

Sediment Issues for the Mission Project

Based on information in the First Stage Consultation Report (FSCR), the Technical Leadership Team (TLT) identified sediment accumulation in the main-stem reservoirs as an area of concern. The TLT also recommended the development of a sediment management plan for the Mission Project. The present plan contains information about sediment accumulation in the reservoir, particle size analysis in different areas of the reservoir, cleaning trash racks, downstream bank stability and a review of bathymetric mapping results for 2001.

The Mission Project only generates electricity when there is sufficient flow in the river. Flows up to about 786 cfs can be routed through the units and flows above that are spilled. Daily upstream releases of approximately 1500 cfs from Chatuge Reservoir result in spilling of at least 700 cfs through the tainter gates. There is negligible useable storage for electric generation and, consequently, there is no need nor are there plans for dredging sediments from the reservoir. The only maintenance activity in the reservoir is trash and debris removal from the trash racks.

Bathymetric Surveys

Bathymetric surveys were conducted in August 2001; no bathymetric maps were done in 1999. Measurements were taken along transects as indicated in Figure 5.3.7-1. An aluminum boat equipped with an outboard motor and an electric trolling motor was used to obtain depth readings using a depth finder with an accuracy of +/- 0.1 ft. To locate each transect, a Trimble model AgGPS 132, with sub-meter differential accuracy (correction factors from Omnistar Satellite service) was used to establish GPS points established as close to the right-hand bank left-hand bank (facing downstream) as possible. In some cases the GPS points were established between the shore and mid-channel because the tree canopy near the banks interfered with satellite signal reception. In these cases the GPS points are located on the map (for instance transect 6 in Figure 5.3.7-1) and depths placed along regular intervals to the shore. In other cases the GPS point was recorded at an area where the water depth was less than 2 ft and not accessible

by boat. A field estimate was made as to the distance to the bank; a more accurate distance measure was made using the Arc-View (version 3.2a) measuring tool on the aerial imagery. The image was geo-referenced and has a 3-ft resolution. The bathymetric map was produced by transferring the GPS points, transects, and depth data to the aerial image.

Sediment samples were collected from transects established at points 1/5th, 2/5th, 3/5th, and 4/5th along the midline of the impoundment from the dam to the headwater area. At each transect, PONAR grab samples were taken at 4 equidistant points across the impoundment. Particle sizing was done according to ASTM D422 method using standard sieve sizes (number in parenthesis is sieve opening in mm) of: # 4 (4.750 mm), #10 (2.000 mm), #20 (0.850 mm), #40 (0.425 mm), #60 (0.250 mm), #80 (0.180 mm), #100 (0.150 mm), #120 (0.125 mm), #200 (0.075 mm), #270 (0.053 mm). Sediment particle size analysis was done by Standard Laboratories, Inc. of Jacksboro, Tennessee.

Results and Discussion

Based on the August 2001 depth measurements, Figure 5.3.7-1 illustrates a channel pattern similar to a meandering alluvial river. The deepest parts of the reservoir also have characteristics of a low gradient river with an entrenched meander type channel (US Army Corps of Engineers 1994). The channel cross section is broadly “U” shaped, deeply incised with very steep slopes. Much of the reservoir is bounded by bedrock on the outside of the “bends”, e.g., transects 4-6 (right bank), transects 8-12 (left bank) and transects 14-17 (both banks). These bedrock controls serve to “confine” the channel and limit lateral migration and erosion. Because of the limited lateral migration, increased forces due to increased discharge can create channel bed erosion, with some limited bank erosion, assuming the channel has force sufficient to transport both the material available from upstream and material in the bed and banks. The ability of the stream within the reservoir to transport material is a function of the channel and flow characteristics influenced by upstream Lake Chatuge reservoir releases, and the downstream Mission Dam. Mission Dam and the tainter gates act as a base-level control, controlling

deposition within the pond. Lake Chatuge acts as a very effective sediment storage reservoir.

