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SUSPENDED-SEDIMENT INFLOWS TO WATTS BAR RESERVOIR

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SUMMARY

Suspended-sediment inflows to Watts Bar Reservoir are important data that are required in numerical modeling of transport and deposition of sediment in the reservoir. Acceptable numerical modeling requires sediment inflow rates and locations in order to be able to compute the location and quantity of sediment deposited within the reservoir. Therefore, the representativeness of modeling results is highly dependent on the characteristics of sediment input to the model.

The following recommendations, that account for suspended-sediment inflows to be used in the numerical modeling of sediment transport and deposition in Watts Bar Reservoir, were developed through an evaluation of available watershed and sediment deposition data.

1. Use the suspended-sediment rating regression equations of Gaydos et al. (1982), for Emory River at Oakdale, TN, and for Poplar Creek near Oak Ridge, TN, to represent the suspended-sediment inflows into Watts Bar Reservoir from its tributaries;
2. Use a suspended-sediment rating regression equation that was derived from suspended-sediment and streamflow data of the Little Tennessee River at McGhee, TN, to represent sediment inflow from the Little Tennessee River for simulation of any historical year before the completion of Tellico Dam;
3. Check the appropriateness of any assumption for suspended-sediment inflows from upstream reservoirs by using its long-term relationship to local suspended-sediment inflows and to the suspended-sediment outflow through Watts Bar Dam; and
4. Focus refinements to suspended-sediment inflow rates on the Clinch arm of Watts Bar Reservoir.

SUSPENDED-SEDIMENT INFLOWS TO WATTS BAR RESERVOIR

INTRODUCTION

Suspended-sediment inflows to Watts Bar Reservoir are important data that are required in numerical modeling of transport and deposition of sediment in the reservoir. Acceptable numerical modeling requires sediment inflow rates and locations in order to be able to compute the location and quantity of sediment deposited within the reservoir. Therefore, the representativeness of modeling results is highly dependent on the characteristics of sediment input to the model.

The phenomenon of accumulated sediment in a reservoir can be described by the principle of continuity, which states that the change in accumulated sediment in a reservoir is equivalent to the difference between suspended-sediment inflows and outflows from the reservoir. Suspended-sediment inflows come from sediment borne by water flowing from off the watershed of the reservoir and from sediment discharged from upstream reservoirs. The primary outflow of sediment from the reservoir is through the dam.

This report presents recommendations to account for suspended-sediment inflows to be used in the numerical modeling of sediment transport and deposition in Watts Bar Reservoir.

RECOMMENDATIONS

Through evaluation of available information, recommendations are as follows:

1. Use the suspended-sediment rating regression equations of Gaydos et al. (1982), for Emory River at Oakdale, TN, and for Poplar Creek near Oak Ridge, TN, to represent the suspended-sediment inflows into Watts Bar Reservoir from its tributaries. Specifically, the Emory River suspended-sediment rating curve should be used to represent Emory River. Poplar Creek suspended-sediment rating curve should be used to represent all other tributaries; Piney River, Whites Creek, King Creek, Caney Creek, Riley Creek, Paint Rock Creek, Pond Creek, Sweetwater Creek, Poplar Creek, White Oak Creek, and all other minor streams.

The Emory River suspended-sediment rating curve is

$$q_s = 0.0273 q_w^{1.40}$$

and the Poplar Creek suspended-sediment rating curve is

$$q_s = 0.0686 q_w^{1.74}$$

where, q_s = suspended-sediment load, ton/day/mi², and q_w = stream discharge, cfs/mi².

2. Use the suspended-sediment rating regression equation,

$$q_s = 0.0267 q_w^{1.81}$$

to represent sediment inflow from the Little Tennessee River for simulation of any historical year before the completion of Tellico Dam.

