4.22 Flood Control

4.22.1 Introduction

Resource Issues
▸ Magnitude of flood flows
▸ Potential flood damage
▸ Flood recovery

For the purpose of this EIS, flood control is addressed in terms of flood risk. Flood risk is defined in terms of peak flows, the expected frequency of occurrence of those peak flows, and the resulting potential flood damage. Under the existing reservoir operations policy, the reservoir system reduces flood risk in the Tennessee Valley by reducing peak flood flows and thus, flood levels. This flood reduction is provided by reserving a volume of storage—called the flood storage allocation—in each storage reservoir and making it available during rainfall events. The amount of storage currently allocated to flood control varies from reservoir-to-reservoir and from month-to-month as described in Section 2.2, Water Control System. During high river flow periods, discharge from the storage projects is either reduced or stopped entirely, and the inflows are stored, filling a portion—or all—of the allocated flood storage volume. After the downstream peak river flows have reached their highest level and begun to recede, the water is released in accordance with the flood recovery policy (Section 2.3.2, Operations for Flood Control) to make the flood storage available for the next storm event.

The effect of an alternative reservoir operations policy on flood risk depends on whether the alternative modifies the amount of flood storage allocation and the store and release policy to the extent that peak river flows are altered downstream. Further, to understand whether changes in peak flows due to an alternative are meaningful, changes in flood elevations and flood damage potential associated with the altered flows must also be evaluated. In addition to these direct effects, changes in the flood recovery policy considered in this EIS to improve fish spawning habitat would affect flood risk. Thus, the key issues related to flood risk that were evaluated in this EIS are:

- How the expected magnitude of flood flows are affected by changes in flood storage allocation, and flood storage and recovery policies; and,
- The potential flood damage that is associated with changes in peak flows and flood elevations.

The discussion of effects of the proposed alternative reservoir operating policies focuses on the changes in flood risk and potential damage in the Tennessee Valley through 2030. This section addresses potential flooding impacts and the role of FEMA. No siting activities are proposed in floodplains, and the Preferred Alternative minimizes floodplain effects to the extent practicable consistent with Executive Order 11988.

4.22.2 Regulatory Programs and TVA Management Activities

TVA's responsibility to provide flood control and thus reduce flood risk in the Tennessee Valley is outlined in Section 9a of the TVA Act. Authority for the regulation of flow from the Tennessee River by the USACE during flood periods on the lower Ohio and Mississippi Rivers is outlined in Section 7 of the Flood Control Act of 1944. In addition, TVA cooperates with local governments and the FEMA to encourage sound floodplain management.

- **TVA Act—**Section 9a of the TVA Act provides the legal context for the policies that guide the operation of TVA's dams and reservoirs today. Section 9a requires that the reservoir system be operated primarily to promote navigation and flood control and—to the extent consistent with these purposes—for power production.

- **U. S. Army Corps of Engineers—**Consistent with the Flood Control Act of 1944, the USACE may direct TVA flow releases from Kentucky Reservoir to reduce flood crests on the lower Ohio and Mississippi Rivers. A declaration of a flood control operation is made at the discretion of the USACE when the stage at the Cairo, Illinois gage reaches 35 feet and is predicted to go above 40 feet. The flood control operation ends when the stage at Cairo falls to 40 feet and further recession is predicted.

- **Federal Emergency Management Agency—**FEMA administers the National Flood Insurance Program (NFIP). In exchange for federally backed flood insurance for their homeowners, renters, and business owners, communities adopt and enforce floodplain management ordinances to reduce future flood damage (www.fema.gov). TVA works closely with FEMA and local governments responsible for administration of NFIP requirements to guide sound floodplain development below TVA projects, provide assistance with identification of areas within the Tennessee Valley that are prone to flooding, provide information on flood risks, and advise communities on appropriate steps needed to ensure consistency with the NFIP.

