# SEDIMENTATION IN THREE SMALL EROSION CONTROL RESERVOIRS IN NORTH MISSISSIPPI

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**Abstract** The water storage capacity and dam integrity of thousands of flood control reservoirs built in the last 50 years are compromised by excessive impounded sediments. The fate of these structures depends on the amount and characteristics of the impounded material. To aid in understanding the scope of this issue in the hill lands of northern Mississippi, physical sediment characteristics and reservoir holding capacity were evaluated in three small reservoirs (<20 acres) built 40+ years ago as part of the Yazoo-Little Tallahatchie erosion control project. A vibracoring system was used to collect continuous cores of impounded sediment and parent material. Particle size, bulk density, and a limited amount of $^{137}$Cs data were used to define the pre-impoundment level. Sediment accumulation rates were found to range from 1 to 3 mm/year with reductions in storage capacity of 7% to 19%.

## INTRODUCTION

There are approximately 11,000 flood control dams in the United States that have been constructed since the 1940's by the USDA-NRCS (Caldwell, 1999), and there are about 75,000 dams of various sizes in all (Graf, 1999). These structures, many of which have a design life of 50 years, are reaching a point in their lifespan where assessment is required so that informed decisions regarding the eventual fate of the reservoirs can be made.

Exploitative agricultural methods applied since in the 1830's resulted in excessive erosion in areas of west Tennessee and north-central Mississippi. Many of these upland areas were rendered almost completely unproductive, and the eroded sediments from upland areas buried fertile bottomlands as excessive runoff led to frequent flooding. During the years 1948-1976, the Yazoo-Little Tallahatchie Project (YLTP) was instituted to combat these erosion effects. The YLTP is credited with planting over 690,000,000 pine trees over 106,000 acres of highly eroded land (Ursick, 1963). As part of the project, numerous small erosion control dams were built.

In the work described here, three small lakes installed in North Mississippi’s Holly Springs National Forest as part of the YLTP were chosen for investigation of the physical characteristics of impounded sediments (Figure 1). In related work, the same site is being used by the University of Mississippi National Center for Physical Acoustics (NCPA) for development of acoustic instrumentation to aid in reservoir sediment assessments. The field data from the present study will be used to augment the work being done at the NCPA. Lake schematics with core locations are shown in Figures 2-4, and Table 1 contains specific lake characteristics.

