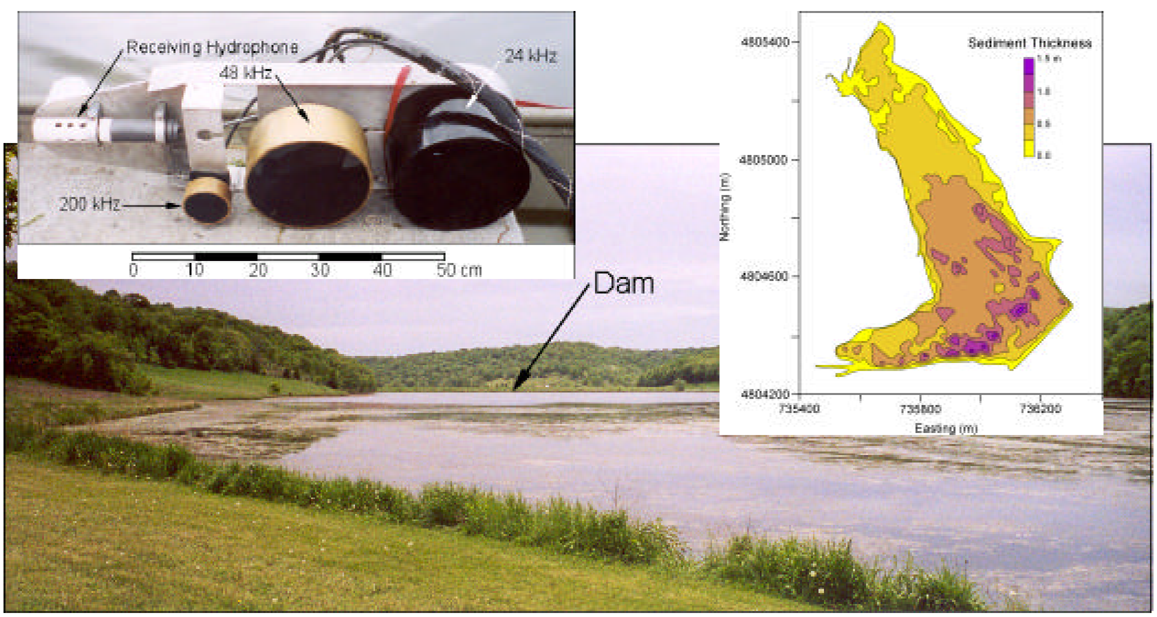
Agricultural Research Service

National Sedimentation Laboratory
Channel and Watershed Processes Research Unit
Oxford, Mississippi

Acoustic Imaging of Sediment Impounded Within USDA-NRCS Flood Control Dams, Wisconsin



By John A. Dunbar, Paul D. Higley, and Sean J. Bennett

Research Report No. 30 **August 2002**

Executive Summary

Since 1948, the USDA-NRCS has constructed nearly 11,000 upstream flood control dams in 2000 watersheds in 47 states, most with a design life of 50 years. The watershed projects, which represent a $14 billion infrastructure, have provided flood control, municipal water supply, recreation, and wildlife habitat enhancement. Because of population growth and land use changes through time, sediment pools are filling, some structural components have deteriorated, safety regulations are stricter, and the hazard classification for some dams has changed. Presently, 42 dams in Wisconsin are in need of immediate rehabilitation at an estimated cost (1999 dollars) of $3 million.

Before any rehabilitation strategy can be designed and implemented, the sediment impounded by these dams must be assessed in terms of the structure's efficiency to regulate floodwaters and the potential hazard the sediment may pose if reintroduced into the environment. At the direct request of the USDA-NRCS in Wisconsin, two reservoirs, White Mound Lake located in Sauk County and Twin Valley Lake located in Iowa County, were chosen as part of their statewide assessment program. To this end, this study was undertaken to determine the amount and distribution of post-impoundment sediment contained within these selected flood control reservoirs using an acoustic profiling system.

The acoustic profiling system used in the surveys was developed in collaboration with Specialty Devices, Inc. of Plano, TX. The complete system consists of one, suitcase-sized, 10 kg, water resistant control module, a 50 cm long, 15 kg acoustic source array, GPS and differential correction antennas, and associated cables. The system images the bottom and sub-bottom sediments with acoustic signals produced at 200, 48, and 24 kHz, deployed from a single Johnboat.

The results from the two surveys were quite similar. The acoustic response of sediments onlapping the dam face shows three distinct acoustic layers. The upper-most layer, which appears white on the multifrequency displays, corresponds to fine-grain, water-rich sediments. The layer beneath the first, which appears light blue in the display, preferentially fills the lows and channel axes, and thins and becomes more restricted upstream. The bottom-most layer deposited on the dam face, which appears dark blue in the display, is relatively thin in both reservoirs, but reaches considerable thickness in the channel axes.

At Twin Valley Lake, the sediment isopach map indicates a maximum thickness of 3.1 m, in a small area along the main channel axis, and a total volume of post-impoundment sediment of 458,659 m^3 (371.8 acre-ft). At White Mound Lake, the sediment isopach map indicates a maximum thickness of 1.4 m (4.6 ft) and a total volume of post-impoundment sediment of 203,205 m^3 (164.7 acre-ft). These values represent conservative estimates of sediment accumulation without corroboration with ancillary data.

Table of Contents

List of Figures

Acknowledgments

We thank Barbara Lensch and Scott Mueller, both of the USDA-NRCS, Wisconsin, for providing technical and logistical assistance, and the USDA-NRCS, Wisconsin, for financial support.

Author contact information:

John A. Dunbar
Department of Geology
Baylor University
P.O. Box 97354
Waco, TX 76798-7354
john_dunbar@baylor.edu

Paul D. Higley
Specialty Devices, Inc.
1104 Summit Avenue
Suite #104
Plano, TX 75074
sdipdh@aol.com

Sean J. Bennett
USDA-ARS
National Sedimentation Laboratory
P.O. Box 1157
Oxford, MS 38655
sjbennett@ars.usda.gov

1. Introduction

1.1 Federal Program for Flood Control

In response to devastating floods of the 1930's and 1940's, Congress enacted legislation for the construction of flood control dams on small tributary streams. The Flood Control Act of 1944 (PL-534) authorized 11 projects in the United States. Since 1948, more than 3,400 flood control dams have been constructed in the 320 subwatershed projects covering more than 35 million acres in 12 states (Caldwell, 1999).

In 1954, Congress enacted the Watershed Protection and Flood Preventaion Act (PL-566), commonly referred to as the Small Watershed Program (Caldwell, 1999). Since that time, more than 6,300 flood control dams have been constructed in 47 states as well as Puerto Rico and the Pacific Rim, covering over 109 million acres.

The Pilot Watershed Program provided the transition between PL-534 and PL-566 (Caldwell, 1999). More than 400 flood control dams were constructed in 62 projects in 33 states, covering almost 3 million acres. In addition, the RC&D Program has provided technical and financial assistance to local sponsors for the planning, designing, and construction of more than 200 flood control dams since the 1960's.

In total, the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) and its cooperators have constructed nearly 11,000 flood control dams in 47 states. More than $8.5 billion (1997 dollars) of federal funds and over $6 billion of local funds have been invested in these projects since 1948. This $14.5 billion infrastructure provides over $1 billion in benefits annually.

The primary purposes for these structures were to prevent flooding and to protect watersheds. Other dams were built or have evolved into structures for water management, municipal and industrial water supply, recreation, and the improvement of fish and wildlife, water quality, and water conservation. Local sponsors were to provide leadership in the program and secure land rights and easements for construction. The USDA-NRCS was to provide technical assistance and cost-sharing for the construction of these dams.

Flood control dams typically consist of an earthen embankment 6 to 20-m high with a principal spillway made of concrete pipe 0.3 to 1.8-m wide (Caldwell, 1999). Because the dams were built on small streams in the upper reaches of watersheds, upstream drainage areas range from 1.6 to 16 km^2. The majority of these dams were planned and designed for a 50-year service life. The inlet pipe of the principal spillway is placed at an elevation that would provide water retention for the design storm and storage for sediment accumulation. Each reservoir also has an emergency or auxiliary spillway for safe conveyance of water around the embankment when runoff rates exceed storage capacity.

1.2 Current Status of Small Watershed Program

At present, more than half of the dams constructed are older than 34 years and more than 1,800 will reach their 50-year design life within the next 10 years (Caldwell, 2000). A rapid survey conducted in April 1999 by the USDA-NRCS revealed more than 2,200 dams in need of immediate rehabilitation at an estimated cost of more than $540 million. The primary issues of dam rehabilitation are: replacement of deteriorating components, change in hazard classification, reservoir sedimentation, failure to meet dam safety regulations, failure to meet resource needs of the watershed, inadequate land and water rights, inadequate community benefits, and the potential transfer of responsibility. Common approaches to address rehabilitation typically involve dredging the reservoir to remove accumulated sediment, raising the dam to increase storage capacity, and removing or decommissioning the dam.

1.3 USDA-NRCS Flood Control Structures in Wisconsin

Because of the dustbowl era and through the 1950's, rainfall in western Wisconsin caused severe soil erosion, stream sedimentation, and flooding, which also adversely impacted stream trout populations. Flood control structures and conservation practices built and promoted by the USDA-NRCS helped mitigate these problems. Since the inception of the PL-566 program, 83 dams have been constructed in Wisconsin, with 3 additional dams constructed under the related programs. These structures provide over $3.5 million in annual benefits in the form of flood control, recreation, and erosion control, according to the USDA-NRCS.

Presently, 42 dams in Wisconsin are in need of immediate rehabilitation at an estimated cost (1999 dollars) of $3 million. Twelve of these dams require hazard classification upgrades while the remaining 30 dams require an extension of their service life, restoration, and repair.

1.4 Problem Statement

At the direct request of the USDA-NRCS in Wisconsin, two reservoirs, White Mound Lake located in Sauk County and Twin Valley Lake located in Iowa County, were chosen for this study. As part of their statewide assessment program, the USDA-NRCS are interested in determining the volume of sediment deposited within each of these lakes and the spatial distribution of the impounded sediment, since loss of storage capacity is an integral part of the assessment and rehabilitation process.

In the absence of previously collected survey data, acoustic technology offers the possibility of mapping the subsurface distribution of sediment within reservoirs. In previous work, Bennett et al. (in press), Dunbar et al., (2001), and Bennett and Dunbar (in press) used a multifrequncy acoustic system for sub-bottom profiling. The system can comprise up to five acoustic transducers with operating frequencies of 200, 24, 24, 12, and 3.5 kHz, a receiving hydrophone, and a signal processor that controls the acoustic profiling, data collection and processing, and navigational systems. This portable system can be deployed from Johnboats, and it works extremely well in shallow-water environments with clay and silt-rich sediments typical of flood control reservoirs.

