Chapter Three

Affected Environment

Chapter Three: Affected Environment

This chapter contains an assessment of those natural and socioeconomic resources in the region that may be influenced by Energy Vision 2020 decisions about future energy resources. The assessment is made at a macro, or regional, scale rather than at a micro, site-specific scale.

The primary study area covers the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area.

Appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee, both in the primary study area, and a portion of the Green and Ohio Rivers in Kentucky outside the study area, are included in this report, since TVA power plants are located in these river basins and, in the case of the Cumberland River, one hydroelectric plant. The assessment region for air quality is not limited to the TVA service area. There are pollutant emissions originating outside the region, pollutants leaving the area, and pollutant effects such as haze, ozone, and acidic precipitation that are recognized as regional issues.

Natural resources include regional air, water, and land resources. Overall, air and water quality are generally good and have been steadily improving. Land resources are adequate for siting energy supply facilities.

Understanding the conditions of these resources, trends in the region's environmental quality, and the relationship to TVA's activities is important. This provides the necessary reference or baseline for assessing the potential environmental consequences of implementing alternative energy strategies developed in Energy Vision 2020.

This Chapter Includes:

- Overview
- The Socioeconomic Environment
- Regional Air Resources
- Regional Water Resources
- Regional Land Resources

Affected Environment

Overview

Energy Vision 2020 evaluates the affected environment to help provide a baseline for assessing the environmental consequences of alternative energy strategies. Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment. A regional perspective takes in both natural conditions and those resulting from human development. It considers socioeconomic, air, water, and land resources. All topics in this chapter are considered in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

The primary study area for Energy Vision 2020, shown in *Figure 3-1*, includes the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area. Within this study area, appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee are considered because TVA coal-fired plants are located on these rivers and, in the case of the Cumberland River, one hydroelectric plant. Outside the study area, a portion of the Green and Ohio Rivers in Kentucky are considered because TVA coal-fired plants are located on these rivers.

Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment in this report.

The Socioeconomic Environment

In 1994, the TVA power service region had an economy of $146 billion in total personal income, 3.6 million in total non-farm employment, and $175 billion in gross product. The population was 7.7 million in 1994. Per capita income in the region was about $19 thousand the same year, or about 86 percent of the national average.

Close to half of the region's population lives in non-metropolitan counties, compared to less than one-fourth in the nation. In 1994, about 26 percent of total non-farm employment in the region was in manufacturing, as compared to 16 percent for the United States. Manufacturing's predominance in the region is due to several advantages that have helped it in the past and should continue in the future. They include:

- A location in the South, with good access to the markets of the Northeast, the Midwest, the Southwest, and Florida
- Good transportation for shipping commodities to these markets
- A low wage (for the U.S.) workforce with good work habits
- Abundant, relatively low-cost resources including water, electricity, and land.

FIGURE 3-1. **The Energy Vision 2020 Study Area Includes the TVA Service Area and the Tennessee River Watershed**

LEGEND

Tennessee Watershed Boundary.....

Power Service Boundary .....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

ECONOMY

A large manufacturing base has helped this area outperform the United States economy and is expected to continue to do so. Strong manufacturing gains since 1985 have stimulated the region's growth. Three critical factors hampered manufacturing in the early to mid-1980s: exceptionally high oil and energy prices, high interest rates, and high foreign exchange rates. These have returned to relatively lower levels and are expected to remain there, creating favorable conditions for growth in the region's manufacturing capabilities.

A strong manufacturing base has helped this area outperform the United States economy and is expected to continue to do so.

Although manufacturing is the core of the region's economic base, non-manufacturing industries accounted for two-thirds of total gross regional product in 1994. The service sector, which makes up the bulk of the non-manufacturing side of the economy, has provided, and is expected to continue to provide, the great majority of all new jobs created in the region.

For the balance of the decade, the region's performance is expected to continue the trend of the 1985-1994 period. Relatively favorable national conditions and TVA's electric rates for regional manufacturing are both expected to continue. TVA expects the region's newer manufacturing industries to continue further expansion. After the year 2000, TVA expects the region's growth will slow considerably as the area's newer manufacturing industries reach maturity. Nevertheless, manufacturing's intensity is expected to continue to provide enough impetus for the region to expand somewhat faster than the national rate.

POPULATION

In 1994, about 7.7 million people lived in the TVA power service area, with almost half residing in the major metropolitan areas of Nashville, Memphis, Knoxville, Chattanooga, and Tri-Cities, Tennessee, and Huntsville, Alabama. These metropolitan areas are all mid-sized, without any one large dominating area in the region and are distributed fairly evenly throughout the region. Surrounding these metropolitan areas are a few smaller metropolitan areas and numerous satellite cities, along with the surrounding rural communities connected by both economic and transportation links. Thus, the region, while largely rural, is generally well served by centers of commerce and government, and the workforce is evenly distributed across the region rather than focused in any particular central area.

Regional Air Resources

Natural resources such as soils, forests, crops and other vegetation, surface waters, aquatic ecosystems and aquatic life are sensitive to air quality impacts of acidic deposition (including acid rain), ozone exposure, and deposits of heavy metals. TVA affects air quality through emissions from power plants. Air quality in the TVA region is generally good.

CRITERIA AIR POLLUTANTS

Air quality is important to protect human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards serves as a key indicator of how well human health and the environment are protected.

The Environmental Protection Agency has established standards for six "criteria" pollutants. Pollutant concentration levels were established for two classes of effects: primary and secondary. Primary standards protect public health, and secondary standards protect public welfare (e.g., visibility, aquatic ecosystems, crops and forests, soils, materials). Current national ambient air quality standards are shown in *Figure 3-2*.

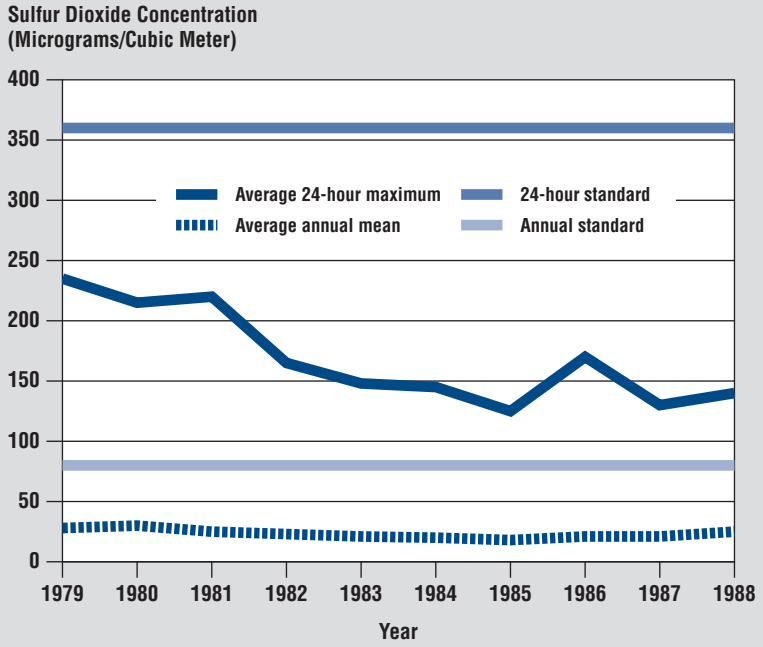
Locales where concentrations do not exceed the level of the standards are considered to be in compliance with the National Ambient Air Quality Standards and are thus designated as attainment areas. Areas where standards are not achieved are designated as non-attainment. (See *Figure 3-3 through 3-5.)*

FIGURE 3-2. **The National Ambient Air Quality Standards Set Limits for Six Pollutants to Protect Human Health and the Environment**

Pollutant	Averaging Time	STANDARD Primary	STANDARD Secondary
Carbon Monoxide	8-hour 1-hour	9.0 35.0	none none
Lead	Quarter Year	1.5	1.5
Nitrogen Dioxide	Annual	0.053	0.053
Ozone	1-hour	0.12	0.12
Particulate matter less than 10 microns in size (PM10)	24-hour Annual	150 µg/m^3 50 µg/m^3	150 µg/m^3 50 µg/m^3
Sulfur Dioxide	3-hour 24-hour Annual	none 0.14 0.03	0.50 none none

National standards, other than annual standards, are not to be exceeded more than once per year (except where noted in the figure). Units are parts per million by volume of air except for particulate matter with diameters less than or equal to 10 microns which is expressed in micrograms per cubic meter. The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one day.

