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Reminders:

In each numbered section of the chapter, the first mention of an alternative will be in bold print.

Alternative A - Limited TVA Role Along Open Shoreline and Additional Areas
Alternative B1 - Existing Guidelines Along Open Shoreline and Additional Areas (No Change/No Action)
Alternative B2 - Existing Guidelines Along Open Shoreline Only
Alternative C1 - Managed Development Along Open Shoreline and Additional Areas
Alternative C2 - Managed Development Along Open Shoreline Only
Alternative D - Minimum Disturbance Along Open Shoreline Only
Blended Alternative - Maintain and Gain Public Shoreline

Please see the Glossary in Chapter 5 for the meaning of unfamiliar words.

Ownership Categories on 10,995 Miles of TVA Reservoir Shoreline
• Flowage easement shoreland • TVA-owned residential access shoreland • TVA-owned-and-jointly-managed shoreland • TVA-owned-and-managed shoreland

CHAPTER 3

AFFECTED ENVIRONMENT

3.1 Introduction

Chapter 3 provides baseline information for understanding environmental and socioeconomic impacts associated with SMI alternatives analyzed in Chapter 4, Environmental Consequences. More specifically, this chapter describes the setting and existing conditions of natural, social, and economic resources that would be affected by the SMI alternatives. Resource issues to be discussed in detail are:

- Shoreline Vegetation
- Wildlife
- Endangered and Threatened Species
- Soils
- Wetlands
- Floodplains/Flood Control
- Aquatic Habitat
- Water Quality
- Recreational Use of Shoreline
- Aesthetic Resources
- Cultural Resources
- Socioeconomics
- Navigation

Chapter 3 also includes a description of the study area boundaries, an explanation on compilation of shoreline mileage data, and a discussion of existing shoreline conditions.

3.2 Study Area Boundaries

The study area boundaries used in Chapter 4, Environmental Consequences, are shown in *Figure 3.2-1*. The boundary for direct effects is the area between winter pool elevation and the maximum shoreline contour or TVA backlying property line (whichever is farther from the shoreline).

Indirect effects are measured on (1) adjacent private lands one-fourth mile from the maximum shoreline contour or TVA backlying property line (approximately equal to the average depth of a subdivision), (2) the remainder of the reservoir area (both above and below the lake surface), and (3) counties immediately adjacent to the reservoirs. However, the study area boundaries of some resources will vary, especially the boundaries associated with consideration of cumulative impacts.

3.3 Compilation of Shoreline Development Data

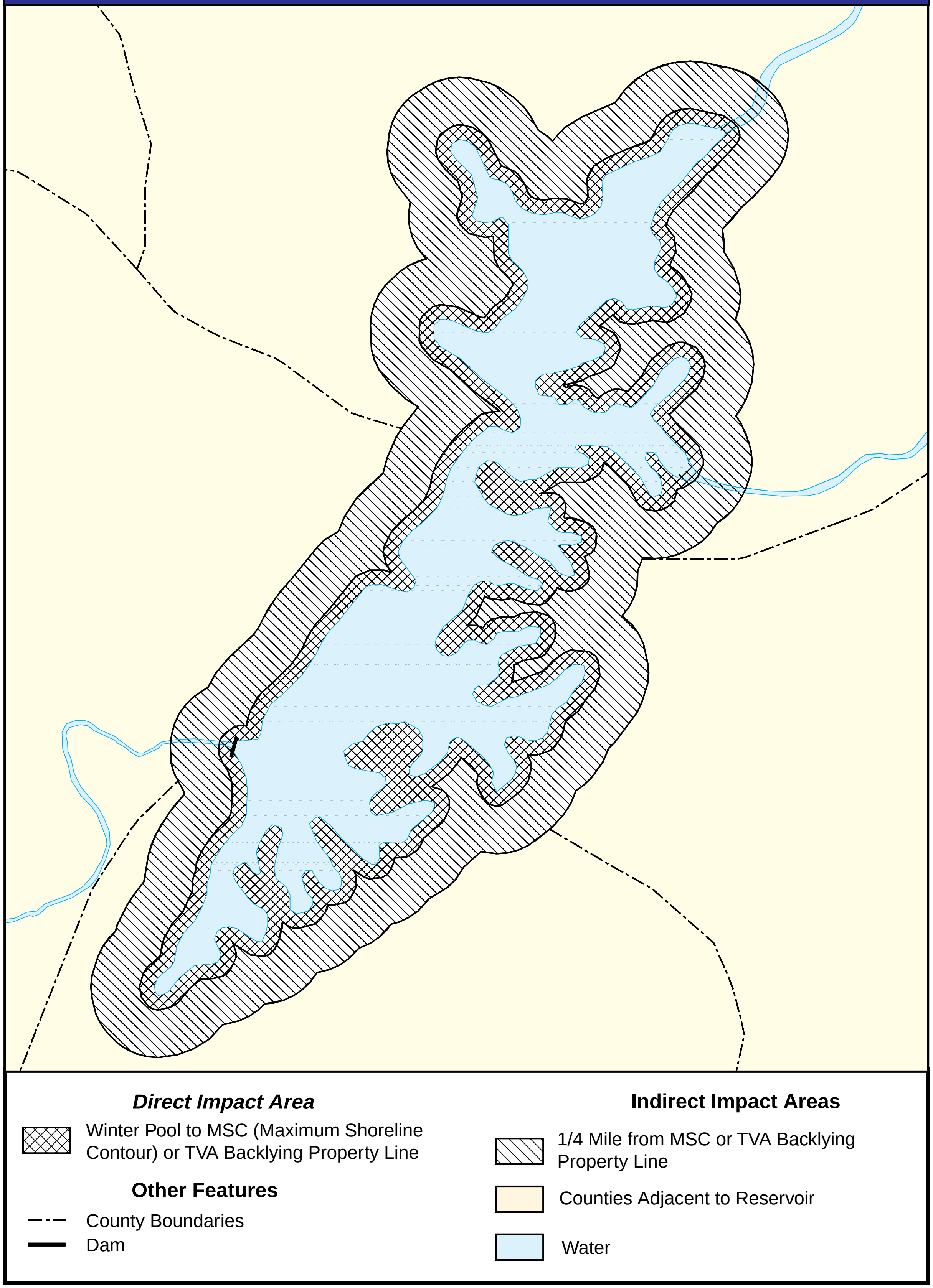
In 1994 TVA's Land Management Offices conducted boat surveys of TVA reservoir shorelines and delineated developed and undeveloped shoreline segments on topographic maps. Segments were identified as developed if shoreline structures such as docks and retaining walls were present. If vegetation disturbance also occurred, then the total extent of the disturbed area was marked as developed. These field data maps were digitized using TVA's GIS, and miles of developed, undeveloped, and total shoreline were computed for each reservoir.

3.4 Existing Shoreline Conditions

3.4.1 Developed Shoreline by Land Use or Allocation

As the population and economy of the Tennessee Valley have grown, so have the pressures for the use and development of land surrounding TVA reservoirs. As of 1994, development from all uses had

Figure 3.2-1. Study Area Boundaries of a Typical Reservoir.



impacted about 17 percent (1,833 miles) of the 10,995 miles of reservoir shoreline *(Table 3.4-1).* Residential access and associated development (including private docks, boathouses, retaining walls, and other related uses) is the dominant use (13 percent) along the shoreline. Developed recreation (i.e., public facilities and commercial marinas) is a distant second (3 percent), followed by a very small amount of industrial development and natural resource management (both less than 1 percent).

Developed shoreline areas are subjected to various levels of vegetation management. These range from little or no vegetation removal to extensive removal of native vegetation and, in some places, replacement with grass and nonnative plant species. In many instances, developed shorelines are mowed and maintained as an extension of adjoining residential lawns.

3.4.2 Undeveloped Shoreline by Land Use or Allocation

Most (83 percent) of the shoreline was undeveloped as of 1994 *(Table 3.4-1)*. Anticipated use of the majority of this undeveloped land is for natural resource protection/management; it is notable, however, that 1 out of every 4 shoreline miles is designated as residential access (i.e., has outstanding landrights).

Table 3.4-1. Miles of Developed and Undeveloped Shoreline by Land Use and/or Allocation.

Land Use and/or Allocation	Developed		Undeveloped	
	Miles	Percent of Total Shoreline	Miles	Percent of Total Shoreline
Residential Access	1,383.2	12.6	2,809.0	25.5
Recreation	319.0	2.9	829.8	7.6
Industrial	52.7	0.5	246.8	2.2
Natural Resource Management/ Protection	78.2	0.7	5,276.3	48.0
Total	***1,833.1***	***16.7***	***9,161.9***	***83.3***

Undeveloped shoreline varies in land use/land cover from open grassland (i.e., pasture) to mature forest. With the exception of agricultural activities, these shorelands are relatively undisturbed. TVA has designated some of these lands for natural area protection. In other cases, land has been transferred to state and federal agencies for use as wildlife refuges/management areas.

3.4.3 Developed Shoreline by Ownership Category

The number of miles of developed shoreline is listed by ownership category in *Table 3.4-2*. (See Chapter 1 for a detailed explanation of TVA landrights and shoreline ownership patterns.) These categories are briefly defined as:

- *Flowage easement shoreland:* privately owned lakeshore properties where TVA has the right to flood the land as part of its reservoir operations.
- *TVA-owned residential access shoreland:* TVA-owned land where adjoining private property owners have access rights across TVA land.
- *TVA-owned-and-jointly-managed shoreland:* TVA-owned property that adjoins lands sold, transferred, or otherwise conveyed to developers, entrepreneurs, or local, state, or federal agencies for commercial recreation, public recreation, industrial development, or resource management.
- *TVA-owned-and-managed shoreland:* TVA-owned land where there are no outstanding access rights potentially affecting its future use.

Table 3.4-2. Miles of Developed and Total Shoreline by Ownership Category.				
Landrights Category	**Developed Miles**	**Total Miles**	**% of Ownership Category Developed**	**% of Total Shoreline Developed**
Flowage Easement Shoreland	645.0	2,345.2	27.5	5.9
TVA-Owned Residential Access Shoreland	738.2	1,847.0	40.0	6.7
TVA-Owned-and-Jointly-Managed Shoreland	343.3	4,043.2	8.5	3.1
TVA-Owned-and-Managed Shoreland	106.6	2,759.6	3.9	1.0
Total (or Percent)	**1,833.1**	**10,995.0**		**16.7**

The proportion of total shoreline currently developed under flowage easement is only slightly less than that of residential access shoreland (6 percent and 7 percent, respectively). However, because there are fewer miles of residential access shoreland, this category shows a higher rate of development (40 percent) than for flowage easement (28 percent). Most of the undeveloped shoreline is jointly managed or owned and managed by TVA. These two ownership categories are primarily under public ownership and control and/or have no outstanding access rights and, therefore, are not as highly developed. See tables in Appendix I for the number of developed and undeveloped miles by reservoir and category.

3.4.4 Developed Shoreline by Reservoir

The amount of total development varies greatly between reservoirs. Three reservoirs (Boone, Fort Loudoun, and Wilson) are more than 50 percent developed *(Table 3.4-3)*. Conversely, eight reservoirs (Apalachia, Bear Creek Project, Hiwassee, Kentucky, Normandy, Ocoee Project, Tellico, and Wheeler) are less than 10 percent developed. Fort Loudoun has the greatest number of developed shoreline miles (199), followed by Guntersville (171), Kentucky (168), and Watts Bar (159). With a few exceptions, the proportion of residential shoreline development tracks closely with total developed.

Development has occurred on approximately one-third of shoreland currently available for residential access (i.e., flowage easement and TVA-owned residential access). More than 75 percent of shoreland with residential access rights has been developed on two reservoirs (Guntersville and Tims Ford). Eight other reservoirs (Blue Ridge, Boone, Chatuge, Fort Loudoun, Fort Patrick Henry, Hiwassee, Pickwick, and Wilson) exceed 50 percent.

3.4.5 Reservoir Subdivisions

In 1995, subdivisions with lakefront property were randomly sampled to further characterize existing shoreline development. Data on the frequency, types, and dimensions of subdivision lots were collected from 684 subdivision plats. These data were then expanded to give estimates for all 1,443 reservoir subdivisions *(Tables 3.4-4 and 3.4-5).*

3.4.6 Residential Shoreline Alterations

Development can also be characterized by the number, density, and kinds of residential shoreline alterations along the shoreline *(Table 3.4-6).* These structures include a wide variety of land- and water-based facilities but generally consist of fixed and floating piers and docks, retaining walls, decks, patios, steps, riprap, boathouses, etc. A total of 67,692 residential alterations (49 per mile) existed along developed shorelines in 1994.

Table 3.4-3. Miles of Developed Residential, Total Developed, Total Available for Residential, and Total Shoreline by Reservoir, Ranked by Percentage of Total Shoreline Developed.

Reservoir	Developed Residential			Total Developed		Total Miles Available for Residential[1]	Total Shoreline Miles
	Miles	% of Total Available for Residential[1]	% of Total Shoreline	Miles	% of Total Shoreline		
Wilson	85.9	54	52	90.1	54	157.8	166.2
Boone	64.3	63	51	67.1	53	102.6	126.6
Fort Loudoun	184.8	58	49	198.6	53	317.2	378.2
Chatuge	52.1	65	41	54.4	43	79.6	128.0
Ft. Patrick Henry	7.8	51	25	10.4	34	15.4	31.0
Nottely	25.9	44	25	28.5	28	58.8	102.1
Cherokee	59.9	35	15	98.0	25	172.3	394.5
Blue Ridge	15.5	60	23	17.3	25	26.0	68.1
Watts Bar	141.8	42	20	159.2	22	340.4	721.7
Watauga	19.4	39	18	22.3	21	50.2	104.9
Fontana	2.6	13	1	47.6	20	19.3	237.8
Guntersville	87.3	77	10	170.5	19	113.3	889.1
Tims Ford	43.2	91	14	58.5	19	47.7	308.7
Pickwick	63.7	54	13	91.5	19	118.3	490.6
Melton Hill	17.1	28	9	35.4	18	62.1	193.4
Douglas	78.1	17	15	86.4	17	454.9	512.5
Beech River Project	10.7	19	13	12.6	15	56.4	82.3
Wilbur	0.0	0	0	0.7	15	0.0	4.8
Chickamauga	88.7	36	11	110.3	14	248.7	783.7
Nickajack	13.4	14	7	24.8	14	98.0	178.7
South Holston	18.1	38	10	25.0	14	48.2	181.9
Norris	91.0	25	11	107.0	13	360.8	809.2
Wheeler	59.7	36	6	87.9	9	165.4	1,027.2
Kentucky	120.5	13	6	167.5	8	936.9	2,064.3
Hiwassee	12.0	59	7	12.8	8	20.3	164.8
Ocoee Project	0.0[2]	0	0	8.1	7	0.0	109.5
Tellico	19.7	18	6	25.5	7	110.4	357.0
Normandy	0.0[2]	0	0	4.6	6	11.2	75.1
Bear Creek Project	0.0[3]	0	0	10.5[3]	4	0.0	271.6
Apalachia	0.0[2]	0	0	0.0	0	0.0	31.5
Total Miles	**1,383.2**			**1,833.1**		**4,192.2**	**10,995.0**
% of Total		**33**	**13**		**17**		

[1]Sum of flowage easement and TVA-owned residential access shoreland.

[2]A negligible amount of residential shoreline development exists.

[3]An undetermined portion of the 10.5 developed shoreline miles is developed for residential use.

Table 3.4-4. Reservoir Subdivision and Lakefront Lot Dimensions.	
Attribute	**Dimension**
Total subdivision shoreline length	1,137 miles
Average subdivision shoreline length	4,160 feet
Average maximum subdivision depth	1/4 mile
Average lakefront lot width	157 feet
Average lakefront lot depth	257 feet

Table 3.4-5. Number of Reservoir Subdivision Lots by Type.		
Type of Lot	**Number**	**Lots per Shoreline Mile**
Developed private lakefront lots	23,639	20.8
Undeveloped private lakefront lots	14,031	12.3
All private lakefront lots	37,670	33.1
Common lakefront lots	641	0.6
All lakefront lots	38,311	33.7
All backlots	41,885	—
All reservoir subdivision lots	80,196	—

- Boone Reservoir has the highest density of structures, with 102 per developed mile, followed by Blue Ridge (80), Chickamauga (71), and Tellico (70).
- Fort Loudoun supports the largest number of facilities (8,946), followed by Watts Bar (7,683), Boone (6,582), and Chickamauga (6,323).
- Wilbur has the fewest residential shoreline alterations (0), followed by Apalachia (9), Fontana (86), and Hiwassee (211). A complete list of the types and number of land- and water-based residential shoreline alterations by reservoir can be found in Appendix J.

3.4.7 Average Depth of Reservoir Shoreland

TVA's GIS was used to determine the average depths of flowage easement and TVA-owned residential access shoreland *(Table 3.4-7)* from data collected by the Land Management Offices. Averages and proportions were calculated for developed and undeveloped shoreland along selected mainstream and tributary reservoirs. Data were also subdivided into shoreland less than or equal to 100 feet deep and shoreland greater than 100 feet in depth.

Flowage Easement Shoreland

- Average depth for all shoreland is significantly higher on undeveloped properties than it is on developed lands. This difference is more pronounced on mainstream reservoirs than it is on tributaries.
- Average shoreland depths greater than 100 feet are significantly higher on mainstream reservoirs than they are on tributaries.
- Overall, shoreland depth averages 36 feet on properties less than or equal to 100 feet deep and 802 feet on those with depths greater than 100 feet.
- Slightly more than 60 percent of flowage easement shoreland is less than or equal to 100 feet deep. This proportion is 51 percent on mainstream reservoirs and 86 percent on tributaries.

Table 3.4-6. Number of Land- and Water-Based Residential Shoreline Alterations by Reservoir.

Reservoir	Number of Alterations			
	Land-Based	Water-Based	Total	Per Developed Mile of Residential Shoreline
Apalachia[1]	—	—	—	—
Bear Creek Project	NA[2]	NA	NA	NA
Beech River Project	NA[2]	NA	NA	NA
Blue Ridge	513	720	1,233	80
Boone	2,209	4,373	6,582	102
Chatuge	1,087	1,226	2,313	44
Cherokee	216	756	972	16
Chickamauga	1,361	4,962	6,323	71
Douglas	698	1,203	1,901	24
Fontana	21	65	86	33
Fort Loudoun	2,244	6,702	8,946	48
Fort Patrick Henry	154	375	529	68
Guntersville	2,523	3,315	5,838	67
Hiwassee	76	135	211	18
Kentucky	1,611	3,423	5,034	42
Melton Hill	297	697	994	58
Nickajack	123	555	678	51
Normandy	NA[2]	NA	NA	NA
Norris	455	1,258	1,713	19
Nottely	586	497	1,083	42
Ocoee Project[1]	—	—	—	—
Pickwick	566	2,292	2,858	45
South Holston	649	429	1,078	60
Tellico	413	961	1,374	70
Tims Ford	819	1,268	2,087	48
Watauga	510	321	831	43
Watts Bar	1,733	5,950	7,683	54
Wheeler	1,160	2,436	3,596	60
Wilbur	0	0	0	0
Wilson	63	3,686	3,749	44
Total	**20,087**	**47,605**	**67,692**	**49**

[1]The shoreline area is managed by TVA and other agencies for purposes other than residential access. A few residential alterations exist as a result of special use permits, but these are not included in the total.

[2]NA = Not available

Table 3.4-7. Average Shoreland Depth by Reservoir Group, Depth Classification, and Development Status for Two Ownership Categories.