The goal of the present report was to determine the current water storage capacity and the amount and distribution of post-impoundment sediment contained within two selected flood control reservoirs in Wisconsin. To achieve this end, acoustic profiling surveys were conducted in order to image the subsurface reservoir fill.

2. Field Sites

2.1 White Mound Lake

White Mound Lake is located in west-central Sauk County, about 13 miles southwest of Reedsburg, WI. Located within White Mound County Park (Figure 2-1), the lake area is approximately 104 acres (Figure 2-2) and it has a maximum depth of about 4.9 m (16 ft). White Mound Lake gets its name from a village once located on the southern end of the park, named for the mounds of white limestone in the region. A boat ramp is available at the location. The reservoir impounding White Mound Lake is structure number 15 on Honey Creek, which has a watershed drainage area of about 4,474 acres. Honey Creek flows eastward from White Mound Lake into the Wisconsin River.

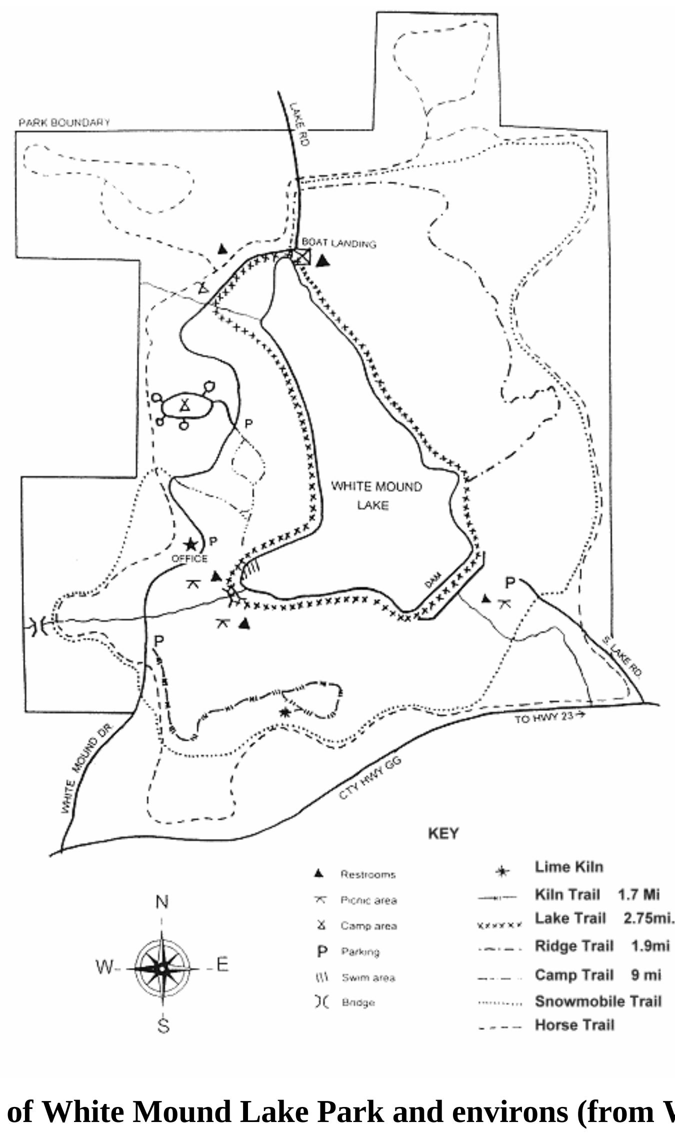


Figure 2-1. Map of White Mound Lake Park and environs (from Wisconsin Department of Natural Resources).

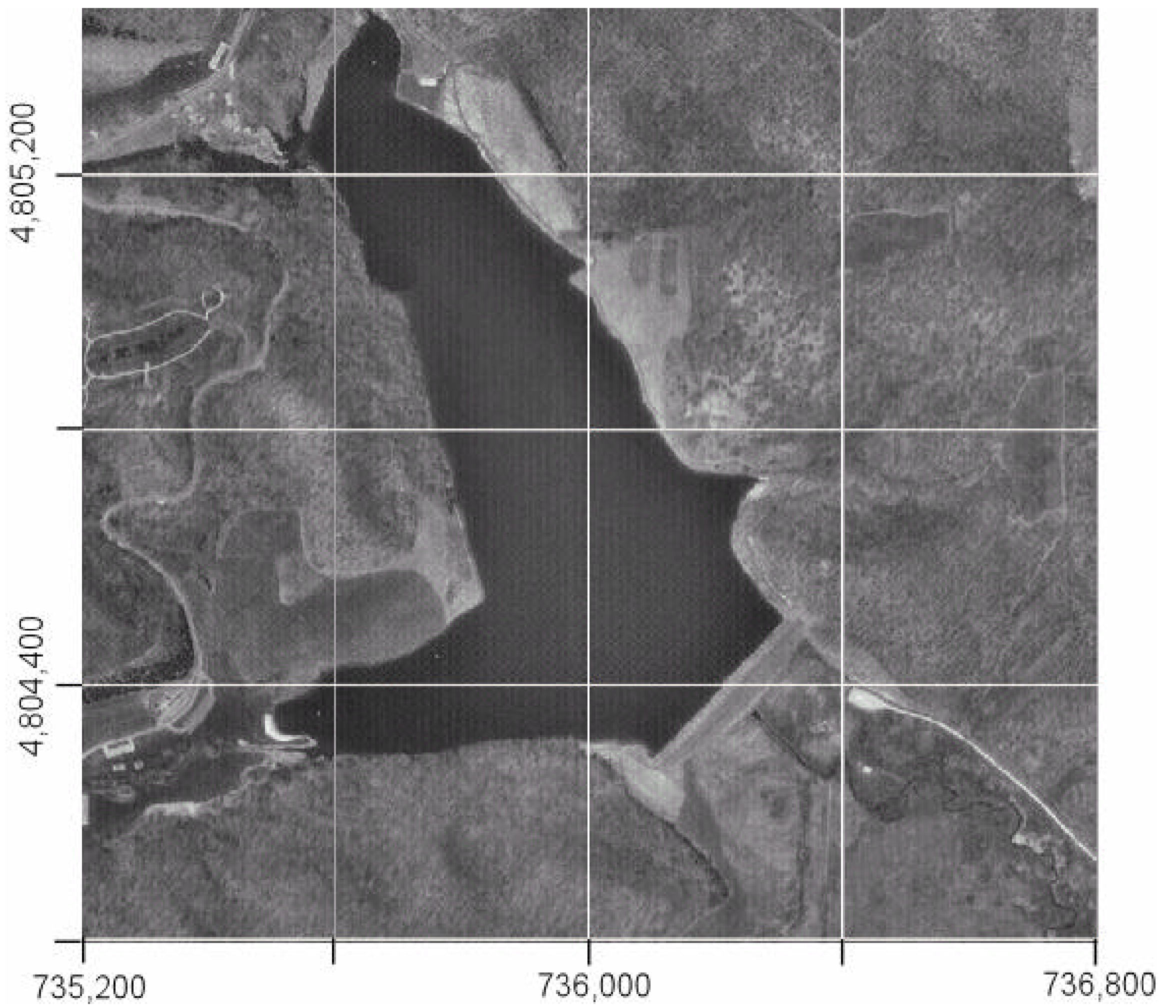


Figure 2-2. Orthographic composite photographic of White Mound Lake, WI. Coordinates are in meters (UTM Zone 15).

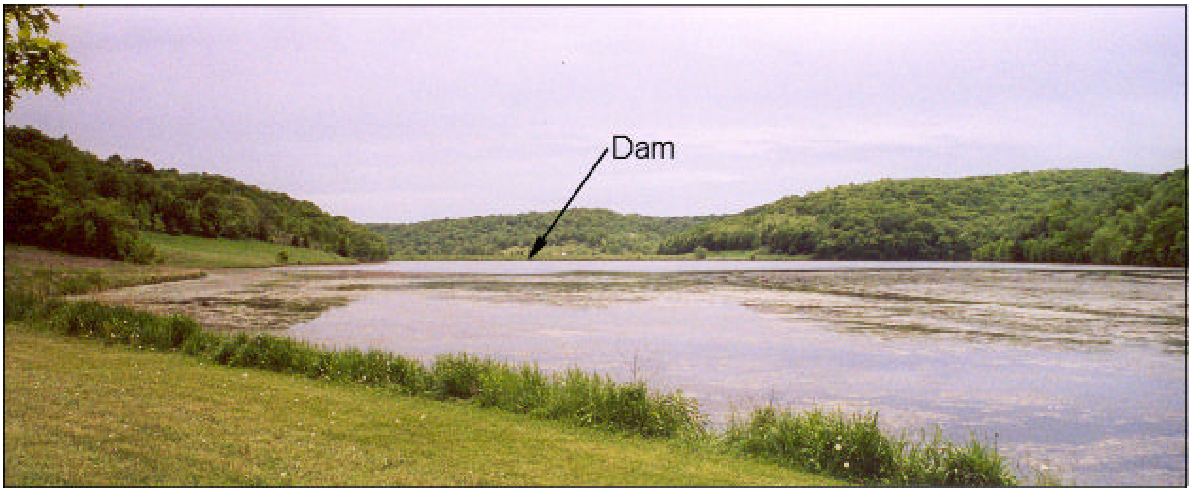


Figure 2-3. The photograph of White Mound Lake taken from the boat ramp area and facing south. Areas of the lake with 4 m of water depth or less contain aquatic vegetation that extends from the bottom to the lake surface as shown in distance.

2.2 Twin Valley Lake

Twin Valley Lake is located in Iowa County approximately 6 miles north of Dodgeville, WI. Located within Governor Dodge State Park (Figure 2-3), the lake area is approximately 152 acres and it has a maximum depth of about 9.8 m (32 ft). Twin Valley Lake was constructed in 1967 for wildlife habitat, recreation, and flood control. The reservoir impounding Twin Valley Lake is structure number 15 on Mill Creek (Figure 2-4). From Twin Valley Lake, Mill Creek flows eastward, northward, and then westward (counterclockwise rotation) into the Wisconsin River.

