

Sediment Issues for the Dillsboro

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 Dillsboro 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 1999 and 2001.

The Dillsboro Project only generates electricity when there is sufficient flow in the river and flows in excess of 284 cfs are spilled. 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 June 2001. Measurements were taken along transects used to produce the 1999 maps ((Nantahala Power and Light 2000). 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 +/- 0.5 ft. The shoreline points used in the 1999 survey were used to establish transects used for the 2001 survey. 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. At some locations the GPS points were established a considerable distance from the shore due to a lack of signal because of overhanging trees. Here the GPS points were located on the map (e.g. transect 11 in Figure 5.3.7-1) and depths recorded along regular intervals to the shore. At other locations 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

The results of the June 2001 bathymetry survey compared to the 1999 depth profiles reveal no major changes. Comparisons of the maps yield little information regarding changes in the storage volume of the reservoir and give no useable information about the rate of sediment accumulation.

There are several reasons why detailed comparisons can not be made. The accuracy of the 2001 and 1999 depth measurements is roughly comparable (+/- 0.5 ft). Though the 1999 transects were re-run in 2001, the intervals where depth measurements were taken are not the same. The 1999 survey relied on taking depth readings at timed intervals along a transect (the accuracy of the distance measured for this was not available) or, where the reservoir was narrow enough, a calibrated chain was used (the original data were not available). In 2001, depth readings were taken at given distances based on distances measured using a hip chain (a distance measuring device where a thin thread-line runs across a calibrated wheel; accurate to +/- 0.5 ft per 100 ft). Due to the difference in the measuring methods, the distances from shore where the depth measurements were taken were not the same. The 1999 depth and distance results were plotted on an enlargement of a topographic map and the depth contours drawn by hand.

The resulting maps had no horizontal scale so distances could not be measured on the 1999 bathymetric maps. The 2001 depth and distance data were plotted on a geo-registered digital photo with GPS points used to locate the contour lines. Cross sections of the reservoir could be measured to +/- 3 feet using the ArcView (version 3.2a) GIS software. Placement of the contour lines is an important variable in determining volumes of the reservoir. Selection of the 1999 contour intervals, the distance from shore and the actual depth interval, determined the accuracy of the comparisons for evaluating any loss of reservoir volume. The depth intervals were also too great for the amount of sedimentation that might have actually occurred between the two measurement periods. Furthermore, as discussed below, it appears that filling of the reservoir has reached a balance in which either deposition or scouring is predominant depending on river flows.

Sediment carried by the Tuckasegee River is highly mobile and composed of suspended sands and silts which are deposited on the falling limb of the hydrograph in backwater areas, but easily re-suspended and moved during high flow events. Based on the bathymetric maps, the general form of the channel bed upstream of the dam remained unchanged. Material deposited behind the dam is very fine grained (generally less than 1 mm) and is of such a composition that it is easily re-suspended during high flows. There is no decrease in particle size from upstream to downstream near the dam, which would have indicated coarse particles aggrading due to backwater effects of the dam. Particle sizes along the length of the reservoir indicate that deeper areas have 1 mm particles, and shallower areas have essentially very fine, suspendable particles less than 0.1 mm (see A through D Figure 5.3.7-1 and Table 5.3.7-1). During high flows, observations upstream and downstream of the dam indicated the presence of large amounts of suspended materials; as flows dropped, this material was not stored in the main channel except in backwaters and deep pools.

The bathymetry and particle size data show that the reservoir is similar to a river with a sandy-silt bed (Figure 5.3.7-1). Sediment translocation within and transport through the reservoir are dependent on the river flows. During periods of lower flows (roughly less than half bankfull) there is sediment deposition, and during high flows (roughly bankfull

or greater) there is sediment mobilization and transport through and out of the reservoir. The river channel width is confined which limits lateral migration; thus, only the channel bed can change in response to flow changes. Scouring occurs at set points in the reservoir, such as in bends and in constricted areas. The extent of scouring changes in relation to flow and the incoming sediment loads. Since the flow is unregulated and, considering the present sediment accumulation within the reservoir, there will be little net increase of sediment storage.

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 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 not occurring at the dam face due to the shear stress at the unit intakes. The elevation of the bottom of the intake opening determines the depth of sediment accumulation at the dam, and acts as the “base level”. The funneling effect of water where flow enters the intake opening causes an increase in the water velocity in the forebay area. The increased flow velocity and shear stress causes erosion of any deposited sediment and the sediments are transported downstream. Headward (upstream) migration of the deposited sediments continues, creating a channel within the sediments. This channel is evident from the bathymetric data, and the depth of the channel approximately equals the depth of the intake.