FIGURE 3-6. **Concentrations of Sulfur Dioxide in the Energy Vision 2020 Study Area Are 40 Percent Below 1979 Levels**

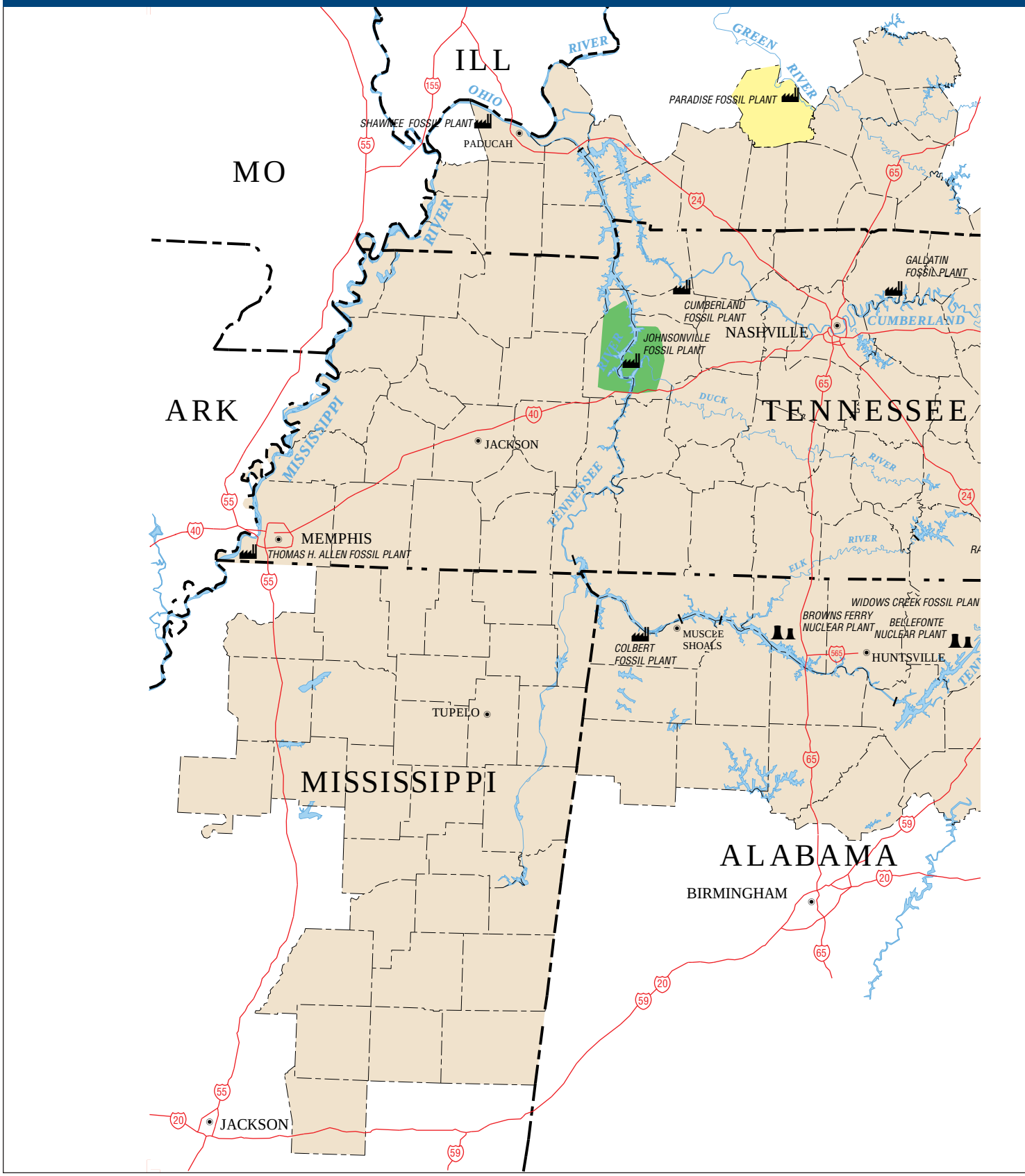


SULFUR DIOXIDE (SO_2)

Health and Welfare Concerns

Sulfur dioxide can impact human health at sufficient concentrations. Concentrations of sulfur dioxide in the Tennessee Valley have been reduced by more than 40 percent since 1979 *(Figure 3-6)*. Current ambient levels of sulfur dioxide are generally below thresholds that pose risk of damage to vegetation and materials. Sulfur dioxide also combines with other elements to form sulfate, a secondary pollutant that contributes to acidic deposits and fine particles that can have an impact on human health and impair visibility.

FIGURE 3-3. **Areas in Nonattainment for Sulfur Dioxide Under the National Ambient Air Quality Standards**



LEGEND

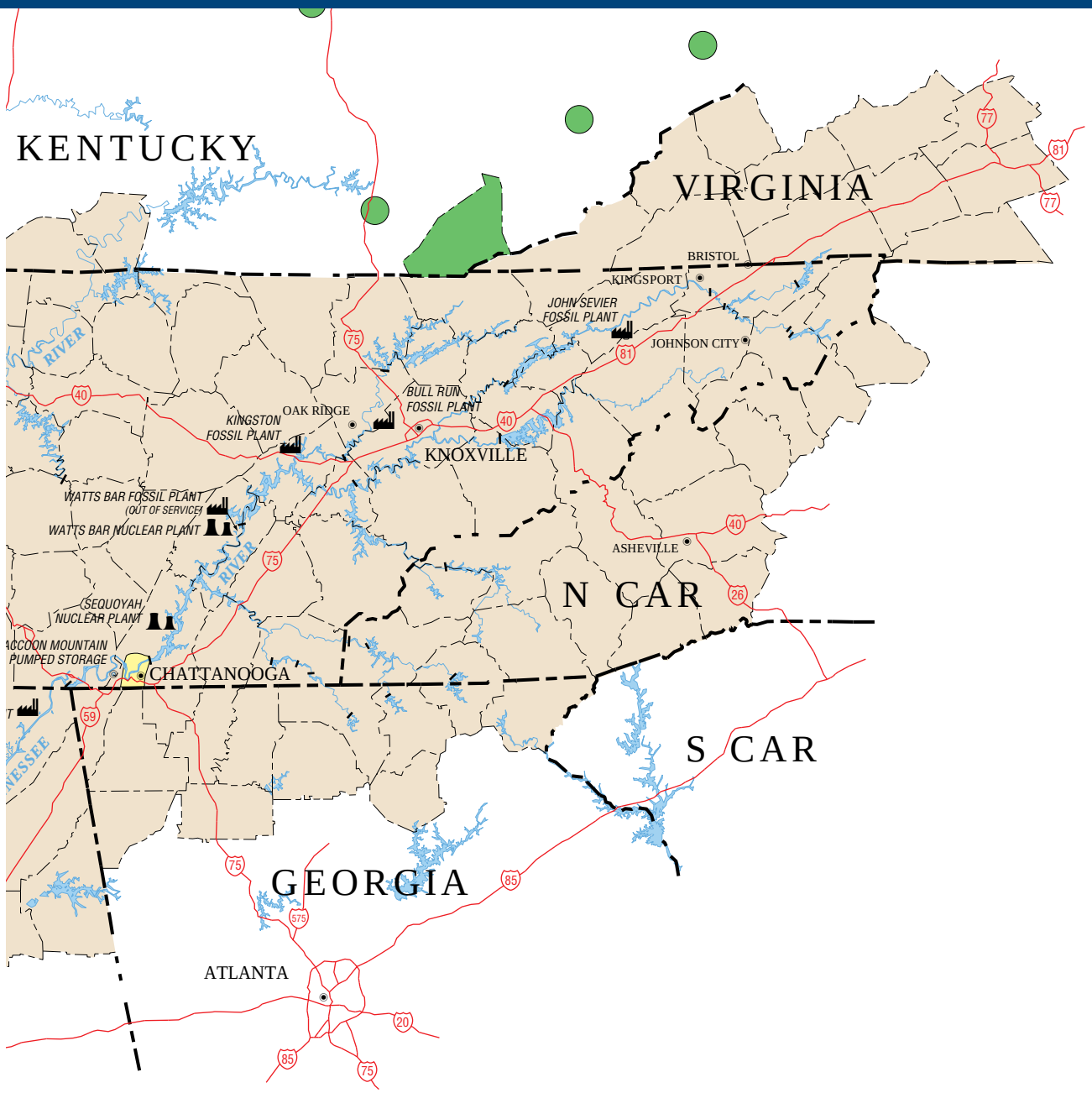
Does not meet Secondary Standard .....
Does not meet Primary or Secondary Standard .....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-4. **Areas in Nonattainment for Ozone Under the National Ambient Air Quality Standards**


KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
Does not meet Primary Standard (SERIOUS)
Does not meet Primary Standard (MODERATE)
Does not meet Primary Standard (MARGINAL)
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-5. **Areas in Nonattainment for Total Suspended Particulate Matter Under the National Ambient Air Quality Standards**