Shoreland Depth Classification	Flowage Easement Shoreland[1]			TVA-Owned Residential Access Shoreland[2]		
	Developed	**Undeveloped**	**All Shoreland**	**Developed**	**Undeveloped**	**All Shoreland**
Mainstream Reservoirs						
	Average Depth (ft.)					
Shoreland ≤100 ft.	42	29	32	55	47	51
Shoreland >100 ft.	551	947	867	314	357	337
All Shoreland	256	497	441	148	165	157
	Percent					
Shoreland ≤100 ft.	58	49	51	60	58	59
Shoreland >100 ft.	42	51	49	40	42	41
Tributary Reservoirs						
	Average Depth (ft.)					
Shoreland ≤100 ft.	43	40	41	54	54	54
Shoreland >100 ft.	205	317	279	206	472	431
All Shoreland	61	87	75	71	231	181
	Percent					
Shoreland ≤100 ft.	89	83	86	80	50	59
Shoreland >100 ft.	11	17	14	20	50	41
All Reservoirs						
	Average Depth (ft.)					
Shoreland ≤100 ft.	43	33	36	55	50	52
Shoreland >100 ft.	492	889	802	294	419	377
All Shoreland	169	400	331	122	199	167
	Percent					
Shoreland ≤100 ft.	72	57	61	66	54	59
Shoreland >100 ft.	28	43	39	34	46	41

[1]Averages based on data collected on 4 mainstream and 9 tributary reservoirs.
[2]Averages based on data collected on 7 mainstream and 13 tributary reservoirs.

TVA-Owned Residential Access Shoreland

- Average depth of all TVA-owned residential access shoreland is significantly higher on undeveloped properties than it is on developed lands. The difference is much more pronounced on tributaries than on mainstream reservoirs.
- When compared to mainstream reservoirs, average shoreland depths greater than 100 feet are higher on undeveloped tributary reservoir shoreland but lower on developed properties.
- Average depths of shoreland less than or equal to 100 feet in depth are about equal between developed and undeveloped properties and also between mainstream and tributary reservoirs.
- Overall, TVA-owned residential access shoreland depth averages 52 feet on properties less than or equal to 100 feet deep and 377 feet on those with depths greater than 100 feet.
- Almost 60 percent of shoreland in this ownership category is less than or equal to 100 feet deep. This proportion is the same on mainstream and tributary reservoirs.

3.5 Shoreline Vegetation

3.5.1 Introduction

Almost all of the reservoir shoreline and study area is vegetated with some combination of trees, shrubs, forbs, and grasses. Forest is the principal land cover type. Based on an analysis of late successional forests, Braun (1950) described four forest regions in the Tennessee River drainage basin:

- Oak-Chestnut Forest Region.
- Mixed Mesophytic Forest Region.
- Western Mesophytic Forest Region.
- Oak-Pine Forest Region.

The first three of these regions are primarily composed of deciduous trees, with conifers restricted to particular conditions such as dry ridges and early successional stages of forest development.

With the demise of American chestnut (about 1930), the Oak-Chestnut Forest Region is now characterized by several species of oak, with yellow-poplar, maple, and American beech common on more moist sites. This region includes the Blue Ridge and most of the Valley and Ridge physiographic provinces (Fenneman, 1938) *(Figure 3.5-1)*.

The Cumberland Plateau Physiographic Province is within the Mixed Mesophytic Forest Region. This region is characterized by numerous tree species which share dominance. Common dominant species include tuliptree, basswood, sugar maple, buckeye, northern red oak, white oak, and white ash.

The rest of the Tennessee Valley, including the Highland Rim, Nashville Basin, and eastern portion of the Coastal Plain Physiographic Provinces, is in the Western Mesophytic Forest Region. Its forests are less diverse than those of the Mixed Mesophytic region and are characterized by several species of oaks, hickories, maples, and elms.

A small portion of the Valley and Ridge and Coastal Plain Provinces, along the southern border of the Tennessee Valley, lies within the Oak-Pine Forest Region. This region is characterized by a mixture of several species of oaks, hickories, and shortleaf and loblolly pines.

3.5.2 Shoreline Vegetation Types

Vegetation types along reservoir shorelines were surveyed on six reservoirs *(Table 3.5-1),* as described in Section 3.8.9 and Appendix K. The proportions of most vegetation types within 25 feet of the shoreline and 25 to 100 feet from the shoreline are similar. Within each distance zone, the proportions of forest (called the tree category in Section 3.8.9 and Appendix K) and tree/grass categories differ significantly (chi-square tests, $P < 0.05$) between developed and undeveloped shorelines. Most of the tree/grass vegetation type is open woodland with a mowed understory typical of wooded yards. The forest category is comparatively undisturbed woodland.

The proportions of the major vegetation types along developed shorelines also vary between ownership categories *(Table 3.5-2).* Compared to TVA-owned residential access shoreland, flowage easement shoreland has a higher proportion in the grass/forb category and a lower proportion in the combined tree-dominated categories (forest, tree/grass, and tree/shrub). These differences are due in part to limited vegetative management on TVA-owned residential access shoreland (Section 1.4.5).

The species composition of study area forests varies greatly within Braun's (1950) regions because of variation in elevation, relief, soil fertility, moisture, and history of human disturbance. Young to mid-successional forests tend to have fairly similar species composition on sites with similar environmental conditions. Eastern redcedar and mixed cedar types are common on reverting old fields and on sites with shallow soils over limestone. Pines are widespread and occur both naturally in early successional stands and in plantations. Loblolly pine plantations are fairly common along reservoir shorelines, especially in the southern and western portions of the Valley.

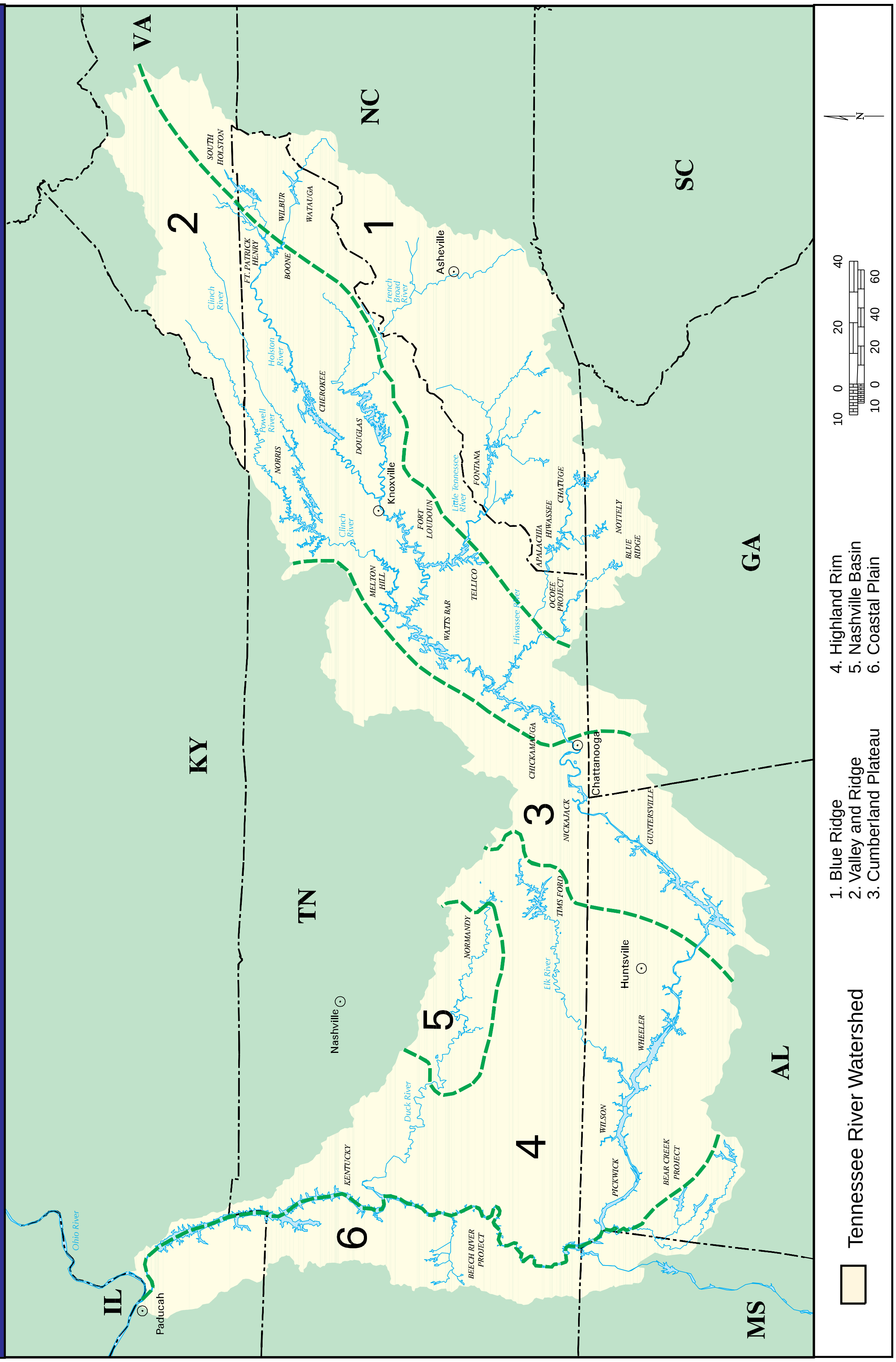


Figure 3.5-1. Physiographic Provinces of the Tennessee Valley.

Table 3.5-1. Percent of Shoreline in Different Vegetation Types Along Developed and Undeveloped Shorelines of Six Reservoirs.[1]

Vegetation Type	Up to 25 ft. from Shoreline			25 to 100 ft. from Shoreline		
	Developed	Undeveloped	Weighted Average	Developed	Undeveloped	Weighted Average
No Vegetation	1.0	2.4	1.9	5.7	6.2	6.1
Grass/Forb	7.9	5.2	6.0	15.4	11.3	12.5
Shrub/Brush	0.6	0.8	0.7	0.4	0.5	0.4
Shrub/Grass	3.4	3.5	3.5	1.2	1.4	1.3
Forest	31.0	69.8	57.9	26.1	69.1	56.2
Tree/Grass	52.0	11.8	24.3	50.2	9.4	21.7
Tree/Shrub	4.1	6.5	5.7	1.0	2.1	1.8

[1]Chatuge, Fort Loudoun, lower third of Kentucky, Melton Hill, Tellico, and most of Watts Bar.

Table 3.5-2. Percent of Developed Shoreline in Different Vegetation Types Within 25 Feet of Shoreline of Six Reservoirs[1] *by Ownership Category.*

Vegetation Type	Ownership Category		
	Flowage Easement	TVA-Owned Residential Access Shoreland	TVA-Owned-and-Jointly-Managed/TVA-Owned-and-Managed Shoreland
No Vegetation	0.7	0.3	3.9
Grass/Forb	9.3	4.8	11.8
Shrub/Brush	0.7	0.3	0.8
Shrub/Grass	4.2	2.5	3.1
Forest	30.3	27.4	44.5
Tree/Grass	50.5	61.6	29.3
Tree/Shrub	4.3	3.1	6.6

[1]Chatuge, Fort Loudoun, lower third of Kentucky, Melton Hill, Tellico, and most of Watts Bar.

Oak-hickory forests, often mixed with pines, are widespread on drier, upland sites. Bottomland hardwoods containing such species as oaks, sweetgum, maples, and other wet-site hardwoods are typical of river bottoms. Sugar maple and American beech frequently occur on rich, north slopes, often with species such as hemlock, northern red oak, and basswood at higher elevations in the eastern Valley. Widespread shrubs occurring in forest understories include spicebush, viburnum, blueberry, poison ivy, privet, and shrub honeysuckle.

Coniferous forests typically support fewer wildlife species than deciduous forests, and the number of species present increases with the proportion of deciduous trees present and density of the shrub layer. Young stands typically have a sparse shrub layer, while privet, blueberry, sumac, rose, and other shrubs may be present in older stands.

Grasslands and croplands make up part of the grass/forb and no-vegetation types listed in *Tables 3.5-1* and *3.5-2*. They are fairly common along the reservoirs, especially in the southern and western portions of the Valley. Agricultural grasslands (pastures, hayfields) and croplands have decreased in the study area since the 1940s (U.S. Census of Agriculture data). Grasslands are early successional communities maintained by grazing, mowing, or fire. This plant community contains numerous grasses, sedges, and forbs and has few woody species. Agricultural crops commonly grown near reservoirs include soybeans, corn, cotton, tobacco, and tomatoes. In addition to the principal crop, various invasive weeds such as cocklebur, pigweed, and Johnson grass are often present.

Brushlands are areas dominated by shrubs and saplings and include the shrub/brush and part of the shrub/grass types listed in *Table 3.5-1*. They are less common near reservoirs than are forests and grasslands, and their area has decreased since the 1940s (U.S. Census of Agriculture data). Brushlands include abandoned farmlands in the early stages of reverting to forest, as well as recently clearcut forests. Blackberry, persimmon, sassafras, and numerous native and nonnative herbs are widespread in brushlands. Without periodic mowing or burning, brushlands eventually revert to forest.

The plant communities of urban and suburban areas vary greatly and include portions of all the shoreline vegetation types listed in *Table 3.5-1*. The vegetation types and species present are affected by the density of development, previous land use, amount of clearing, and type of landscaping. Extensive areas of mowed lawns are common, and trees and shrubs often occur in clumps or as scattered individuals. Tree species present often include such natives as pin oak, sycamore, sweetgum, flowering dogwood, and maples, as well as planted and invasive nonnative species such as tree-of-heaven, Bradford pear, ginkgo, and mimosa.

3.5.3 Forest Area and Tract Size

Forest covers 55.1 percent (standard deviation = 18.6) of the area[1] of the 67 counties adjoining TVA reservoirs. This contrasts with the area within one-fourth mile of the reservoir shoreline, which is 67.4 percent (standard deviation = 18.5) forested; the difference in these two proportions is significant (paired T-test, $P < 0.01$). When analyzed county by county, the proportion of forested land within one-fourth mile of the shoreline correlated poorly with the proportion for the whole county. This suggests that land use patterns adjacent to a reservoir are often different from those of surrounding counties. In many counties with a low proportion (e.g., less than one-third) of forested land, forests within one-fourth mile of the shoreline made up a disproportionately large amount of the total forested area. These counties are dominated by agricultural and urban land uses and include Limestone, Alabama, and Hamblen, Loudon, Meigs, and Union, Tennessee. All of these counties have at least 20 percent of their forest area within one-fourth mile of reservoir shorelines.

The proportion of forested land within the study area increased by about 8 percent between 1940 and 1980 (USDA Forest Service, Forest Inventory and Analysis data). This increase, due mostly to the reforestation of abandoned farmland, has slowed in recent years; since 1980, forest cover has increased about 0.4 percent. Quantitative information on the trend in the proportion of forested land within one-fourth mile of the reservoir shorelines is not available. The current proportion of forested land within this zone, however, is weakly correlated with the age of the reservoir. Extrapolating from this relationship to a trend, however, is difficult because of varying land ownership patterns, physiographic settings, and local population densities.

Both the proportion of forested land and the size of contiguous tracts of forest within the one-fourth-mile shoreline zone are related to the development status of the reservoir shoreline. Analysis of nine reservoirs[2] showed that 53.1 percent of this zone is in forest. The proportion of forested land is significantly greater (paired T-test, $P = 0.01$) along undeveloped shorelines (average 54.2, standard deviation = 15.0) than along developed shorelines (average 42.8, standard deviation = 16.2) on a reservoir-by-reservoir basis. Contiguous tracts of forest within this zone average 18.2 acres in size.[3] Along undeveloped shorelines, contiguous tracts of forest average 24.6 acres (standard deviation = 17.9), significantly greater (paired T-test, $P < 0.05$) than the average of 10.5 acres (standard deviation = 5.1) along developed shorelines.

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[1]Determined from interpreted 1989-1992 LANDSAT satellite imagery with a minimum resolution (pixel size) of approximately 100 by 100 feet.

[2]Chatuge, Chickamauga, Fort Loudoun, lower one-third of Kentucky, Melton Hill, Norris, Tellico, Watts Bar, and Wheeler; determined from interpreted 1989-1992 LANDSAT satellite imagery with a minimum resolution (pixel size) of approximately 100 by 100 feet.

[3]Determined from LANDSAT forest cover data after overlaying 150-foot-wide unforested buffer along primary roads and 75-foot-wide unforested buffer along secondary roads. Because of the one-fourth-mile zone limits, tract sizes are underestimated; some extended further from the shoreline.

3.6 Wildlife

3.6.1 Introduction

Because it includes portions of six physiographic regions (Fenneman, 1938) (*Figure 3.5-1)* and many different plant communities, the reservoir area and adjacent counties support a large number of wildlife species, including about 500 species of vertebrates other than fish. Many of these animals are conspicuous parts of the shoreline environment.

3.6.2 Forest Wildlife Populations

This section describes the wildlife found in the upland forests of the study area. Wildlife species found in forested wetlands are listed in Appendix L.

Deciduous forests support the greatest diversity of wildlife. Common mammals in this type include the red bat, short-tailed shrew, gray squirrel, and white-footed mouse. The bird community includes species present throughout the year, species which nest in the region and migrate to winter in the Caribbean and Latin America (often referred to as neotropical migrants), and species which winter in the region. Common birds present throughout the year include woodpeckers, the blue jay, Carolina chickadee, tufted titmouse, and Carolina wren. Common neotropical migrants include the yellow-billed cuckoo, wood thrush, red-eyed vireo, Kentucky and hooded warblers, and summer tanager. Wintering birds include the winter wren, gold-crowned kinglet, and yellow-rumped warbler. Among the common reptiles are the five-lined skink, eastern box turtle, and ringneck and rat snakes. Common amphibians, especially near water, are the American toad, spring peeper, and dusky and slimy salamanders. The number of wildlife species present tends to increase with the size of the forested area. This has been especially well documented for neotropical migrant birds (e.g., Robbins et al., 1989).

Coniferous forests typically support fewer wildlife species than deciduous forests, and the number of species present increases with the proportion of deciduous trees present and the density of the shrub layer. The pine warbler, ground skink, and southeastern crowned snake are among the few species frequently found in pine forests across the Valley. Several of the species found in deciduous forests also occur in mixed coniferous-deciduous forests, and several species found in dry, upland pines also occur in dry, upland, deciduous forests.

Several common game animals occur in shoreline forests. The gray squirrel and ruffed grouse occur primarily in forests. White-tailed deer and wild turkey occur in deciduous and coniferous forests and also use adjacent grassland, cropland, and brushland habitats. With the exception of the ruffed grouse, these species occur around most TVA reservoirs. Ruffed grouse are restricted to forests in the eastern end of the Valley. Harvest surveys and census results compiled by state wildlife agencies show that populations of both white-tailed deer and wild turkey are generally increasing. Gray squirrel and ruffed grouse populations appear relatively stable.

Information on the population trends of other forest wildlife is only available for birds at the regional scale. North American Breeding Bird Survey results for 1966-1994 show significant ($P < 0.10$) increasing or decreasing trends (analyzed as described by Link and Sauer, 1994) in 20 birds nesting in Valley forests. For those species requiring extensive tracts of forest, the proportion with decreasing trends is significantly greater (chi-square test, $P < 0.01$) than the proportion with increasing trends. The proportion of neotropical migrants with decreasing trends is also greater than the proportion with increasing trends. There are no significant differences in these proportions for permanent residents or species nesting in small tracts of forest.

3.6.3 Wintering Waterfowl Populations

TVA reservoirs provide migration and winter habitat for many waterfowl species. On a continental basis, they are very important to Canada geese, mallards, American black ducks, American widgeons, and gadwalls, as well as to migrating blue-winged teal, northern pintails, ring-necked ducks, and lesser scaup (Bellrose, 1980).

Since the 1930s, numerous actions designed to increase the suitability of TVA reservoirs for waterfowl have been carried out (Wiebe, 1946; Wiebe et al., 1950). These actions have included establishing two national wildlife refuges and numerous state wildlife refuges and management areas, constructing subimpoundments, operating dewatering areas, and planting food crops. Wildlife refuges and management areas presently make up a large percentage of the TVA-owned-and-jointly-managed shoreland.