There is no delta formation (i.e., indicating excessive sediment availability) downstream of Dillsboro dam. There appears to be a balance between sediment delivered to this area and the ability of the river to move this material (US Army Corps of Engineers 1997).

Trash Rack Maintenance

Based on a review of hydro operations at Dillsboro, 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 penstock 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 cannot 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. 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 Dillsboro. 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.

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 take place 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 occurred 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 are shut off and the water is allowed to spill over the dam 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 is removed using large equipment (clam shell or track hoes) and disposed of properly. In the area affected by debris removal (approximately 50 feet upstream of the trash rack), once debris removal ceases, the sediments that became suspended will either settle out or will be carried away over the dam and dispersed by the downstream currents. Once the debris removal is completed and the heavy equipment removed, the generating unit is ready for operation. The reservoir is kept at full pond during the entire operation so there is never a time when the pond is drained or lowered. The entire operation may take two to three days.

Required Drawdowns for Planned or Emergency Work

The Licensee shall notify the NCDENR, the NCWRC, and the US fish and Wildlife Service 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.

Drawdown Procedure

The turbines are the only means of drawing down the reservoir at Dillsboro. Using the turbines would cause a major debris build-up in front of the intake racks which would need to be removed before the units could be operated. If a need arises to drain the reservoir then the appropriate resource agencies will be notified and a plan of action developed.

Timing of Drawdown

If a need arises to drain the reservoir then the appropriate resource agencies will be notified and a plan of action developed.

Rate of Drawdown

If a need arises to drain the reservoir then the appropriate resource agencies will be notified and a plan of action developed.

Rate of Refilling

If a need arises to drain the reservoir then the appropriate resource agencies will be notified and a plan of action developed.

Agency Notification

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) if a need arises to drain the reservoir and develop a plan of action.

Downstream Bank Erosion

Based on information in the FSCR, the TLT identified excessive bank erosion as a potential problem below Dillsboro 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 1997).

At the Dillsboro 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 a March 25, 1967 TVA over-flight (Figure 5.3.7.4-) was obtained and compared to the digital photograph taken in February 2001 (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 over the 34-yr 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 Dillsboro Project.

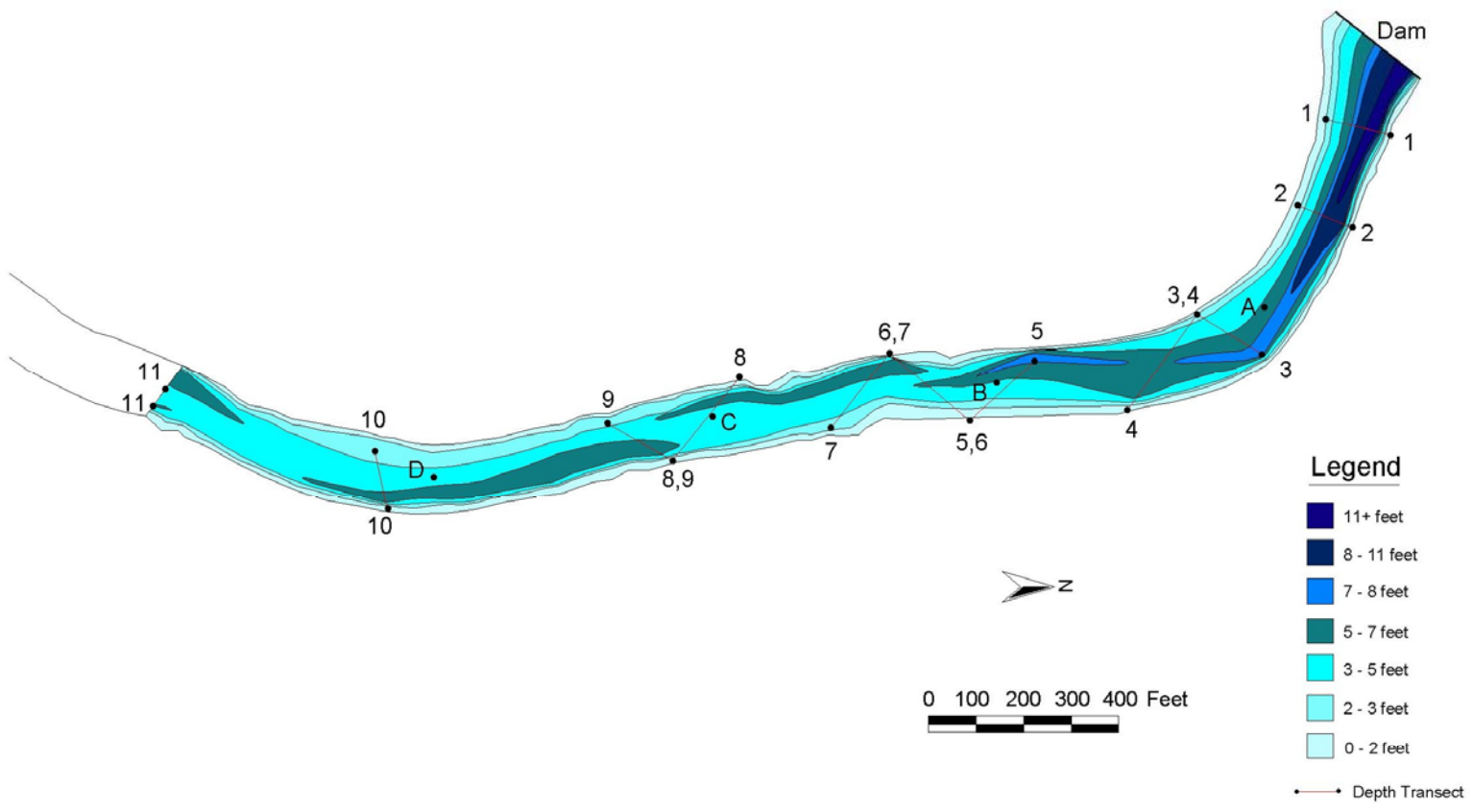
Literature Cited:

Nantahala Power and Light. 2000. FERC relicensing first stage consultation package. Dillsboro Hydroelectric Project. Nantahala Power and Light, Division of Duke Energy Corporation, Franklin, NC.

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

Table 5.3.7-1. Dillsboro 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.

	RIGHT						LEFT				
	Sieve size (mm)	1P1	1P2	1P3	1P4		Sieve size (mm)	3P1	3P2	3P3	3P4
Location A	4,75	100	100	99,86	96,9	Location C	4,75	100	100	100	100
	2	99,9	99,96	96,44	85,16		2	99,98	99,96	99,9	99,4
	0,85	91,33	94,59	66,28	54,22		0,85	99,73	97,16	97,4	87,24
	0,425	48,02	54,71	32,73	35,41		0,425	99,23	77,95	84,79	71,49
	0,25	20,55	28,18	18,84	26,38		0,25	97,18	44,9	65,47	53,15
	0,18	12,24	21,49	13,75	21,66		0,18	83,71	23,51	43,36	29,95
	0,15	9,41	18,64	11,31	18,84		0,15	70,33	18,28	33,22	22,54
	0,125	6,62	13,79	8,12	14,42		0,125	50,38	12,22	24,07	13,41
	0,075	5,1	10,73	6,02	10,81		0,075	33,89	8,52	19,27	9,12
	0,053	4,27	9,24	4,6	8,31		0,053	25,49	6,68	17,18	7,56
Location B	Sieve size (mm)	2P1	2P2	2P3	2P4	Location D	Sieve size (mm)	4P1	4P2	4P3	4P4
	4,75	100	100	100	100		4,75	100	100	100	99,83
	2	99,4	99,93	99,65	99,82		2	99,7	99,86	99,1	96,38
	0,85	83,7	93,13	96,72	95,41		0,85	91,81	95,14	87,81	62,2
	0,425	42,5	56,73	86,19	84,86		0,425	52,94	85,4	77,01	40,89
	0,25	19,07	24,93	66,58	67,92		0,25	32,54	72,49	58,74	27
	0,18	11,51	12,91	43,53	51,66		0,18	25,9	52,25	34,97	19,25
	0,15	9,44	10,03	32,52	42,06		0,15	21,84	37,08	23,84	15,88
	0,125	6,82	7,43	21,03	30,58		0,125	15,02	21,11	14,1	11,85
	0,075	5,22	5,89	15,17	25,17		0,075	11	14,23	9,62	9,13
0,053	4,3	4,91	12,49	23,45	0,053	8,94	11,78	7,78	7,27		





Dillsboro Tailrace from
Digital Photography
February 2001

0 200 400 600 Feet

