VOLUMETRIC
and
SEDIMENT SURVEY
OF
LAKE CHEROKEE

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CHEROKEE WATER COMPANY

Prepared by:
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EXECUTIVE OVERVIEW

The Texas Water Development Board (TWDB) and Lake Cherokee Water Company entered into contract TWDB 2004-4801-059 in December 2003 to survey the capacity of the lake at the conservation pool elevation and to estimate the post-impoundment sediment volume. Staff of the Hydrographic Survey Team of the TWDB conducted a volumetric and sediment survey of Lake Cherokee during the period of November 10 through 13, 2003. During the November survey, the water levels remained at a constant elevation of 278.6 ft. Staff returned on March 13, 2004, to verify estimated data in the lake's upper reaches. During the March trip, the lake was 0.5 ft above the conservation pool elevation (CPE) of 280.0 ft elevation at elevation 280.5 ft.

For this survey, staff delineated the lake boundary (shoreline) using digital orthophoto quadrangle images (DOQs) photographed in March 1995. Using the Global Positioning System (GPS) and commercially available guidance software, depth and positional data were collected along a layout of transects (pre-plotted navigation lines) spaced approximately 500 feet apart. Acoustic sub-bottom profiles were taken with a three-frequency depth sounding system operating at 200, 50, and 24 kilohertz (kHz). Eight core samples were taken throughout the lake to physically validate the acoustic measurement of sediment thickness.

Approximately 68,000 data points were collected over 80 miles of pre-planned transects. The results of the current survey indicate the lake encompasses 3,467 surface acres and has a capacity of 43,737 acre-feet (ac-ft) at elevation 280.0 ft. The total post-impoundment sediment volume was estimated to be 1,279 ac-ft or 23 ac-ft/yr. The average annual sedimentation rate over 55 years in the Lake Cherokee watershed (158 mi^2) was estimated to be 0.15 ac-ft/mi^2/yr.

LAKE CHEROKEE
VOLUMETRIC and SEDIMENTATION SURVEY REPORT

INTRODUCTION

The Hydrographic Survey Team of the Texas Water Development Board (TWDB) conducted a volumetric and sediment survey of Lake Cherokee to determine its capacity at conservation pool elevation and estimate the post-impoundment sediment volume. They first visited the lake November 10 through 13, 2003, and then returned on March 13, 2004, to verify estimated data in its upstream reach (Figure 1). Lake Cherokee impounds Mill Creek from the south and Barnes, Bacon, and Tiawichi Creeks from the west. All four creeks feed into an area of the lake known as Beaver Marsh southwest of FM 2011.

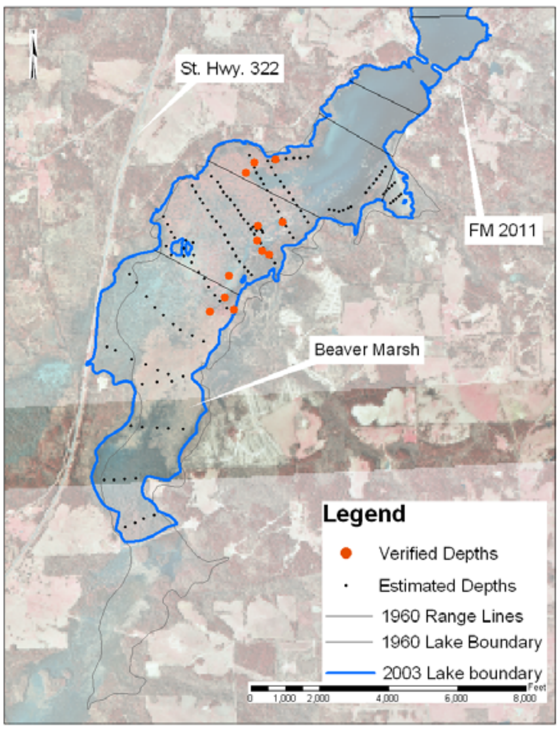

Figure 1. Upstream reach of Lake Cherokee showing range lines established in 1960 by the Soil Conservation Service (SCS). Superimposed on 1995 aerial photos are the 2003 TWDB (blue) and 1960 SCS (light gray) boundaries. The red points indicate where TWDB staff verified depths during the March visit. Smaller black points are estimated depths used in the 2003 model.

The vertical datum used during this survey is referenced to the lake elevation gauge used by the Cherokee Water Company. Volume and area calculations in this report are referenced to water levels provided by the Cherokee Water Company gauge and are presented in Appendix A and C respectively. The elevation volume and elevation area tables in the TWDB 1997 report were revised in order to use the same boundary as this report (2003) and are presented here in Appendix B and D.

A full discussion of the lake history and general information, including water rights permits and adjudications, can be found in the 1997 TWDB report "Volumetric Survey of Lake Cherokee."[1] Summaries of previous sedimentation rates for the Lake Cherokee watershed are presented and discussed. The following table summarizes information for Cherokee Dam and Lake Cherokee based on information furnished by the Cherokee Water Company[2].

Table 1. Cherokee Dam and Lake Cherokee Pertinent Data

Owner of Dam and Facilities:
Cherokee Water Company, Longview, Texas

Engineer (Design)
Powell and Powell

Location:
On Cherokee Bayou in Gregg and Rusk Counties, 12 miles southeast of Longview, Texas (Figure 1).

Drainage area:
158 square miles.

Dam:

Type	Earthfill
Length (including spillway)	4,000 ft
Maximum height	42 ft structure, 39 ft hydraulic
Top width	20 ft
Top Elevation	295.0 above msl

Spillway (emergency):

Location	Near right end of dam
Type	Cut in natural ground
Crest Length	160 ft
Crest elevation	287.7 ft above msl

Spillway (service):

Location	Left end of dam
Type	Uncontrolled concrete structure
Crest Length	828± ft

Crest elevation	280.0 ft above msl

Outlet works:

Type	Concrete pipe, 18-inch diameter
Invert elevation (lowest gate)	260.0 ft above msl
Control	Gate valve operated from tower

Reservoir Data:
The following information was generated for this report:

FEATURE	ELEVATION (Feet)	CAPACITY (Acre-feet)	AREA (Acres)
Top of Conservation Storage Space	280.0	43,737	3,467
Lowest gated outlet (invert)	260.0	4,714	849

METHODS, EQUIPMENT, AND PROCEDURES

A lake boundary, used in preparing a transect line file, was first developed using Geographic Information System (GIS) software and recent aerial photos. Transects or range lines were drawn using commercially available hydrographic surveying software. The survey crew spaced these transects 500 ft apart and positioned them as perpendicular to existing creek and streambeds as possible. During the data collection phase of the survey, the crew navigated the boat along each transect line using a Global Positioning System (GPS) receiver integrated with the surveying software. Depth reading from a multi-frequency sub-bottom profiler and positional data from the GPS were recorded on an on-board computer for each transect line.

After all the depth and positional data were collected, they were stored for later retrieval. The data were processed and imported into the GIS software for developing a triangular irregular network[3] (TIN) model of the lake bathymetry. Surface areas and volumes were calculated from the TIN for 0.1 ft increments. Appendix K of this report contains a detailed description of all methods, equipment, and procedures used for this survey.

RESULTS

Results from the 2003 TWDB survey indicate that Lake Cherokee is encircled by a shoreline approximately 51 miles in length at gauge elevation 280.6 ft. The deepest point measured during the survey was 34.1 ft, corresponding to gauge elevation 245.9 ft, and was located approximately 5,000 ft upstream of Cherokee Dam.

Encompassing 3,467 surface acres, the lake contains a total volume of 43,737 ac-ft at CPE 280.0 ft. The total post-impoundment sediment volume in the lake was estimated to be 1,279 ac-ft. The annual average sedimentation rate over 55 years was estimated to be 0.15 ac-ft/mi^2/yr using a contributing watershed size of 158 mi^2. This rate of sedimentation is significantly lower than previous estimates.

The bar graph presented in Appendix G illustrates the distribution of sediment volume in the reservoir at 5-foot intervals. Each interval is labeled with its associated percentage of total sediment. It is recommended that another survey using modern methods be performed in five to ten years or after a major flood event to evaluate changes to the lake's capacity.

SUMMARY OF SEDIMENTATION ESTIMATES FOR LAKE CHEROKEE, TEXAS

The sedimentation rate established by theTWDB 2003 survey is the best estimate of average annual sedimentation in the Lake Cherokee watershed for the 55-year period since impoundment. Using differential GPS, multi-frequency sub-bottom profiler, and GIS, the survey team created digital terrain models of the lake's pre- and post-impoundment bathymetry. In addition, TWDB staff reviewed five previous estimates of sedimentation in the Lake Cherokee watershed, and they are presented here in abbreviated form.

Out of the sources included, two are reports on sedimentation for the entire state and four are surveys of Lake Cherokee, including the present 2003 survey. Presented in chronological order, methodologies and results are briefly discussed.

1959 Soil Conservation Service Bulletin 5912

The Soil Conservation Service[4] (SCS) published Bulletin 5912 "Inventory and Use of Sedimentation Data in Texas" in January 1959. This report, which collected and analyzed available data for use in planning and developing water resources in Texas, used a limited number of sedimentation surveys and sediment load measurements to estimate sedimentation production rates for watersheds in Texas. The methods used extrapolated data over large areas and the report states that rates given in the report are "what can be expected from an average watershed." Bulletin 5912 estimated a sediment production rate for the watershed containing the Lake Cherokee watershed to be 0.23 ac-ft/mi^2/yr.

1960 Soil Conservation Service Survey

The SCS performed a sedimentation survey[5] of Lake Cherokee in April 1960. This survey used an aerial mosaic of 1954 photographs and consisted of 34 range lines, from which approximately 1,025 data points were collected. Two significant findings described in the report are (1) conversion of cultivated land to pastureland, and (2) the effects of the1952-57 drought on those and other conservation efforts. Trees and aquatic growth predominate the upstream area of the reservoir; accordingly, the report described the difficulty in collecting data and comments on the probable inaccuracy of calculations in this area. This portion of the reservoir continued to be problematic during 1996 and 2003 surveys (see Figure 1).

The volumes were determined from the collected data by using the range contour formula described in United States Department of Agriculture[6] (USDA) Technical Bulletin No. 524. The 1960 capacity at elevation 280.0 was calculated to be 46,705 acre-feet, and the surface area at this elevation was calculated as 3,987 acres. The average annual sedimentation rate for the 12-year period from 1948 to 1968 was calculated to be 1.37 ac-ft/mi^2/yr at this time.

1979 Soil Conservation Service Report 268

In 1979, the Soil Conservation Service revised and updated the sediment production rates published in the 1959 "Bulletin 5912" by publishing Report 268 "Erosion and Sedimentation by Water in Texas"[7] for the Texas Department of Water Resources. This report, which included a more comprehensive and updated data set compared to the data set used in Bulletin 5912, observed substantial land use change in the 20-year period between the 1959 bulletin and the 1979 report. For example, soil conservation measures had reduced cultivated acres by about 88% during that period. The 1979 calculations used updated, suspended sediment data, whereas the 1959 report used data that was sometimes 30 to 40 years old. Formulas for erosion rates used in the 1979 report were not used in the 1959 report. In addition, the Universal Soil Loss equation was added to the analysis in 1979. Report 268 estimated a sediment production rate for the larger watershed containing the Lake Cherokee watershed to be 0.25 ac-ft/mi^2/yr.