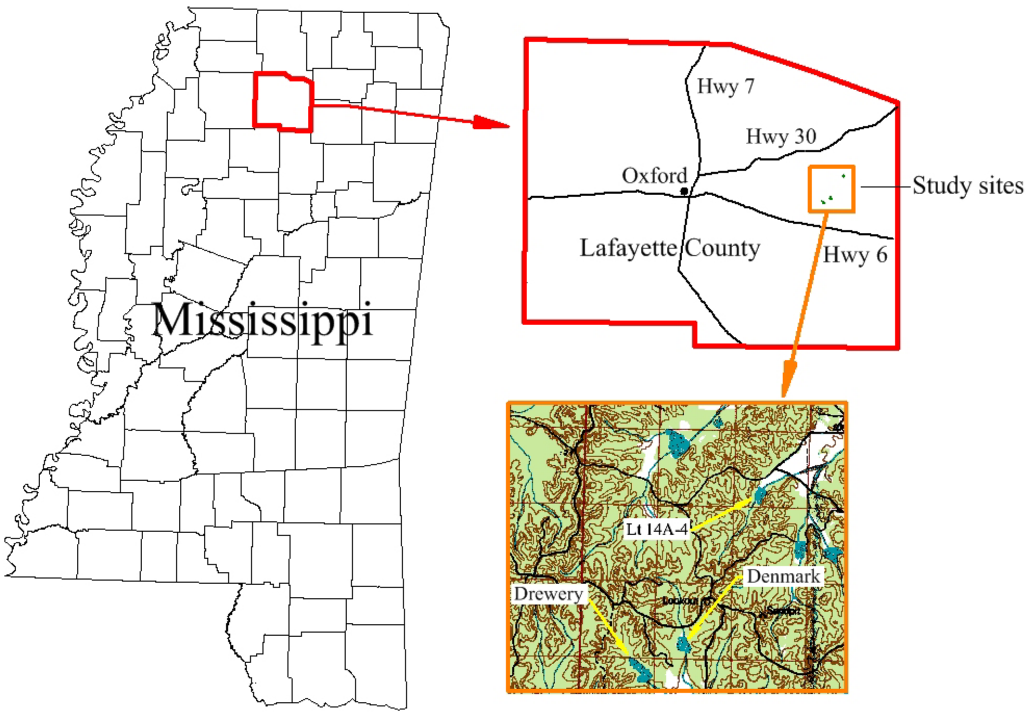


Figure 1 Location of study sites.

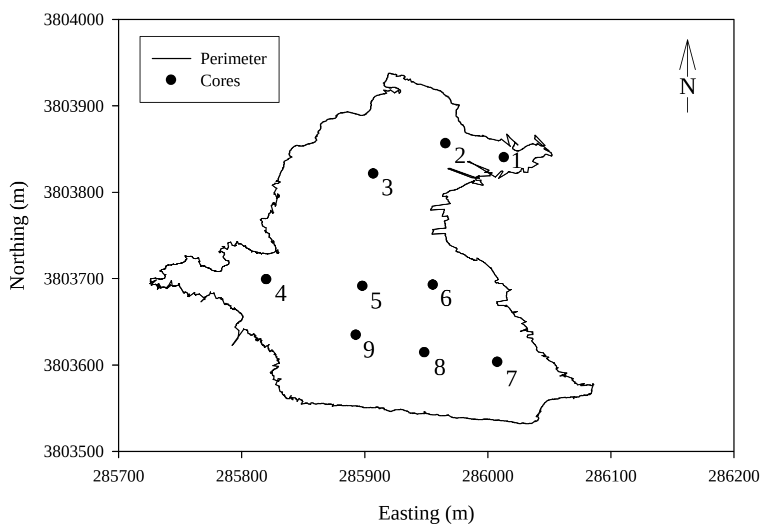


Figure 2 Denmark Lake.

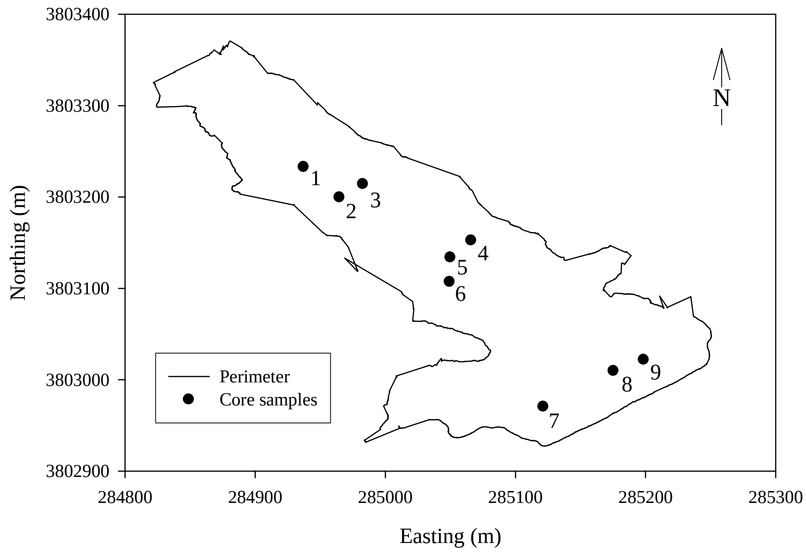


Figure 3  Drewery Lake.