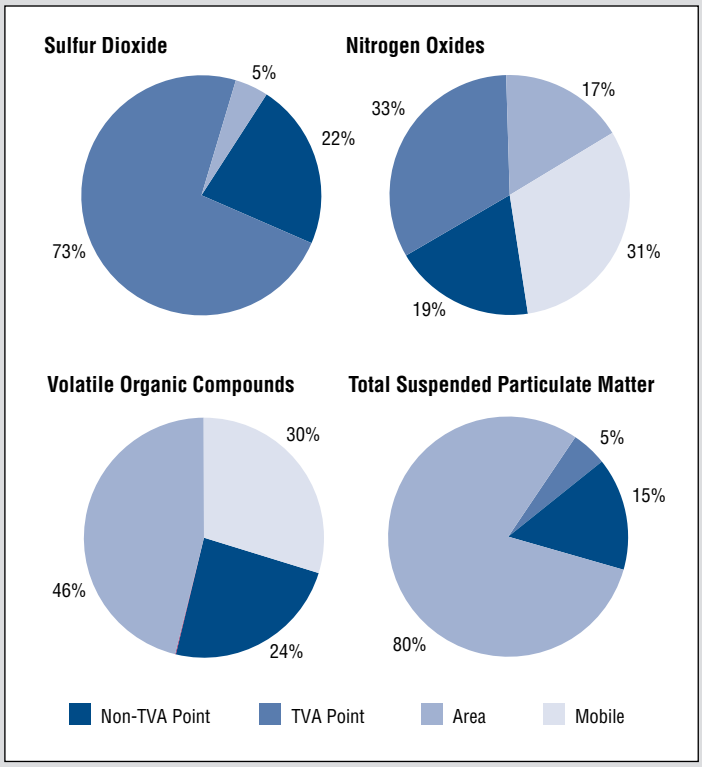


LEGEND

Does not meet Primary Standard .....
Does not meet Secondary Standard .....
Cannot be Classified .....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-7. **Total Emissions of Human-Produced Sulfur Dioxide, Nitrogen Oxides, Volatile Organic Compounds, and Total Suspended Particulate Matter from the 201-County TVA Service Area**



Total emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds, and total suspended particulate matter. Emissions from point, area, and mobile sources from the 201-county TVA service area are derived from Environmental Protection Agency 1990 Interim Inventory. Total suspended particulate matter emissions are derived from the 1985 Interim Inventory.

Sources of Contributions

Coal-fired power plants, industrial boilers, ore smelters, and petroleum refineries are major human-produced sources (point or stationary sources). In the TVA region, TVA accounts for three-fourths of the total sulfur dioxide emissions produced by human activity *(Figure 3-7)*. In the greater source area that contributes to sulfur dioxide loadings in the Tennessee Valley, TVA's emissions are roughly one-fourth of total emissions. Installation of emission controls, coal washing, and switching to coals with lower sulfur content have reduced TVA's sulfur dioxide emissions by 60 percent over the past two decades *(Figure 3-8)*. Following full implementation of the 1990 Clean Air Act Amendments (i.e., following Phase II), TVA sulfur dioxide emissions are expected to remain below 500 thousand tons per year.

NITROGEN OXIDES (NO_X)

Health and Welfare Concerns

Nitrogen oxides can be a respiratory irritant but at typical outdoor concentrations, health impacts are negligible. Nitrogen oxides emissions, however, contribute to acid rain, ozone, and visibility impairment.

Sources of Contributions

Natural sources of nitrogen oxides include microbial activity, lightning, and forest fires. Major sources produced by humans include motor vehicles, fossil-fuel power plants, industrial boilers, nitrogen fertilizers, and agricultural burning. Within the TVA region, nitrogen oxides emissions from TVA power plants accounted for 33 percent of total human-produced nitrogen oxides emissions, with mobile sources a close second at 31 percent. *(See Figure 3-7.)* TVA emissions of nitrogen oxides annually have been 500,000 tons. These emissions will be reduced to roughly 300,000 tons annually as TVA installs control equipment in response to the 1990 Clean Air Act Amendments. (See *Figure 3-9.)*

The variations in nitrogen oxides emissions from 1984 to 1993 are a result of changes in coal-fired plant generation to meet varying load requirements

and also reflect the availability of both coal-fired and nuclear plants during this period. Reductions during 1993 to 1995 are partially a result of environmental control measures. The large reductions in 2000 are the results of the implementation of more significant environmental control measures in response to the Clean Air Act Amendments.

TOTAL SUSPENDED PARTICULATE MATTER (TSP)

Health and Welfare Concerns

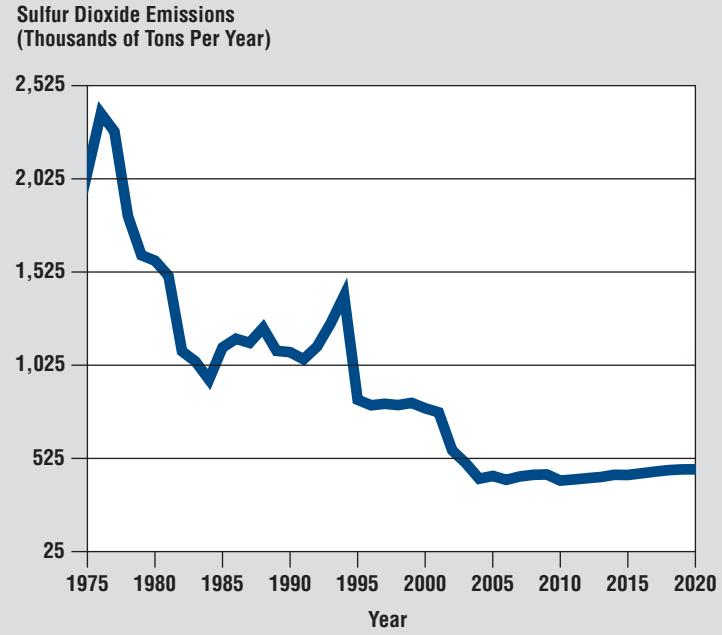
Particulate matter consists of small aerosol particles in the atmosphere that can impact the health of sensitive individuals and impair regional visibility. The particles of major concern for human health are less than 10 microns in size.

Particles emitted directly from a source are called primary particulate matter, whereas those formed in the atmosphere from emitted gases are called secondary particulate matter. Formation of secondary particulate matter of sulfates and nitrates from sulfur dioxide and nitrogen oxides and other elements occurs in the atmosphere as the pollutants are transported several hundred kilometers downwind from the points of origin. As with ozone, summertime conditions favor sulfate and nitrate particle formation. Because sulfate particles are the major contributor to regional haze in the eastern United States, visibility is usually poorest in the summer months.

Sources of Contributions

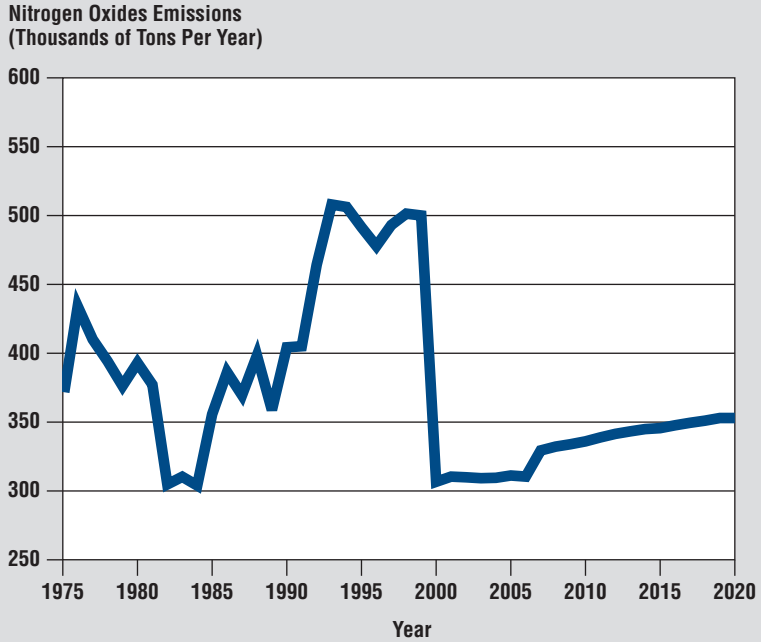
Particles in the air have many natural and human-produced sources. Human-produced sources include agriculture, waste incineration, industrial processing, fossil-fuel combustion,