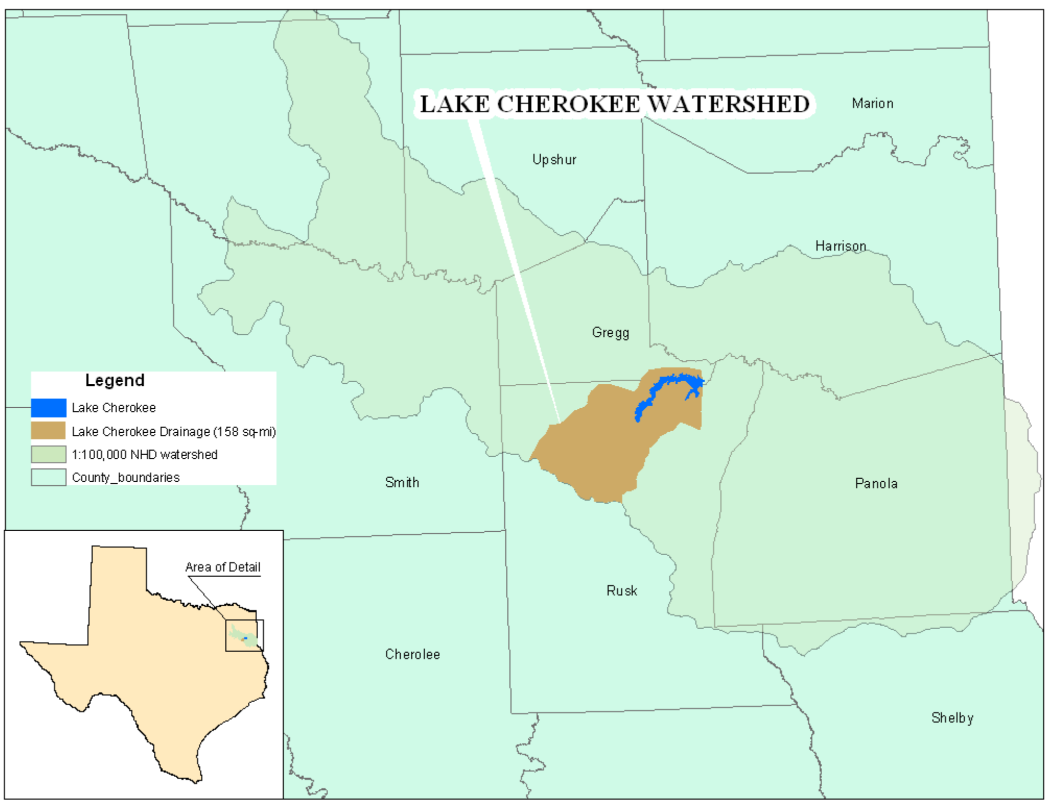

Figure 2. Lake Cherokee watershed imposed on larger portion of Sabine Watershed. The larger watershed approximates the area used in the analysis for sedimentation rates published in 1959 and 1979.

1986 TWDB Reconnaissance Survey

In February 1986, the Texas Water Development Board performed a reconnaissance survey of Lake Cherokee. The TWDB survey ran the same range lines as the 1960 SCS survey[1]. A small boat was driven at a constant speed across the lake, while tracing the bottom profile on a chart recording depth sounder. Collected data was processed by the same formulas as the SCS survey. However, it appears that the analysis used a significantly smaller lake boundary than the 1960 SCS report. The capacity at elevation 280.0 ft. was calculated to be 45,186 acre-feet and an area of 3,367 acres. The average annual sedimentation production rate for the 26-year period between 1960 and 1986 was calculated to be 0.37 ac-ft/mi2/yr.

1996 TWDB Volumetric Survey

In October 1996, using modern depth sounding and Global Positioning System (GPS) equipment, the Texas Water Development Board performed a volumetric survey of Lake Cherokee. TWDB issued a final report in January 1997. This survey used a boundary digitized from 1986 USGS topographical maps and estimated most of the depths upstream of the FM 2011 bridge. This survey collected over 41,000 data points on approximately 120 transect lines. These lines were spaced parallel to one another, about 500 ft apart, and positioned as perpendicular to existing stream and creek beds as possible. The capacity at gauge elevation 280.0 ft was calculated to be 41,560 acre-feet with a surface area of 3,083 acres[1]. The volume and area tables in the 1997 report were revised in this report (2003) using the current boundary derived from 1995 aerial photographs. The revised 1997 capacity and area at elevation 280.0 ft were recalculated to be 42,428 ac-ft and 3,443 acres respectively. The average annual sedimentation production rate for the 10-year period between the 1986 and 1996 surveys was calculated to be 1.75 ac-ft/mi^2/yr.

2003 TWDB Volumetric and Sediment Survey

The 2003 Texas Water Development Board volumetric and sediment survey of Lake Cherokee used a multi-frequency, sub-bottom profiling depth sounder and differential GPS equipment. The survey collected over 67,000 data points, while navigating over approximately the same transect lines used in the 1996 survey (1997 report). An updated boundary file digitized from 1995 aerial photos was used in the volume and area calculations. While depths in a portion of the lake upstream of FM 2011 were still estimated as in the 1996 survey, real data was collected over a significantly larger area in the current survey (see Figures 1 and 5). The survey crew returned to the lake in March 2004 after the vegetation had receded and verified, both manually and acoustically, more of the estimated depths. The capacity at gauge elevation 280.0 ft. was calculated to be 43,737 acre-feet with an area of 3,467 acres. The volume of post-impoundment sediment was estimated to be 1,279 ac-ft. The average annual sedimentation production rate for the 55-year period between the 1948 and 2003 surveys was calculated to be 0.15 ac-ft/mi^2/yr.

DISCUSSION

The use of modern equipment and modeling techniques provides a valuable tool in establishing the rate of sedimentation in reservoirs. Variations in the rate of sedimentation between decades occur because of changes in the watershed, such as land use and new flood control structures. The technologies and methodologies used also affect projections of sedimentation rates.

Based on the 2003 survey, the original total capacity of Lake Cherokee would have been 45,016 ac-ft. or 8% smaller than the original capacity of 49,295ac-ft calculated in the 1960 SCS survey. These results are offset by the fact that the estimated sedimentation rate appears to be smaller than previously thought.

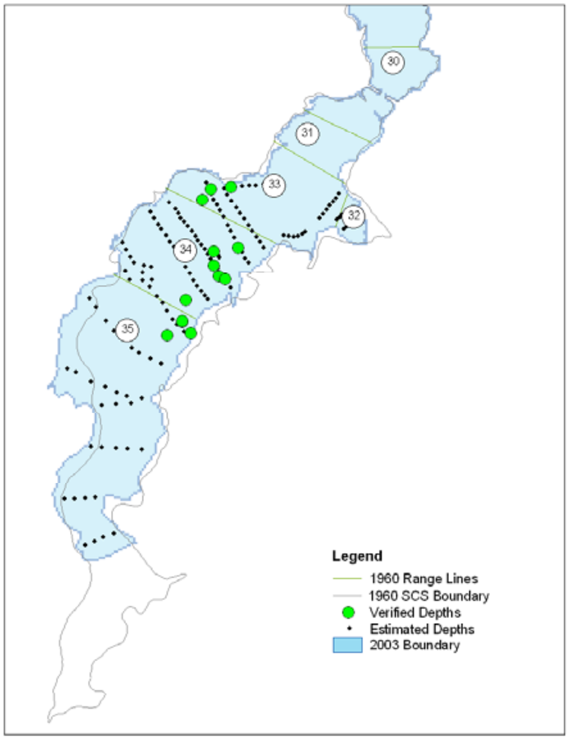

Figure 3. The figure to the left illustrates differences in surface acreage between the 1960 and 2003 boundaries. The area containing segment-35, established for the 1960 SCS report, is about 120 acres smaller in the 2003 report. Depths of 1 ft to 2 ft were assumed for an area of approximately 500 acres, contained in segments 34 and 35. Predominated by Beaver Marsh, this area contains heavy aquatic vegetation.

Prior methodologies for calculating volumes, areas, and sedimentation from bathymetric data included the range survey and contour survey methods[6, 8, 9]. Due to the different computational methods, comparisons between those methods and the current method used for the 2003 survey are not recommented[9]. While not recommended, these comparisons are presented here to illustrate the variability and range for calculated sedimentation rates.

A summary of the historical data and the results of the TWDB 2003 survey are presented below in Table 2. The uses of current positioning (GPS) technologies, navigation software, and modeling techniques have provided us with the best possible estimates of sedimentation rate and volumes available at this time.

	Original Design (established in the 1960 SCS Report)	*USDA SCS Bulletin 5912	USDA SCS Report on Sedimentation	*USDA SCS Report 268	TWDB Survey	TWDB Survey	TWDB Survey
Year	1948	1959	1960	1979	1986	1996 (revised)**	2003
Area (acres)	3,987	NA	3,987	NA	3,367	3,443	3,452
Volume (ac-ft)	49,295	NA	46,705	NA	45,186	42,428	43,297
Change in volume from original design. (ac-ft)	NA	NA	2,590	NA	4,109	6,867	1,279
Sedimentation Rate from year of impoundment. (ac-ft/mi^2/yr)	NA	0.23	1.37	0.25	0.68	0.91	0.15

Table 2. Area, Volume, and Sedimentation Rate Comparisons for Lake Cherokee, Texas. Sedimentation rates are based on a 158-mi^2 watershed.

Sedimentation rates presented above are calculated based on changes from the original volume established in the 1960 SCS report. The 2003 Survey sedimentation rate is based on measurements taken during the survey.

*The 1959 SCS Bulletin and the 1979 SCS Report addressed sedimentation rates for watersheds in Texas. While individual lake surveys were used in the analysis, individual volumes and areas were not reported in these two reports.

** Revisions to the 1996 Survey results are discussed in Appendix K in the section entitled “Data Processing.”

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APPENDIX J – CORE SAMPLING REPORT

APPENDIX K – EQUIPMENT, PROCEDURES AND METHODS

VOLUMETRIC SURVEYING TECHNOLOGY

Equipment

The equipment used to perform the latest volumetric survey (TWDB 2003) consisted of a 20-foot aluminum, shallow-draft, flat bottom SeaArk craft (River-runner) with cabin and equipped with a 100-horsepower Yamaha outboard motor. To collect data on board, we used a Specialty Devices, Inc. (SDI) multi-frequency sub-bottom profiler[10], a Trimble Navigation, Inc. AG132 GPS receiver with Omnistar differential GPS correction signal, and a laptop computer. A verification trip in March 2004 used a 17-foot Jon boat powered by a 9.9 Horsepower Evinrude outboard motor. The on-board equipment was reconfigured to use a Knudsen 320 B/P Echosounder[11] (depth sounder) instead of the SDI sub-bottom profiler. The combination of survey vessels, GPS equipment, and depth sounders provide efficient hydrographic survey systems.

PRE-SURVEY PROCEDURES

The lake's boundary was digitized using Environmental Systems Research Institute's (ESRI) [12] ArcGIS 8.3 from digital orthophoto quadrangle images (DOQs). VARGIS of Texas LLC produced the DOQs for the Texas Orthoimagery Program (TOP). The DOQs produced for the Department of Information Resources and the GIS Planning Council under the TOP reside in the public domain. More information can be obtained on the Internet at http://www.tnris.state.tx.us/DigitalData/doqs.htm. The lake elevation at the time the DOQs were photographed on March 9, 1995 was 280.6 ft. The lake and island boundaries were given an elevation of 280.6 ft and TWDB Staff used this updated boundary in modeling Lake Cherokee for this report.

The survey layout was designed by placing survey track lines at 500-foot intervals (Figure 2) within the digitized lake boundary using HYPACK MAX[11] software. The survey design required the use of approximately 160 survey lines placed perpendicular to the original creek channel and tributaries.

SURVEY PROCEDURES

Equipment Calibration and Operation

On board the River-runner boat, the SDI sub-bottom profiler depth sounder was calibrated using the DIGIBAR-Pro Profiling Sound Velocimeter by Odem Hydrographic Systems[14]. To determine the speed-of-sound, the probe was first placed in the water to acclimate it, then raised to the water surface where the depth was considered zero. The probe was then gradually lowered on a cable to a depth just above the lake bottom, and then raised again to the surface. During this lowering and raising, local speed-of-sound measurements were collected, from which the average speed was computed by the velocimeter. The speed of sound was then entered into the SDI data collection system. The depth was then checked manually with a surveying stadia rod or weighted measuring tape to ensure that the depth sounder was properly calibrated and operating correctly.

The speed of sound in the water column ranged from 4,870 feet per second to 4,860 feet per second during the Lake Cherokee survey. Based on the measured speed of sound for various depths and the average speed of sound calculated for the entire water column, the depth sounder is accurate to within $\pm$0.2 ft. An additional estimated error of $\pm$0.3 ft arises from variation in boat inclination. These two factors combine to give an overall accuracy of $\pm$0.5 ft for any instantaneous reading. These errors tend to be fairly minimal over the entire survey, since some errors are positive and some are negative, canceling each other out[15].

During the survey, the horizontal mask setting on the on-board GPS receiver was set to 10 degrees and the PDOP (Position Dilution of Precision) limit was set to seven to maximize the accuracy of the horizontal positioning. If the PDOP rises above seven, an internal alarm sounds to advise the field crew that the horizontal position has degraded to an unacceptable level.

Further positional accuracy is obtained through differential corrections using the internal Omnistar receiver[16]. The HYPACK initialization file for Lake Cherokee was set up to perform an "on-the-fly" conversion from the collected Differential GPS positions to state-plane coordinates.

Field Survey

During the two-day survey in November 2003, the water levels remained below CPE (280.0 ft) at a constant gauge elevation of 278.22 ft. The survey crew experienced excellent weather conditions with no weather related delays. Upon arriving at Lake Cherokee, TWDB staff met with personnel from the Cherokee Water Company and after discussing the logistics for the survey, the crew began data collection.

The survey team made an additional field trip on March 10, 2004 to verify depths that were estimated in the upper portion of Lake Cherokee. This area of the lake is characterized by a large stand of cypress and other trees and dense aquatic vegetation, making data collection difficult. The survey crew was able to progress further into this region in March. The bottom was probed with a survey stadia rod in several locations and after the vegetative layer was penetrated, hard bottom was found. Root crowns of the cypress trees were also visible in the areas the crew was able to approach. Visible root crowns are another indication of no significant sediment build up in these areas.

