldspathic and migmatitic augen gneiss with zones of intense shearing (Schamel et al., 1980; Sears and Cook, 1984). The rocks have a fine- to medium-grained ground mass with augen up to 6 mm (0.234 in) long (Sears and Cook, 1984). The foliation varies from absent to blastomylonitic (Schamel and Bauer, 1980).

The Jeff Davis granite constitutes approximately 75% of the preliminary candidate area and consists of fine-grained leucocratic charnockite that displays moderate to strong foliation (Clarke, 1952; Sears and Cook, 1984). Mafic xenoliths are commonly flattened (Sears and Cook, 1984). Locally, the charnockite has been strained to a porphyroclastic gneiss with mafic schlieren (Sears and Cook, 1984). Contacts with the Woodland gneiss are generally concordant and locally discordant (Clarke, 1952).

The Cunningham granite consists of charnockite that contains mafic xenoliths (Sears and Cook, 1984). It varies from fine to medium grained and from massive to weakly foliated (Sears and Cook, 1984).

Although not recognized during detailed field mapping (Schamel et al., 1980; Schamel and Bauer, 1980; Sears and Cook, 1984; Stieve, 1984), the Geologic Map of Georgia (Georgia Geologic Survey, 1976) indicates that a small section (less than 10 km^2 [4 mi^2]) of the preliminary candidate area is overlain by an undifferentiated metasedimentary cover sequence consisting of the Sparks schist and Manchester schist.

The Sparks schist rests nonconformably on the Woodland gneiss and consists of interbedded feldspar augen schist, layered paragneiss, aluminous schist, and quartzite (Schamel and Bauer, 1980). The Hollis quartzite occurs between the Sparks [illegible] schists and ranges from 10 to 250 m (32.8 to 820 ft) (Schamel and Bauer, 1980). [illegible] schist consists of thick, aluminous, garnet-(kyanite)-biotite-muscovite schist that is, in part, graphitic and commonly contains thin quartzite beds (Schamel and Bauer, 1980).

The remaining rocks in the area include granitic gneiss and hornblende gneiss (Georgia Geologic Survey, 1976) that have not been studied or mapped in detail.

The Woodland gneiss complex is a Grenville-age (about 1,100 million years old) basement complex that is overlain by metasediments of varying compositional maturity (Schamel et al., 1980). The Woodland gneiss complex may be a remobilized section of continental crust that was partially rifted from the early Paleozoic continental margin (Schamel and Bauer, 1980). During this event, the complex was metamorphosed to granulite-grade. During the major Paleozoic metamorphic events, the basement-cover sequence was transported, overridden, complexly folded, and arched into a series of large antiformal and nappe structures that are overturned to the northwest (Schamel and Bauer, 1980). The complex has been metamorphosed to the middle to upper amphibolite facies. The Jeff Davis granite is exposed in the core of one of the nappes (Sears and Cook, 1984) and, therefore, may be the oldest unit in the Woodland gneiss complex. All of the rocks have experienced late Paleozoic brittle deformation.

Two major faults occur within 10 km (6 mi) of the preliminary candidate area (Figure 3-160a). These include the Towaliga fault to the northwest and the Goat Rock fault to the southeast. The Towaliga fault is a postmetamorphic fault that displaces the base of the Piedmont allochthon. The Towaliga fault appears as a zone of silicified breccia. Locally, the Towaliga fault is cut by a diabase dike, indicating that the last movement along the fault occurred prior to the Triassic (Schamel et al., 1980).

The Goat Rock fault bounds the southeastern margin of the Woodland gneiss complex and is marked by zones of mylonite that may be up to 1 km (0.62 mi) thick. The Goat Rock fault probably last moved during the late Paleozoic (Schamel et al., 1980).

Estimates of regional uplift and subsidence are not site specific and are discussed in detail within Section 3.2.3 1.1.2.

Estimates of regional uplift and subsidence are discussed in detail in Section 3.2.3.1.1.3. Regional data indicate recent uplift has occurred but there is a wide range of interpretation on the magnitudes of uplift. No data are available for the preliminary candidate area, therefore, until data are obtained, no conclusion can be drawn concerning effects of uplift. There are no in situ stress data available for the vicinity of the preliminary candidate area.

There is no evidence of Quaternary igneous activity, folding, faulting or subsidence within the geologic setting. Regional uplift data suggest the possibility of active tectonic process, however, there appears to be no significant potential for tectonic deformations that could effect the regional ground-water flow system.

3.2.3.8.3 <u>Seismicity</u>. The preliminary candidate area is located within a relatively aseismic region (see Figures 3-118 and 3-119 in Section 3.2.3.1.1.3). No earthquakes have been reported within 30 km (18.6 mi) of the preliminary candidate area. The largest historical earthquake in this region is an MM VI which occurred on March 5, 1914, approximately 60 km (38 mi) northeast of the preliminary candidate area near Athens, Georgia.

The major faults near the preliminary candidate area are discussed in Section 3.2.3.8.2. There is no evidence of correlation between major faults and observed seismicity near the preliminary candidate area.

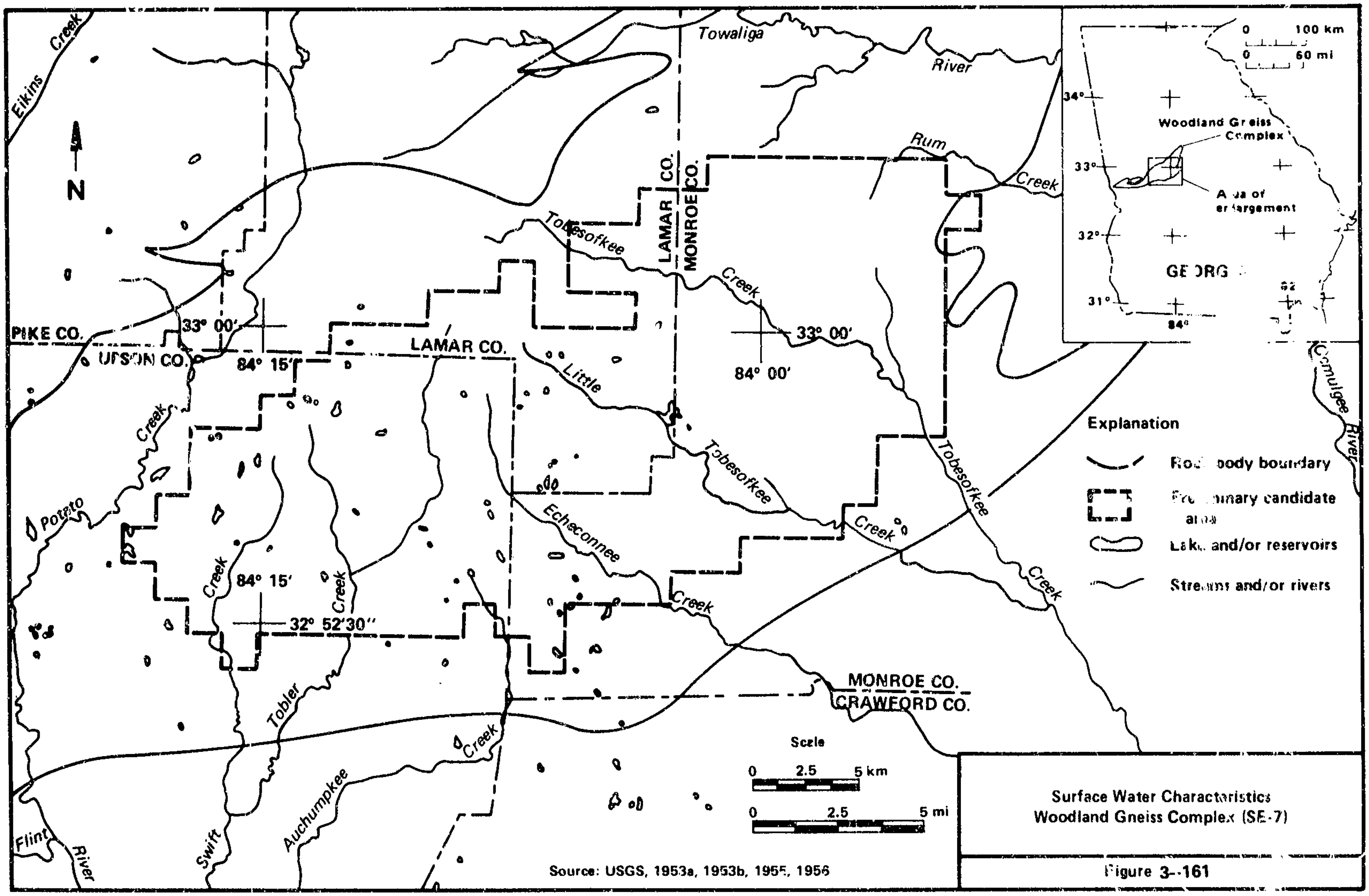
Considering the low level and magnitude of seismic activity in the region and the absence of active tectonic processes within the geologic setting during the Quaternary Period, it is unlikely that future seismic activity would produce ground motion in excess of reasonable design limits or could affect waste containment or isolation, and it is unlikely that the frequency of occurrence of earthquakes in the area will increase in the future.

3.2.3.8.4 Mineral Resources. There are no known strategic, metallic, or energy-related resources within the preliminary candidate area or within 10 km (6 mi) of the preliminary candidate area. There is no information available to indicate that deep drillholes (greater than 100 m [328 ft] in depth) are present in the preliminary candidate area.

3.2.3.8.5 Topography and Surface-Water Characteristics. The preliminary candidate area is characterized by broad, convex, gently sloping uplands that are moderately to highly dissected. Elevations within the preliminary candidate area range from 128 to 266 m (420 to 871 ft). Local relief averages 34 m (112 ft) along stream corridors, with a maximum relief of 91.5 m (300 ft) (USGS, 1971a; 1971c; 1973a; 1973b; 1973c; 1973e; 1974a through 1974d). Floodplains range in width from 31 m (100 ft) to 336 m (1,000 ft), averaging about 122 m (400 ft) wide.

The surface-water system within the preliminary candidate area is characterized by a dendritic drainage pattern that consists of several creeks, including Tobesofkee Creek, Wolf Greek, Swift Creek, and Tobler Creek, and their tributaries (Figure 3-161). Streams in the northeast section drain southeast into the Ocmulgee River, approximately 40 km (24 mi) southeast of the preliminary candidate area (USGS, 1953a; 1956). Streams in the southwest and central portions drain south-southwest into the Flint River, approximately 14 km (8.3 mi) south of the candidate area (USGS, 1955). There are no large lakes or reservoirs within or adjacent (within 10 km [6 mi]) to the preliminary candidate area, although numerous small (less than 4 ha [10 ac]) impoundments occur on upland surfaces throughout the preliminary candidate area.

The presence of relatively low relief, narrow to moderately wide floodplains, and occasional swamps and marshes indicates that the preliminary candidate area is generally moderately well drained but is locally poorly drained. Therefore, there is only localized flooding potential in less than 1% of the preliminary candidate area.



Surface Water Characteristics
Woodland Gneiss Complex (SE-7)

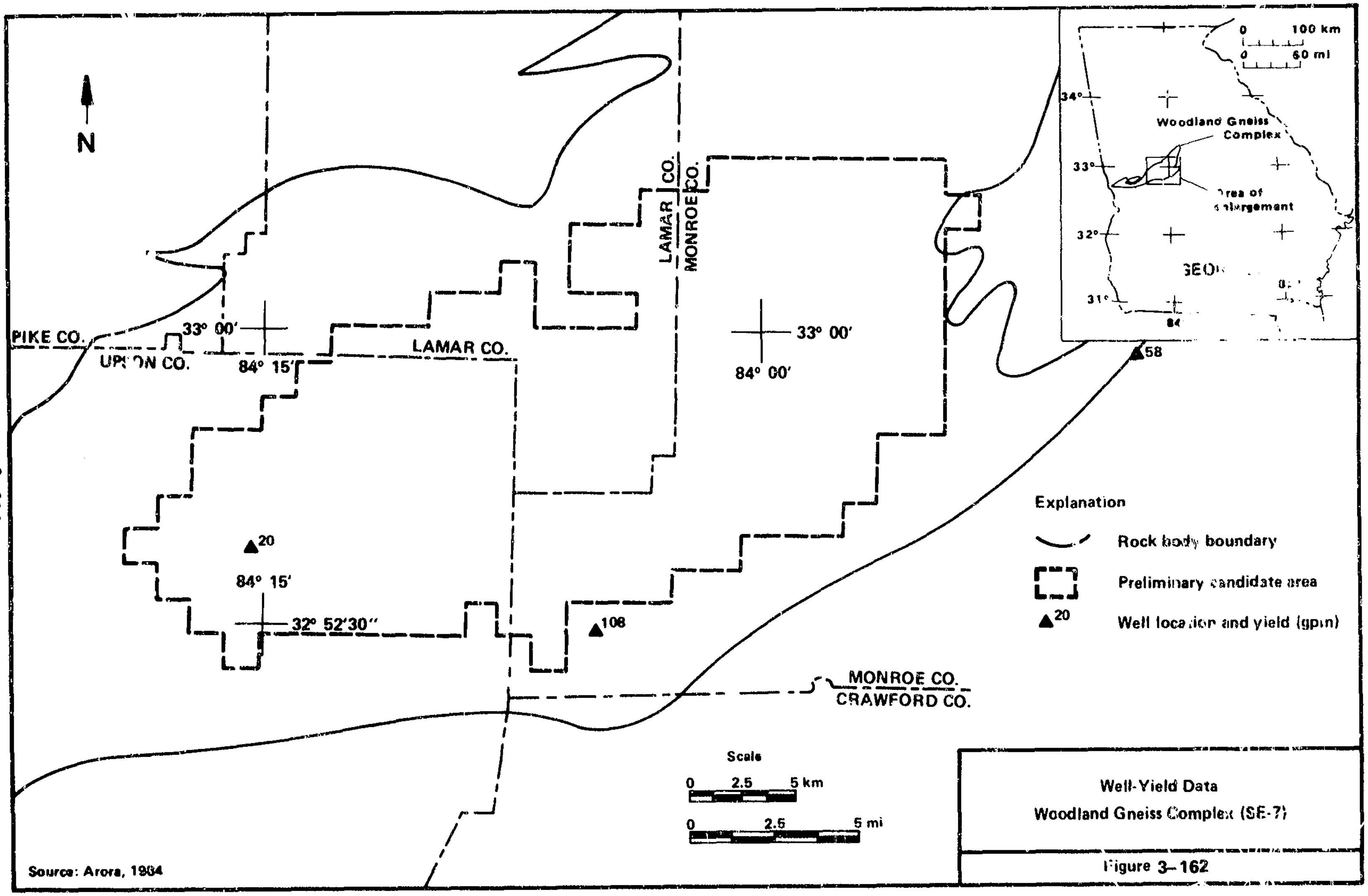
Figure 3-161

3.2.3.8.6 Ground Water Resources. Regional ground-water data in the Southeastern Region are discussed in Section 3.2.3.1.1.5. Available data in the preliminary candidate area do not allow differentiation between saprolite-producing wells and crystalline bedrock wells nor are water-level contour maps available for the preliminary candidate area. Well data were obtained from Arora (1984). Water well data in the vicinity of the preliminary candidate area are expressed in terms of well yields. Figure 3-162 presents the available well-yield data in the vicinity of the preliminary candidate area. Two wells located within the Woodland gneiss average 4.04 L/s (64 gpm). One occurs within the preliminary candidate area and yields 1.26 L/s (20 gpm), the other is located south of the preliminary candidate area and yields 6.8 L/s (108 gpm). One additional well located in surrounding units yields 3.66 L/s (58 gpm).

Wells in the vicinity of the preliminary candidate area yield potable water. Data are insufficient to draw conclusions on any relationships between structure, lithology and well yields. No data are available on the deep ground water flow system in the preliminary candidate area.

3.2.3.8.7 Quaternary Climate. A discussion of Quaternary climatic conditions including palepclimatic conditions, vertical crustal movement, and changes in sea level is in Section 3.2.3.1.1.1.

3.2.3.8.8 Federal Lands. There are no Federal lands within the preliminary candidate area. The Piedmont National Wildlife Refuge is 10 km (6 mi) east, and the Oconee National Forest is 10 km (6 mi) northeast of the preliminary candidate area, respectively. These features are greater than 130 ha (320 ac) in size and are depicted in Plate 2B of the Southeastern RECR (DOE, 1985h) (see also Figure 3-163). There is no evidence in the data base that Federal lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.