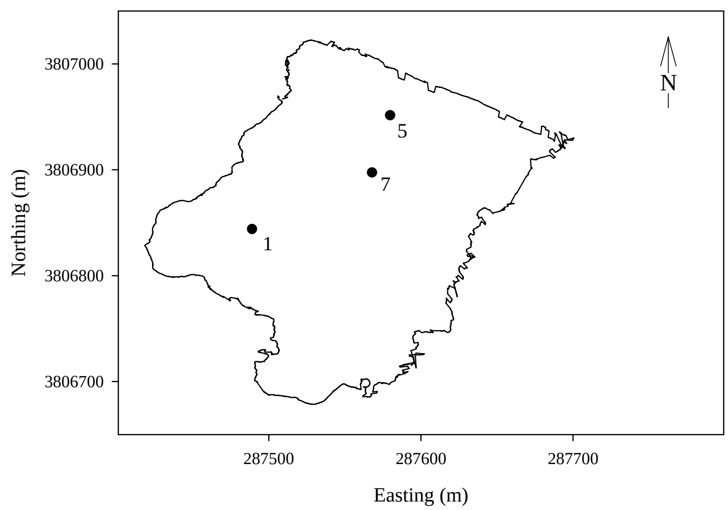


Figure 4  Lt 14A-4.

Table 1  Lake characteristics.

| Lake | Year Built | Drainage area (ha) | Surface area (ha) | Reduction in storage | Mean accumulation rate (mm/yr) |
|---|---|---|---|---|---|
| Lt 14A-4 | 1962 | 280 | 3 | 19% | 3 |
| Drewery Lake | 1965 | 171 | 7 | 7% | 1 |
| Denmark Lake | 1965 | 284 | 4 | 9% | 3 |

## METHODS

A commercially available vibracoring system was used to collect a total of 21 sediment cores from the three lakes. The vibracoring system was suspended from an aluminum tripod with flotation provided by plastic drums connected to wooden platforms. The vibracorer was raised and lowered by an electric winch. The cores were collected in 76 mm diameter aluminum irrigation pipe that had a wall thickness of 1.5 mm. The vibracoring method has been shown to collect relatively undisturbed samples of bottom sediments due to liquefaction of the sediment at the vibrating interface between the sample pipe and sediment (Lanesky et al., 1979; Smith, 1984). It was assumed that minimal core compaction occurred. This was informally verified by observing the depth of penetration and resulting core length from selected cores. All cores were capped immediately after extraction and secured with duct tape. Care was taken to ensure that no air voids were present at the top of the cores. While awaiting processing, the cores were stored at $4^{o}$ C.

Each core was photographed after splitting the aluminum pipe longitudinally. The cores were sectioned at 2-cm intervals for the first 10-cm and 5-cm intervals for the remainder of the core. A portion of the top 20-cm of each sample was stored in airtight foil packs for use in pesticide analysis. Samples were initially weighed wet, dried at $60^{o}$C for 48 hours and weighed again. Bulk densities for each depth interval were found as follows: Bulk density=dry mass/total volume, total volume=$V_{voids}$+$V_{particles}$, $V_{voids}$=(wet mass-dry mass)/1 g/cm$^3$), $V_{particles}$=dry mass/2.65 g/cm$^3$. Particle size fractions in each core increment were determined using an established pipette method (Method 3A1 (Soil Survey Staff, 1992)).

The depth of sedimentation was determined by locating the position in each core profile where clay began to be enriched relative to lower increments in the profile. This data was then checked against the bulk density data. The position in the core profile where a sharp decrease in bulk density was observed was used to augment the identification of the pre-impoundment sediment horizon. When the bulk density data showed a more clear trend than clay enrichment, the bulk density derived estimate was used. The depth of a marked depletion in % silts was also used as an identifier when possible, although these data generally did not show a clear trend. Limited comparison with photographs of cores also served to verify the determination of sedimentation depth. The minimum possible error in depth determination ranges from ±1 cm in the first 10 cm to ±2.5 cm in the rest of the core. A similar approach for determining the depth of sedimentation was used by Bennett et al. (2005).