Over 67,600 data points were collected during the survey (see Figure 5). Random data were collected in those areas where the crew could not stay on course because of navigational obstructions. As the channels became too narrow for perpendicular transects, data were collected in a zigzag pattern. The boat's computer stored all data points in 154 data files.

TWDB contracted with Baylor University's professors John A. Dunbar and Peter M. Allen to collect core samples throughout the lake. The professors collected eight core samples in December 2003, which were used to validate the SDI sub-bottom profiler acoustic records. Their report "Sediment Thickness from Coring and Acoustic, Lake Cherokee, Rusk County, TX" is presented in this report as Appendix J.

Data Processing

The collected data were transferred from the survey computers onto TWDB's network computers and backups were made for future reference as needed. Each raw data file was processed through the DEPTHPIC program, which graphically displayed the acoustic record collected by the SDI sub-bottom profiler and allows the operator to change the weighting of each frequency to highlight different sediment characteristics[10]. The lake post- and pre-impoundment surfaces were then digitized and stored for further processing. Core sample information (sediment thickness) can be displayed with the corresponding cross sectional acoustic record for calibrating and verifying the sediment layer thickness with acoustic signal. (see Appendix J). The 200 kHz frequency was used to define the present post-impoundment surface, and the 50kHz frequency was used to define the pre-impoundment surface. The water surface elevation of the lake for each day was then added to the post-processed data converting depths into elevations. After all changes had been made to the data files, they were then saved and combined into a separate X, Y, Z data file for each frequency.

The resulting data files were imported into ESRI's Arc/Info Workstation GIS 8.3 software[12]. This software was used to convert each data set to a MASS points file. The MASS points and the boundary file were then used to create a Digital Terrain Model (DTM) of the lake's pre- and post-impoundment surfaces using Arc/Info's TIN software module. The module generates a triangulated irregular network (TIN) from the data points and the boundary file using a method known as Delauney's criteria for triangulation[3]. Using this method, a triangle is formed between three non-uniformly spaced points, including all points along the boundary. If there is another point within the triangle, additional triangles are created until all points lie on the vertex of a triangle. All of the data points are used in this method. The generated network of three-dimensional triangular planes represents the bottom surface. With this representation of the bottom, the software then calculates elevations along the triangular surface plane by determining the elevation along each leg of the triangle. The lake area and volume can be determined from the TIN created using this method of interpolation. Volumes were calculated for the post-impoundment surface (200kHz frequency) and the pre-impoundment surface (50kHz frequency) and then subtracted from each other to derive the estimated total post-impoundment sediment.

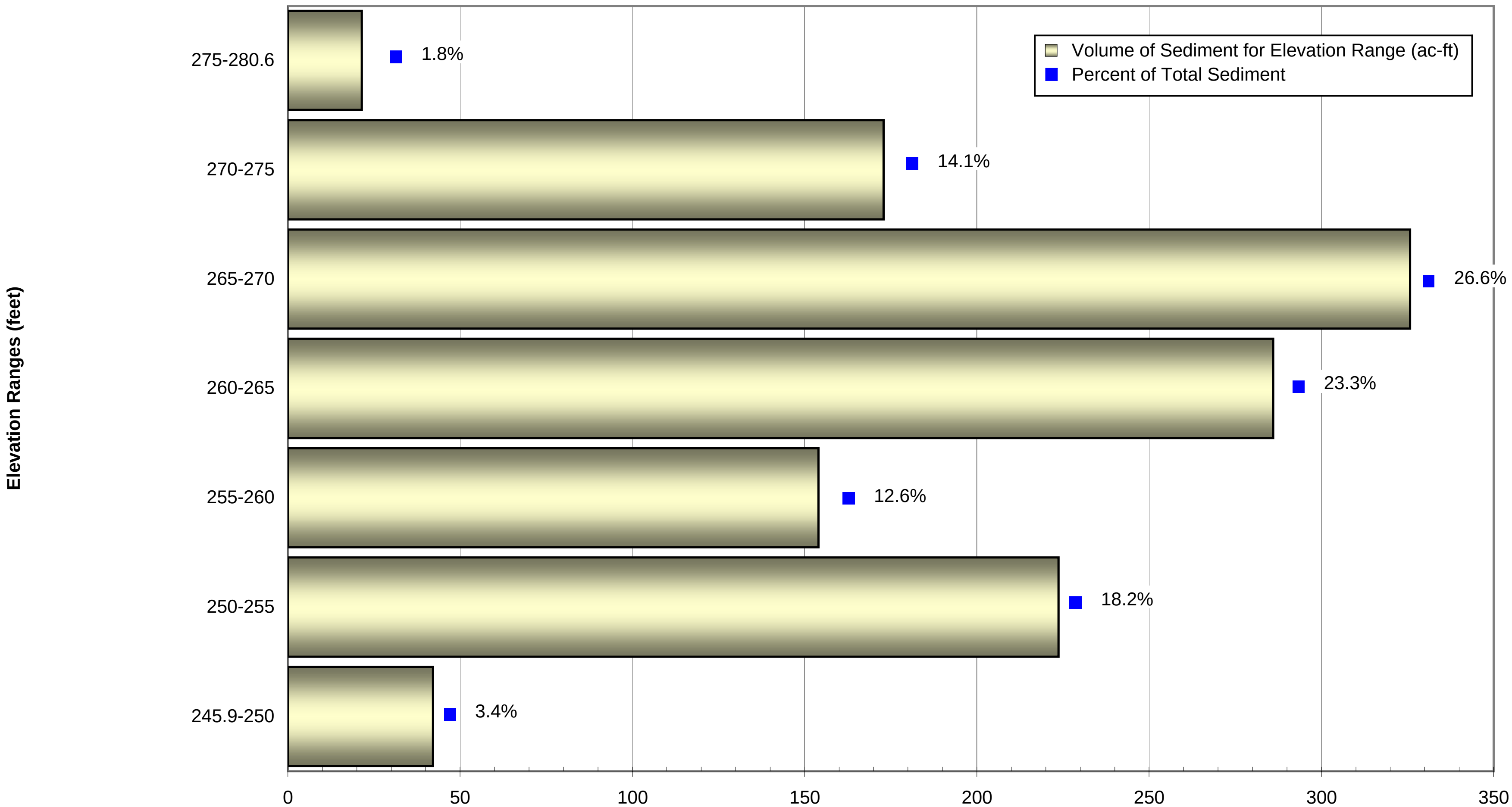
Volumes and areas were calculated from the 200 kHz TIN from elevation 245.9 ft to 280.6 ft at one-tenth foot intervals using Arc/Info software. Volumes were calculated from the 50 kHz TIN from elevation 240.9 ft to 280.6 ft at one-tenth foot intervals. The computed post-impoundment volume table is presented in Appendix A and the area table in Appendix C. An elevation-volume graph and an elevation-area graph are presented in Appendix E and Appendix F respectively.

The volume and area tables in the 1997 TWDB report “Volumetric Survey of Lake Cherokee” were revised to use the 2003 report boundary. The 1997 report boundary was digitized from USGS topographical maps and the current boundary is considered more accurate. The area and volume calculations in the 1997 survey report were further revised by substituting all 2003 data upstream of the FM 2011 Bridge (Figure 2). This substitution was used in order to minimize errors in the estimated depths between the two data sets and to allow for differences in the boundaries.

Two sets of figures were produced to illustrate the location and distribution of sediment in the reservoir. The first set, Figures 6, 6a, and 6b were developed directly from a TIN model derived from sediment isopack (thickness) values returned by the DEPTHPIC program. Figure 6 displays the complete reservoir while Figures 6a and 6b are enlarged views of the upper and lower portions of the reservoir. All three figures show sediment location and thickness at 0.25-ft intervals. The second set, Figures 7a through 7e were also developed from the isopack TIN model, which was converted, to a lattice using the TINLATTICE command and then to a polygon coverage using the LATTICEPOLY command. These five figures contain fourteen views of the reservoir showing sediment thickness ranges throughout the reservoir.
Figure 8 shows the bottom relief of the lake in elevations. The Figure 8 map was developed using the same processes as Figure 7 by substituting the TIN developed from the 200kHz data points. Figure 9, a 2-ft interval contour map was also developed from this TIN. As with Figures 7 and 8, the TIN was converted to a lattice using the TINLATTICE command and then to a polygon coverage using the LATTICEPOLY command. Linear filtration algorithms were applied to the resultant DTM to produce smooth cartographic contours. Finally, thirty-four cross-sections were produced from the TINs with positions that closely match cross-sections

presented in the 1960 SCS report. The cross-section endpoints are presented in Appendix H with the corresponding cross-section plots presented in Appendix I.

Volume of Sediment for Elevation Range



	245.9-250	250-255	255-260	260-265	265-270	270-275	275-280.6
Volume of Sediment (ac-ft)	42.1	223.7	154.0	286.0	325.7	172.9	21.5

Appendix A

Lake Cherokee

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD

NOVEMBER 2003 SURVEY

Conservation Pool Elevation 280.0

VOLUME IN ACRE-FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
245										0
246	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	0	0	0	0	1
248	1	1	1	1	2	2	3	3	4	5
249	5	6	7	9	10	12	14	16	18	22
250	25	30	35	40	46	53	61	69	78	88
251	99	111	123	136	150	165	181	197	215	234
252	254	275	298	322	347	373	400	429	458	488
253	519	552	585	619	655	692	730	769	809	850
254	892	935	979	1023	1068	1114	1160	1207	1255	1303
255	1352	1401	1451	1501	1552	1604	1656	1709	1762	1816
256	1871	1926	1983	2039	2097	2156	2215	2275	2336	2398
257	2461	2525	2590	2655	2722	2790	2858	2928	2998	3069
258	3141	3213	3287	3361	3435	3511	3587	3663	3740	3818
259	3896	3975	4055	4135	4216	4297	4379	4462	4545	4629
260	4714	4799	4885	4972	5059	5148	5237	5327	5417	5508
261	5600	5693	5786	5880	5975	6071	6167	6265	6363	6461
262	6561	6662	6763	6865	6968	7072	7177	7282	7389	7496
263	7604	7713	7823	7934	8045	8158	8272	8387	8503	8620
264	8738	8857	8977	9097	9219	9342	9465	9589	9715	9841
265	9969	10098	10229	10360	10493	10626	10761	10896	11033	11170
266	11309	11448	11589	11730	11873	12017	12162	12309	12456	12605
267	12755	12906	13058	13211	13365	13520	13676	13833	13991	14149
268	14309	14470	14633	14796	14961	15127	15294	15463	15632	15803
269	15975	16148	16323	16499	16677	16857	17037	17220	17404	17590
270	17777	17965	18155	18346	18539	18732	18928	19124	19322	19522
271	19722	19924	20128	20332	20539	20746	20955	21165	21377	21591
272	21805	22022	22240	22459	22680	22902	23126	23351	23577	23804
273	24032	24262	24492	24724	24956	25190	25424	25660	25897	26135
274	26374	26615	26857	27101	27347	27595	27844	28095	28347	28601
275	28856	29113	29370	29629	29889	30150	30412	30675	30940	31205
276	31471	31738	32006	32275	32545	32816	33088	33361	33635	33910
277	34186	34463	34741	35021	35302	35584	35868	36152	36438	36726
278	37014	37304	37595	37888	38182	38477	38774	39072	39372	39673
279	39975	40295	40618	40944	41272	41603	41937	42273	42612	42953
280	43297	43644	43994	44346	44702	45062	45424			

Elevations above CPE (280.0 ft)

