Section III - Navigation Conditions

1. Historical Development

Before the Civil War, development of navigation on the Tennessee River was constrained by physical obstructions, by a comparatively low level of economic development in areas served by the river, and by an undeveloped transportation technology. Physical obstructions such as sand and gravel bars and shoals were the most serious; other obstructions included reefs, ledges and snags. Swift currents, caused by channel constrictions and the steeply sloped streambed, and uncertain channel depths, caused by seasonal differences in rainfall, also hindered navigation. The most significant area of obstruction was Muscle Shoals in northern Alabama. Muscle Shoals effectively closed the river at Florence, causing the Upper Tennessee River to be treated as a separate river by navigation interests.

Because of the limitations of the unimproved river as a transportation artery, settlements adjacent to the river occurred at points where physical obstructions prevented continuous river navigation. At these pints, transshipment of commodities to other modes, primarily the railroad, was necessary. Such settlements on the Upper Tennessee River included Kingsport, Dandridge, Clinton, and Knoxville, Tennessee. Chattanooga’s development was enhanced because of downstream obstructions and because of railroad connections with the Atlantic ports of Savannah and Charleston. Settlements on the Tennessee River along its “Big Bend” in northern Alabama initially located near the navigation termini at each end of Muscle Shoals. These include Decatur, Florence, Sheffield, and Tuscumbia. Paducah, Kentucky, was the only sizeable settlement to develop along the Lower Tennessee River, which was "fairly navigable” from the mouth to Colbert Shoals, just east of Florence.

Transportation technology was also important to the growth of navigation on the Tennessee River during this period. The types of vessels on the Tennessee River before 1835 ranged from dugout canoes to rafts and flatboats. Steamboats were in use after 1835. During the period before the Civil War, the quantity of upstream freight was always much smaller than that going downstream because of the hazards and difficulties the unimproved river system posed on the upstream journey. The only two-way traffic to develop during this period was local trade between points on the same navigable portion of the river.

Before the Civil War, improvements to the navigable conditions of the river were few and largely ineffective. A canal connecting Huntsville, Alabama, with the river was completed in 1831 and a canal around Muscle Shoals was opened in 1836. Both were soon abandoned because of poor design.

There was only one significant navigation improvement to the river between the Civil War and 1900. A second Muscle Shoals canal, which provided 5-foot minimum depth, was opened in 1890 (construction began in 1875). The canal was built in response to pressure from Chattanooga industrialists on the federal government for improvements that would encourage waterborne commerce. The industrialists believed that competition would force railroads to reduce their rates, an event that was evident before completion of the canal.

Navigation enhancement on the Tennessee River during the period 1900 to 1933 was characterized by isolated attempts to solve specific problems. They were accomplished primarily by the federal government, acting under a series of Rivers and Harbors Acts, of which the first affecting the Tennessee River was the 1852 Act.

The first improvement to be completed during this period was the Colbert Shoals Canal near Florence, Alabama. The canal and lock, completed in 1911, provided a 7-foot minimum navigable depth around Colbert Shoals. Hales Bar Dam and Lock, completed in 1913, was the second navigation improvement of the period. It was constructed by a private interest, the Tennessee Electric Power Company, and provided a 6-foot navigable channel upriver to Chattanooga, a distance of 33 miles.

Widow’s Bar Locks and Dam, a low-profile navigation structure, was constructed 23 miles below Hales Bar. Upon completion in 1925, Widow’s Bar Dam provided a 5-foot navigable channel from Scotts Point, 16 miles upstream from Hales Bar, to Lock A at the Elk River.

Wilson Dam was the last major navigation structure to be completed in this period. Authorization for the dam was contained in the National Defense Act of 1916, which assigned it three purposes: national defense, navigation, and power. When completed in 1925, the dam created a slackwater pool with a 9-foot navigable depth that extended 15.5 miles upstream. Wilson Dam, however, did not completely solve the problems posed to navigation by the Muscle Shoals area of the river. An auxiliary lock and dam 2.5 miles below Wilson Dam was placed in operation in 1927 to provide a better approach to the Wilson Locks. Florence Canal, the channel created by the auxiliary structures had a navigable depth of approximately seven feet.

Between Muscle Shoals and Paducah, Kentucky, only dredging and snag removal was necessary to provide a navigable depth of 4.5 feet throughout the year. Numerous other projects were authorized for construction between 1900 and 1933, but either was not built or contributed little to navigation.

The region served by navigation on the Tennessee experienced a rapid rate of growth in the years immediately after 1900, although the patterns of that growth reflected the effects of limited river improvements and more rapidly developing railroad and trucking industries. Industrial and population growth in the region began to be more independent of the river during this time period. Manufacturing centers such as Knoxville and Chattanooga were oriented primarily to local markets because of the lack of inexpensive transportation for manufactured goods.

The most important developments affecting navigation between 1900 and 1933 included shifts of traffic to other modes, development of barge technology, and several pieces of legislation that provided the first effective regulation of common carriers.

As part of the federal program of navigation improvements, the Corps of Engineers made several surveys of the Tennessee River, the most important being a report originally authorized in 1922 and published in 1930, entitled Tennessee River and Tributaries. The report presented a preferred alternative and other alternative plans to develop the river, whether accomplished by public or private interests. It later became the basis for subsequent Congressional policy toward the river. The report showed that building 7 high dams or 32 low navigable dams to supplement the two existing dams on the river

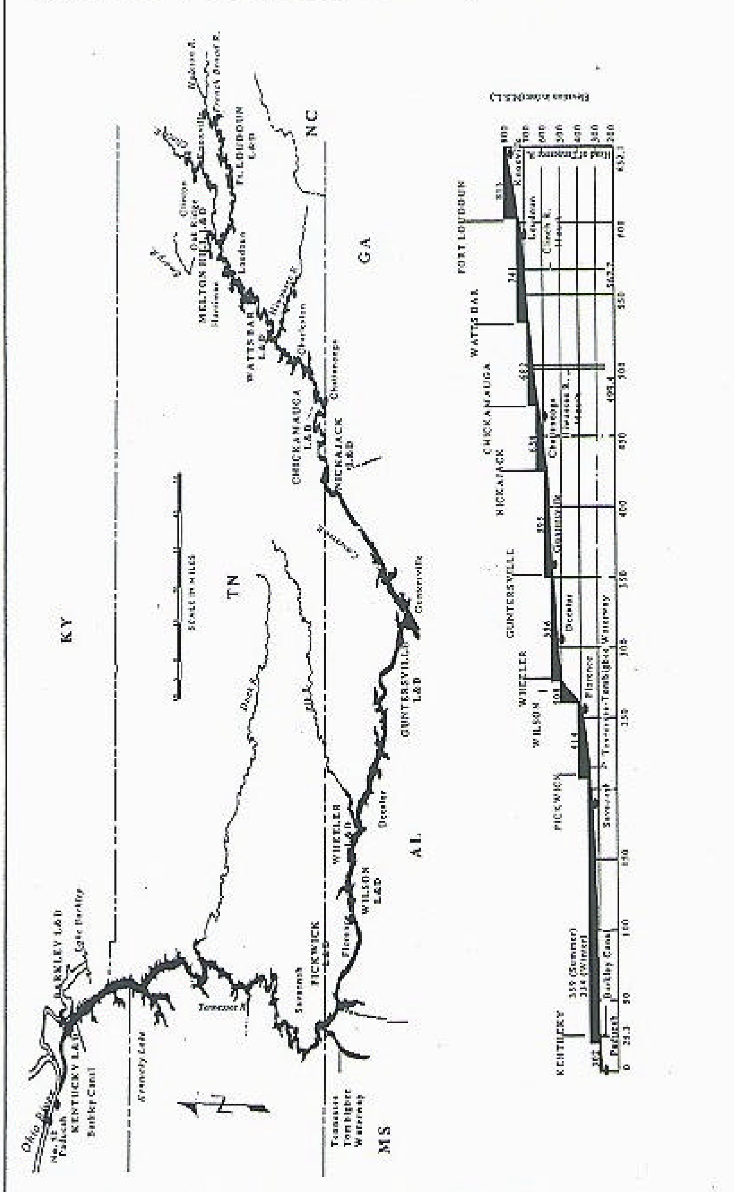
(Wilson and Wheeler, then under construction) could develop a 9-foot channel from Paducah to Knoxville. The high-dam system incorporated hydroelectric power and flood control in addition to navigation. Because of the doubt that sufficient funding would be available for the high-dam navigation structures, the study recommended proceeding with the plan for low navigation structures. However, little progress, other than work on Wheeler Lock, was made by the time the Tennessee Valley Authority (TVA) was organized in 1933.