3. Check the appropriateness of any assumption for suspended-sediment inflows from upstream reservoirs by using its long-term relationship to local suspended-sediment inflows and to the suspended-sediment outflow through Watts Bar Dam. This relationship can be expressed as

$$SSO = (1 - LTE)(LSI) + (1 - OTE)(USI)$$

where, SSO = suspended-sediment outflow, LTE = local sediment trap efficiency, LSI = local sediment inflow, OTE = trap efficiency for outflow from upstream reservoirs, and USI = sediment inflow from upstream reservoirs. Sediment inflow from upstream reservoirs is equal to the sum of sediment inflows from Melton Hill Reservoir and Fort Loudoun Reservoir. Assuming that upstream sediment inflows are in proportion to their local watershed areas, 20 percent of the upstream sediment inflows would come from Melton Hill Reservoir and 80 percent would come from Fort Loudoun Reservoir.

This relationship is based on long-term aggregated sediment inflows and outflows. Therefore, additional assumptions would be necessary to relate this expression to the dynamics of upstream sediment inflows.

4. Focus refinements to suspended-sediment inflow rates to the Clinch arm of Watts Bar Reservoir. Suspended-sediment rating curves could be refined through calibration. Each equation contains two parameters, a coefficient and an exponent, whose values might be adjusted through calibration. The most effective refinements would be to calibrate the coefficient of each equation for the Clinch arm tributaries, particularly for the Emory River.

BASIS FOR RECOMMENDATIONS

Recommendation 1

The procedure for determining suspended-sediment inflows for the tributaries to Watts Bar Reservoir involves regressing from an ideal situation to the best feasible alternative. Ideally, measured suspended-sediment discharges, associated with measured streamflows for each inflow location identified in the model representation of Watts Bar Reservoir, should be used for suspended-sediment inflows. Alternatively, suspended-sediment rating curves (mathematical relationships between sediment discharge and streamflow discharge) derived from historical data

for each inflow location could be used. With insufficient historical data available to know sediment inflows or to develop rating curves, available data or developed rating curves for nearby representative streams could be used. This last alternative is the best feasible alternative for the present problem.

Gaydos et al. (1982) provide suspended-sediment rating curves for three streams located in the Watts Bar Reservoir watershed: Emory River at Oakdale, TN, Poplar Creek near Oak Ridge, TN, and Daddys Creek near Hebbertsburg, TN. Suspended-sediment inflows could possibly be estimated using these relationships. Their adaptation is dependent on their representativeness of the tributary streams of the reservoir. Representativeness can be judged according to location (surrogate for climate and many other spatially related characteristics), topography, watershed area, soils, and land use, since these characteristics influence the delivery of eroded soil from a watershed. The greater the similarities between the gaged stream and an ungaged stream, the greater the representativeness of the gaged stream for the ungaged stream.

As described by Gaydos et al. (1982), the watershed of Watts Bar Reservoir is composed of two physiographic regions, the Cumberland Plateau and the "Ridge and Valley." The Cumberland Plateau is located in the northwest 60 percent and the Ridge and Valley is located in the southeast 40 percent of the watershed area. The regions are divided by a southeast-facing escarpment, named Walden Ridge. The Cumberland Plateau is a rolling upland area with slopes of 10 percent or less and deeply incised streams. The Ridge and Valley is characterized as long southwest-northeast direction ridges separated by valleys. The streams run primarily parallel to the ridges with occasional crossings through gaps in the ridges. The valleys are generally flat and ridge slopes are generally 20 to 35 percent, with some slopes as steep as 60 to 70 percent. The Walden Ridge is greatly dissected with slopes ranging from 50 to 80 percent and cliffs sometimes present in the upper 100 feet.

Soils of the Cumberland Plateau have derived from sandstone, and some shale and siltstone. These soils are predominantly loamy and well drained. The potential for erosion is slight to moderate, except for steep slopes in which it is great, and erosion can become severe if the vegetation cover has been removed. Soils of the Ridge and Valley have derived from dolomite, limestone, and shale. These soils are clayey and loamy and generally well drained to excessively well drained. The potential for erosion is slight to moderate for these soils.

The land use on the Cumberland Plateau is approximately 90 percent deciduous and evergreen forests, 5 percent agriculture, 3 percent urban, 1 percent water, and 1 percent mining. The ridges of the Ridge and Valley are predominantly forested and the valleys are primarily used for agriculture. Urban areas cover approximately the same proportion of area as on the Cumberland Plateau.