Well-Yield Data
Woodland Gneiss Complex (SE-7)

Figure 3–162

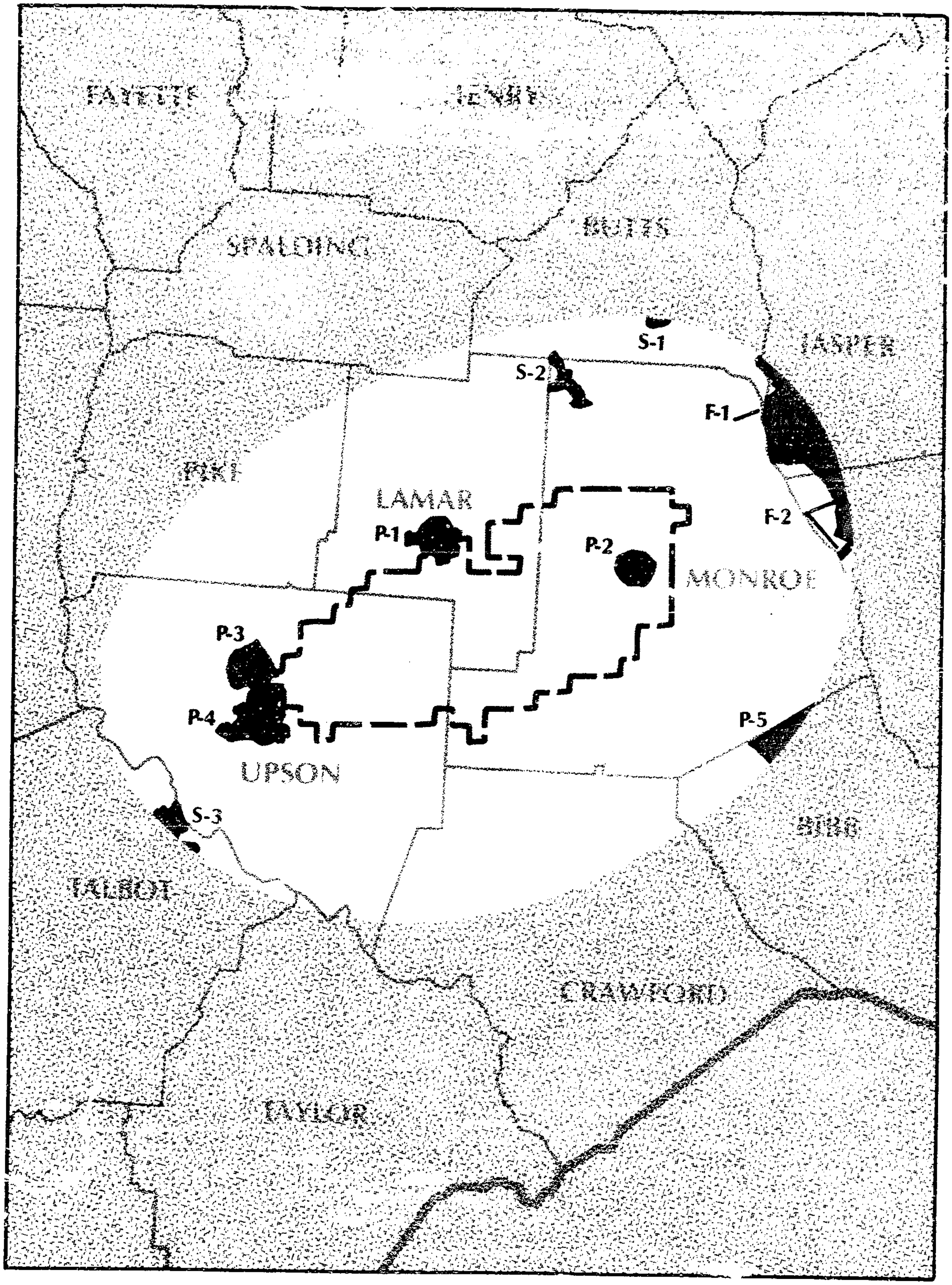


Figure 3—163 Sheet 1 **Environmental Features Woodland Gneiss Complex (SE-7)**

Environmental Features Legend

Preliminary Candidate Area

Environmental Features

- **P** Highly Populated Areas and Areas with Density Greater Than 1000 Persons per Square Mile
- **F** Federal Lands Greater Than 320 Acres
- **S** State Lands Greater Than 320 Acres
- **I** Federal Indian Reservations
- **●** Federal or State Lands Less Than 320 Acres
- **F-5** Map Alpha-numeric Codes are Keyed to Environmental Features

Rock Bodies

Beyond Ten Miles from Preliminary Candidate Area

State Boundary

County Lines

Scale 1:500,000

0 miles 20

0 kilometers 20

Figure 3–163 Sheet 2

**ENVIRONMENTAL FEATURES WITHIN 16 KM (10 MI)
OF PRELIMINARY CANDIDATE AREA SE-7***

Code	Feature
Population Features	
P-1	Barnesville Highly Populated Area (HPA)
P-2	Forsyth HPA
P-3	Hannahs Mill HPA
P-4	Thomaston HPA
P-5	Macon Minor Civil Division
Federal Lands	
F-1	Oconee National Forest
F-2	Piedmont National Wildlife Refuge
State Lands	
S-1	Indian Springs State Park (SP)
S-2	High Falls SP
S-3	Big Lazer Creek Wildlife Management Area
Indian Reservations	
None	

* The accompanying text identifies only those environmental features within 10 km (6 mi) of the preliminary candidate area.

Figure 3-163, Sheet 3

3.2.3.8.9 State Lands. here are [illegible] lands greater than 130 ha or 320 ac in size within the boundary of the preliminary candidate area. High Falls State Park lies approximately 8 km (5 mi) north of the preliminary candidate area. This feature is greater than 130 ha (320 ac) in size and is depicted on Plate 3B of the Southeastern RECR (DOE, 1985h) (see also Figure 3-163). There is no evidence in the data base that State lands less than 130 ha (320 ac) in size are located in or within 10 km (6 mi) of the preliminary candidate area.

3.2.3.8.10 Environmental Compliance. No portion of the preliminary candidate area lies within a current air quality nonattainment area. There are no Prevention of Significant Deterioration (PSD) Class I Areas within 40 km (25 mi) of the preliminary candidate area. Six sites on the National Register of Historic Places (NRHP) are located within the preliminary candidate area boundary near Forsyth. These sites are Hil' Ardin (45 FR 17452, 1980), Front Circle (Tift College), Monroe County Courthouse (46 FR 10629, 1981), Berner House, Old Main Post Office (47 FR 4961, 1982), and Forsyth Commercial Historic District (49 FR 4617, 1984). No proposed NRHP sites exist within the preliminary candidate area. In the regional data base, there are no known existing archaeological sites or districts or any proposed for designation within the preliminary candidate area. No National Trails are within 40 km (25 mi) of the preliminary candidate area.

3.2.3.8.11 Population Density and Distribution. The preliminary candidate area contains parts or all of four highly populated areas (Forsyth, Barnesville, Hannahs Mill, and Thomaston) (see Figure 3-163). Barnesville has a population of 4,887, while Forsyth's population is 4,624. The population of Hannahs Mill and Thomaston are 2,616 and 9,682, respectively. There are no other highly populated areas within 16 km (10 mi) of the preliminary candidate area. The preliminary candidate area contains no areas with population densities greater than or equal to 1,000 persons per square mile. There is one area [illegible] density greater than or equal to 1,000 persons per square mile within [illegible] km (1[illegible]) of the preliminary candidate area (see Figure 3-163). Macon is located 13 km (8 mi) southeast of the preliminary candidate area and has a population of 126,381. The average population density of the preliminary candidate area is 53 persons per square mile. The average population density within 80 km (50 mi) of the preliminary candidate area is approximately 140 persons per square mile. Low population density is defined as a density in the general region of the site less than the average population density for the conterminous United States (76 persons per square mile) based on the 1980 census.

3.2.3.8.12 <u>Site Ownership</u>. There are no Federal or DOE-owned lands located within the preliminary candidate area. The Cherokee Indian Reservation is 216 km (135 mi) north of the preliminary candidate area (See Plate SE-1B).

3.2.3.8.13 <u>Offsite Installations</u>. No commercial nuclear reactors are located within the preliminary candidate area. The nearest operating commercial nuclear reactor is Edwin I. Hatch Nuclear Plant, Units 1 and 2, which is located approximately 192 km (120 mi) to the southeast (Wamsley, 1985). The nearest commercial nuclear reactor under construction is Alvin W. Vogtle Electric Generating Plant which is approximately 192 km (120 mi) to the east (Wamsley, 1985). There are no other known nuclear installations or operations that must be considered under the requirements of 40 CFR 191, Subpart A, within or in proximity to the preliminary candidate area.

3.2.3.8.14 <u>Transportation</u>. I75 crosses the eastern portion of the preliminary candidate area. Two U.S. highways (U.S. 41 and 341) cross portions of the preliminary candidate area. U.S. 341 runs north and south through the center of the preliminary candidate area and U.S. 41 runs east and west in the northeast part of the preliminary candidate area. U.S. 19 is within 3.2 km (2 mi) of the western edge of the preliminary candidate area. While no State highways are shown on the plot, several highways do cross over the preliminary candidate area (State Routes 36, 74, and 83).

However, none of these highways are principal through highways. The nearest mainline is the Southern line between Atlanta and Jacksonville, Florida, which is located 10 km (6 mi) east of the preliminary candidate area. The Seaboard mainline between Atlanta and Jacksonville, Florida is located about 24 km (15 mi) west of the preliminary candidate area. Two branchlines of the Southern cross this preliminary candidate area. One of these lines runs between Macon, Georgia, which is about 32 km (20 mi) southeast of the preliminary candidate area, and Barnesville, Georgia, which is on the northern edge of the preliminary candidate area. This line roughly parallels U.S. 41. The other branchline runs through the western portion of the preliminary candidate area between Barnesville and Thomaston, Georgia.

Based on the data presented above, access to the preliminary candidate area from both local and regional highway and railway systems appears to be available.

3.2.3.8.15 Preliminary Candidate Area Deferral Analysis. This section identifies significant additional information (specified in Section 3.2) not directly incorporated into Steps 1 through 3 on preliminary candidate area SE-7 that could affect DOE's decision to defer further consideration of the area. Based on evaluation of this additional available information, the area exhibits the following favorable characteristics:

- presence of host rock with sufficient thickness and lateral extent to allow significant flexibility in selecting the depth, configuration, and location of the underground facility to ensure isolation [960.4-2-3(b)(1), 960.5-2-9(b)(1), 960.5-2-9(c)(1)]
- presence of host rock that permits emplacement of waste at least 300 m (1,000 ft) below ground surface [960.4-2-5(b)(1)]
- low potential for tectonic deformations suggests that the regional ground-water flow system should not be significantly effected [960.4-2-7(c)(6)]

- absence of active faulting within the geologic setting [960.5-2-11(c)(1)]
- absence of historical earthquakes of a magnitude and intensity that, if they recurred, could affect waste containment or isolation [960.4-2-7(c)(2)]
- no indications, based on correlations of earthquakes with tectonic processes and features, that the frequency of earthquake occurrence within the geologic setting may increase [960.4-2-7(c)(3)]
- the frequency of occurrence or magnitude of earthquakes within the geologic setting are no higher than within the region [960.4-2-7(c)(4)]
- absence of historical earthquakes that, if they recurred, could produce ground motion in excess of reasonable design limits [960.5-2-11(c)(2)]
- absence of evidence, based on correlations of earthquakes with tectonic processes and features within the geologic setting, that the magnitude of earthquakes during repository construction, operation, and closure may be larger than predicted from historical seismicity [960.5-2-11(c)(3)]
- no evidence of subsurface mining or extraction for resources that could affect waste containment or isolation [960.4-2-8-1(c)(2)]
- no evidence of drilling to a depth sufficient to affect waste containment or isolation [960.4-2-8-1(c)(3)]
- no evidence of significant concentrations of any naturally occurring material that is not widely available from other sources [960.4-2-8-1(c)(4)]
- presence of generally flat terrain [960.5-2-8(b)(1)]
- presence of generally well-drained terrain [960.5-2-8(b)(2)]
- general absence of surface characteristics or surface-water systems that could lead to flooding [960.5-2-8(c), 960.5-2-10(b)(2),

- located within a geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period [960.4-2-4(b)(2)]
- absence of Federal lands less than 130 ha (320 ac) within and in proximity to the preliminary candidate area [960.5-2-5(c)(3)]
- absence of State lands less than 130 ha (320 ac) within and in proximity to (i.e., within 10 km [6 mi] of) the preliminary candidate area [960.5-2-5(c)(4)]
- low population density within its boundaries [960.5-2-1(b)(1)]
- absence of nuclear installations [960.5-2-4(b) and (c)(2)]
- no projected land ownership conflicts that cannot be successfully resolved through voluntary purchase-sell agreements, nondisputed agency-to-agency transfer of title, or Federal condemnation proceedings [960.4-2-8-2(c), 960.5-2-2(c)]
- available access to the national transportation system through regional highways and railroads and through local highways and railroads [960.5-2-7(b)(2), 960.5-2-7(b)(3)].

The preliminary candidate area also exhibits the following characteristics which could detract from repository siting and performance in the absence of further evaluation:

- evidence of active tectonic uplift [960.4-2-7(c)(1)]
- presence of shallow ground-water resources that could be economically extractable in the foreseeable future [960.4-2-8-1(c)(1)(i)]
- the preliminary candidate area is within 16 km (10 mi) of highly populated areas or areas containing more than 1,000 persons per square mile [960.5-2-1(c)(2)].

The results indi[illegible] there are no significant adverse features identified to date that would preclude us from conducting further study of this area as a candidate for repository siting. In addition, many favorable characteristics have been identified in the area. Therefore, on balance, there is no basis for deferral of preliminary candidate area SE-7 at this time.

3.3 OTHER SITING [illegible]

This section documents the consideration which was given to the Implementation Guidelines of Subpart B of the DOE siting guidelines in identifying the candidate areas which warrant further examination in the area phase of the CRP screening process.

The implementation guidelines considered were:

- Diversity of Geohydrologic Settings (10 CFR 960.3-1-1)
- Diversity of Rock Types (10 CFR 960.3-1-2)
- Regionality (10 CFR 960.3-1-3).

Implementation of Steps 1 through 3 of the region-to-area screening process and exclusion of preliminary candidate area NE-N5 because of its close proximity to Canada have provided 20 preliminary candidate areas. Distribution of these preliminary candidate areas is as follows: 10 in the North Central Region, 3 in the Northeastern Region, and 7 in the Southeastern Region.

In USGS Water Supply Paper No. 2242, Ground-Water Regions of the United States, all the preliminary candidate areas of the North Central and Northeastern Regions were indicated to be part of a single "Geohydrologic Region": Northeast and Superior Uplands. Based on the distinct differences of topography, bedrock geology, and surficial glacial deposits between the Northern Appalachians of New England and the Precambrian Shield of Wisconsin and Minnesota, the DOE has determined for the CRP to divide the Northeast and Superior Uplands geohydrologic region into two geohydrologic settings: (1) Northeast Uplands; and (2) Superior Uplands. These distinct differences include tectonic style, topographic relief, and near surface geology that are shown in the following table:

Region	Te[illegible]	Relief	Surface Material
NC	Precambrian	[illegible]	Nearly continuous glacial sediments
NE	Paleozoic	Locally High	Discontinuous glacial sediments

In addition to these differences, deep drilling in many Precambrian shield rocks has shown that high-salinity is common in deep ground water found in the North Central Region. The currently available literature for the Northeastern Region has not indicated a presence of high-salinity ground water at repository depths.

Thus, three separate geohydrologic settings encompass the preliminary candidate areas discussed in this draft report. The preliminary candidate areas in the Northeastern Region are in the Northeast Uplands geohydrologic setting; those in the North Central Region are in the Superior Uplands geohydrologic setting; and those in the Southeastern Region are in the Piedmont and Blue Ridge geohydrologic setting. Accordingly, the guideline requirement for diversity of geohydrologic settings is satisfied in having a distribution of preliminary candidate areas in three settings.

Twenty preliminary candidate areas in crystalline rock, when considered with salt, basalt, and tuff formations that may be available to the second repository project if not nominated or characterized but not selected for the first repository site, provide a diversity of rock types thus satisfying the requirements of 10 CFR 960.3-1-2.

Consideration of regionality can only be made after the site for the first repository has been recommended, since such consideration shall take into account the proximity of sites to locations at which waste is generated or temporarily stored and at which the first repository is being developed. [illegible] the first repository has yet to be designated and therefore, at present, it is too early to apply regionality.

3.4 SELECTION OF CANDIDATE AREAS

Each of the 20 preliminary candidate areas was examined to determine whether any significant adverse features identified to date would prevent DOE from conducting further study of the area. The information used to conduct this review consisted of data (not directly incorporated in Steps 1 through 3) contained in the geologic and environmental characterization reports for each of the three regions and other publically available references that, when relied upon, were cited. This review is documented in Section 3.2 of this report and the results indicate that there is no basis to defer any of the 20 preliminary candidate areas. As a result, DOE believes that all 20 preliminary candidate areas warrant further examination in the area phase. Accordingly, each of the 20 preliminary candidate areas is designated as a candidate area.

4.0 ANALYSES OF DISQUALIFYING CONDITIONS

10 CFR 960.3-2-1 of the siting guidelines requires that to identify a site as potentially acceptable, the evidence shall support a finding that the site is not disqualified in accordance with the application requirements set forth in Appendix III of 10 CFR 960. This chapter presents evaluations of the 20 candidate areas against the 10 disqualifier conditions in Appendix III. (For type of findings to be made refer to 10 CFR 960.)

For purposes of the evaluations described, the term "site" as used in these 10 disqualifying conditions means the total area encompassed within the boundaries of the 20 candidate areas identified in Section 3.4. For these evaluations data presented in Section 3.2 and this chapter are used. Table 4-1 provides a reference to the data presented in Chapter 3 on regional and preliminary candidate area descriptions for eight disqualifying conditions (Erosion, Tectonics (2), Natural Resources, Population Density and Distribution (2), Environmental Quality (2)). The data for Dissolution and Offsite Installations and Operations is contained in this chapter. For all ten disqualifying conditions Table 4-1 references the location of evaluations in this chapter.

If it is determined that geology-related disqualifiers are present within a candidate area, and the resulting impact totally negates the flexibility to locate the repository within the candidate area, then a finding of disqualification is made for the candidate area. Otherwise only the portion of the candidate area directly affected by the disqualifier will be eliminated from further consideration, with the remaining portion(s) of the candidate area continued to be studied. This is because the guidelines associated with the geology disqualifiers [960.4-2-5(d), 960.4-2-6(d), 960.4-2-7(d), 960.4-2-8-1(d), and 960.5-2-11(d)] prohibit the siting of the repository underground facilities, restricted area, controlled area, or any support facilities where such features are present.