2. Description of Present Navigation System

A system of multipurpose dams on the main-stem Tennessee River creates a 652-mile long, 9-foot deep commercially navigable channel. In addition, commercial navigation has been extended 61.5 miles up the Clinch River, 21.5 miles up the Hiwassee, and 19.0 miles up the Little Tennessee River. Of the eleven existing multiple-purpose projects on the main-stem Tennessee, Clinch, and Little Tennessee Rivers, two were originally constructed by the U.S. Army Corps of Engineers: Wilson Dam and initial locks, and Wheeler Lock. TVA constructed the remaining navigation facilities, some of which were designed by the Corps. In accordance with the general navigation laws placing control and supervision over navigable waters under the Secretary of the Army and under agreements with TVA, the Nashville District operates and maintains all the locks on the Tennessee River. Figure III-1 shows the location of all the projects in the Tennessee River Basin and the Tennessee-Tombigbee Waterway (TTW), which enters the Tennessee River at mile 215 near the Tennessee, Alabama, and Mississippi state lines. Following is a brief description of Nickajack, the first lock downstream of the Chickamauga project, the three Upper Tennessee River locks, Watts Bar and Fort Loudoun Locks on the Tennessee River and Melton Hill Lock on the Clinch River.

a. Nickajack Lock and Dam is the newest of the TVA multi-purpose projects. Completed in 1968, Nickajack replaced the 55-year-old Hales Bar project, which was completed in November 1913. Hales Bar was constructed by a private concern under the direction of the U.S. Army Corps of Engineers and contained a hydropower unit, a 60 X 265-foot lock with a maximum lift of 41 feet, and sufficient size to provide a 6-foot deep channel upstream to Chattanooga, Tennessee. Authorization was provided by

Figure III-1 Location of Tennessee River Projects



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Congress in 1905 (33 Stat. 603). The Hales Bar project mitigated many of the early navigation problems in the Tumbling Shoals, the Suck, the Boiling Pot, and the Skillet (or Frying Pan) stretches of the river below Chattanooga. Hales Bar was replaced because of persistent and excessive leakage through its extremely poor foundation.

The Nickajack project was built under the authority granted in the TVA Act of 1933. Nickajack is located at river mile 424.7, approximately six miles downstream of the old Hales Bar site. The dam is 83 feet high and 3,767 feet long. Nickajack pool is 46.3 miles long with a surface area of 10,370 acres. Flood storage capacity is 32,300 acre-feet under controlled conditions, and gross storage capacity is 252,400 acre-feet. The project has 192 miles of shoreline.

Two parallel locks were begun in 1964. The completed lock measures 110 X 600 feet, and the incomplete facility provides a 110 X 800 foot dimension for future development. Normal lift of the completed lock is 39 feet.

b. Chickamauga Lock and Dam is located at river mile 471 near Chattanooga, Tennessee, and was begun in 1936 and completed in 1940. It was authorized under the TVA Act of 1933. The dam is 129 feet high and 5,800 feet long. Chickamauga pool extends 58.9 miles upstream, has a surface area of 35,400 acres, and has a shoreline 810 miles long. Controlled flood storage capacity is 347,000 acre-feet, and gross storage capacity is 739,000 acre-feet.

The clear chamber dimensions of the single-lift (normal lift of 49 feet) navigation lock are 60 X 360 feet. Chickamauga Lock is the first small lock encountered when moving upstream on the mainstem Tennessee River. Chickamauga’s four hydropower electrical generation units have a total capacity of 108,000 kilowatts.

c. Watts Bar Lock and Dam is located halfway between the cities of Knoxville and Chattanooga, Tennessee, at river mile 529.9, and represents the eighth step in the Tennessee River waterway system. Construction on the project began in 1939 with completion of the project in 1942. Watts Bar was authorized under the TVA Act of 1933 and received its name from the island and slough upon which the lock and dam were constructed.

Watts Bar extends navigable waters 72 miles upstream to Fort Loudoun Lock and Dam. Two channel cutoffs reduce the sailing distance by approximately 10 miles. Watts Bar is 112 feet high and 2,960 feet long. The small navigation lock has clear dimensions of 60 X 360 feet with a normal lift of 58 feet, and minimum navigation clearance is about 12 feet over both of the guard sills. The Watts Bar pool extends a 9-foot deep slack water channel 23.1 miles up the Clinch River to Melton Hill Dam and about 12 miles up the Emory River to Harriman, Tennessee.

The normal storage capacity of Watts Bar pool is 1,175,000 acre-feet; the controlled flood storage capacity is 379,000 acre-feet. The lake has a surface area of 39,000 acres with a shoreline of 783 miles at full pool. The four electrical generation units at Watts Bar are capable of generating 153,300 kilowatts.

d. Fort Loudoun Lock and Dam is located at river mile 602.3 and extends the Tennessee River Navigation System to Knoxville, Tennessee. The Fort Loudoun slack waters provide a 9-foot deep channel upstream to river mile 649, three miles below the confluence of the Holston and French Broad Rivers, which form the Tennessee River. Construction on the Fort Loudoun project began in 1940 with completion in 1943. Authorization was provided in the Tennessee Valley Authority Act of 1933.

Fort Loudoun Dam is 122 feet high and 4,190 feet long. Fort Loudoun Lake has a surface area of 14,600 acres, which is the smallest surface area of all mainstem Tennessee River projects, and has a shoreline 360 miles in length. Gross storage capacity is 393,000 acre-feet of with 111,000 acre-feet are classified as controlled flood storage capacity. Fort Loudoun has four power units capable of generating 135,590 kilowatts. The lock is a single-lift unit, completed in 1943. Clear chamber dimensions are 60 X 360 feet with a normal lift of 72 feet.

e. Melton Hill Lock and Dam is located at Clinch River mile 23.1 near the Oak Ridge National Laboratories. Construction began in 1960 and the lock was opened to traffic in 1963. The Melton Hill pool extends the navigation channel 38.4 miles upstream to Clinton, Tennessee, giving the Clinch River a total of 61.5 miles of navigable channel. Melton Hill Dam is 103 feet high and 1,020 feet long. The surface area of the pool is 5,690 acres of which gross storage capacity is 126,000 acre-feet. A 31,900 acre-feet capacity exists for controlled flood storage. The two power generation units are capable of 72,000 kilowatts. Melton Hill Lock is a single-lift unit measuring 75 X 400 feet. Normal lift is 54 feet.

3. Historic Traffic Development

a. Historic Growth Factors. Since completion of the Upper Tennessee navigation system in the early 1940s, commercial traffic on the river has expanded primarily in response to the transportation needs of the region’s manufacturers and activities such as highway construction, and to a lesser extent, mineral extraction. The region’s manufacturing-based economy developed around its abundant natural resources – water, coal, wood and nonferrous metal ores – and demands of larger regional economies driven by the textile, furniture, and poultry industries.

Activities of the Tennessee Valley Authority have played a highly important role in the development of the Upper Tennessee region. The TVA was established in 1933 to provide for the multi-purpose development of the Tennessee Valley. TVA’s electric power and navigation development programs are responsible for much of the industrial, population, and overall economic growth that have taken place in the region.

Area manufacturing activities expanded rapidly through the 1950s and 1960s, but since the early 1970s relatively little growth in the manufacturing sector has occurred. Industry representatives attribute this to the perception that the lock is an unreliable transportation resource because of structural problems, and in part, to the small (60’x360’) outdated locks at the Chickamauga, Watts Bar, and Fort Loudoun projects. Industry representatives point out that companies that rely heavily on waterway transportation are reluctant to locate or expand facilities where they will be dependent on the Chickamauga facility, given its deteriorated condition and uncertain future. The risk of encountering very high delays and the loss of navigation that occurs when any of the Upper Tennessee facilities, especially Chickamauga, is down for maintenance and repairs has made companies reluctant to commit themselves to water transportation in this area.

Due to commercial navigation rates being typically much higher on this river segment than on other rivers. Backhaul opportunities for towing companies are practically non-existent, and consequently, many towing companies will not operate above the Chickamauga lock and dam. Because of the higher cost of navigation on the Upper Tennessee, rate differentials sometimes favor overland modes. Many companies maintain the capability to switch from water to overland transportation to take advantage of these opportunities.

b. Historic Commodity Traffic. Upper Tennessee system traffic for the period 1970-1999 is presented in Table III-1. Upper Tennessee system traffic data for periods prior to 1970 are unavailable. It should be noted that during 1999, Chickamauga and Watts Bar locks were closed for 30-days and 14-days, respectively, for major maintenance. These closures had an impact on traffic that utilized the waterway during 1999. Several commodities were trucked from Chattanooga to the Knoxville area during the Chickamauga Lock closure. This reduced the tonnage that would have processed through the lock without the long closures. The highest levels of commodity traffic on the Upper Tennessee were attained in 1987, when 3.1 million tons of traffic moved on the system. Between 1970 and 1999, Upper Tennessee traffic grew from 1.6 to 2.3 million tons, representing annual growth of about 1.3 percent. During the same period, Tennessee River system and Ohio River system traffic each grew more rapidly, about 2.5 and 1.8 percent, respectively. A vast majority of Upper Tennessee commodity traffic transits the Chickamauga lock. In 1970, Chickamauga traffic accounted for about 79 percent of the traffic and by 1999, this had increased to over 99 percent. Traffic growth rates for each of the Upper Tennessee projects exceeded the growth rate for the system as a whole over the period 1970 through 1999. Chickamauga traffic grew at a rate of 2.1 percent while Watts Bar and Fort Loudoun grew at rates of 5.7 and 4.1 percent respectively. The Upper Tennessee segment had a substantial reduction in internal (mostly aggregates) traffic and an increase in inbound and outbound traffic over the 1970-99 period.

In 1999, about 2.3 million tons of commodities moved on the Upper Tennessee navigation system, accounting for about 4.4 percent of traffic on the entire Tennessee River system. More than 99 percent of this traffic moved through the Chickamauga facility. Table III-2 shows the 1999 Upper Tennessee traffic by major commodity group and by project. The commodity distributions for the Upper Tennessee segment and for Chickamauga, Watts Bar and Fort Loudoun are shown in Figures III-2 and III-3.