The existing sediment deposits throughout the reservoir must have been formed prior to the present hydro operating mode. Due to the effective sediment storage capacity of Lake Chatuge, extensive sediment accumulation probably occurred in the period prior to its creation in 1942. While the 15 miles of channel and drainage area between Lake Chatuge and Mission Dam can act as sediment sources, the existing stored sediment behind the Mission Dam is likely from the greater area upstream of Lake Chatuge. During the pre-Chatuge period, the hydro (only two units were installed at this time) was operated to maximize generation while avoiding spilling water through the tainter gates. Hydro operations maintained a full reservoir at all times. Whenever sufficient flow was available, it was routed through one of the generating units. When flows exceeded the 500 cfs capacity of the two generating units, the tainter gates were opened to maintain full-pond elevation. Maintaining full pond throughout most of the year must have caused extensive sediment deposition throughout the reservoir as the incoming water slowed and suspended particles settled out of the water column. During flood flows, incoming new and remobilized sediments were deposited farther downstream towards the Dam. Eventually the sediment deposits formed a delta near the dam.

In May 1997 the reservoir was drained for extensive repairs. The reservoir was not refilled until October 1999. During this time the flows from upstream Lake Chatuge were passed through the reservoir through the open tainter gates. As is apparent from the deep incision due to erosion during drawdown, flows delivered to the dam are sufficient to remobilize deposited sediments. As water storage capacity is limited, flows of 1,500 cfs delivered from the Chatuge reservoir appear to be sufficient to prevent extensive additional sediment build-up.

Once Mission Reservoir was refilled in 1999 and the operations returned to normal, the sediment dynamics in the reservoir have also become re-established. Particle size information from grab samples taken at four transects (perpendicular to the flow) in the

reservoir (see A through D Figure 5.3.7-1 and Table 5.3.7-1) reveal a substrate consisting mostly of particles 1.0 mm or less in size. Particle size differences across each transect vary in relation to flow conditions at that point of the reservoir. The deeper areas are sites where the greater flow velocities cause scouring while the shallower areas are sites where the lower flow velocities allow deposition. For instance, the particle sizes at transect A show a gradation of ever increasing percentage of fines from grab 1P1 to 1P4; the depth profile reveals a change from deep waters on the right hand side to extensive shallow areas. At transect D, however, the sediments consist mostly of fines with more than 60% comprised of particles less than 0.053 mm in size. The depth profile reveals a uniformly deep cross section.

Sediment in the system consists of suspended silts and sands that deposit only when stopped by downstream controls. Trash blocking the trash rack and preventing these suspended sediments from moving through the system enhances deposition. The routine maintenance removal of trash and debris from the trash rack assures that the trash rack opening does not become obstructed. The funneling effect of water entering the unit intakes and tainter gates causes an increase in the water velocity in the forebay area. The increased flow velocity causes erosion of the toe of the foreset slope and the sediments are transported downstream.

Sediment accumulation is precluded at the dam face due to the shear stress by opening of the tainter gates. The elevation of the bottom of the tainter gate opening determines the depth of sediment accumulation at the dam. The sediment delta has in effect reached the dam so that the toe of the foreset slope is located at the elevation of the tainter gate opening. Sediment accumulation above this elevation is precluded by the high flow velocity at the point where waters discharge under the tainter gates. The funneling effect of water at this point causes an increase in the water velocity in the forebay area. The increased flow velocity causes erosion of the toe of the foreset slope and the sediments are transported downstream.

There is no delta formation downstream of Mission dam since the flow velocities in the river channel are sufficient to carry the sediment load downstream. The available energy in the flow below the dam will be in equilibrium with the material removed from the forebay area (U S Army Corps of Engineers 1997).

Trash Rack Maintenance

Based on a review of hydro operations at Mission, it was determined that the main operational problems were related to debris accumulation on the trash racks. Sediment accumulation in the reservoirs had little direct effect on unit operation. The trash racks are designed to keep large debris from blocking or entering the hydro unit and causing damage. The racks also accumulate small debris, such as leaves. This small debris is continuously removed using a leaf rake to keep the rack open so that the debris does not accumulate to such an extent that the flow into the tunnel would be reduced or stopped. The small amount of sediment associated with routine debris removal is carried downstream and widely dispersed by the water used in generation. However, the leaf rakes do not keep the racks completely clean and small debris and leaves accumulate in front of the racks and become buried under silt and sediment. Once this layer forms the leaf rake can not remove this material and a new layer starts forming. This process is repeated until the debris and sediment mixture has accumulated to such an extent that it interferes with unit operation and it must be cleaned to provide sufficient water flow to the unit. Under extreme conditions the accumulated debris and sediment might result in collapse of the rack. Compounding the problem of routine cleaning is the presence of large objects, such as trees, which lodge against the rack and interfere with the rake cleaning. Eventually the debris and sediment obstruction must be removed in order to provide sufficient water depth and flow for the unit.