In Denmark Core 1 and Lt 14A-4 core 1, $^{137}$Cs was used to further check the selection of the pre-impoundment level. Gamma spectroscopy was used to determine the activity of $^{137}$Cs in the lake core samples. Samples were counted in standardized geometries for at least 82,800 seconds on a High Purity Germanium (HPGe) gamma detector. Counting efficiencies for $^{137}$Cs were established using two mixed radionuclide solutions (Bonniwell, 2001; Wilson, 2003). In cases where there was disagreement between the clay enrichment/bulk density decrease derived sedimentation depth and that derived from $^{137}$Cs data, the former was used since $^{137}$Cs data were only available for 2 cores.

## RESULTS AND DISCUSSION

Bulk density, particle size, and preimpoundment levels for selected cores from each site are shown in Figure 5. Figure 5A is an example of a situation where bulk density and a small enrichment in % clay were in agreement on the depth of sedimentation. Figure 5D shows a strong trend in bulk density, which in this case was used to identify the pre-impoundment level. Overall, the agreement between clay enrichment and a downward trend in bulk density for identifying the depth of stored sediments was judged to be acceptable. The clear correlation of decrease in bulk density with clay enrichment differs somewhat from the findings of Bennett et al. (2005), where a weaker relationship was found.

$^{137}$Cs data was used to verify the pre-impoundment level in Denmark Lake core 1 (Figure 6) and Lt 14A-4 core 1 (Figure 7). Since these lakes were constructed so close to 1964±2 year peak in atmospheric nuclear testing, the peak in $^{137}$Cs activity was taken to indicate the depth of sediment accumulation. Figure 6 shows good agreement of the $^{137}$Cs peak with clay enrichment and reasonable agreement with decreasing bulk density. Here, % silt was not plotted because it showed no discernable trend and obscured the % sand and % clay plots. In Figure 7, the $^{137}$Cs differs from the bulk density and clay enrichment derived bottom depth by 10 cm. Within the constraints and error bounds of the current sampling methodology, the $^{137}$Cs data were in agreement with the clay enrichment/bulk density decrease for determining the depth of impounded sediments. Figure 7 also shows a significant depletion in % sand near the pre-impoundment level indicated by bulk density and % clay depletion.

The mean sedimentation rates shown in Table 1 were unexpectedly low. It was expected that high sedimentation rates early in the reservoirs' life spans would create an overall higher sedimentation rate. The methods used in the present study only allow average rates of sedimentation to be assessed, so positive identification of such a trend is not possible. The loss in storage data also shows little impairment of these structures. Lt 14A-4 shows the most loss in storage at 19%. This is not surprising since, of those examined here, it is the smallest lake and is part of the largest watershed. Lt14A-4 had a similar accumulation rate to Denmark Lake, but because of its increased area, Denmark shows only a 9% reduction in storage.

## CONCLUSIONS

Sedimentation rates and loss in storage for 3 small erosion control lakes in the Holly Springs National Forest east of Oxford, Mississippi, were assessed. Sediment accumulation rates and reductions in storage caused by impounded sediments were found to be lower than expected. Accumulation rates were significantly less than those found by Bennett et al. (2005) in Grenada Lake. Using the method described by Bennett et al. (2005) for determining the depth of deposition appears to have been successful. Comparison with limited $^{137}$Cs data shows reasonable agreement with % clay enrichment and decrease in bulk density data. An interesting divergence from the findings of Bennett et al. (2005) was the clear delineation of bulk density corresponding to $^{137}$Cs peaks and % clay enrichment. Differences of this nature are likely to be associated with the smaller size and largely forested nature of the watersheds examined in the present study.