FIGURE 3-8. **Historic and Projected TVA Emissions of Sulfur Dioxide**



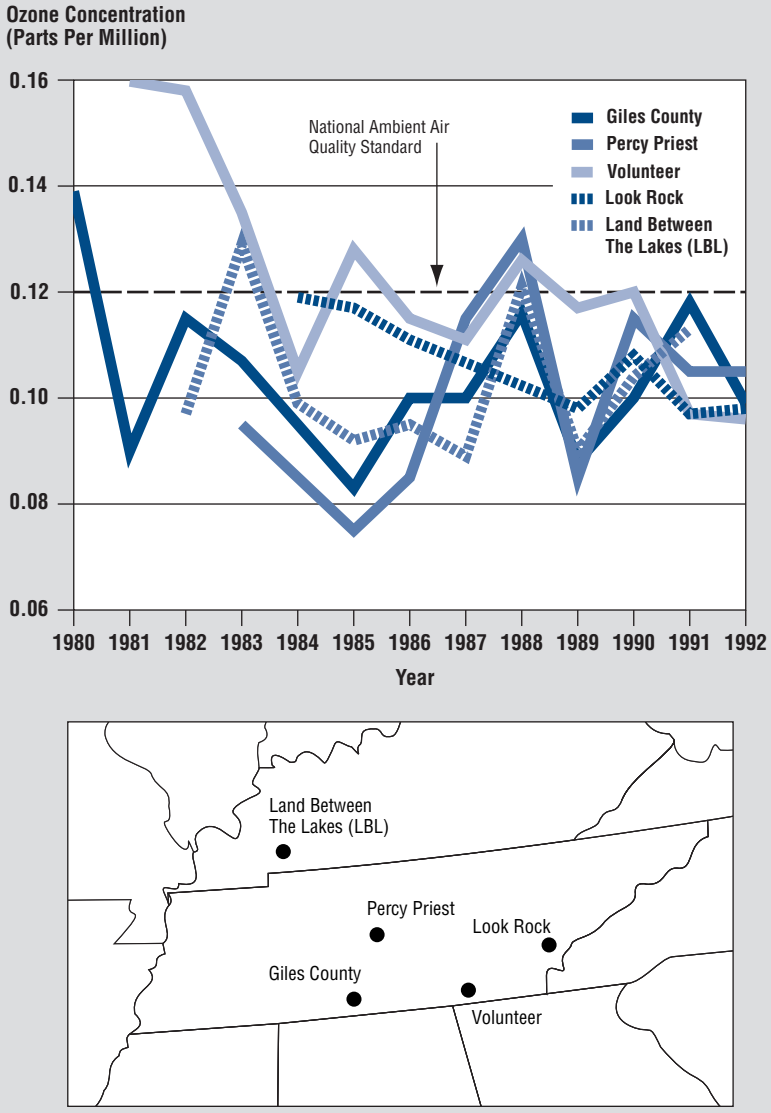
TVA emissions of sulfur dioxide have been reduced 60% since the 1970s and will be further reduced in compliance with the 1990 Clean Air Act Amendments.

FIGURE 3-9. **Historic and Projected TVA Emissions of Nitrogen Oxides**



TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.

FIGURE 3-10. **Maximum Hourly Ozone Concentrations at Five Monitoring Sites in the Energy Vision 2020 Study Area Have Shown Little Improvement**



construction, and mining. Human-produced emissions predominate in urban and industrial areas. Based on the 1985 emissions inventory by the National Acid Precipitation Assessment Program, TVA was found to contribute 5 percent of the human-produced total suspended particulate matter emitted in the 201 counties of the Tennessee Valley *(Figure 3-7)*. TVA emissions are primarily from coal-fired plants.

OZONE (INCLUDING NITROGEN OXIDES AND VOLATILE ORGANIC COMPOUNDS)

Health and Welfare Concerns

Ozone is a secondary air pollutant produced in the presence of sunlight from nitrogen oxides and volatile organic compounds in the lower atmosphere (troposphere). Ozone can irritate the eyes, nose, and throat, but typically the effects are temporary and pose no long-term health risks. Ozone at sufficient concentrations can harm vegetation and some materials.

In the Tennessee Valley, the cities of Chattanooga, Knoxville, Memphis, and Huntsville have recently attained the ozone standard. However, Nashville remains in non-attainment status. Other measures of ozone exposure across the Tennessee Valley have not shown any improvement that is discernable above the annual variability in trends due to meteorology *(Figure 3-10)*.

Sources of Contributions

Human-produced sources of nitrogen oxides, one of the contributors to ozone formation, were discussed earlier in this section. Human-produced sources of volatile organic compounds include motor vehicles, petrochemical storage and transport, chemical and industrial processing, and smaller sources. Vegetation, biological decay, and forest fires are natural sources of volatile organic compounds. In many areas of the southeastern United States, natural sources can contribute up to 90 percent of total volatile organic compounds. As shown in *Figure 3-7*, TVA emissions of volatile organic compounds are insignificant compared to the total amount emitted.

PREVENTION OF SIGNIFICANT DETERIORATION

The section of the 1977 Clean Air Act Amendments entitled "Prevention of Significant Deterioration" provides special protection for air quality and air quality-related values in national parks and wilderness areas, designated in the legislation as Class I areas. The Class I areas in the TVA region are designated on the map in *Figure 3-11*.

OTHER AIR QUALITY CONCERNS

Several air quality concerns have emerged in the past two decades. Acid deposition, regional visibility impairment, hazardous air pollutants, and greenhouse gases are now either regulated or being considered for regulation.

ACID DEPOSITION (INCLUDING SULFUR DIOXIDE AND NITROGEN OXIDES)

Health and Welfare Concerns

Acid deposition, or acid rain, is the acidification of rainfall below "natural" pH levels. Acid deposition can affect sensitive forests where ability to buffer incoming acids is depleted. High elevation spruce-fir forests, where loadings from wet, dry, and cloud deposition are greatest, are the most sensitive to acidification.

Data for the region around Tennessee indicate the most acidic (lowest pH) precipitation region to be Kentucky and portions of east Tennessee, with slightly lower acidity to the west and south. The lowest annual pH values for six sites across the TVA region are near 4.2 versus 5.2 to 5.6 for natural rainfall.

Sources of Contributions

TVA sulfur dioxide and nitrogen oxides emissions contribute to acid deposition. *(Figures 3-8 and 3-9)* The potential source area contributing to acid deposition in the Tennessee Valley is greater than that for ozone because the production rate of sulfate is slower than that for ozone. The rate of nitric acid formation is comparable to that of ozone. Conversion of sulfur dioxide to sulfate occurs within roughly 48 hours or an 800 to 1,000 kilometer distance from emissions sources. Thus, distant sources could be impacting sensitive areas such as the southern Appalachians, and TVA emissions could contribute to deposition outside the Tennessee Valley. However, the rate of sulfate formation can be very rapid in clouds, so depending on meteorological conditions, nearby sources may have greater contribution to deposition. TVA's contribution to acid deposition or acid rain is expected to decrease as its emissions of sulfur dioxide and nitrogen oxides are reduced in response to the 1990 Amendments to the Clean Air Act.