TABLE 4-1. Location Of Data For Each Candidate Area*

DISQUALIFYING CONDITIONS	Section of Draft ARR	NC 2	NC 3	NC 6	NC 7	NC 9	NC 10	NC 12	NC 13	NC 14	NC A5	NE 2	NE 4	NE 6	SE 1	SE 2	SE 3	SE 4	SE 5	SE 6	SE 7
EROSION 4-2-5(d)	4.1.1	1.1.1.1 1.1.1.3 1.2.2	1.1.1.1 1.1.1.3 1.3.2	1.1.1.1 1.1.1.3 1.4.2 1.5.2	1.1.1.1 1.1.1.3 1.5.2	1.1.1.1 1.1.1.3 1.6.2	1.1.1.1 1.1.1.3 1.7.2	1.1.1.1 1.1.1.3 1.8.2	1.1.1.1 1.1.1.3 1.9.2	1.1.1.1 1.1.1.3 1.10.2	1.1.1.1 1.1.1.3 1.11.2	2.1.1.1 2.1.1.3 2.2.2	2.1.1.1 2.1.1.3 2.2	2.1.1.1 2.1.1.3 2.4.2	3.1.1.3 3.2.2	3.1.1.3 3.3.2	3.1.1.3 3.4.2	3.1.1.3 3.5.2	3.1.1.3 3.6.2 3.6.7	3.1.1.3 3.7.2	3.1.1.3 3.8.2
DISSOLUTION 4-2-6(d)	4.1.2								DISSOLUTION OF CRYSTALLINE ROCKS IS DISCUSSED IN SECTION 4.1.2												
TECTONICS 4-2-7(d)	4.1.3	1.1.1.3 1.2.2 1.2.3	1.1.1.3 1.3.2 1.3.3	1.1.1.3 1.4.2 1.4.3	1.1.1.3 1.5.2 1.5.3	1.1.1.3 1.6.2 1.6.3	1.1.1.3 1.7.2 1.7.3	1.1.1.3 1.8.2 1.8.3	1.1.1.3 1.9.2 1.9.3	1.1.1.3 1.10.2 1.10.3	1.1.1.3 1.11.2 1.11.3	2.1.1.3 2.2.2 2.2.3	2.1.1.3 2.3.2 2.3.3	2.1.1.3 2.4.2 2.4.3	3.1.1.3 3.2.2 3.2.3	3.1.1.3 3.3.2 3.3.3	3.1.1.3 3.4.2 3.4.3	3.1.1.3 3.5.2 3.5.3	3.[illegible] 3.[illegible] 3.6.[illegible]	[illegible]	3.[illegible] 3.[illegible] [illegible].3
NATURAL RESOURCE 4-2-8-1(d)(1)	4.1.4	1.1.1.4 1.1.1.5 1.2.4 1.2.6	1.1.1.4 1.1.1.5 1.3.4 1.3.6	1.1.1.4 1.1.1.5 1.4.4 1.4.6	1.1.1.4 1.1.1.5 1.5.4 1.5.6	1.1.1.4 1.1.1.5 1.6.4 1.6.6	1.1.1.4 1.1.1.5 1.7.4 1.7.6	1.1.1.4 1.1.1.5 1.8.4 1.8.6	1.1.1.4 1.1.1.5 1.9.4 1.9.6	1.1.1.4 1.1.1.5 1.10.4 1.10.6	1.1.1.4 1.1.1.5 1.11.4 1.11.6	2.1.1.4 2.1.1.5 2.2.4 2.2.6	2.1.1.4 2.1.1.5 2.3.4 2.3.6	2.1.1.4 2.1.1.5 2.4.4 2.4.6	3.1.1.4 3.1.1.5 3.2.4 2.2.6	3.1.1.4 3.1.1.5 3.3.4 3.3.6	3.1.1.4 3.1.1.5 3.4.4 3.4.6	3.1.1.4 3.1.1.5 3.5.4 3.5.6	3.1.1.4 3.1.1.5 3.6.4 3.6.6	[illegible]	3.[illegible].1.4 3.[illegible].1.5 3.8.4 3.8.6
POPULATION DENSITY & DISTRIBUTION 5-2-1(d)(1)	4.1.5	1.1.2.3 1.2.11	1.1.2.3 1.3.11	1.1.2.3 1.4.11	1.1.2.3 1.5.11	1.1.2.3 1.6.11	1.1.2.3 1.7.11	1.1.2.3 1.8.11	1.1.2.5 1.9.11	1.1.2.3 1.10.11	1.1.2.3 1.11.11	2.1.2.3 2.2.11	2.1.2.3 2.3.11	2.1.2.3 2.4.11	3.1.2.3 3.2.11	3.1.2.3 3.3.11	3.1.2.3 3.4.11	3.1.2.3 3.5.11	3.1.2[illegible] 3.6.[illegible]	3.1.2.3 3.7.11	3.1.2.3 3.8.11
POPULATION DENSITY & DISTRIBUTION 5-2-1(d)(2)	4.1.6	1.2.11	1.3.11	1.4.11	1.5.11	1.6.11	1.7.11	1.8.11	1.9.11	1.10.11	1.11.11	2.2.11	2.3.11	2.4.11	3.2.11	3.3.11	3.4.11	3.[illegible].11	3.[illegible]	3.7.11	3.8.11
OFFSITE INSTALLATIONS & OPERATIONS 5-2-4(d)	4.1.7								ATOMIC ENERGY DEFENSE ACTIVITIES ARE DISCUSSED IN 4.1.7												
ENVIRONMENTAL QUALITY 5-2-5([illegible])(2)	4.1.8	1.2.8	1.3.8	1.4.8	1.5.8	1.6.8	1.7.8	1.8.8	1.9.8	1.10.8	1.11.8	2.2.8	2.3.8	2.4.8	3.2.8	3.3.8	3.4.8	3.5.8	3.6.8	[illegible].8	3.[illegible].8
ENVIRONMENTAL QUALITY 5-2-5(d)(3)	4.1.9	1.2.9	1.3.9	1.4.9	1.5.9	1.6.9	1.7.9	1.8.9	1.9.9	1.10.9	1.11.9	2.2.9	2.3.9	2.4.9	3.2.9	3.3.9	3.4.9	3.5.9	3.6.9	3.[illegible].9	3.8.9
TECTONICS 5-2-11(d)	4.1.10	1.1.1.3 1.2.2 1.2.3	1.1.1.3 1.3.2 1.3.3	1.1.1.3 1.4.2 1.4.3	1.1.1.3 1.5.2 1.5.3	1.1.1.3 1.6.2 1.6.3	1.1.1.3 1.7.2 1.7.3	1.1.1.3 1.8.2 1.8.3	1.1.1.3 1.9.2 1.9.3	1.1.1.3 1.10.2 1.10.3	1.1.1.3 1.11.2 1.11.3	2.1.1.3 2.2.2 2.2.3	2.1.1.3 2.3.2 2.3.3	2.1.1.3 2.4.2 2.4.3	3.1.1.3 3.2.2 3.2.3	3.1.1.3 3.3.2 3.3.3	3.1.1.3 3.4.2 3.4.3	3.1.1.3 3.5.2 3.5.3	3.1.1.3 3.6.2 3.6.3	3.1.1.3 3.7.2 3.7.3	3.[illegible].1.3 3.[illegible].2 3.8.3

*All reference numbers in columns NC 2 through SE 7 are preceded by 3.2.

Similarly, if it is determined that environmental disqualifiers are present within a candidate area, then a further evaluation is made as whether there is sufficient flexibility to locate surface facilities within the candidate area. This is because the guidelines associated with the environmental disqualifiers [960.5-2-1(d)(1),(d)(2), 960.5-2-5(d)(2), (d)(3)] prohibit the siting of the repository restricted area and support facilities; however, such disqualifying factors could be present in the repository controlled area or could overlie the repository underground facilities.

4.1 ANALYSES OF AND FINDINGS ON DISQUALIFYING CONDITIONS

4.1.1 Erosion, 960.4-2-5(d)

> "The site shall be disqualified if site conditions do not allow all portions of the underground facility to be situated at least 200 meters below the directly overlying ground surface."

The objective of this guideline is to ensure that erosional processes will not degrade the waste-isolation capabilities of a site. In evaluating the potential effects of erosion on waste isolation and considering the proposed repository horizon, the overburden thickness and thickness of the repository host rock are the most important considerations. The host rock at a site should allow the repository to be placed at a depth sufficient to ensure that the underground workings will not be uncovered or otherwise adversely affected by erosion, and the ground-water regime adversely affected. Pertinent data to making an evaluation of this guideline include host rock thickness, overburden thickness and the climatic, tectonic, and geomorphic evidence of rates and patterns of erosion in the geologic setting during the Quaternary Period. Erosion rates are presented in Sections 3.2.1.1.3 and 3.2.2.1.3 which indicates a maximum erosion of 188 m (617 ft) in the Northeast Region and 120 m (394 ft) in the North Central Region. The repository horizon will be at least at 350 m (1,148 ft) below the ground surface.

Geologic evidence examined for all 16 candidate areas indicates that the host rock thickness is greater than 1,000 m (3,330 ft) for all preliminary candidate areas except NE-4 which may be less than 1 km (0.6 mi) and that overburden thickness ranges from 0 to 141 m (0 to 460 ft). Therefore, the underground workings at each of the candidate areas can be placed at a depth greater than 200 m (656 ft) below the ground surface, the minimum depth at which the repository would be protected from erosional processes acting on the surface.

The potential for erosion in the three regions is in the North Central and Northeastern Regions where glaciation has been the major factor in the depth of erosion during the Quaternary Period. Erosion due to glaciation has not directly affected the Southeastern Region during the Quaternary Period and therefore is of no concern for the region. Data on glaciation which applies to the North Central and Northeastern Regions have indicated the following:

- The observed maximum amount of localized erosion due to sudden flooding and fluvial action during deglaciation is 60 m (197 ft) (Matsch, 1983). Based on our knowledge of glacial processes it is not likely that such erosion might occur at the same location more than once.
- No more than 20 m (66 ft) of glacial erosion (Kaszycki and Shilts, 1980) should be expected during a single glacial event, or in the next 100,000 years.
- No more than 40 m (131 ft) (Bell and Laine, 1985) of glacial erosion should be expected over 10 glacial events, or in the next 1 million years.

Uplift in any of the three regions due to either tectonics or isostatic rebound due to deglaciation has been estimated to have a maximum rate of 10 mm/yr (0.24 in./yr)(Brown and Oliver, 1976). If this rate of uplift continues for the next 10,000 years, the maximum uplift would be 60 m (197 ft).

This amount of [illegible],000 years is insignificant to waste isolation as it is occurring over broad regional areas and is not localized; therefore this uplift will not affect gradients or incision rates.

At all of the candidate areas, the underground facilities can be placed at a depth great enough to protect the repository from erosional processes acting on the surface.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.2 Dissolution, 960.4-2-6(d)

> "The site shall be disqualified if it is likely that, during the first 10,000 years after closure, active dissolution, as predicted on the basis of the geologic record, would result in a loss of waste isolation."

The objective of this guideline is to ensure that dissolution processes will not adversely affect the waste-isolation capabilities of the site. The principal concern is that the dissolution of the host rock might create pathways for radionuclide migration to the surrounding geohydrologic system. The host rocks at all of the candidate areas being considered in the CRP are crystalline rocks defined in part as intrusive igneous and high-grade metamorphic rocks rich in silicate minerals. By definition, crystalline rocks are not subject to significant dissolutioning. A review of solubility data indicates that silicate minerals have very low solubilities when compared with common carbonates, sulfates, and chlorides. Common minerals in fractures include calcite, quartz, and epidote, and under some conditions such as high temperatures these minerals will dissolve and thus change fracture aperture. However, unless large quantities of more highly soluble minerals such as calcite exist, the dissolution will be limited by the silicate mineralogy in a crystalline rock environment.

Based on laboratory d... (Clark, 1966) and knowledge of field conditions in crystalline rocks, it is concluded that all crystalline rock bodies (excluding fracture-fill material) fall into the same category with respect to dissolution; dissolution is negligible.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.3 Tectonics, 960.4-2-7(d)

> "A site shall be disqualified if, based on the geologic record during the Quaternary Period, the nature and rates of fault movement or other ground motion are expected to be such that a loss of waste isolation is likely to occur."

The objective of this guideline is to ensure that tectonic processes do not adversely affect the waste-isolation capabilities of the site. Tectonic processes and events during the postclosure period, if they were to occur, could adversely affect waste containment and isolation by creating new ground-water pathways to the accessible environment. Igneous activity, uplift, subsidence, folding, and faulting are all important to evaluating the tectonic characteristics of the candidate areas. The Quaternary tectonic history of the candidate areas shows little evidence of active tectonism.

The present tectonic stability of the three regions makes the possibility of ground motions related to igneous activity over the next 10,000 years highly unlikely. There is no known documented evidence of Quaternary faulting or folding in the three regions. There have been suggestions that post-glacial movement may have occurred along the Norumbega fault which is 10 km (6 mi) and 20 km (12 mi) from preliminary candidate areas NE-2 and NE-4 respectively. However, movement has not been substantiated by recent detailed mapping of Quaternary features along the fault (Thompson, 1981). Probabilistic estimates for maximum horizontal ground accelerations in rock in the conterminous Unites States have been computed by Algermissen et al., (1982) using regional magnitude and intensity data tied to seismic source zones, magnitude versus distance ground motion attenuation relationships, and regional earthquake recurrence curves.

The resulting horizontal ground accelerations indicate that acceleration in rock with a 90% probability of not being exceeded in 250 years ranges from 0.08 g to 0.24 g for the 20 candidate areas. The maximum accelerations shown by Algermissen et al., (1982) for the North Central, Northeastern, and Southeastern preliminary candidate areas are 0.08 g, 0.16 g and 0.24 g, respectively. These acceleration values are within reasonable design, construction, operation, and closure limits for critical facilities as shown in licensing documents of nuclear power plants in the eastern United States.

The uplift rates in the three regions ranges from 0 to 6 mm/yr (0 to 0.24 in/yr) (Brown and Oliver, 1976) due to tectonic activity and/or glacial rebound. These rates imply between 0 and 60 m (0 to 197 ft) of uplift over the next 10,000 years. There are no demonstratable Quaternary or tectonic processes that could lead to radionuclide releases from a repository at any of the 20 candidate areas.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.4 Natural Resources, 960.4-2-8-1 (d)(1)

> "A site shall be disqualified if previous exploration, mining, or extraction activities for resources of commercial importance at the site have created significant pathways between the projected underground facility and the accessible environment."

The objective of this guideline is to evaluate the candidate areas for previous mining, exploration, or extraction activities which may have created significant pathways between the underground facility and the accessible environment that could adversely affect the isolation capability of a site. Evidence necessary to make an evaluation of the disqualifying condition include:

- metallic and nonmetallic mine, quarry, and prospect locations, depth, and present value within a candidate area
- identification of ground-water resources and present demand within a candidate area
- energy resource location, depth, and present value within a candidate area
- exploratory borehole and well locations and depths within a candidate area.

The regional geologic studies performed to determine locations of mineral and energy deposits in the three regions indicate that there are no deep mineral deposits, energy resources, or ground-water resources at any of the 20 candidate areas such that previous mining or extraction activities have created significant pathways between the projected underground facility and the accessible environment. For conservatism, during Step 1 of the region-to-area screening methodology it was assumed that deep mines or quarries (greater than 100 m or [328 ft] in depth) have created significant pathways. There are no deep mines or quarries in any of the candidate areas or in their vicinity. There is no evidence to indicate that deep exploratory drillholes and water wells would create significant hydrologic pathways to the accessible environment from the projected underground facility.

Exploratory data including borehole and limited information on wells were evaluated as part of the qualitative/descriptive review of literature (Chapter 3.?). Based on that review, it is unlikely that deep exploration boreholes for commercial mineral deposits exist in any of the 20 candidate areas as the majority of the known commercial mineral deposits occur outside and adjacent to the crystalline rock bodies rather than within a crystalline rock body. Based on the current level of data and due to the nature and origin of the identified mineral deposits in the vicinity of the candidate areas, it is not expected that commercial deposits will occur in the candidate areas. Two scientific boreholes were drilled within preliminary candidate area at SE-4 by Virginia Polytechnic Institute and State University (VPI). These boreholes are approximately 213 m (700 ft) in depth. To DOE's knowledge there are presently no plans by VPI for further drilling at SE-4. Evaluation of ground-water resources (Section 3.2) for all of the candidate areas indicates that these resources are generally available and that availability in the candidate areas is similar to other comparable areas in the regions. In all three regions, the most common source of water for wells is in glacial sediments or saprolite overlying bedrock. Those wells that do tap bedrock aquifers generally produce water from zones that are relatively more highly fractured. Because any repository site will be located in such a way as to avoid pathways created by fracture zones, wells that may be producing from such bedrock fracture zones such as the deep wells (greater than 91 m or 300 ft) in and around candidate area NE-4 are not considered to represent pathways that might connect the repository with the accessible environment.

The evidence does <u>not</u> support a finding that any of the 20 candidate areas is disqualified.

4.1.5 <u>Population Density and Distribution, 960.5-2-1(d)(1)</u>

> "A site shall be disqualified if... (1) any surface facility of a repository would be located in a highly populated area."

The objective of this guideline is to ensure that selection of a repository site location will minimize risk to the public and permit compliance with EPA and NRC regulations. Surface facilities are defined to include the repository restricted area and any support facilities within the restricted area. It is assumed that the restricted area of a repository constructed in crystalline rock will occupy approximately 160 ha (400 acres) or less than 2.6 km^2 (1 mi^2).

During Step 1 of the region-to-area screening methodology, highly populated areas were treated as a disqualifying factor and, during Step 2, proximity to highly populated areas was used as a screening variable. The effect of this was to generally exclude highly populated areas from being located within the boundaries of the 20 candidate areas. As a result, candidate areas NC-2, NC-3, NC-6, NC-7, NC-9, NC-10, NC-13, NC-14, NC-15, NE-2, NE-4, NE-5, SE-1, SE-3, SE-4, SE-5 and SE-6 have no highly populated areas within their boundaries. Two candidate areas, NC-12 (see Section 3.2.1.8.11) and SE-2 (see Section 3.2.3.3.11) each contain one highly populated area (Sauk Centre, Minnesota and Bedford, Virginia, respectively). Candidate area SE-7 (see Section 3.2.3.8.11) contains four highly populated areas (Forsyth, Barnesville, Hannahs Mill, and Thomaston all of which are in Georgia). Given the limited number of highly populated areas within NC-12, SE-2 and SE-7, in comparison to the areal extent of these areas (see Sections 3.2.1.8.1, 3.2.3.3.1 and 3.2.3.8.1 respectively) there is sufficient flexibility to locate a surface facility so that it would not be coincident with any of the highly populated areas located in these three candidate areas. It is clearly recognized, however, that no surface facility could be constructed within the boundaries of these highly populated areas.