The characteristics of the three gaged streams are determined by their location. Emory River primarily drains approximately three-fourths of the Cumberland Plateau and some of the Walden Ridge escarpment. The Poplar Creek watershed is primarily in the Ridge and Valley, yet a significant portion is in the eastern part of the Cumberland Plateau and Walden Ridge. Daddys Creek is a tributary of the Emory River and its watershed is entirely in the Cumberland Plateau.

Through considering these characteristics of the watershed of Watts Bar Reservoir, the following representations can be assigned. Obviously the Emory River suspended-sediment discharge should be computed using the rating curve for the Emory River at Oakdale, TN. The rating curve for Poplar Creek near Oak Ridge should be used to compute suspended-sediment discharge for all streams in the Ridge and Valley; this includes all tributaries to the Clinch River and Tennessee River arms of the reservoir, except the Emory River and the Little Tennessee River. Suspended-sediment inflow from tributaries on the west bank of Watts Bar Reservoir should be computed using the Poplar Creek rating curve. These watersheds are primarily in the Walden Ridge escarpment region and are much smaller than the Emory River watershed.

Recommendation 2

Prior to the closing of Tellico Dam, suspended-sediment delivery to Watts Bar Reservoir by the Little Tennessee River was not inhibited. Therefore, historical simulations of that period will require estimates of the suspended-sediment inflows.

Daily suspended-sediment and streamflow data are available for the Little Tennessee River at McGhee, TN, for a three-year period from 1935 to 1938. The data consist of daily concentrations of suspended sediment (mg/L) and streamflow (cfs). These data were used to develop a suspended-sediment rating curve for the Little Tennessee River. Missing data were ignored in the analysis.

The suspended-sediment rating curve relationship was assumed to have the same form as the rating curve relationships described above, $q_s = a q_w^b$. First, suspended-sediment concentrations were converted to suspended-sediment discharge (ton/day) using the relationship (Trimble and Carey, 1984),

$$Q_s = Q_w C_s 0.0027$$

where, Q_s = suspended-sediment discharge, ton/day; Q_w = streamflow, cfs; and C_s = suspended-sediment concentration, mg/L. Then, suspended-sediment discharge and streamflow data were normalized by dividing by the watershed area, 2443 mi². Finally, least-squares linear regression analysis was performed on logarithms of the paired data to compute the coefficient and exponent parameters of the rating curve relationship.

The derived suspended-sediment rating curve is

$$q_s = 0.0267 q_w^{1.81}$$

This relationship has a coefficient of determination equal to 0.56, which is fair considering the hysteresis typically exhibited by sediment delivered to streams by surface runoff. The fit of this curve to the data is shown in Figure 1.

LITTLE TENNESSEE RIVER AT MCGHEE, TN SUSPENDED-SEDIMENT RATING CURVE AND DATA

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Figure 1. Suspended-Sediment and Streamflow Data and Rating Curve for the Little Tennessee River at McGhee, Tennessee

Recommendation 3

Suspended-sediment inflows to Watts Bar Reservoir through the upstream dams of Melton Hill Reservoir and Fort Loudoun Reservoir are needed to simulate sediment deposition and redistribution within the reservoir. No data of these inflows are available. However, Trimble and Carey (1984) have estimated trap efficiencies for Watts Bar Reservoir to be 85 percent for local sediment and 60 percent for sediment from upstream reservoirs.

Using these two trap efficiencies, a relationship for sediment inflow from upstream reservoirs can be developed. The suspended-sediment outflow (SSO) from Watts Bar Reservoir can be expressed as

$$SSO = (1 - LTE)(LSI) + (1 - OTE)(USI)$$

where, LTE = local sediment trap efficiency, LSI = local sediment inflow, OTE = trap efficiency for outflow from upstream reservoirs, and USI = sediment inflow from upstream reservoirs. Sediment inflow from upstream reservoirs is equal to the sum of sediment inflows from Melton Hill Reservoir and Fort Loudoun Reservoir. Assuming that upstream sediment inflows are in proportion to their local watershed areas, 20 percent of the upstream sediment inflows would come from Melton Hill Reservoir and 80 percent would come from Fort Loudoun Reservoir.