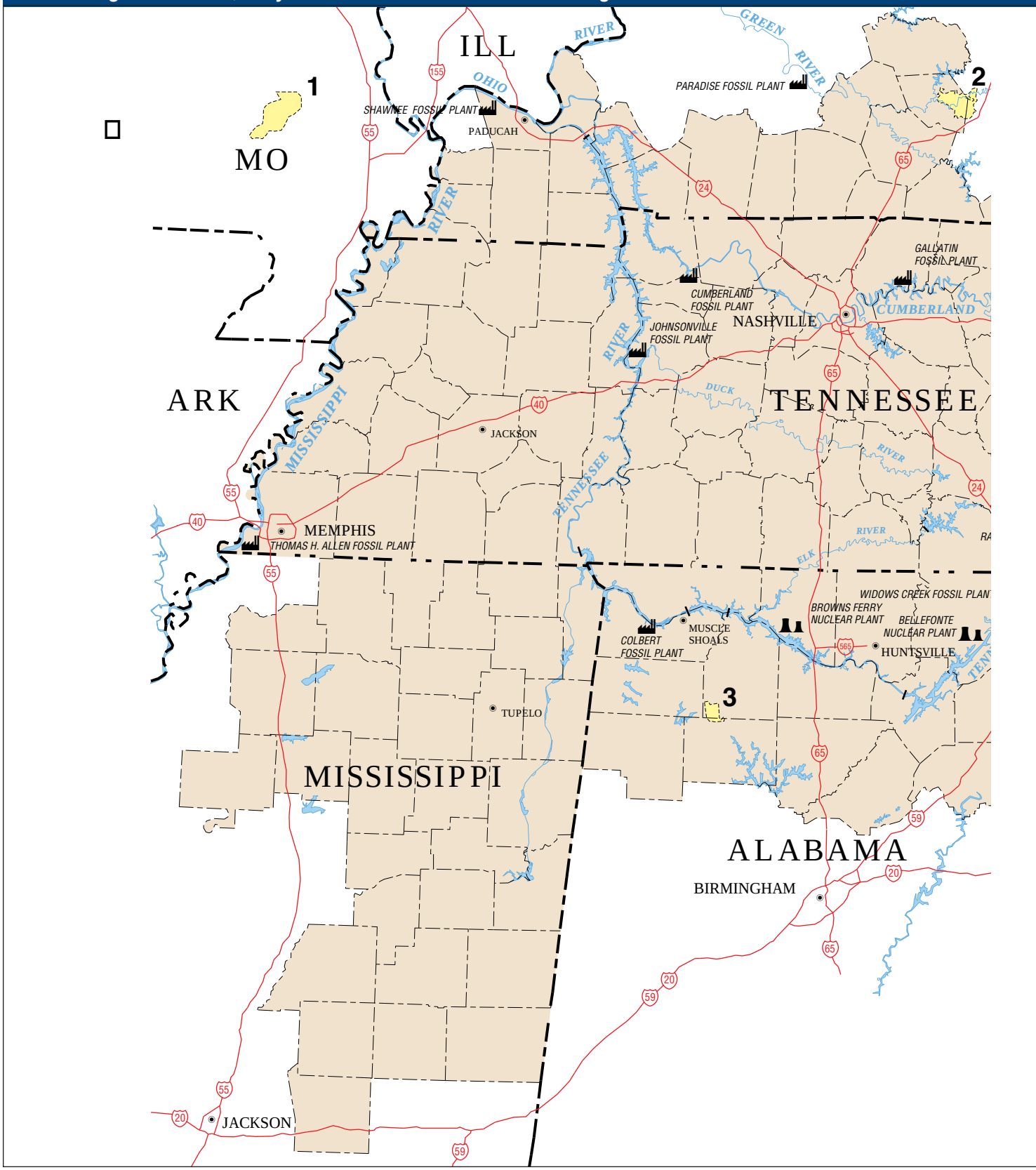
VISIBILITY IMPAIRMENT

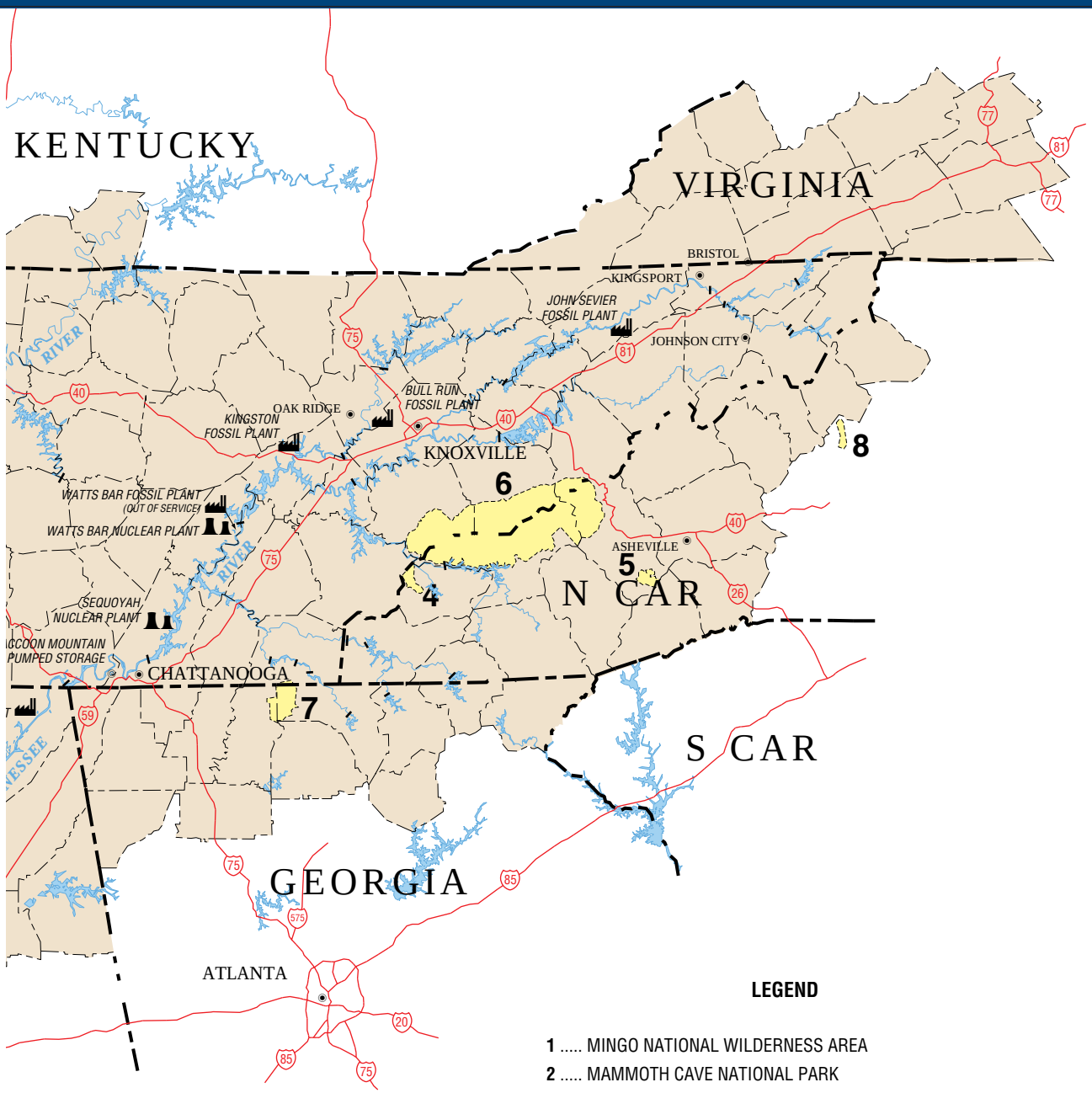
Health and Welfare Concerns

Visibility impairment refers to atmospheric conditions where the ability of an observer to discern form, color, or texture of a vista is reduced and therefore the scenic value of that vista is diminished.

Despite improvement in levels of sulfur dioxide *(Figure 3-6)* and particulate matter of less than 10 microns over the past decades, visibility has not

FIGURE 3-11. **National Park and National Wilderness Areas in the Energy Vision 2020 Study Area Designated as Air Quality Class I Areas for the Prevention of Significant Deterioration**





LEGEND

1 ..... MINGO NATIONAL WILDERNESS AREA
2 ..... MAMMOTH CAVE NATIONAL PARK
3 ..... SIPSEY NATIONAL WILDERNESS AREA
4 ..... JOYCE KILMER/SLICKROCK NATIONAL WILDERNESS AREA
5 ..... SHINING ROCK NATIONAL WILDERNESS AREA
6 ..... GREAT SMOKY MOUNTAINS NATIONAL PARK
7 ..... COHUTTA NATIONAL WILDERNESS AREA
8 ..... LINVILLE GORGE NATIONAL WILDERNESS AREA

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

improved in the TVA region. According to the U.S. Environmental Protection Agency's visibility studies, sulfates dominate visibility impairment in the eastern United States.

Sources of Contributions

The size of particles emitted directly from TVA facilities is generally larger than the size that impairs visibility. However, TVA sulfur dioxide and nitrogen oxides emissions contribute to levels of secondary sulfate and nitrate particles. The potential source area contributing to visibility impairment at areas of concern such as Class I areas in the southern Appalachians is roughly the same as that for acid deposition.

HAZARDOUS AIR POLLUTANTS

Health and Welfare Concerns

In the 1990 Clean Air Act Amendments, Congress identified 189 chemicals as air toxics. Depending on concentration, hazardous air pollutants can cause adverse health effects. From this list, the air toxics of greatest concern emitted by coal-fired power plants are arsenic, beryllium, cadmium, chromium, copper, and mercury. However, these pollutants are emitted in relatively small amounts.

Mercury is of special concern because levels observed in some sensitive watersheds in the upper midwestern United States, Canada, and Florida are sufficient to cause toxic effects to aquatic wildlife and to humans that consume contaminated fish. However, mercury levels in the Tennessee River and its tributaries are generally below thresholds set by the United States Environmental Protection Agency to protect human health. Atmospheric deposition in the Tennessee Valley is considered a minor contributor.

Radionuclides are one of the hazardous air pollutants being evaluated by the Environmental Protection Agency in its study of utility industry hazardous air pollutant emissions. Coal-fired boilers emit trace amounts of radioactive elements (uranium, radium, thorium, and their decay products) found in the fuel. These radionuclides become incorporated into fly ash and are released to the air in the particulate matter emitted from the boilers. Particulate air pollution control equipment, such as electrostatic precipitators, limit radionuclide emissions.

Sources of Contributions

The Electric Power Research Institute, the Environmental Protection Agency, and the Department of Energy have characterized toxic emissions for nearly 100 United States utility boilers representing a range of fuels, boiler configurations, and control technologies. On the basis of this data, the Electric Power Research Institute has estimated emissions and risk to human health from emissions at more than 600 utility plants. The Electric Power Research Institute's assessment indicated that none of the TVA plants and only 3 of the 600 plants in the study posed cancer risks greater than the 1-in-1-million criteria used by the Environmental Protection Agency as a level of possible health concerns.

GLOBAL CLIMATE CHANGE

The balance of solar energy received and heat radiated from the earth to space controls the earth's climate. Greenhouse gases absorb infrared (long wave) or thermal radiation emitted by the earth. This helps seal in some of the heat the earth would otherwise have lost from solar energy it received. The greenhouse effect is a natural phenomenon that makes the earth habitable. Greenhouse gases produced by human activities include water vapor, carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons.