Historical Review of Maintenance Activities

The review of operational maintenance activities indicates that, in general, major cleaning of the trash racks is done about every 7 to 8 years at Mission. This cleaning of the racks is done with large equipment, such as track hoes and clam-shells, that is capable of removing the accumulated debris. The reservoir was drained from October 23, 1989 to

November 22, 1989 to replace the intake racks and, while the reservoir was drained, debris was removed from in front of the trash rack area. The reservoir was drained from May 16, 1997 through October 10, 1999 for FERC mandated repairs.

Proposed debris/sediment management plan

Routine trash rack cleaning is done using leaf rakes on a day-to-day basis. Major cleaning using heavy equipment will be done when operations become affected by debris build-up. The major debris removal can be done at any time of year and under different flow regimes since no flow will pass through the turbines during this time (see 5.3.7.2.3 below for details). As noted above, historically, major debris removal from trash racks occurs approximately every 7 to 8 years. It is difficult to provide a more precise estimate for scheduling cleaning of the racks since the rate of debris accumulation is dependent on the amount of debris transported from the area upstream of the project. There are no permit requirements for trash rack maintenance and Duke Power plans to continue routine maintenance program.

Major debris removal process

Present plans call for cleaning the racks under a wide range of flow conditions. Prior to cleaning the generating units will be shut off and the water will be allowed to spill through the tainter gates so that currents in the debris removal area are minimized. The impoundment will be kept at full pond during the entire debris removal operation. The debris will be removed using large equipment (clam-shell or track hoes) and properly disposed of. Once debris removal ceases, the sediments that became suspended will either settle out or will be carried away through the tainter gates and dispersed by the downstream currents. After the debris removal is completed and the heavy equipment removed, the generating units will be returned to operation. The reservoir will be maintained at full pond during the entire operation. The debris removal operation may take two to three days.

Required Drawdowns for Planned or Emergency Work

The Licensee shall notify the North Carolina Department of Environment and Natural Resources (NCDENR), the North Carolina Wildlife Resources Commission (NCWRC), and the United States Fish and Wildlife Service (USF&WS) at least 15 days prior to planned major debris removal activities or planned drawdowns for maintenance or inspection purposes that will require a temporary modification of the reservoir elevation limits. The licensee shall notify the NCDENR, the NCWRC, and the USF&WS as soon as practical, but no later than ten days after any temporary modification of the reservoir elevation limits required by an operating emergency beyond the control of the Licensee.

Drawdown Procedure

The tainter gates will be used to release water during normal or emergency drawdowns at the Mission Project. Using the tainter gates to release water will provide for the best dispersion of debris and sediment downstream of the project. If the automatic tainter gates fail to operate, the manually operated tainter gates (with a back-up kohler set) could be used to lower or drain the reservoir. No sluice or sediment gates exist at the Mission Project. The turbines will not be used during drawdowns, due to the potential for major debris build-up in front of the intake racks.

Timing of Drawdown

Considering local weather patterns and inflow levels, summer and fall are the preferred times of year for planned drawdowns. The NCWRC and Duke fisheries biologists will be consulted as to the spawning periods for species that inhabit the project reservoir. Drawdowns during the spawning period will be avoided whenever possible to ensure that spawning beds will not be de-watered. Whenever possible drawdowns will be scheduled during high flow periods of the year to ensure that adequate flow will be available to move the sediment through the system.

Rate of Drawdown

Historically, drawdown of the Mission Reservoir was accomplished in 2-3 hours. The current drawdown procedure for scheduled maintenance is to gradually drain the reservoir over a 24-hour period. This slower drawdown rate should minimize any flow or

sediment related downstream impacts. To address the drawdown rate, a cooperative field study with representatives from North Carolina resource agencies and the USFWS will be conducted to develop project-specific guidelines for the Mission Project.

Rate of Refilling

Typically, to facilitate maintenance and repair activities, drawdowns will be conducted in the summer or fall during the natural low-flow period of the year. Refilling the reservoir of the Mission Project will be readily accomplished due to the releases from Chatuge Reservoir.