The expression could be used to check the appropriateness of assumed upstream sediment inflows by aggregating computed sediment outflow from the reservoir, computing the aggregate local sediment inflow, and solving for the aggregate upstream sediment inflow. This quantity should be equivalent to the assumed aggregate upstream sediment inflow; if not, appropriate adjustments should be made.

Although the expression for SSO is necessarily based on long-term phenomena, additional assumptions could be made to estimate the dynamic nature of upstream sediment inflows. For instance, suspended-sediment inflows could be assumed to be in constant proportion to dam release rates; thereby associating the upstream sediment inflow dynamics to dam release rates.

Recommendation 4

Suspended-sediment rating curves that have been recommended could be adjusted through calibration to fine tune their representation. Each relationship has two parameters, a coefficient and an exponent. Increasing or decreasing the coefficient translates the rating curve such that uniformly greater or lesser sediment, respectively, is delivered by all streamflows. Increasing the exponent will decrease sediment rates for streamflows less than 1.0 cfs/mi² while increasing sediment rates for greater streamflows. Decreasing the exponent will give the opposite effect.

Accumulated sediment distribution in Watts Bar Reservoir was studied to determine if any particular local inflow region was contributing a predominant share of sediment to the reservoir. Data available were sediment deposition quantities for each reservoir reach between

TVA designated silt ranges. Reaches were numbered downstream to upstream as: Tennessee River, reaches 1 through 22; Piney River, reaches 23 through 27; Whites Creek, reaches 28 through 30; Clinch River, reaches 31 through 35; and Emory River, reaches 36 through 41. Confluences occur as: Piney River discharges to reach 2; Whites Creek discharges to reach 6; Clinch River discharges to reach 12; and Emory River discharges to reach 32. The following analysis was based on sediment conservation of mass for Watts Bar Reservoir, i.e., the accumulated sediment of each reach and all upstream reaches equalled the difference between sediment delivered from the watershed area of each reach and from upstream reservoirs, and the sediment that passed through each reach.

Accumulated Sediment--Total accumulated sediment amounts deposited in Watts Bar Reservoir for subperiods of the period 1946 through 1991 were determined from silt range data (Table 1). Accumulated sediment was computed for each particular reach and all upstream reaches for the subperiods (Figure 2).

TABLE 1	
Accumulated Sediment (Ac-ft) in Watts Bar Reservoir	
Period	Accumulated Sediment (Ac-ft)
1946 - 1951	2309.6
1946 - 1956	11523.8
1946 - 1961	20431.1
1946 - 1991	29112.0

Trap Efficiencies--Trimble and Carey (1984) reported sediment trap efficiencies for pertinent reservoirs upstream from Watts Bar Reservoir (Table 2). They reported values for the two types of trap efficiencies, local sediment trap efficiency (LTE), and outflow sediment trap efficiency (OTE).

TABLE 2		
Trap Efficiencies of Certain TVA Reservoirs (Trimble and Carey, 1984)		
Reservoir	Local Trap Efficiency	Outflow Trap Efficiency
Watts Bar	0.85	0.60
Melton Hill	0.85	0.60
Norris	1.00	0.95
Fort Loudoun	0.80	0.50
Douglas	1.00	0.95
Cherokee	1.00	0.95
Fontana	1.00	1.00

WATTS BAR RESERVOIR ACCUMULATED SEDIMENT IN RIVER SEGMENT 8 ABOVE

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Figure 2. Sediment Accumulated for Each River Segment and Upstream River Segments of Watts Bar Reservoir

The high trap efficiencies of Norris, Douglas, Cherokee, and Fontana Reservoirs have resulted in negligible sediment outflows to reservoirs downstream. Therefore, it was assumed that no sediment in Watts Bar Reservoir had originated upstream of Norris Dam for the Clinch River, upstream of Douglas and Cherokee Dams into Fort Loudoun Reservoir, or upstream of Fontana Reservoir for the Little Tennessee River.