The evidence does <u>not</u> support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.6 Population Density and Distribution, 960.5-2-1(d)(2)

> "A site shall be disqualified if... (2) any surface facility of a repository would be located adjacent to an area 1-mile by 1-mile (1.6 km by 1.6 km) having a population of not less than 1,000 as enumerated by the most recent U.S. census."

The objective of this guideline is to ensure that selection of repository site location will minimize risk to the public and permit compliance with the EPA and NRC regulations. Surface facilities are defined to include the repository restricted area and any support facilities within the restricted area. It is assumed that the restricted area of a repository constructed in crystalline rock will occupy approximately 160 ha (400 ac) or less than 2.6 km^2 (1 mi^2).

During Step 1 of the region-to-area screening methodology, areas with population densities of 1,000 or more persons per square mile were treated as a disqualifying factor and, during Step 2, proximity to areas with population densities of 1,000 or more persons per square mile was used as a screening variable. The effect of this was to exclude areas with population densities of 1,000 or more persons per square mile from all of the candidate areas except NC-6 (see Section 3.2.1.4.11) and NC-12 (see Section 3.2.1.8.11), which each contain one area (Warren, Minnesota and Sauk Centre, Minnesota*, respectively) with population density greater than 1,000 persons per square mile.

As noted in the SMD (DOE, 1985b), the CRP made a conservative assumption that a repository surface facility, if sited any place within a minor civil division or census county division of 1,000 or more persons per square mile, would be adjacent to an area 1-mile by 1-mile (1.6 km by 1.6 km) having a population of not less that 1,000 persons. This disqualifying factor as well as the highly populated areas disqualifying factor, addresses the coincidence and adjacency conditions of Section 112(a) of NWPA. Since minor civil division (MCD) and census county division (CCD) information (i.e., populations and boundaries) was the basis for these density estimates (through a simple population over area calculation), high population concentrations were distributed over the extent of the MCD/CCD thereby overstating the number of areas where density exceeds 1,000 persons per square mile.

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* Sauk Centre in NC-12 is also a highly populated area (see Section 4.1.5).

Given the existence of only one area with a population density greater than 1,000 or more persons per square mile within each of the candidate areas NC-6 and NC-12 in comparison to their areal extent (see Sections 3.2.1.4.1 and 3.2.1.8.1 respectively), there is sufficient flexibility to locate a surface facility so that it would not be adjacent to areas with a population density greater than 1,000 or more persons per square mile. It is clearly recognized, however, that no surface facility could be constructed adjacent to either Warren in NC-6 or Sauk Centre in NC-12.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.7 Offsite Installations and Operations, 960.5-2-4(d)

> "A site shall be disqualified if atomic energy defense activities in proximity to the site are expected to conflict irreconcilably with repository siting, construction, operation, closure, or decommissioning."

The objective of this guideline is to ensure that the impacts of atomic energy defense activities in repository siting, construction, operation, closure, and decommissioning are adequately considered and to ensure that the nature of the atomic energy defense activities would not preclude or significantly disrupt repository activities.

Two atomic energy defense facilities exist within the three regions (Savannah River Plant in Aiken, South Carolina, and the Knolls Atomic Power Laboratory near Schenectady, New York). The closest candidate areas to the Savannah River Plant are SE-6 and SE-7 which are located approximately 194 km (120 mi) to the northwest, and 192 km (120 mi) to the west, respectively. The nature of activities occurring at the Savannah River Plant (defense nuclear materials production and defense nuclear waste management), when considered with the location of this site in relation to candidate areas SE-6 and SE-7, do not represent an irreconcilable conflict w[illegible] geologic repository. The Knolls Atomic Power Laboratory is located approximately 144 km (90 mi) west of NE-5, which is the closest candidate area. The nature of activities occurring at the Knolls Atomic Power Laboratory (research and development work for naval nuclear reactors), when considered with the location of this laboratory in relation to candidate area NE-5, do not represent an irreconcilable conflict with a geologic repository.

A third atomic energy defense facility, the Oak Ridge Y-12 Plant in Oak Ridge, Tennessee, is located outside of the three regions as defined by the CRP. This complex is 115 km (72 mi) west of the closest candidate area SE-5. In addition, candidate area SE-6 (which is also located 194 km (120 mi) northwest of the Savannah River Plant) lies approximately 208 km (130 mi) south of Oak Ridge. The types of the activities occurring at the Y-12 Plant (weapons activities), when considered with the location of this site in relation to SE-5 and SE-6, do not represent an irreconcilable conflict with the geologic repository.

The evidence does not support a finding that any of the 20 candidate areas are disqualified (Level 1).

4.1.8 Environmental Quality, 960.5-2-5(d)(2)

> "Any of the following conditions shall disqualify a site: ... or (2) any part of the restricted area or repository support facilities would be located within the boundaries of a component of the National Park System, the National Wildlife Refuge System, the National Wilderness Preservation System, or the National Wild and Scenic Rivers System."

The objective of this guideline is to ensure protection of Federal lands and to avoid conflicts between Federal lands and the repository restricted area and support facilities. For purposes of application of this guideline, there must be sufficient open areas for placement of a restricted area and repository support facilities within the candidate area and there will be access to the candidate area for establishment of support facilities. It is assumed that the restricted area of a repository constructed in crystalline rock will occupy approximately 160 ha (400 ac) or less than 2.6 km^2 (1 mi^2).

During Step 1 of the region-to-area screening methodology the four categories of Federal-protected lands (noted in this disqualifying condition and in excess of 130 ha (320 ac) in size) were treated as disqualifying factors and, during Step 2, proximity to these Federal-protected lands (in excess of 130 ha [320 ac]) was used as a screening variable. The effect of this was to generally exclude Federal-protected lands (in excess of 130 ha [320 ac]) from being located within the boundaries of the candidate areas.

As part of the qualitative/descriptive literature review, each candidate area was reviewed to determine if any Federal-protected lands smaller than 130 ha (320 ac) in size was contained within the boundaries of the candidate area. As a result of applying the disqualifying factor and screening variable noted above and conducting this final review, candidate areas NC-2, NC-6, NC-7, NC-10, NC-14, NC-A5, NE-2, NE-4, NE-5, SE-1, SE-2, SE-3, SE-4, SE-5, SE-6, and SE-7, have no Federal-protected lands within their boundaries. Four candidate areas (NC-3, NC-9, NC-12 and NC-13) do contain a limited number of these Federal-protected lands. The Wolf National Wild and Scenic River lies within NC-3 in the northeastern portion, however, it covers less than 1% of the candidate area (see Section 3.2.1.3.8). Eleven waterfowl production areas are located within NC-9; they comprise 1,376 ha (3,400 ac) or approximately 2% of the candidate area (see Section 3.2.1.6.8). Candidate area NC-12 contains twelve waterfowl production areas which cover approximately 862 ha (2,130 ac) or less than 2% of the candidate area (see Section 3.2.1.8.8). Three waterfowl production areas cover approximately 170 ha (420 ac) or approximately 1% of candidate area NC-13 (see Section 3.2.1.9.8). Given the total areal extent of candidate areas

NC-3, NC-9, NC-12* and ... there is sufficient flexibility to locate the restricted area or ... support facilities outside the boundaries of these Federal-protected lands.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.9 Environmental Quality, 960.5-2-5(d)(3)

> "Any of the following conditions shall disqualify a site... the presence of the restricted area or the repository support facilities would conflict irreconcilably with the previously designated resource-preservation use of a component of the National Park System, the National Wildlife Refuge

The objective of this guideline is to ensure protection of Federal lands and comparably significant State lands and to avoid conflicts between these Federal and State lands and the repository restricted area and support facilities. For purposes of application of this guideline, there must be sufficient open areas for placement of a restricted area and repository support facilities within the candidate area and there must be access to the candidate areas for establishment of support facilities. It is assumed that the restricted area of a repository constructed in crystalline rock will occupy approximately 160 ha (400 ac) or less than 2.6 km^2 (1 mi^2).

For purposes of application during Step 1 of the region-to-area screening methodology, the phrase "The presence of the restricted area or repository support facilities would conflict irreconcilably..." was defined as "coincidence." The comparable significance of State-protected

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* The presence of a highly populated area, Sauk Centre (which is also an area of population density greater than 1,000 persons per square mile) does not change the conclusion, due to the large areal extent of the candidate area (44,30? ha or 109,440 ac).

resources was determined through a statutory review of legislation establishing the various categories of State lands and comparing those statutes to the legislation establishing the categories of Federal lands. National Forest Lands components were evaluated to determine whether they could meet the tests of irreconcilable conflict of use and designation for resource preservation at this time. Three components were judged to meet these tests and warrant disqualification: research natural areas, primitive areas, and national recreation areas. There are no primitive areas within any of the three regions.

During Step 1 of the region-to-area screening methodology, State-protected lands (in excess of 130 ha [320 ac]) and the above-noted components of National Forest Lands (in excess of 130 ha [320 ac]) were treated as disqualifying factors, and, during Step 2, proximity to State-protected lands (in excess of 130 ha [320 ac]) and proximity to the disqualified components of the National Forest Lands (in excess of 130 ha [320 ac]) were treated as screening variables. The effect of this was to generally exclude State-protected lands (in excess of 130 ha [320 ac]) and disqualified components of the National Forest Lands (in excess of 130 ha [320 ac]) from being located within the boundaries of the candidate areas.

As part of the qualitative/descriptive literature review, each candidate area was reviewed to determine if any State-protected lands or disqualified components of the National Forest Lands smaller than 130 ha (320 ac) were contained within the boundaries of the candidate area. As a result of applying the disqualifying factor and screening variables noted above and conducting a final review, nine of the candidate areas have no State-protected lands or disqualified components of the National Forest Lands within their boundaries. Eleven of the candidate areas: NC-3, NC-6, NC-7, NC-9, NC-10, NC-12, NC-13, NC-14, SE-4, NE-4, and NE-5) do contain a limited number of these State-protected lands. Table 4-2 identifies the number, size, and total areal extent of these State-protected lands for each of these candidate areas. No research natural areas or national recreation areas are located within the candidate areas. Given the total areal extent of candidate areas NC-3, NC-6, NC-7*, NC-9*, NC-10, NC-12**, NC-13*, NC-14, SE-4, NE-4, and NE-5 there is sufficient flexibility to locate the restricted area or repository support facilities outside the boundaries of these State-protected lands.

The evidence does not support a finding that any of the 20 candidate areas is disqualified (Level 1).

4.1.10 Tectonics, 960.5-2-11(d)

> "A site shall be disqualified if, based on the expected nature and rates of fault movement or other ground motion, it is likely that engineering measures that are beyond reasonably available technology will be required for exploratory shaft construction or for repository construction, operation, or closure."

The objective of this preclosure guideline is to ensure that the selected site is not likely to be affected by tectonic events of such magnitude that could require unreasonable or unfeasible design features to protect the facilities, the repository workers, and the public.

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* The presence of Federal-protected lands within NC-7, NC-9, and NC-13 does not change the conclusion, due to the large areal extent of the candidate area (29,400 ha or 72,320 ac for NC-7, 64,780 ha or 159,400 ac for NC-9, and 15,610 ha or 38,400 ac for NC-13).

** In addition to the presence of State-protected lands within NC-12, the presence of a highly populated area, Sauk Centre (which is also an area of population density greater than 1,000 persons per square mile), and the presence of Federal-protected lands within NC-12 do not change the conclusion due to the large areal extent of the candidate area (77,308 ha or 109,400 ac).

Table 4-[illegible] [illegible]ted Lands Within Candidate Areas

Candidate Area	Feature	Number	Size of Features ha (ac)	Areal Extent (% of Candidate Area)	Section Reference
NC-3	Scientific and Natural Areas	4	138 (342)	<1%	3.2.1.3.9
NC-6	Wildlife Management Areas	2	3,659(9,040)	~5%	3.2.1.4.9
NC-7	Wildlife Management Area	1	526(1,300)	<2%	3.2.1.5.9
NC-9	Wildlife Management Areas	6	377 (931)	<1%	3.2.1.6.9
	State Park	1	388 (960)	<1%	
NC-10	Wildlife Management Areas	2	197 (488)	<1%	3.2.1.7.9
NC-12	Wildlife Management Areas	3	606(1,498)	<2%	3.2.1.8.9
NC-13	Wildlife Management Areas	4	171 (422)	~1%	3.2.1.9.9
NC-14	Wildlife Management Areas	2	60 (149)	<1%	3.2.1.10.9
SE-4	State Park and Natural Heritage Area	1	27 (67)	<1%	3.2.3.5.9
	Natural Heritage Area	1	24 (60)	<1%	
NE-4	State Parks	3	930(2,290)	1%	3.2.2.3.9
	Wild and Scenic River	1	17.6(11)*	3%	
	Critical Areas/ Wildlife Management Area	5/1	71 (176)	<1%	
NE-5	Wildlife Management Area	1	118 (291)	<1%	3.2.2.4.9

* Kilometers (miles)

The evidence necessary to make an evaluation of the preclosure guideline consists of geologic and tectonic history, historical seismicity and preliminary estimates of ground motion in the vicinity of the candidate areas.

There is no known documented evidence of Quaternary faulting or folding in the three regions. There have been suggestions that postglacial movement may have occurred along the Norumbega fault which is 10 km (6 mi) and 20 km (12 mi) from preliminary candidate areas NE-2 and NE-4 respectively in the Northeastern Region, but movement along this fault has not been substantiated by recent detailed mapping of Quaternary features along the fault (Thompson, 1981).

The uplift rates in the three regions range from 0 to a maximum of 6 mm/yr (0 to 0.24 in/yr) (Brown and Oliver, 1976) due to tectonic activity and/or glacial rebound. These rates imply between 0 and 60 m (0 to 197 ft) of uplift over the next 10,000 years.

Probabilistic estimates for maximum horizontal ground accelerations in rock in the conterminous Unites States have been computed by Algermissen et al. (1982) using regional magnitude and intensity data related to seismic source zones, magnitude versus distance ground motion attenuation relationships, and regional earthquake recurrence curves. A report by Algermissen et al. (1982) provided these maximum horizontal ground accelerations as it describes a method that takes into account accelerations east of the Rockies on a uniform basis. Although development of this type of information requires a number of generalities and assumptions, the end product is useful for providing an indication of ground motion to be expected during exploratory shaft construction and for repository construction, operation or closure. Horizontal ground accelerations shown by Algermissen et al. (1982) indicate the acceleration in rock with a 90% probability of not being exceeded in 250 years ranges from 0.089 g to 0.24 g for the 20 candidate areas.

The maximum accelerations shown by Algermissen et al. (1982) for the North Central, Northeastern, and Southeastern preliminary candidate areas are 0.08 g, 0.16 g and 0.24 g, respectively. These acceleration values are within reasonable design, construction, operation, and closure limits for critical facilities as shown in licensing documents of nuclear power plants in the eastern United States.

The evidence does not support that any of the 20 candidate areas is disqualified (Level 1).

4.2 CONCLUSIONS

The evaluations made on characteristics of each of the 20 candidate areas against the 10 applicable disqualifying conditions of Appendix III of the siting guidelines indicate that "the evidence does not support a finding that the site is disqualified." Therefore, all 20 candidate areas are suitable for identification as proposed potentially acceptable sites in accordance with 10 CFR 960.3-2-1.

5.0 IDENTIFICATION OF PROPOSED POTENTIALLY ACCEPTABLE SITES

This chapter presents the DOE's rationale for identifying 12 proposed potentially acceptable sites in accordance with 10 CFR 960.3-2-1 of the siting guidelines from among the 20 candidate areas identified in Section 3.4. It also presents a list of the remaining eight candidate areas considered in the event that during the finalization of the ARR or the area phase it is determined that other areas are required to meet program requirements. Figure 5-1 summarizes the region-to-area screening process.

5.1 RESULTS OF APPLICATION OF STEPS 1 THROUGH 3 OF THE REGION-TO-AREA SCREENING PROCESS

Section 3.1 provides the basis for the identification of 21 preliminary candidate areas based on the application of Steps 1 through 3 of the region-to-area screening methodology. These 21 preliminary candidate areas all occur at a 7 out of 9 or higher frequency of occurrence as determined by the use of the weight sets developed at two workshops by nine groups for both Phases A and B. That is, 21 preliminary candidate areas represent those land units which consistently appear as the more favorable areas (as defined by the nine weight sets), and accordingly, demonstrate, in the aggregate, the highest composite favorability within the 235 exposed and near-surface crystalline rock bodies evaluated in accordance with 10 CFR 960.3-2-1. Due to the close proximity of preliminary candidate area NE-N5 to Canada, the DOE has excluded this area from further consideration (see Section 3.1.5).

5.2 RESULTS OF APPLICATION OF STEP 4 OF THE REGION-TO-AREA SCREENING PROCESS

Prior to the final selection of candidate areas, the DOE conducted a complete review of the results of region-to-area screening process to ensure its accuracy and technical defensibility (see Appendix D). The basis for identifying each of the 20 preliminary candidate areas as

REGION-TO-AREA SCREENING PROCESS

235 Crystalline Rock Bodies	Apply Steps 1 through 3 of region-to-area screening process to data base contained in six regional characterization reports.
22 Preliminary Candidate Areas	22 areas all have a frequency of occurrence of 7 out of 9 or higher as determined by the nine weight sets for Phases A and B. These 22 preliminary candidate areas demonstrate, in the aggregate, the highest composite favorability.
21 Preliminary Candidate Areas	Preliminary candidate areas resulting from DOE's decision to combine NC-3 and NC-4.
20 Preliminary Candidate Areas	Preliminary candidate areas resulting from DOE's decision to exclude NE-N5 since it appears highly probable that sampling/field work would have to be conducted in Canada.
20 Candidate Areas	Candidate areas are identified after application of Step 4 to the 20 preliminary candidate areas, on the basis of the qualitative/descriptive literature review, which utilized data not directly incorporated in Steps 1 through 3 of the region-to-area screening methodology. All 20 preliminary candidate areas contained many favorable characteristics. The DOE concluded that all 20 preliminary candidate areas warrant further examination in the area phase.
20 Candidate Areas Suitable for ID as Proposed PASs	Candidate areas identified as suitable for identification as proposed potentially acceptable sites based on DOE's evaluation of each candidate area against the 10 disqualifying conditions. Ten candidate areas have a frequency of occurrence of 9 out of 9, one at 8 out of 9, and ten at 7 out of 9.
12 Proposed PASs	Proposed potentially acceptable sites identified by DOE as follows:

Ten candidate areas have frequency of occurrence of 9 out of 9 or 8 out of 9.