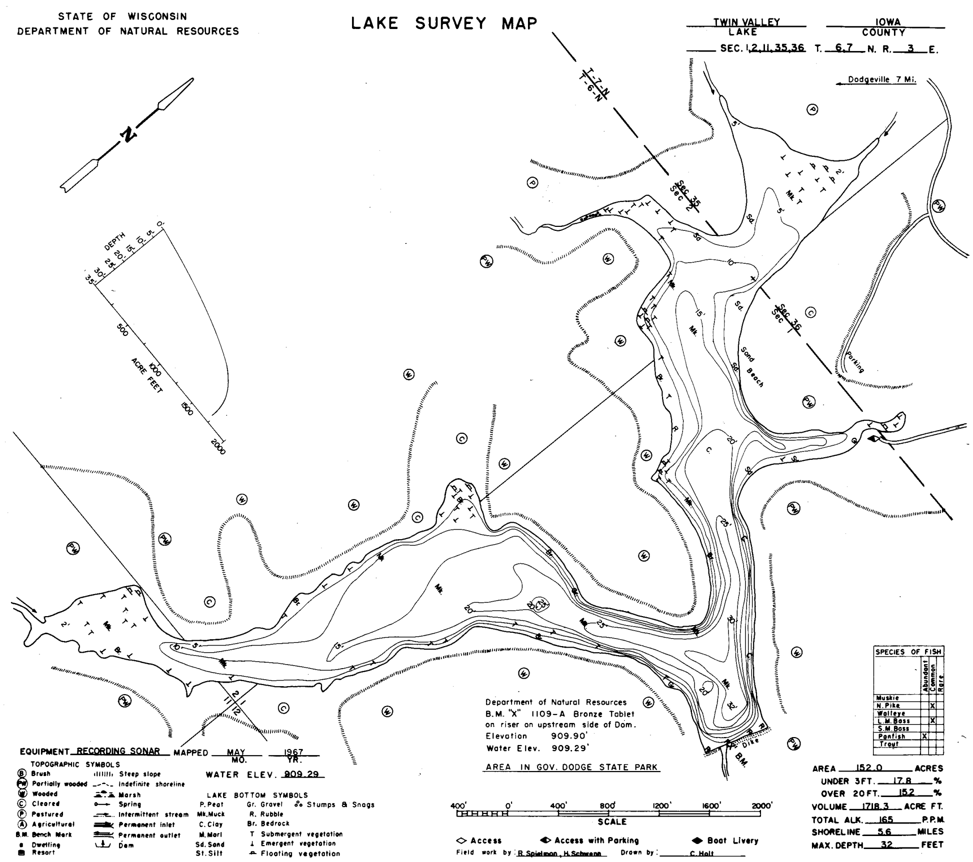


Figure 2-4. 1967 base map of Twin Valley Lake (from Wisconsin Department of Natural Resources).

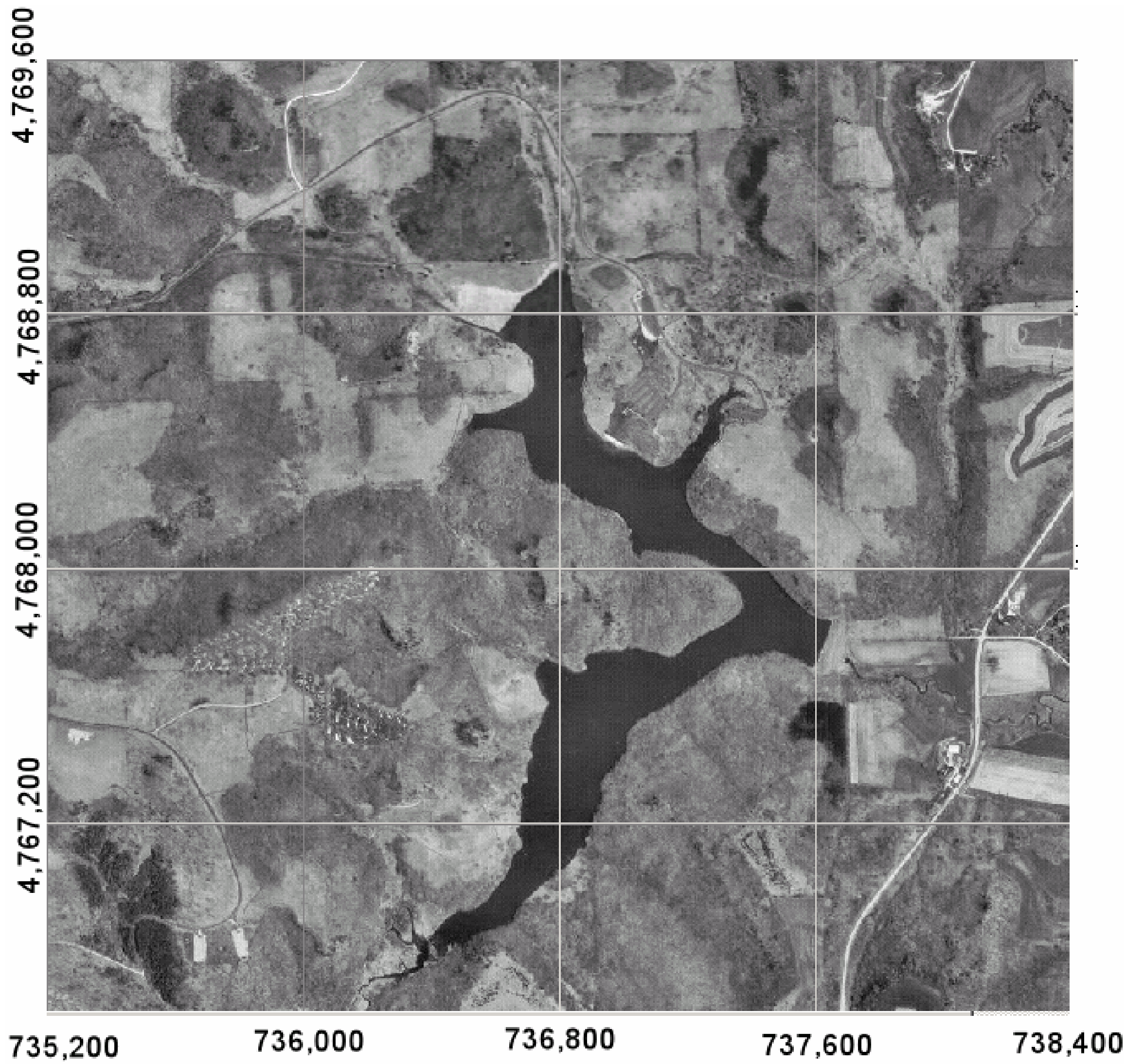


Figure 2-5. Orthographic composite photographic of Twin Valley Lake, WI. Coordinates are in meters (UTM Zone 15).

3. Acoustic Survey System

3.1 Acoustic Profiling System

The acoustic profiling system used herein was developed in a collaboration between Baylor University and Specialty Devices, Inc., Plano, TX (SDI; Dunbar, et al., 1999; Figures 3-1 and 3-2). The system was designed for sediment surveys of large water supply reservoirs, but the commercialized version has been used to survey lakes, harbors, and rivers as well. The prototype electronics module includes one computer that controls the acoustic profiling, another that controls navigation, a built-in computer monitor, and a differential GPS navigation system. All of these components are contained in one, suitcase-sized water-resistant box. The prototype module weighs 15 kg. In the commercialized version, both subsurface profiling and navigation operations are controlled by a single, faster computer, resulting in an electronics module that is smaller and lighter. Power for the electronics and acoustic source is supplied by a 12-volt marine battery. Depending on the number and type of acoustic transducers used, the sound source may weigh between 15 and 30 kg. Hence, even though the system was designed for large reservoir surveys, deployment in small floodwater retention reservoirs is logistically practical.

The system images the bottom and sub-bottom sediments with up to five widely separated acoustic frequencies at a time. For large reservoirs, with water depths of 5 to 50 m and sediment fill thickness of 1 to 10 m, acoustic transducers with central frequencies of 200, 48, 24, 12, and 3.5 kHz are used. During acquisition the system collects traces using each transducer independently in rapid succession in round-robin fashion. The high-frequency signals provide a sharp image of low-density fluid mud at the water bottom, whereas the low-frequency signals penetrate many meters of sediment to image the base of sediment fill, even in areas of high sediment accumulation. The limitation of the 12 and 3.5 kHz transducers is that they require a minimum of 3 to 5 m of water depth to produce usable records while adding significantly to the weight of the sound source (50 kg). The 24 and 48 kHz transducers require 1 to 2 m of water depth to produce usable records. For the present applications, acoustic transducers with central frequencies of 200, 48, and 24 kHz were used (Figure 3-2).

In surveys of water supply reservoirs with boat ramps and significant water depth, the profiling system is deployed from a 24-ft pontoon boat. As is typical of USDA-NRCS flood control reservoirs, boat access to White Mound Lake and Twin Valley Lake were limited to Johnboats. The sound source was suspended from a sling over the side of the boat, holding the transducers at a constant depth below the surface and in a fixed position relative to the GPS antenna. Control over the transducer location is required to achieve precision water depth information and sub-meter horizontal positioning accuracy.

Figure 3-1. Photograph of acoustic profiler control module. All acoustic profiling and DGPS navigation electronics are contained in a compact, water-resistant control module.

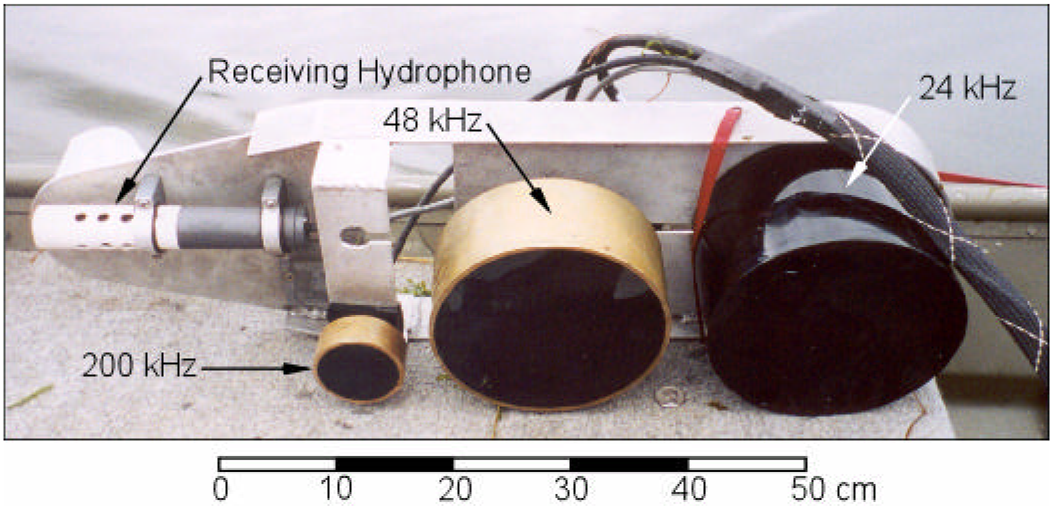


Figure 3-2. Picture of acoustic profiler transducer array. The profiling system produces acoustic signals with three widely separated frequencies (200, 48, and 24 kHz) in rapid succession as the profiles are traversed.