Local Watershed Areas--The local watershed area for Watts Bar Reservoir has changed due to dam closings during the period from 1946 through 1991. From 1946 through 1963, the dams upstream of Watts Bar Reservoir were Norris Dam (Clinch River), Fort Loudoun Dam (Tennessee River), and Fontana Dam (Little Tennessee River). In 1963, Melton Hill Dam was closed and replaced Norris Dam as being the upstream dam on the Clinch River. In 1979, Tellico Dam was closed and it replaced Fontana Dam as being the upstream dam on the Little Tennessee River. Therefore, since 1979, the dams upstream of Watts Bar Reservoir have been Melton Hill Dam (Clinch River), Fort Loudoun Dam (Tennessee River), and Tellico Dam (Little Tennessee River). Local watershed areas for Watts Bar Reservoir and other pertinent reservoirs are given in Table 3.

TABLE 3			
Local Watershed Area (mi ²) of Certain TVA Reservoirs (TVA, 1970)			
Reservoir	1946 - 1963	1964 - 1979	1980 - 1991
Watts Bar	3277	2846	1790
Melton Hill	---	431	431
Fort Loudoun	1581	1581	1581
Tellico	---	---	1056

The areas listed in Table 3, for the respective periods, are the watershed areas that contributed sediment into Watts Bar Reservoir. Sediment from the local watershed area of Watts Bar Reservoir entered the reservoir directly. Sediment from the local watershed areas of the other reservoirs was regulated by their respective dams according to the trap efficiencies of their respective reservoirs.

Uniform Sediment Delivery--The primary assumption of this analysis is that every unit area that contributed sediment to Watts Bar Reservoir did so at a uniform amount. This uniform sediment delivery (K) can be computed using the total accumulated sediment in Watts Bar Reservoir, trap efficiencies, and local watershed areas. The relationship for computing K is derived below.

The sediment conservation of mass relationship for Watts Bar Reservoir over a given period is

$$SED_{WB} = LSD_{WB} + \sum_i OSD_i - OSD_{WB} \quad [1]$$

where,

- SED_{WB} = sediment deposited in Watts Bar Reservoir, Ac-ft;
- LSD_{WB} = sediment delivered to Watts Bar Reservoir from its local watershed area, Ac-ft;
- OSD_i = sediment delivered to Watts Bar Reservoir through the dam of an upstream reservoir, Ac-ft;
- OSD_{WB} = sediment outflow through Watts Bar Dam, Ac-ft; and
- i = dams immediately upstream.

From 1946 through 1963, the upstream dams were Norris, Fort Loudoun, and Fontana. From 1964 through 1979, the upstream dams were Melton Hill, Fort Loudoun, and Fontana. From 1980 through 1991, the upstream dams were Melton Hill, Fort Loudoun, and Tellico.

Sediment outflow from a reservoir can be related to the sediment delivered to the reservoir through its trap efficiencies. This relationship is

$$OSD_i = (1 - LTE_i) LSD_i + (1 - OTE_i) \sum_j OSD_j \quad [2]$$

where,

- LTE_i = local trap efficiency of reservoir i ;
- OTE_i = outflow trap efficiency of reservoir i ; and
- j = dams immediately upstream from reservoir i .

By the assumption of uniform sediment delivery, the sediment delivered to a reservoir (i) from its local watershed area is related to that area by

$$LSD_i = LWA_i \cdot K \quad [3]$$

where,

- LWA_i = local watershed area, mi^2 , and
- K = uniform sediment delivery rate, $Ac-ft/mi^2$.

Equations [2] and [3] are substituted into Equation [1] to obtain the relationship between sediment delivery, trap efficiencies, and accumulated sediment for Watts Bar Reservoir. This relationship is

$$SED_{WB} = LTE_{WB} LWA_{WB} K + OTE_{WB} \sum_i (1 - LTE_i) LWA_i K \quad [4]$$

In applying Equation [2] to the reservoirs upstream from Watts Bar Reservoir, the high trap efficiencies of any reservoir further upstream (Table 2) have allowed the simplification of equating with zero the second term on the right-hand-side of Equation [2]. Therefore, any sediment that may originate from reservoirs upstream of the reservoirs immediately upstream of Watts Bar Reservoir has been neglected in this analysis.