Other ten candidate areas to be considered (7 out of 9) except for NE-2 & SE-4 which are proposed as PASs based on the presence of favorable geologic considerations.

Proposed PASs	Proposed PASs	Candidate Areas
NC-3, NC-6,	NE-2	NC-2
NC-7, NC-10,	SE-4	NC-9
NE-4, NE-5		NC-12
SE-2, SE-3		NC-13
SE-5, SE-7		NC-14
		NC-A5
		SE-1
		SE-6

Figure 5-1

candidate areas is the a[illegible]s and information presented in Section 3.2. The results indicate that there are no significant adverse features identified to date that would preclude the DOE from conducting further studies of any of the 20 preliminary candidate areas as a candidate for repository siting. In addition, many favorable characteristics have been identified in each of the 20 candidate areas. The Step 4 deferral analyses conducted provided the DOE with a reasonable expectation, within the constraints of a regional study, that the 20 candidate areas warrant further examination in the area phase. In addition, a review of the Implementation Guidelines (Subpart B of 10 CFR 960) were considered and applied as appropriate (Section 3.3).

5.3 RESULTS OF DISQUALIFICATION ANALYSES

The data and evaluations contained in Chapter 4.0 provides the basis for the conclusion by the DOE that each of the 20 candidate areas is not disqualified in accordance with the application requirements set forth in Appendix III of the DOE siting guidelines (DOE, 1984a). Therefore, all 20 candidate areas are suitable for identification as proposed potentially acceptable sites in accordance with 10 CFR 960.3-2-1.

5.4 PROPOSED POTENTIALLY ACCEPTABLE SITES

Based on the above conclusion, DOE could propose to identify all 20 of the candidate areas as potentially acceptable sites. In order to provide sufficient confidence that DOE will be able to nominate up to five sites in crystalline rock for characterization, the DOE has determined that it is only necessary to identify approximately 12 of the candidate areas as proposed potentially acceptable sites for the area phase investigations as discussed below. The eight candidate areas not proposed for identification as potentially acceptable sites will be held in reserve in the event that during ARR finalization or the area phase it is determined that other areas are needed to meet program requirements. The DOE recognizes that the proposed identification of 12 potentially acceptable sites is slightly less than the range of 15 to 20 previously discussed (DOE, 1986b). However, the DOE believes that the initiation of area phase investigations on 12 potentially acceptable sites provides a reasonable basis for proceeding.

The rationale behind this decision is that, in accordance with Section 112(b)(1)(c) of the NWPA, the DOE must nominate five sites for the second repository and recommend three of these sites for site characterization. Besides sites in crystalline rock, potentially acceptable sites for the first repository could be nominated if they were not previously nominated as suitable for site characterization. In addition, any sites that were recommended for characterization but not selected for the first repository are eligible. The NWPA stipulates at lease three of the five sites must not have been previously nominated. Based on these considerations, the DOE has assumed that the second repository program will need to nominate from three to five crystalline sites.

In considering the number of potentially acceptable sites necessary to provide sufficient confidence that the DOE will be able to nominate up to five sites in crystalline rock for characterization, the DOE took into account the areal extent of the candidate areas [ranging from 166 km^2 (64 mi^2) to 2,844 km^2 (1,094 mi^2)] and their distribution within three geohydrologic settings (10 in the Superior Uplands, 3 in the Northeast Uplands and 7 in the Piedmont and Blue Ridge). The large areal extent of the candidate areas provides flexibility for siting both surface facilities and underground workings. The distribution of candidate areas in three geohydrologic settings provides a wide range of hydrologic conditions including hydrologic diversity, and therefore, a greater flexibility in nominating sites with different hydrologic attributes. On the basis of these considerations, the DOE has determined that it is appropriate to investigate approximately 12 potentially acceptable sites during the area phase.

Since the DOE has determined that all 20 candidate areas are suitable for identification as potentially acceptable sites, DOE has elected to proceed in the following manner to identify the 12 proposed potentially acceptable sites. Table 3-5, as modified by DOE's decisions to combine NC-3 and NC-4 (Section 3.1.4.1) and exclude NE-N5 (Section 3.1.5), gives the frequency of occurrence for each of the 20 candidate areas. This table summarizes the preferences of the nine weighting groups and establishes that 10 candidate areas (NC-3, NC-6, NC-7, NC-10, NE-4, NE-5, SE-2, SE-3, SE-5, and SE-7) have a frequency of occurrence of 9 out of 9 or 8 out of 9. Accordingly, these 10 candidate areas are proposed as potentially acceptable sites. They are located in the states of Georgia (SE-7), New Hampshire (NE-5), Maine (NE-4), Minnesota (NC-6, -7, -10), North Carolina (SE-5), Virginia (SE-2, -3), and Wisconsin (NC-3). Portions of NC-3 are located within the Menominee and Stockbridge-Munsee Indian Reservations.

Table 3-5 also indicates that there are 10 candidate areas (NC-2, NC-9, NC-12, NC-13, NC-14, NC-A5, NE-2, SE-1, SE-4, and SE-6) with a frequency of occurrence of 7 out of 9. Based on the decision that 12 potentially acceptable sites are sufficient to initiate area phase investigations, the DOE wishes to propose two of these 10 candidate areas as potentially acceptable sites. The two areas were chosen on the basis of those favorable geologic attributes which would facilitate area characterization or are important to repository performance. The other eight candidate areas will be considered and may be designated as potentially acceptable sites during ARR finalization or area phase investigations and investigated, if it is determined that other areas are required to meet program requirements.

The two candidate areas proposed for identification as potentially acceptable sites are NE-2 which overlies the Bottle Lake complex in southeastern Maine and SE-4 which overlies the Rolesville batholith in northeastern North Carolina. Portions of NE-2 are located within the Penobscot and Passamaquoddy Indian Reservations. This selection resulted from application of Steps 1 through 3 of the screening process and the

Step 4 review, as documented in Section 2. Particular attention was given to geologic considerations important to area characterization and postclosure performance; some considerations required evaluation/ interpretation of available data. The favorable geologic attributes of NE-2 and SE-4 relative to the eight other candidate areas with a 7 out of 9 frequency of occurrence are identified as follows:

- Host Rock Geometry - Host rock geometry refers to the size, shape, thickness, and subsurface lateral extent of the host rock, and the thickness of overburden. It is important to site a repository in crystalline rock which is large enough that construction-induced effects in the rock will not compromise expected repository performance. Preliminary candidate areas NE-2 and SE-4 are in the middle of the range of host rock geometries and areal extent of the ten candidate areas which have a 7 out of 9 frequency of occurrence. However, their geometries provide adequate flexibility for siting a repository. Except for NC-2, SE-1 and SE-6, candidate areas NE-2 and SE-4, have the least overburden. The relatively thin overburden of these candidate areas facilitate the early stages of area characterization designed to identify the preferred site location within a candidate area.
- Extent of Exposure - A greater amount of rock exposure is considered advantageous for characterization of a candidate area in order to identify those portions of the candidate area with more favorable geologic characteristics. With the possible exception of SE-6, candidate areas NE-2 and SE-4 have the largest percentages of outcrop exposure (approximately 25%) among the 10 candidate areas.
- Lithologic Homogeneity - Because of their granitic composition and plutonic origin, all ten of the 7 out of 9 frequency of occurrence candidate areas are considered to be massive in texture, and relatively homogeneous. Therefore, rock strength should vary little from point-to-point

throughout all candidate areas. Among the 10 candidate areas NE-2, SE-4 and NC-2 exhibit the most homogeneous granitic lithologies of the 10 candidate areas (See Sections 3.2.2.2.2, 3.2.3.5.2, and 3.2.1.2.2). Therefore, they have the most potential to be free of internal geologic contacts which could be potential ground-water flow paths. Other areas that contain some relatively homogeneous zones include NC-12, NC-13, NC-14 (primarily metamorphic gneisses); SE-1 (granitic gneiss) and NC-9 and NC-A5 (inferred granitoid rocks). Candidate area SE-6 (banded gneiss) exhibits the least amount of homogeneity.

- Major Structures, Faults or Fracture Zones - Lack of major structures, such as faults, and fracture zones within a candidate area represents a favorable characteristic for repository siting as such features may be potential ground-water flow paths. In very old rocks such as those that occur in the North Central Region, many of the shear zones and faults probably have been healed to the extent that they are difficult to distinguish from the surrounding rock mass. With the exception of NC-2, none of the 10 candidate areas are known to have cross-cutting faults within the rock body closer than 4 km (2.5 mi) to their boundaries. Thus, postemplacement faults are unlikely to represent potential ground-water flow paths. Candidate area SE-4 is known to be intruded by diabase dikes (See Section 3.2.3.5.2). These features may have the potential to be ground-water flow paths; they will be evaluated if they occur in what are otherwise more favorable portions of SE-4.

- Deformation [illegible] - Among the 10 candidate areas, NE-2 and SE- [illegible] [illegible]ally unaffected by later deformation (metamorphic [illegible] tectonic [illegible]) which may have caused the development of structures that could have become ground-water flow paths. In the North Central Region, the last tectonic event occurred approximately 1 billion years ago and, in general, most faults and structures have been healed through recrystallization to the point that they are not ground-water flow paths (NC-12, NC-13 and NC-14). Also, the metamorphic rocks have been recrystallized to the point that internal contacts do not represent discontinuities.
- Extent of Data Base - A relatively comprehensive data base from recent literature is available for the two rock bodies within which candidate areas NE-2 and SE-4 are located, as compared to the other 7 out of 9 candidate areas. The only exception is NC-2 on which a recent 1985 USGS professional paper has been published (Sims, et al., 1985).

In summary, the favorable geologic characteristics of NE-2 and SE-4 based on regional phase data are: massive texture, general homogeneity, good exposure, thick and deep-seated host rock, and little affects by later regional metamorphism or deformation. No known major structures or fracture zones cut across either candidate area. As discussed above, none of the other eight candidate areas with a frequency of occurrence of 7 out of 9 possess all of the above favorable geologic attributes.

In conclusion, the 12 proposed potentially acceptable sites and the eight candidate areas that may be designated as potentially acceptable sites, during [illegible] finalization or area phase investigations, are shown on Figure 5-2 and listed below:

Proposed Potentially Acceptable Sites	Candidate Areas	Plate
NC-3 (Wisconsin)	NC-2 (Wisconsin)	NC-1B
NC-6, -7, -10 (Minnesota)	NC-9, -12, -13, -14, -A5 (Minnesota)	NC-1A
NE-2, 4 (Maine)		NE-1A
NE-5 (New Hampshire)		NE-1A
SE-2, -3, (Virginia)	SE-1 (Virginia)	SE-1A
SE-4, -5, (North Carolina)		SE-1A
SE-7 (Georgia)	SE-6 (Georgia)	SE-1B

Prior to finalization of this draft area recommendation report the DOE will consider comments from Federal Agencies, States, Indian Tribes, and the general public.

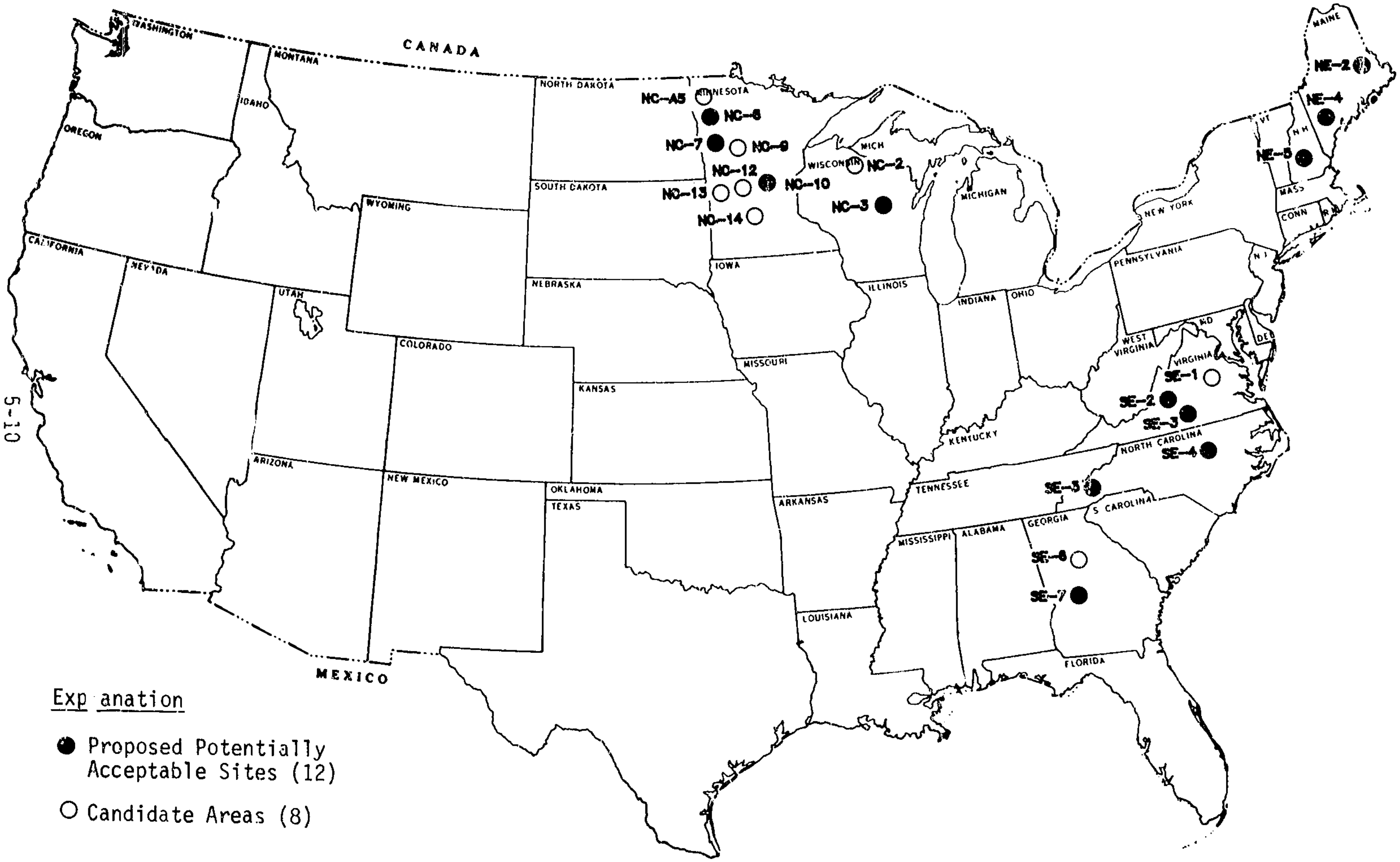

Figure 5-2. Proposed Potentially Acceptable Sites and Candidate Areas for the Second Repository

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APPENDIX A

STEPS 1 THROUGH 3 OF THE REGION-TO-AREA SCREENING PROCESS

A.1 DISQUALIFYING FACTORS SCREEN (STEP 1)

The first step in the region-to-area screening methodology is the elimination* of rock bodies or portions of rock bodies from further consideration based on the presence of one or more of five disqualifying factors (Deep Mines and Quarries, Federal-Protected Lands, Components of the National Forest Lands, State-Protected Lands, and Population Density and Distribution) set forth in the SMD (DOE, 1985b).

The disqualifying factors screen was accomplished by using data presented in the regional characterization reports to prepare maps that show the geographic distribution of these five disqualifiers in each of the seventeen involved States.

A.1.1. Deep Mines and Quarries

The DOE siting guidelines [10 CFR 960.4-2-8-1(d)(1)] state that a site shall be disqualified if "previous exploration, mining, or extraction for resources of commercial importance at the site have created significant pathways between the projected underground facility and the accessible environment."

One of the hazards associated with siting near a mined resource in crystalline rock arises from the possibility that the mine workings

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* The disqualification of rock bodies, (or portions thereof) during Step 1 precludes DOE from locating (i) the surface facility, or (ii) the restricted area or repository support facilities, as appropriate within the boundaries of the disqualified areas. In addition, a deep mine or quarry cannot be located within the controlled area.

intersect fractures and thus create significant hydrologic pathways from the repository horizon to the accessible environment. For the purpose of utilizing this disqualifier during region-to-area screening, the CRP disqualified an area of 23 km^2 (9 mi^2) centered on each 1-square-mile-grid cell containing an active or inactive mine or quarry deeper than 100 m (328 ft) based on the assumption that these would tend to intercept ground water in the regional flow regime and thereby create hydrologic pathways to the accessible environment. The depth measure for deep mines and quarries was conservative and was chosen to allow for potential effects on the regional ground-water flow system based on the available regional and local data from the eastern United States. The disqualification of the additional area around each deep mine or quarry is due to the lack of specific information in the regional data base concerning the extent and direction of workings and fractures and represents additional conservatism with respect to this condition. Workings in crystalline rocks or rock formations immediately adjacent to crystalline rocks in the eastern United States seldom extend more than 1.6 km (1 mi). Where workings were known to extend beyond the disqualified area, additional grid cells encompassing those workings were also disqualified.

A.1.2 Federal-Protected Lands

Section 960.5-2-5(d)(2) of the DOE siting guidelines provides that a site shall be disqualified if "any part of the restricted area or repository support facilities would be located within the boundaries of a component of the National Park System, the National Wildlife Refuge System, the National Wilderness Preservation System, or the National Wild and Scenic Rivers System." The CRP implemented this provision by disqualifying lands within the administrative boundaries of the Federal-protected lands listed below from further consideration as a location for the restricted area or repository support facilities.

A.1.2.1 National Park System (16 U.S.C. 1 et seq.)

National Parks	National Battlefield Parks
National Monuments	National Battlefield Sites
National Preserves	National Battlefields
National Lakeshores	National Historical Parks
National Seashores	National Memorials
National Historic Sites	National Recreation Areas
National Military Parks	National Parkways

A.1.2.2 National Wildlife Refuge System (16 U.S.C. 668 dd)

National Wildlife Refuges
Waterfowl Production Areas
Wildlife Management Areas
Wildlife Ranges
Other Protection and Conservation Areas for Species Threatened with Extinction

A.1.2.3 National Wilderness Preservation System (16 U.S.C. 1131 et seq.)