The population trends of waterfowl vary among species. The number of migrant Canada geese wintering in the Valley has decreased since the 1960s, as they have shifted their wintering grounds northward. Nonmigratory Canada geese have greatly increased in the Valley since stocking programs began in the 1970s, and on some reservoirs these geese have become nuisances. Wood duck numbers have increased as shoreline forests matured, resulting in more suitable nest sites, and as increasing beaver populations created more suitable wetlands habitats. Populations of most other ducks have shown a long-term decrease consistent with their continental trends. Local populations of several ducks such as the gadwall and American widgeon fluctuate with the availability of aquatic bed wetlands (Section 3.9.3).

To quantitatively describe the quality of reservoir areas for wintering waterfowl populations, a waterfowl habitat suitability model was developed. This model focuses on dabbling ducks, such as the mallard, American black duck, American widgeon, and gadwall, which frequent shallow water and shoreline areas.

The major components of the model are the presence and diversity of wetlands, the degree of human disturbance along the shoreline (based on the type of shoreline development), and the proximity to wildlife refuges and management areas. Another important habitat component, the proximity to croplands of cultivated grains, notably corn (Allen, 1986; Johnson and Montalbano, 1989), was not included because current maps showing their distribution were not available. The model was applied to Chatuge, Chickamauga, Tellico, Watts Bar, and the downstream third of Kentucky Reservoirs. Within each reservoir, the area of analysis was the drawdown zone between the normal summer and winter pool levels. Habitat quality was scored on a scale from 0, indicating low suitability, to 3, the highest suitability. A detailed description of the model is given in Appendix M.

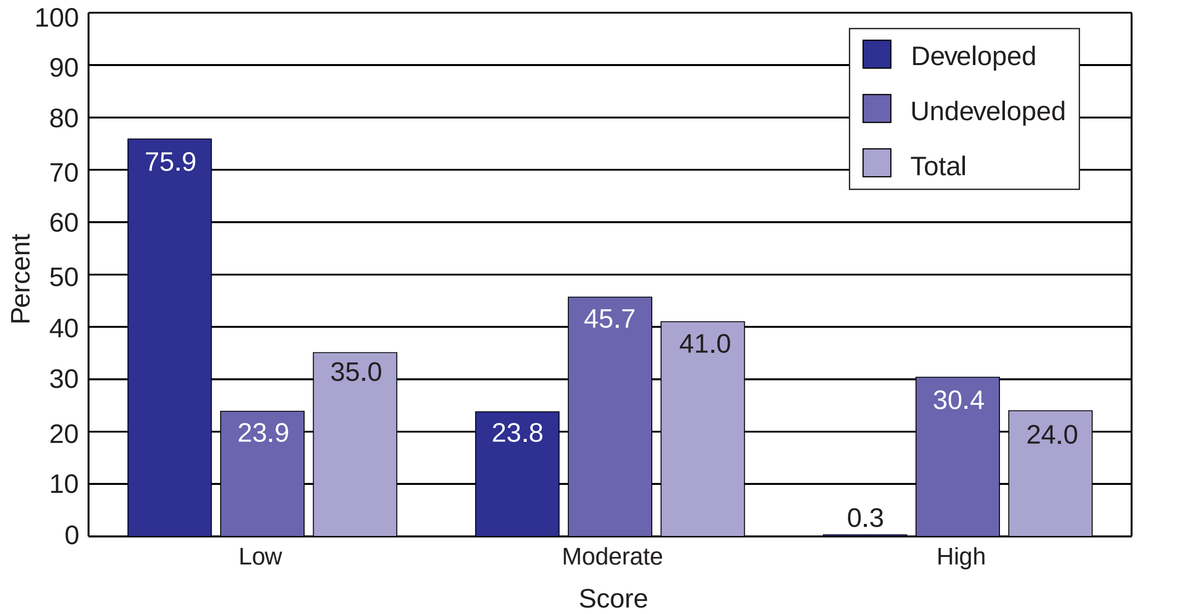
Existing Conditions

The drawdown zone of each reservoir was divided into three suitability classes. Thirty-five percent of the area was classified as low suitability (score 0-1), 41 percent as moderate suitability (score 1-2), and 24 percent as high suitability (score 2-3) wintering waterfowl habitat *(Figure 3.6-1)*. The drawdown zone fronting developed shoreline has a higher proportion of low suitability habitat and a lower proportion of both moderate and high suitability habitat than the drawdown zone fronting undeveloped shoreline. The differences in the proportions of developed and undeveloped shoreline in the low and high suitability classes are significant (paired T-test, $P < 0.01$ and $P = 0.02$, respectively). The difference in the proportion of developed and undeveloped shoreline in the moderate suitability class approaches significance ($P = 0.06$). Much of the difference is due to increased human disturbance along developed shorelines. The lower frequency of wetlands occurrence near developed shorelines (Section 3.9.5) was also a factor.

3.6.4 Other Wildlife Communities

Grasslands and croplands support few wildlife species. Common species present in grasslands include the eastern meadowlark, red-winged blackbird, rat snake, eastern garter snake, and Fowler’s toad. Species commonly occurring in croplands include the common grackle, red-winged blackbird, black racer, eastern garter snake, and Fowler’s toad. Several of these species feed in croplands but require other habitats for breeding.

Figure 3.6-1. Wintering Waterfowl Habitat Suitability in Relation to Shoreline Development.



Brushlands support wildlife populations with diversity intermediate between those of deciduous forests and grasslands. Common species include the cotton rat, white-eyed vireo, common yellowthroat, yellow-breasted chat, indigo bunting, field sparrow, black racer, fence lizard, and Fowler's toad.

North American Breeding Bird Survey results show declining population trends since 1966 for the majority of grassland and brushland birds. This declining trend is occurring in both permanent resident and neotropical migrant species and is in part due to the decrease in grassland and brush-land habitats. Little population trend information is available for other animals occurring in grasslands and brushlands.

The eastern cottontail and northern bobwhite are common game species which use grasslands, croplands, and brushlands. Another common game species, the mourning dove, frequently feeds in croplands. Area populations of the cottontail and bobwhite are decreasing, while mourning dove populations appear relatively stable.

Urban and suburban areas vary in their wildlife populations, depending on the density of development, previous land use, amount of clearing, and type of landscaping. Species present in areas with extensive lawns and few trees include both nonnative species such as the house mouse, rock dove, European starling, and house finch, and native species such as the American robin and northern mockingbird. The nonnative house finch and native gray squirrel, mourning dove, chimney swift, northern cardinal, and eastern garter snake occur in urban and suburban areas over a wide range of vegetation density. Several of the wildlife species present in deciduous and coniferous forests occur in suburban areas that have a high proportion of forest cover.

In addition to waterfowl, a variety of shorebirds and other waterbirds use Valley reservoirs. Shorebirds (mostly sandpipers and plovers) are most numerous during their spring and late summer/ early fall migration periods and prefer very shallow water (less than 3 inches deep) and moist areas within the drawdown zone. Their numbers in reservoir habitats vary with seasonal weather patterns and reservoir drawdown regimes. Other waterbirds present include the double-crested cormorant, great blue heron, great egret, black-crowned night heron, and osprey. Populations of these species within the reservoir area have greatly increased since the 1940s as a result of expansion into newly created habitat, recovery from pesticide poisoning, and responses to specific management actions (Beddow, 1990; Pullin, 1990; Palmer-Ball, 1991).

3.7 Endangered and Threatened Species

The Endangered Species Act of 1973, as amended,

- Establishes procedures for identifying animal and plant species in need of protection.
- Requires all federal agencies to determine if their activities are likely to jeopardize the continued existence of listed species.
- Requires federal agencies to cooperate in programs for the conservation of listed species.
- Sets penalties for illegal taking, possession, or sale of listed species, their parts, or products.

Information presented in the most recent USF&WS listing of endangered and threatened species (USF&WS, 1994) and records maintained in TVA's Natural Heritage database indicate that a number of listed and well-studied candidate plant and animal species occur, or have occurred, in the Tennessee River watershed. The names and listing status of these species are presented in *Table 3.7-1*, along with listed species that occur within the area potentially impacted, either directly, indirectly, or cumulatively, by the various shoreline management alternatives. This study area is considered to be the shoreline and pools of TVA reservoirs, the land area extending about 3 miles from the shoreline, the tailwaters downstream of the dams, and the lower stretches of tributary streams within about 3 miles of reservoir pools. The 3-mile distance was used to better account for the distributions, biology, and home ranges of the different listed species.

Table 3.7-2 lists the habitat requirements of the 25 species in this study area. These species vary greatly in their distribution in the reservoir area. The three plant species and one of the bird species occur in a small portion of the region. The remaining four terrestrial species, two bats and two birds, are relatively widespread.

Two of the 17 aquatic species included in *Table 3.7-2* occur in relatively unique habitats: underground pools for the Alabama cavefish, and low gradient, open water pools with submergent vegetation for the spring pygmy sunfish. Most of the other federally protected aquatic species potentially affected by shoreline management alternatives occur downstream from dams where important habitat conditions persist. Several of these species typically occur together as parts of diverse communities in places such as the Tennessee River downstream from Pickwick Landing Dam or the Elk River, a considerable distance downstream from Tims Ford Dam. Populations of several of these species also survive upstream from some reservoirs (on stream reaches) and would not be affected by reservoir shoreline management decisions.

3.8 Soils

3.8.1 Introduction

The Tennessee Valley is a diverse area made up of six different physiographic provinces (Fenneman, 1938) *(Figure 3.5-1).* These range from the rugged Blue Ridge Mountains in the eastern portion of the Valley region to the flat coastal plain area in the western portion. Variations in factors such as topography, climate, and parent material account for the development of different soils within each province. These soils range from shallow and loamy to deep clay.

3.8.2 Climate

The Tennessee Valley has a warm, temperate, humid climate. Most of the Valley receives 46 to 54 inches of rainfall annually. The Blue Ridge province is cooler and wetter due to the higher elevations, with rainfall averaging 54 to 80 inches annually in the Unaka Mountains. The Cumberland Mountains, located in the Cumberland Plateau province, receive 54 to 60 inches of precipitation annually, also due to the higher elevation. Rainfall of this amount influences soil erosion potential. Average annual temperature varies from 62^{o}F in the southwest portion of the Tennessee Valley region to 45^{o}F in the high mountain peaks of the Unakas.

Table 3.7-1. Federally Listed Endangered (LE), Threatened (LT), and Former High Probability Candidate Species (C1) Known or Likely to Occur in the Tennessee River Watershed.

Common Name	Scientific Name	Federal Status	In Study Area?
Mammals			
Red Wolf	*Canis rufus*	LE	No
Carolina northern flying squirrel	*Glaucomys sabrinus coloratus*	LE	No
Gray bat	*Myotis grisescens*	LE	Yes
Indiana bat	*Myotis sodalis*	LE	Yes
Virginia big-eared bat	*Plecotus townsendii virginianus*	LE	No
Birds			
Peregrine falcon	*Falco peregrinus*	LE	Yes
Bald eagle	*Haliaeetus leucocephalus*	LT	Yes
Red-cockaded woodpecker	*Picoides borealis*	LE	Yes
Fishes			
Spotfin chub	*Cyprinella monacha*	LT	No
Spring pygmy sunfish	*Elassoma alabamae*	C1	Yes
Slender chub	*Erimystax cahni*	LT	No
Boulder darter	*Etheostoma wapiti*	LE	Yes
Duskytail darter	*Etheostoma percnurum*	LT	Yes
Slackwater darter	*Etheostoma boschungi*	LT	No
Palezone shiner	*Notropis albizonatus*	LE	No
Pygmy madtom	*Noturus stanauli*	LE	Yes
Smoky madtom	*Noturus baileyi*	LE	No
Yellowfin madtom	*Noturus flavipinnis*	LT	No
Snail darter	*Percina tanasi*	LT	Yes
Alabama cavefish	*Speoplatyrhinus poulsoni*	LE	Yes
Arthropods			
Lee County cave isopod	*Lirceus usdagalun*	LE	No
Spruce-fir moss spider	*Microhexura montivaga*	LE	No
Alabama cave shrimp	*Palaemonias alabamae*	LE	No
Holsinger’s cave beetle	*Pseudanophthalmus holsingeri*	C1	No
Mollusks			
Appalachian elktoe	*Alasmidonta raveneliana*	LE	No
Birdwing pearlymussel (pm)	*Conradilla caelata*	LE	No
Fanshell	*Cyprogenia stegaria*	LE	Yes
Dromedary pm	*Dromus dromas*	LE	Yes
Cumberlandian combshell	*Epioblasma brevidens*	LE	No
Oyster mussel	*Epioblasma capsaeformis*	LE	No
Yellow-blossom pm	*Epioblasma f. florentina*	LE	No
Purple cat’s paw pm	*Epioblasma o. obliquata*	LE	No
Green-blossom pm	*Epioblasma torulosa gubernaculum*	LE	No
Tubercled-blossom pm	*Epioblasma t. torulosa*	LE	No
Turgid-blossom pm	*Epioblasma turgidula*	LE	No
Tan riffleshell	*Epioblasma walkeri*	LE	Yes
Shiny pigtoe pm	*Fusconaia cor*	LE	No
Fine-rayed pigtoe pm	*Fusconaia cuneolus*	LE	No
Cracking pm	*Hemistena lata*	LE	Yes

Table 3.7-1 (Cont.). Federally Listed Endangered (LE), Threatened (LT), and Former High Probability Candidate Species (C1) Known or Likely to Occur in the Tennessee River Watershed.

Common Name	Scientific Name	Federal Status	In Study Area?
Mollusks *(cont.)*			
Pink mucket pm	*Lampsilis abrupta*	LE	Yes
Alabama lampshell	*Lampsilis virescens*	LE	No
Ring pink mussel	*Obovaria retusa*	LE	Yes
Little-wing pm	*Pegias fabula*	LE	No
White wartyback pm	*Plethobasus cicatricosus*	LE	Yes
Orange-foot pimpleback pm	*Plethobasus cooperianus*	LE	Yes
Clubshell	*Pleurobema clava*	LE	No
Rough pigtoe pm	*Pleurobema plenum*	LE	Yes
Rough rabbitsfoot (mussel)	*Quadrula cylindrica strigillata*	LE	No
Winged mapleleaf mussel	*Quadrula fragosa*	LE	No
Cumberland monkeyface pm	*Quadrula intermedia*	LE	No
Appalachian monkeyface pm	*Quadrula sparsa*	LE	No
Pale lilliput pm	*Toxolasma cylindrellus*	LE	No
Purple bean	*Villosa perpurpurea*	LE	No
Cumberland bean pm	*Villosa trabilis*	LE	Yes
Snails			
Painted snake coiled forest snail	*Anguispira picta*	LT	No
Anthony's riversnail	*Athearnia anthonyi*	LE	Yes
Royal marstonia (snail)	*Pyrgulopsis ogmorhaphe*	LE	No
Noonday globe	*Mesodon clarki nantahala*	LT	No
Plants			
Price potato-bean	*Apios priceana*	LT	No
Virginia roundleaf birch	*Betula uber*	LT	No
Morefield's leather flower	*Clematis morefieldii*	LE	No
Cumberland rosemary	*Conradilla verticillata*	LT	No
Prairie clover	*Dalea foliosa*	LE	No
Spreading avens	*Geum radiatum*	LE	No
Eggert sunflower	*Helianthus eggertii*	LT	No
Swamp pink	*Helonias bullata*	LT	No
Small whorled pogonia	*Isotria medeoloides*	LT	No
Lyre-leaf bladderpod	*Lesquerella lyrata*	LT	No
Barbara buttons	*Marshallia mohrii*	LT	No
American harts-tongue fern	*Phyllitis scolopendrium var. americanum*	LE	No
Ruth's golden aster	*Pityopsis ruthii*	LE	Yes
Harperella	*Ptilimnium nodosum*	LE	No
Arrowhead	*Sagittaria fasciculata*	LE	No
Arrowhead	*Sagittaria secundifolia*	LT	No
Green pitcher plant	*Sarracenia oreophila*	LE	Yes
Mountain sweet pitcher plant	*Sarracenia rubra ssp. jonesii*	LE	No
Mountain skullcap	*Scutellaria montana*	LE	Yes
Blue Ridge goldenrod	*Solidago spithamaea*	LT	No
Yellow-eyed-grass	*Xyris tennesseensis*	LE	No

Table 3.7-2. Habitat Requirements and Distribution of Federally Listed Species Occurring in the TVA Reservoir Study Area.

Species	Habitat Requirements
Mammals	
Gray bat	Caves; surrounding woodlands; over lake and river surfaces
Indiana bat	Caves; riparian woodlands
Birds	
Peregrine falcon	Rock bluffs; tall buildings; reservoir areas with shorebird or waterfowl concentrations
Bald eagle	Large rivers; reservoirs; adjacent forested areas
Red-cockaded woodpecker	Extensive mature/old growth yellow pine forests near Parksville Reservoir
Fishes	
Spring pygmy sunfish	Open water in springs, runs, and swamps with fine-leaved, submergent vegetation in north Alabama counties along the Tennessee River
Boulder darter	Around large rocks in moving water, in or near lower Elk River
Duskytail darter	Rocky areas in small and medium rivers; large creeks in east Tennessee
Pygmy madtom	Riffle/run areas in upper Clinch and lower Duck Rivers
Snail darter	Gravel shoals on creeks and rivers; adjacent parts of mainstream Tennessee River from Paint Rock River upstream to lower Holston and French Broad Rivers
Alabama cavefish	Underground pools in single cave system west of Florence, Alabama
Mussels	
Fanshell	Gravel substrates in medium and large rivers
Dromedary pearlymussel (pm)	Gravel substrates in medium and large rivers
Tan riffleshell	Gravel substrates in small and medium rivers
Cracking pm	Gravel substrates in medium and large rivers
Pink mucket pm	Gravel substrates in medium and large rivers
Ring pink mussel	Gravel substrates in medium and large rivers
White wartyback pm	Gravel substrates in large rivers
Orange foot pimpleback pm	Gravel substrates in large rivers
Rough pigtoe pm	Gravel substrates in medium and large rivers
Cumberland bean pm	Gravel substrates in small and medium rivers
Snails	
Anthony's riversnail	Rock substrates in flowing water; one site in Alabama, two in Tennessee
Plants	
Ruth's golden aster	Sunny rock crevices in rivers in Polk County, Tennessee
Green pitcher plant	Sunny, moist fields and bogs with sandy, acidic soils in northeast Georgia and southwest North Carolina
Mountain skullcap	Dry to moderately moist rocky slopes forested primarily with oaks and hickories in northwest Georgia and southeast Tennessee

3.8.3 Soils of the Blue Ridge

The Blue Ridge physiographic province is located in extreme eastern Tennessee, western North Carolina, and portions of northern Georgia. Ten TVA reservoirs are located in this easternmost province of the Tennessee Valley *(Table 3.8-1)*. Elevations range from 100 to over 6,000 feet. Colluvium, which is material carried down slopes by gravity, is the parent material for soils found from the footslopes almost to the ridges. The loamy soils on the upper slopes of the mountains are about 1 to 3 feet thick over rock and contain various amounts of rock fragments. The soils gradually become deeper (3 to 7 feet) farther down the slope. The valley soils are deep, well-drained, and loamy. The soils of the Unaka Mountains region are not highly erodible due to the loamy texture and high organic content, but erosion can be a major problem on steep slopes where woody vegetation has been cleared.

3.8.4 Soils of the Valley and Ridge

The Valley and Ridge physiographic province is located west of the Blue Ridge province and east of the Cumberland Plateau. It extends from southwest Virginia, through eastern Tennessee, and into northern Georgia and Alabama. Ten TVA reservoirs are located in this province, which has elevations ranging from 600 to 3,000 feet. The region is underlain by steeply tilted and folded rock formations extending in a northeast to southwest direction. The parent materials for the soils on the ridges are sandstone and hard shale, with some formed from cherty, dolomitic limestone. Soft shales and limestones intermixed with clay, along with colluvium from the upland slopes, form the parent material in the valleys. The soils are generally shallow over the shales and sandstones and very deep over the dolomitic limestone. Due to clay and the loamy texture, erosion potential is low for these soils, except on slopes without adequate vegetative cover.