Table III-1 Historic Traffic on the Tennessee River (Thousand Tons)

Year	Upper Tennessee Projects			Upper Tenn. System	Tenn. River System
	Chickamauga	Watts Bar	Fort Loudoun		
1960	668	531	440	NA	12,441
1970	1,248	368	195	1,584	25,489
1980	1,334	638	349	1,467	43,062
1990	2,123	1,370	579	2,237	44,536
1991	1,848	1,046	390	1,944	42,087
1992	2,172	1,388	464	2,239	46,083
1993	1,966	1,224	491	2,006	48,161
1994	2,311	1,560	619	2,327	48,731
1995	2,182	1,399	600	2,186	46,393
1996	2,253	1,474	645	2,255	45,529
1997	2,567	1,807	542	2,574	48,595
1998	2,584	1,735	627	2,586	52,086
1999	2,282	1,812	621	2,284	51,689
Annual Growth 1970-99	2.1%	5.7%	4.1%	1.3%	2.5%

SOURCE: Waterborne Commerce Statistics

The leading commodity group on the system in 1999 was grains, which comprised about 37 percent of total traffic. Ores and minerals was next in importance (24 percent) followed by asphalt (13 percent), chemicals (8 percent), iron and steel (7 percent), forest products (5 percent), and aggregates (5 percent). Collectively, these commodity groups total over 98 percent of total traffic on the system. The remaining tonnage, classified as all other, was comprised of fabricated metal products, but included petroleum coke, slag, nonferrous metals, and machinery as well.

Table III-2 Upper Tennessee Commodity Distributions, 1999 (Tons)

Commodity	Chickamauga	Watts Bar	Fort Loudoun	Upper Tenn. System	Tenn. River System
Coal & Coke	0	0	0	0	20,118,458
Petroleum Fuels	0	0	0	0	2,147,585
Asphalt	282,368	282,368	282,368	282,368	1,184,303
Aggregates	109,087	109,347	46,147	109,597	11,760,688
Grains	854,552	854,552	0	854,552	4,995,607
Chemicals	172,735	110,517	5,914	172,735	2,701,672
Ores & Minerals	547,802	244,345	217,803	547,802	1,978,884
Iron & Steel	159,617	159,617	45,711	159,617	3,462,431
Forest Products	119,065	18,705	18,705	119,065	1,067,622
All Others	36,961	32,651	4,779	37,821	2,271,632
Total	2,282,187	1,812,102	621,427	2,283,557	51,688,882

SOURCE: Waterborne Commerce Statistics

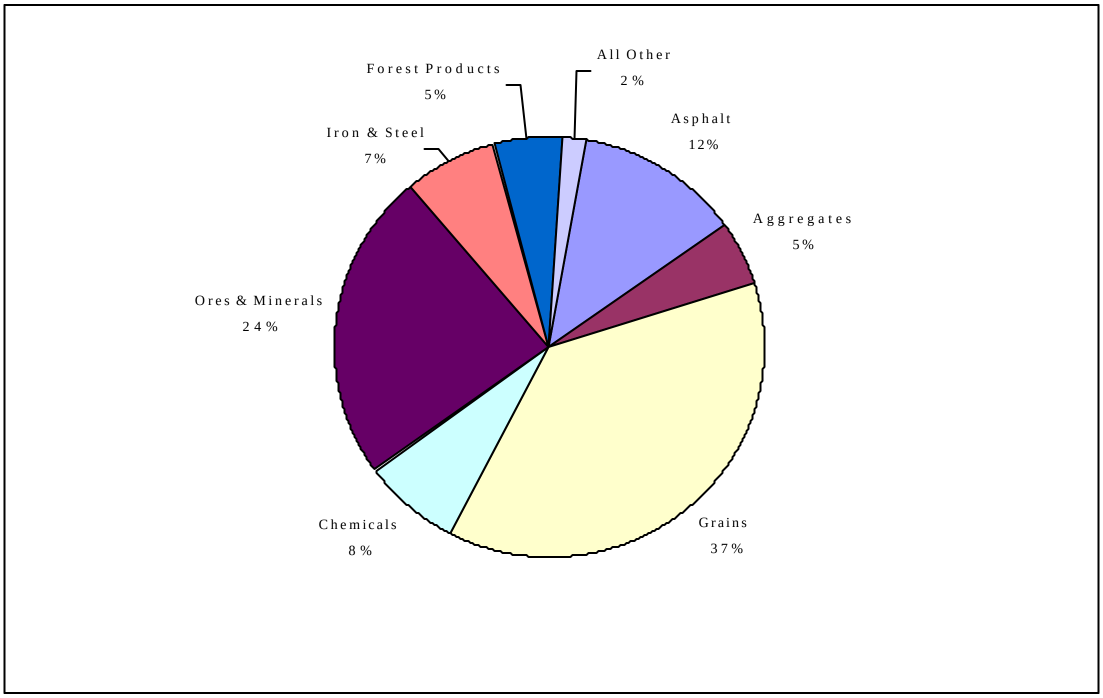

FIGURE III-2. UPPER TENNESSEE SYSTEM TRAFFIC, 1999

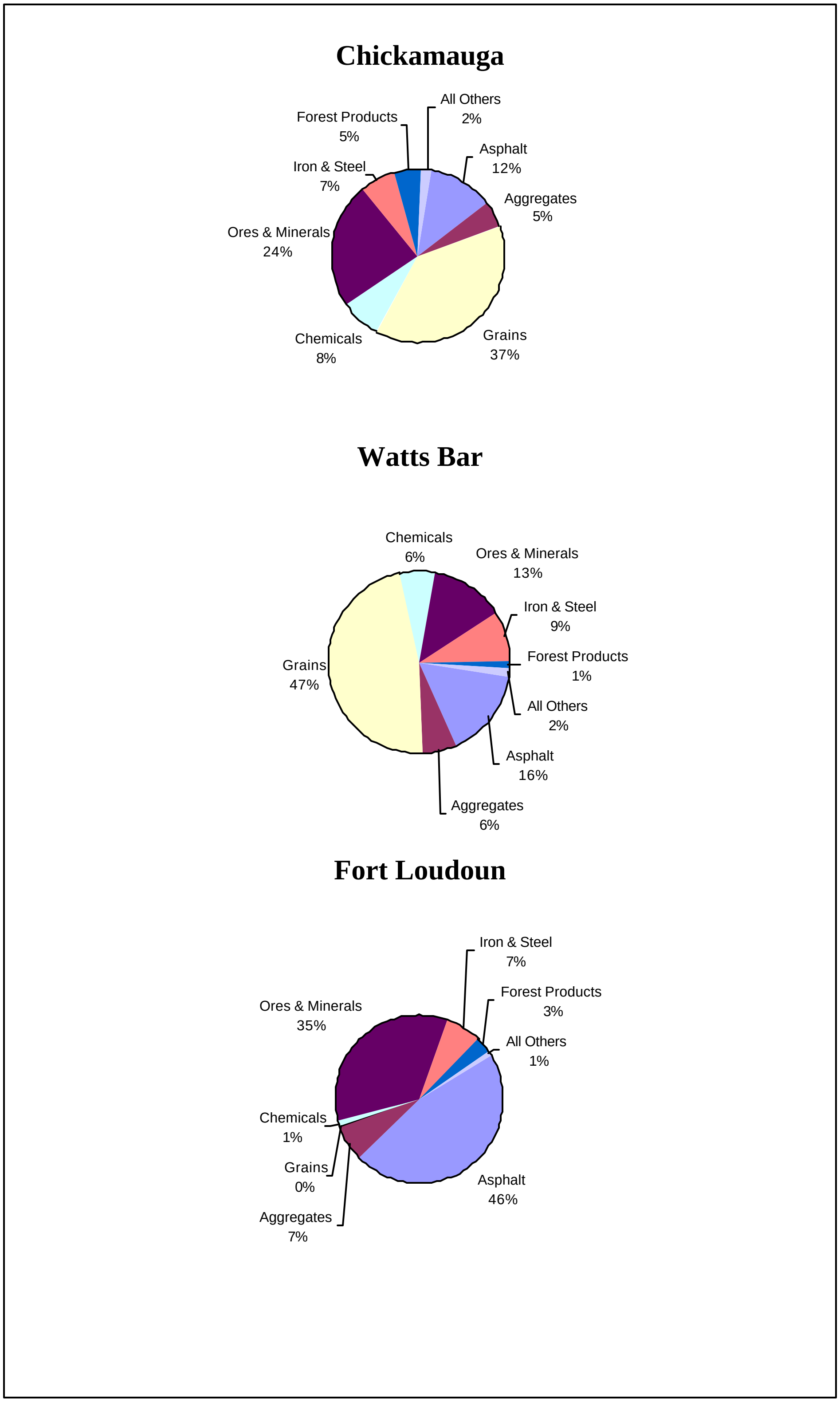

FIGURE III-3. UPPER TENNESSEE LOCK TRAFFIC, 1999

Tonnage densities on the Upper Tennessee segment are the greatest at Chattanooga and diminish gradually toward the head of navigation at Knoxville. The Chickamauga facility, at Chattanooga, is the lowermost and the most heavily used of the Upper Tennessee projects, followed by Watts Bar and Fort Loudoun. In 1999, the Chickamauga facility processed about 2.3 million tons of traffic, representing over 99 percent of total Upper Tennessee system traffic. Watts Bar recorded about 1.8 million tons of traffic, while Fort Loudoun processed about 621,000 tons.