National Wilderness Areas

A.1.2.4 National Wild and Scenic Rivers System (16 U.S.C. 1271 et seq.)

Wild Rivers
Scenic Rivers
Recreational Rivers

A.1.3 <u>Components of the National Forest Lands</u>

National Forest Lands are defined in Federal statutes and regulations to comprise the following components: (1) forests (16 U.S.C. 581a), (2) forest experiment stations (36 CFR 251.23), (3) research natural areas (36 CFR 251.23), (4) national forest wilderness or primitive areas

(36 CFR 293, 16 U.S.C. 529), (5) special areas (36 CFR 294), and (6) national recreation areas. All six components were evaluated to determine whether they could meet the disqualifying condition tests of irreconcilable conflict-of-use and designation for resource preservation. Three components of the National Forest Lands were consequently judged by the CRP to warrant categorical disqualification under the provision of 10 CFR Part 960.5-2-5(d)(3), which requires disqualification if: "The presence of the restricted area or the repository support facilities would conflict irreconcilably with the previously designated resource-preservation use." The three components determined to categorically meet this test for region-to-area screening are research natural areas, primitive areas, and national recreation areas. These three components of National Forest Lands are typically dedicated to single-purpose use and are oriented to scientific value, public recreation, and environmental preservation.

Lands within the boundaries of these components, as indicated on forest maps published by the Forest Service, were disqualified from further consideration as a location for the restricted area or repository support facilities. The remaining portions of National Forest Lands were treated as a Step 2 variable in accordance with 10 CFR 960.5-2-5(c)(3).

A.1.4 State-Protected Lands

The DOE siting guideline 960.5-2-5(d)(3) also provides for the disqualification of any site where "the presence of the restricted area of the repository support facilities would conflict irreconcilably with ...any comparably significant State protected resource dedicated to resource preservation at the time of the enactment of the Act." The CRP worked extensively with the involved States to apply this guideline for purposes of region-to-area screening. The evaluation of "comparably significant" was based on a thorough study of the statutory and resulting descriptions of each category of lands that the involved States or the CRP staff suggested could warrant disqualified status.

Based on the language in these State statutes or regulations and on the existence of a reasonable analog with the Federal-protected lands components, including ownership of State wildlife areas, the CRP categorized the diverse and complex array of State-protected lands into three categories: disqualified status; potentially adverse status; or land without status under these provisions of the siting guidelines. Because of the length and complexity of the results of this analysis, the results are not reported here but may be found in their entirety, by State, in Appendix B of the SHD (DOE, 1985b). In general, however, lands within the administrative boundaries of State parks, State wild and scenic rivers, State wilderness areas, State natural areas, and certain types of State wildlife areas were disqualified from further consideration as a location for the restricted area or the repository support facilities. Those State-protected lands not determined to warrant disqualified status but which merit treatment in the regional phase under the DOE siting guidelines are identified and mapped as potentially adverse conditions in Step 2. These lands are also identified by State in Appendix B of the SMD.

A.1.5 Population Density and Distribution

It is the intent of the NWPA and the DOE siting guidelines to locate a repository outside of highly populated areas. The disqualifying factor of Population Density and Distribution addresses the coincidence and adjacency conditions of Section 112(a) in the NWPA. Guidelines 960.5-2-1(d)(1) and (2) provide that "A site shall be disqualified if - (1) Any surface facility of a repository would be located in a highly populated area, [coincidence] or (2) Any surface facility of a repository would be located adjacent to an area 1 mile by 1 mile having a population of not less than 1,000 individuals... [adjacency]." Highly populated area is defined in the DOE siting guidelines to mean "any incorporated place (recognized by the decennial reports of the U.S. Bureau of the Census) of 2,500 or more persons, or any census designated place (as defined and delineated by the Bureau) of 2,500 or more persons, unless it can be demonstrated that any such place has a lower population density than the mean value for the continental United States [76 persons per square mile in 1980.* [illegible] or county equivalents, whether incorporated or not, are specifically excluded from the definition of place as used herein."

For purposes of the region-to-area screening, the CRP made a conservative assumption that a repository surface facility sited any place within a minor civil division or census county division of 1,000 or more persons per square mile would be adjacent to an area 1 mile by 1 mile having a population of not less than 1,000 individuals.

Highly populated areas, as well as minor civil division and census county divisions with 1,000 or more persons per square mile, were identified on the basis of the 1980 census reports Series PC80-1-A (U.S. Bureau of the Census, 1982) of characteristics of the population. Boundaries for those places were taken from Bureau of the Census maps, and those areas were eliminated from further consideration as a location for repository surface facilities.

A.2 THE SCALED REGIONAL VARIABLES SCREEN (STEP 2)

The objective of Step 2 of the region-to-area screening methodology was to further evaluate the crystalline rock bodies or portions thereof that remained after Step 1, in terms of the regionally applicable potentially adverse and favorable conditions contained in the DOE siting guidelines. These potentially adverse and favorable conditions served as the basis for the 16 Step 2 variables defined in the SMD (DOE, 1985b). Section A.2.1 presents these variables, including their definition and associated scales. A given crystalline rock body that exhibited potentially adverse conditions was penalized in Step 2. Conversely, a

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* It should be noted that the SMD (DOE 1985b) inappropriately used 64 persons per square mile. This figure included Alaska and Hawaii.

crystalline rock body that exhibited favorable conditions was favored in Step 2 of the region-to-area screening methodology. The degree to which a crystalline rock body was penalized or favored because of any single variable was determined by how the variable was scaled (see Section A.2.1) and on how heavily weighted that variable was relative to the other Step 2 variables (see Section A.2.4). The product of Step 2 was a numerical value representing the aggregate favorability of each grid cell (1 square mile each) which were the accounting unit for those crystalline rock bodies (or portions thereof) not disqualified in Step 1.

A.2.1 Scaling

Scaling was the process by which the CRP translated physical conditions for each screening variable (potentially adverse or favorable) into a numerical value that could be used to consistently evaluate the aggregate favorability of crystalline rock bodies. As a result of substantial interaction with representatives from the seventeen involved States at three workshops (June 1983, November 1983, and February 1984)*, and comments received from the States subsequent to these workshops and after reviewing the draft SMD, for each region-to-area screening variable a standard 1 to 5 scale that represented degrees of adversity and favorability was developed as follows:

1	2	3	4	5
More Adverse				More Favorable

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* In the June 1983 meeting, only 15 States were represented; in the November 1983 and February 1984 meetings, only 16 States were represented.

To the extent practicable, each variable was given the same number of increments and numerical assignments corresponding to a range of conditions for that variable. In all cases, the end points on the standard scale were given values of 1 and 5. Intermediate points on the scale were also given values, except for the Suspected Quaternary Faulting variable which had no intermediate increments.

A.2.2 Scaled Geologic and Environmental Variables

A.2.2.1 Rock Mass Extent

This Step 2 variable was based on guidelines 10 CFR 960.4-2-3(b)(1) and 960.5-2-9(b)(1) and (c)(1), which address the areal extent of the host rock body. Any rock body selected for further characterization must be large enough to accommodate the subsurface space required for construction of the repository. This minimum size is the area of a circle approximately 3 km (2 mi) in diameter. The regional survey included rocks with a horizontal areal extent of at least 100 km^2 (39 mi^2), as shown on a bedrock map, irrespective of shape. For region-to-area screening, the CRP inscribed circles in each rock body after application of the Deep Mines and Quarries disqualifying factor (the only disqualifying factor which eliminates portions of rock bodies from consideration as the location of underground components of the repository). The favorability of each crystalline rock body was then determined by the diameter of the maximum circle that fit into the rock body, on the following scale:

Diameter of Maximum Circle That Will Fit in Rock Body (miles)

≤2	>2-8	>8-14	>14-20	>20
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.2 Major Ground-Water Discharge Zones

This Step 2 variable was based on guideline 10 CFR 960.4-2-1(b)(4)(ii) and NRC regulation 10 CFR 60.122(b)(2)(ii), which address hydraulic gradient as related to distance and travel time to the accessible environment. In areas of major ground-water discharge (such as water bodies and major through-flowing streams), the primary direction of ground-water flow is toward the surface; distance and travel time to the accessible environment are thus at a minimum, which is an unfavorable condition with respect to siting a high-level nuclear waste repository. The CRP used distance from major ground-water discharge points in developing the scale for this variable, as follows:

Distance to Discharge Point (Major Water Body)

Underneath Major Stream (Discharge Zone)	0–6 miles from Discharge Zone or to Drainage Basin Divide if ≤6 miles			>6 miles from Discharge Zone to Drainage Divide
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.3 Rock and Mineral Resources

This Step 2 variable was based on guidelines 10 CFR 960.4-2-8-1(b)(1) and (c)(1)-(4), which address the concern that the presence of nearby resources could encourage human intrusion into the repository and jeopardize waste isolation. Conversely, the presence of the repository preempts the future use of such resources. The favorability of each rock body was determined by its distance from shallow deposits (<100 m or 328 ft) of strategic or unique minerals, as follows:

Distance from Resource Deposit (miles)

0–1		>1–2		>2
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.4 Seismicity

This Step 2 variable was based on guidelines 10 CFR 960.4-2-7(b) and (c), and NRC regulation 10 CFR 60.122 which address ground motion due to earthquakes. Such ground motion could result in damage to surface and subsurface facilities, as well as the creation of ground-water flow paths due to possible reactivation of surface faults. Data on seismicity could be used as a screening variable because they can be related to known or suspected seismic source zones and can be expressed as probabilistic occurrences of maximum ground acceleration which can be used to define areas of relative seismic hazard. The scale used in assessing the favorability of each rock body rated the maximum horizontal ground acceleration which has a 90 percent probability of not being exceeded in 250 years, as shown below:

Maximum Probable Ground Acceleration (% g)

>70	>50–70	>30–50	>10–30	<10
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.5 Suspected Quaternary Faulting

Quaternary faulting is defined as a potentially adverse condition by the NRC (10 CFR 60.122) and the DOE (10 CFR 960.4-2-7(b) and (c) and 10 CFR 960.5-2-11 (c)(1)). Land units where Quaternary faulting or fault movement have been noted should be avoided due to the potential for fault movement to compromise the integrity of a repository system and impair its ability to isolate waste by changing the ground-water flow system. The favorability of each rock body was assessed using distance from known and suspected zones of Quaternary faulting as follows:

Distance From Fault (miles)

≤5				>5
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.6 Postemplacement Faulting

This Step 2 variable also was based on guidelines 10 CFR 960.4-2-7(b) and (c), and 10 CFR 960.5-2-9(c)(5) The intent of this variable was to avoid very large faults and zones of brittle deformation that are likely to represent potential ground water flow paths. The favorability of each rock body was assessed using the distance from faults, shear zones, and zones of brittle deformation of any age having a length of greater than 24 km (15 mi) or that are shown on small-scale bedrock maps, assessed as follows:

Distance From Fault (miles)

0-3	>3-4	>4-5	>5-6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.7 Proximity to Federal-Protected Lands

Federal-protected lands identified as being disqualified in Step 1 of the region-to-area screening methodology have been established to protect and provide for public enjoyment of important national resources. The use of adjacent lands for repository surface facility development could have direct and indirect adverse effects on these lands; therefore, consistent with 10 CFR 960.5-2-5(c)(3), proximity to Federal-protected lands was treated as a Step 2 screening variable, using straight-line distance from those lands as an estimate of potential impact/adversity.

Distance From Boundary (miles)

0-3	>3-4	>4-5	>5-6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.8 Proximity to State-Protected Lands

Based on guideline 10 CFR 960.5-2-5(c)(4), proximity to State-protected lands which were disqualified was treated as a region-to-area screening variable indicating potentially adverse conditions. Favorability of each rock body was determined using a straight-line distance from those lands as follows:

Distance From Boundary (miles)

0-3	>3-4	>4-5	>5-6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.9 Proposed Federal-Protected Lands

This Step 2 variable was based on guideline 10 CFR 960.5-2-5(c)(3), which is a potentially adverse condition addressing Federal-protected lands. Proposed Federal-protected lands were treated as a regional screening variable indicating potentially adverse conditions. As defined, these lands exhibit potential for inclusion in specific categories of Federal-protected lands. That is, they may become designated protected lands at some future date. The region-to-area screening process will penalize these areas, but because they currently do not enjoy the full measure of Federal protection, treatment as a disqualifying factor is not warranted. The scale for assessing the favorability of each rock body was based upon distance from these features. Areas within the administrative boundaries of proposed Federal-protected lands were assigned the least favorable scale value for repository siting. More favorable designations were assigned for increased distance from proposed Federal-protected area boundaries.

Distance From Proposed Federal-Protected Lands (miles)

Inside Boundary	≤ 2	>2–4	>4–6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.10 National Forest Lands

As discussed under Section A.1.3, all lands within the administrative boundaries of national forests which are not classified as disqualifiers were treated as potentially adverse conditions, consistent with 10 CFR 960.5-2-5(c)(3). Location within the feature was given the most adverse rating, with the degree of adversity decreasing with increased distance outside the boundaries, as follows:

Distance from National Forests (miles)

Inside Boundary	≤2	>2–4	>4–6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.11 State Forest Lands

This Step 2 variable was based on guideline 10 CFR 960.5-2-5(c)(4). State forest lands were treated in a fashion analogous to national forest lands. Existing administrative boundaries for State forest lands were mapped, and greater distances from these boundaries used to determine lesser degrees of adversity, as indicated below:

Distance From State Forests (miles)

Inside Boundary	≤2	>2–4	>4–6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.12 Designated Critical Habitat for Threatened and Endangered Species

The presence of critical habitats for threatened and endangered species that may be compromised by the repository or its support facilities is a potentially adverse condition, under guidelines 10 CFR 960.5-2-5(c)(2) and (6). Therefore, lands within the existing boundaries of areas designated as critical habitat for federally listed threatened and endangered species were treated as more adverse, with the estimated degree of adversity decreasing with distance, as follows:

Distance From Boundary (miles)				
Inside Boundary	≤2	>2–4	>4–6	>6
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.13 Wetlands

This Step 2 variable was based on guidelines 10 CFR 960.5-2-5(c)(1) and (2). The importance of preserving wetlands has been officially recognized and made part of national policy in Executive Order 11990, Protection of Wetlands, and is implemented by the DOE in 10 CFR 1022. Development of a repository in or near a wetland feature could represent major conflicts with environmental requirements and/or could result in significant environmental impacts that cannot be avoided or mitigated. Areas that are classified as wetlands include swamps, marshes, bogs, and similar features such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds. Given the large number of wetlands in the regions, the widely varying data sources, and dense areas of small wetlands, the treatment of this variable was complex. However, the sampling technique used (see Section 5.3.8 of the SMD, DOE, 1985b) effectively depicts the boundaries of large wetlands as well as areas with a high density of small wetlands. Proximity again was used as a measure of adverse impact; however, the distance limit for wetlands is narrower because the potential surface hydrology, water quality, ecological, and noise-related impacts of repository construction and operation are judged by the CRP to be unlikely, in most instances, to extend beyond a 5-km (3-mi) limit around a given wetland.

Distance From Wetlands (miles)

Inside Boundary	≤1	>1-2	>2-3	>3
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.14 Surface Water Bodies

The concerns associated with the occurrence of water bodies in the regional phase were that their presence could prohibit surface facility development or lead to the flooding of surface facilities. These concerns are reflected in guidelines 10 CFR 960.5-2-8(c) and 10 CFR 960.5-2-10(b)(2). This variable received similar treatment to wetlands in the sampling technique used to identify dense areas of small water bodies, and in the distance limit, which was also reduced to 5 km (3 mi). The CRP used this Step 2 variable to assess the favorability of rock bodies based upon distance from major rivers, perennial lakes, reservoirs, oceans, bays, and estuaries, as follows:

Distance From Water Body (miles)

Water Body Indicated	≥1	>1-2	>2-3	>3
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.15 Population Density

This Step 2 variable, like the related Step 1 disqualifying factor, was based on the intent of the NWPA and guidelines 10 CFR 960.5-2-1(b)(1) and (c)(2) to locate a repository outside of highly populated areas. The use of population densities less than 1,000 persons per square mile as a Step 2 variable provided a conservative surrogate for the more detailed studies required at later phases to accurately assess the health and safety and other impacts which may result from the siting, construction and operation of a repository. The scale for this variable, as set forth below, used equal increments of density below the 1,000 person per square mile disqualifying threshhold, reflecting the regional phase assumption that impacts of a repository are a function of population density.

Population Density (persons per square mile)

800-999	600-799	400-599	200-399	0-199
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.2.16 Proximity to Highly Populated Areas or to 1-Mile Square Areas with 1,000 or More Persons

This Step 2 variable is based upon 10 CFR 960.5-2-1(b)(2) and (c)(2), and 960.5-2-6(b)(1)-(4) and (c)(1), (2) and (4), which address proximity to population centers, as a safety concern and as related to socioeconomic impacts on the area. Greater distances from highly populated areas and from an MCD or CCD with 1,000 or more persons per square mile were scaled more favorably, as shown below:

Proximity to Highly Populated Areas or to 1-Mile Square Areas With 1,000 or More Persons (miles)

0-12	>12-24	>24-36	>36-48	>48
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.2.3 Favorability Maps

Using the variable scales established in the SMD, favorability maps, utilizing the final data base applicable to Steps 2 and 3 of the region-to-area screening methodology as contained in the six regional characterization reports (DOE, 1985c through h) issued in September 1985 were prepared for each variable that geographically depicted those numerical assignments as shades of gray. Each number (1 through 5) was assigned a standardized shade of gray for all variables. By convention, the darker the gray tone, the more adverse was the condition being depicted.

A.2.4 Composite Map Development

Composite favorability maps were prepared after favorability maps were generated for each variable and after sets of weights were developed. Each grid cell was given a numerical entry for each Step 2 variable, depicting the appropriate level (from 1 to 5) of adversity or favorability. Composite or aggregate adversity or favorability maps were prepared by calculating the weighted (arithmetic) average of all numerical entries in each grid cell as an index or estimate of composite favorability. One composite favorability map was prepared using each set of weights with the same set of variable scales. The composite favorability maps indicate [illegible] the potentially most favorable rock bodies or portions of rock bodies are located as determined by that specific set of variable weights.