3.2 Survey Procedure

Conventional sediment surveys are conducted by collecting data along a series of parallel profiles at a set spacing that provides adequate spatial coverage, plus a number of tie lines to insure consistency in interpretation between profiles. During the surveys, the pre-planned lines and the current boat location are displayed on the system monitor as the boat is navigated. DGPS corrections are received from U.S. Coast Guard beacons so that the location of the boat can be determined with sufficient accuracy to guide it down the line in real-time. For both surveys presented herein, strong correction signals were available from a station in Milwaukee.

The present survey was conducted on May 30 and 31, 2002 by John Dunbar and Paul Higley. Barbara Lensch and Scott Mueller, both of the USDA-NRCS, Wisconsin, provided technical and logistical assistance.

3.3 Digital Processing and Interpretation of Collected Acoustic Data

The main difference between conventional bathymetric surveying and subsurface profiling is that subsurface profiling involves more extensive digital processing and interpretation of the collected data. During post-survey interpretation, recordings of the frequencies are combined to produce a single, false-color cross-section through the water column and sediment. In the present application, the red component of the RGB display was set to the intensity of the 200 kHz signal, the green component was set to the intensity of the 48 kHz signal, and the blue component was set to the intensity of the 24 kHz signal.

The task of the user is to identify the water bottom and the base of post-impoundment sediment and to trace these surfaces along each profile. This is again accomplished using the program *Depthpic*. The user traces the water bottom and sub-bottom surfaces by drawing on the displayed acoustic data using the computer mouse. The depth and horizontal position of each interpreted point is exported to a file that can be read by commercial mapping programs.

The interpreted base of post-impoundment sediment was identified by locating the deepest stratal surface (acoustic horizon) onlapping the face of the dam. This base of sediment was then traced continuously from deposits on the face of the dam out into the reservoir and up the tributary arms. Once this was done, the same basal surface was identified and traced on each of the crossing profiles. For both surveys, a velocity of 1477 m/s was used to represent the average velocity of both water and sediment in the conversion from sound travel time to depth. This corresponds to the speed of sound in fresh water at 65° F and to near bottom sediments with a composition intermediate between clay and sand.

An additional surveying difficulty was caused by the occurrence of thick aquatic vegetation in areas of the reservoirs with 4 m of water depth or less (Figure 3-3). During the surveys, the weeds fouled the outboard propeller and transducer array. It was discovered during post-processing, that the vegetation efficiently scatters high frequency sound, making the 200 kHz data useless in heavily vegetated areas. Fortunately, the vegetation was nearly transparent to the 48 kHz signal. Hence, the water bottom was traced using the 48 kHz data alone in the vegetated areas.

To generate water depth maps, the interpreted depths and horizontal positions for each profile were exported from *Depthpic* to an ASCII file of x, y, z values. These data were combined with points defining the shorelines of each lake that were digitized from orthographic composite photographs. The combined data were read by *Surfer*™, grided using a triangulation and linear interpolation procedure, and contoured. The contour maps generated by *Surfer*™ were then exported to a drafting program to make the final figures presented herein. The sediment thickness maps were generated in the same way, except that the sediment isopach thickness (difference between the depth to the base of sediment and the water depth) was exported directly from *Depthpic*. Volumes were computed by trapezoidal rule applied to the interval grids.

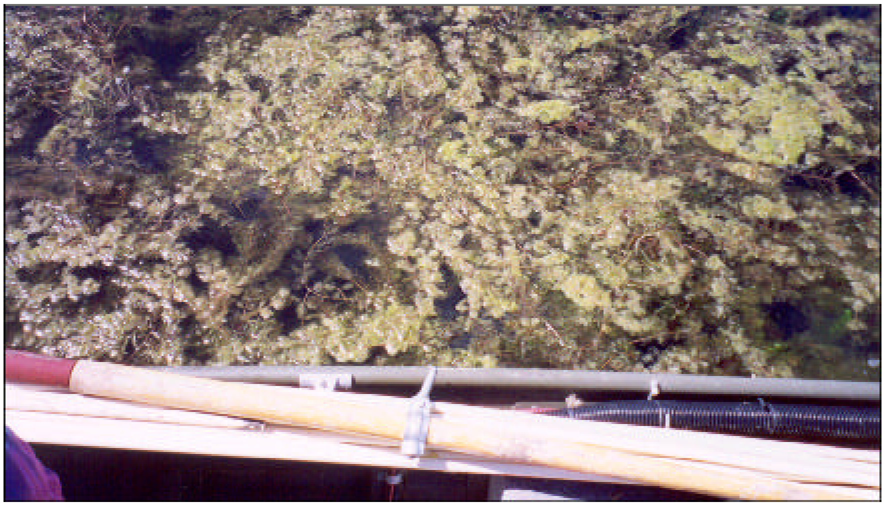


Figure 3-3. Picture of aquatic vegetation. Both White Mound Lake and Twin Valley Lake contain vegetation that extends from the water bottom to the surface in areas of 4 m water depth and less. The vegetation scatters the 200 kHz acoustic signals.

4. Results

4.1 Acoustic Survey of Twin Valley Lake

The survey of Twin Valley Reservoir was conducted on May 30, 2002. The survey began by collecting track lines across the main body of the reservoir near the dam at 25 m spacing. Line-spacing was then switched to 50-m for the tributary arms, in order to complete the survey in one day (Figure 4-1).

The acoustic response of sediments onlapping the dam face show three distinct acoustic layers (Figure 4-2). The upper-most layer appears white on the multifrequency displays, indicating scattered returns from all three frequencies. Such a response commonly corresponds to fine-grain, water-rich sediments. This layer has a nearly uniform thickness, 0.3 to 0.4 m, throughout the reservoir and appears to drape bottom topography. The layer beneath the first appears light blue in the false-color display, indicating returns from the 48 and 24 kHz signals, but not the 200 kHz. This interval preferentially fills the lows and channel axes, is 0.6 m thick near the dam, and thins upstream (Figures 4-2 and 4-3). In the upper reaches of the tributary arms, the light blue layer is only present at the base of the channel axes. The bottom-most layer deposited on the dam face appears dark blue, indicating returns from only the 24 kHz signal. This interval is relatively thin (0.1 to 0.2 m) over most of the reservoir, but reaches considerable thickness in the channel axes.

The resulting map of the water depth indicates a maximum depth of 10.2 m (33.4 ft) near the dam and a total current water capacity of 2,089,500 m^3 (1693.6 acre-ft; Figure 4-4). The sediment isopach map indicates a maximum thickness of 3.1 m, in a small area along the main channel axis, and a total volume of post-impoundment sediment of 458,659 m^3 (371.8 acre-ft; Figure 4-5).

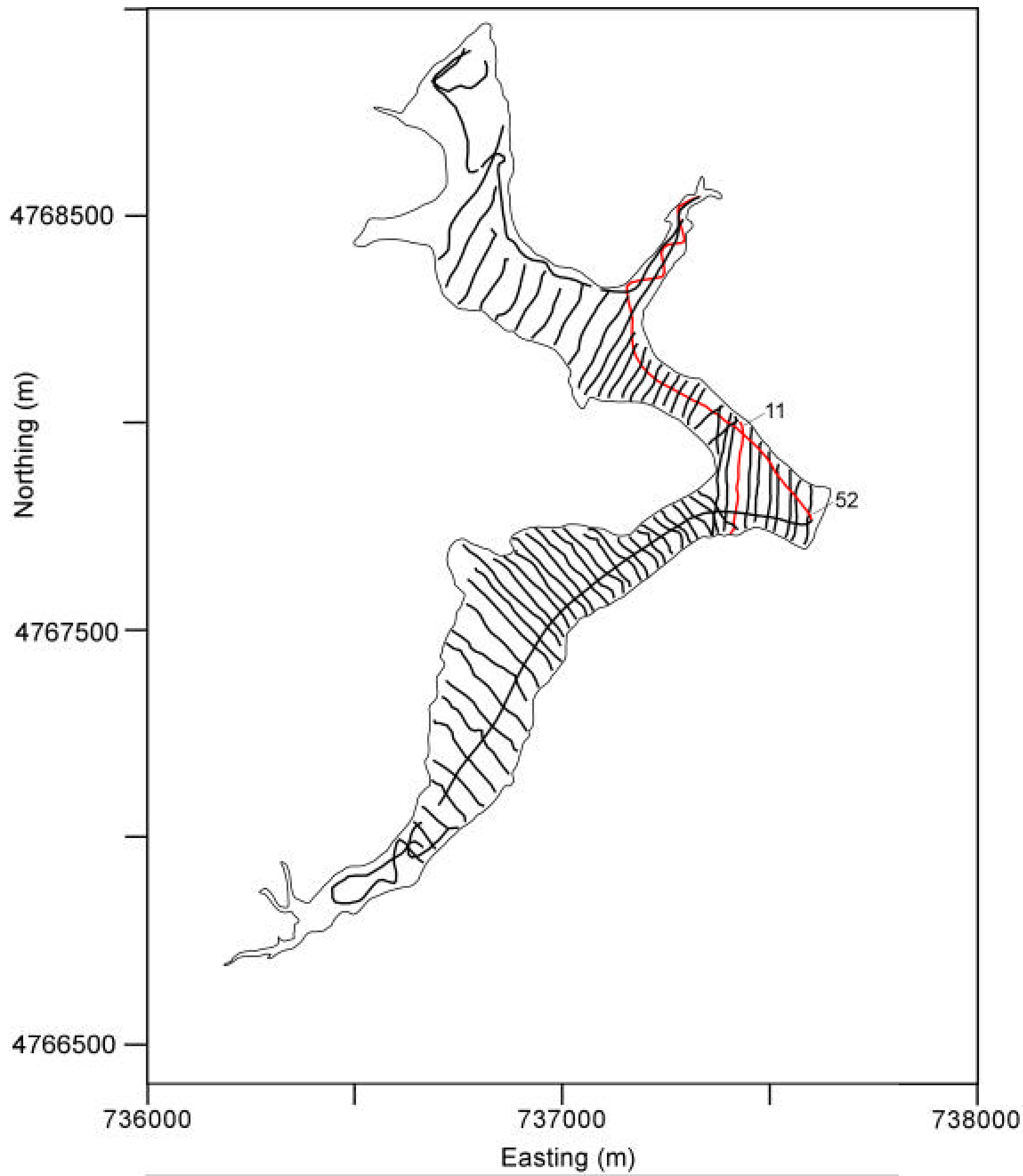


Figure 4-1. Profile map of Twin Valley Lake acoustic survey. The survey contains 17 km of profile lines. Profiles 11 and 52, highlighted in red, are shown as example profiles in accompanying figures. Coordinates are in meters (UTM Zone 15).