The changes in commodity traffic by major commodity group on the Upper Tennessee for selected years between 1970 and 1999 are shown in Table III-3. Total 1999 commodity traffic represented an increase of about 699,000 tons over 1970. Each of the major commodity groups displays an increase in tonnage except for coal and coke; petroleum fuels; aggregates, and forest products. The largest tonnage increases occurred in shipments of grains, ores and minerals, asphalt, iron and steel, and chemicals.

Table III-3 – Historic Upper Tennessee River Traffic Growth by Commodity Group, 1970-1999 (Thousand Tons)

Commodity	1970	1980	1990	1995	1996	1997	1998	1999	Annual % Change 1970-99
Coal & Coke	35.2	377.7	14.8	-	-	-	-	-	-
Petroleum Fuels	37.1	126.6	23.7	9.6	8.5	7.4	-	-	-
Asphalt	111.0	62.5	202.0	205.6	194.7	228.1	292.7	282.4	3.3
Aggregates	656.3	41.0	6.3	62.2	47.8	57.2	75.3	109.6	-6.0
Grains	38.0	42.9	591.9	472.7	551.7	964.3	818.3	854.6	11.3
Chemicals	79.5	133.8	94.8	184.5	155.4	213.4	226.3	172.7	2.7
Ores & Minerals	204.1	179.4	633.7	711.1	783.4	604.8	652.4	547.8	3.5
Iron & Steel	13.9	42.6	77.2	118.4	129.1	119.4	116.3	159.6	8.8
Forest Products	399.1	448.4	522.3	390.1	352.1	319.4	387.2	119.1	-4.1
All Others	10.3	21.3	70.4	29.3	32.6	60.2	78.2	37.8	4.6
TOTAL	1,584.4	1,476.3	2,237.4	2,186.4	2,255.4	2,574.2	2,585.7	2,283.6	1.3
Chickamauga's % Of Total	78.8%	90.4%	94.9%	99.8%	99.9%	99.7%	99.9%	99.9%	

SOURCE: Waterborne Commerce Statistics

Historically, coal and coke traffic has moved in relatively small quantities from the Upper Tennessee to southeastern utility plants and to export. Despite the area’s location with respect to major Appalachian coal-producing areas, no significant and sustained traffic in coal has yet developed. Since the early 1990s, no coal traffic has moved on the Upper Tennessee.

Petroleum fuels traffic has not moved on the Upper Tennessee system since 1997. The petroleum fuels traffic that typically moves is comprised of inbound distillate and residual fuel oil originating in the Huntington-Ashland area on the Ohio River. Petroleum fuels traffic on the Upper Tennessee was seriously undermined by the extension of the Colonial and Plantation petroleum product pipelines into Knoxville in the mid-1970s. The Colonial and Plantation pipeline systems move petroleum products from southeastern and Gulf Coast refineries into Tennessee. Prior to the pipelines’ extension, both heavy and light petroleum products were transported to the Knoxville area by waterway.

Along with the distillate and residual fuel oil, asphalt is the only other petroleum product that typically moves on the Upper Tennessee. All of this traffic moves inbound to the Upper Tennessee to support highway maintenance in Eastern Tennessee. In 1999, about 282,000 tons of asphalt moved to terminals at Knoxville. This was an increase of slightly more than 171,000 tons over 1970.

Traffic in aggregates now includes inbound sand and gravel, inbound lightweight aggregate, a small amount of outbound limestone, and local traffic in waterway improvement materials. The sand and gravel is dredged from the Lower Tennessee and the Ohio and used in construction and highway maintenance activities in Eastern Tennessee. The limestone is an agricultural product that is a byproduct of zinc mining and is shipped to the Gulf Coast states. Construction of the Interstate highway system generated considerable traffic in aggregate in the 1960s and early 1970s, but with completion of the system in this area in the mid-1970s, waterborne aggregates traffic diminished significantly. Aggregates traffic in 1999 amounted to nearly 110,000 tons, which was 547,000 tons less than the 1970 traffic level.

Grains traffic, which includes both grains and animal feeds, reached a level of about 855,000 tons in 1999, an increase of 817,000 tons over 1970. Grains are now the largest commodity group moving on the Upper Tennessee.

This category comprises mostly inbound corn and outbound animal feeds. Grain processing is relatively new to the regional economy. From Eastern Tennessee, access is provided to three major markets: the poultry market of north Georgia, Alabama, and South Carolina; the southeastern market for corn sweeteners and vegetable oils; and the growing export feed market.

The chemicals group is comprised of inbound chemical fertilizers and outbound industrial chemicals. Chemicals traffic reached a level of nearly 173,000 tons in 1999, an increase of 93,000 tons from 1970. The industrial chemical traffic typically comprises ethyl alcohol, chlorine, and sodium hydroxide.

The ores and minerals category is largely inbound salt, gypsum, and manganese ores and outbound zinc ore. Salt traffic on the Upper Tennessee is closely linked to both chemicals and forest products, and a large share of the salt traffic is used as road salt. In 1999, ores and minerals traffic was the second largest commodity group moving on the system, amounting to nearly 548,000 tons. This represents an increase of about 344,000 tons over the 1970 level.

Iron and steel traffic on the Upper Tennessee consists of inbound finished iron and steel products and ferroalloys and outbound iron and steel scrap. Iron and steel traffic on the Upper Tennessee in 1999 totaled nearly 160,000 tons, which was an increase of about 146,000 tons over 1970. The Knoxville area is a regionally important iron and steel service center.

The forest products category includes woodchips, newsprint, and paper and paperboard. The forest products category had been one of the largest commodity groups moving on the Upper Tennessee system for many years. In 1999, however, traffic in the forest products category amounted to only 119,000 tons, a decrease of 280,000 tons from the 1970 traffic level. Wood chips traffic is mostly inbound to the system. Traffic in newsprint; paper and paperboard are largely outbound.

4. Commodity Shipping Patterns

Table III-4 shows Upper Tennessee and Chickamauga traffic by commodity group and direction of movement for 1999. More than 99 percent of Upper Tennessee traffic in 1999 moved inbound to or outbound from the system, thus transiting the Chickamauga lock. Typically, very little local traffic moves on this system. More than two-thirds of the system traffic was inbound (upbound) to the area in 1999. This external orientation is determined largely by the locations of product supply and market areas for area industry.

Table III-4 Upper Tennessee Traffic by Direction of Movement, 1999
(Tons)

Commodity	Chickamauga Lock Traffic			Internal		Upper Tenn System
	Inbound (Upbound)	Outbound (Downbound)	Total	Upbound	Downbound	
Coal & Coke	0	0	0	0	0	0
Petroleum Fuels	0	0	0	0	0	0
Asphalt	282,368	0	282,368	0	0	282,368
Aggregates	109,087	0	109,087	0	510	109,597
Grains	559,642	294,910	854,552	0	0	854,552
Chemicals	49,401	123,334	172,735	0	0	172,735
Ores & Minerals	437,049	110,753	547,802	0	0	547,802
Iron & Steel	43,349	116,268	159,617	0	0	159,617
Forest Products	76,417	42,648	119,065	0	0	119,065
All Others	13,234	23,727	36,961	200	660	37,821
TOTAL	1,570,547	711,640	2,282,187	200	1,170	2,283,557
SOURCE: Waterborne Commerce Statistics						

The 1999 shipments and receipts by economic areas for Chickamauga traffic are shown in Table III-5. Economic areas (EA) are economic regions defined by the Bureau of Economic Analysis, U. S. Department of Commerce. Economic areas consist of a major city or Metropolitan Statistical Area that serves as a center for economic activity and outlying areas that are economically connected to the center. The Upper Tennessee navigation system is about evenly divided between two economic areas: Chattanooga (EA 43) and Knoxville (EA 44).

Chickamauga traffic moves from/to points as distant as Brownsville, on the Gulf Intracoastal Waterway, and Minneapolis, on the Upper Mississippi. Nearly half of 1999 shipments originated and one fifth of 1999 receipts terminated at locations on the Mississippi. The Knoxville EA accounts for about 28 percent of shipments (628,997 tons) and about 51 percent of receipts (1,182,685 tons) moving through the facility. The Chattanooga EA, downriver, accounts for about four percent of the shipments

(82,643 tons) and about 17 percent of the receipts (387,862 tons). Other important origin economic areas for Chickamauga traffic include Lafayette, Louisiana (400,451 tons); Des Moines (232,180 tons); New Orleans (222,887 tons); St. Louis (126,414 tons); and Paducah (107,912. Other major destination economic areas include New Orleans (287,715 tons); Chicago (89,397 tons); Nashville (63,936 tons); St. Louis (60,964 tons); and Huntsville, Alabama (49,580 tons).