4.22.3 Peak Flows and Frequency

Existing Conditions

It was necessary to define a consistent methodology for this EIS in order to describe the existing flood risk condition. Flood risk is typically described in terms of the magnitude of peak flows and the expected frequency of occurrence of those peak flows. Frequency of occurrence is typically described either using exceedance probabilities or recurrence intervals. Thus, a peak flow of a given magnitude can be said to have a certain probability of being equaled or exceeded (the exceedance probability) in a given season (usually an annual period). That same peak flow can also be described as being equaled or exceeded, on average, every so often (the recurrence interval). A 100-year flood has a 1-percent chance of being equaled or exceeded in any given year, and its recurrence interval is said to be 100 years. How often a given flow can be expected to occur at a location is determined by performing a flow frequency analysis. This analysis is typically based upon historical basin runoff recorded at gaged locations and can be performed to determine annual or seasonal flow frequency. For watersheds with storage reservoirs, the analysis must take into account the effect of both natural runoff characteristics and reservoir regulation.

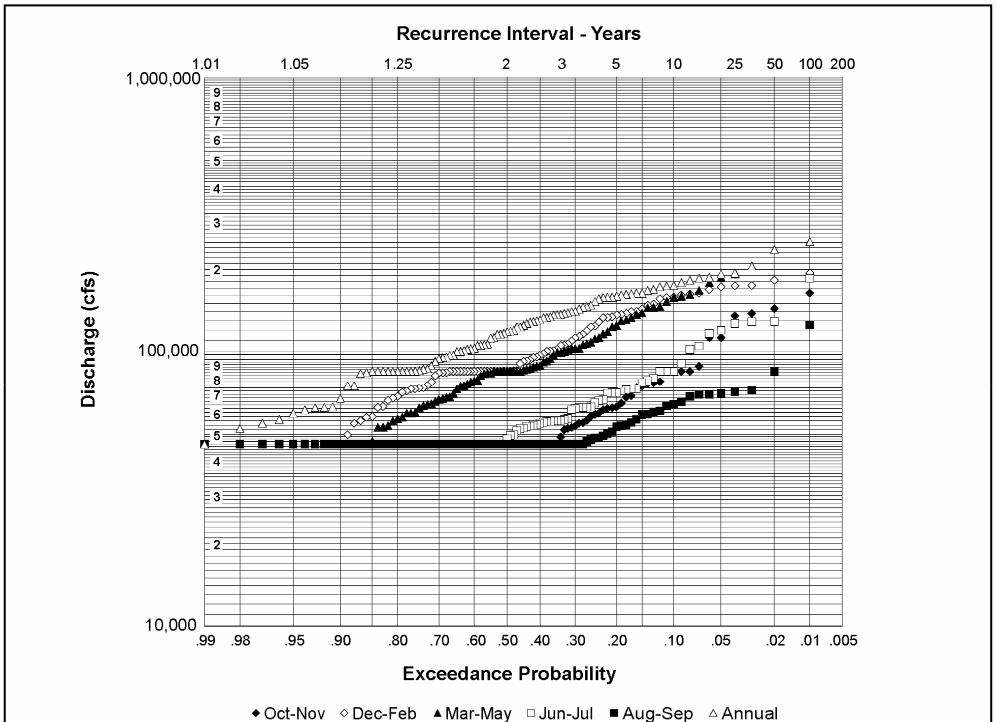
TVA has a record of historical discharges since reservoir operations began in 1936. In addition, stream gage and site-specific flood event data are available back into the mid- to late-1800s. The observed discharges account for the effect of local inflow and reservoir storage. However, since 1936 the reservoir system has undergone many changes—most notably the construction of new reservoirs. As new reservoirs were constructed, the reservoir system operating policy necessarily evolved to integrate them into the system. The historical discharges reflect these system and operating policy changes over time and do not always represent expected discharges under the existing operating policy.

To evaluate potential changes in flood risk (given the complexity of the frequency analysis for the Tennessee River), TVA selected a methodology using historical inflows as regulated by the existing reservoir system and operating policy. The TVA analysis included: (1) a 99-year continuous RiverWare model simulation using 6-hour inflows at 55 locations for the entire reservoir system; (2) the use of design storms based on actual observed events with inflow volumes increased to produce storm inflow volumes in the 100- to 500-year range; and (3) the evaluation of the impact of changes, if any, on the Maximum Probable Flood (MPF) and the Probable Maximum Flood (PMF).