Appendix B

Lake Cherokee

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD

OCTOBER 1996 SURVEY

REVISED 2003

VOLUME IN ACRE-FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION IN FEET	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
245										0
246	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	0	0	0	0	0
248	0	0	0	0	0	1	1	1	1	1
249	2	2	2	3	3	4	5	6	7	8
250	10	11	14	16	19	23	27	32	38	44
251	51	59	67	76	86	96	107	118	130	143
252	156	171	186	202	219	237	255	275	296	317
253	340	363	388	413	440	467	496	526	556	588
254	621	655	690	726	763	802	841	881	923	965
255	1008	1053	1098	1144	1190	1238	1286	1335	1384	1434
256	1485	1537	1589	1642	1696	1751	1806	1863	1919	1977
257	2035	2094	2154	2214	2276	2338	2401	2465	2529	2595
258	2662	2729	2798	2867	2937	3008	3080	3152	3226	3300
259	3374	3450	3526	3603	3681	3759	3838	3918	3998	4079
260	4161	4243	4326	4409	4494	4578	4664	4750	4838	4926
261	5015	5105	5195	5287	5379	5473	5567	5662	5758	5854
262	5952	6050	6149	6249	6350	6452	6554	6658	6762	6867
263	6973	7080	7188	7297	7406	7516	7627	7739	7852	7966
264	8082	8198	8315	8434	8554	8676	8799	8923	9049	9175
265	9303	9432	9562	9693	9825	9958	10092	10227	10363	10500
266	10639	10778	10919	11060	11203	11346	11491	11636	11782	11930
267	12078	12227	12378	12530	12683	12837	12992	13149	13307	13466
268	13627	13788	13950	14114	14278	14444	14611	14779	14948	15118
269	15289	15462	15636	15811	15987	16165	16344	16524	16706	16888
270	17072	17257	17444	17632	17821	18011	18203	18396	18590	18786
271	18983	19182	19382	19583	19786	19990	20195	20402	20610	20820
272	21031	21243	21458	21674	21891	22110	22331	22553	22776	23001
273	23227	23454	23682	23912	24143	24376	24610	24845	25082	25319
274	25558	25798	26040	26283	26527	26772	27019	27268	27517	27768
275	28021	28275	28531	28788	29046	29306	29566	29828	30090	30354
276	30619	30885	31152	31420	31689	31960	32231	32504	32778	33053
277	33329	33606	33884	34163	34444	34727	35010	35295	35580	35868
278	36156	36446	36737	37029	37323	37618	37914	38212	38511	38811
279	39113	39432	39755	40080	40407	40738	41071	41406	41744	42085
280	42428	42774	43122	43474	43829	44188	44549			

Elevations above CPE (280.0 ft)

Appendix C

Lake Cherokee

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

NOVEMBER 2003 SURVEY

Conservation Pool Elevation 280.0

AREA IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
245										0
246	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	1	1	1	1	1
248	2	2	3	3	4	4	5	6	7	8
249	9	10	12	13	15	18	21	24	28	33
250	40	47	53	59	66	72	80	88	96	104
251	112	120	127	135	144	153	162	172	183	194
252	206	219	232	244	256	268	279	289	298	308
253	317	328	338	350	363	375	386	396	406	416
254	425	433	440	447	454	460	466	472	478	484
255	490	496	502	508	514	519	525	531	537	543
256	550	557	565	572	581	589	598	607	615	624
257	633	643	652	662	671	681	689	698	707	715
258	723	730	737	743	749	756	762	769	775	781
259	787	793	799	805	811	817	823	829	835	842
260	849	856	864	872	880	888	895	902	909	916
261	923	930	937	945	953	960	968	976	984	993
262	1001	1009	1017	1025	1034	1043	1052	1060	1068	1076
263	1085	1094	1103	1113	1122	1133	1144	1154	1164	1174
264	1185	1195	1204	1213	1221	1229	1238	1249	1260	1271
265	1284	1298	1310	1320	1330	1340	1350	1360	1370	1380
266	1390	1400	1410	1422	1434	1446	1459	1471	1483	1494
267	1504	1515	1524	1534	1545	1555	1564	1573	1583	1594
268	1605	1618	1630	1642	1654	1666	1678	1689	1701	1713
269	1726	1740	1755	1771	1787	1802	1817	1833	1849	1863
270	1877	1891	1905	1919	1932	1945	1959	1973	1987	2001
271	2014	2027	2040	2054	2068	2082	2096	2111	2126	2142
272	2157	2172	2186	2201	2216	2230	2242	2254	2266	2277
273	2288	2299	2310	2320	2331	2341	2352	2362	2373	2385
274	2399	2416	2434	2451	2467	2483	2499	2515	2530	2544
275	2562	2573	2584	2594	2605	2615	2626	2636	2646	2656
276	2666	2676	2685	2695	2705	2715	2725	2735	2745	2755
277	2765	2778	2790	2803	2815	2828	2841	2853	2866	2879
278	2892	2906	2919	2933	2947	2961	2974	2988	3002	3017
279	3188	3215	3243	3270	3297	3323	3350	3376	3401	3427
280	3452	3482	3513	3544	3576	3609	3791			

Elevations above CPE (280.0 ft)

Appendix D

Lake Cherokee

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

OCTOBER 1996 SURVEY

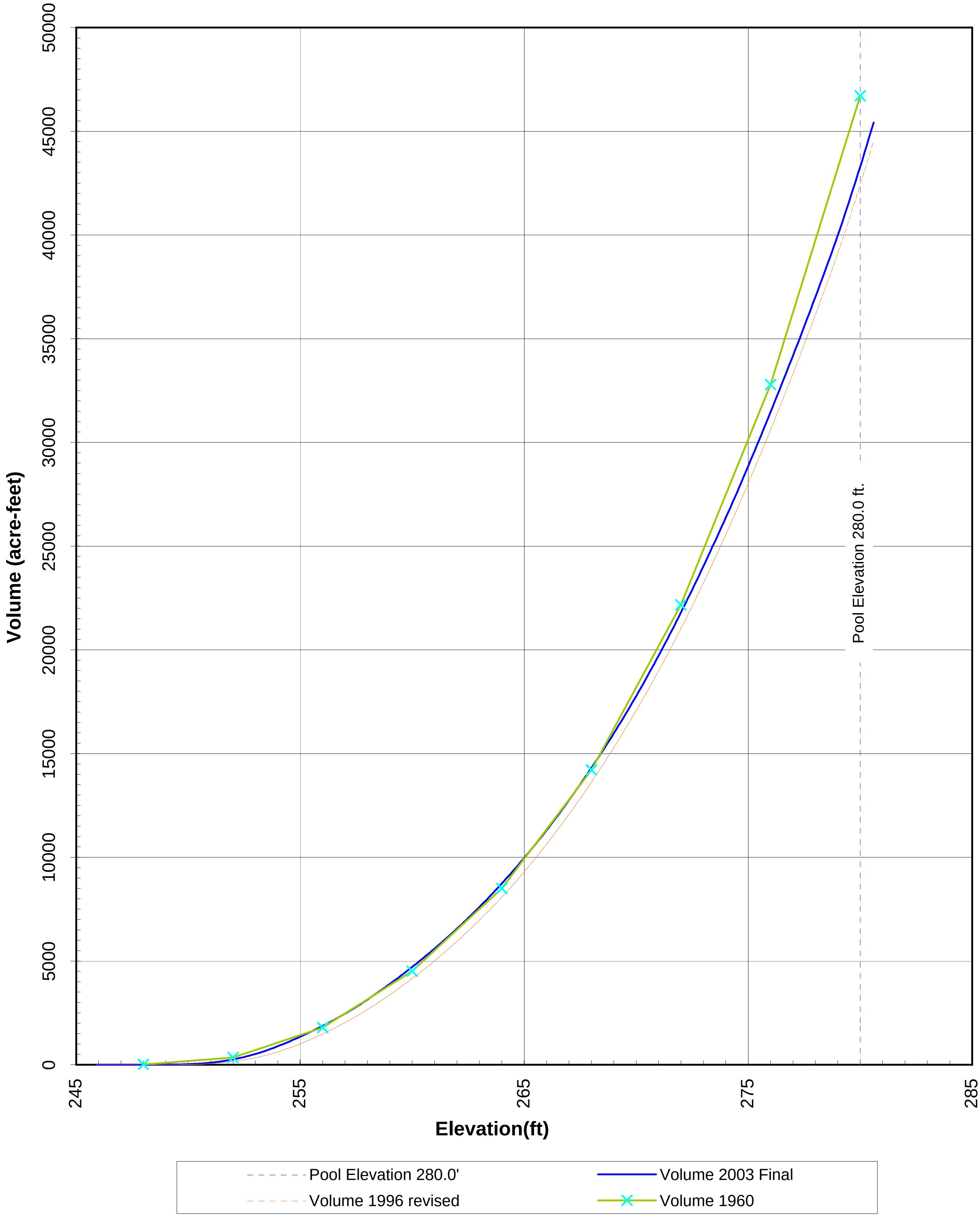
REVISED 2003

AREA IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

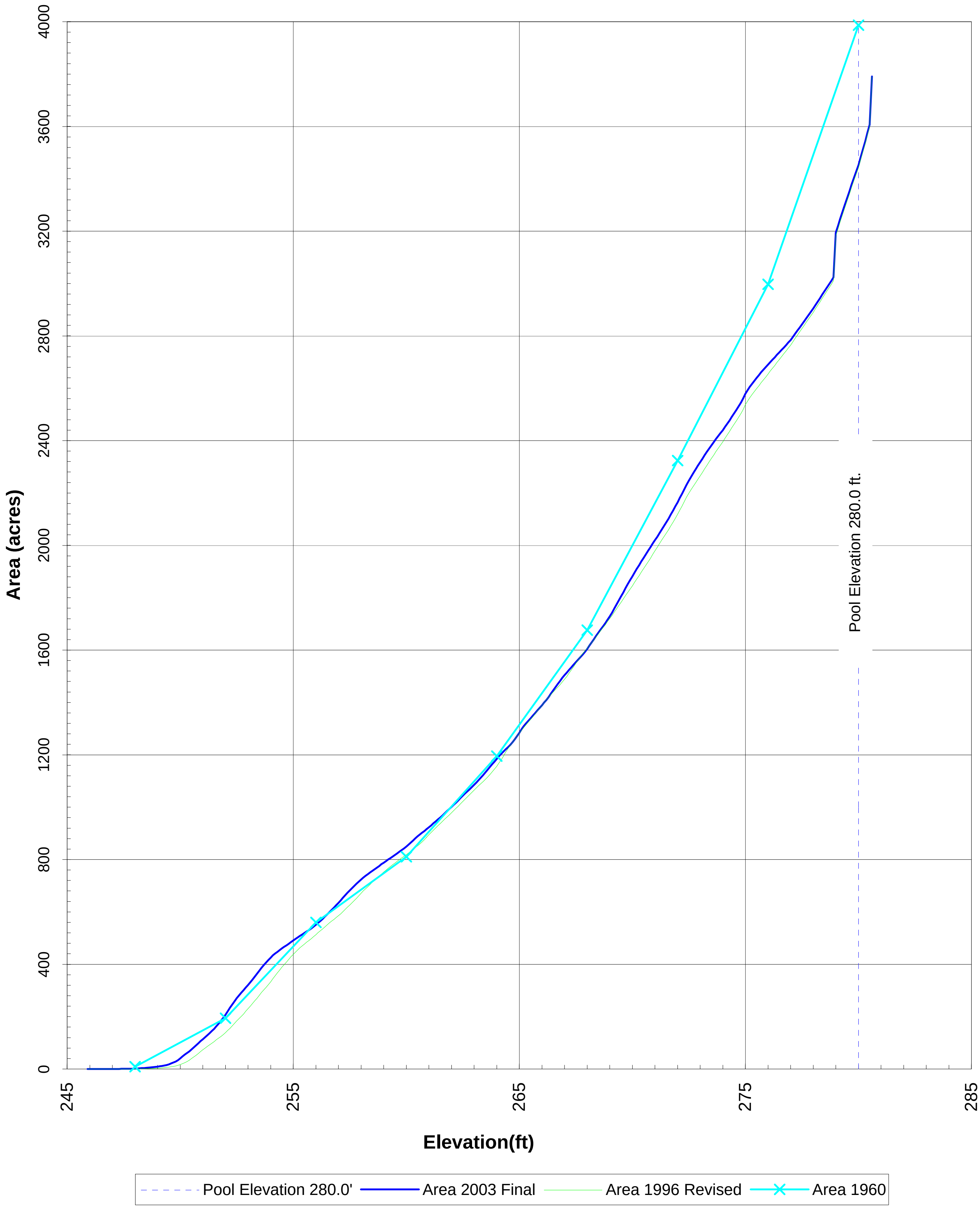
ELEVATION IN FEET	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
245										0
246	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	0	0	0	0	0
248	0	1	1	1	1	1	2	2	2	3
249	3	4	4	5	6	7	9	10	12	14
250	17	20	24	28	34	40	46	53	59	66
251	73	80	86	92	99	105	111	117	124	131
252	139	147	155	164	174	183	192	201	210	220
253	230	240	250	260	270	282	292	302	312	322
254	333	345	356	367	378	389	399	409	419	429
255	438	447	455	463	471	478	484	491	498	506
256	513	521	528	535	543	550	558	565	571	578
257	585	593	601	609	618	626	635	643	652	662
258	671	680	689	697	705	713	721	729	737	745
259	752	759	767	774	780	787	794	800	806	812
260	818	825	832	838	845	852	860	868	876	885
261	894	904	912	920	929	938	946	954	962	970
262	979	987	996	1004	1012	1021	1031	1040	1048	1056
263	1065	1074	1082	1090	1098	1106	1115	1125	1135	1145
264	1156	1168	1181	1195	1210	1223	1236	1248	1260	1272
265	1283	1294	1304	1314	1325	1336	1346	1356	1368	1378
266	1389	1399	1410	1420	1430	1440	1449	1459	1468	1478
267	1488	1499	1511	1524	1537	1549	1562	1575	1586	1597
268	1607	1617	1629	1639	1651	1662	1674	1686	1697	1709
269	1721	1732	1744	1757	1770	1783	1796	1808	1821	1833
270	1846	1859	1872	1884	1897	1911	1924	1938	1951	1965
271	1979	1993	2006	2020	2034	2047	2060	2074	2088	2104
272	2119	2135	2151	2168	2184	2199	2213	2226	2240	2252
273	2265	2278	2292	2306	2319	2332	2345	2358	2371	2383
274	2395	2409	2422	2435	2448	2462	2475	2489	2503	2518
275	2538	2551	2564	2576	2588	2599	2610	2621	2632	2643
276	2654	2665	2676	2687	2698	2709	2721	2732	2743	2754
277	2764	2777	2790	2802	2816	2828	2840	2853	2865	2877
278	2890	2903	2916	2930	2943	2957	2970	2984	2997	3011
279	3182	3209	3236	3263	3290	3316	3342	3368	3393	3418
280	3443	3473	3504	3535	3567	3599	3791			