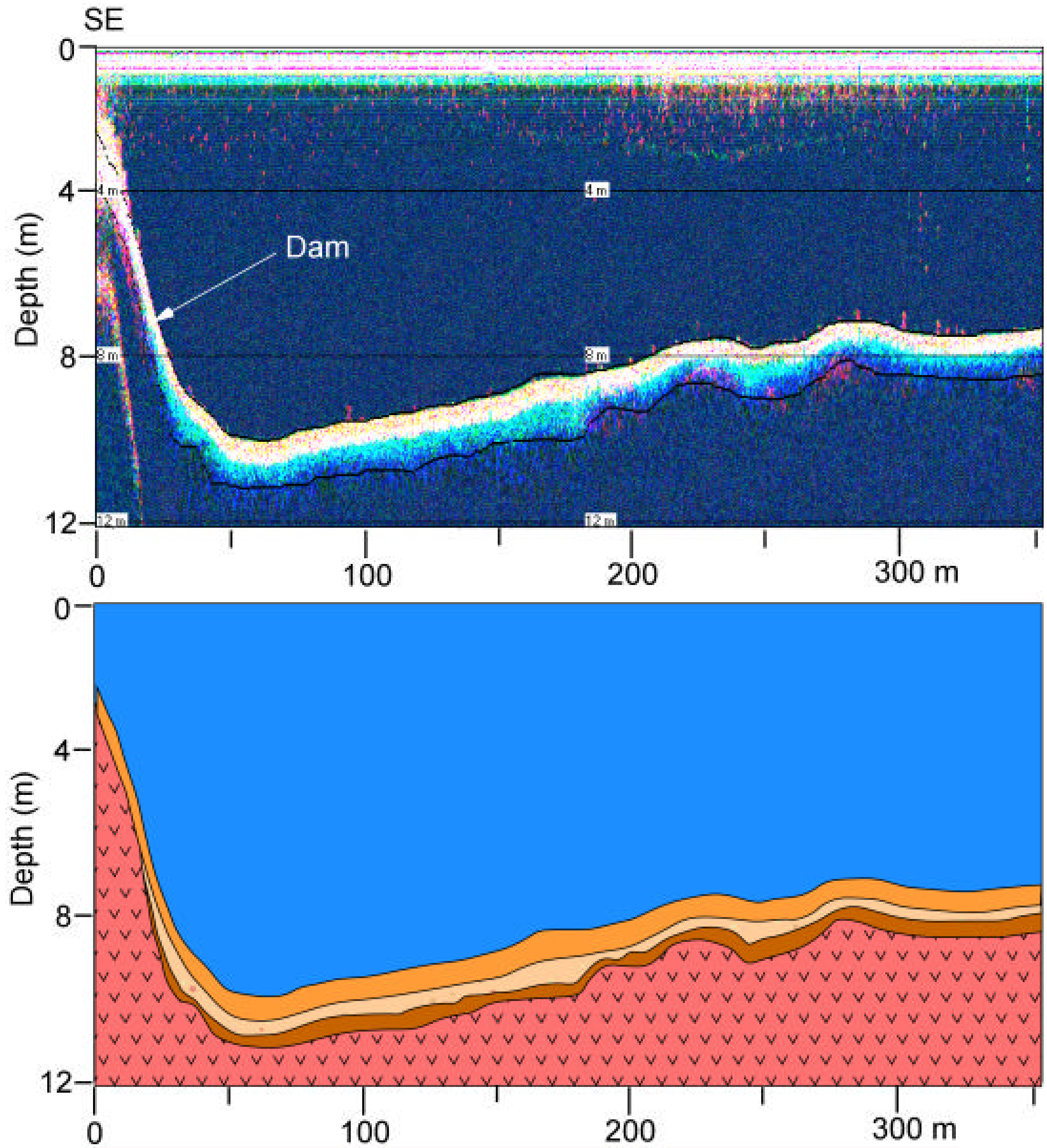


Figure 4-2. Southeast end of Twin Valley Lake axial profile, Line 52 (see Figure 4-1 for line location). Three acoustic intervals are seen within the sub-bottom in Twin Valley Lake. All three onlap onto the dam face. Hence, all three must be part of the post-impoundment sediment fill package.

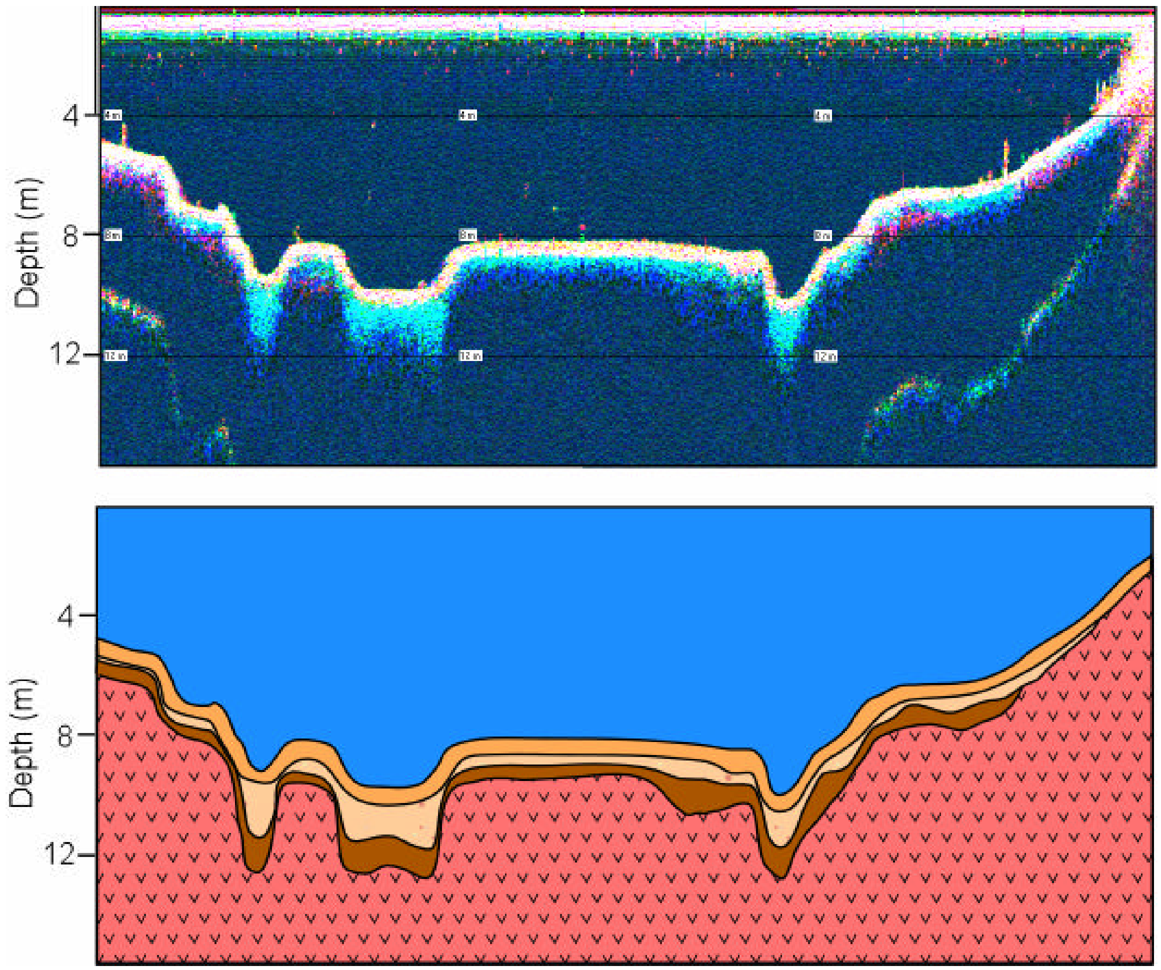


Figure 4-3. Processed Line 11 with interpretation (see Figure 4-1 for line location). The multifrequency acoustic profiles show three distinct sediment layers within the post-impoundment fill.

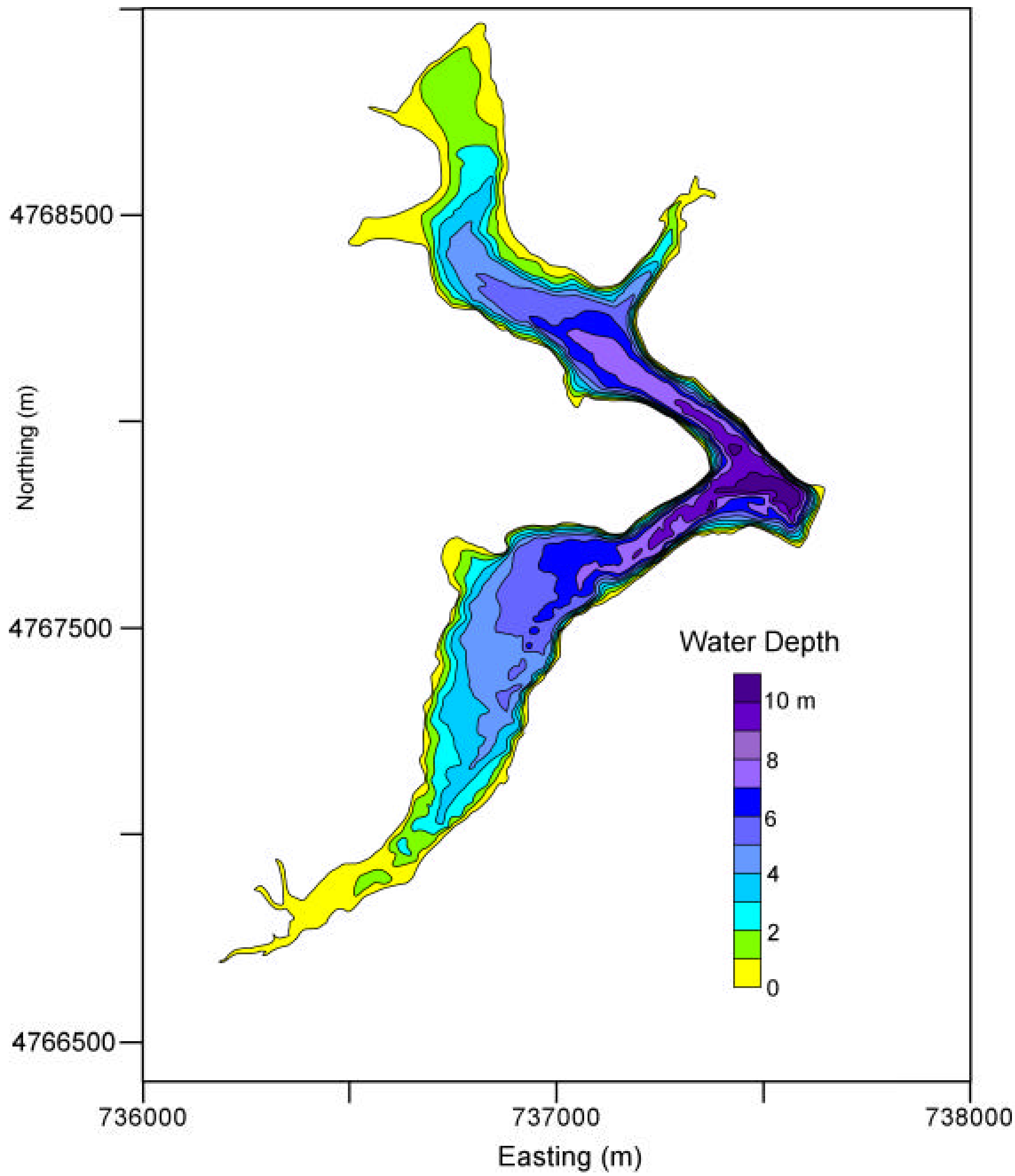


Figure 4-4. Contour map of water depth in Twin Valley Lake, WI. Depth is measured from the water surface at an elevation of 277.4 m (910 ft). Coordinates are in meters (UTM Zone 15).