To assess the adequacy of TVA's methodology, TVA convened a panel of flood risk experts to review and comment on the TVA approach. The panel concurred with TVA's approach to perform the continuous simulation using the RiverWare model and to use simulation results to assign flow frequencies out to the 100-year recurrence interval. For the hypothetical design storms, the panel agreed that the existing condition would be adequately described by a discrete simulation of each storm using the RiverWare model.

To determine discharges that would result from the historical runoff as regulated by the existing reservoir system and operating policy, TVA computed historical natural watershed runoff for the 99-year period from 1903 to 2001 for each sub-basin within the Tennessee Valley based upon historical flow records. This 99-year dataset of inflow data was then input into a RiverWare model that mimicked the existing system and operating policies. From this model, the discharge at 35 dams and flows at 13 flood damage centers were computed for each 6-hour time step in the 99-year simulation.

To establish the recurrence interval for various flows, the frequencies were estimated by using a standard approach in hydrologic analysis. The annual peak discharges from the model for each of the 99 years were sorted in descending order and assigned a frequency of one chance in 100 to the highest flow, two chances in 100 to the second-highest flow, and so on. To illustrate this process, the discharge data for Chickamauga Dam are plotted in Figure 4.22-01.



Source: TVA data 2003.

Figure 4.22-01 Simulated Peak Discharge Frequency for Chickamauga Dam (1903 to 2001)

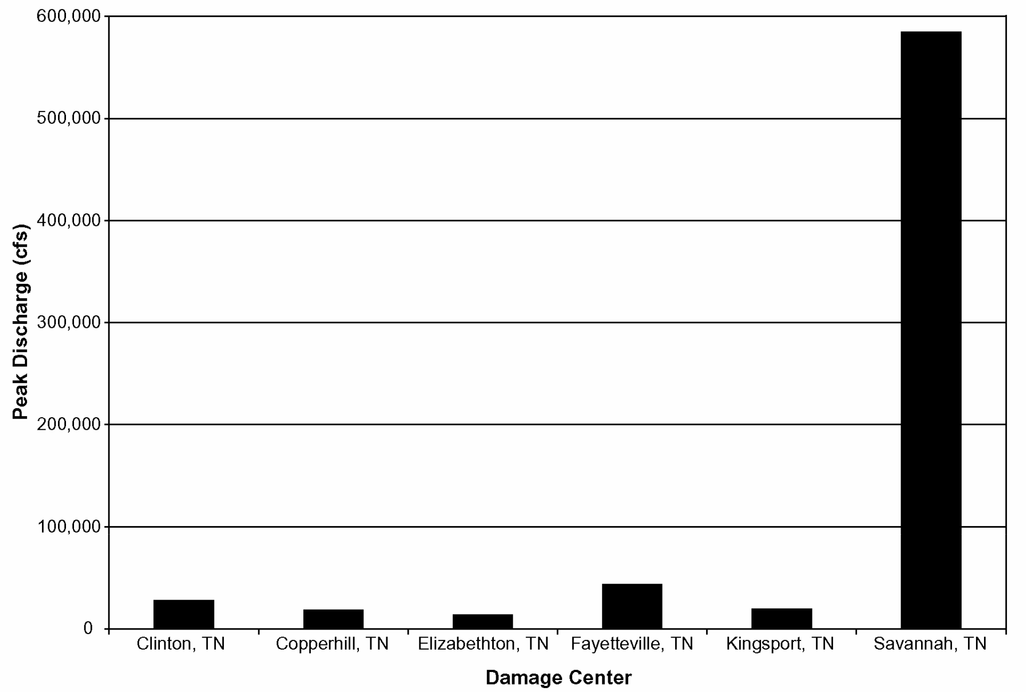
Figure 4.22-01 graphically represents the relationship between peak discharges below Chickamauga Dam and the probability that those discharges will be equaled or exceeded. Under the existing reservoir operations policy, a discharge from Chickamauga Dam of 250,000 cfs or larger would be expected to be equaled or exceeded only once in approximately 100 years on average. Similar plots were developed in this way to estimate the peak flows and frequencies for the 99-year historical inflows for all 48 locations (Table 4.22-01). The peak flows from the 99-year continuous simulation at six selected flood damage centers under the existing reservoir system and operations policy are presented in Figure 4.22-02.