Elevations above CPE (280.0 ft)



Lake Cherokee
November 2003
Prepared by: TWDB

Appendix E Elevation vs. Volume



Lake Cherokee
November 2003
Prepared by: TWDB

Appendix H

Lake Cherokee

TEXAS WATER DEVELOPMENT BOARD NOVEMBER 2003 SURVEY

Range Line Endpoints

State Plane NAD83 Units-feet

L-Left endpoint
R-right endpoint

Range Line	X	Y
SR 01-L	3170028.0	6838922.0
SR 01-R	3169919.8	6835194.5
SR 02-L	3168492.3	6839448.0
SR 02-R	3167957.5	6835400.5
SR 03-L	3167317.0	6839274.0
SR 03-R	3166247.5	6834703.0
SR 04-L	3165108.3	6839165.5
SR 04-R	3163977.0	6835819.0
SR 05-L	3163335.0	6839998.5
SR 05-R	3162083.5	6837333.0
SR 06-L	3160718.8	6841199.0
SR 06-R	3160693.0	6838412.0
SR 07-L	3158437.8	6840102.0
SR 07-R	3158502.5	6838828.5
SR 08-L	3156195.0	6839613.5
SR 08-R	3156242.8	6838071.5
SR 09-L	3154252.5	6840233.5
SR 09-R	3154084.0	6838294.0
SR 10-L	3151921.5	6840634.0
SR 10-R	3151753.5	6838476.5
SR 11-L	3150255.0	6840003.5
SR 11-R	3150034.3	6838524.0
SR 12-L	3148388.3	6839960.5
SR 12-R	3148836.8	6838400.5
SR-13-L	3145915.8	6838869.0
SR-13-R	3148326.3	6837231.0
SR 14-L	3145161.3	6836958.5
SR 14-R	3146662.5	6835292.5
SR 15-L	3143328.5	6835220.5
SR 15-R	3145306.0	6833092.5
SR 16-L	3141308.5	6834033.0
SR 16-R	3142767.0	6832093.5

Lake Cherokee

TEXAS WATER DEVELOPMENT BOARD NOVEMBER 2003 SURVEY

Range Line Endpoints

State Plane NAD83 Units-feet

L-Left endpoint
R-right endpoint

Range Line	X	Y
SR 17-L	3141130.0	6829907.5
SR 17-R	3142763.8	6829918.0
SR 18-L	3139335.5	6828045.5
SR 18-R	3141370.8	6827035.5
SR 19-L	3138420.5	6827090.0
SR 19-R	3140592.8	6825820.5
SR 20-L	3135204.0	6825718.5
SR 20-R	3138489.3	6824040.5
SR 21-L	3133644.0	6823114.0
SR 21-R	3136099.8	6821795.0
SR 22-L	3140265.0	6824541.5
SR 22-R	3140641.5	6825534.5
SR 23-L	3151373.5	6837887.5
SR 23-R	3151649.3	6837641.0
	3152077.3	6838684.5
SR 24-L	3152806.3	6838668.5
SR 24-R		
SR 25-L	3155558.0	6838073.0
SR 25-R	3155821.0	6838071.5
SR 26-L	3158111.8	6840226.5
SR 26-R	3157556.8	6840423.5
SR 27-L	3168417.5	6839548.5
SR 27-R	3168106.5	6839680.0
SR 28-L	3166254.5	6834486.0
SR 28-R	3167557.5	6834110.5
SR 29-L	3165406.0	6833172.5
SR 29-R	3166853.0	6832950.5
SR 30-L	3165864.3	6831736.0
SR 30-R	3167390.5	6832183.0
SR 31-L	3166839.8	6829785.5
SR 31-R	3167363.5	6829491.0
SR 32-L	3164932.5	6833293.5
SR 32-R	3164781.3	6832251.0

Appendix H (continued)

Lake Cherokee

TEXAS WATER DEVELOPMENT BOARD NOVEMBER 2003 SURVEY

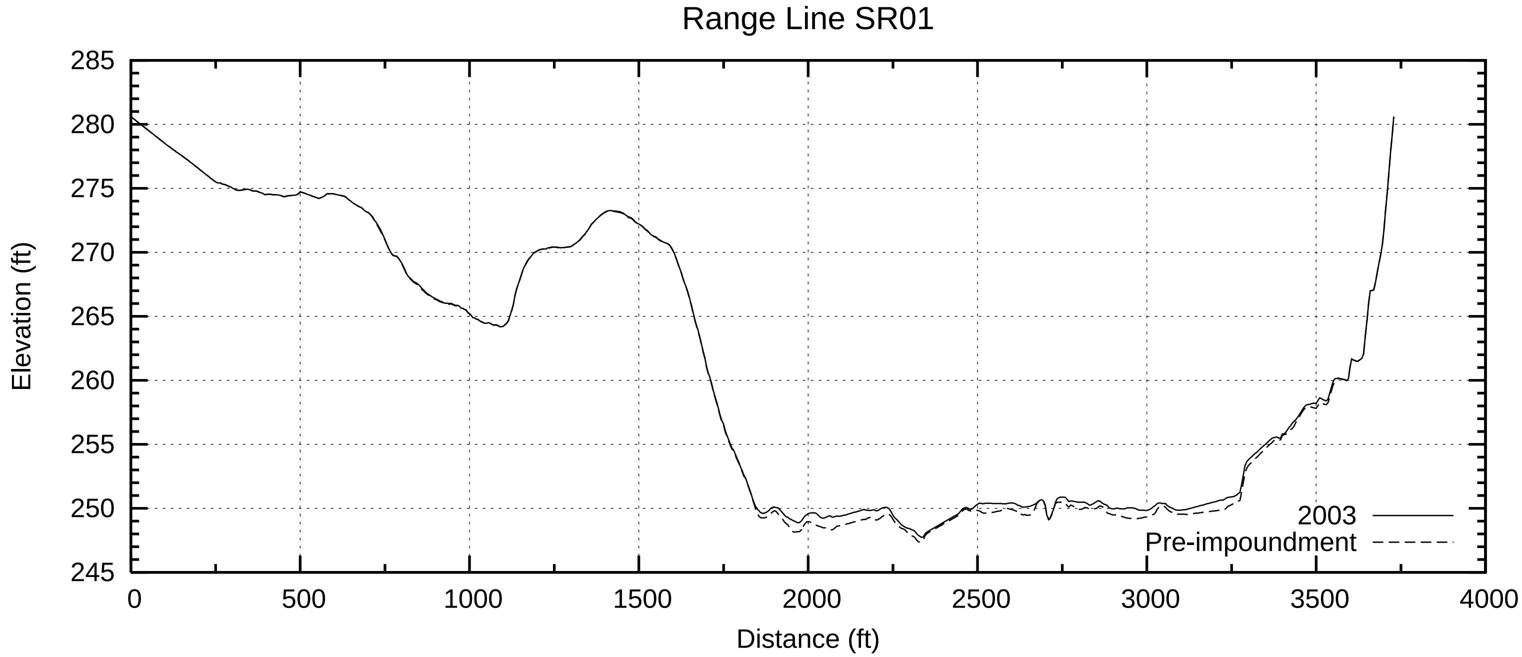
Range Line Endpoints

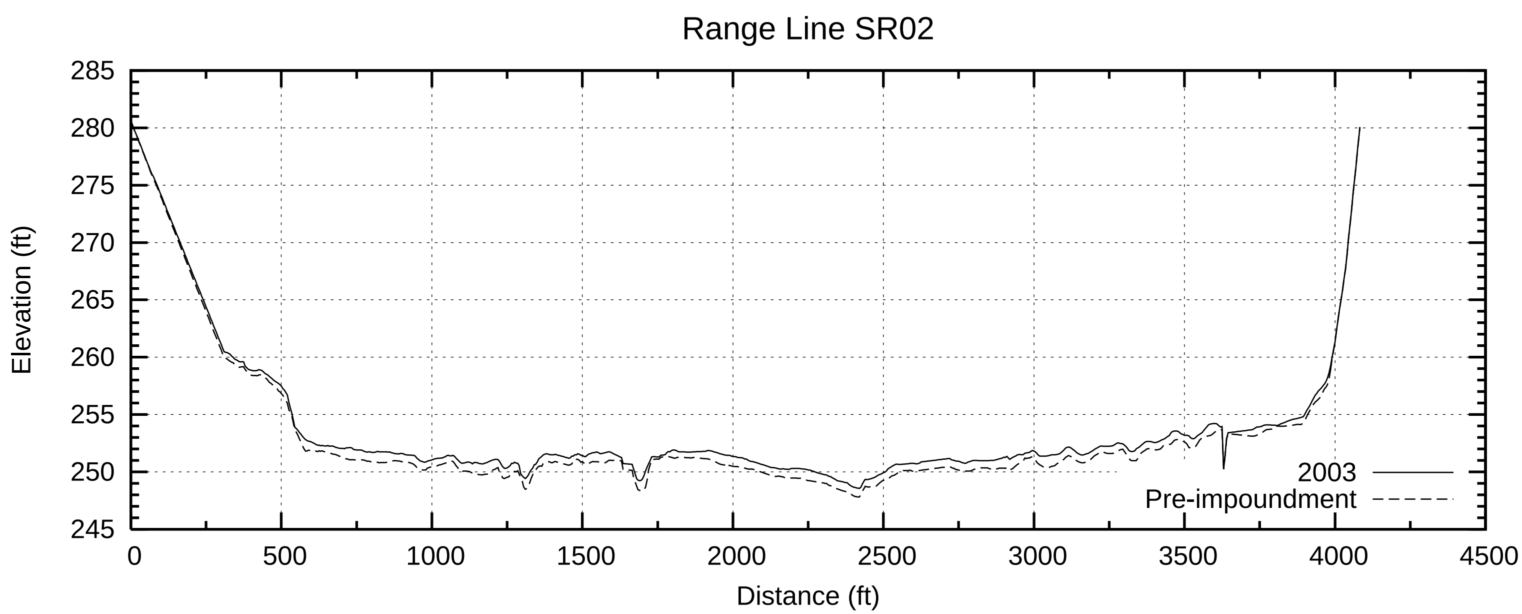
State Plane NAD83 Units-feet

L-Left endpoint
R-right endpoint

Range Line	X	Y
SR 33-L	3163669.8	6831708.5
SR 33-R	3164051.3	6831457.0
SR 34-L	3162010.0	6829903.0
SR 34-R	3162386.0	6829818.5