3.8.5 Soils of the Cumberland Plateau

The Cumberland Plateau physiographic province is located east of the Highland Rim and west of the Valley and Ridge Province. It extends from southwestern Virginia through east central Tennessee into northeastern Alabama. Two TVA reservoirs are located in this province, which has elevations ranging from 600 feet in the valleys to 3,000 feet in the northeast mountains. The parent materials underlying this area are Pennsylvanian sandstone and shales. Soils in the valleys also formed from alluvium and colluvium, which had weathered and moved downslope. The dominant soils in this region range from 2 to 4 feet deep over rock. Sandstone outcroppings are common on slopes. Plateau soils are loamy in texture, which usually means a low erosion potential. However, shallow soil depth, rock content, and steep slopes result in slippage and subsequent erosion problems.

3.8.6 Soils of the Highland Rim

The Highland Rim physiographic province is located west of the Cumberland Plateau. It is the largest physiographic province in Tennessee and occurs in central Tennessee and small portions of northern Alabama and western Kentucky. Three TVA reservoirs are located in this province, which has elevations ranging from 400 to 1,300 feet. In western Tennessee, the Tennessee River is the dividing boundary between the Highland Rim and Coastal Plain provinces. Therefore, portions of two other reservoirs (50 percent of Kentucky and 70 percent of Pickwick) are also located here. Limestone underlies all of the Highland Rim. The soils on the upper slopes formed from limestone and have clay subsoils. The parent materials for the footslopes and flats are limestone residuum and thin loess, which is windblown silt (Vanderford, 1957). In the eastern and northern parts some of the soils formed in old alluvium (silt carried by water), which was then covered by thin loess. The soils have a silt texture where the parent material is loess, and erodibility in these areas is high. In other areas of the Highland Rim where limestone is the parent material, the soils have a loamy or clay texture which is not highly erodible.

Table 3.8-1. Reservoir Shoreline Miles by Physiographic Province.

Physiographic Province	Reservoir	Number of Shoreline Miles	Percent
1. Blue Ridge			
	Apalachia	31.5	2.8
	Blue Ridge	68.1	6.0
	Chatuge	128.0	11.3
	Fontana	237.8	21.0
	Hiwassee	164.8	14.5
	Nottely	102.1	9.0
	Ocoee Project	109.5	9.7
	South Holston	181.9	16.0
	Watauga	104.9	9.3
	Wilbur	4.8	0.4
	Total	**1,133.4**	**100.0**
2. Valley and Ridge			
	Boone	126.6	2.9
	Cherokee	394.5	9.1
	Chickamauga	783.7	18.2
	Douglas	512.5	11.9
	Fort Loudoun	378.2	8.8
	Fort Patrick Henry	31.0	0.7
	Melton Hill	193.4	4.5
	Norris	809.2	18.8
	Tellico	357.0	8.3
	Watts Bar	721.7	16.8
	Total	**4,307.8**	**100.0**
3. Cumberland Plateau			
	Guntersville	889.1	83.3
	Nickajack	178.7	16.7
	Total	**1,067.8**	**100.0**
4. Highland Rim			
	Kentucky (50%)	1,032.2	35.9
	Pickwick (70%)	343.4	11.9
	Tims Ford	308.7	10.7
	Wheeler	1,027.2	35.7
	Wilson	166.2	5.8
	Total	**2,877.7**	**100.0**
5. Nashville Basin			
	Normandy	75.1	100.0
	Total	**75.1**	**100.0**
6. Coastal Plain			
	Bear Creek Project	271.6	17.7
	Beech River Project	82.3	5.4
	Kentucky (50%)	1,032.1	67.3
	Pickwick (30%)	147.2	9.6
	Total	**1,533.2**	**100.0**

3.8.7 Soils of the Nashville Basin

The Nashville Basin physiographic province is located in central Tennessee. It is completely surrounded by the Highland Rim. Normandy is the only TVA reservoir located in this province, which has elevations ranging from 500 feet in the flat glade lands to 800 feet in the rugged ridges near the Highland Rim. The Nashville Basin can be divided into outer and inner parts. The outer part of the Basin is underlain by phosphate limestone. Outcrops of this bedrock can be seen on nearly every farm. This limestone, along with some thin loess, is the parent material for the soils here. The soils vary in depth but are generally deep and well drained. Most of the soil is clay and loam with low erosion potential except in areas where much loess is present. The inner part of the Basin is smoother and lower than the outer part. Most of the soils were formed from limestone. The soil may be only a few inches deep in cedar glades to 6 or 8 feet deep near rivers where alluvium has been deposited. In most places the soils are shallow with a clay texture. Erosion is low in this area of the Basin, except on the terraces where alluvium has formed a more erodible, silty textured soil.

3.8.8 Soils of the Coastal Plain

The Coastal Plain physiographic province extends from northwestern Alabama through northeastern Mississippi and western Tennessee. The Highland Rim lies to the east of the Coastal Plain and the Mississippi Valley to the west. Two TVA reservoirs are located in this province, which has elevations ranging from 150 to 700 feet. Portions of two other reservoirs (50 percent of Kentucky and 30 percent of Pickwick) are also located here. The entire area is made up of unconsolidated marine sediments — clays, sands, and gravels (Smith and Soileau, 1966). These sediments are overlaid by a layer of loess in western areas.

The Coastal Plain province can be divided into two regions: Coastal Plain and Loess. The Coastal Plain region consists of sediment deposits of ancient seas, which formed soils that are loamy or sandy and sometimes clay. The hilltops are commonly capped with a thin layer of loess. These soils are usually silty on top and sandy, loamy, or clay in the lowest part. The medium texture of these soils makes them, along with those in the Loess region, the most highly erosive soils in the Tennessee Valley. Gullies are frequently present on hillsides where vegetation has been removed. The Loess region is an area west of the Coastal Plain region made up of windblown silt from the Mississippi River Valley. It varies in depth from 70 feet in the bluffs along the western edge to 3 feet thick to the east near Jackson. The soils here have a silty texture and are the most erodible in the Tennessee Valley region.

3.8.9 Shoreland Soil Erosion

Shoreline erosion and the resultant loss of property and degradation of water quality are of great concern to most users of TVA reservoirs, as evidenced by public comments. Several variables contribute to shoreland erosion. To gain a better understanding of the extent of these factors, TVA investigated erosion, land use, vegetation type, and vegetation impacts in a 100-foot riparian zone. Shoreline riparian zones of six reservoirs — Melton Hill, Tellico, Chatuge, Fort Loudoun, Watts Bar, and Kentucky — were examined from the spring of 1994 through the spring of 1995.

Two zones around each reservoir were characterized. Zone 1 extends from the water and shoreline interface to 25 feet inland, and Zone 2 extends from 25 feet to 100 feet further inland. An investigation sheet was developed to document vegetation type categories, such as tree, shrub, wetlands, and grass; and land use categories such as agriculture, forest, and recreation. Vegetation management impacts, such as from clearing, thinning, mowing, and livestock grazing, were also included.

Soil erosion was categorized as none, minimal, moderate, severe, and critical. The field investigation sheet was sequentially numbered to correspond to a location on a topographic map. Data were collected and later tabulated for each reservoir to give miles and percent of total shoreline by zone and classification (Appendix K). A description of the investigation classes and categories of vegetation type, land use, vegetation impacts, and soil erosion are also in Appendix K.

One of the long-range objectives of the reservoir soil erosion investigation is to develop an erosion classification system that would be used to prioritize erosion sites for possible future treatment. For the purpose of the investigation, moderate, severe, and critical erosion classes are considered in need of treatment. Erosion rates for the other two categories (none and minimal) are considered acceptable and would not be treated. *Table 3.8-2* summarizes results of the six reservoirs investigated to date. About 9 percent of the shoreland along these reservoirs is in need of treatment for erosion. Less than 1 percent is critically eroded.

Table 3.8-2. Results of Reservoir Soil Erosion Investigation From the Water/Shoreline Interface to 25 Feet Inland (Zone 1) on Six Representative TVA Reservoirs.

Reservoir	Shoreline Miles Investigated	Number of Miles by Erosion Class			
		Moderate	Severe	Critical	Total
Chatuge	111.7	4.1	0.1	0.0	4.2
Fort Loudoun	250.0	5.5	15.2	2.1	22.8
Kentucky[1]	218.0	22.2	5.7	1.2	29.1
Melton Hill	160.8	13.4	5.0	0.1	18.5
Tellico	311.0	9.1	6.3	0.3	15.7
Watts Bar[1]	277.1	14.4	3.3	5.5	23.2
Total	**1,328.6**	**68.7**	**35.6**	**9.2**	**113.5**
% of Miles Investigated	**100.0**	**5.2**	**2.7**	**0.7**	**8.6**

[1]Only representative portions of these reservoirs were investigated.

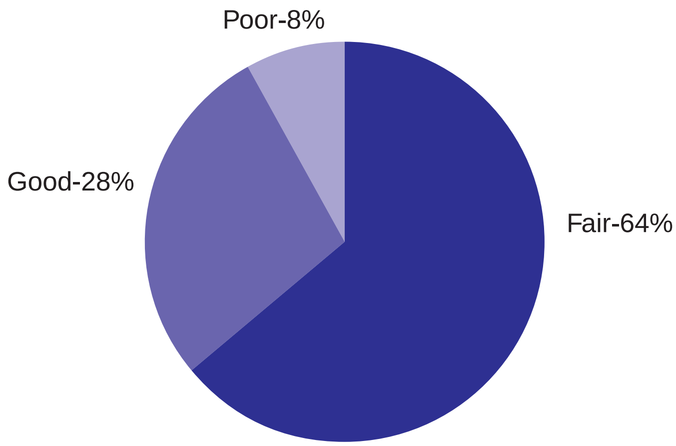
In 1996 TVA also initiated a widespread, intensive effort to treat critical erosion sites. Because of the extent of the erosion problem, TVA only has the resources to demonstrate the various methods that can be used for stabilization. Treatment techniques are focused on natural methods of bioengineering where appropriate, because of increased benefit to aquatic habitat, water quality, and aesthetics. However, site characteristics often dictate the use of more intensive treatment techniques such as a combination of bioengineering and riprap or straight riprap application. Still more intensive techniques, such as gabion walls or live crib walls, may also be utilized when warranted. During the past two years, 39 critically eroding sites have received stabilization treatment. It is hoped that landowners will look at these sites and perhaps use some of these techniques on privately held areas.

As other reservoir investigations are completed, TVA will continue to gather information with which to prioritize sites for future treatment or consideration in other land management activities. This information will also be useful in developing demonstrations of various treatment techniques.

3.8.10 Shoreline Bank Stability

Along both mainstream channels and embayments, shoreline bank stability is affected by adjacent land uses. As a result, most developed and undeveloped shorelines exhibit some degree of erosion. Shoreline bank stability was one of the parameters used to develop the SAHI, a measure of aquatic habitat quality (Section 3.11.4). Extrapolation of data from four representative reservoirs (Chatuge, Fort Loudoun, a portion of Kentucky, and Tellico) indicates that currently as much as 64 percent of shoreline banks along TVA reservoirs are in fair condition with respect to erosion; 8 percent are in poor condition; and 28 percent are in good condition *(Figure 3.8-1)*.

Figure 3.8-1. Current Conditions of Shoreline Bank Stability for TVA Reservoirs.



Average Bank Stability Score = 3.42

3.9 Wetlands

3.9.1 Introduction

Wetlands are highly productive and biologically diverse ecosystems that provide multiple public benefits such as flood control, reservoir shoreline stabilization, improved water quality, and habitat for fish and wildlife resources.

As defined in *TVA Environmental Review Procedures*,

> Wetlands are those areas inundated by surface or ground water with a frequency sufficient to support, and under normal circumstances, do or would support a prevalence of vegetation or aquatic life that requires saturated or seasonably saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, mud flats, and natural ponds (TVA, 1983).

Along reservoir shorelines, wetlands are transitional ecosystems between terrestrial and aquatic communities. The creation of the TVA reservoir system resulted in the loss of thousands of acres of natural wetlands throughout the Tennessee River Valley. However, reservoir creation and management resulted in the formation of many new wetlands areas (Amundsen, 1994).

Although numerous definitions exist for what constitutes a wetland, they primarily include three identifying characteristics: hydrophytic vegetation, hydric soils, and wetlands hydrology (National Research Council, 1995).

- *Hydrophytic vegetation* is defined as plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.
- *Hydric soil* is defined as a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic (oxygen deficient) conditions in the upper part.
- *Wetlands hydrology* is generally defined as permanent or periodic inundation or prolonged soil saturation sufficient to create anaerobic conditions in the soil.

3.9.2 Wetlands Mapping and Interpretation

The USF&WS National Wetlands Inventory (NWI) is the only comprehensive federal wetlands mapping effort and is based on the classification system of Cowardin et al. (1979). TVA cooperated with the USF&WS in the production of several NWI maps for the Tennessee Valley region in the early 1980s. TVA continues to use NWI-published standards for cartography, photointerpretation, and digitization following the Cowardin classification system for reservoir lands planning and other resource management activities. Much of the information contained in these maps and reports, such as vegetation structure, hydrologic regime, water quality, and substrate type, is relevant in assessing the functions of wetlands. Efforts are being made to determine ways to maximize use of NWI map information in assessing wetlands functions (Smith, 1993). Bingham and Roberts (1994) found a high degree of correspondence between areas mapped as wetlands by NWI and areas that were actually determined to be wetlands by on-site data collection.

TVA uses NWI maps as first-level information for wetlands delineation and assessment to ensure consistency with provisions of Executive Order 11990 (Protection of Wetlands) and implementation of NEPA. Due to a lack of quantified information on reservoir shoreline wetlands functions, a qualitative assessment of impacts to wetlands wildlife and waterfowl use of available wetlands habitats was conducted. The fact that most knowledge concerning the ecological integrity function is qualitative is not unique to wetlands (Smith, 1993). Through the public involvement process, state and federal natural resource management agencies and the general public have expressed the value of TVA reservoir wetlands as wildlife and waterfowl habitats.

3.9.3 Wetlands Analysis Zones and Acreage Calculations

GIS analysis of NWI maps and digital data was conducted for all or portions of six representative TVA reservoirs to determine acreage of wetlands types. NWI maps used in the analysis were photointerpreted from 1:24,000 and 1:58,000 scale color infrared and true color photography. The dates of the photography ranged from 1980 to 1992.

Wetland acreages were stratified by the following zones *(Figure 3.9-1):*

- Zone 1 — area from winter pool to normal summer pool elevation.
- Zone 2 — area from normal summer pool elevation to maximum shoreline contour.
- Zone 3 — area from maximum shoreline contour to one-fourth mile inland.

Table 3.9-1 lists the acreage of the most common wetlands types found within these zones on selected TVA reservoirs. In Zone 1, 79 percent of all wetlands were the aquatic bed type. In Zones 2 and 3, forested wetlands was the dominant type, comprising 82 percent and 89 percent, respectively, of all wetlands within these zones. Wetlands types and wetlands wildlife/waterfowl species that use these habitats are described in detail in Appendix L.

3.9.4 Wetlands Functions and Values

Recent wetlands regulatory and protection strategies at both state and federal levels emphasize the need to assess wetlands functions and values in an effort to protect important public interests.

- Smith (1993) described *wetlands functions* as the processes necessary for the self-maintenance of an ecosystem.
- Kusler (1983) listed the primary functions of wetlands as flood conveyance, flood storage, barriers to waves and erosion, sediment and pollution control, habitat for waterfowl and other wildlife, and habitat for endangered and threatened species.
- Principal functions of TVA reservoir-based wetlands include sediment and pollution control, habitat for waterfowl and other wildlife, and habitat for rare and endangered species.
- Wetlands values are the realized public benefits that result from wetlands functions (Smith, 1993).

Figure 3.9-1. GIS Wetlands Analysis Zones of a Representative Reservoir.

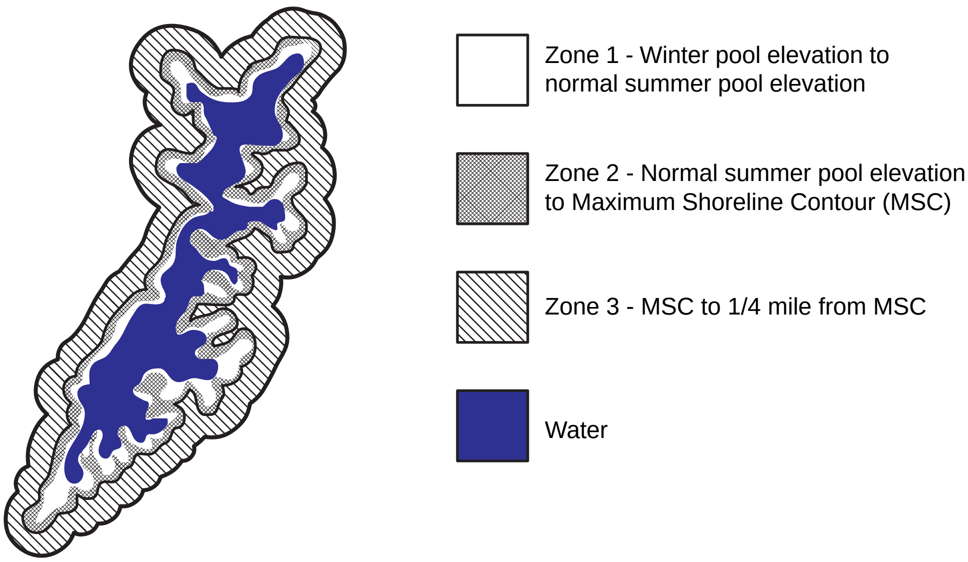


Table 3.9-1. Acreage of Wetlands Types Found on Six TVA Reservoirs[1] by Zones Based on the Cowardin Classification System (1979).

Wetlands Type	Zone 1		Zone 2		Zone 3	
	Acres	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Aquatic Bed	3,705	79	5	0	5	0
Emergent	287	6	1,301	7	279	3
Scrub-Shrub—includes combinations with emergent type	349	7	1,976	11	602	8
Forested—includes combinations with scrub-shrub and emergent types	384	8	14,539	82	7,282	89
Totals	**4,725**	**100**	**17,821**	**100**	**8,168**	**100**

[1]Chatuge, Chickamauga, lower third of Kentucky, Tellico, Watts Bar, and Wheeler.

- Recognized wetlands values include recreation, water supply and quality, food and timber production, education and research, and open space and aesthetics (Kusler, 1983).
- Primary values associated with TVA reservoir wetlands include recreation (hunting, fishing, wildlife observation), water quality, and open space and aesthetic values.

3.9.5 Wetlands Trends

There is little quantified information describing wetlands trends for TVA reservoirs and shorelines. Although wetlands have been mapped and digitized using a GIS for most of TVA mainstream reservoirs, these data have not been quantified by wetlands types and areas. NWI mapping is available for all TVA reservoirs, but most of the data on tributary and select mainstream reservoirs is not currently available in digital format. In addition, NWI data spans a 15-year time frame, making trend analysis difficult.

The area of emergent, scrub-shrub, and forested wetlands on and immediately adjacent to TVA reservoirs has probably remained relatively stable, compared to the trend for these wetlands types in the Southeast (Hefner et al., 1994). Forested wetlands have been the most heavily impacted on private land throughout the TVA region over the last 50 years.

The presence of wetlands on or adjacent to TVA reservoirs appears related to the development status of the shoreline. Within the one-fourth-mile shoreline area (Zones 1, 2, and 3), the proportion of total wetlands acreage was greater along undeveloped shorelines than along developed shorelines *(Table 3.9-2)*. This is partially explained by the fact that many wetlands occur in low-lying or flood-prone areas where development is often restricted.