For the design storms, TVA selected a group of historical storms from the 99-year data set to represent each of five periods, or seasons, during the annual cycle. The inflows for each storm were increased by a factor of 1.5 and 2.0 to reflect a reasonable range of postulated larger storms. While a specific recurrence interval was not assigned to the design storms, use of the 99-year inflow record to develop volume frequency curves provides information on the magnitude of the multiplier to be applied. This approach ensured that the inflow volumes associated with the design storms were at least up to the 500-year range.

The scaled-up inflows were evaluated using a RiverWare model similar to the one used for the 99-year data set. The peak discharge for each storm was then plotted versus the day and month of the historical storm peak as shown in Figure 4.22-03 for Chickamauga Dam. The highest discharge resulting from the 69 selected design storms is also presented in Figure 4.22-04 for each of seven flood damage centers.

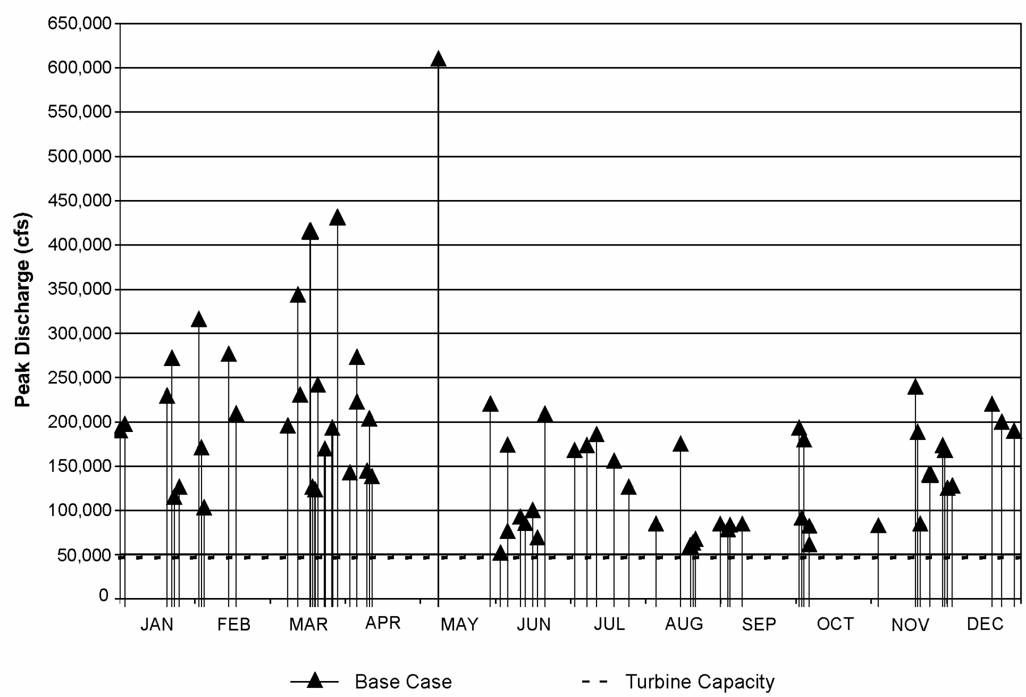
Table 4.22-01 Critical Locations for Evaluation of Flood Risk Potential