By rearranging Equation [4], the equation for computing the uniform sediment delivery is

$$K = SED_{WB} / (LTE_{WB} LWA_{WB} + OTE_{WB} \sum_i (1 - LTE_i) LWA_i) \quad [5]$$

The denominator of the right-hand-side of Equation [5] is the sum of the local watershed area of Watts Bar Reservoir and an equivalent contributing watershed area that represents inflows through upstream dams, each adjusted by the appropriate trap efficiency.

Uniform sediment delivery for each period analyzed can be determined by application of Equation [5] and data from Tables 1, 2, and 3.

1946-1961--Reservoir configuration remained constant during this period, so computations for each subperiod during this period are similar. Reservoirs that were immediately upstream from Watts Bar Reservoir during this period were Norris, Fort Loudoun, and Fontana. Therefore, by substituting into Equation [5],

- a) for 1946 - 1951, $K = 2309.6 \text{ Ac-ft} / 2975.2 \text{ mi}^2 = 0.776 \text{ Ac-ft/mi}^2$;
- b) for 1946 - 1956, $K = 11523.8 \text{ Ac-ft} / 2975.2 \text{ mi}^2 = 3.87 \text{ Ac-ft/mi}^2$; and
- c) for 1946 - 1961, $K = 20431.1 \text{ Ac-ft} / 2975.2 \text{ mi}^2 = 6.87 \text{ Ac-ft/mi}^2$.

1946-1991--Computation of the uniform sediment delivery for this period is more complicated because of the changes in the local watershed area resulting from the closing of Melton Hill Dam (in 1963) and Tellico Dam (in 1979). Computations commence by considering three periods, 1946-1963, 1964-1979, and 1980-1991. The uniform sediment delivery for the entire period is composed of the K values for each subperiod as

$$K = K_a + K_b + K_c \quad [6]$$

where subscripts a, b, and c denote the subperiods 1946-1963, 1964-1979, and 1980-1991, respectively.

Each subperiod K is the ratio of the sediment deposited in Watts Bar Reservoir during that subperiod to the trap efficiency adjusted equivalent watershed area. The adjusted equivalent watershed areas for each subperiod are:

- a) $(0.85)(3277) + (0.60)[(1-1.00)(2912) + (1-0.80)(1581) + (1-1.00)(1571)] = 2975.2 \text{ mi}^2$;
- b) $(0.85)(2896) + (0.60)[(1-0.85)(431) + (1-0.80)(1581) + (1-1.00)(1571)] = 2647.6 \text{ mi}^2$; and
- c) $(0.85)(1790) + (0.60)[(1-0.85)(431) + (1-0.80)(1581) + (1-0.80)(1056)] = 1876.7 \text{ mi}^2$.

For subperiod (c), the local sediment trap efficiency for Tellico Reservoir is assumed to equal 0.80, i.e., equivalent to that of Fort Loudoun. This is a reasonable assumption since much of the flow through Tellico Reservoir drains through Fort Loudoun via the connecting canal.

The sediment deposited during each subperiod can be estimated by linearly interpolating according to the difference between sediment deposited during the 1946-1991 period and that during the 1946-1961. Interpolation is performed according to both subperiod length and adjusted equivalent watershed area. The total interpolation weight is

$$(2)(2975.2) + (16)(2647.6) + (12)(1876.7) = 70832.4.$$

Sediment deposited during each subperiod is then

- a) $(2)(2975.2)(29112-20431.1) / 70832.4 = 729.3 \text{ Ac-ft};$
- b) $(16)(2647.6)(29112-20431.1) / 70832.4 = 5191.6 \text{ Ac-ft};$ and
- c) $(12)(1876.7)(29112-20431.1) / 70832.4 = 2760.0 \text{ Ac-ft}$

Therefore, the uniform sediment delivery for each subperiod is

- a) $K_a = (20431.1 + 729.3) / 2975.2 = 7.11 \text{ Ac-ft/mi}^2;$
- b) $K_b = 5191.6 / 2647.6 = 1.96 \text{ Ac-ft/mi}^2;$ and
- c) $K_c = 2760.0 / 1876.7 = 1.47 \text{ Ac-ft/mi}^2.$

Finally, the uniform sediment delivery for the entire period, 1946-1991, is

$$K = 7.11 + 1.96 + 1.47 = 10.54 \text{ Ac-ft/mi}^2.$$

Analysis--The uniform sediment delivery and sediment outflow through upstream dams for each period is summarized in Table 4.