TABLE III-5 Chickamauga Lock Traffic
Shipments and Receipts by Economic Area – 1999
(Tons)

	Shipping/Receiving Economic Area	Shipments (Origin)	Receipts (Destination)
43	Chattanooga, TN-GA	82,643	387,862
44	Knoxville, TN	628,997	1,182,685
48	Charleston, WV-KY-OH	10,416	6,200
49	Cincinnati-Hamilton, OH-KY-IN	0	1,400
53	Pittsburgh, PA-WV	0	14,111
64	Chicago-Gary-Kenosha, IL-IN-WI	54,386	89,397
69	Evansville, IN-KY-IL	8,686	0
70	Louisville, KY-IN	2,911	12,607
71	Nashville, TN-KY	5,950	63,936
72	Paducah, KY-IL	107,912	13,200
73	Memphis, TN-AR-MS-KY	1,487	7,294
74	Huntsville, AL-TN	76,747	49,580
75	Tupelo, MS-AL-TN	0	0
77	Jackson, MS-AL-LA	3,261	0
80	Mobile, AL	0	0
82	Biloxi-Gulfport-Pascagoula, MS	0	0
83	New Orleans, LA-MS	222,887	287,715
84	Baton Rouge, LA-MS	40,172	13,888
85	Lafayette, LA	400,451	0
86	Lake Charles, LA	0	0
87	Beaumont-Port Arthur, TX	0	0
90	Little Rock-North Little Rock, AR	0	8,700
91	Fort Smith, AR-OK	0	1,350
95	Jonesboro, AR-MO	742	25,755
96	St. Louis, MO-IL	126,414	60,964
97	Springfield, IL-MO	79,264	0
100	Des Moines, IA-IL-MO	232,180	0
101	Peoria-Pekin, IL	83,078	28,584
102	Davenpport-Moline-Rock Island, IA-IL	51,543	0
104	Madison, WI-IL-IA	22,667	0
107	Minneapolis-St. Paul, MN-WI-IA	24,916	0
118	Omaha, NE-IA-MO	0	0
124	Tulsa, OK-KS	0	8,516
131	Houston-Galveston-Brazoria, TX	8,366	18,443
132	Corpus Christi, TX	0	0
133	McAllen, TX	6,111	0
	TOTALS	2,282,187	2,282,187

SOURCE: Waterborne Commerce Statistics

5. Lock Traffic Patterns and Commonality of Traffic

Detailed listings of the 1999 directional distribution of commodity flows for the Chickamauga, Watts Bar, and Ft. Loudoun facilities are shown in Table III-6. From the data, it is apparent that a substantial majority of the traffic at each of the facilities (two thirds or more) is upbound traffic. A majority of the upbound ores and minerals traffic, nearly all of it salt, as well as the forest products traffic terminate in the Chickamauga pool, accounting for the significant drop in upbound traffic at the Watts Bar and Ft. Loudoun facilities. Over half of the downbound traffic, mostly grains, chemicals, and iron and steel originates in the Watts Bar pool.

TABLE III-6 Upper Tennessee Projects Traffic by Direction of Movement, 1999 (Tons)

Commodity	Chickamauga		Watts Bar		Fort Loudoun	
	Upbound	Downbound	Upbound	Downbound	Upbound	Downbound
Coal & Coke	0	0	0	0	0	0
Petroleum Fuels	0	0	0	0	0	0
Asphalt	282,368	0	282,368	0	282,368	0
Aggregates	109,087	0	109,087	260	45,887	510
Grains	559,642	294,910	559,642	294,910	0	294,910
Chemicals	49,401	123,334	41,483	69,034	0	123,334
Ores & Minerals	437,049	110,753	133,592	110,753	107,050	110,753
Iron & Steel	43,349	116,268	43,349	116,268	38,171	116,268
Forest Products	76,417	42,648	0	18,705	0	42,648
All Others	13,234	23,727	13,164	19,487	4,119	24,387
TOTAL	1,570,547	711,640	1,182,685	629,417	477,595	712,810

SOURCE: Waterborne Commerce Statistics

Table III-7 shows the commonality of traffic at the Chickamauga project with the other Upper Tennessee projects and with other selected projects on the inland navigation system for calendar year 1999. Since most of the Upper Tennessee traffic is moved to or from points outside of the Upper Tennessee segment, and since the uppermost pool serves the Knoxville urban area, there is a large amount of common traffic moving through all three Upper Tennessee projects. In 1999, nearly all of the traffic originating in or destined for the Watts Bar and Fort Loudoun pools transited the Chickamauga lock. The Chickamauga lock, on the other hand, shared about 79 percent of its traffic with Watts Bar, but only 27 percent of its traffic with Fort Loudoun.

The largely external orientation of the Upper Tennessee system traffic means that significant volumes of Upper Tennessee traffic also passes through other projects on the inland navigation system. Table III-7 shows that 84 percent of the traffic that transited the Chickamauga project also transited Lock and Dam 52 on the Ohio River downstream of its confluence with the Tennessee River, demonstrating a strong link to the Mississippi. On the other hand, only about two percent of Chickamauga traffic passed through Smithland Locks and Dam on the Ohio River upstream of its confluence with the Tennessee River, indicating a rather weak link to the Ohio River above the mouth of the Tennessee. Table III-7 shows that the Upper Tennessee had no traffic in common with the Cheatham project, on the Cumberland River and very little traffic in common with the Bay Springs project on the Tennessee-Tombigbee Waterway. Upper Tennessee traffic moving to/from each of these waterways has been sporadic in recent years.

TABLE III-7 Commonality of Chickamauga Traffic with Other Selected Projects, 1999

Project	Chickamauga Traffic Through Other Projects	Other Project Traffic Chickamauga
Chickamauga	100%	100%
Watts Bar	79.4%	100%
Fort Loudoun	28.2%	99.8%
Nickajack	100%	53.3%
Wilson	94.5%	14.7%
Bay Springs (TTW)	0.1%	0%
Pickwick	94.4%	10.8%
Kentucky-Barkley	91.3%	5.1%
Cheatham	0%	0%
L/D 52	83.6%	2.0%
Smithland	2.5%	0.1%
Myers	2.5%	0.1%
Greenup	1.4%	0%
Winfield	0.3%	0%
Emsworth	0.2%	0%
Monongahela L/D 2	0.2%	0%

SOURCE: Waterborne Commerce Statistics

6. Projected Traffic Demands

a. Introduction. The traffic demand forecasts for the Chickamauga Lock/Upper Tennessee River System were developed separately from the Ohio River System traffic demand forecasts. The Upper Tennessee forecast pertains to commodity movements that utilize the Upper Tennessee segment and not with commodity movements that move only on other segments of the inland navigation system.

In general, future traffic demands for the Upper Tennessee were projected as a function of future economic growth in the markets served by waterway-using industries. These markets include both end-use/industry markets and geographic markets, whether local, broader regional, national, or international. In this context, the traffic demand projections were developed by reference to specific company plans, industry-produced supply/demand forecasts, and to government-produced economic and demographic forecasts.

Actual waterway traffic is the most obvious component of traffic demand, and consequently, existing traffic serves as the starting point for identifying and forecasting waterway traffic demands. A composite of traffic for calendar years 1995-1997 was used as the base for forecasting existing traffic. In the case of the Upper Tennessee segment, where the navigation system is constrained by industry perceived reliability problems and inadequate lock size at Chickamauga, existing waterway traffic is considered to be inadequate to identify traffic demands for a reliable or improved system. This is particularly important when the future could involve a larger replacement lock at Chickamauga. In this sense, the Chickamauga analysis bears similarity to the analysis of a new waterway. In an attempt to fully capture the traffic demands for an improved system, an extensive market analysis was undertaken.

b. Market Survey Results. As a part of the market analysis, a comprehensive mail survey of 350 companies in eastern Tennessee and Kentucky and western North and South Carolina was conducted.

The traffic survey was designed specifically for the Chickamauga Lock Study. It sought to identify commodity movements that might use the Upper Tennessee system given improvements at Chickamauga.

In addition to the survey, historical Upper Tennessee traffic was researched to identify commodity traffic that had previously moved on the system but has since ceased. The resource bases and markets for these products were also researched in an effort to identify potential movements. Additional research of potential commodity traffic was conducted using the STB waybill sample, TVA records, and information gathered in extensive interviews of Upper Tennessee terminal operators.

The traffic identified by the survey and the additional commodity research was screened for reasonableness and susceptibility to barge transportation. Through these efforts, a total of approximately 4.3 million tons was identified as potential traffic demand for an improved Chickamauga Lock. A breakdown of this tonnage by major commodity group is provided in Table III-8.

TABLE III-8 Potential Waterway Traffic Demand (Tons)

Commodity Group	Traffic Identified
Coal & Coke	2,645,000
Petroleum Fuels	0
Asphalt	45,000
Aggregates	0
Grains	15,000
Chemicals	586,000
Ores & Minerals	267,000
Iron & Steel	594,000
Forest Products	18,000
All Others	105,000
TOTAL	4,275,000

Concurrent with the market survey work, Jack Faucett Associates conducted a survey of non-utility Ohio River System (ORS) commodity recipients/shippers for use in the Corps of Engineers' Ohio River Mainstem Study. The Faucett survey involved approximately 250 of the largest commodity recipients/shippers, and incidentally included the largest companies involved in Upper Tennessee traffic. The purpose of the Faucett work was to identify the normal levels of non-utility traffic to serve as a base for forecasting purposes. The Faucett work identified the normal levels of existing traffic as well as any near-term change, i. e., expansions, closures, and new commodity traffic to serve as a base for forecasting traffic basin-wide. The information gathered for companies involved in Upper Tennessee traffic was used along with the market survey to establish the base for forecasting purposes.

c. Forecast Methodology. The Upper Tennessee traffic demand forecasts were developed using a similar forecasting framework for all commodities. The approach is similar to that used by the Corps of Engineers in forecasting traffic demands for the Ohio River System. The Upper Tennessee effort, additionally, draws upon the output from the system forecast. The first step in generating the forecast was to identify all potential traffic for an improved (reliable) Upper Tennessee system. Secondly, waterborne commerce data and industry-supplied information were used to establish a base year of traffic that was considered normal in terms of traffic patterns and traffic volumes. In the third step, industry and government-generated forecasts that describe the growth prospects of the industries/companies involved with the Upper Tennessee traffic are identified. Over the short term, industry forecasts are frequently available, but over the longer term the demographic and economic forecasts prepared by the U. S. Department of Commerce, Bureau of Economic Analysis (the OBERS forecasts) are relied upon. In the final step, industry and government-supplied forecasts are used to generate the future traffic demand projections.

d. Forecast Results.