Globally, atmospheric concentrations of greenhouse gases are believed to have increased from pre-industrial levels. The current rate of increase of carbon dioxide is 1.8 parts per million per year or 0.5 percent per year. Fossil fuel combustion and global deforestation are the primary contributors to carbon dioxide buildup. There is little doubt that carbon dioxide concentrations are increasing, but scientific debate continues about its consequences. Should changes in temperature and rainfall occur within a region such as the Tennessee Valley, there could be far-reaching impacts in areas such as energy, transportation, agriculture, forestry, and socioeconomic factors.

Despite the scientific uncertainties, TVA has agreed, along with some 75 other utilities, to participate in the United States Department of Energy's Climate Challenge initiative and to voluntarily limit equivalent TVA carbon dioxide emissions by the year 2000.

AIR QUALITY INDICES

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas.

A separate measure was also developed to sum the net greenhouse gas emissions for alternative future energy supply strategies. The measure is expressed in equivalent tons of carbon dioxide, the most common greenhouse gas.

A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Water Resources

INTRODUCTION TO WATER RESOURCES AND POLLUTANTS

The quality of the region's water (surface water and groundwater) is critical to protection of human health and aquatic life. These water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits.

Water quality can be affected through air emissions and deposition and wastewater from power plants, construction of facilities, and extraction of fuels to be used in power plants.

The scope of Energy Vision 2020 covers the TVA operating area, which includes the entire Tennessee and Cumberland River basins and portions of the lower Ohio, lower Mississippi, and Green and Ohio River basins *(Figure 3-12)*. Fresh water abounds in this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation such as swimming. Water quality in the TVA region is generally good.

THE TENNESSEE RIVER

The Tennessee River basin contains all except one of TVA's dams and covers most of the TVA region. A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows nav-

FIGURE 3-13. **Principal Water Quality Concerns in TVA Reservoirs**

Navigation & West Tributary Reservoirs	USES AFFECTED				SOURCE	
	Aquatic Life	Fish Consumption	Recreation	Water Supply	Point	Non-Point
Kentucky			Aquatic Plants			
Normandy	Low Dissolved Oxygen			Taste, Odor, Iron, Manganese	X	
Pickwick				Algae		X
Wilson	Low Dissolved Oxygen			Taste, Odor		X
Wheeler	Low Dissolved Oxygen	DDT			X	X
Tims Ford	Low Dissolved Oxygen					X
Guntersville			Aquatic Plants			X
Nickajack		PCBs, Chlordane			X	X
Chickamauga	Low Dissolved Oxygen				X	X
Watts Bar	Low Dissolved Oxygen	PCBs			X	X
Melton Hill		PCBs				X
Ft. Loudoun		PCBs	Bacteria		X	X
Tellico	Low Dissolved Oxygen	PCBs				X
East Tributary Reservoirs						
Norris	Low Dissolved Oxygen					X
Cherokee	Low Dissolved Oxygen				X	X
Ft. Patrick Henry						
Boone	Low Dissolved Oxygen	Metals, Toxics			X	X
South Holston	Low Dissolved Oxygen					X
Wilbur						
Watauga						
Douglas	Low Dissolved Oxygen			Color	X	X
Nolichucky	Siltation		Siltation	Siltation		X
Fontana	Low Dissolved Oxygen					X
Ocoee 1-3	Metals, Siltation	PCBs	Siltation		X	X
Blue Ridge						
Appalachia						
Hiwassee	Low Dissolved Oxygen					X
Nottely	Low Dissolved Oxygen				X	X
Chatuge	Low Dissolved Oxygen					X

igation to Knoxville. Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. *Figure 3-12* is a map of the basin, showing dams and reservoirs. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

Surface Water

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. The principal water quality concerns in TVA reservoirs are summarized in *Figures 3-13* and *3-14* . This informataion was derived primarily using data and analysis generated through TVA's comprehensive ecological health and use suitability monitoring program as well as other TVA aquatic monitoring and assessment activities. The criteria used in making the determinations were state water quality standards and fish consumption advisories.

Point and Non-Point Sources of Pollution

Point and non-point sources of pollution include:

- **Heat-release**—Utility plants and industry may release into streams or lakes water that has been heated above the temperature of the body of water.
- **Wastewater**—Sewage treatment systems, industry, and others dispose of waste into streams and lakes.
- **Runoff**—from agriculture, urban uses, and mined land are non-point sources that result in stream or lake pollution.
- **Air pollution**—Pollutant concentrations in the air can affect surface waters through rainout and deposition.

TVA Heat Releases

TVA conducts extensive aquatic monitoring programs to ensure that thermal and other discharges do not cause adverse impacts even at permitted levels. Recent programs have focused primarily on potential effects on spawning and development of cool-water fish species such as sauger, but have also included attraction of fish to thermal plumes from power plants and possible increases in undesirable aquatic micro-organisms, such as blue-green algae. In general, these monitoring programs have detected no significant negative effects resulting from release of heated water from TVA facilities. That is, there

FIGURE 3-14. **Principal Water Quality Concerns in Tennessee Valley Watersheds [1]**

Watershed	USES AFFECTED [2] Aquatic Life	Fish Consumption	Recreation	SOURCE Point	Non-Point
Chickamauga-Nickajack		PCBs	Bacteria		X
Pickwick-Wilson	Toxics				X
Watts Bar-Melton Hill	Siltation	PCBs	Bacteria		X
Duck River	Siltation		Bacteria		X
Guntersville-Sequatchie	Siltation		Bacteria		X
Clinch-Powell	Siltation				X
Wheeler-Elk		DDT, PCBs	Bacteria		X
Holston	Toxics	Mercury	Bacteria	X	X
French Broad	Siltation	Dioxin	Bacteria	X	X
Little Tennessee	Siltation	PCBs		X	X
Hiwassee	Metals, Siltation			X	X

[1] As designated by TVA's Clean Water Initiative

[2] Uses are affected by the problem noted on at least one stream in the watershed.

Figure 3-12. **Water Resources Considered in Energy Vision 2020 Include the Entire Tennessee River Basin and Portions of the Cumberland, Ohio, Mississippi, and Green River Basins**

LEGEND

State Boundary .....

County Boundary .....

Stream, Tributary, Lake .....

TVA Power Facilities; Fossil, Hydro .....

Nuclear, Pumped Storage.....

Major Cities .....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

has been no demonstrable damage to established water uses or aquatic ecological integrity.

TVA Wastewater

Nuclear Plant Wastewater. Nuclear power plants have noncomplex wastewaters that are subjected to various levels of treatment and usually discharged to surface waters. These releases are controlled through state-issued National Pollutant Discharge Elimination System permits, which are part of Federal Clean Water Act statutes. Periodic toxicity testing is performed on this discharge as part of the National Pollutant Discharge Elimination System permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life.

Coal-Fired Plant Wastewater. Coal-fired plants have several liquid waste streams that are treated and released to surface waters. These releases are permitted by each state under the National Pollutant Discharge Elimination System. Periodic toxicity testing of coal-fired wastewater ensures that there are no acute or chronic toxic effects to aquatic life.

Runoff and Air Pollution. Many non-point sources of pollution have not been subjected to government regulations or control and can contribute as much as five times more dissolved oxygen-consuming wastes than point sources. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, and pesticide and herbicide applications, erosion, and animal wastes; mining, including erosion and acid drainage; and urban runoff. Atmospheric deposition is another potential source of water pollution, particularly in relation to acid rain and fallout of toxic metals.

Low Dissolved Oxygen Levels

Another major water quality concern in the Tennessee River is low dissolved oxygen levels in stream reaches downstream of TVA dams. Long stretches of river can be affected, especially in areas where non-point source pollution uses up the dissolved oxygen restored through natural reaeration. TVA addressed this issue in its 1990 environmental impact statement, "Tennessee River and Reservoir System Operation and Planning Review." TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams based on this study.

Groundwater

Groundwater refers to water located beneath the surface in rock formations known as aquifers. Approximately half of the region has limited groundwater availability because of natural geohydrological conditions.

More than 64 percent of the region's residents rely totally, or in part, on groundwater for drinking water. More than 1.7 million residents (22 percent) in the region maintain individual household groundwater systems, usually a well. All areas in the Tennessee Valley region can generally supply enough

water at least for domestic needs. For the most part, the groundwater quality is adequate to support existing water supply uses even though some minimal treatment, such as filtration and chlorination, might be required.

Aquatic Life

The construction of the TVA dam and reservoir system fundamentally changed the character of the Tennessee River and its tributaries. While dams promote navigation, flood control, power benefits, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river.