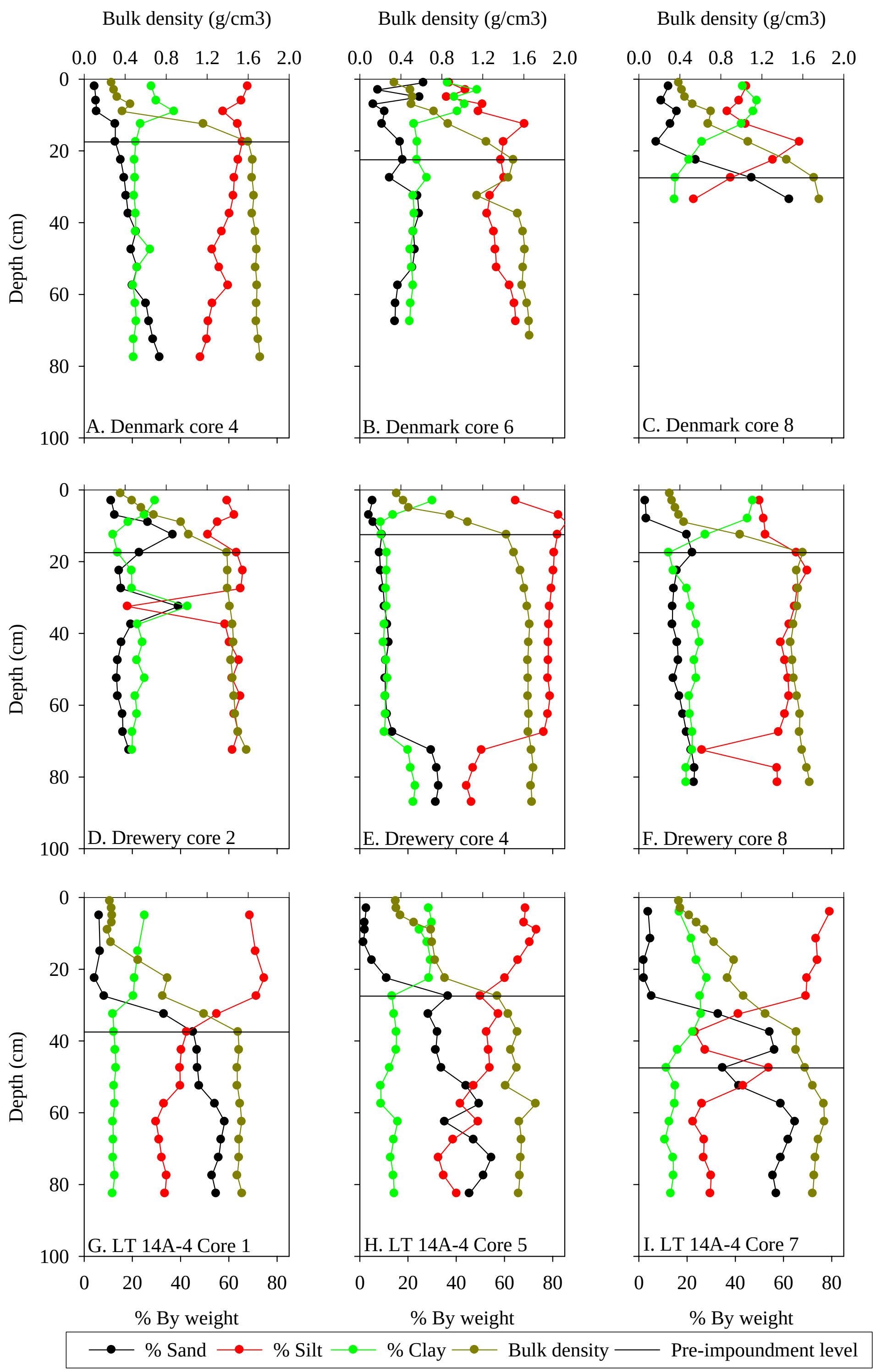


Figure 5 Selected particle size and bulk density data.