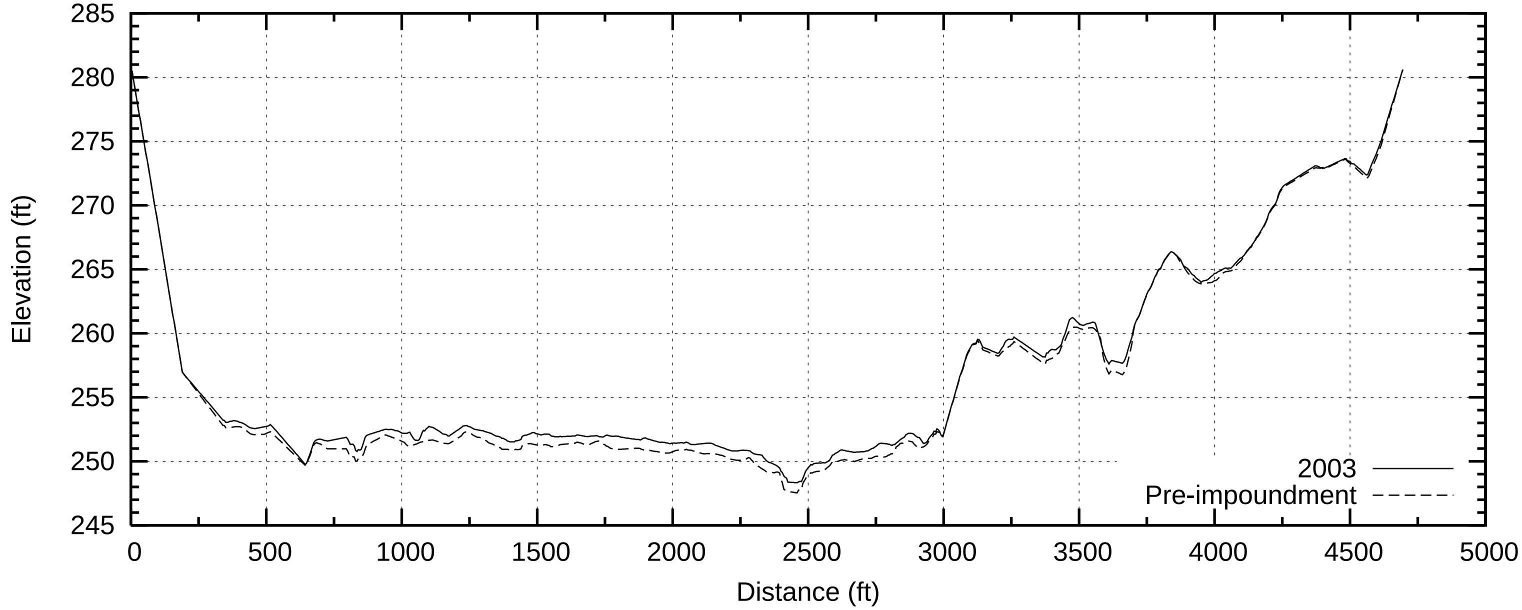
Lake Cherokee





Lake Cherokee

Range Line SR03



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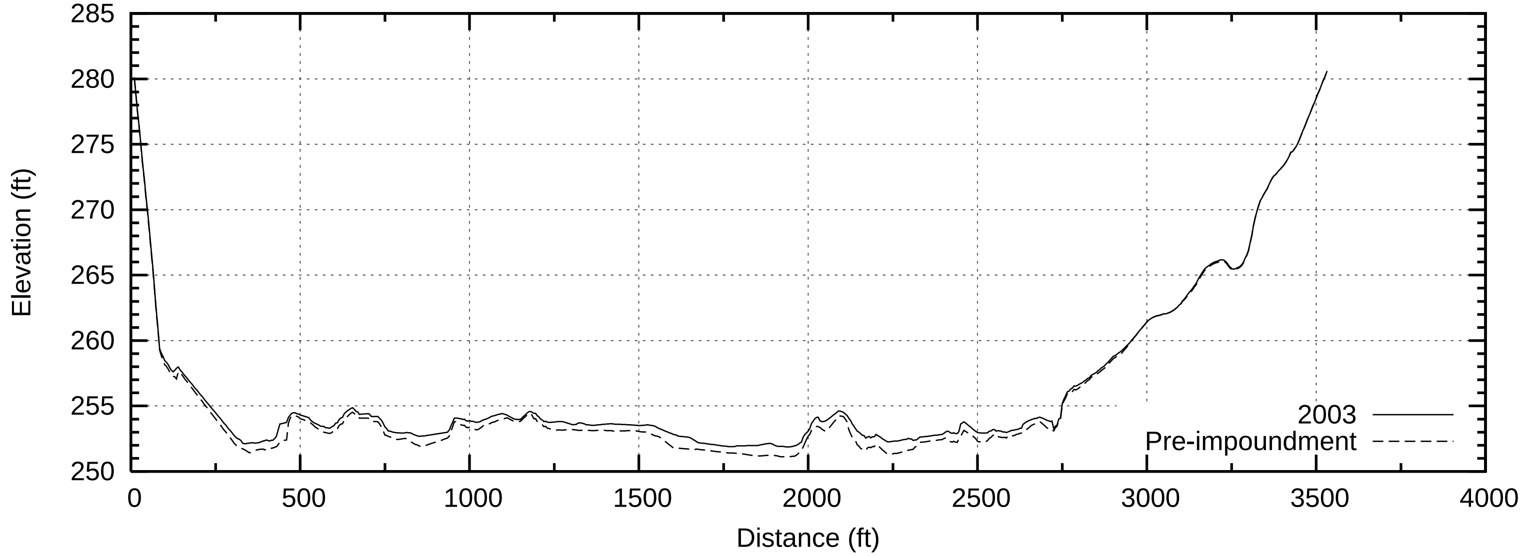
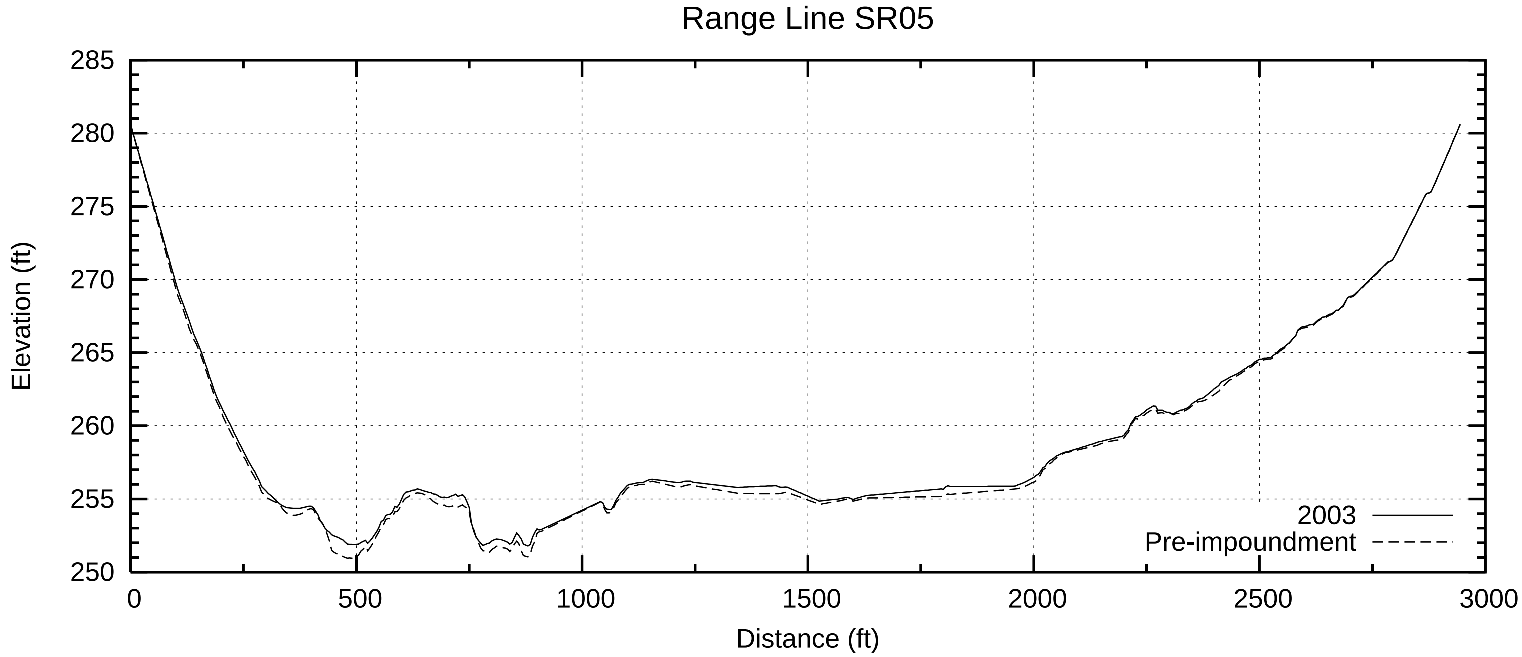
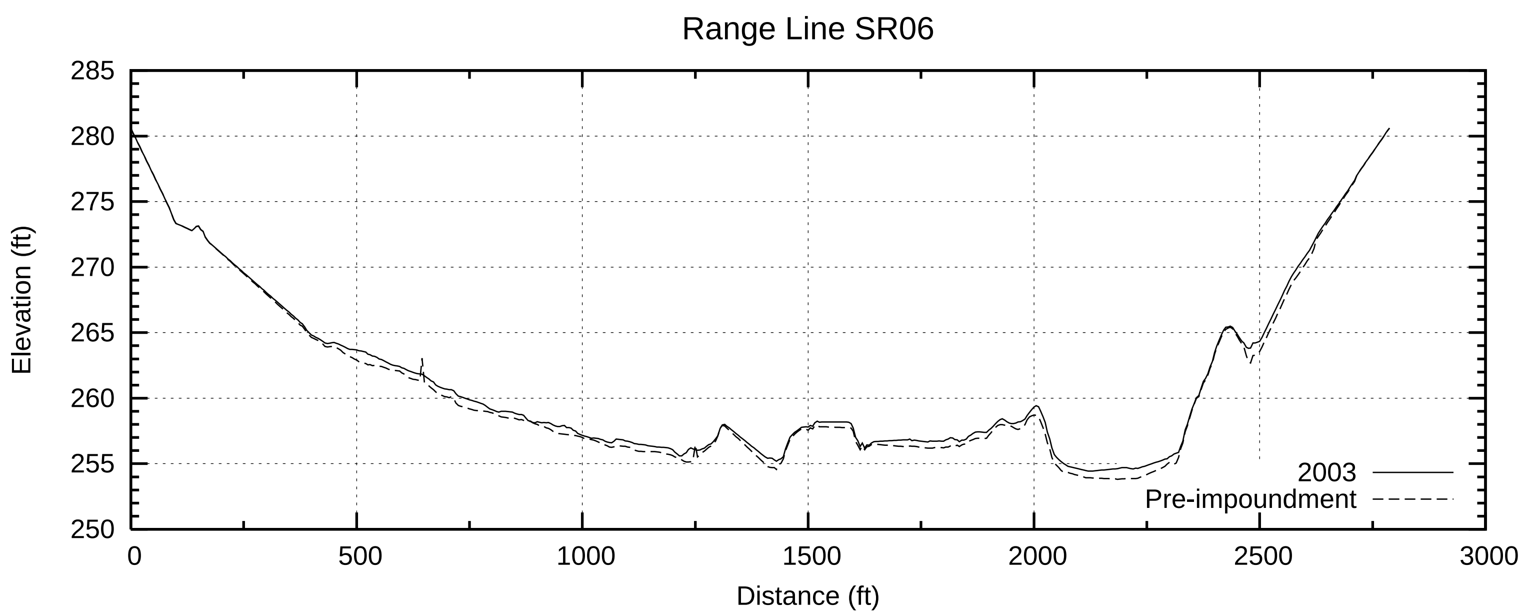