Dams	
Apalachia	Little Bear Creek
Bear Creek	Melton Hill
Blue Ridge	Nickajack
Boone	Normandy
Calderwood	Norris
Cedar Creek	Nottely
Chatuge	Ocoee #1
Cheoah	Ocoee #3
Cherokee	Pickwick
Chickamauga	South Holston
Chilhowee	Tellico
Douglas	Tims Ford
Fontana	Upper Bear Creek
Fort Loudoun	Watauga
Fort Patrick Henry	Watts Bar
Great Falls	Wheeler
Guntersville	Wilson
Hiwassee	
Damage Centers	
Chattanooga, TN	Huntsville, AL
Clinton, TN	Kingsport, TN
Copperhill, TN/McCaysville, GA	Knoxville, TN
Decatur, AL	Lenoir City, TN
Elizabethton, TN	Savannah, TN
Fayetteville, TN	South Pittsburg, TN
Florence, AL	



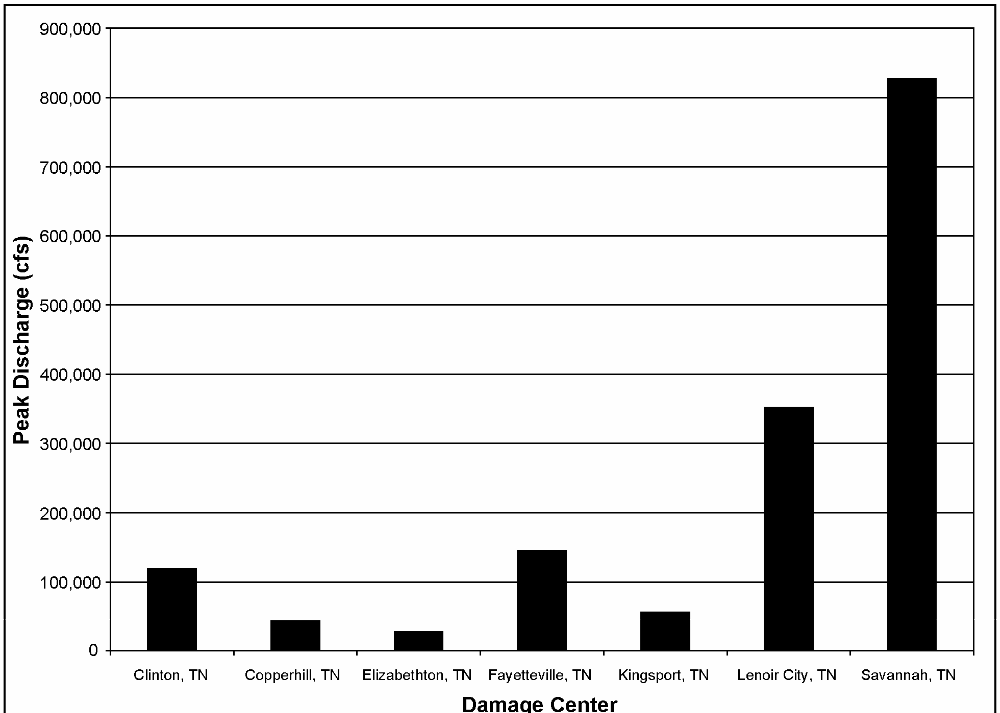
Source: TVA data 2003.

Figure 4.22-02 Simulated Peak Flow under Existing Reservoir Operations Policy for the Historical Inflows at Six Flood Damage Centers in the Tennessee Valley Region



Source: TVA data 2003.

Figure 4.22-03 Simulated Peak Discharges from Hypothetical Design Storms for Chickamauga Dam (Scaling Factor 1.50)



Source: TVA data 2003.

Figure 4.22-04 Simulated Peak Discharge from 69 Hypothetical Design Storms (Scaling Factor 2.0) at Seven Flood Damage Centers in the Tennessee Valley Region

In addition to the inflow observed historically, it is also important to understand the peak flows and elevations for larger storms such as the MPF and the PMF. These larger storms are typically the design basis for the facilities within and adjacent to the rivers, including TVA's dams and coal-fired and nuclear facilities. The MPF and the PMF are much larger storms and are sometimes called "synthetic" storms because they are developed by imposing the worst-case hydrologic conditions on a watershed and modeling the basin response. TVA formalized its Dam Safety program in 1982, adopting an Inflow Design Flood (IDF) as the design storm for TVA projects. Since that time, TVA has evaluated all of their projects for their adequacy to safely pass the IDF event (see Section 4.20.04 for additional discussion of the IDF).