Table 3.9-2. Wetlands Acreage on Six TVA Reservoirs[1] by Zones Along Developed and Undeveloped Shorelines.

Shoreline Development Status	Zone 1		Zone 2		Zone 3	
	Acres	Percent	Acres	Percent	Acres	Percent
Developed	408	9	147	1	244	3
Undeveloped	4,317	91	17,841	99	7,880	97
Totals	**4,725**	**100**	**17,988**	**100**	**8,124**	**100**

[1]Chatuge, Chickamauga, lower third of Kentucky, Tellico, Watts Bar, and Wheeler (Zone 1 for Wheeler includes only aquatic bed wetlands).

Wetlands are not randomly distributed along TVA reservoirs, as substantiated by the acres per developed and undeveloped shoreline mile *(Table 3.9-3)*. Wetlands acreage per undeveloped shoreline mile was over six times greater than along developed shorelines.

Table 3.9-3. Number and Proportion of Wetlands Acres[1] Within One-Fourth-Mile Shoreline Area Surrounding Six TVA Reservoirs[2] in Relation to Shoreline Development Status.

Attribute	Shoreline Development Status	
	Developed	Undeveloped
Wetlands Acres	799	30,038
Acres per Mile	1.5	9.9

[1]Determined from GIS analysis of NWI map polygons with a minimum mapping unit size of approximately half an acre.

[2]Chatuge, Chickamauga, lower third of Kentucky, Tellico, Watts Bar, and Wheeler.

3.10 Floodplains/Flood Control

As stated in the TVA Act, one of the primary reasons that TVA was established in 1933 was to "control the destructive floodwater in the Tennessee River and the Mississippi River Basins" (U.S. Congress, 1933). A series of dams and reservoirs was constructed to make flood control a reality. The operation of the dams and reservoirs provides substantial protection against flooding in the Tennessee Valley and in the Ohio and Mississippi River basins.

A common misconception about dams is that they prevent flooding. Floods cannot be prevented, but the operation of the TVA reservoir system can reduce damages. Efforts are made to reduce the peak flood elevations that would occur naturally without the dams. This is done by holding back water upstream in the storage tributary reservoirs until the rains have subsided, and then gradually releasing water until normal reservoir operations can be resumed. These actions substantially reduce the peak water elevations that would occur without the reservoir system.

Even with the system of dams, there is a floodplain adjacent to the reservoir. The 100-year floodplain is defined as that area inundated by the 100-year flood. The 100-year flood is the level of flooding that has a 1 percent chance of being equaled or exceeded in any given year and does not indicate a time period of 100 years between floods of this magnitude. Floodplain areas along reservoir shorelines are normally owned by TVA or covered by TVA flowage easements (Section 1.4.5).

Floodplains provide and support many natural resources and functions of considerable economic, social, and environmental value. These values and benefits include natural wetlands and wildlife habitat, improved water quality, stormwater management, recreational opportunities, and aesthetics.

3.11 Aquatic Habitat

3.11.1 Introduction

Reservoir construction has greatly impacted the character of the Tennessee River. These impoundments were developed for flood control, navigation, and power generation. However, recreation has become an important benefit of the reservoir system, with sport fishing being one of the major attractions.

About 50 to 75 percent of the nutrients and organic materials that flow into a reservoir settle into the sediment and become trapped. This contributes to a higher reservoir productivity than would be present in an unimpounded river (Yeager, 1993). Higher productivity, while not desirable from a water quality standpoint, does enhance the quality of the fishery as long as plant growth does not increase to eutrophic levels (Section 3.12.2). Tailwater areas, in contrast, are deprived of nutrients and organic material, making them less productive than before the dam was built.

While impoundment has benefited aquatic resources, there have also been negative effects. Prior to impoundment, low dissolved oxygen (DO) levels (i.e., less than 4 mg/l) were relatively rare occurrences caused mainly by pollution. Stratification occurs in moderately deep lakes (i.e., more than 16 feet) where water takes months to pass through the reservoir. After stratification begins during summer, DO levels in the lowermost, cold layer of the reservoir are progressively reduced to 0, due to decomposition of organic materials which have settled to the bottom. This condition seriously impacts communities of organisms (such as benthic invertebrates) that do not have the mobility to leave affected areas. The shallow-water reservoir shoreline area generally is not impacted by stratification.

3.11.2 Benthic Macroinvertebrates

Benthic organisms (e.g., aquatic insects, mussels, crayfish) are a vital part of the food chain of aquatic systems. These organisms transform nutrients and organic materials into food for fish and other vertebrate predators. Most benthic organisms have specific habitat requirements which depend upon certain physical, chemical, and biological factors. Alterations of any of these factors can cause changes in composition and productivity of benthic communities. Many benthic organisms have narrow habitat requirements which are often not met in reservoirs.

Benthic communities are extremely limited in the deep portions of tributary and some mainstream reservoirs, due to the lack of DO during summer stratification; and in the shallow areas of tributary reservoirs, due to winter drawdowns that leave these areas dry for extended periods. Low DO, excessive current, and cold water temperatures also limit benthic communities in tailwater areas immediately below the dam in reservoirs with a deepwater release.

Mussels

Freshwater mussels are unusual benthic invertebrates because they are extremely long-lived, have complex life cycles (including a time as parasites on fish), and are commercially valuable. Many of these mussels live more than 25 years, and the beads made from some shells are used in producing cultured pearls. Nearly all native mussel species occur in stable gravel or cobble substrates which are kept silt-free by flowing water.

Native mussels are extremely rare in tributary reservoirs for the same reasons mentioned for other benthic macroinvertebrates. In mainstream reservoirs, the mussel distribution pattern is more complex. Mussels rarely exist in the deepest parts of mainstream reservoirs, probably because those areas are covered with soft sediment and may occasionally have very low DO levels. Shallow areas in these reservoirs may contain large populations of a few mussel species if there is enough water movement to bring in food materials and remove excess silt. The most species-rich mussel communities in mainstream reservoirs occur in the original river channel where bottom conditions and currents are much the same as they were before the dams were built.

Because of their long lives, sedentary nature, and clumped distribution in areas of suitable habitat, freshwater mussels are highly vulnerable to habitat disruptions or changes in environmental conditions. During the last 60 years, native mussel resources have decreased because of habitat losses and intense harvest pressures. To help counter these losses, state fish and wildlife agencies have established mussel sanctuaries in various parts of the Tennessee River system. Some of these sanctuaries could be affected by shoreline management activities *(Table 3.11-1)*.

Table 3.11-1. State-Designated Mussel Sanctuaries.

Tennessee River Miles	State	Sanctuary (or Management Area) Boundaries
17.8-22.4	KY	From Little Chain navigation light upstream to Kentucky Dam
103.5-107.8	TN	East overbank from Tennessee National Refuge upstream to Rockport Island navigation light
140.0-141.5	TN	Mouth of Elkin Branch upstream to mouth of Cedar Creek
201.9-206.7	TN	Tennessee Gas pipeline upstream to Pickwick Landing Dam
416.5-424.7	TN	Alabama state line upstream to Nickajack Dam
465.9-471.0	TN	Marine Way upper navigation light upstream to Chickamauga Dam
520.0-529.9	TN	Hunter navigation light upstream to Watts Bar Dam
253.2-259.4	AL	Upper end of Seven Mile Island upstream to Wilson Dam
333.4-336.5	AL	Whitesburg Bridge upstream to head of Hobbs Island
347.2-349.0	AL	Mouth of Shoal Creek upstream to Guntersville Dam

3.11.3 Fish Communities

There are 205 species of fish inhabiting the Tennessee River system (Etnier and Starnes, 1993). The dynamics of fish communities shifted, as a result of reservoir construction. Prior to impoundment, fish communities in the Tennessee River were dominated by species which favored riverine conditions with associated periodic flood events. For the most part, reservoirs stabilized the habitat, reduced the flow of water in most sections, and trapped organic material, which increased nutrient availability. Fish species — such as largemouth bass, bluegill, and crappie — that prefer the more stable environments became much more numerous. Fish species — such as lake sturgeon, most sucker species, sauger, walleye, paddlefish, and other stream-spawning species (i.e., darters and many minnows) — that depend more on current and shoal areas were significantly reduced in numbers and diversity.

Commercial and sport fishing attract people from across the nation to TVA reservoirs. Over 3.5 million pounds of commercial fish were harvested during 1993 from TVA reservoirs located in the state of Tennessee (Todd, 1994). The majority of the catch were catfish, buffalo fish, paddlefish, and freshwater drum. Recreational fishing accounted for 872,476 trips and 4,362,378 hours of use on 13 TVA reservoirs in Tennessee during 1993 (O'Bara, 1994). Extrapolation of these results suggests that over 2 million trips per year and 10.5 million hours were spent fishing on all TVA reservoirs during 1993. Most sought-after species were black bass (48 percent of the total effort) and crappie (15 percent).

Fishing enthusiasts and state fish and wildlife agencies responsible for fisheries management want to maximize fisheries in the Tennessee Valley. TVA attempts to enhance spawning along the shoreline; once water temperatures at a depth of 5 feet reach 62°F, TVA keeps reservoir pool levels stable for a two-week period during spring. This is the anticipated peak spawning season for shoreline species such as black bass and crappie. The most productive region of a reservoir for the most sought-after species (black bass and crappie) is along the shoreline because of the spawning requirements of these species; the importance of cover such as submerged vegetation; and availability of aquatic invertebrates as a food source.

Commercial species that require suitable habitat in shoreline areas include catfish — which spawn in cavities such as those found in hollow logs or created by groupings of large rocks — and buffalo fish — which broadcast their adhesive eggs over the river bottom or on vegetation. Many nonsport fish species also rely heavily on this productive zone of the reservoir. Minnows such as bluntnose and bullhead; shiners such as golden, spotfin, steelcolor, and emerald; brook silversides; and logperch all require relatively unspoiled shoreline habitat.

Shoreline development results in modification of adjacent fish and benthic invertebrate habitat and other environmental factors which shape the quality of the fish community. For example, removal of vegetation in and near the water subjects the area to more nonpoint source pollution from runoff on nearby lands and destroys aquatic habitat. Mining, timber harvesting, domestic and industrial effluents, erosion, agricultural practices, and urbanization have affected nearly all fish habitat in the Tennessee River watershed.

3.11.4 SAHI and Existing Conditions

The SAHI described in Appendix G was developed to determine the quality of aquatic habitat adjacent to the shoreline. The index is based upon shoreline habitat characteristics important to maintenance of good populations of sport fishes (a major concern during public meetings). Data on the following parameters (which also apply to nonsport fishes) were collected and used to calculate the index values:

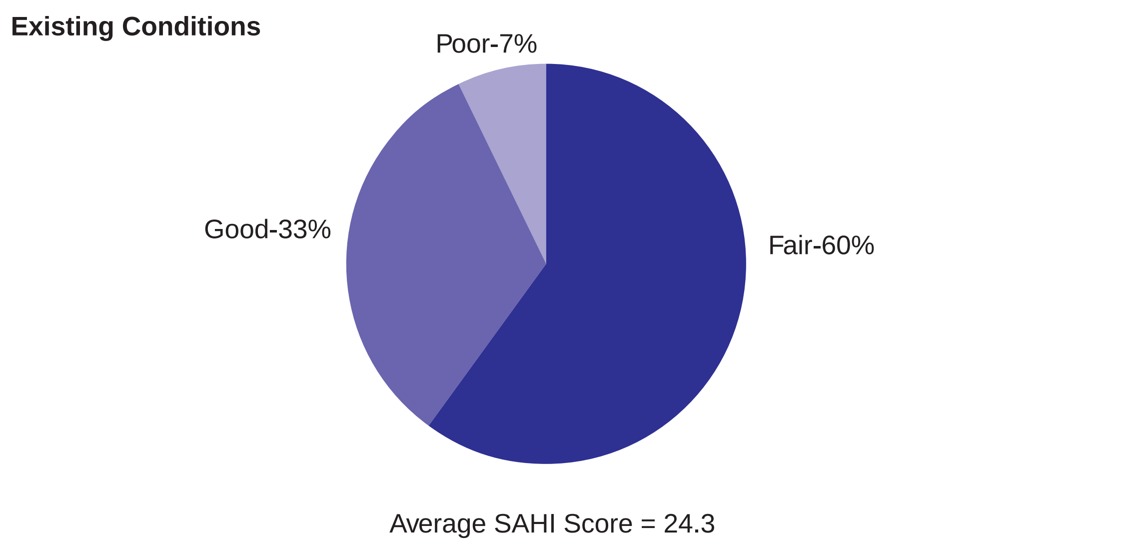
- Cover, which in the form of boulders, rootwads, brushpiles, logs, aquatic vegetation, etc., provides shelter for young fish and ambush areas for adult predators.
- Gravel substrate, which is critical for nest-building spawners such as bass and sunfish species.
- Bank stability, which is a measure of erosion that covers spawning areas with silt, limiting spawning success.
- Canopy over shoreline areas, which provides shade as a form of cover, in addition to reducing undesirable overwarming of shallow water during summer.
- Width of riparian zone, which reduces siltation and pollution entering the water.
- Habitat diversity, or number of different habitat types, which increases the number of species supported within a reservoir as represented habitats increase.
- Dredging, which removes spawning habitat but can be, at low levels, beneficial in providing access routes for adults to shallow spawning areas.

Observed conditions were compared with those anticipated under ideal conditions and a corresponding value assigned: good = 5, fair = 3, poor = 1. The scores for each parameter were summed to obtain the SAHI value. The potential range of SAHI scores (7 - 35) was subdivided into thirds to provide a general descriptor of habitat quality (good, fair, poor); however, there is little difference between sites that have similar scores.

Existing Conditions

SAHI results from four representative reservoirs (Chatuge, Fort Loudoun, Tellico, and the lower third of Kentucky) were used to describe existing shoreline aquatic habitat conditions with respect to adjacent land uses. Results from these sample reservoirs were expanded to represent shoreline areas and existing land uses around all TVA reservoirs. The estimated average SAHI score for all TVA reservoirs is 24.3 and was used as the baseline for comparing the effects of the alternatives on aquatic habitat (Section 4.9). Sixty percent of the TVA reservoir shoreline aquatic habitat scored fair, 7 percent scored poor, and 33 percent scored good *(Figure 3.11-1)*.

Figure 3.11-1. SAHI Results Extrapolated for All TVA Reservoirs.



3.12 Water Quality

3.12.1 Introduction

About two-thirds of the approximately 2,100 miles of rivers and large streams in the Tennessee River Valley are reservoirs impounded by dams (TVA, 1990b). TVA reservoirs support numerous water quality-dependent human uses, as well as a diversity of fish, freshwater mussels, and other aquatic organisms. Water bodies within the Tennessee River Valley are classified for specific uses by the states, and water quality criteria are established for those uses. The water quality of TVA reservoirs typically meets environmental requirements for supporting these varied beneficial uses. With some local exceptions, reservoirs within the Tennessee River Valley are generally clean, and water quality is considered fair to good (TVA, 1990b, 1995a).

Reservoir Uses

Multipurpose reservoir uses include:

- Recreation, such as swimming, wading, fishing, and boating.
- Drinking water supplies.
- Industrial water supplies.
- Propagation and growth of aquatic life and water-dependent wildlife.
- Flood protection.

- Navigation.
- Generation of electricity.
- Irrigation.
- Wildlife.
- Livestock watering.
- Residential access.

People use reservoir embayments (i.e., sloughs, coves, sheltered areas off the mainstream) more than other areas. Residential shoreline development tends to be located along embayment shorelines which are also preferred sites for marinas. Swimming, wading, fishing, and boating are more concentrated in these areas. However, water moves out of embayments more slowly than in the main reservoir channels. This means that sediment and other pollutants are flushed out of embayments more slowly. As a result, embayments are more environmentally sensitive, and most water quality problems, except those related to low DO, are found there. In contrast, the water quality along main channel shorelines is usually better because:

- Water flows more quickly,
- Wave action is greater and mixes the water,
- Water volume is greater, and
- Fewer people use main channel areas.

Factors Affecting Water Quality

Several factors currently determine whether reservoirs and embayments meet water quality criteria for established uses. Reservoir construction along the Tennessee River profoundly affected the quantity and quality of water passing through the system. Naturally-occurring seasonal stratification (Section 3.11.1) affects water quality in both the lower layers of reservoirs and the stream reaches into which the reservoirs discharge. Seasonally low levels of DO are the primary problem. With implementation of the *Lake Improvement Plan* (TVA, 1990b), many miles of habitat historically affected by low DO and lack of minimum flows have been recovered within tributary and selected mainstream reservoirs, as well as below their dams.

Although water quality of TVA reservoirs is generally good, the public, as well as state and federal resource and regulatory agencies, have identified other concerns. Many of the remaining pollution problems are related to diverse, nonpoint sources of pollution resulting from watershed development and improper land use practices both in the tributary watersheds and along reservoir shorelines. These problems include (1) nutrient enrichment causing occasional nuisance growth of aquatic plants, including algae, and (2) bacterial contamination. TVA's *Lake Improvement Plan* (TVA, 1990b) also recognizes and acknowledges the importance of additional nonpoint sources contributing to nutrient and water quality problems.

3.12.2 Nutrient Enrichment

Phosphorus and nitrogen are the most important added nutrients that affect water quality. These and other nutrients come from several major nonpoint sources, including:

- Industrial/commercial processes,
- Municipal sewage,
- Agricultural areas and urban development both along reservoirs and in watersheds draining into the river system, and
- Soils.

Industrial/Commercial Processes. Various point-source industrial processes produce and discharge nutrients containing nitrogen and phosphorus into water bodies. In some instances, additional runoff from industrial sites storing raw materials or finished products contributes nutrients to reservoirs and streams.

In the Tennessee River Valley, pesticide, herbicide, and industrial chemical pollution potentially entering the human food chain is localized and predominantly limited to five industrial/commercial chemicals (PCBs, chlordane, DDT, dioxins, and mercury). Three of these are no longer commercially available in the United States. These chemicals do not dissolve well in water, so they are found mostly in mud on the bottom of rivers and lakes. However, they can build up in the fatty tissues of fish, particularly those that feed on the lake bottom. TVA cooperates with state agencies checking for toxic contamination of fish tissue. The states then decide whether to issue advisories on fish consumption for a particular area. Chlordane has been associated with fish consumption advisories in Tennessee. Whether the source is lawn runoff or improper chemical use and disposal is unknown. No other potential sources of chemically laden runoff from insect or weed killers have been associated with any fish consumption advisories.

Municipal Sewage. Some reservoir water quality impacts from residential shoreline development currently come from nutrients contributed by failing septic systems and inadequate package sewage systems, as well as the additional contributions from municipal sewage systems. Even the best designed and operated secondary sewage treatment facilities do not remove substantial amounts of nitrogen and remove only modest percentages of phosphorus.

Information on the number and extent of leaking and failed septic systems along TVA reservoirs is scarce. Many lakefront homes are not connected to municipal wastewater treatment systems and rely on septic tanks and field lines for treatment. A study conducted by Swanson Environmental, Inc., (TVA, 1985a) indicates that septic systems were failing and contributing elevated nutrient levels to embayments on Guntersville Reservoir. Accelerated lake eutrophication in other areas of North America has also been linked to malfunctioning domestic sewage systems releasing bacteria and nutrients into lake water and bottom sediments. The cumulative addition of nutrients from existing development comes from both properly operating and failing septic systems; package sewage systems operated for specific subdivisions; and municipal wastewater treatment systems. The amount of nutrients added is related to the total number of septic systems, the population density, and the proximity of development to the shoreline.

Agricultural Areas and Urban Development. Soil characteristics in certain areas of the Tennessee River Valley, abundant rainfall, and the economic encouragement to adopt row-crop-practice systems contribute to erosion of agricultural areas near reservoirs and tributary streams. Construction activities related to residential or other urban development also mobilize soils. In addition to siltation problems, erosion of agricultural lands moves various agricultural chemicals, including fertilizers, into streams, rivers, and reservoirs. Removal of vegetation in the shoreline management (riparian) zone is the major obstacle in protecting water quality. Improper management of shoreline vegetation reduces its capacity to stabilize banks and filter lawn fertilizers (nutrients) and chemicals (pesticides and herbicides).