Agency Notification

The Licensee shall notify the NCDENR, the NCWRC, and the USFWS at least 15 days prior to commencing planned drawdowns for maintenance or inspection purposes that will require a temporary modification of the reservoir elevation limits or planned major debris removal activities. The licensee shall notify the NCDENR and the NCWRC of any temporary modification of the reservoir elevation limits required by an operating emergency beyond the control of the Licensee as soon as practical, either before, during, or immediately following such emergency, but no later than ten days after each such incident.

Downstream Bank Erosion

Based on information in the FSCR, the TLT identified excessive bank erosion as a potential problem below Mission Dam. The concern about downstream bank erosion in excess of the natural rate is based, in part, on the erosive power of water released from storage reservoirs.

“Initially, after reservoir construction, the hydraulics of flow (velocity, slope, depth, and width) remain unchanged from pre-project conditions. However, the reservoir acts as a sink and traps sediment, especially the bed material load. This reduction in sediment delivery to the downstream channel causes the energy in the flow to be out of balance with the boundary material for the downstream channel. Because of the available energy,

the water attempts to re-establish the former balance with sediment load from material in the stream bed, and this results in a degradation trend. Initially, degradation may persist only a short distance downstream from the dam because the equilibrium sediment load is soon re-established by removing material from the stream bed.” (US Army Corps of Engineers 1977).

At the Bryson Project, the sediment rich waters and the lack of sediment trapping ability of the reservoir mean that any waters released from the project are essentially “in balance”, and removal of sediment from the streambed is minimal. In order to approximate the rate of streambed and, consequently, bank erosion, the TLT agreed that a comparison of the river channel downstream of the dam over a long time interval should indicate if extensive bank erosion has occurred over time. To that end, historical (circa 1970) USDA aerial photographs were examined to determine if excessive bank erosion was occurring downstream of the project. Additionally, an aerial photograph from an April 14, 1973 TVA over-flight (see Figure 5.3.7.4-) was obtained and compared to the digital photograph taken in February 2001 (see Figure 5.3.7.4-). A visual comparison of these figures revealed no major changes in the downstream bank configuration nor any signs of excessive bank erosion had occurred in the 28 year time period. Additionally, visual searches for a distance of 200 meters downstream of the dam for obvious signs of bank erosion were made as part of macrobenthic sampling or bathymetric mapping. Those searches also support the lack of excessive bank erosion downstream of the Mission Project.