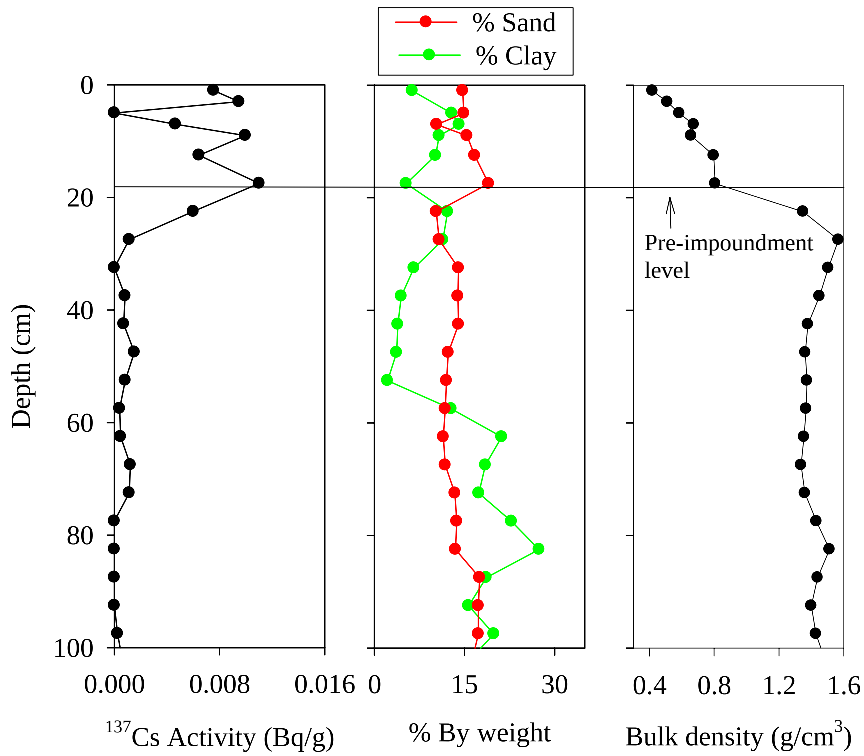


Figure 6 $^{137}$Cs activity, % sand, % clay, and bulk density data from Denmark Lake core 1.

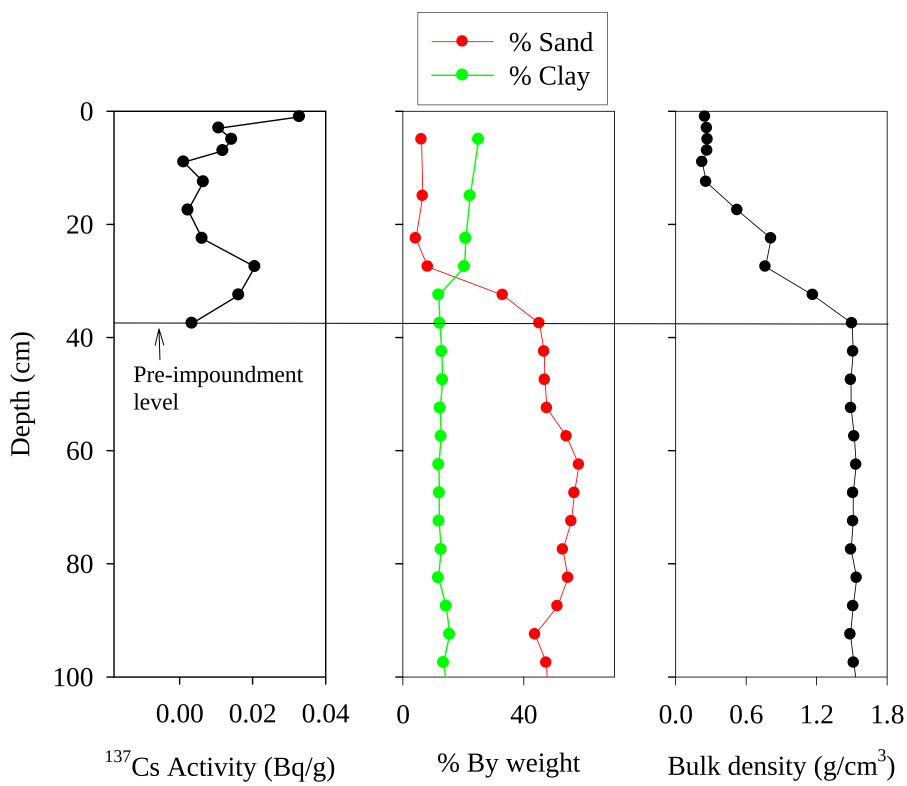


Figure 7 $^{137}$Cs activity, % sand, % clay, and bulk density data from lake Lt 14A-4.

## ACKNOWLEDGEMENTS

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