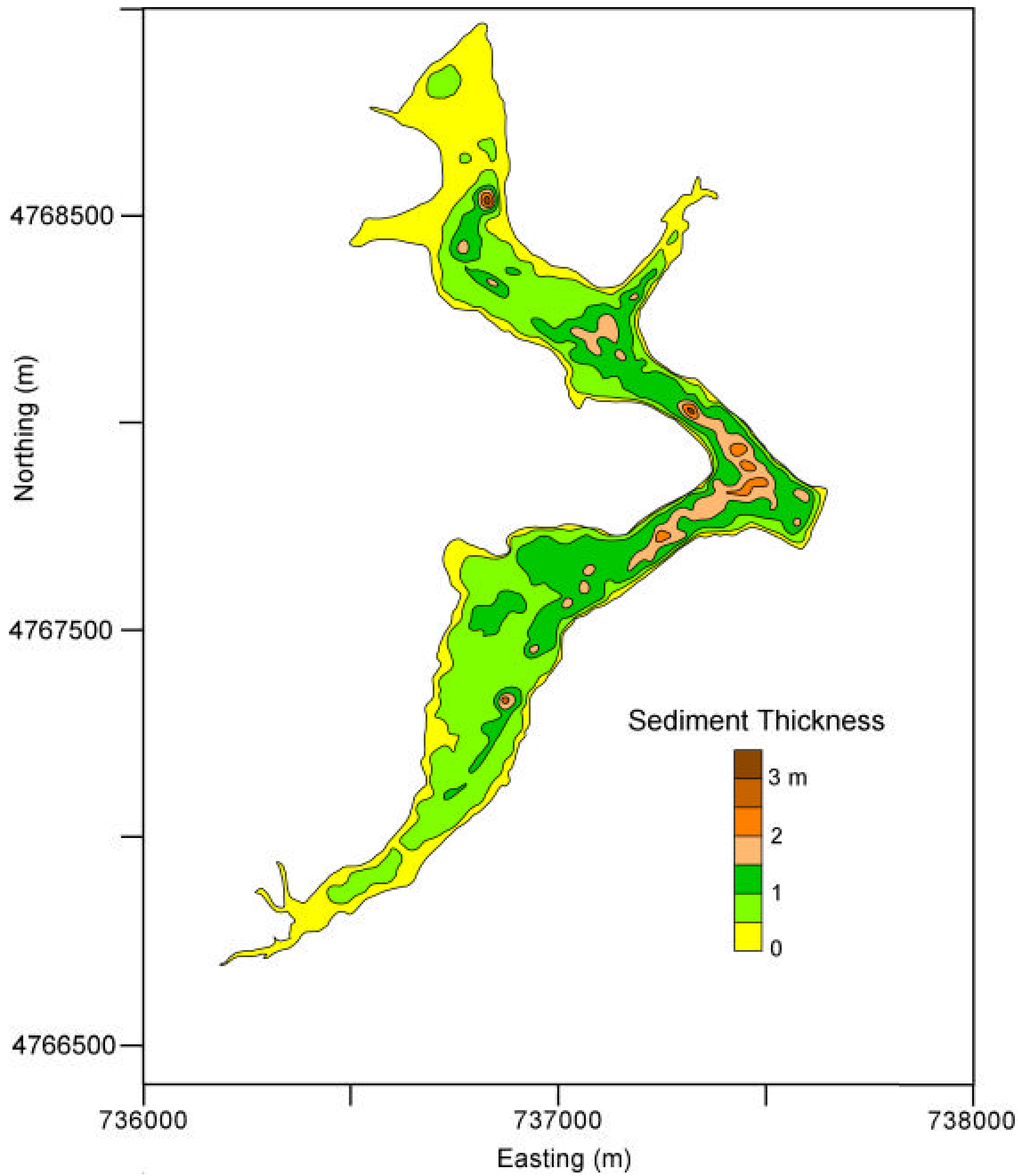


Figure 4-5. Contour map of sediment thickness in Twin Valley Lake, WI. Sediment thickness is measured from the water bottom to the interpreted base of post-impoundment fill. Coordinates are in meters (UTM Zone 15).

4.2 Acoustic Survey of White Mound Lake

White Mound Reservoir was surveyed on May 31, 2002. The entire survey was conducted with a 25-m track line spacing (Figure 4-6). Acoustic intervals similar to those seen in Twin Valley Lake were observed in White Mound Lake onlapping onto the dam face (Figure 4-7) and thinning upstream (Figure 4-8). The resulting maps indicate a maximum water depth of 8.6 m (28.3 ft) and a current water storage capacity of 1,462,460 m^3 (1,185.4 acre-ft; Figure 4-9). The sediment thickness map indicates a maximum thickness of 1.4 m (4.6 ft) and a total volume of post-impoundment sediment of 203,205 m^3 (164.7 acre-ft; Figure 4-10).

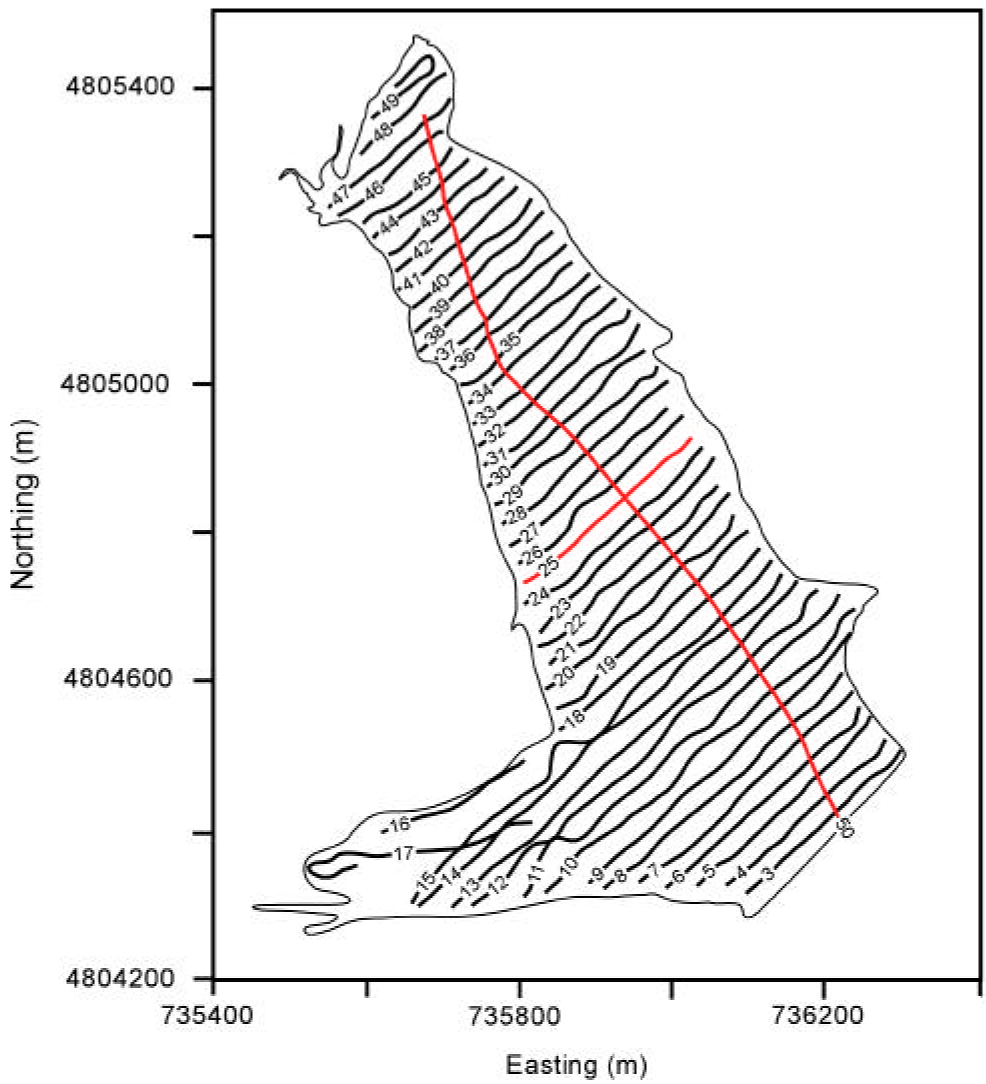


Figure 4-6. Profile map of White Mound Lake acoustic survey. Profiles 25 and 50, highlighted in red, are shown as example profiles in accompanying figures. Coordinates are in meters (UTM Zone 15).