(1) Projected Traffic Demands. The Upper Tennessee traffic identified by the traffic survey was subjected to detailed transportation rate analysis. During this process, it was discovered that many of the movements could currently realize a rate savings using the existing system, even with the degraded project at Chickamauga. Further investigations revealed that reliability of the Chickamauga project is an important concern of both existing and potential users of the system. Existing shippers are reluctant to expand their waterway traffic and potential shippers are reluctant to commit their businesses to using waterway transportation when that option is viewed

as unreliable.

Concerns over reliability of the Chickamauga project have been echoed repeatedly by area shippers and business concerns. These concerns have surfaced during shipper surveys, interviews and in public forums. Area shippers and business concerns have been aware of the AAR-related problems and the associated repairs that have been required for many years. It became apparent to TVA by 1995 that, without substantive action, the problems associated with AAR would eventually reach a critical mass and that the project would have to be closed. At that time, TVA estimated that the project could not remain open beyond 2005, and presented this information to the public. A 1999 study by the Corps concluded that with aggressive maintenance and monitoring it is reasonable to assume the lock could be kept open to at least 2010. TVA agrees with this position, but both agencies also acknowledge that an earlier closure resulting from unpredictable events is possible.

The reliability issue becomes even more evident during and after closures at the Chickamauga facility. Because of a planned 30-day closure in August of 1999, some shippers using the waterway made a permanent switch to overland modes, citing the impact of the long closure and their concerns about the reliability of the lock. One public terminal lost customers permanently to overland modes due to the shutdown. Other companies made permanent switches to overland modes for parts of their shipments/receipts. During a survey meant to gauge shipper reactions to closures of various durations, several shippers indicated a preference to shift permanently to overland modes, rather than endure lengthy closures.

Although the transportation rate analysis would seem to indicate that certain potential shippers could realize a rate savings moving on the Upper Tennessee currently, rather than using the waterway, the traffic persists in using overland modes. For these shippers, it is believed that the cost of using the waterway is, in fact, higher than what is reflected in the rates alone. The true cost of waterway transportation is, in fact, the waterway cost plus a "reliability cost" (similar to an insurance premium), such that the true cost of using the waterway is equal to or higher than the overland mode for these risk-averse individuals. Although the comparison of rates would seem to indicate that they should, shippers are reluctant to make infrastructure improvements needed to use the waterway or to become involved with waterway transportation at all.

The forecast of traffic demand identifies the traffic that could move on the system at a rate saving if the constraint imposed by Chickamauga lock were not a consideration, as well as, including the existing waterway traffic. It is recognized that traffic expansion will always be problematic as long as project reliability is a significant concern. In effect, the traffic demand forecast assumes the availability of a reliable Chickamauga lock.

Summaries of the projected traffic demands for the Upper Tennessee segment and the Chickamauga, Watts Bar, and Fort Loudoun projects from 1996 to 2060 are presented in Table III-9. In this instance, the 1996 base is a constructed base year for forecasting purposes consisting of existing and potential waterway traffic. The data in Table III-9 show Upper Tennessee traffic demands increasing from a level of 6.7 million tons in 1996 to about 11.3 million tons in 2060, representing annual growth of about 0.8 percent.

The traffic numbers are nearly identical for the Chickamauga project, reflecting the near absence of local traffic on the system. Growth rates for traffic demand are identical for all three projects, Chickamauga, Watts Bar and Fort Loudoun.

A large portion of the projected traffic demand is shift-of-mode traffic identified by the shipper survey. Approximately two-thirds of the base year traffic demand is composed of traffic identified by the survey. This traffic demand is largely utility and industrial coal traffic as well as increases in grains, aggregates, ores and minerals, iron and steel, and forest products traffic currently moving to/from waterside plants along the Upper Tennessee.

TABLE III-9 Projected Traffic Demand, 1996-2060 (Thousands of Tons)				
Year	**Chickamauga**	**Watts Bar**	**Fort Loudoun**	**Upper Tennessee System**
1996 Base*	6,668	5,716	920	6,669
2000	7,586	6,530	978	7,590
2010	8,283	7,116	1,082	8,287
2020	8,777	7,522	1,171	8,782
2030	9,400	8,039	1,272	9,404
2040	10,209	8,710	1,393	10,213
2050	10,874	9,261	1,492	10,878
2060	11,322	9,628	1,563	11,326
Annual % Change 2000-60	0.8	0.8	0.8	0.8

*Base traffic is a combination of an average of traffic moving on the waterway during 1995-1997 and the risk-averse traffic identified through the traffic survey.

(2) Commodity Mix of Projected Traffic Demand. The commodity mix of projected traffic demand for a reliable Chickamauga Lock is shown in Table III-10. The data for years 1996 and 2060 show only a slight change in the relative commodity mix. Coal and chemicals diminish their shares of total traffic while grains, ores and minerals, and iron and steel increase. The largest tonnage increases between 1996 and 2060 occur in coal and coke (1.4 million), iron and steel (0.8 million), grains (0.8 million), and ores and minerals (0.7 million). Coal traffic accounts for a large majority of projected traffic demand throughout the forecast period. Its share of total traffic diminishes somewhat over the period, from 40 to 36 percent. The change in coal traffic demand is aligned with the expected future growth in coal consumption by southeastern utilities. The commodity mixes for years 2000 and 2060 are displayed in Figure III-4.

(3) Future Shipping Patterns. Downbound movements dominate the pattern of future traffic demands on the Upper Tennessee, accounting for more than half of the traffic demand each year. This contrasts sharply with the existing situation in which around two-thirds of the traffic is upbound. This change in direction is largely

coal traffic that was identified during the traffic survey. This traffic would originate in the Watts Bar pool and destined for southeastern utility and industrial plants.

TABLE III-10 Projected Traffic Demand for a Reliable Chickamauga Lock by Commodity Group, 1996-2060 (Thousand Tons)

Commodity	Base 1996*	Projected Traffic Demand 2000	2010	2020	2030	2040	2050	2060	Annual % Change 1996-60
Coal & Coke	2,645	3,166	3,339	3,480	3,641	3,838	3,998	4,086	0.7
Petroleum Fuels	8	9	10	10	11	12	12	12	0.7
Asphalt	251	264	289	314	338	360	377	390	0.7
Aggregates	82	87	100	110	123	138	152	161	1.1
Grains	839	1,008	1,158	1,214	1,309	1,447	1,561	1,642	1.1
Chemicals	763	773	796	829	881	956	1,017	1,061	0.5
Ores & Minerals	998	1,051	1,168	1,269	1,389	1,542	1,668	1,758	0.9
Iron & Steel	715	836	971	1,063	1,175	1,321	1,443	1,531	1.2
Forest Products	222	242	287	313	346	389	425	451	1.1
All Others	146	154	169	179	192	209	224	234	0.7
TOTAL	6,669	7,590	8,287	8,782	9,404	10,213	10,878	11,326	0.8

*Base traffic is a combination of an average of traffic moving on the waterway during 1995-1997 and the risk-averse traffic identified through the traffic survey.

NOTE: More than 99 percent of projected traffic demand transits Chickamauga

The commonality of traffic demands at Upper Tennessee projects with other projects on the navigation system is projected to display some important changes relative to the existing situation. The coal traffic demands assume expanded usage of the Tennessee-Tombigbee Waterway in accessing southeastern utility and industrial plants, and therefore, Upper Tennessee traffic would account for a much larger portion of traffic at the Tennessee-Tombigbee projects. Similarly, Upper Tennessee traffic demand would constitute a larger share of traffic demands at Tennessee and lower Ohio River projects, due to shift of mode and traffic demand in grains, aggregates, ores and minerals, iron and steel, forest products, and other commodities.