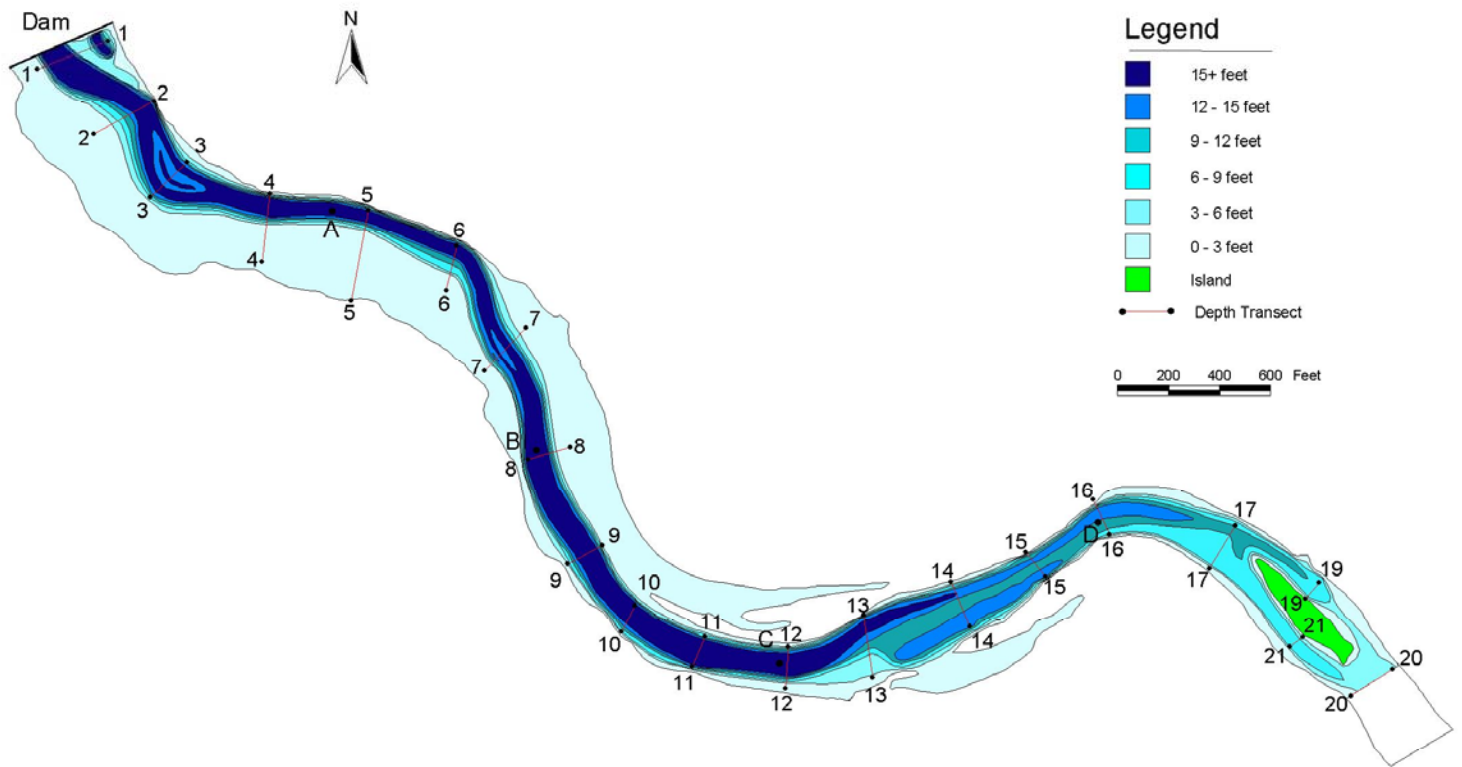
Literature Cited

US Army Corps Engineers. 1994. Channel stability assessments for flood control projects. EM 1110-2-1418.

US Army Corps Engineers. 1997. Hydroelectric engineering requirements for reservoirs. EM 1110-2-1420.

Table 5.3.7-1. Mission Project. Percentage of sediments passed through nested standard sieves. Locations designated by capital letters correspond to locations in Figure 5.3.7-1. Results are represented with RIGHT as the right-hand side facing the dam.

Location	Sieve size (mm)	RIGHT				LEFT			
		1P1	1P2	1P3	1P4	1P1	1P2	1P3	1P4
Location A	4,75	83,14	99,37	100	100				
	2	59,22	88,78	99,87	99,97				
	0,85	42,05	73,97	98,49	99,73				
	0,425	30,56	56,26	82,2	98,83				
	0,25	24,85	40,57	59,22	97,56				
	0,18	21,76	35,48	53,77	95,86				
	0,15	19,43	32,99	52,25	94				
	0,125	15,8	29,95	48,84	89,2				
	0,075	12,73	27,56	46,54	86,32				
	0,053	10,28	25,27	44,38	83,55				
Location B	Sieve size (mm)	RIGHT				LEFT			
		2P1	2P2	2P3	2P4	2P1	2P2	2P3	2P4
Location B	4,75	100	99,96	98,56	77,63				
	2	99,92	99,9	91,81	59,17				
	0,85	99,24	97,65	80,98	51,21				
	0,425	97,94	80,56	65,82	41,51				
	0,25	96,93	64,83	55,22	35,14				
	0,18	96,65	59,59	51	31,68				
	0,15	96,25	58,11	48,91	29,48				
	0,125	94,77	54,95	44,43	26,03				
	0,075	92,54	53,31	40,89	23,83				
	0,053	90,91	52,35	38,4	22,33				
Location C	Sieve size (mm)	RIGHT				LEFT			
		3P1	3P2	3P3	3P4	3P1	3P2	3P3	3P4
Location C	4,75	100	68,49	100	100				
	2	99,97	53,02	100	100				
	0,85	99,18	47,7	99,93	99,95				
	0,425	98,22	40,98	99,66	98,46				
	0,25	96,39	35,43	98,18	96,76				
	0,18	95,04	32,39	96,59	95,02				
	0,15	93,63	30,95	95,73	93,24				
	0,125	90,03	27,3	92,91	88,34				
	0,075	84,61	24,96	89,71	84,56				
	0,053	78,67	23,38	85,79	82,05				
Location D	Sieve size (mm)	RIGHT				LEFT			
		4P1	4P2	4P3	4P4	4P1	4P2	4P3	4P4
Location D	4,75	100	100	100	100				
	2	100	100	100	100				
	0,85	99,92	99,47	99,82	98,85				
	0,425	99,23	99,02	99,58	97,21				
	0,25	96,49	97,88	98,07	95,31				
	0,18	92,86	96,65	94,55	93,2				
	0,15	90,62	95,39	89,05	90,54				
	0,125	81,39	92,15	79,37	83,55				
	0,075	74,33	89,59	70,58	77,51				
	0,053	71,33	87,59	65,25	73,32				