Tributary Reservoirs and Tailwaters

Reservoirs on the tributaries to the Tennessee River are typically of the deep storage type that retain water for long periods of time. Little flow and regular periods of thermal stratification result in oxygen depletion in the deeper water. These aquatic habitats are simplified relative to undammed streams, and fewer species are found. Lack of minimum flows and low dissolved oxygen in the first few miles below tributary dams may severely limit the habitat needed by native fish. This may restrict their movement, migration, reproduction, and available food supply.

Dams on tributary rivers affected the habitat of benthic invertebrates (benthos), which are a vital part of the food chain of aquatic ecosystems. Benthic life includes worms, snails and crayfish, which spend all of their lives in or on the stream beds, and aquatic insects, mussels and clams, which live there during all or part of their life cycle. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Further downstream from dams, the number of benthic species increases as natural reaeration occurs and dissolved oxygen and temperatures rise.

Mainstream Reservoirs

The nine mainstream reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are shallower, have greater flows, and thus retain the water in the reservoir for a shorter period of time. They generally do not become as strongly stratified as tributary reservoirs. Although dissolved oxygen in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstream reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs.

Tennessee River mainstream reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish, and catfish. The primary commercial species are channel and blue catfish and buffalo.

OTHER RIVERS IN THE STUDY

The Tennessee River basin contains most of TVA's dams and power plants. In addition to these facilities, the Ohio, Green, and Mississippi Rivers each host a TVA coal-fired plant; and the Cumberland River basin, two coal-fired plants and a hydroelectric plant.

Any surface water, groundwater, and aquatic life characteristics in these rivers that differ from those described under the Tennessee River can be found in Volume 2, Technical Document 1, Comprehensive Affected Environment, as can a more detailed discussion of the affected environment of the Tennessee River.

WATER QUALITY INDICES

Water indices were developed to help characterize how TVA power system operations might contribute to each of the environmental impact areas selected. The indices provide measures to evaluate environmental impacts of alternative future energy supply strategies. Measures in the indices are weighted by the relative contribution of TVA power system operations to water quality impacts and issues. A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Land Resources

INTRODUCTION TO LAND RESOURCES

The TVA region encompasses some 58 million acres. Of this area, non-federal rural land occupies about 50 million acres. As in all areas inhabited by humans, resource problems do exist. Humans have influenced the entire Tennessee Valley and its adjacent region through agriculture, timber harvesting, and other land uses.

A broad range of land uses takes in management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Factors such as soils, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, are critically important in supporting and preserving these uses.

TVA affects land resources through site selection for power plants, reservoirs, and transmission lines; fuel procurement; air emissions; radioactive waste management; and solid waste management.

AGRICULTURAL LANDS AND CROP PRODUCTION

The TVA region is a predominantly rural area with 40 percent of the land area in crop production or pasture and 55 percent in forest. Small farms that grow and market a wide diversity of agricultural products characterize agriculture in the Tennessee Valley. Corn, cotton, soybeans, tobacco, wheat, and vegetables account for the major crops produced in the region. Livestock production is

another major agricultural activity and land use. About 14 million acres of prime farmland occupy the Tennessee Valley region, distributed as 55 percent cropland, 23 percent pasture, 20 percent forest, and 2 percent nonagricultural.

FOREST RESOURCES

Fifty-five percent of the TVA region is forested. Reserved forest land, consisting of parks, wilderness areas, and other forested lands specifically withdrawn from commercial timber cutting by legislation or administrative designation, totals 944,976 acres. The remainder of the forested area, 31 million acres, or 97 percent of the forest, is classified as timberland.

Forest stressors include past land use practices that resulted in erosion and site degradation, extreme climactic conditions (freezing injury, ice damage, drought, flooding), air pollutants, and exotic, as well as native, forest insects and diseases.

CULTURAL RESOURCES

The Tennessee Valley region features many archaeological sites. The National Historic Preservation Act requires federal agencies to appropriately identify, protect, and manage significant cultural resources on their land or those affected by their undertakings whether on federal or nonfederal property.

OTHER LAND USE CONDITIONS

Electric and Magnetic Fields

Electric and magnetic fields (EMF) are both natural and man-made. For example, every device that generates, transmits, or uses electricity produces these two types of energy fields. These include electric power lines, electric appliances, motor vehicles, and electric wiring.

A 1979 epidemiological study suggested that there might be a potential link between magnetic fields associated with electric distribution lines and childhood leukemia. After 15 years of further research, results have been mixed. If EMF does indeed pose a risk, most researchers believe that it is low.

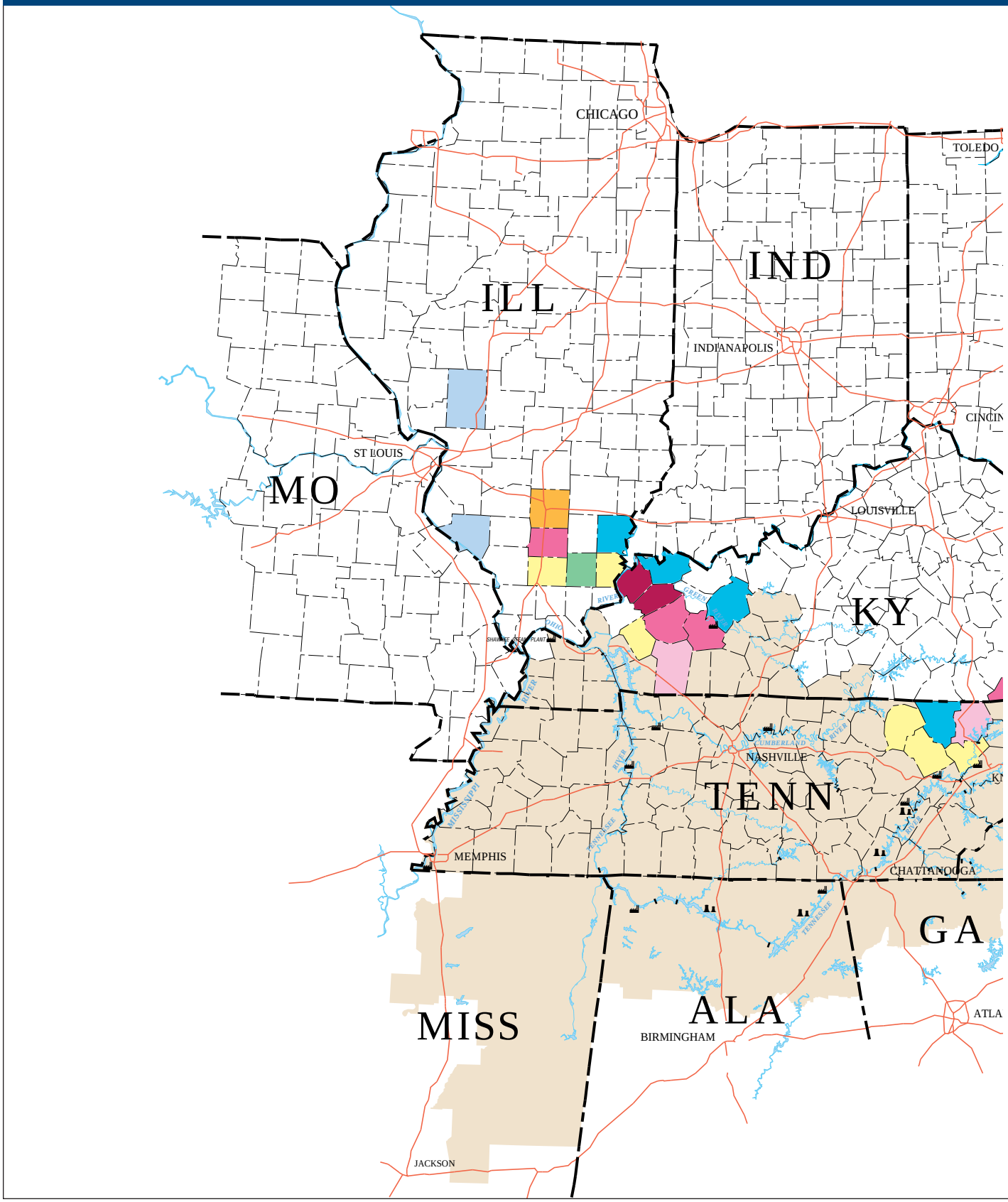
No federal regulations govern EMF exposure levels. TVA adopted interim guidelines in 1993 that address EMF exposures. Under these guidelines, TVA will take into account EMF exposure when planning new transmission lines. In addition, TVA will design upgrades of existing lines to reduce EMF levels when practicable.