Nutrients Naturally Occurring in Soils. Soils of the Valley also contain naturally occurring nutrients which are mobilized and carried into water bodies as a result of certain agricultural and soil-disturbing activities. These nutrients also affect the productivity of reservoirs, rivers, and streams.

Algal and Aquatic Plant Growth Problems

Once nutrients enter a water body, the main effects are associated with a process called *eutrophication*. Eutrophication in TVA tributary reservoirs leads to increased productivity of algae. In mainstream reservoirs, eutrophication typically results in abundant production of aquatic plants and in floating algal mats along shorelines or embayments. Undesirable algal and aquatic plant growth are responsible for much of the water quality deterioration that accompanies eutrophication. Excessive production often results in increased demand for management and control of aquatic plant growth.

There are no uniform guidelines for what constitutes excessive productivity of algae or aquatic plants. For instance, high algal or aquatic plant production is desirable for maximum fish production but undesirable for protecting community water supplies or maintaining access to marinas and residentially developed shorelines. Impacts on water quality from excessive algal productivity or overproduction of particular algal types (e.g., bluegreens or diatoms) in TVA reservoirs have included:

- Taste and odor problems in water supplies.
- Odor incidents in embayments.
- Filter clogging and increased treatment costs at industrial water treatment plants.
- Discoloration and oily surface films.
- Surface algal blooms and scums.
- Algal mats in embayments.
- Contribution to DO depletion due to decomposition of algae and plants.

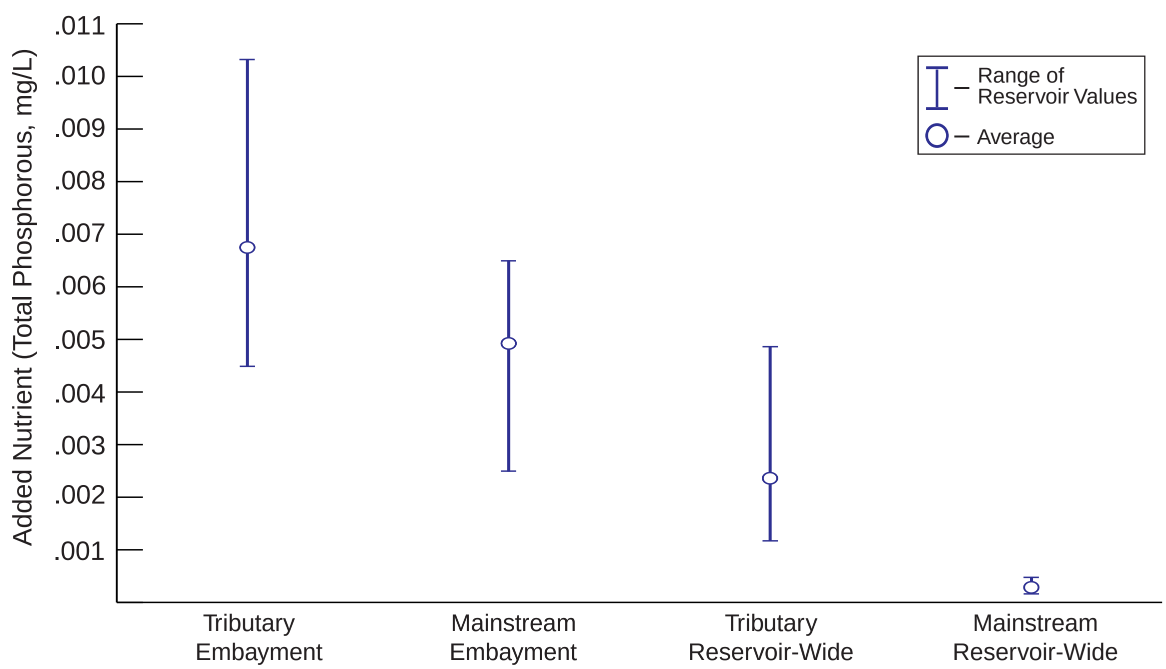
Greater depletion of oxygen increases the costs of operation and maintenance of aerating technologies and affects TVA's ability to meet DO targets established in the *Lake Improvement Plan* (TVA, 1990b) for reservoir releases.

After finding all existing methods of assessing eutrophication to be inappropriate for application, Placke (1983) developed a system of evaluating eutrophication specific to TVA reservoirs. Reservoirs were ranked from least to most eutrophic. The ranking of tributary reservoirs was: Hiwassee, Blue Ridge, Chatuge, Norris, Fontana, Watauga, South Holston, Tims Ford, Cherokee, Douglas, and Boone. The ranking of mainstream reservoirs was: Pickwick, Kentucky, Chickamauga, Nickajack, Wilson, Fort Loudoun, Watts Bar, Wheeler, and Guntersville.

Current Nutrient Levels

Estimated average nutrient (total phosphorus) amounts added to embayments and total waterflow from existing residential shoreline development are shown in *Figure 3.12-1* for eight representative TVA tributary and mainstream reservoirs. Nutrient concentrations added by residential shoreline

Figure 3.12-1. Average Amounts and Range of Nutrient Phosphorus (Total P) From Current Residential Shoreline Development on Eight Representative TVA Reservoirs[1] Contributed at the Embayment Level or Reservoir-Wide.



[1]Blue Ridge, Chatuge, Cherokee, Chickamauga, Fort Loudoun, Nickajack, Tims Ford, and Wilson.

development currently do not exceed levels likely to produce changes in aquatic communities or independently affect suitability of water bodies for human uses. However, these amounts of additional phosphorus do substantially increase the total nutrients available in a reservoir and are probably having some effect on the productivity of aquatic communities in highly developed embayments.

3.12.3 Bacterial Contamination

Fecal coliform contamination can directly affect the acceptability of areas for water contact recreation such as swimming, wading, and fishing. The presence of fecal coliform bacteria indicates that water has been contaminated by human or animal wastes, which may contain disease-causing microorganisms. No reservoir, lake, or stream is completely free of pathogenic organisms, but the lower the fecal coliform count, the less chance there is of persons becoming ill from water contact.

Urban runoff and inadequate municipal wastewater treatment are frequent causes of high bacteria concentrations in reservoirs. Large waterfowl populations raise fecal coliform concentrations in a few areas. For instance, the Forest Service temporarily closed one of its swimming areas in 1995 due to high bacteria concentrations caused by local geese. Several other sources, including failing septic systems, livestock operations, and wildlife management areas, contribute to high fecal coliform concentrations in streams entering reservoirs.

There are only a few reservoir sites which do not meet state criteria for water contact recreation. However, the state of Tennessee has issued public advisories against water contact at 12 sites in TVA reservoir embayments or at the mouths of streams entering TVA reservoirs. Urban runoff is not the sole source for the water contact advisories; however, inefficient wastewater systems and combined sewer overflows are primary causes. TVA sampled 129 reservoir sites in 1993 and 1994 other than those posted by the state of Tennessee advising against water contact (TVA, 1995a). Two of the sites did not meet state criteria, and an additional 14 sites failed to meet the criteria when samples were taken within 48 hours of rainfall. Most of the high concentrations in TVA samples were due to large populations of waterfowl, but one of the two sites not meeting state criteria was due to urban runoff.

3.13 Recreational Use of Shoreline

3.13.1 Introduction

The Tennessee Valley region provides diverse scenic and outdoor recreation resources. TVA reservoirs support a wide variety of outdoor recreation activities, including fishing, skiing, hunting, swimming, and camping. Travel and tourism associated with these recreation resources represent significant and growing contributions to the economy of the region.

3.13.2 Total Visitation

Recreational use of TVA reservoirs has attained high levels. The last year that TVA collected comprehensive recreation visitation data was 1978. In that year, an estimated 71 million visits occurred on TVA reservoirs and lands, including Land Between The Lakes. *Figures 3.13-1, 3.13-2,* and *3.13-3* reveal trends in visitation data collected by Tennessee State Parks (Boswell, 1995); USACE Nashville District (Yann, 1995); and Joe Wheeler State Park, Alabama (Thrasher, 1995). If similar trends were observed on TVA reservoirs, estimated recreation visitation in 1995 would be 113 million visits. This estimate encompasses all recreational visits to TVA reservoirs and surrounding developed and undeveloped lands.

3.13.3 Recreation Activities Occurring Along the Shoreline

Fishing from the bank and by boat are the most popular recreation activities that occur along the shoreline. In *TVA Land Management and Use Study* (Larsen, 1993a), 73 percent of those interviewed said they participated in these activities at some time. Forty-one percent of respondents said they fished from a boat, and 32 percent fished from the bank.

Figure 3.13-1. Visits to 14 Tennessee State Parks on TVA Reservoirs, 1977-1995.

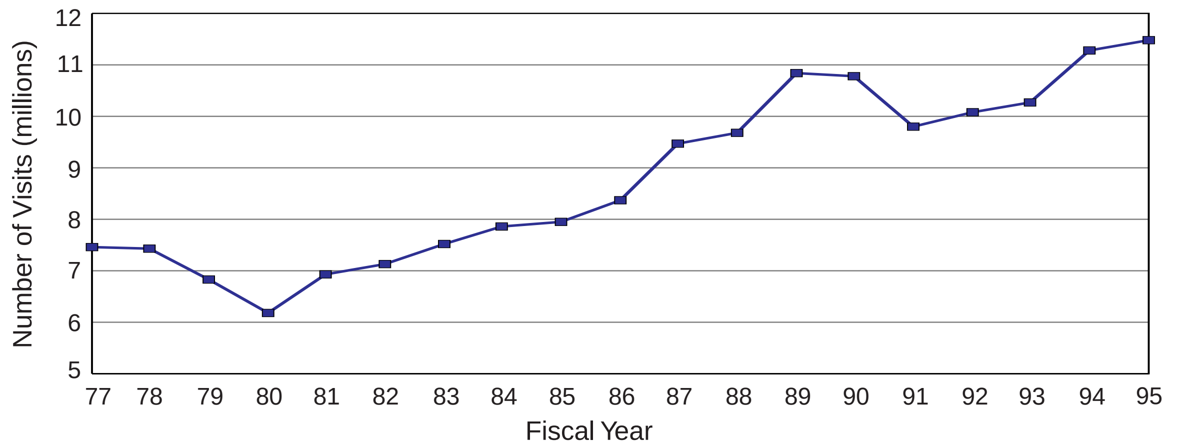


Figure 3.13-2. Visitation to USACE Projects in the Nashville District, 1976-1994.

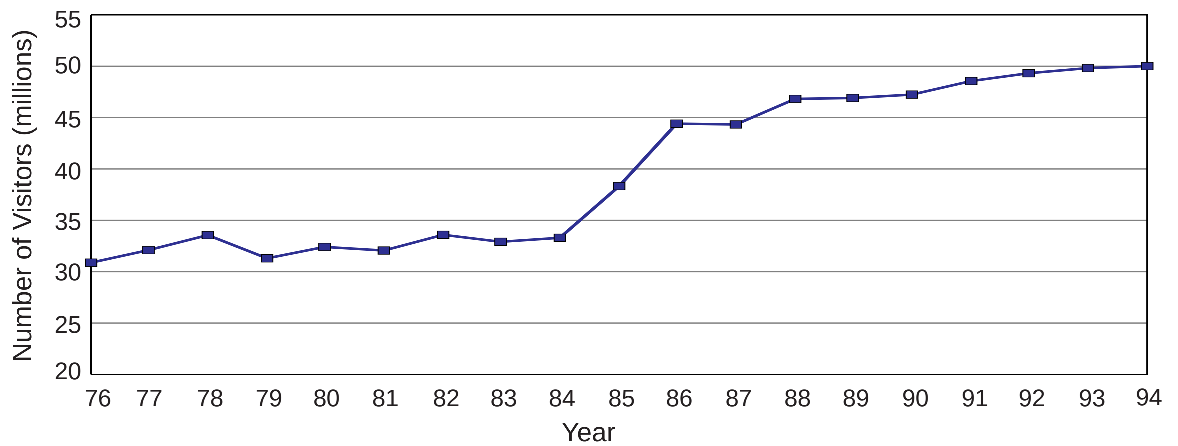
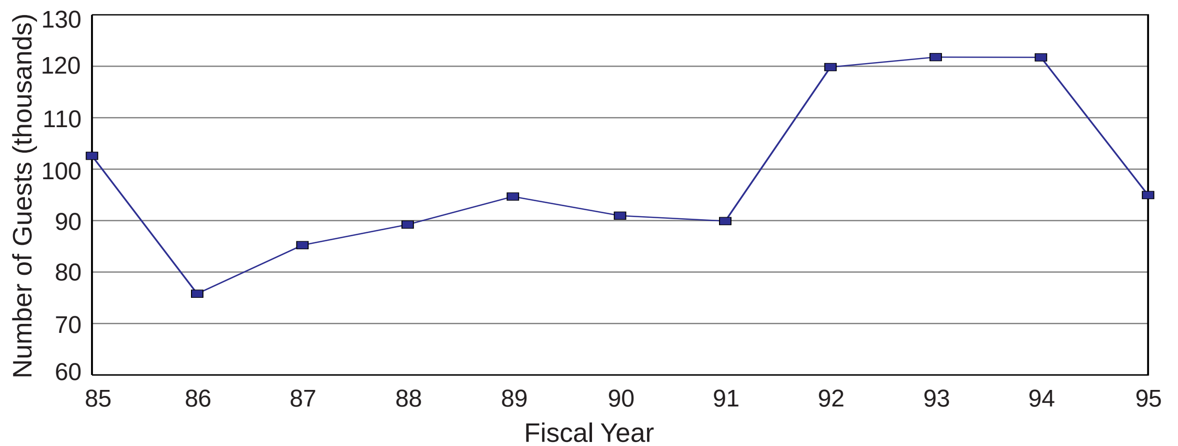


Figure 3.13-3. Lodge Guests at Joe Wheeler State Park, 1985-1995.



Other recreational uses of the shoreline include:

- Picnicking and swimming. People come by boat and by car to shoreline areas that provide water of reasonable depth for swimming.
- Camping on undeveloped shoreline land.
- Walking along the shoreline, especially when the lake bottom is exposed in fall and winter.
- Hunting.

The following recreational activities occur when adjacent landowners use existing shoreline facilities, including docks, boathouses, and swim floats:

- Boating.
- Swimming, picnicking, fishing, and other active recreational uses of the lake.
- Relaxing and observing activities occurring on the lake. This includes general enjoyment of the lake environment.

According to *TVA Lake Users Study* (Larsen, 1993b), 59 percent of lake users chose a lake because it was closest to them. Fifty-three percent also had used other TVA lakes. When choosing a lake, other responses in order of frequency of occurrence were: best fishing (25 percent), cleanliness (12 percent), recreation facilities (10 percent), and familiarity (9 percent). Together, scenery, setting, and quality of management accounted for 7 percent of the reasons for choosing a lake.

Boat and bank fishing accounted for 33 percent of the respondents' primary use of TVA lakes, followed by camping in developed campgrounds (16 percent), boating (14 percent), enjoying scenery (10 percent), and swimming and/or sunbathing (8 percent). Other uses included: camping in undeveloped areas (4 percent), picnicking (4 percent), hiking (4 percent), skiing (2 percent), bike riding (1 percent), jet skiing (1 percent), photography (1 percent), and other (1 percent).

3.13.4 Informal Recreation

TVA allows the public to use undeveloped lands for informal recreation. For example, most islands and many shoreline areas accessible by road or boat are frequently used for fishing and primitive camping. On holiday weekends during the summer, when public and commercial recreation areas are full, people who want to camp on undeveloped lands often cannot find a camping spot.

Undisturbed and undeveloped reservoir shorelines are highly valued for walking, nature observation, bank fishing, and other passive forms of recreation, according to public meetings participants (TVA, 1988, 1990a).

When shorelands are developed with residential shoreline alterations and industrial facilities, their public recreational value is lost. In some cases private property owners maintain public land as if it were a part of their own yard. Thus, the public recreational value is lost because the land appears to be private, and people no longer feel welcome to stop along these public shorelands to fish, picnic, swim, or camp. Also, some backlying landowners routinely ask visitors to leave the strip of public land fronting their lot. Actions like these give the impression that public lands are no longer available for public use.

Baseline of Existing Informal Recreational Opportunities

The effects of the alternatives on informal recreational use of the shoreline are addressed in Section 4.11. The baseline for this analysis is the number of existing informal recreational opportunities for day-use activities, camping, and hunting on undeveloped public land.

To establish this baseline, the total number of shoreline miles available for public use was first determined for each of these activities. From this total, the number of shoreline miles with potential for recreational activity was calculated. Using these estimates, the number of miles suitable for recreation was determined *(Table 3.13-1)*. Recreation planning standards were then applied to the number of suitable shoreline miles, to yield existing recreational opportunities. A more detailed explanation of each of these steps is as follows.

Table 3.13-1. Number of Undeveloped Shoreline Miles Available for Public Use Compared to Miles With Potential for and Suitable for Informal Recreation by Type of Activity.

Undeveloped Shoreline	Informal Recreation Activity		
	Day Use (Miles)	**Camping (Miles)**	**Hunting (Miles)**
Total Available	7,500	7,300	6,600
Potential	1,900	1,500	1,100
Suitable	1,300	1,000	1,100

Total Available Miles. The total number of shoreline miles available for public use was calculated by subtracting the number of miles of undeveloped flowage easement shoreline from the total number of undeveloped shoreline miles. This yielded an estimate of approximately 7,500 shoreline miles available for day-use activities (i.e., bank fishing, walking the shoreline, swimming) *(Table 3.13-1)*. This number was reduced somewhat for camping and hunting because various natural resource management agencies prohibit these activities in some areas.

Potential Miles. Landrights data and land characteristics from six representative reservoirs (Chickamauga, Kentucky, Nickajack, Tellico, Watts Bar, and Wheeler) were used to determine the number of shoreline miles with potential for informal recreational activity. Using the total shoreline miles available (described above) as a basis, shoreland on these six reservoirs was evaluated according to the following spatial criteria:

- For day-use activities, a tract of land had to be at least 500 feet long and at least 25 feet deep from the shoreline to the backlying property line.
- For informal camping, a tract of land had to be at least 500 feet long and at least 100 feet deep from the shoreline to the backlying property line.
- For hunting, a tract of land had to be at least 500 feet long, and the backlying property line had to be 300 feet from the winter drawdown elevation. A 300-foot minimum width from the winter drawdown elevation was chosen because most hunting takes place in the winter, and this width provides the minimum required distance from dwellings for discharge of firearms.

The lengths of shoreline segments meeting these criteria were summed to give shoreline miles having potential for day-use, informal camping, and hunting activities. Using these estimates, the ratio of potential miles to available miles was calculated for each of the recreational activities. These ratios were then multiplied by the number of available miles for each reservoir, resulting in a Valleywide estimate of potential miles *(Table 3.13-1).*

Suitable Miles. To determine the number of miles suitable for informal recreational activities, slope of the shoreline was first calculated at 1-mile intervals for each reservoir. Using the number of potential miles (described above) as a basis, steep areas were then eliminated according to the following criteria:

- Day-use activities: Shoreline areas with slopes greater than 30 percent were eliminated.
- Informal camping: Shoreline areas with slopes greater than 40 percent were eliminated.
- Hunting: No shoreline areas were eliminated.

The result was the total number of miles suitable for the three informal recreational activities *(Table 3.13-1)*. At current development levels, only 18 percent of the total undeveloped shoreline available for public use is suitable for day-use activities. For informal camping and hunting these proportions are 14 and 17 percent, respectively.

Existing Informal Recreational Opportunities. State Comprehensive Outdoor Recreation Planning standards from Tennessee and Kentucky were applied to the number of suitable shoreline miles to determine existing recreational activity occasions *(Table 3.13-2)*.