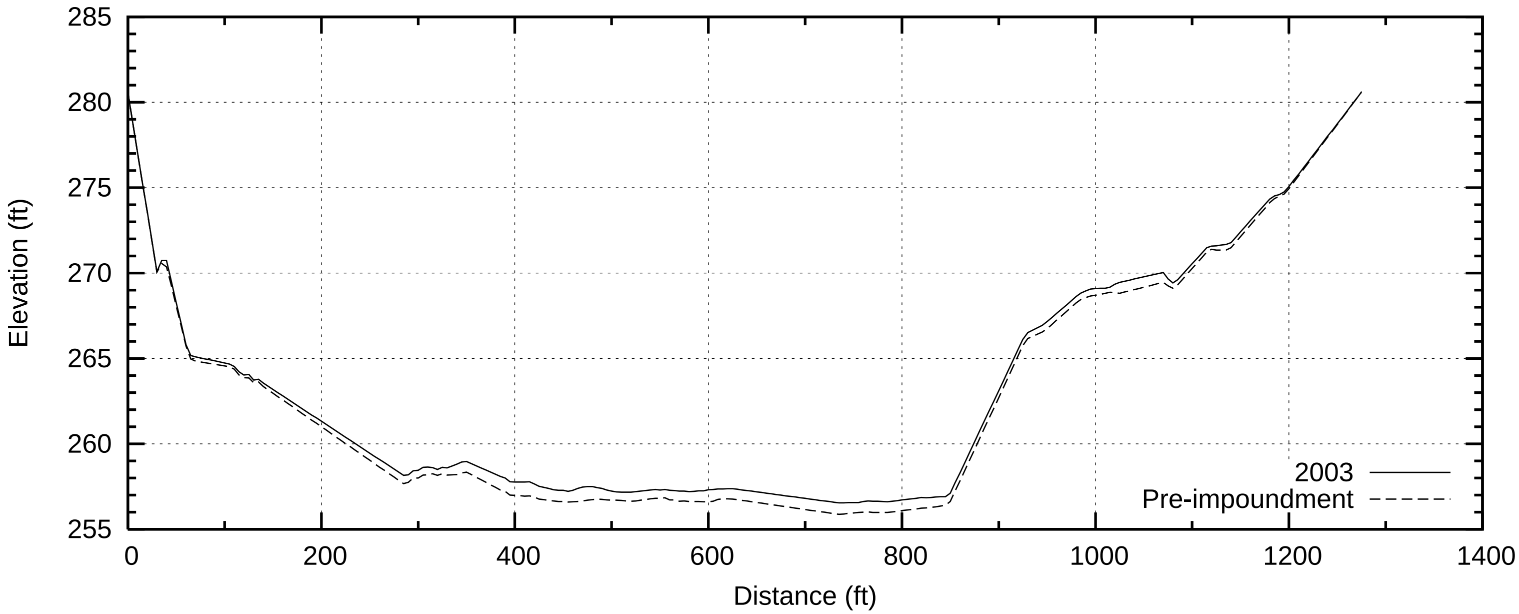
Lake Cherokee



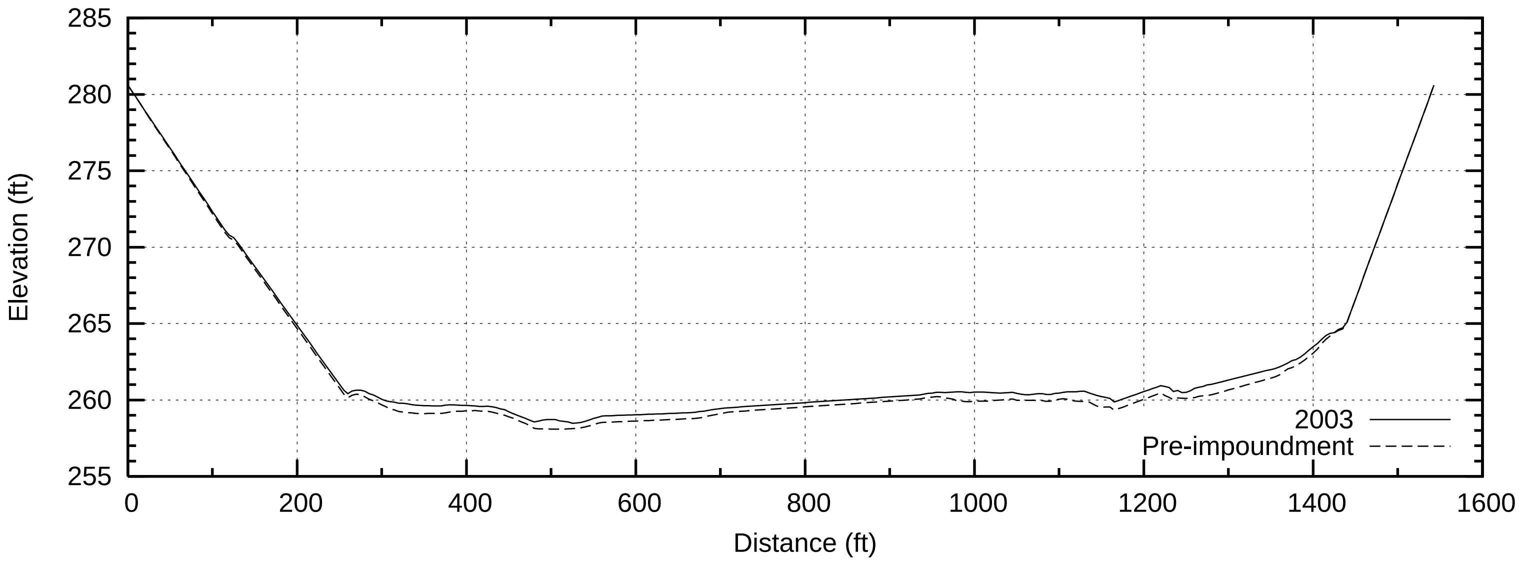


Lake Cherokee

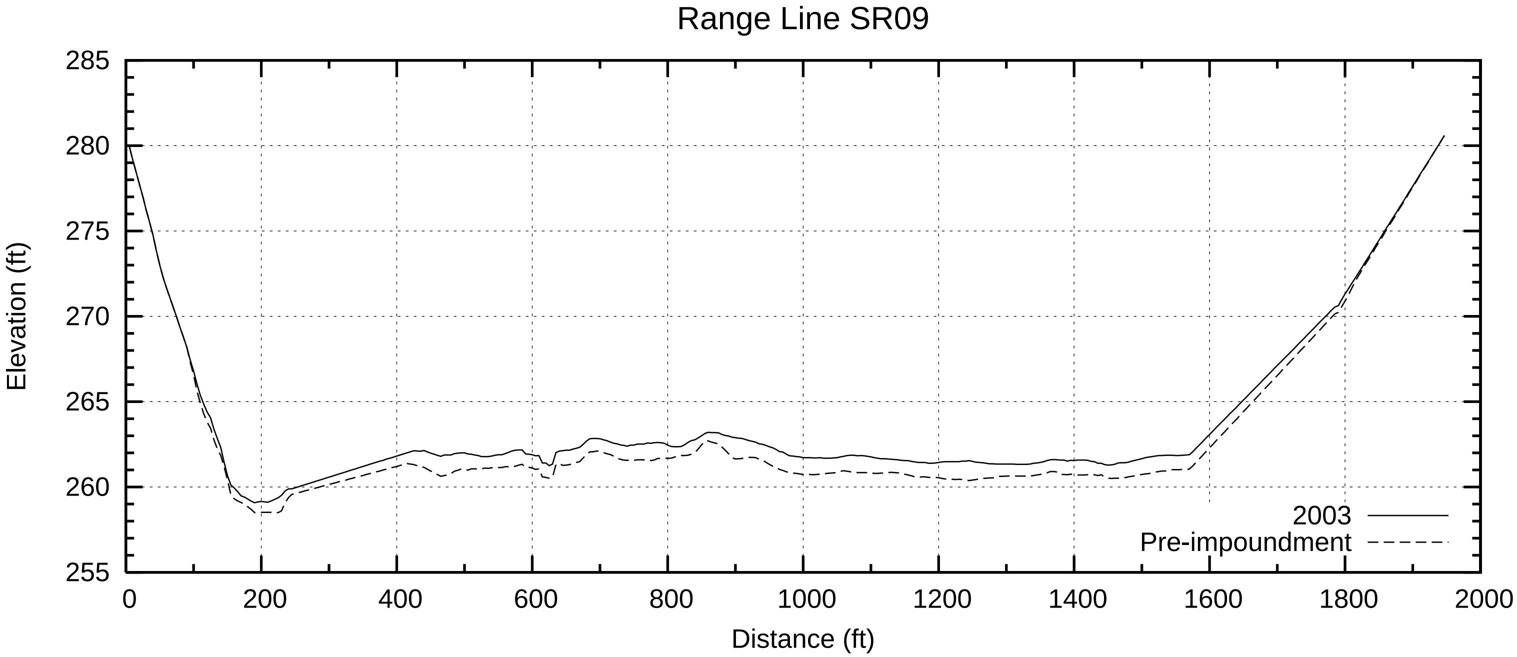
Range Line SR07

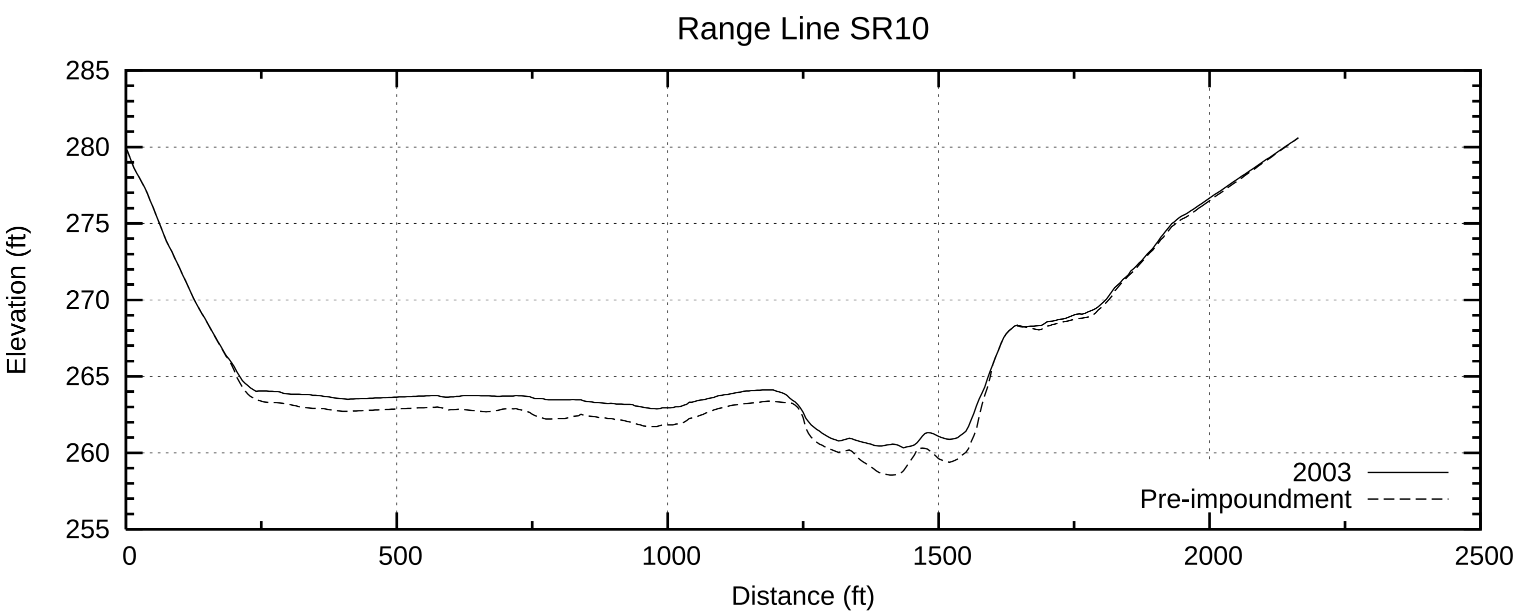


Range Line SR08



Lake Cherokee