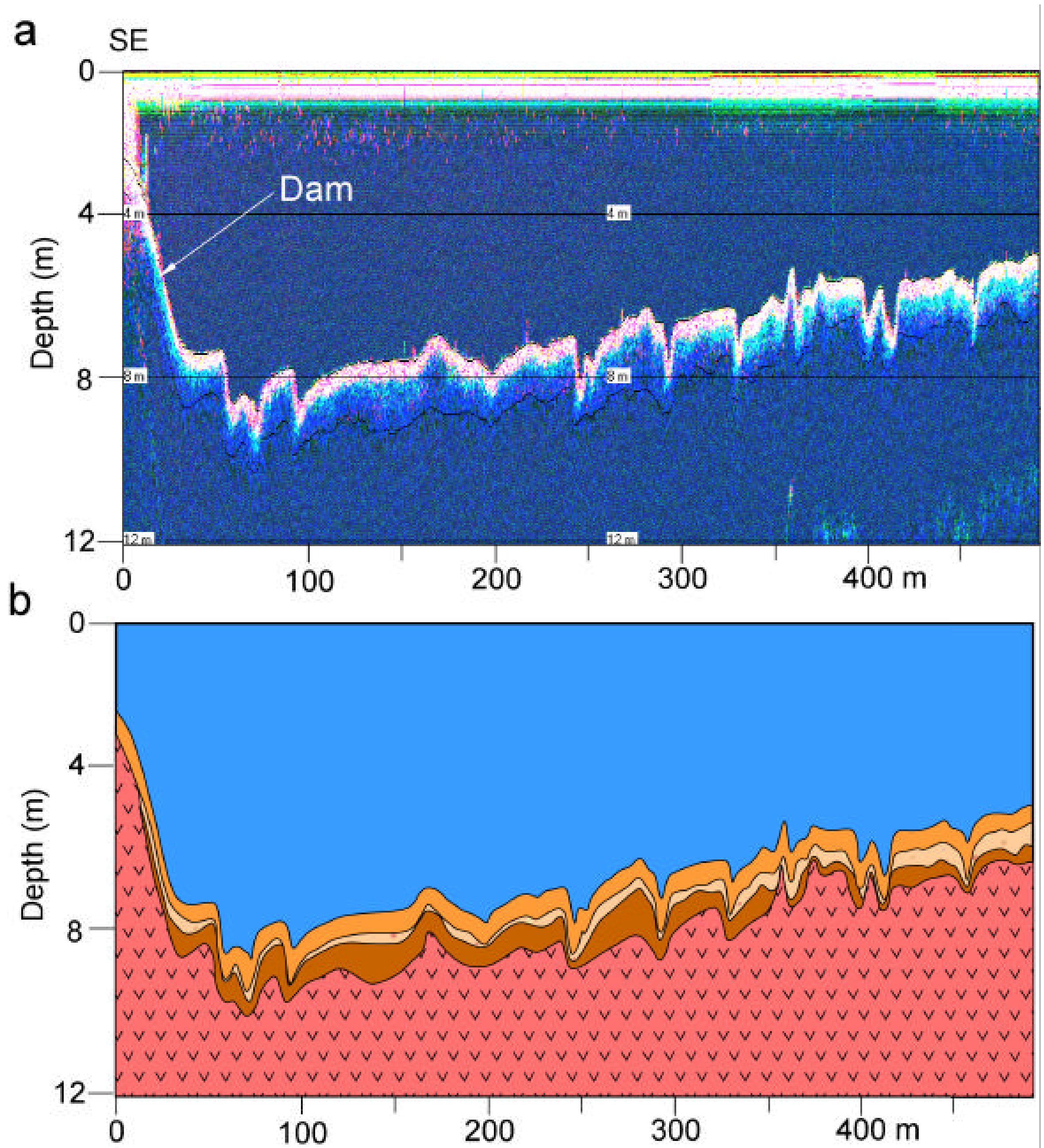


Figure 4-7. Southeast end of White Mound Lake axial profile, Line 50 (see Figure 4-6 for line location). Three acoustic intervals are seen within the sub-bottom in White Mound Lake. All three onlap onto the dam face. Hence, all three must be part of the post-impoundment sediment fill package.

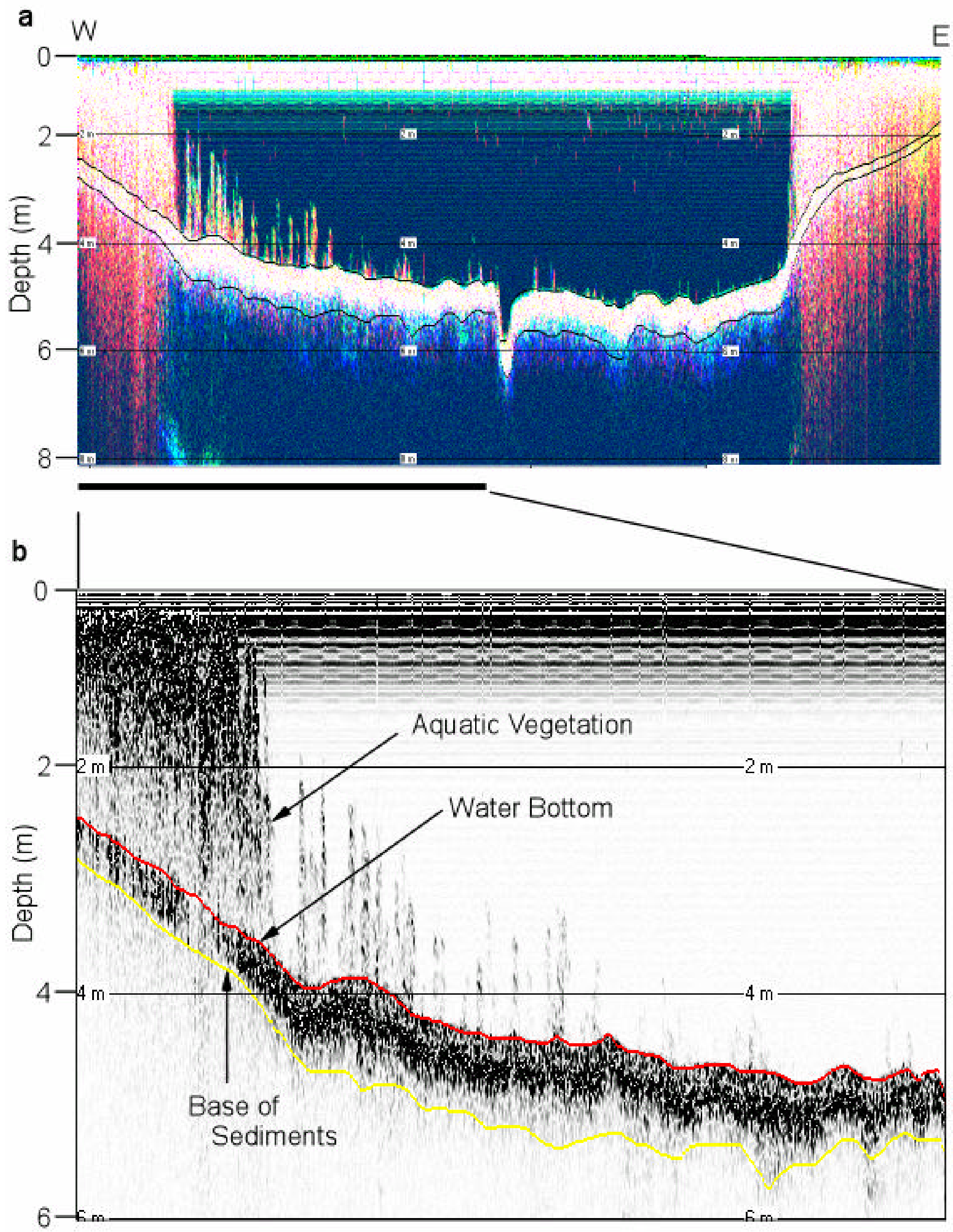


Figure 4-8. Acoustic profile 25 of the White Mound survey (see Figure 4-6 for line location). (a) Multifrequency display in which 200 kHz is red, 48 kHz in green and 24 kHz is blue intensity in the RGB image. The interpreted top and base of the post-impoundment fill are marked with black lines. (b) Aquatic vegetation blocks the 200 kHz signal, but is relatively transparent to the 48 kHz signal.

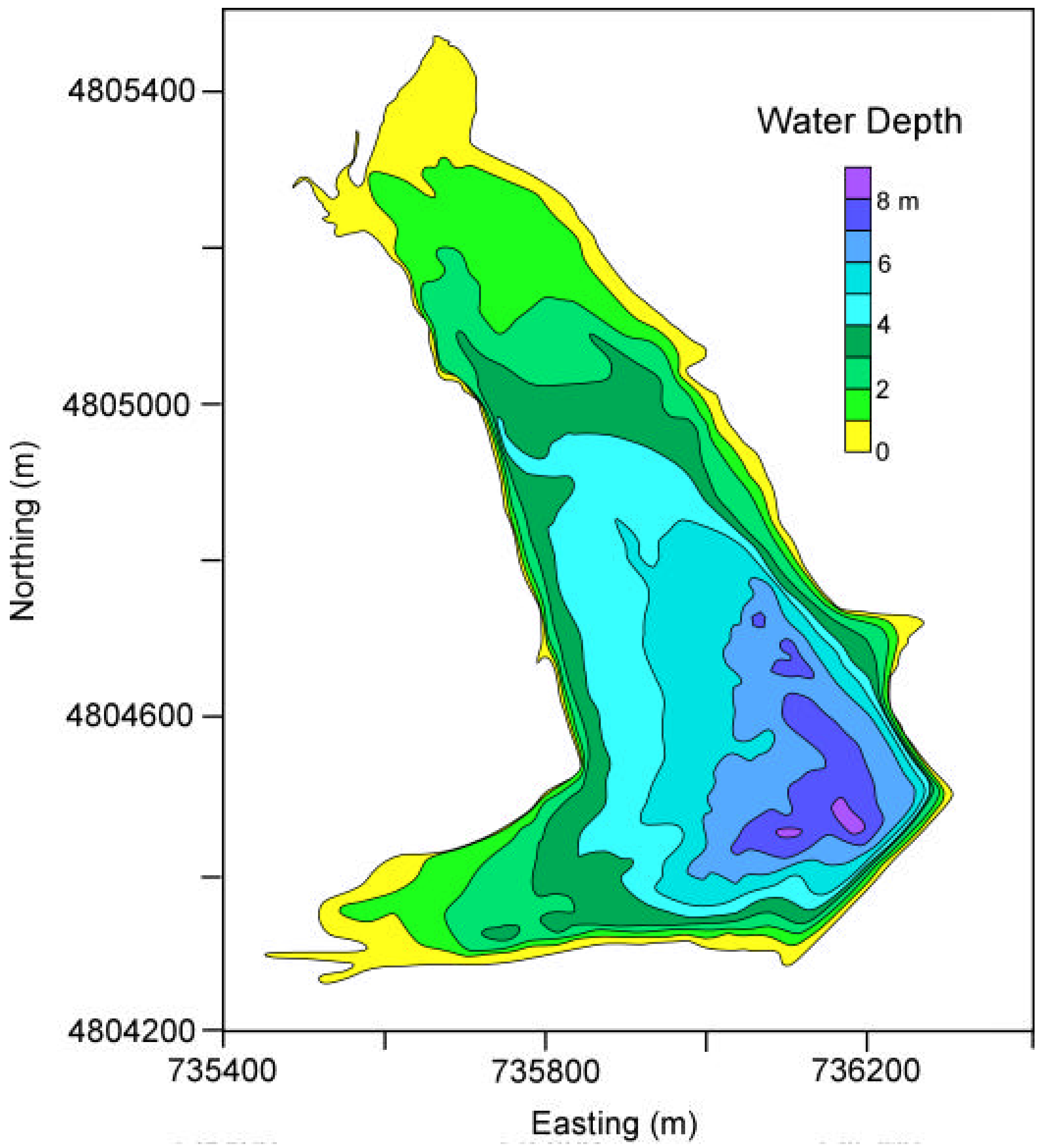


Figure 4-9. Contour map of water depth in White Mound Lake, WI. Depth is measured from the water surface at an elevation of 278.4 m (913 ft). Coordinates are in meters (UTM Zone 15).