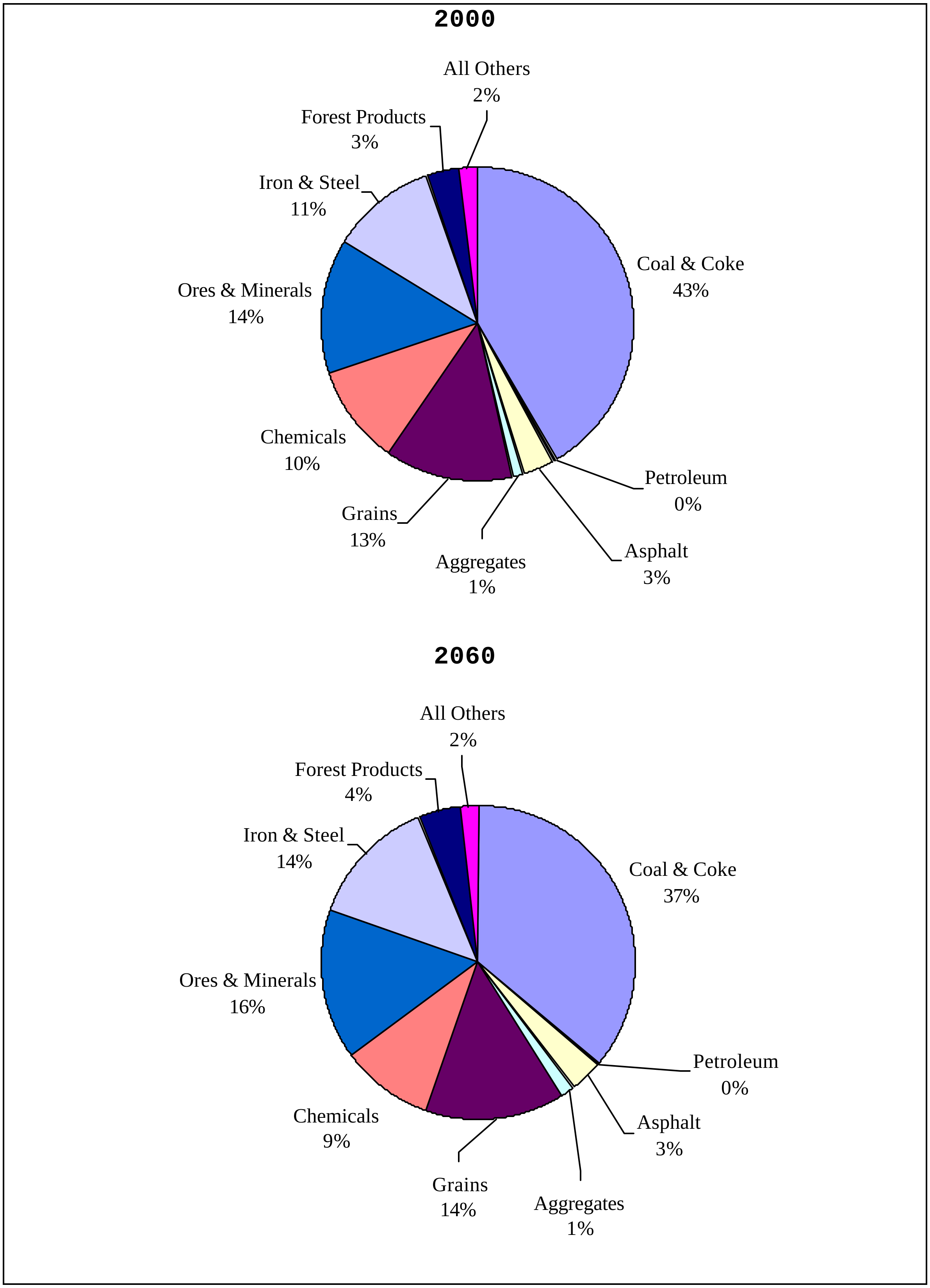

FIGURE III-4. PROJECTED UPPER TENNESSEE TRAFFIC DEMAND

7. Vessel Traffic

a. Existing Traffic and Trends. Table III-11 summarizes vessel traffic for the Upper Tennessee projects for selected years between 1976 and 1998. In 1998, Chickamauga lock processed a total of 407 commercial tows and 2,673 barges, or an average of about 1.1 tows and 7.3 barges per day. The comparable daily values were 0.8 tows and 4.2 barges at Watts Bar and 0.5 tows and 1.5 barges at Fort Loudoun. The average tow through Chickamauga in 1998 consisted of 6.6 barges carrying 6,500 tons, compared to 5.6 barges loaded with 5,700 tons at Watts Bar and 2.7 barges loaded with 2,600 tons at Fort Loudoun.

Owing to increased tonnage levels, the number of barges transiting each of the Upper Tennessee locks has increased substantially since the mid-1970s. The highest historic level of barge traffic at the Upper Tennessee projects occurred in 1987. Between 1976 and 1998, the numbers of barges processed at Chickamauga, Watts Bar, and Fort Loudoun increased by 79, 156, and 125 percent, respectively. In response to increased traffic demands, carriers in this river segment have increased tow sizes and barge loadings, and generally increased the number of tows.

TABLE III-11 Tonnage, Barges, and Tows Transiting Upper Tennessee River Locks, 1976-1998

Project/Item	1976	1980	1985	1990	1996	1998	% Change 1976-98
Chickamauga:							
Tons (000)	1,144	1,512	1,847	2,200	2,273	2,518	120.1%
Barges	1,497	2,106	2,393	2,418	2,509	2,673	78.6%
Tows	414	367	495	384	385	407	-1.7%
Barges/Tow	3.6	5.7	4.8	6.3	6.5	6.6	81.6%
Tons/Tow	2,800	4,100	3,700	5,700	5,900	6,500	132.1%
Watts Bar:							
Tons (000)	452	686	1,078	1,465	1,487	1,694	274.8%
Barges	651	1,009	1,219	1,535	1,510	1,666	155.9%
Tows	214	206	327	286	279	295	37.9%
Barges/Tow	3.0	4.9	3.7	5.4	5.4	5.6	85.6%
Tons/Tow	2,100	3,300	3,300	5,100	5,300	5,700	171.4%
Fort Loudoun:							
Tons (000)	288	326	565	602	662	619	114.9%
Barges	285	248	591	556	667	642	125.3%
Tows	125	125	241	191	243	242	93.6%
Barges/Tow	2.3	2.8	2.5	2.9	2.7	2.7	16.4%
Tons/Tow	2,300	2,600	2,300	3,100	2,700	2,600	13.0%

SOURCE: Performance Monitoring System

Table III-12 shows tow size distributions at the Upper Tennessee projects in 1976 and 1998. Although the average tow operating on the Upper Tennessee River segment is a five to seven-barge tow, a wide range of tow sizes is encountered. In 1998, tow sizes at Chickamauga ranged from one to 18 barges, with concentrations occurring in the three to four and seven to ten barge ranges. A comparison of the 1976 and 1998 tow size distributions in Table III-12 shows a clear movement toward larger tows at each of the projects.

TABLE III-12 Tow Size Distributions for Upper Tennessee River Lock 1976-1998

Barges/ Tow	Chickamauga				Watts Bar				Fort Loudoun			
	1976		1998		1976		1998		1976		1998	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1-2	190	46	58	14	93	43	59	20	88	70	131	54
3-4	108	26	86	21	84	39	72	24	28	22	85	35
5-6	62	15	70	17	31	14	56	19	10	8	17	7
7-10	50	2	127	31	6	3	84	28	0	0	10	4
>10	4	1	66	16	0	0	24	8	0	0	0	0
TOTAL	414	100	407	100	214	100	295	100	125	100	242	100

SOURCE: Lock Performance Monitoring System

The percentage of empty barges that move on a given waterway segment indicates the level of backhaul (loaded in both up bound and down bound directions) opportunities available. Fifty-percent empty indicates the total absence of backhauls, with barges moving loaded in one direction, and empty in the opposite direction. In 1998, 35 percent of the barges transiting Chickamauga were empty. This implies that 15 percent of the barges at Chickamauga, 18 percent at Watts Bar, and 5 percent at Fort Loudoun were loaded both upbound and downbound through the locks. In other words, there is only limited opportunity for barges to be loaded on both the up bound and down bound trips.

b. Vessel Characteristics and Trends. All three Upper Tennessee River locks have one chamber measuring 60’x360’. The barge type that best fits a 60’x360’ system is the standard barge (26’x176’). Standards can fit twice the tonnage of jumbo barges (35’x195’) into a 60’x360’ chamber. The predominant barge type currently being used on the Upper Tennessee, however, is the jumbo barge. Apparently, the inefficiencies of using jumbo barges on the Upper Tennessee segment are offset by the efficiency of using them elsewhere on the inland navigation system.

The percentage distribution of barges by type transiting the Chickamauga, Watts Bar, and Fort Loudoun locks in 1976 and 1998 are presented in Table III-13. In 1998, jumbo barges accounted for 91 percent of all barges processed at Chickamauga. Aggregates, coal, and road salt are some of the commodities normally transported in open hopper jumbo barges, while grains, ores & minerals, and some forest products are some of the commodities normally transported in covered jumbo barges. Integrated liquid barges (tanker barges) of various sizes were also important, accounting for eight percent of the traffic at Chickamauga. The remaining barges included various irregular-sized vessels. The commercial tow operators on the Upper Tennessee River demonstrated an ever-increasing preference for modern jumbo barges in the 1976-98-time period, evidenced by the fact that standard barges have disappeared from the Tennessee River.

TABLE III-13 Barge-Type Distribution at Upper Tennessee River Locks, 1976 and 1998

Project/ Barge Type	Barge-Type Distribution			
	1976	(%)	1998	(%)
Chickamauga:				
Standard	106	7.1	0	0
Jumbo	1015	67.8	2421	90.6
Tanker	305	20.4	214	8.0
Other	71	4.7	38	1.4
TOTAL	1497	100.0	2673	100.0
Watts Bar:				
Standard	251	38.6	0	0
Jumbo	247	37.9	1440	86.4
Tanker	113	17.4	185	11.1
Other	40	6.1	41	2.5
TOTAL	651	100.0	1666	100.0
Fort Loudoun:				
Standard	20	7.0	0	0
Jumbo	108	37.9	435	67.8
Tanker	110	38.6	175	27.3
Other	47	16.5	32	5.0
TOTAL	285	100.0	642	100.0

SOURCE: Lock Performance Monitoring System

8. Lock Utilization and Performance

a. Operating Hours. Originally, all three of the projects were operated year-round on a 24-hour basis except during intermittent periods when the locks were closed due to weather conditions or for inspection and maintenance/repair work. Chickamauga and Watts Bar are still operated on this basis; however, beginning in the early 1970s, the operating hours at Fort Loudoun were reduced to 16 hours per day, seven days per week. The operating hours at Fort Loudoun are from 6 a.m. to 10 p.m. This reduction in service was instituted due to Federal budgetary restrictions and the level of utilization at Fort Loudoun.

b. Lockage Policy and Procedures. Tows are normally locked through the Upper Tennessee projects on a first come/first served basis. Because of the size of the three locks, multiple cut locking operations are normally required for any tow larger than one barge. The average tow on the Upper Tennessee segment contains five to seven barges, however, larger tows (up to 18 barges) frequently move on this river segment. Occasionally, if two tows arrive at a lock at the same time, moving in opposite directions, the towboat operators voluntarily assist each other in pulling barges through the locks and in remaking the tow. This mutual assistance speeds the lockage process.