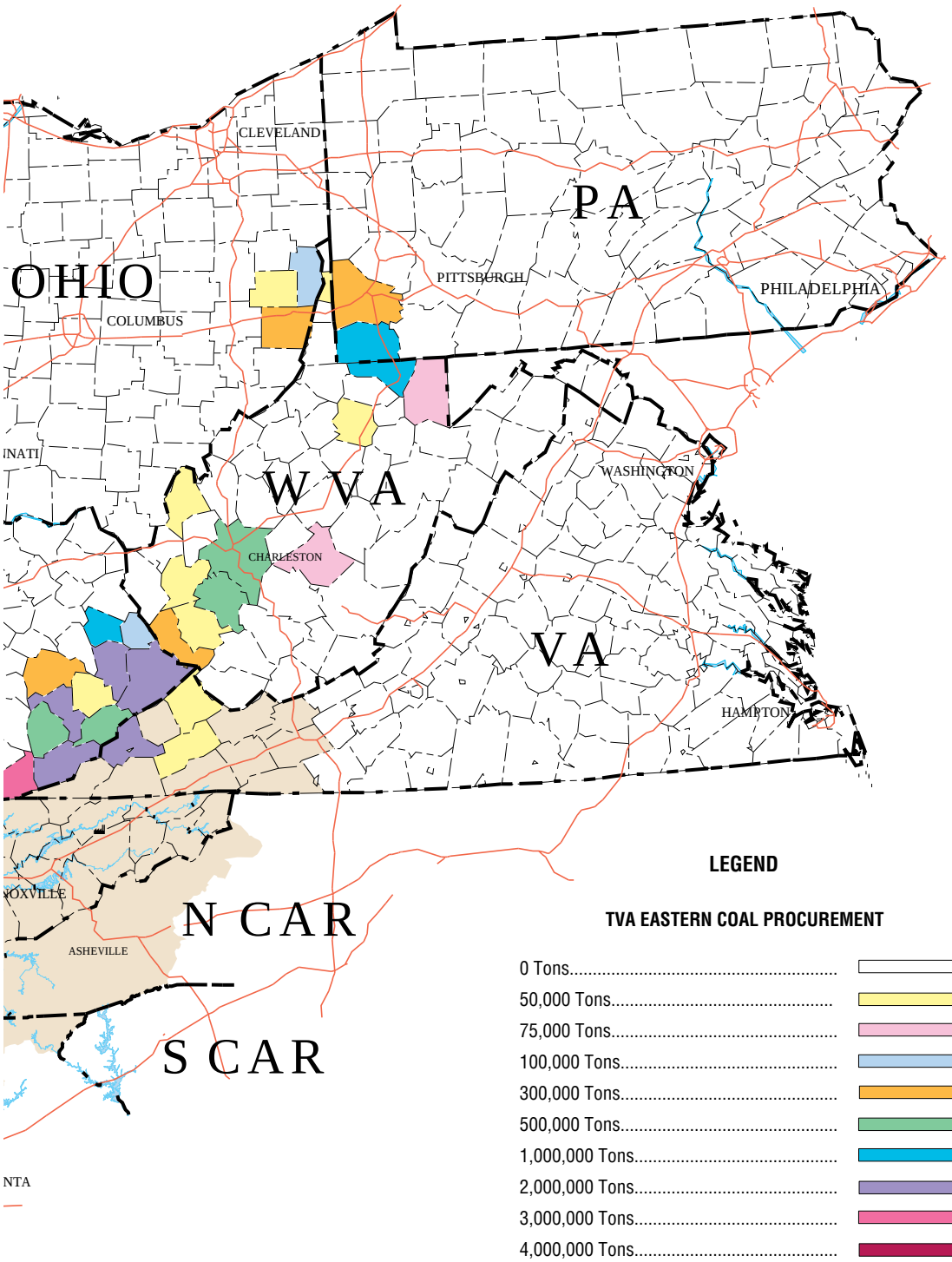
Fuel Procurement

TVA's eastern coal procurements are about 7.1 percent of the eastern United States production (east of the Mississippi River) and about 0.36 percent of the western United States production. The map in *Figure 3-15* shows the location and intensity of TVA coal procurement in the eastern United States by county for fiscal year 1994.

Land-related environmental impacts of mining are primarily the direct and indirect effects of changes in land use. These impacts may include acid drainage from exposed sulfur-bearing rock, erosion from disturbed mining areas

FIGURE 3-15. **TVA Procured Coal From Seven Eastern States in Fiscal Year 1994**





MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

and coal transport roads, loss of wildlife habitat, stream siltation, unstable land situations, and fugitive dust. Various regulations, including those implementing the Surface Mining Control and Reclamation Act of 1977, have reduced the potential risk of significant impacts.

The natural uranium for TVA's nuclear plants comes from uranium producing areas all over the world. TVA's five nuclear units use a total of about 2.5 million pounds of U308 per year. TVA currently has sufficient inventory to last until 1999. TVA and a number of other United States utilities are expected to soon be using commercial grade slightly enriched uranium derived from nuclear warheads. The highly enriched uranium obtained from both United States and Russian nuclear warheads will be diluted to low levels, which allows its use in commercial nuclear plants.

Coal Combustion Solid Wastes

The combustion of pulverized coal in power plant boilers produces solid wastes such as fly ash and bottom ash (or boiler slag in some boiler designs). Any of these wastes may be marketed as byproducts, depending on their quality and on market conditions.

TVA production of these byproducts during fiscal year 1994 was nearly 6 million tons, with almost half being fly ash. Of the 6 million tons, 1.177 million tons, or 20 percent, were utilized or marketed. The remainder of the byproducts is either disposed of or stored on the plant site in ash ponds or in dry-stacked landfills.

Nuclear Waste

The nuclear fuel used for power plants produces radioactive solid wastes requiring storage and disposal. These wastes are placed in two categories: high-level radioactive waste and low-level radioactive waste. These indicate the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Nuclear Waste

Background. Operation of TVA's 5 nuclear units will produce about 115 metric tons of used fuel each year. After it is removed from the reactor, used or spent fuel is stored at nuclear plant sites either in pools or in dry casks. The Nuclear Waste Policy Act of 1982 established a program to build the nation's first underground high-level waste repository early in the next century. In 1987, amendments to the Nuclear Waste Policy Act designated the remote area of Yucca Mountain, Nevada, northwest of Las Vegas, for study as a permanent repository site. The Department of Energy has begun site characterization and the comprehensive scientific investigation of Yucca Mountain's suitability.

TVA Spent Fuel Storage. TVA plans to continue to store spent nuclear fuel on-site at plant locations until the Department of Energy accepts physical custody by shipment off-site to a monitored retrievable storage facility or to an underground repository for ultimate disposal by burial. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2004, and Browns

Ferry Nuclear Plant until 2007. Based on a one-unit operation of Watts Bar Nuclear Plant, spent fuel storage capacity will be sufficient until 2018.

TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities and life-of-plant quantities of used fuel. As the pools approach the current storage limits, TVA will initiate studies to increase on-site storage capacity.

Low-Level Nuclear Waste

In a nuclear energy plant, the low-level radioactive waste comes from items such as filters, cloth and paper wipes, plastic shoe covers, tools and materials, water purification media (resins), and other residues.

Until July 1995, the low-level waste generators located in the eight Southeastern states were required to dispose of their waste at the Barnwell, South Carolina disposal facility. In July, South Carolina withdrew from the Southeast Compact Commission in order to open the Barnwell facility to all states except North Carolina. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to select, license, and construct a new disposal site. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants.

BIOLOGICAL RESOURCES

The biological resources of the Valley are summarized in this section.

Terrestrial Ecology

Wetlands

Wetlands are typically lands that are covered by shallow water or have a water table near the surface, or support plants typically found in wet habitats. Although wetlands occur throughout the TVA region, they are most extensive in the south and west.

Wildlife

The TVA region contains portions of seven physiographic regions and a great variety of plant and animal communities. About 70 species of mammals, 300 species of birds (including 175 which nest within the region), 65 species of reptiles, and 77 species of amphibians can be found regularly in the region. Several salamander species are only found in the TVA region (endemic). Few other terrestial vertebrate species are restricted to the TVA region

Vegetation

TVA's 201-county region contains approximately 4,300 species of herbs, shrubs, and trees in numerous habitats and plant communities. Much of the region is heavily forested. Based on an analysis of mature forests, Braun recognized

five major forest regions in the TVA area. Local vegetation types vary greatly within Braun's regions because of variation in elevation, relief, soil fertility, moisture, and the degree of human disturbance. These forest regions are described in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Sensitive or Threatened Ecosystems

The TVA region includes several terrestrial communities that are either restricted to the TVA region, are best represented there, or include a large proportion of their total area in the region. These include the Southern Appalachian spruce-fir, cedar glade, and limestone cave systems. Several endangered plant and/or animal species, as well as species not found outside the TVA region, occur in each of these communities.

Threatened and Endangered Species

Thirty-eight species of plants and 100 species of animals in the TVA region are either listed as endangered or threatened species or formally proposed for such listing by the United States Fish and Wildlife Service. These species, their distribution by river basin, and their habitats are listed in Volume 2, Technical Document 1, Comprehensive Affected Environment. An additional 380 species in the TVA region have been identified by the United States Fish and Wildlife Service as candidates for listing.