Future Trends

The primary factors that could affect peak flows in the Tennessee Valley are changes in precipitation and the runoff characteristics of the watershed. The changes that might be anticipated during the next 30 years that could affect these two factors are:

- **Precipitation.** The analysis performed for this EIS took into consideration 99 years of estimated historical inflows resulting from precipitation, with the assumption that this length of record would be representative of the range of expected inflow conditions. Although no explicit climate change study was undertaken as a part of the flood risk analysis, TVA has observed no measurable changes in precipitation and runoff during this period that would suggest climate changes significant enough to result in impacts to the flood risk will occur through 2030.

- **Watershed Runoff Characteristics.** Extensive land development or change in land use in the Tennessee River basin has the potential to change the rainfall runoff volume and rate. While localized areas of rapid development may result in changes to local runoff characteristics, changes in basin-wide land use anticipated through 2030 are not expected to result in a measurable change in watershed runoff characteristics during this period (see Section 4.15, Land Use).

Comparison with FEMA Flood Insurance Studies

Other flow frequency studies have been performed over the years to define flood risk in the Tennessee Valley, the most well-known and recognized being the Flood Insurance Studies funded by FEMA. As a part of their NFIP, flow frequency studies were developed to delineate floodplain areas and to determine a premium cost structure for FEMA's federally backed flood insurance policies. In the Tennessee Valley, TVA has served as a contractor to FEMA in this effort, performing the flood studies to develop flood profile data and preparing inundation maps that define 100- and 500-year floodplains. The Flood Insurance Studies were developed over a period of years and were based on historical discharge records, which reflect reservoir system changes over time. Flood Insurance Studies for different locations within the Tennessee Valley were also completed at different times, using varying periods of observed hydrologic records.

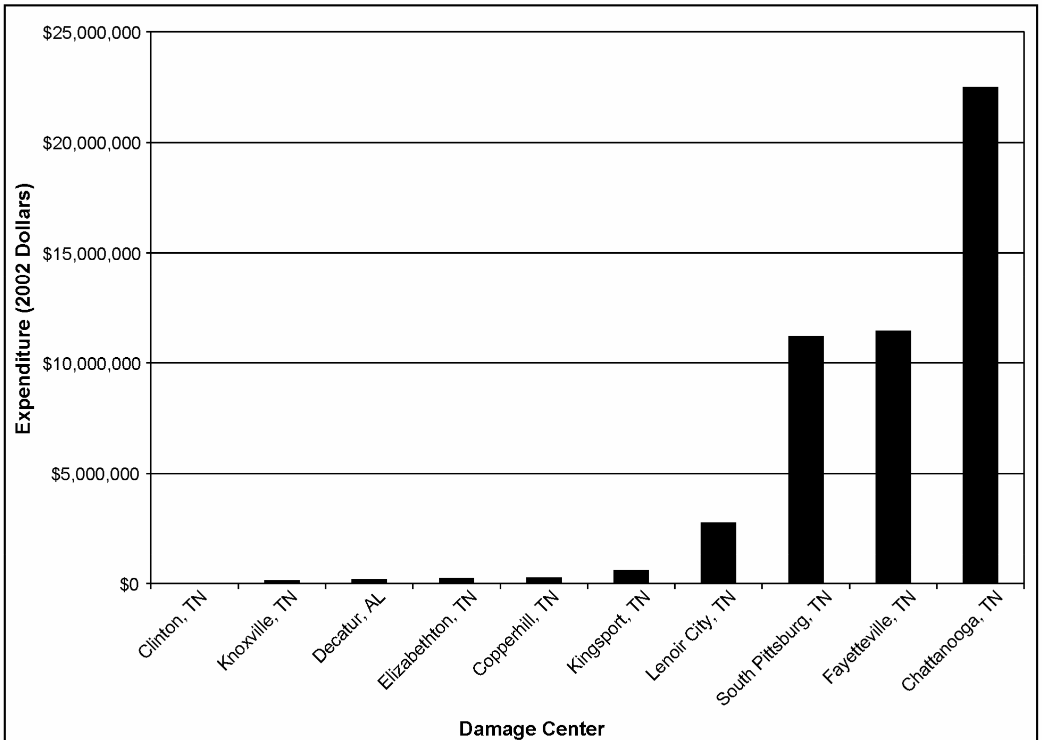
The impediments in using historical data and the need to assess impacts on a regional basis necessitated TVA using a different approach. This approach is described earlier in this section. The approach TVA adopted allowed a rigorous, consistent comparison of the incremental flood risk impacts associated with alternative operations policies throughout the system.