Under ordinary circumstances, tows larger than four barges require the tow operator to tie off at the approach point and begin locking through in three- or four-barge strings. A barge string is pushed into the chamber far enough to allow the first barge to be untied from the string and tied off on the chamber wall. After chambering is completed, the barge is removed from the chamber by a tow haulage unit. Each succeeding unpowered barge of the string is handled in a similar manner. The tow haulage unit pulls each unpowered barge far enough up the lock approach wall to allow the last lockage of that string to remake on the wall. The last cut of the string includes the towboat and during remake, the stern of the towboat is partially in the chamber, rendering it unusable until the string leaves the wall. The towboat ties off the string at a mooring cell and returns light (no barges) through the chamber to retrieve another string of barges and begin the lockage procedure again. At Chickamauga Lock this procedure takes approximately one hour per barge for tows requiring multiple strings, this time will vary depending on lock delays, river conditions and towboat crew efficiency. For a 15-barge tow, the processing time may vary from a minimum of 13 hours to as much as 24 hours according to lock personnel.

c. Lockage Characteristics. Table III-14 shows the number of lockages at the Upper Tennessee projects by type of lockage for 1976 and 1998. It is important to note that noncommercial lockages, meaning recreation boat and other type lockages comprise a larger share of lockages at the Upper Tennessee projects than at other projects on the inland navigation system. Recreation boat and other type lockages in 1998 comprised 44 percent of total lockages at Chickamauga lock. Between 1976 and 1998, commercial lockages at Chickamauga have increased both in number and as a share of total lockages. This increase is attributable to both the growth in tonnage levels and a gradual increase in tow size, resulting in more lockages per tow.

TABLE III-14 Lockages at Upper Tennessee River Projects 1976 and 1998

Project/Lockage Type	1976	(%)	1998	(%)	% Change 1976-98
Chickamauga:					
Commercial Lockage	1453	40.0	2734	56.3	88.2
Recreational/Other Vessels	2179	60.0	2120	43.7	-2.7
TOTAL	3632	100.0	4854	100.0	33.6
Watts Bar:					
Commercial Lockage	532	23.9	1705	49.9	220.5
Recreational/Other Vessels	1698	76.1	1713	50.1	0.9
TOTAL	2230	100.0	3418	100.0	53.3
Fort Loudoun:					
Commercial Lockage	299	20.9	702	33.2	134.8
Recreational/Other Vessels	1129	79.1	1413	66.8	25.2
TOTAL	1428	100.0	2115	100.0	48.1

SOURCE: Lock Performance Monitoring System

The data for Chickamauga Lock in Table III-14 shows 4,854 lockages occurred at the facility in 1998. The total number of lockages at Chickamauga increased by about 34 percent since 1976, while the number of commercial lockages increased 88 percent. Commercial traffic accounted for only 40 percent of the total number of lockages at Chickamauga in 1976, but by 1998, commercial lockages made up 56 percent of the total. The average number of lockages per tow fluctuated over the 1976-1998 period, reaching 6.7 lockages in 1998.

As demonstrated in Table III-15, all three projects have experienced a decline in the percentage of single lockages and, at Chickamauga and Watts Bar double lockages have also decreased. While these locks are having a steady increase in the percentage of multi-cut (greater than 2) lockages. In this regard, the most dramatic changes over the 1976-1998 period occurred at Watts Bar. In 1976, nine percent of the lockages at that facility were singles, 37 percent were doubles and 27 percent were triples or greater. In 1998, only two percent of the lockages at Watts Bar were singles, 20 percent were doubles, and 78 percent were triples or greater.

TABLE III-15 Lockage Characteristics Upper Tennessee River Locks 1976-1998

Project	1976	1980	1985	1990	1998
Chickamauga:					
Commercial Lockages	1453.0	2036.0	2193.0	2284.0	2734.0
Lockages per Tow	2.5	5.5	4.4	5.9	6.7
% Single Lockages	11.4	10.1	9.7	9.1	9.1
% Double Lockages	13.0	14.7	12.9	11.2	11.2
%> 2 Lockages	75.6	75.2	77.4	79.7	79.7
Watts Bar:					
Commercial Lockages	532.0	756.0	113.0	1404.0	1705.0
Lockages per Tow	2.5	3.7	3.5	4.9	5.8
% Single Lockages	8.9	5.8	6.1	2.1	2.1
% Double Lockages	37.4	22.8	22.6	19.6	19.6
%> 2 Lockages	53.7	71.4	71.3	78.3	78.3
Fort Loudoun:					
Commercial Lockages	299.0	340.0	616.0	588.0	702.0
Lockages per Tow	2.4	2.7	2.6	3.1	2.9
% Single Lockages	16.0	13.6	27.4	10.5	10.5
% Double Lockages	27.2	23.2	27.0	27.7	27.7
%> 2 Lockages	56.8	63.2	45.6	61.8	61.8

SOURCE: Lock Performance Monitoring System

d. Lock Transit Times. Table III-16 provides a breakdown of average processing times for the three Upper Tennessee projects. In 1998, the average processing times for lock chambers on the Upper Tennessee segment were 8.0 hours at Chickamauga, 6.4 hours at Watts Bar, and 3.5 hours at Fort Loudoun. The Upper Tennessee projects have the longest average processing times of all the locks in the Ohio River System. This is partly a function of the fleet, i.e. the predominance of jumbo barges and the fact that these barges must lock one at a time; the size of tows on the Upper Tennessee segment; and the greater-than-normal lift at these projects. Average processing times have increased at each of the Upper Tennessee projects in the 1976-1998 period. Again, this has resulted from the growth in tow sizes and the increase in multiple lockages.

TABLE III-16 Average Processing, Delay and Transit Times for Upper Tennessee Projects, 1976-1998 (Hours/Tow)

Project/Item	1976	1980	1985	1990	1996	1998
Chickamauga:						
Processing Time	3.0	5.6	4.7	6.2	6.4	6.3
Delay Time	2.2	0.7	1.0	1.1	1.3	1.7
Total Transit Time	5.2	6.3	5.7	7.3	7.7	8.0
Watts Bar:						
Processing Time	2.1	4.4	3.5	5.1	5.3	5.6
Delay Time	0.3	0.2	0.4	0.6	0.6	0.8
Total Transit Time	2.4	4.6	3.9	5.7	6.0	6.4
Fort Loudoun:						
Processing Time	2.2	3.3	2.7	3.4	3.1	3.2
Delay Time	0.3	0.2	0.1	0.4	0.3	0.3
Total Transit Time	2.5	3.5	2.8	3.8	3.4	3.5

SOURCE: Lock Performance Monitoring System

The data in Table III-16 shows average 1998 delay times of 1.7 hours at Chickamauga, 0.8 hours at Watts Bar and 0.3 hours at Fort Loudoun. In contrast to the average processing times, average delays changed very little during the 1976-1998 period. The level of utilization at these locks and the coordination that occurs among the towing companies operating on the Upper Tennessee produces only minimal delays at the lock facilities.

9. Lock Availability

Lock availability refers to the amount of time a lock is available in a year to process tows. Normal downtime refers to the amount of time in a normal year that a lock is unavailable for use. Normal downtime occurs because of weather conditions, high water, routine maintenance, hardware malfunctions or accidents. It does not include the time the locks are closed for scheduled or unscheduled major maintenance, which is defined to include downtimes with duration's in excess of 24 hours.

The Upper Tennessee projects differ from most of the other navigation projects in the inland navigation system in that each of these projects has only one lock. This means that, because of the orientation of traffic on this river segment, downtime at any one of the projects results in a complete loss of commercial navigation to reaches upstream of that project. This has very serious adverse impacts on the companies that rely on waterway transportation on the Upper Tennessee.

Historic data on lock downtimes for the period 1976-1998 were obtained from the Corps' Performance Monitoring System (PMS) stall reports. PMS records downtime events by chamber, date, duration and cause of outage. A complicating issue is that the PMS system records downtime only when tows are actually delayed by the lock being unavailable for locking. Downtime events that occur when no vessels are waiting to be locked are not recorded in the system. In addition, methods used to record downtime apparently changed during the 1976-1998 period, making comparisons of early to later years difficult.

In an effort to fully account for downtime at the Chickamauga and Watts Bar projects, the lock operation logbooks and maintenance books for those projects were reviewed in addition to the PMS records. The years examined were calendar years 1984-1990. A downtime file was developed for the two projects and a normal downtime estimate was generated. Normal downtime at the two projects was estimated to have a total duration of about 17 days per lock or 4.6 percent of the year.