Table 3.13-2. Estimated Number of Existing Informal Recreational Opportunities by Activity.

Activity	Number of Annual Opportunities
Day Use	700,000
Informal Camping	580,000
Hunting	64,000
Total	**1,344,000**

3.14 Aesthetic Resources

3.14.1 Introduction

Based on the number of public comments TVA received by SMI participants, it is apparent that aesthetic values are important. In order to determine existing public preferences, both qualitative and quantitative studies were used. These sources include:

- The 1993 Gallup Poll, *TVA Land Management and Use Study* (Larsen, 1993a).
- Public comments generated during scoping.
- The 1995 questionnaire, *Viewing Tennessee Valley Shoreline* (Appendix H).

3.14.2 Findings of the Gallup Poll, *TVA Land Management and Use Study*, January 1993

This telephone poll surveyed 1,652 lake users who lived in counties which abut TVA reservoirs. The study showed that almost 7 out of 10 respondents rated the beauty of the shoreline as excellent or good. According to those surveyed, the most important attributes of scenic quality were an abundance and variety of trees (37 percent), wildlife (10 percent), and cleanliness (10 percent). Trash and litter (52 percent), water quality problems (16 percent), fluctuating water levels (7 percent), and certain types of development (6 percent) were listed as detriments to visual quality.

3.14.3 SMI Public Scoping

The public was asked to comment on the way TVA manages its reservoir shoreline. Approximately 7,800 comments were received from over 2,000 participants. Numerous comments stressed the importance of natural beauty. Wildlife, trees/natural vegetation, and an undeveloped shoreline were listed as positive visual attributes. Trash/litter and erosion were listed as the main detriments to visual quality. Downed trees and debris also created a negative impression. A considerable number of comments supported standards for the design, construction, and maintenance of waterfront facilities.

These studies suggest that aesthetic qualities are determined by at least three main criteria:

- Presence of viewable wildlife, trees, and natural landscape features.
- Absence of trash/litter, erosion, and natural debris.
- Amount and condition of shoreline development.

3.14.4 Results of the TVA Questionnaire, *Viewing Tennessee Valley Shoreline*

A questionnaire (Appendix H) was mailed to previous SMI participants to obtain a more comprehensive understanding of visual preferences related to residential shoreline development. This survey resulted in 663 responses (a 70 percent return rate).

The vast majority of respondents (96 percent) indicated that the appearance of residential shoreline development was either “extremely important” (74 percent) or “very important” (22 percent) to their enjoyment of the reservoir. About 4 percent of the respondents disclosed that the appearance of residential shoreline development was not important, or they did not have an opinion.

3.14.5 Existing Conditions

Preference scores of four measurement indicators (Section 1.8.10) were used to gauge the effects of the alternatives on the visual quality and scenic beauty of TVA reservoirs. Baseline conditions for aesthetic resources using these indicators are as follows:

Water-Use Facility Design. Current shoreline structures include a variety of land- and water-based facilities but generally consist of fixed and floating piers and docks, decks, patios, steps, and boat-houses. These water-use facilities vary in size, shape, color, and building materials.

Density. The distance between private docks varies. Sometimes docks appear crowded, particularly in coves. In certain situations, neighbors cooperatively construct community slips.

Amount of Residential Shoreline Development. The amount of residential shoreline development varies a great deal between reservoirs (Section 3.4). For example, Boone, Fort Loudoun, and Wilson Reservoirs are more than 50 percent developed. Conversely, eight reservoirs (Apalachia, Bear Creek Project, Hiwassee, Kentucky, Normandy, Ocoee, Tellico, and Wheeler) are relatively undeveloped (less than 10 percent). As of 1994, almost 13 percent of the shoreline had been developed for residential purposes. However, if current trends continue, TVA estimates that the majority of the shoreline could be developed within the next 25 years.

Shoreline Vegetation Alterations. Developed shoreline areas are subject to various levels of vegetation management, ranging from little vegetation clearing to more extensive disturbance of native vegetation and introduction of nonnative plant species. In many cases, public shorelines are routinely mowed and maintained as an extension of adjoining residential lawns.

3.15 Cultural Resources

3.15.1 Introduction

TVA is mandated under the National Historic Preservation Act of 1966 and the Archaeological Resources Protection Act of 1979 to protect significant cultural resources (i.e., archaeological resources and historic structures) located on TVA lands or affected by TVA actions. Therefore, TVA is responsible for the protection of literally thousands of cultural resources.

For the past 12,000 years, through changing climates and environmental conditions, the Tennessee River Valley has attracted humans because of its system of water routes and its abundance of natural resources. Areas where Native Americans once dwelled are often the same places where current generations want to live. Just as people do today, prehistoric Native Americans chose living sites that were reasonably level, well drained, not prone to flooding, and near water sources. As in the past, one popular area for habitation today is along waterways. However, distributed along these water routes are numerous archaeological sites or areas where archaeological resources are found.

3.15.2 Archaeological Resources

An *archaeological resource* is defined as any material remains of human life or activities which could provide scientific or humanistic understandings of past human behavior and cultural adaptation. Archaeological resources could include, but are not limited to, remains of surface or subsurface structures, such as domestic, cooking, or ceremonial structures, earthworks, fortifications, cooking pits, refuse pits, and burial pits or graves. Other examples of archaeological resources include whole or fragmentary tools, weapons, containers, ceramics, human remains, rock carvings or rock paintings, and all portions of shipwrecks (18 CFR Part 1312.3). Archaeological sites that occur along TVA reservoir shorelines include those from the following time periods: Paleo (10,000 BC - 7,500 BC), Archaic (7,500 BC - 1,000 BC), Woodland (1,000 BC - AD 1,000), Mississippian (AD 1,000 - AD 1,650) and Historic (AD 1,650 - AD 1,900).

In response to this federal legislation, TVA conducts inventories of its lands to record significant archaeological sites. Reservoir land is sampled to get an idea of archaeological site types and distribution, with 80 percent of the sampling conducted along the shoreline. Sampling also occurs at the confluence of streams with the main river channel.

Five mainstream reservoirs (Chickamauga, Guntersville, Nickajack, Pickwick, and Wheeler), or about 3,370 miles of shoreline, have been systematically surveyed for archaeological resources. From these surveys, 1,722 archaeological sites were identified along the shoreline or in the shoreline area.

Site distribution models developed from these survey data (Solis and Futato, 1987) indicate that distribution and density of Native American archaeological sites can vary greatly. Solis and Futato (1987) categorized TVA-controlled lands adjacent to Guntersville Reservoir by soil type, order of nearest water source, distance to water source, elevation, and topographic relief. They found that archaeological sites were most likely to occur on terraces or stream bottoms close to the main river channel or its primary tributaries. However, significant site distribution variables may be different in other parts of the Tennessee Valley. Most of these known archaeological sites are currently situated on undeveloped land *(Table 3.15-1).*

Table 3.15-1. Current Number of Archaeological Sites on Undeveloped and Developed Land for Five Reservoirs.

Reservoir	**Undeveloped Land (Number of Sites)**	**Developed Land (Number of Sites)**
Chickamauga	380	52
Guntersville	348	29
Nickajack	24	2
Pickwick	351	52
Wheeler	448	36
Total	**1,551**	**171**

Even though the majority of shoreline has not been surveyed, the total number of archaeological sites can be extrapolated using the following assumptions:

1. Unsurveyed reservoirs have similar numbers of sites per mile of shoreline.
2. The upper end of most reservoirs has more sites because the floodplain is not inundated.
3. Most sites are located along undeveloped shoreline.

Conservatively estimated, there are at least 5,500 archaeological sites along reservoir shorelines that could be affected by shoreline development.

Currently, these archaeological sites are protected by conducting site-by-site surveys of areas where ground-disturbing activities are scheduled to occur. If significant archaeological resources are found, either the ground-disturbing activity is denied or its impacts are mitigated. Ground-disturbing activities that could be harmful to archaeological sites include channel excavation; construction of boat docks, piers, and retaining walls; and vegetation removal.

3.15.3 <u>Historic Structures</u>

A significant historic structure is defined as any building or structure included in, or eligible for inclusion in, the National Register of Historic Places (36 CFR Part 800.2). To be eligible for the National Register, a structure must generally be at least 50 years old or older and meet a set of criteria established by the Secretary of the Interior (refer to 36 CFR Part 60 for further information on National Register Criteria).

Besides archaeological resources, TVA must protect any significant historic structures located along the shoreline, in the shoreline area, or on backlying property. Historic structures are not as prevalent along the shoreline as archaeological resources. Most of the structures located along the shoreline were either moved or destroyed when the reservoirs were built. However, the remains of these structures, such as foundations of houses or outbuildings, are considered to be archaeological resources and are protected under federal law. As noted above, historic structures are rarely located along TVA's shoreline or in the shoreline area but, rather, are located primarily on backlying private property. Again, these sites are protected by conducting site-by-site surveys of specific project areas. In most cases, any visual disturbance can be decreased with vegetative SMZs or other forms of mitigation.

3.16 Socioeconomics

3.16.1 Introduction

From comments received during public involvement, TVA has determined that socioeconomics is a key issue in the SMI. Population, income and employment, and property values are the measurement indicators for this issue. Baseline data related to these indicators are presented below.

3.16.2 Population

In 1994 counties which border the reservoirs had a total estimated population of about 3.1 million *(Table 3.16-1)*. About 38 percent of this population was concentrated in five counties with populations greater than 100,000 (see Appendix N for population of individual counties in the vicinity of each reservoir). These counties and their metropolitan areas are Madison (Huntsville) and Morgan (Decatur) in Alabama and Sullivan (Johnson City-Kingsport-Bristol), Knox (Knoxville), and Hamilton (Chattanooga) in Tennessee. Outside of the metropolitan areas, which include these five plus Florence, Alabama, much of the shoreline is highly rural.

Table 3.16-1. Population of Counties Along TVA Reservoirs, 1980-1994.[1]

Reservoir Group[2]	Population			Percent Increase	
	1980	1990	1994	1980-94	1990-94
Eastern Commercially Navigable	1,023,638	1,057,859	1,115,380	9.0	5.4
Eastern Tributary[3]	798,499	828,166	873,694	9.4	5.5
Western Commercially Navigable	867,321	929,462	985,903	13.7	6.1
Western Tributary[3]	215,311	222,209	231,532	7.5	4.2
Total, All Reservoir Counties[4]	**2,802,150**	**2,934,114**	**3,098,559**	**10.6**	**5.6**

[1]Source: U.S. Department of Commerce, Bureau of the Census (1995).

[2]See Classification in Appendix N.

[3]All commercially nonnavigable reservoirs are included in the tributary classifications.

[4]Total is slightly less than the sum of the groups because a few counties are in more than one group.

From 1980 to 1994, population of the reservoir counties grew by 10.6 percent, well below the national growth rate of 14.9 percent. However, during the latter part of that period, 1990 to 1994, these counties had a growth rate of 5.6 percent, above the national rate of 4.7 percent.

Growth has not been evenly distributed throughout the region. The western commercially navigable group of counties is the only group that has grown faster than the average for all reservoir counties since 1980. However, the fastest-growing counties, those growing more than 20 percent between 1980 and 1994, are located around Knoxville, around Huntsville, at Nottely and Chauge Reservoirs in north Georgia, and at Watts Bar in East Tennessee *(Table 3.16-2)*.

Table 3.16-2. Fastest Growing Counties (More Than 20 Percent) Along TVA Reservoirs, 1980-1994.[1]

County	State	Reservoir	Population		Percent Increase
			1980	1994	
Union	GA	Nottely	9,390	13,606	44.9
Sevier	TN	Douglas	41,418	58,184	40.5
Madison	AL	Wheeler	196,966	258,035	31.0
Towns	GA	Chatuge	5,638	7,350	30.4
Limestone	AL	Wheeler	46,005	58,099	26.3
Union	TN	Norris	11,707	14,607	24.8
Loudon	TN	Ft Loudoun, Melton Hill, Tellico, Watts Bar	28,553	35,078	22.9
Blount	TN	Fort Loudoun, Tellico	77,770	94,565	21.6
Meigs	TN	Chickamauga, Watts Bar	7,431	8,942	20.3

[1]Source: U.S. Department of Commerce, Bureau of the Census (1995).

Urbanization trends have impacted many reservoir counties over the last several decades. As shown in *Figures 3.16-1, 3.16-2,* and *3.16-3*, population density has increased greatly in some areas, in particular North Alabama and the eastern Valley. In 1930 only one reservoir county, Knox County, Tennessee, had a population density greater than 300 persons per square mile. By 1994 four more counties had passed this level: Madison County, Alabama; and Hamilton, Hamblen, and Sullivan Counties, Tennessee. Near these five counties were several others where the density level had increased to over 100 persons per square mile.

Current Shoreline Population

Population data are not available for the area along the shoreline. However, a rough estimate of the current shoreline population can be made. The sample of reservoir subdivisions (Section 3.4.5) averages 20.8 developed lakefront lots per shoreline mile. Assuming that this average applies to all developed residential shoreline (1,383 miles), there are about 28,800 developed lakefront lots. According to the Gallup poll (Larsen, 1993b), approximately 80 percent, or about 23,000 lots, are being used as full-time residences. Assuming these households are the national average size of 2.67 persons (U.S. Department of Commerce, 1995), there are about 61,000 people now living on lakefront properties.

Current Backlot Population

The subdivision data also show that, on average, a subdivision has 1.1 backlots for each lakefront lot. Assuming that 90 percent of these backlots are used as full-time residences and also have an average household size of 2.67, there are an additional 76,000 persons in these developments.

Current Total Population

There are an estimated 137,000 people living on the lakefront or in backlots associated with lakefront developments. This represents about 1.6 percent of the 1994 population of the Tennessee Valley 201-county region (8.7 million).

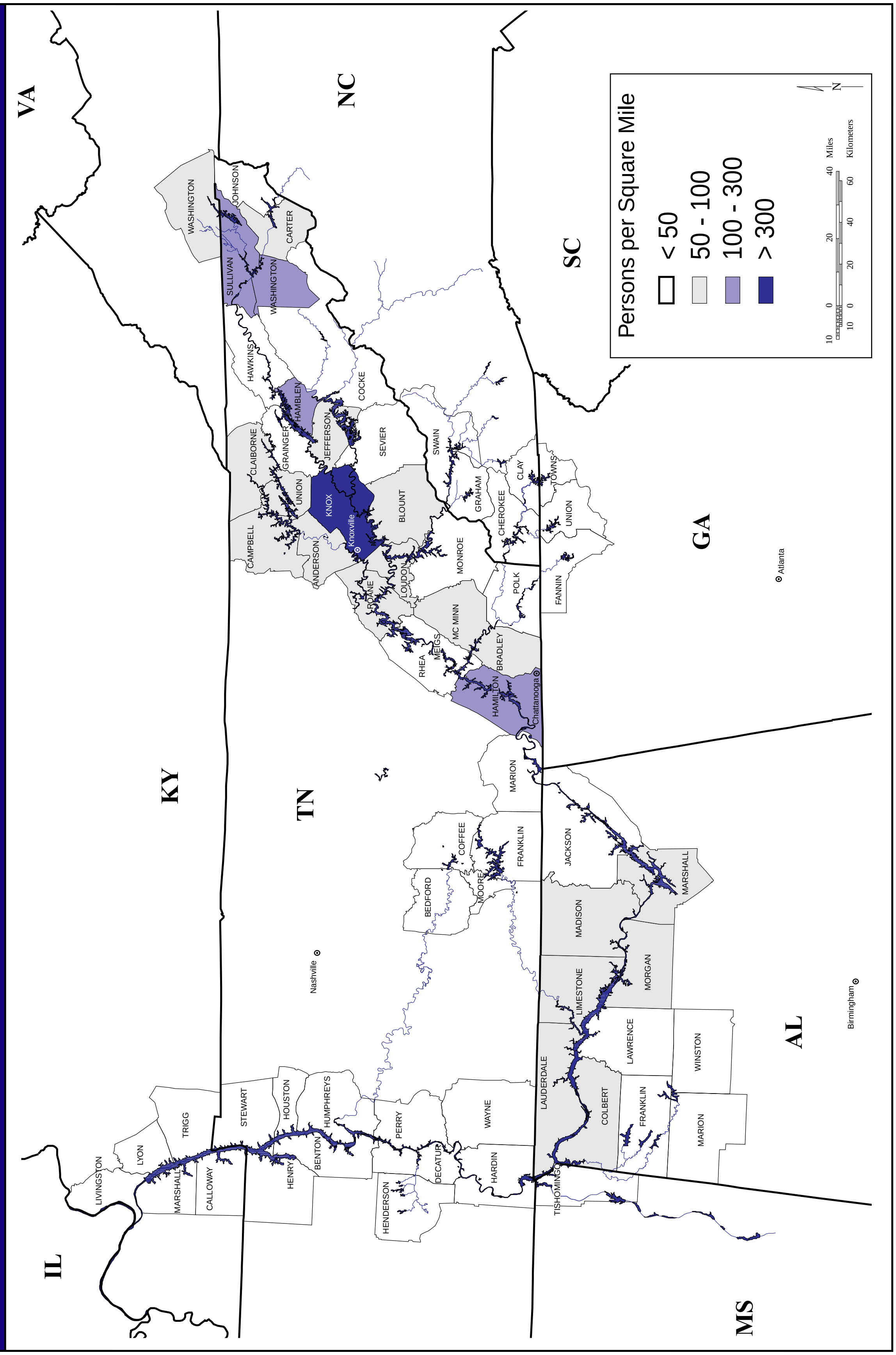
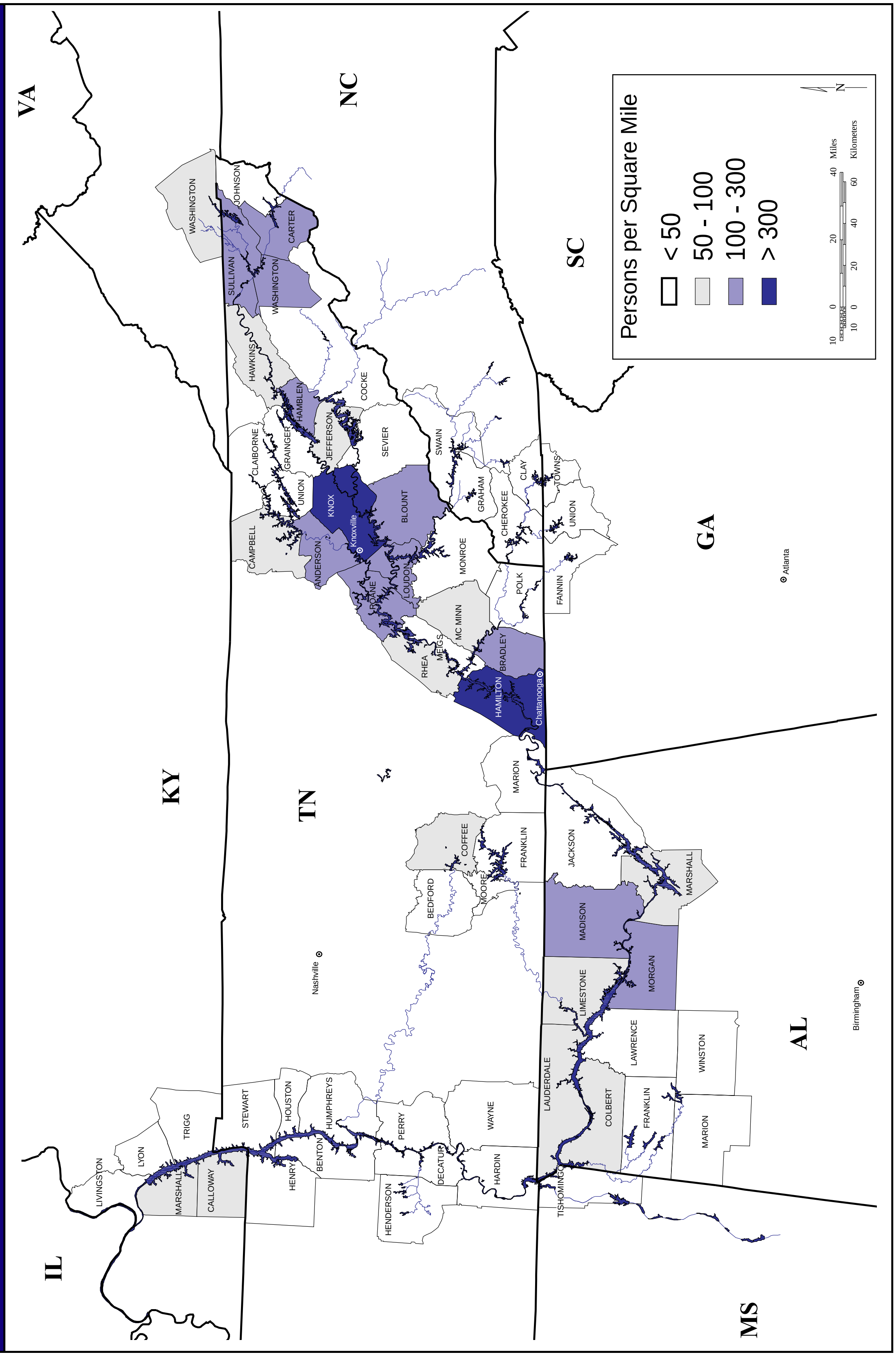


Figure 3.16-1. Population Densities of Tennessee Valley Counties Bordering TVA Reservoirs, 1930.