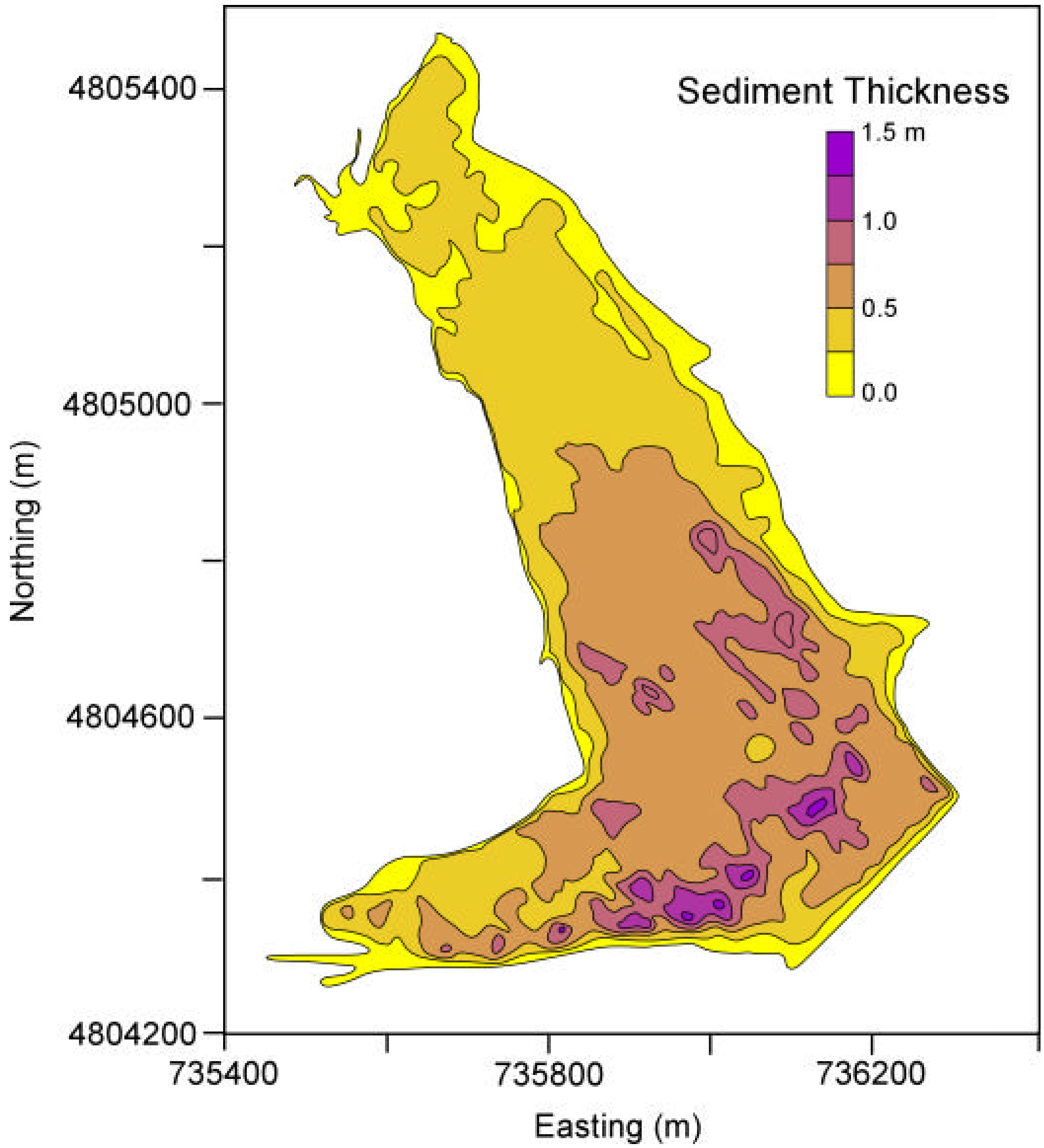


Figure 4-10. Contour map of sediment thickness in White Mound Lake, WI. Sediment thickness is measured from the water bottom to the interpreted base of post-impoundment fill. Coordinates are in meters (UTM Zone 15).

4.3 Discussion

The SDI acoustic profiling system produced interpretable images of the water bottom and the base of sediment fill throughout both reservoirs. The major uncertainties and sources of error in the surveys are associated with error in the speed of sound and potential error in identifying the base of post-impoundment sediment. The speed of sound in fresh water varies about 0.6 % due to a 5° F temperature change from 65° F. Hence, variation in the water velocity with the average temperature would not contribute to more than 1 to 2% error in water volume estimates. Unconsolidated sediments near the water bottom range in velocity from 1530 m/s for pure sand to 1430 m/s for pure clay. Hence, it is possible, though unlikely, that sediment thickness estimates could be in error by as much as 3 to 4%, because of uncertainty in the speed of sound in the sediments.

Misidentification of the stratal surface marking the base of post-impoundment sediment could result in significant error in the estimated total sediment volume. In reservoirs characterized by water- and clay-rich sediment fill, the acoustic contrast between the pre-impoundment soils and alluvium and the overlying low-density fill is easily identified and mapped. The sediments in the Twin Valley and White Mound Reservoirs appear to be predominantly composed of silt and clay and produce reasonably distinct acoustic contrast with the pre-impoundment material. Tracing the basal surface of sediments deposited on the dam face provides an additional check on the correct identification of the base of post-impoundment fill in these surveys.

As discussed in Bennett et al. (in press) and Bennett and Dunbar (in press), the critical interpretation in sedimentation assessment is to accurately discriminate between the pre-impoundment material and the post-impoundment sediment deposition. This discrimination is made more easily with ancillary data, obtained through coring activities, such as the physical, textural, and chemical characteristics of the sediment or through the use of isotopic signatures of elements or radioactive emissions of Cesium-137 to facilitate dating specific sediment horizons. In the absence of these data, the maps of sediment thickness presented herein represent conservative estimates of sediment accumulation rates.

5. Conclusions

Since 1948, the USDA-NRCS has constructed nearly 11,000 upstream flood control dams in 2000 watersheds in 47 states, most with a design life of 50 years. The watershed projects, which represent a $14 billion infrastructure, have provided flood control, municipal water supply, recreation, and wildlife habitat enhancement. Because of population growth and land use changes through time, sediment pools are filling, some structural components have deteriorated, safety regulations are stricter, and the hazard classification for some dams has changed. Presently, 42 dams in Wisconsin are in need of immediate rehabilitation at an estimated cost (1999 dollars) of $3 million. Twelve of these dams require hazard classification upgrades while the remaining 30 dams require an extension of their service life, restoration, and repair.

Before any rehabilitation strategy can be designed and implemented, the sediment impounded by these dams must be assessed in terms of the structure's efficiency to regulate floodwaters and the potential hazard the sediment may pose if reintroduced into the environment. At the direct request of the USDA-NRCS in Wisconsin, two reservoirs, White Mound Lake located in Sauk County and Twin Valley Lake located in Iowa County, were chosen for this study. As part of their statewide assessment program, the USDA-NRCS are interested in determining the volume of sediment deposited within each of these lakes and the spatial distribution of the impounded sediment, since loss of storage capacity is an integral part of the assessment and rehabilitation process. To this end, this study was undertaken to determine the current water storage capacity and the amount and distribution of post-impoundment sediment contained within two selected flood control reservoirs in Wisconsin using an acoustic profiling system.

Two field sites were chosen for this study. The first site is White Mound Lake, located in White Mound County Park in west-central Sauk County, about 13 miles southwest of Reedsburg, WI. The lake area is approximately 104 acres and it has a maximum depth of about 4.9 m. The reservoir impounding White Mound Lake is structure number 15 on Honey Creek, which has a watershed drainage area of about 4,474 acres. Honey Creek flows eastward from White Mound Lake into the Wisconsin River. The second site is Twin Valley Lake, located in Governor Dodge State Park in Iowa County, approximately 6 miles north of Dodgeville, WI. The lake area is approximately 152 acres and it has a maximum depth of about 9.8 m (32 ft). The reservoir impounding Twin Valley Lake is structure number 15 on Mill Creek, which flows eastward, northward, and then westward into the Wisconsin River.

The acoustic profiling system used in the surveys was developed in collaboration with Specialty Devices, Inc. of Plano, TX (SDI; Dunbar, et al., 1999). The complete system consists of one, suitcase-sized, 10 kg, water resistant control module, a 50 cm long, 15 kg acoustic source array, GPS and differential correction antennas, and associated cables. A 12-volt marine battery provides power for the system. The system was originally intended to be used for sediment surveys of large water supply reservoirs, but the commercialized version has been used to survey lakes, harbors and rivers as well. The system images the bottom and sub-bottom sediments with acoustic signals produced at 200, 48, and 24 kHz, deployed from a single Johnboat. All collected data were post-processed to amplify the acoustic signals at depth (spherical divergence) and to remove reverberations or multiple sound waves due to the shallow water depth (predictive deconvolution). Once processed, the acoustic data can be interpreted and subsurface stratigraphic horizons can be identified with the aid of false-color coding of the frequency data, although the presence of thick aquatic vegetation scattered some of the high frequency sound.

The results from the two surveys were quite similar. The acoustic response of sediments onlapping the dam face shows three distinct acoustic layers. The upper-most layer appears white on the multifrequency displays, indicating scattered returns from all three frequencies. Such a response commonly corresponds to fine-grain, water-rich sediments. The layer beneath the first appears light blue in the false-color display, indicating returns from the 48 and 24 kHz signals, but not the 200 kHz. This interval preferentially fills the lows and channel axes and thins upstream. In the upper reaches of the tributary arms, the light blue layer is only present at the base of the channel axes. The bottom-most layer deposited on the dam face appears dark blue, indicating returns from only the 24 kHz signal. This interval is relatively thin in both reservoirs, but reaches considerable thickness in the channel axes.

At Twin Lake, the sediment isopach map indicates a maximum thickness of 3.1 m, in a small area along the main channel axis, and a total volume of post-impoundment sediment of 458,659 m^3 (371.8 acre-ft). At White Mound Lake, the sediment isopach map indicates a maximum thickness of 1.4 m (4.6 ft) and a total volume of post-impoundment sediment of 203,205 m^3 (164.7 acre-ft). These values represent conservative estimates of sediment accumulation without corroboration with ancillary data.

6. References

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