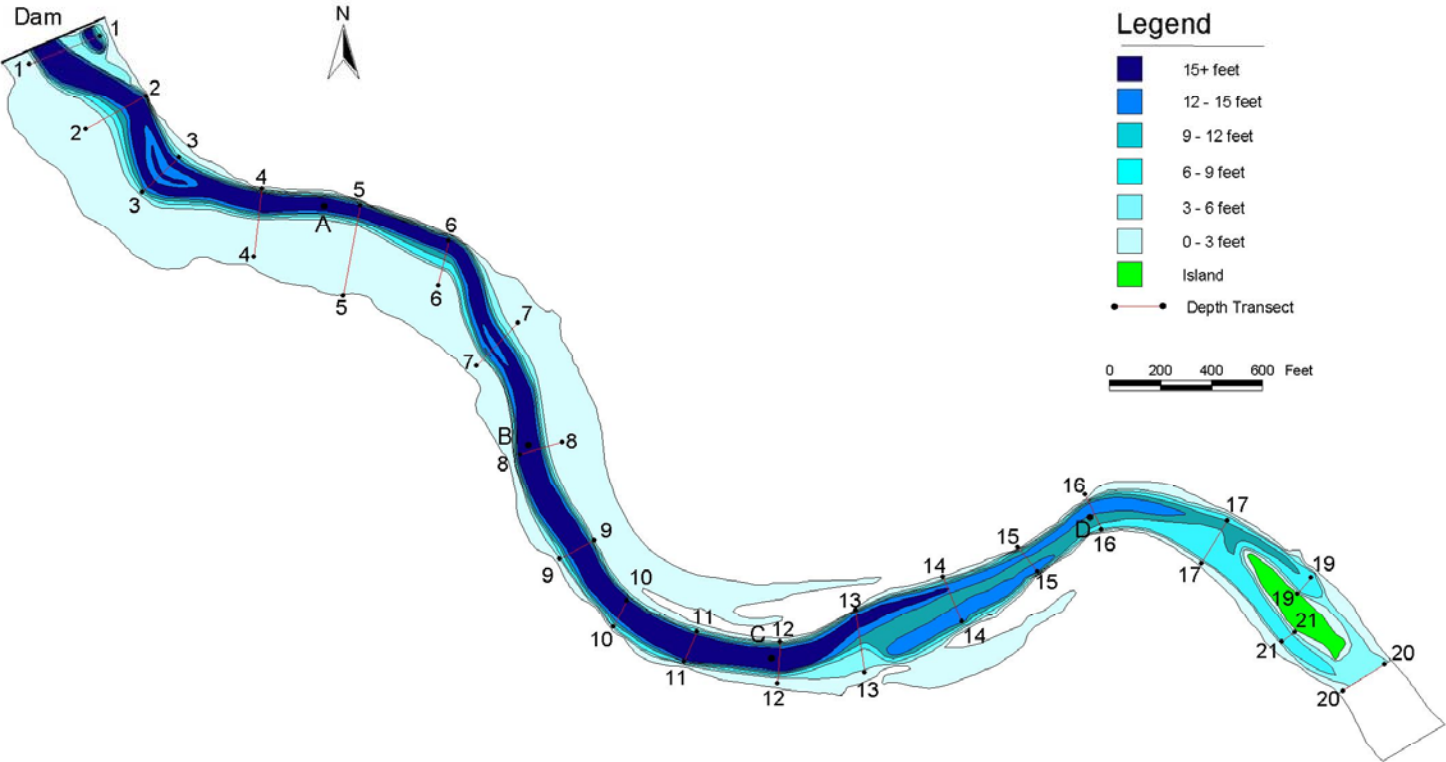
Dam



Legend

- 15+ feet
- 12 - 15 feet
- 9 - 12 feet
- 6 - 9 feet
- 3 - 6 feet
- 0 - 3 feet
- Island
- Depth Transect

0 200 400 600 Feet





Mission Tailrace from
TVA Aerial Photography
April 14, 1973