Figure 3.16-2. Population Densities of Tennessee Valley Counties Bordering TVA Reservoirs, 1960.



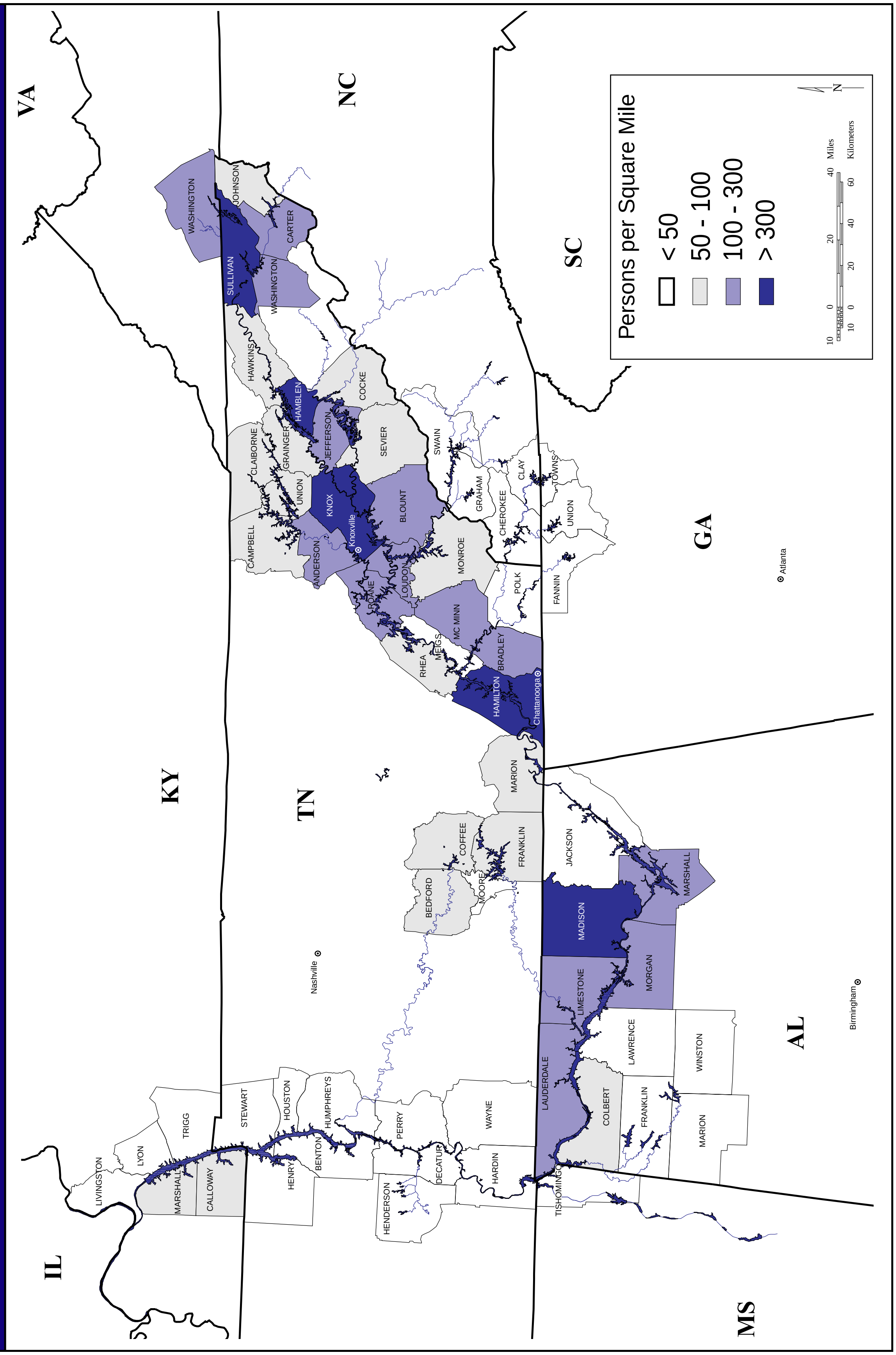


Figure 3.16-3. Population Densities of Tennessee Valley Counties Bordering TVA Reservoirs, 1994.

3.16.3 Income and Employment

Income

Per capita personal income grew by 28.3 percent in reservoir counties from 1980 to 1992, as measured in 1992 dollars (latest available data). This was well above the national rate of 18.8 percent *(Tables 3.16-3 and 3.16-4.)* Because of geographic and locational differences, it is sometimes useful to group reservoirs by location and commercial navigability, as in Appendix O. Only the western commercially navigable group, at 30.6 percent, exceeded the overall per capita personal income growth rate. This was due to high growth rates in the Alabama counties on Guntersville and Wheeler Reservoirs. The slowest rate of increase (25.4 percent) was in the western tributary group, which was held down by slow growth in the Bear Creek Project area and, to a lesser extent, the Normandy area. In the east, the navigable and tributary areas grew at about the same rate — 27.3 and 27.0 percent, respectively.

Table 3.16-3. Per Capita Personal Income in Counties Along TVA Reservoirs, 1980-1992 (1992 $).[1]

Reservoir Group[2]	Per Capita Income		Percent Increase
	1980	1992	
Eastern Commercially Navigable	14,277	18,173	27.3
Eastern Tributary[3]	12,053	15,306	27.0
Western Commercially Navigable	12,959	16,929	30.6
Western Tributary[3]	11,869	14,878	25.4
Average, All Reservoir Counties	**13,070**	**16,766**	**28.3**

[1]Source: U.S. Department of Commerce, Bureau of Economic Analysis (1994).

[2]See classification in Appendix O.

[3]All commercially nonnavigable reservoirs are included in the tributary classifications.

Table 3.16-4. Counties Along TVA Reservoirs With Fastest Per Capita Personal Income Growth (More Than 30 Percent), 1980-1992 (1992 $).[1]

County	State	Reservoir	Population		Percent Increase
			1980	1992	
Union	GA	Nottely	8,573	13,430	56.7
Towns	GA	Chatuge	8,639	13,440	55.6
Hawkins	TN	Cherokee	10,129	14,767	45.8
Grainger	TN	Cherokee, Norris	8,518	11,910	39.8
Hamblen	TN	Cherokee, Douglas	11,428	15,948	39.6
Madison	AL	Wheeler	15,006	20,876	39.1
Limestone	AL	Wheeler	11,944	16,570	38.7
Jackson	AL	Guntersville	11,447	15,724	37.4
Clay	NC	Chatuge	9,526	13,011	36.6
Cocke	TN	Douglas	9,824	13,412	36.5
Bradley	TN	Chickamauga	12,436	16,868	35.6
Morgan	AL	Wheeler	13,497	18,119	34.2
Lawrence	AL	Wheeler, Wilson	10,410	13,821	32.8
Franklin	TN	Tims Ford	11,028	14,586	32.3
Knox	TN	Fort Loudoun, Melton Hill	14,859	19,601	31.9
Henderson	TN	Beech River	10,562	13,861	31.2

[1]Source: U.S. Department of Commerce, Bureau of Economic Analysis (1994).

Employment

Total employment grew by 27.6 percent in reservoir counties from 1980 to 1993 (latest available data) *(Tables 3.16-5* and *3.16-6)*. This was above the national rate of 23.6 percent. Because of geographic and locational differences, it is sometimes useful to group reservoirs by location and commercial navigability, as in Appendix O. The western commercially navigable group, at 32.0 percent, had the highest rate of growth in employment. However, all groups (except eastern commercially navigable) grew faster than the average for all reservoir counties. The high rate of increase in the western commercially navigable group was due largely to high rates in the Alabama counties on Guntersville and Wheeler Reservoirs. In the eastern tributary group, it was due largely to high growth in several counties around Knoxville and counties in north Georgia and southwestern North Carolina. The slowest rate of growth (24.6 percent) was in the eastern commercially navigable group, which was held down by slow growth in the Watts Bar, Chickamauga, and Nickajack areas.

Table 3.16-5. Total Employment in Counties Along TVA Reservoirs (Including Self-Employed), 1980-1993.[1]

Reservoir Group[2]	Total Employment		Percent Increase
	1980	1993	
Eastern Commercially Navigable	523,842	652,554	24.6
Eastern Tributary[3]	349,654	449,532	28.6
Western Commercially Navigable	395,469	522,179	32.0
Western Tributary[3]	94,242	121,926	29.4
Total, All Reservoir Counties[4]	**1,320,396**	**1,685,020**	**27.6**

[1]Source: U.S. Department of Commerce, Bureau of Economic Analysis (1994).

[2]See classification in Appendix O.

[3]All commercially nonnavigable reservoirs are included in the tributary classifications.

[4]Total is slightly less than the sum of the groups because a few counties are in more than one group.

Table 3.16-6. Counties Along TVA Reservoirs With Fastest Total Employment Growth (More Than 50 Percent), 1980-1993.[1]

County	State	Reservoir	Employment		Percent Increase
			1980	1993	
Union	TN	Norris	2,407	4,666	93.9
Sevier	TN	Douglas	18,849	32,887	74.5
Towns	GA	Chatuge	1,618	2,717	67.9
Union	GA	Nottely	3,447	5,771	67.4
Madison	AL	Wheeler	108,286	170,013	57.0
Limestone	AL	Wheeler	18,278	28,234	54.5
Lyon	KY	Kentucky	1,838	2,833	54.1
Wayne	TN	Kentucky	4,326	6,654	53.8
Anderson	TN	Melton Hill, Norris	31,072	46,897	50.9
Marshall	AL	Guntersville, Wheeler	29,080	43,750	50.4

[1]Source: U.S. Department of Commerce, Bureau of Economic Analysis (1994).

3.16.4 Property Values

Shoreland property values vary among reservoirs. The main variables are location (i.e., proximity to population centers) and accessibility to highways. These factors are important to attract both full-time and seasonal residents and to provide accessibility to work and amenities. Full-time residents are usually within a one-hour drive from their place of employment, while seasonal residents commute two to three hours to their lakefront property. Some lots are also owned by residents from other states who use the property only occasionally until they are able to retire and move to the property.

Shoreland property values for different areas of the same reservoir vary due to location, accessibility to urban areas, neighborhood, amenities, availability of utilities, and views. Accessibility to the water and water depth for boat docks also affect property values. General property values for lakefront, lakeview, and interior lots on TVA reservoirs are presented in *Table 3.16-7.*

Property taxes are levied by local and/or state governments and reflect the actual market value of the property. Estimation of actual property value is determined by applicable state and local laws and procedures. Property taxes are directly tied to property values, which can vary widely among shoreland properties, as shown in *Table 3.16-7.*

Table 3.16-7. Residential Lot Prices,[1] by Type and Selected Reservoir, 1995.[2]

Reservoir	Lakefront	Lakeview	Backlot
Blue Ridge	$50,000 - $95,000	$19,000 - $38,000	$12,000 - $32,000
Boone	$35,000 - $80,000	NA[3]	NA
Chatuge	$50,000 - $95,000	$19,000 - $38,000	$12,000 - $32,000
Cherokee	$15,000 - $100,000	$10,000 - $30,000	$9,000 - $18,000
Chickamauga	$20,000 - $150,000	$10,000 - $85,000	$10,000 - $45,000
Douglas	$15,000 - $100,000	$15,000 - $30,000	$12,000 - $17,000
Fontana	$25,000 - $75,000	$25,000 - $75,000	$10,000 - $25,000
Fort Loudoun	$100,000 - $350,000	$75,000 - $100,000	$35,000 - $40,000
Fort Patrick Henry	$50,000 - $85,000	NA[3]	NA
Guntersville	$75,000 - $100,000	$37,000 - $50,000	$25,000 - $37,000
Kentucky	$35,000 - $200,000	$15,000 - $35,000	$9,000 - $15,000
Melton Hill	$30,000 - $72,000	$25,000 - $52,000	$8,000 - $37,000
Nickajack	$10,000 - $135,000	$10,000 - $50,000	$5,000 - $25,000
Nottely	$40,000 - $75,000	$15,000 - $30,000	$9,500 - $25,000
Pickwick	$25,000 - $150,000	$15,000 - $50,000	$10,000 - $25,000
South Holston	$15,000 - $40,000	NA[3]	NA
Tellico	$100,000 - $350,000	$20,000 - $45,000	$8,000 - $15,000
Watauga	$15,000 - $40,000	NA[3]	NA
Watts Bar	$30,000 - $75,000	$15,000 - $30,000	$5,000 - $10,000

[1]Lot prices reflect current data for one-third- to one-half-acre lots on each reservoir.

[2]Source: TVA Land Management Offices

[3]NA=Not available.

3.16.5 Tourism

Tourism is an important industry in the Tennessee Valley. For example, travelers (including business travel and tourism) spent about $7.5 billion dollars in Tennessee in 1994 (U.S. Travel Data Center, 1996). These expenditures directly created an estimated 139,000 jobs and $2.5 billion dollars in earnings. Indirect impacts added an estimated 95,000 jobs and $1.2 billion in earnings to the state's economy. About one-third of this activity occurred in counties which border TVA reservoirs. The travel industry is an important component of the economy in other Valley states as well, contributing a significant amount to income and employment.

While much of the travel is not related to TVA reservoirs, these lakes and surrounding shoreland are an important draw for visitors, who use them for a wide variety of outdoor recreation activities, including fishing, skiing, hunting, swimming, and camping. For further discussion of visitation to these reservoirs and of the types of activities associated with them, see Section 3.13.

As discussed in Section 3.13, estimated recreation visitation in 1995 to TVA reservoirs was 113 million visits. While most of these visits were by Valley residents, a significant share involved visits by nonresidents. In some counties, nonresident visitation is an important factor in the local economy.

3.16.6 Environmental Justice

The concept of environmental justice came from studies indicating that low-income and minority populations are disproportionately exposed to adverse health and environmental impacts. A 1983 General Accounting Office report examined four waste landfills in the Southeast and found that most of the residents near these landfills were minorities. *Toxic Wastes and Race in the United States* (Commission for Racial Justice, Church of Christ, 1987) found that race was the most significant variable at three of the five largest commercial hazardous waste landfill sites when characteristics of nearby communities were considered. However, this church commission indicated that additional research was needed on the subject. Subsequent research by the University of Massachusetts-Amherst did not find statistical and consistent evidence of such a disproportionate impact.

On February 11, 1994, President Clinton issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. This executive order directs certain federal agencies to consider environmental justice in the environmental reviews of their programs and activities in order to better ensure that agency actions do not disproportionately impact minority or low-income populations. Although TVA is not one of the agencies designated in the executive order, it does consider, when appropriate, the potential impact that its actions may have on environmental justice.

During an environmental justice analysis, minority or low-income populations in action-impact areas must be identified to determine whether these populations would be impacted disproportionately, compared to other populations, by the proposed action. If such potential impacts are present, agencies are to make special efforts to obtain the input of minority and low-income populations in the review of the proposed action.

3.17 Navigation

3.17.1 Introduction

The TVA Act (1933, as amended) mandated the development of a 9-foot channel to promote navigation on the Tennessee River and its tributaries. Development of the navigation channel was essentially completed in 1945 with the construction of a series of 10 dams and navigation locks extending navigation from Knoxville, Tennessee, to Paducah, Kentucky. The 650-mile-long main channel of the Tennessee River is wide and deep. In dredged sections, generally below locks, a minimum depth of 11 feet has been provided: 2 feet of overdepth for vessels or barges drawing 9 feet. The minimum channel width in dredged cuts is 300 feet with some widening on bends. Depths of more than 25 feet prevail at normal summer reservoir levels for 400 miles, or about 65 percent of the total length.

3.17.2 Commercial Navigation

There are 171 barge terminals located on the Tennessee River waterway. In 1996 about 46 million tons of commodities moved through these terminals. Coal accounted for almost half of the tonnage, with over half going to TVA coal-fired power plants. Grain, stone, sand, gravel, chemicals, metals, and forest products accounted for the remaining tonnage. It is estimated that shippers save about $457 million per year by using barge tows over other modes of transportation.

3.17.3 Navigation Aids (Including Safety Harbors and Landings)

On the Tennessee River system, the U.S. Coast Guard is responsible for installing and maintaining navigation aids marking the commercial navigation channel. Buoys mark the limits of the channel where it passes through shallow areas or dredged cuts below locks. On open stretches of the waterway where buoys are not used, navigation lights and daymarks guide vessels from one point to the next. The visibility of these structures is important, particularly at night.

TVA provides designated shoreline areas along the waterway called *safety harbors* and *landings* where commercial traffic can tie off during fog and other inclement weather, equipment malfunctions, and emergencies. These safety harbors greatly minimize the risk of damage to private property. TVA maintains 142 harbors and landings along the mainstream reservoirs and two tributary reservoirs (Melton Hill and Tellico). The average distance between harbors and landings is 4.7 miles.

Data are not available showing how many accidents have been avoided due to the availability of safety harbors and landings or how often the towing industry uses these facilities. In situations where safety harbors and landings are not readily available, it is common practice for barge tows to push up against the bank during emergencies. During the summer of 1996, TVA, the U.S. Coast Guard, the USACE, and the towing industry conducted a review of all safety harbors and landings. The focus was on retaining those safety harbors and landings that have the most benefit to navigation. When the review was completed, 32 harbors and landings that are no longer usable because of inadequate size, distance from the navigation channel, or changing shoreline conditions were discontinued.

3.17.4 Recreational Navigation

The reservoirs created by TVA dams also provided opportunities for recreational development. Recreational boating has increased sharply on the Tennessee River system since the reservoirs were impounded. The number of registered boaters in the state of Tennessee has increased from 70,889 in 1965 to 254,194 in 1993. It is reasonable to assume that the other Valley states have also experienced increases in recreational boaters.

3.17.5 Recreational Navigation Aids

To help recreational boaters safely navigate the system, TVA maintains about 1,700 navigation aids, marking approximately 345 miles of recreational navigation channels on mainstream reservoirs. Recreational channel navigation aids help boaters avoid underwater obstructions, while accessing marinas, waterfront recreational areas, public launching ramps, and residential property. The majority of recreational channels lead off the commercial channel into large creeks and embayments.

There are no marked navigation channels on tributary reservoirs, since the large fluctuation between summer and winter pool levels makes it impossible to install channel buoys that would be functional year-round. Instead, danger buoys are installed to warn boaters of most isolated underwater boat hazards.