Composite favorability was evaluated for each weighting and scaling scenario to support the candidate area selection process. Each map generated provides a graphic depiction of those crystalline rock bodies, or portions thereof, which are potentially the most favorable with respect to the specific assumptions used in their preparation. The darker the area on the composite maps, the less favorable that area is based on that set of weights and scales. These maps are used as key inputs to the Step 3 sensitivity analyses, and are discussed in Section 3.1.2.

A.3 SENSITIVITY ANALYSES (STEP 3)

The third step in the region-to-area screening methodology was sensitivity analyses performed on the results of Step 2. The following four types of sensitivity analyses were conducted in this step,

- modifying the scales of certain Step 2 variables
- incorporating other geologic variables based upon available rock body-specific data
- evaluating the effects of using the geometric mean instead of the arithmetic mean as an alternate index of aggregate favorability in deriving composite maps
- preparing and comparing summary composite maps.

A.3.1 Modifying Variable Scales

The selection and location of preliminary candidate areas are influenced by the scales developed for Step 2 of the region-to-area screening process. In an effort to test the sensitivity of preliminary candidate area selection to Step 2 scaling, the CRP technical staff modified the scales of three of the Step 2 variables. The selection by

DOE of which scales to modify was based on feedback from the prior methodology development workshops, on formal comments received on the scales contained in the draft SMD (DOE, 1984c), and on CRP staff views of the variable scales. DOE determined that three Step 2 variable scales should be modified as part of the sensitivity analysis. The modified scales to be used for these variables were established by DOE prior to the weighting workshops and these scales were documented in the SMD (DOE, 1985b). The modified scales for these three Step 2 variables are as follows.

A.3.1.1 Rock Mass Extent

The scale on rock mass extent was modified to reflect an extreme of 14 miles instead of 20 miles used in the original scale. The 20-mile scale was originally selected on the basis that it provided adequate flexibility to position a repository site within it. CRP felt that since a repository site can be easily placed within a 7-mile-diameter circle, a 14-mile-diameter rock mass extent would provide the adequate flexibility needed.

Diameter of Maximum Circle That Will Fit in Rock Body (miles)

≤2	>2-8	-	>8-14	>14
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.3.1.2 Seismicity

The more adverse (40% g) end of the modified scale presented below more realistically represents the extreme ground acceleration that may be expected in the three regions being investigated, while the extreme value of 70% g in the original scale was related to maximum acceleration expected for the United States.

Maximum Probable Ground Acceleration (% g)

>40	>30–40	>20–30	>10–20	≤10
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.3.1.3 Proximity to Highly Populated Areas or to 1-Mile Square Areas with 1,000 or More Persons

The scale on population distances was modified from the 48-mile adverse extreme to the 20-mile more favorable extreme to explore the effect on aggragate favorability if the preliminary candidate areas are assumed to have less impact on populated areas. Although at either 48- or 20-mile distances radiological effects are inconsequential based on preliminary accident analyses in the Final Generic Environmental Impact Statement for Management of Commercially Generated Radioactive Waste (DOE, 1980), this change considers the socioeconomic effects related to the preliminary candidate areas.

Distance from Highly Populated Areas or to 1-Mile Square Areas with 1,000 or More Persons (Miles)

0–5	>5–10	>10–15	>15–20	>20
1	2	3	4	5
More Adverse		Scale Value		More Favorable

The set of scales with the three changes noted above was used with corresponding sets of weights developed at the weighting workshops (see Section 2 3) to generate additional composite favorability maps. These maps were compared with the composites that resulted from Step 2 to determine the extent to which scaling differences affected the identification of the most favorable preliminary candidate areas. The results of these comparisons are presented in Section 3.1.3.2.

A.3.2 Incorporating Step 3 Variables

The Step 2 region-to-area screening variables described in Section A.2 were selected with the goal of developing a reasonably consistent data base for all 17 involved States. In response to State requests that other rock body specific data be incorporated into the analysis before making candidate area recommendations, the CRP developed the concept of Step 3 variables. This allowed the consideration of variables which have only scattered data available across the 17 involved States (e.g., state-of-stress), or for which the data collection effort to achieve a consistent data base for use in Step 2 would have been prohibitively expensive in relation to the expected ability of the variable to discriminate among rocks (e.g., ground-water resources). The four Step 3 variables are described below.

A.3.2.1 Thickness of Rock Mass

The DOE siting guidelines favor rock bodies that have greater vertical extent, for ease of modeling repository performance. Guideline 10 CFR 960.4-2-5(b)(1) specifies that a vertical dimension which permits emplacement of the waste at a depth of at least 300 m (984 ft) below the directly overlying ground surface is a favorable condition. Because most crystalline rocks [illegible] depths of many thousands of feet, the scale used for this Step 3 variable was given a broad range, as follows:

Distance to Bottom of Rock Body (feet)				
0-3,000	>3,000-4,500	>4,500-6,000	>6,000-7,500	>7,500
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.3.2.2 Thickness of Overburden

This Step 3 variable is based on guidelines 10 CFR 960.5-2-9(c)(2), and 960.5-2-10(b)(1) and (c), addressing conditions relating to the constructability of the repository. Construction of shafts in crystalline rock is complicated by surficial deposits including soils, glacial drift, and saprolites, especially where these deposits are saturated with ground water. This variable was only applied in the North Central Region where contoured data were available. The scale below was used to reflect concerns on thickness of overburden related to complexity of construction and the available data. The scale adopted is the one that fits the most abundant data and is within the range of values significant to this issue.

Thickness of Overburden (feet)				
>200		>100-200		≤100
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.3.2.3 State-of-Stress

Knowledge of the state-of-stress of the rock mass is an important characteristic to engineering and construction of an underground repository, because it relates to excavation stability. The DOE siting guidelines define a favorable condition under 10 CFR 960.5-2-9(b)(2) as a host rock with characteristics that would require minimal or no artificial support for underground openings to ensure safe repository construction, operation and closure. The measure of stress state is the magnitude of the difference between the maximum and minimum principal stresses expected at the repository horizon. Because relatively few stress measurements have been made in the three regions of interest (and even fewer in crystalline rock bodies, the scale adopted for application of this Step 3 variable was based on (1) the range of stress conditions actually found in nature, (2) the range of conditions of concern in constructing an underground facility, and (3) the uniaxial strength of crystalline rock bodies.

Maximum Stress Difference (MPa)*

>30	>23–30	> 16–23**	> 10–16	≤10
1	2	3	4	5
More Adverse		Scale Value		More Favorable

A.3.2.4 Ground-Water Resources

Concern for major sources of ground water as flow paths to the accessible environment is reflected in DOE Siting Guidelines 10 CFR 960.4-2-1(c)(2) and 960.5-2-10(b)(1). Availability, reliability and utility of data on this condition vary widely among and within the States, but it was considered important enough to apply to favorability determinations of crystalline rock bodies where available. The scale adopted is based on the range of ground-water yield that can be anticipated and the most abundant data available.

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* One MPa (megapascal) equals 145 pounds per square inch.
** This scale was incorrectly presented in the SMD (DOE, 1985b) as 17–23.

Average Ground Water Yield (gpm)

>500	>100-500		>20-100	≤20
1	2	3	4	5
More Adverse		Scale Value		More Favorable

Weights for these additional 4 variables were also developed during the weighting workshops (as discussed in Section 2.3) by having workshop participants assign weights for these four Step 3 variables based upon their perception of the importance of that variable relative to the other variables. The set of weights was then computer-adjusted to the 1,000 point total. To incorporate this data into the favorability analysis, CRP generated new composites and summary composites based upon the addition of the new variable(s) to affected grid cells. For those grid cells without Step 3 data, nothing was assumed about the adversity or favorability of those grid cells. The composites and summary composites which included Step 3 data were evaluated along with those generated with data on Step 2 variables and variables scales, as discussed in Section 3.1.3.

A.3.3 Using Alternative Index of Aggregate Favorability

Step 2 used the weighted average (arithmetic mean) as a measure of central tendency (i.e., aggregate favorability) for development of composite favorability maps. The CRP believes that the weighted average is the appropriate measure of central tendency. In the SMD (DOE, 1985b), it was indicated that the geometric mean might aid in identifying or discriminating among the preliminary candidate areas. A statistical analysis of the use of the weighted average versus the geometric mean was done on the 20 Step 2 and 3 variables to determine whether the use of the geometric mean would significantly change the selection of the preliminary candidate areas. This assessment is documented in Appendix B.

A.3.4 Evaluating Different Sets of Weights by Preparing and Comparing Summary Composite Maps

Step 2 and the sensitivity analyses (Step 3) described previously led to the development of numerous composite favorability maps. The large number of these maps made it difficult to identify preliminary candidate areas for further study without further processing into a form that facilitated decision-making. This form was termed the "summary composite map." Development of summary composite maps is described in Section 3.1.3.1.

The summary composite map was used to identify the degree of similarity or coincidence resulting from the various weight sets for preliminary candidate areas for a related series of composites. The CRP wanted to identify those preliminary candidate areas with the highest aggregate favorability and highest degree of coincidence.

APPENDIX B

ALTERNATE INDEX OF AGGREGATE FAVORABILITY

In accordance with the SMD (DOE 1985b), DOE evaluated the use of the geometric mean as an alternate index of aggregate favorability for the development of composite favorability maps. The weighted average, which is the reference index of aggregate favorability was described in Section 3.1.2.1. The purpose of the evaluation is to determine if the aggregate favorability derived using the weighted averages would differ significantly from the aggregate favorability derived using the geometric mean.

B.1 WEIGHTED AVERAGE

As described in Section 3.1.2.1, Step 2 of the region-to-area screening methodology uses the weighted average as the reference index of aggregate favorability to develop the composite favorability maps. The formula for the weighted average, which is equivalent to the arithmetic mean, is as follows:

$$AM = 1/1000 \sum_{i=1}^{n} W_i \cdot S_i$$

where:

AM = arithmetic mean (weighted average)

$\sum_{i=1}^{n}$ = summation sign (over n variables)

W_i = weight assigned to variable i

S_i = scale value for variable i

1000 = total weighting points allocated

n = number of variables

The weighted average was selected as the reference index of aggregate favorability since it is believed to represent a reasonable statistical measure of central tendency in the context of the composite favorability map development.

B.2 GEOMETRIC MEAN

Section 3.2.5.2 of the SMD (DOE, 1985b) proposed the evaluation of another index, the geometric mean, as part of Step 3 - Sensitivity Analyses. The formula for the geometric mean (GM) for the case where each scaled variable, S_i, is associated with a weighting factor, W_i, is as follows:

$$GM = \left[\prod_{i=1}^{n} S_i^{W_i} \right]^{1/1000}$$

where:

$\prod_{i=1}^{n}$ = Multiplication sign (over n variables)

By taking the logarithm of both sides, the formula reduces to

$$\text{Log } GM = 1/1000 \quad \sum_n W_i \cdot \text{Log } S_i$$

The standard scale used to represent adversity and favorability of the Step 2 and Step 3 region-to-area screening variables is of an interval type as opposed to a ratio scale. Based on this observation and from the standpoint of measurement theory, the geometric mean is not a permissible statistic representing the central tendency for an interval scale (Stevens, 1964).

B.3 COMPARISON OF ALTERNATE INDICES

Before developing composite favorability maps based on the geometric mean, a test was carried out to examine if the use of the geometric mean as an alternate index of aggregate favorability would provide additional insight into the results obtained by the use of the weighted average.

The test involved the calculation and comparison of aggregate composite favorability using the weighted average and geometric mean as the index of favorability for each of the nine weight sets and for a single phase. Phase C, 20 screening variables with the original SMD scales, was chosen as the basis of the test because this phase incorporated all screening variables used in Steps 2 and 3. Rather than using actual scaled regional variables, this information has been developed through simulation. Twenty random, digital numbers in the range 1 through 5 from a uniform distribution were generated to represent the 20 Step 2 and 3 regional variables. Composite favorability values were calculated using the weighted average or arithmetic mean (AM) and the geometric mean (GM) using the randomly generated scale values and the nine weight sets developed at the weighting workshops for Phase C (see Tables 2-6 and 2-10). The calculation of composite favorability was repeated several thousand times for each weight set and for each alternate index of favorability, i.e, AM and GM.

Table B-1 shows the results of 50 runs of the test as well as the averages of using the two means for all runs. Based on this test, the following observations and conclusions were made:

- There is not a single case where the aggregate favorability using the geometric mean is larger than or equal to the aggregate favorability derived using the weighted average.

- The long run averages of the arithmetic versus geometric means are different and the difference between them is essentially constant, i.e., 0.36.

Based on the above observations. if a group of preliminary candidate areas are identified at a given aggregate favorability score by using the arithmetic mean as the index of favorability, the same group of areas would be identified at a slightly lower aggregate favorability score when calculated by using the geometric mean as the index of favorability.

This also demonstrates that the use of the geometric mean instead of the weighted average to establish the benchmarks for use in developing the summary composite maps, as described in Section 3.1.3.1, would not result in different preliminary candidate areas being identified. Using the geometric mean in Step 3 will not provide additional insight into the results which have been derived using the weighted average as the index of aggregate favorability. Thus, this alternate index of aggregate favorability was not used further.

Table B-1. Comparison of Arithmetic and Geometric Means Over 50 Sets of Random Variables in the Range 1 Through 5