Trimble and Carey (1984) reported estimated sediment yields for Fort Loudoun, Watts Bar, and Melton Hill Reservoirs that can be compared to the values presented in Table 4. They computed sediment yields using accumulated sediment in reservoirs and Churchill and Brune trap efficiency relationships. For the period 1946-1961, they estimated sediment yields for Fort Loudoun Reservoir of 490 and 530 tn/mi²/yr using Churchill and Brune trap efficiencies, respectively. For the same period, they estimated sediment yields for Watts Bar Reservoir of 630 and 710 tn/mi²/yr using Churchill and Brune trap efficiencies, respectively. The value of 549 tn/mi²/yr for the period 1946-1961 (Table 4) compares favorably to these estimates. Sediment yield estimates for Melton Hill Reservoir for the period 1963-1970 were 150 and 170 tn/mi²/yr using Churchill and Brune trap efficiencies, respectively. The sediment yield of 147 tn/mi²/yr for the period 1961-1991 (Table 4) compares well to these values also. However, in the opinion of Trimble and Carey (1984), their sediment yield estimates for Melton Hill

appeared to be anomalously low because their estimates were based on seven years of record of substantially below normal runoff.

TABLE 4							
Uniform Sediment Delivery For Various Periods For Watts Bar Reservoir							
Parameter	Period						
	1946-1951	1946-1956	1951-1956	1946-1961	1956-1961	1946-1991	1961-1991
Uniform Sediment Delivery Ac-ft/mi ²	0.776	3.87	3.10	6.87	2.99	10.54	3.68
Sediment Yield,* tn/mi ² /yr	186	465	743	549	718	281	147
Sediment Outflow,** Ac-ft, for							
a) Melton Hill	335	1670	1335	2960	1290	3287	327
b) Ft. Loudoun	246	1225	979	2171	946	3334	1163
c) Tellico	820	4090	3270	7252	3162	9892	3640
*Assuming sediment unit weight = 55 lb/ft ³ .							
**Delivery from local watershed area prior to dam closing.							

Trimble and Carey (1984) reported mean sediment yield for the Emory River, computed from suspended sediment measurements during the periods 1963-1965 and 1979-1981, of 110 tn/mi²/yr. They reasoned that this value underestimated actual sediment yield because the suspended sediment measurements did not account for sediment being transported as bedload. The value of 147 tn/mi²/yr for the period 1961-1991 (Table 4) compares well with their estimate.

Using the uniform sediment delivery for unit watershed areas, sediment delivered from the watershed of each reservoir reach was computed (Figure 3). The difference between the sediment delivered from the watershed of each reach and the accumulated sediment in each reach and upstream reaches is the sediment discharged downstream from each reach (Figure 4).

Analysis of information presented in Figures 2 through 4 demonstrates that much of the sediment has accumulated in the Clinch River (reaches 31 to 35) and in the reaches downstream from the Clinch River confluence (reaches 1 through 12). Much of the sediment delivered to the reservoir has come from the Emory River and has been transported toward Watts Bar Dam. Therefore, any adjustments to improve the estimation of suspended-sediment inflows should focus on the rating curves for Emory River and the Clinch River tributaries.

Figure 3. Estimated Sediment Delivered From the Watershed of Each River Segment of Watts Bar Reservoir

WATTS BAR RESERVOIR SEDIMENT DISCHARGED FROM EACH RIVER SEGMENT

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Figure 4. Estimated Sediment Discharged From Each River Segment of Watts Bar Reservoir

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