4.22.4 Potential Flood Damage

Existing Conditions

The consequences of the peak flows were determined by converting the flows to corresponding water levels and evaluating the resulting potential flood damage at the flood damage centers. The potential flood damage is a function of the extent of development in the floodplain and varies widely depending on location within the Tennessee Valley. The impact assessment included an estimate of the direct flood damage for each of 11 flood damage centers in the Tennessee Valley. The basis for the estimate was an inventory, compiled by TVA from actual field surveys of the properties located in the floodplain that includes the value of the structures and their contents. The indirect effects are more difficult to quantify and include damage to transportation facilities, communication and other infrastructure, disruption of businesses, jobs, and other economic losses. For the impact assessment, TVA estimated indirect losses at 20 percent of the direct losses.

The potential damage associated with the largest historical storm in the 99-year period of record at 10 flood damage centers is depicted in Figure 4.22-05.



Source: TVA data 2003.

Figure 4.22-05 Estimated Peak Flood Damage from 99-Year Continuous Simulation at Ten Flood Damage Centers in the Tennessee Valley Region

Future Trends

The primary factor affecting potential flood damage in the Tennessee Valley is the floodplain management policy of flood-prone communities. As development pressures increase along the streams and rivers within the Tennessee Valley, there is the potential for increased flood damage. The extent of increased damage will depend on continued participation by local governments in the NFIP, enforcement of their local floodplain regulations, and sound floodplain guidance for development in those areas where the flood risk has not been defined (flood elevations have not been determined and/or inundation maps are not available). TVA expects to continue its focus on floodplain management support below TVA dams and work closely with FEMA through 2030. TVA maintains an inventory of the value of structures and contents within the 500-year floodplain for the 11 major flood damage centers and estimates avoided flood damage after each flood event. The potential flood damage would be greater for larger events because most development today is built at, or above, the minimum 100-year standard.

4.22.5 Flood Recovery

Existing Conditions

During flood control operations (i.e., when downstream flooding is forecast and use of the flood storage volume can reduce downstream flooding) the flood operating policy permits TVA to fill the tributary storage reservoirs above their flood guide levels, temporarily storing floodwaters and reducing downstream flood crests. When the danger of flooding has passed, the water stored above the flood guide is released until the reservoir levels are returned to the flood guide level. The existing policy for flood recovery is to bring reservoir levels back to flood guide levels without causing additional downstream flooding, typically within 7 to 10 days after the flood event. Sometimes this drawdown can be accomplished by operating only the hydroelectric plants. However, it is often necessary to release additional water through sluiceways or spillways to lower the reservoir levels more quickly and regain the flood storage space needed for future rainfall events. This recovery policy restores available flood storage volume to reduce flood risk in the event of back-to-back flood events.

To aid fish spawning in the spring for several key popular sport fish species, TVA makes an effort to stabilize reservoir levels to support the spawn. This generally occurs in late-April to mid-May depending on water temperature. The criteria used include attempting to limit the change in reservoir levels to a maximum of 1 foot per week for a 2-week period. Because this is also the time of year when the reservoirs can be in flood recovery mode, it is often difficult to achieve this limit while also maintaining adequate flood storage volume.

Future Trends

No trends exist that would affect the existing flood recovery policy.