	SUBGROUP 1		SUBGROUP 2		SUBGROUP 3		SUBGROUP 4		SUBGROUP 5		SUBGROUP 6		SUBGROUP 7		SUBGROUP 8		SUBGROUP 9	
	AM	GM	AM	GM	AM	GM	AM	GM	AM	GM	AM	GM	AM	GM	AM	GM	AM	GM
1	2.24	1.98	2.74	2.38	2.97	2.63	2.86	2.54	2.81	2.47	2.79	2.40	3.17	2.72	3.01	2.67	2.63	2.30
2	2.64	2.14	2.78	2.33	2.71	2.29	2.87	2.47	2.99	2.60	3.84	3.70	2.95	2.44	3.14	2.78	3.05	2.72
3	3.24	3.10	3.07	2.86	2.94	2.71	2.92	2.67	2.95	2.74	3.08	2.78	3.04	2.82	2.74	2.50	3.03	2.79
4	2.37	1.95	2.60	2.20	2.51	2.15	2.74	2.40	2.80	2.47	3.99	3.89	2.93	2.59	2.85	2.53	3.00	2.70
5	3.56	3.09	3.13	2.63	2.94	2.45	2.68	2.38	2.81	2.33	2.42	2.15	2.74	2.24	2.75	2.28	2.62	2.17
6	2.49	1.99	2.92	2.38	2.91	2.30	3.22	2.68	3.01	2.53	3.64	3.44	3.34	2.82	2.81	2.35	3.07	2.51
7	3.34	2.95	2.98	2.65	2.99	2.61	2.78	2.45	2.88	2.63	2.12	1.97	2.65	2.40	2.56	2.26	2.45	2.16
8	3.25	3.00	3.02	2.72	2.79	2.49	2.97	2.64	2.85	2.54	3.37	2.97	2.76	2.52	2.71	2.45	2.78	2.39
9	3.08	2.92	3.28	3.08	3.37	3.18	3.41	3.16	3.34	3.09	3.56	3.25	3.45	3.23	3.17	2.30	3.24	2.91
10	2.68	2.42	2.92	2.58	3.17	2.79	2.99	2.60	2.78	2.46	2.56	2.23	2.83	2.40	2.57	2.34	3.09	2.80
11	3.26	2.91	2.83	2.39	2.72	2.28	2.67	2.22	2.58	2.14	2.93	2.48	2.87	2.44	2.76	2.31	2.61	2.18
12	2.98	2.87	2.93	2.72	2.90	2.65	2.82	2.51	2.75	2.44	2.06	1.79	3.22	3.01	2.90	2.55	2.55	2.23
13	3.63	3.44	3.73	3.47	3.52	3.25	3.63	3.38	3.83	3.61	3.94	3.83	4.11	3.89	3.62	3.34	3.38	3.08
14	3.79	3.63	3.68	3.40	3.93	3.63	3.53	3.15	3.59	3.23	3.28	2.98	3.65	3.42	3.54	3.27	3.45	3.06
15	3.48	3.34	3.34	3.17	3.29	3.05	3.30	3.07	3.18	2.96	2.69	2.32	3.34	3.16	3.01	2.74	3.02	2.73
16	3.64	3.36	3.47	3.05	2.98	2.50	3.27	2.85	3.38	3.02	4.07	3.54	3.66	3.20	3.49	3.08	3.14	2.77
17	3.90	3.53	3.41	2.86	3.23	2.67	3.23	2.71	3.25	2.70	4.85	4.75	3.33	2.74	3.33	2.67	3.95	3.54
18	3.07	2.72	2.73	2.32	2.50	2.14	2.64	2.25	2.88	2.48	3.32	2.92	2.45	2.01	3.09	2.76	3.16	2.79
19	2.59	2.26	2.74	2.33	2.73	2.31	3.12	2.67	2.98	2.56	2.64	2.16	2.36	2.00	3.19	2.74	2.93	2.42
20	4.12	3.89	3.69	3.35	3.42	2.97	3.61	3.27	3.72	3.43	4.27	4.11	3.44	3.06	3.62	3.25	3.56	3.14
21	3.91	3.61	3.32	2.84	3.16	2.76	2.94	2.46	2.88	2.38	3.06	2.54	3.31	2.77	2.66	2.16	2.51	2.06
22	3.57	3.38	3.63	3.41	3.50	3.29	3.50	3.20	3.74	3.47	4.02	3.73	3.61	3.38	3.82	3.46	3.24	2.82
23	3.02	2.84	2.95	2.64	3.00	2.61	3.26	2.87	3.41	3.10	3.04	2.67	3.14	2.77	3.45	3.07	3.73	3.35
24	2.73	2.20	3.03	2.59	3.04	2.62	3.14	2.75	2.95	2.53	3.56	3.40	3.35	3.02	2.73	2.37	2.87	2.59
25	2.39	2.02	2.66	2.28	2.74	2.37	2.70	2.30	2.69	2.34	2.24	1.89	2.96	2.69	2.33	1.97	2.81	2.39
26	3.27	2.06	3.41	3.09	3.17	2.73	3.40	3.01	3.20	2.93	3.64	3.44	3.57	3.12	3.53	3.31	3.49	3.17
27	3.85	3.64	3.58	3.26	3.52	3.25	3.65	3.39	3.78	3.49	3.61	3.43	3.43	3.04	3.81	3.56	3.85	3.66
28	3.27	3.06	3.35	3.12	3.45	3.20	3.49	3.16	3.57	3.27	3.63	3.37	3.23	2.97	3.85	3.59	3.51	3.19
29	3.74	3.36	3.32	2.98	3.09	2.77	3.12	2.83	3.21	2.93	3.91	3.47	2.89	2.52	3.53	3.22	3.44	3.12
30	3.80	3.47	3.31	2.96	3.47	3.18	3.26	2.91	3.20	2.82	2.42	2.05	3.25	2.97	3.09	2.68	3.23	2.84
31	3.82	3.48	3.33	2.94	3.13	2.69	3.28	2.96	3.22	2.93	3.68	3.55	3.17	2.82	3.74	3.56	3.58	3.30
32	2.36	2.02	2.83	2.48	2.81	2.51	3.29	2.92	3.32	3.01	3.30	2.93	2.98	2.80	3.32	2.92	3.49	3.07
33	4.19	3.98	3.92	3.70	3.63	3.30	3.67	3.44	3.88	3.68	3.31	3.74	4.10	3.89	4.05	3.93	3.70	3.48
34	2.44	1.92	2.80	2.26	2.53	2.01	2.92	2.37	2.82	2.27	3.35	3.02	3.10	2.54	2.33	1.91	3.05	2.54
35	3.53	3.35	3.20	2.88	3.21	2.90	3.03	2.65	3.04	2.64	3.40	2.96	3.02	2.75	2.77	2.33	2.82	2.43
36	2.86	2.39	2.91	2.42	2.94	2.46	3.03	2.54	2.86	2.35	2.03	1.64	3.13	2.61	3.22	2.71	2.77	2.33
37	2.71	2.09	3.12	2.58	3.25	2.74	3.08	2.62	3.27	2.82	3.59	3.13	3.18	2.67	3.03	2.60	3.14	2.62
38	2.76	2.65	2.78	2.55	3.10	2.88	2.79	2.53	2.95	2.68	3.10	2.84	2.80	2.47	3.36	3.16	2.88	2.67
39	2.71	2.19	2.62	2.09	2.72	2.18	2.90	2.44	2.77	2.29	1.87	1.46	2.27	1.78	2.53	2.09	2.67	2.27
40	1.72	1.45	2.32	1.91	2.44	2.08	2.57	2.16	2.43	2.00	2.89	2.36	2.45	2.07	2.37	1.88	2.31	1.89
41	4.01	3.82	3.71	3.51	3.44	3.18	3.44	3.23	3.56	3.41	3.01	2.87	3.74	3.56	3.48	3.34	3.14	2.93
42	2.79	2.64	2.68	2.44	2.78	2.55	2.65	2.24	2.44	2.12	2.20	1.96	2.66	2.43	2.57	2.19	2.78	2.46
43	3.23	2.86	2.97	2.48	3.24	2.78	2.97	2.52	2.83	2.34	1.74	1.54	2.70	2.30	2.55	2.12	2.85	2.36
44	2.05	1.76	2.39	2.07	2.82	2.45	2.56	2.30	2.53	2.18	1.84	1.71	2.39	2.10	2.56	2.23	2.64	2.28
45	2.99	2.74	2.90	2.58	2.99	2.72	3.12	2.79	3.01	2.70	3.03	2.64	2.50	2.10	3.06	2.77	3.51	3.25
46	1.79	1.51	2.18	1.81	2.15	1.73	2.43	2.01	2.30	1.91	3.19	2.72	2.19	1.82	2.87	2.39	2.63	2.16
47	3.06	2.97	3.11	2.94	3.24	3.06	3.27	3.05	3.42	3.23	3.04	2.90	3.12	2.97	3.30	3.02	3.19	2.92
48	2.14	1.92	2.44	2.15	2.65	2.33	3.39	2.78	3.02	2.66	2.81	2.41	2.32	2.01	3.12	2.80	3.43	3.12
49	3.42	3.20	3.19	2.95	3.02	2.75	2.57	2.71	3.12	2.88	3.07	2.85	2.76	2.53	2.98	2.75	2.84	2.59
50	4.21	4.05	4.06	3.80	3.78	[illegible]	[illegible]	3.57	3.95	3.73	4.17	3.93	4.10	3.87	4.11	3.99	3.90	3.63

MEANS OF THE MEANS(5000 ITERATIONS

	SG1 AM	SG1 GM	SG2 AM	SG2 GM	SG3 AM	SG3 GM	SG4 AM	SG4 GM	SG5 AM	SG5 GM	SG6 AM	SG6 GM	SG7 AM	SG7 GM	SG8 AM	SG8 GM	SG9 AM	SG9 GM
	3.00	2.55	3.00	2.64	3.00	[illegible]	3.00	2.63	3.00	2.63	2.99	2.64	3.00	2.65	3.00	2.64	3.00	2.64

APPENDIX C

ALTERNATE SUMMARY COMPOSITE MAPS

C.1 ALTERNATES CONSIDERED

In the process of implementing the region-to-area screening methodology, three other types of summary composite maps (in addition to the frequency of occurrence-best candidate area) were considered for application. These alternatives were the frequency of occurrence-standard cut point summary composite, the frequency of occurrence-percentile summary composite, and the standard cut point-pure coincidence summary composite. Each of these alternatives is discussed briefly below, and a rationale is provided as to why the selected summary composite is believed to be the preferable approach.

C.2 FREQUENCY OF OCCURRENCE-STANDARD CUT POINT SUMMARY COMPOSITE

This summary composite displays the number of times (out of nine) that a given grid cell exceeds a certain aggregate favorability score. This is the type of summary composite that is depicted on Figure 12 of the SMD (DOE, 1985b). To develop this type of summary composite, the information on the individual composite favorability maps is used directly (i.e., aggregate favorability scores for each grid cell). For each grid cell, the aggregate favorability score(s) (as defined by each of the nine weighting subgroups) is compared to a standard aggregate favorability score. This standard aggregate favorability score (or benchmark) is a constant value. To yield the desired number of areas (on the summary composite map), with each area exhibiting the required spatial characteristics described previously, the standard cut point (or benchmark) is adjusted either upwards or downwards.

The major drawback of this type of summary composite is that, depending on the standard cut point selected, the composite favorability maps associated with certain weighting subgroups may not contain cells or areas with aggregate favorability scores above the standard cut point. This is reflected in Tables 3-4a and b where the benchmarks for the Phase A composite favorability maps vary between 4.4 for CRP subgroup 3 and 3.3 for States' subgroup 1. As noted in the SMD (DOE, 1985b), the purpose of summary composite maps is to identify the similarity or overlapping portions of the most favorable areas as defined by a series of composite favorability maps. The DOE believes that if the standard cut point summary composite was implemented it would be somewhat more difficult to demonstrate that the more favorable areas, as defined by each of the weighting subgroups, were considered in the identification of the more favorable preliminary candidate areas. Therefore, this type of summary composite was not used.

C.3 FREQUENCY OF OCCURRENCE-PERCENTILE SUMMARY COMPOSITE

This summary composite displays the number of times (out of nine) that a given grid cell is rated in the highest X percent on any of the composite favorability maps. To develop this type of summary composite a process very similar to that used for development of the frequency of the occurrence-best candidate area summary composite maps is employed. The major difference is that rather than identifying for each weighting subgroup the aggregate favorability score (or benchmark) that yields approximately 20 areas, a desired percentile is specified first and that percentile determines the corresponding benchmark. This same percentile is used for all weighting subgroups, and the aggregate favorability score (benchmark) corresponding to that percentage is adjusted accordingly.

The major drawback to this type of summary composite is that the selection of a percentile as the basis for developing the summary composite maps does not take into account whether groups of cells configure in such a fashion as to accept the 11 km (7 mi) diameter circle (which is used to designate preliminary candidate areas). That is, it is not quite as apparent (as with the frequency of occurrence-best candidate areas summary composite) that each composite favorability map has been evaluated and in doing so the more favorable areas have been identified on each composite prior to development of the summary composite map. Therefore, this type of summary composite maps was not used.

C.4 STANDARD CUT POINT - PURE COINCIDENCE SUMMARY COMPOSITE

This type of summary composite map is a special case of the frequency of occurrence - standard cut point summary composite map discussed in Section C.2. While the frequency of occurrence - standard cut point summary composite displays the number of times out of 9 that the aggregate favorability scores for a given grid cell exceed a standard aggregate favorability score, the standard cut point - pure coincidence summary composite displays for one (or more) standard aggregate favorability scores or cut points, the grid cells that exceed these standard cut points for <u>all</u> nine weighting subgroups. In order for a grid cell on this type of summary composite to be designated as exceeding a given cut point score, the aggregate favorability scores for each of the nine weighting subgroups for the particular cell must exceed the cut point.

The implication of this is that the lowest aggregate favorability score (for a specific grid cell) as defined by one of the nine weighting subgroups becomes the composite favorability score for the grid cell. Depending on how subgroups assigned weights to the screening variables, it is possible that the weights derived by the same (one or two) subgroups may govern the standard cut points associated with a majority of the grid cells. As described below in Section C.5, through the use of a statistical test, it was determined that State 1 Subgroup and CRP Subgroup 4 are the most dissimilar among the subgroups; hence they were the dominant subgr[illegible] result of this, these two subgroups would govern the identification [illegible] the more [illegible]able areas and the remaining subgroups would have significantly diminished input into this process. The CRP does not view such an occurrence as consistent with the intent of the region-to-area screening methodology which was to capture representative views, including the extremes, regarding the relative importance of screening variables and to incorporate these views in the selection of the preliminary candidate areas.

During development of the draft ARR, DOE generated several draft maps using the standard cut point-pure coincidence approach. DOE determined that the weights derived by one or two subgroups did, in fact, govern the standard cut point associated with a majority of grid cells and, therefore, did govern identification of the more favorable areas. For these reasons, DOE abandoned this approach as a method for generating summary composite maps.

C.5 SIMILARITY IN SUBGROUP WEIGHTS

To identify the degree of similarity among the subgroups and subsequently pinpoint the most dissimilar (governing) subgroups, a statistical test was performed. The test was based on hypothesis testing which compared the weight sets in a pairwise fashion. To carry out the test, the weight sets were assumed to represent samples of some population. The number of variables in a subgroup indicated the size of the sample. When two samples have been drawn from the same population, we may practically expect that they differ. The difference between their parameters, i.e., the means, is due to sample variation. The task of proving whether two (or more) samples have been drawn from the same population is a hypothesis testing.

The hypothesis that [illegible] samples represent the same population is called the null hypothesis. To perform the statistical test the null hypothesis is first proposed and then rejected in favor of an alternative hypothesis, if appropriate. This procedure is necessary because statistical tests cannot ascertain agreements.

The two hypotheses related to the weight sets can be phrased as follows:

- Null Hypothesis: The view of subgroup x is the same as that of subgroup y.

- Alternative Hypothesis: The view of subgroup x is different from that of subgroup y.

Since conclusions drawn from statistical tests are not absolute, they must be associated with confidence levels. In order to reject or retain the null hypothesis, it is necessary to assign a probability for making an error in judgement (i.e., level of confidence). Essentially, there are two error types; Type I error, the error of rejecting a correct null hypothesis; Type II error, the error of retaining a false null hypothesis. The error of Type I is more serious error to make and this error is typically assumed to be 5%. It will be interpreted that when the correct null hypothesisis is retained, there will be 95% confidence in the judgement made.

As pointed out, the weights assigned to the regional variables were considered as samples from unknown populations. There were two ways to undertake the statistical test: (1) assuming a distribution for the population (of weights), and (2) performing a distribution-free test. Both tests were carried out.

The tests were [illegible] comparing two subgroups at a time for each of the 16 variables a[illegible] [illegible] Phase A. The number of times the null hypothesis was retained with 95% confidence level were counted. The degree of similarity was defined in terms of the number of times the two subgroups have similar views.

The results of the statistical tests were summarized in a two dimensional array, a matrix of similarity. Each element of the matrix represents the number of times the corresponding subgroups had the same views (i.e., the number of times the null hypothesis was retained). The matrix is symetrical with the main diagonal elements equaling 16, indicating when a subgroup is compared with itself, the null hypothesis is retained for all the variables. Tables C-1 and C-2 show the matrices of similarity determined by the tests for Phase A, using both tests. The same tests were carried out for other phases with similar results.

The sums of the columns (or the sums of rows) are the indicators of similarity among the subgroups. The elements of the matrix depict how similar the pairs of subgroups are.

As indicated in the matrices the most dissimilar subgroups are:

- State Subgroup 1
- CRP Subgroup 4

Table C-1. Matrix of Similarity for 9 Subgroups Over 16 Variables Using the Wilcoxon-Mann-Whitney Test (U-Test)

		PHASE A								
		CRP					STATE			
		1	2	3	4	5	1	2	3	4
	1	16	6	9	1	2	6	11	3	8
	2	6	16	11	4	6	3	11	3	7
CRP	3	9	11	16	4	7	4	10	5	7
	4	1	4	4	16	8	2	5	7	12
	5	2	6	7	8	16	2	7	5	10
	1	6	3	4	2	2	16	8	8	8
STATE	2	11	11	10	5	7	8	16	7	11
	3	3	3	5	7	5	8	7	16	13
	4	8	7	7	12	10	8	11	13	16
COLUMN SUMS:		62	67	73	59	63	57	86	67	92

Table C-2. Matrix of Similarity for 9 Subgroups Over 16 Variables Using the Fisher-Behren Test (Modified T-Test)

		PHASE A								
		CRP					STATE			
		1	2	3	4	5	1	2	3	4
	1	16	6	9	1	4	8	12	3	5
	2	6	16	11	4	4	4	10	3	7
CRP	3	9	11	16	3	6	4	9	4	6
	4	1	4	3	16	7	2	7	7	12
	5	4	4	6	7	16	2	8	6	8
	1	8	4	4	2	2	16	9	7	7
STATE	2	12	10	9	7	8	9	16	6	10
	3	3	3	4	7	6	7	6	16	11
	4	5	7	6	12	8	7	10	11	16
COLUMN SUMS:		64	65	68	59	61	59	87	63	82

APPENDIX D

QUALITY CONTROL OF MAP PRODUCTS

The region-to-area screening methodology utilizes computers to store regional environmental and geologic data and to produce the series of maps described previously in Sections 3.1.1, 3.1.2, and 3.1.3. To ensure that the computer-generated maps (which portray the results of Steps 1 through 3 of the region-to-area screening methodology) are accurate, a series of quality assurance/quality control procedures were implemented. These procedures are briefly described below.

The starting point in this process is a set of hand-drawn maps which have been subjected to the full complement of quality assurance/quality control reviews and sign-off. The data from these plates are entered into the computer (i.e., digitized) and processed so that each data item is represented in a topologically correct digital file. At the completion of this process, each RCR data item (whether linear, polygonal or point data) has been converted to a form which allows it to be processed, and/or reproduced by computer. Once this automation process is completed for a given data set (e.g., Federal-protected lands or postemplacement faults), an edit plot is produced. The computer is, in effect, asked to reproduce the original data (in polygonal form) from the digital files produced in this step. The resultant plot should almost exactly reproduce the RCR data. To verify this, the edit plot is physically overlayed on the original data map and the two are compared. Every feature is checked to ensure that the automated data lie within a ±1 mile error tolerance of the original data (in most cases near coincidence is actually achieved). If corrections are required, the process is repeated until a ±1 mile tolerance is achieved.

The next step in the [illegible]ation process is to convert the digital polygonal, linear, and point data to a grid cell representation (i.e., all data are assigned to one or more 1 mile by 1 mile grid cells in accordance with a set of decision rules which are available upon request) in which form all subsequent screening operations are conducted. A primary objective of this process is to obtain the most accurate possible gridded representation of each data feature.

As with data automation, quality control for this step requires manually checking all of the data features to ensure that they have been converted to gridded form. In this case a plot of both the polygonal data and its grid cell representation is prepared on a single sheet, with each data form depicted in a different color. Quality control checkers examine these plots and note any deviations from proper conversion conventions.

In the next step, buffering (distance calculation) algorithms are applied and scale values are assigned to produce favorability maps for each of the variables listed in the SMD. Certified computer programs are used to accomplish this step.

A quality control graphic (grey-tone map) is produced which displays the resulting favorability maps. Although the use of certified programs provides adequate documentation that these operations were performed correctly, several checks are made to ensure that the program itself was set up and executed properly. The quality control checker first verifies that the computer operator has generated the proper instructions. A quality control graphic is then overlayed on the original data map to ensure that all features appropriate to that variable are represented. Buffers for a few features (<5%) are checked to ensure distance increments and scale values set forth in the SMD were utilized.

Following production of the favorability maps, composite and summary composite maps are produced. The composite and summary composite maps are produced using certified computer programs. As it is impractical (based upon expense, time, and inspection fatigue) to do 100% inspection of each of the tens of thousands of grid cells, it was decided to check a representative portion or sample of grid cells to decide if each of the composite favorability and summary composite maps are acceptable.

For each map, cell descriptions are prepared for the representative sample of cells. These descriptions provide a quality control checker with a list of individual map data which contributes to the values calculated for the composite or summary composite map product being checked. The checker can then verify the accuracy of the mathematical or logical operation used to produce the composite or summary composite map. A review of the computers command is also performed to recheck and set up the execution of the program.

The method arrived at to accept or reject composite favorability or summary composite map set is based on a go-no go basis and not by the number of defective cells per map set. Thus, if no defective grid cells were found in the sample, the composite favorability or summary composite maps would be accepted. If one defective grid cell was found in the sample, the composite favorability or summary composite map set would be rejected.

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