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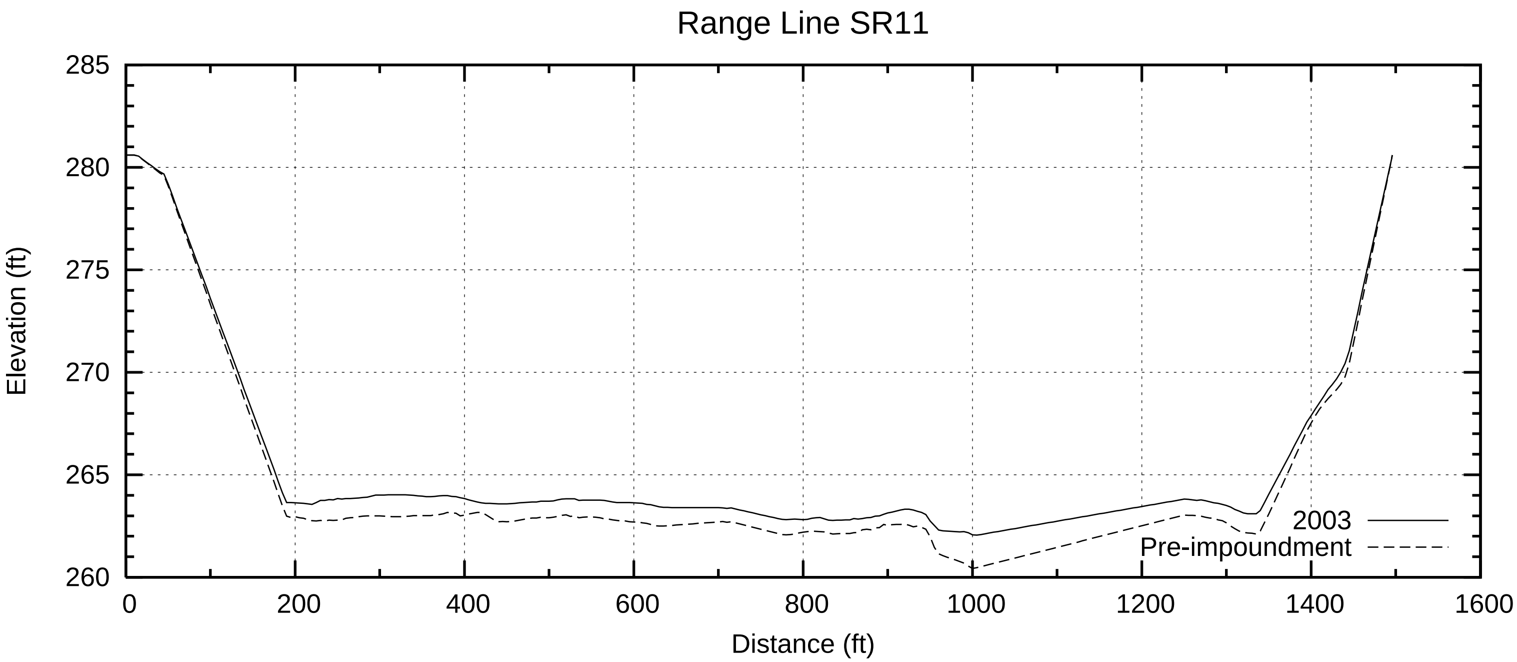
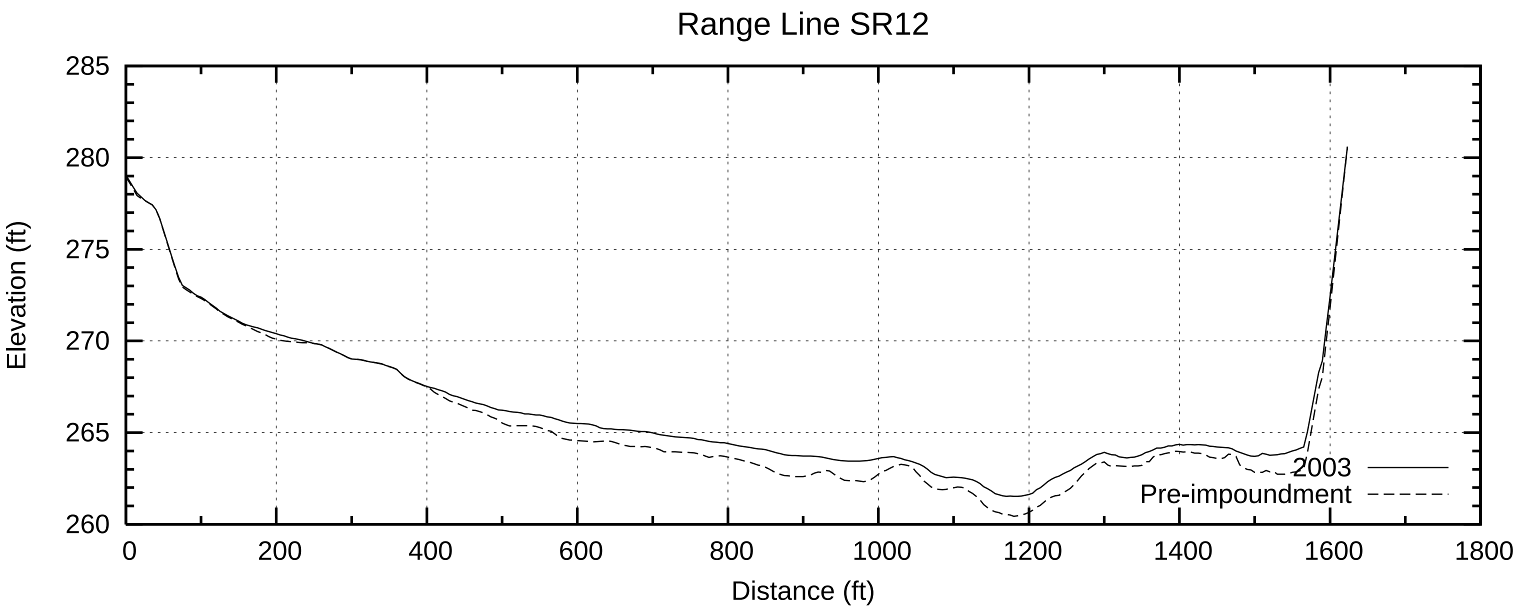
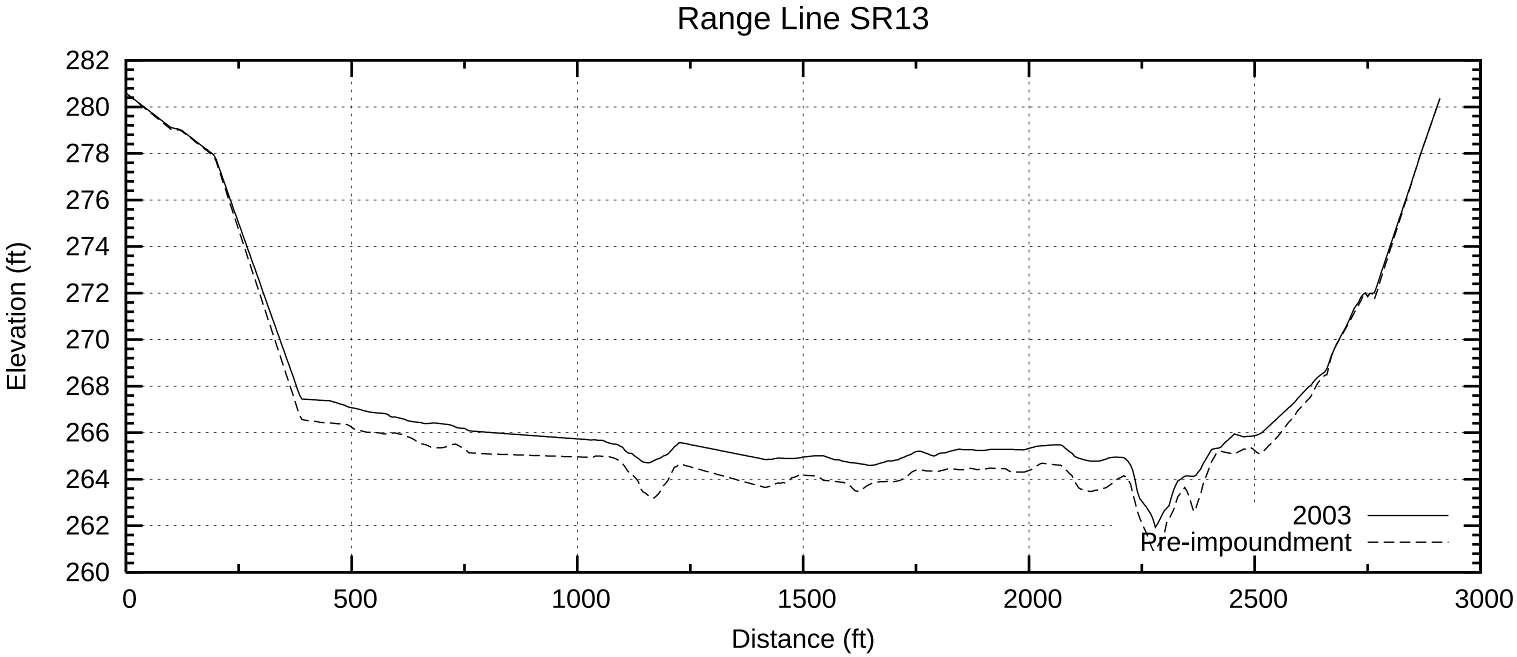
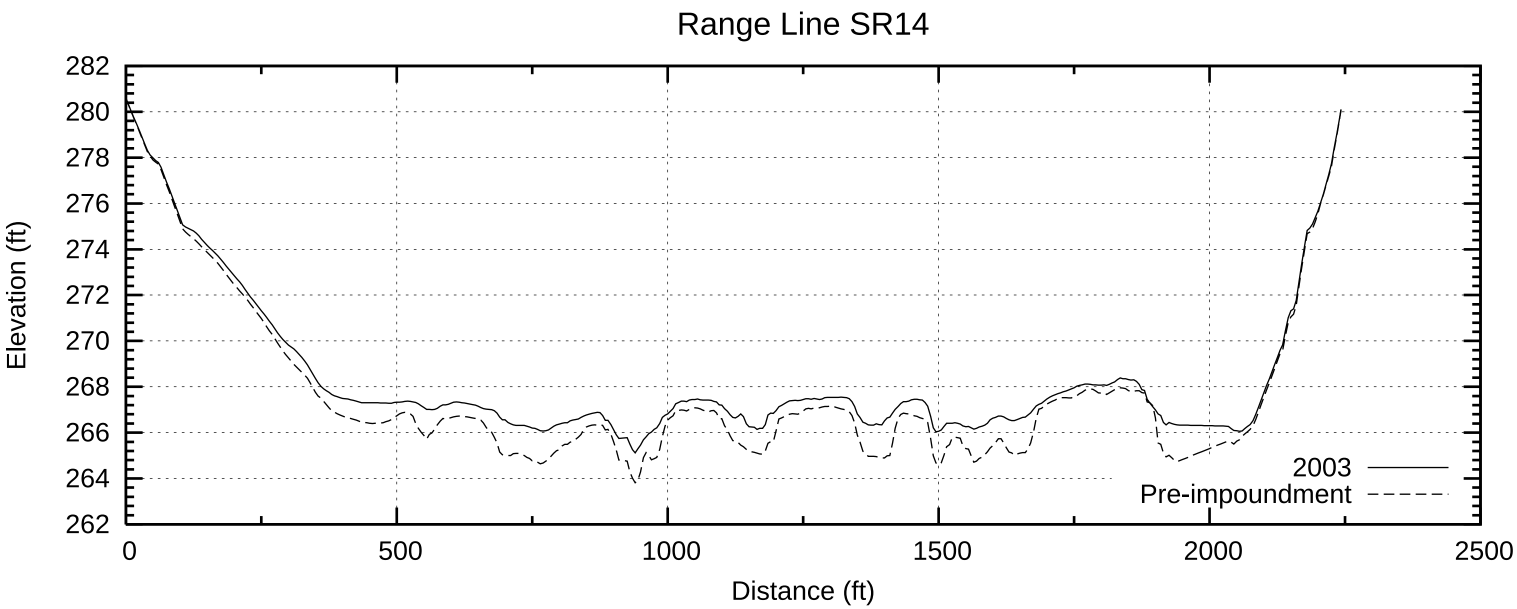




Lake Cherokee

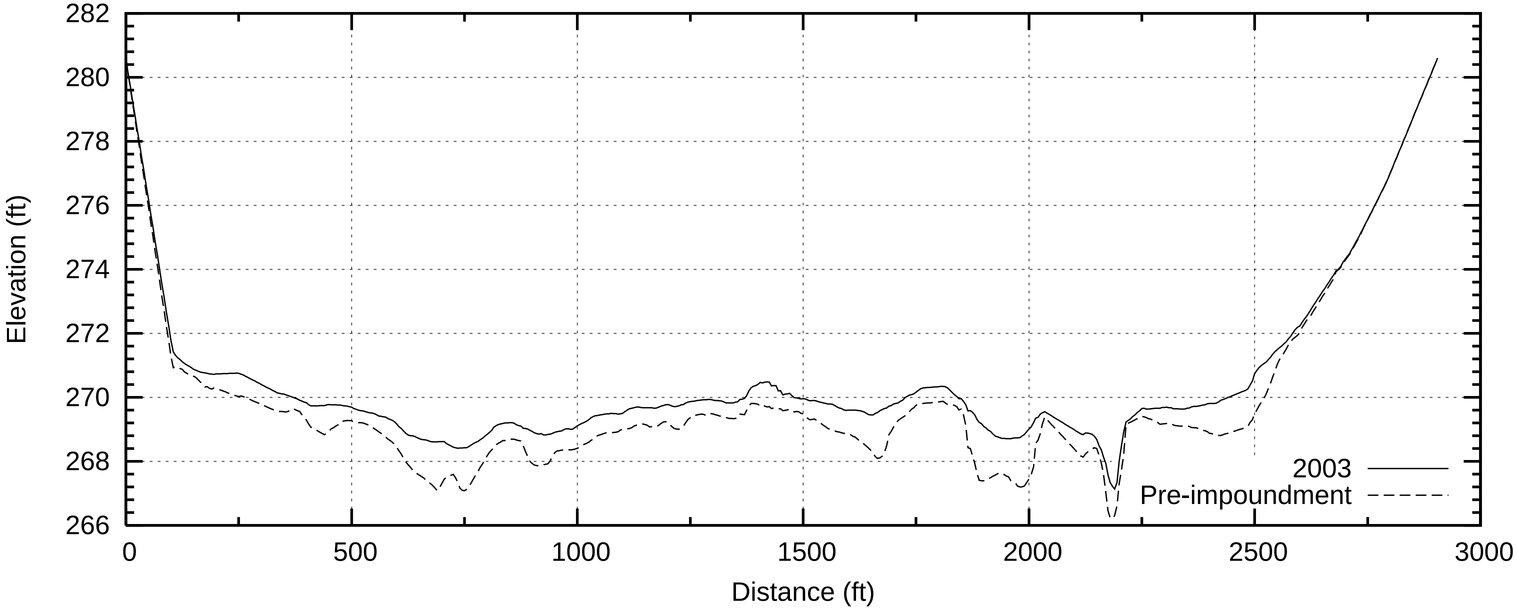




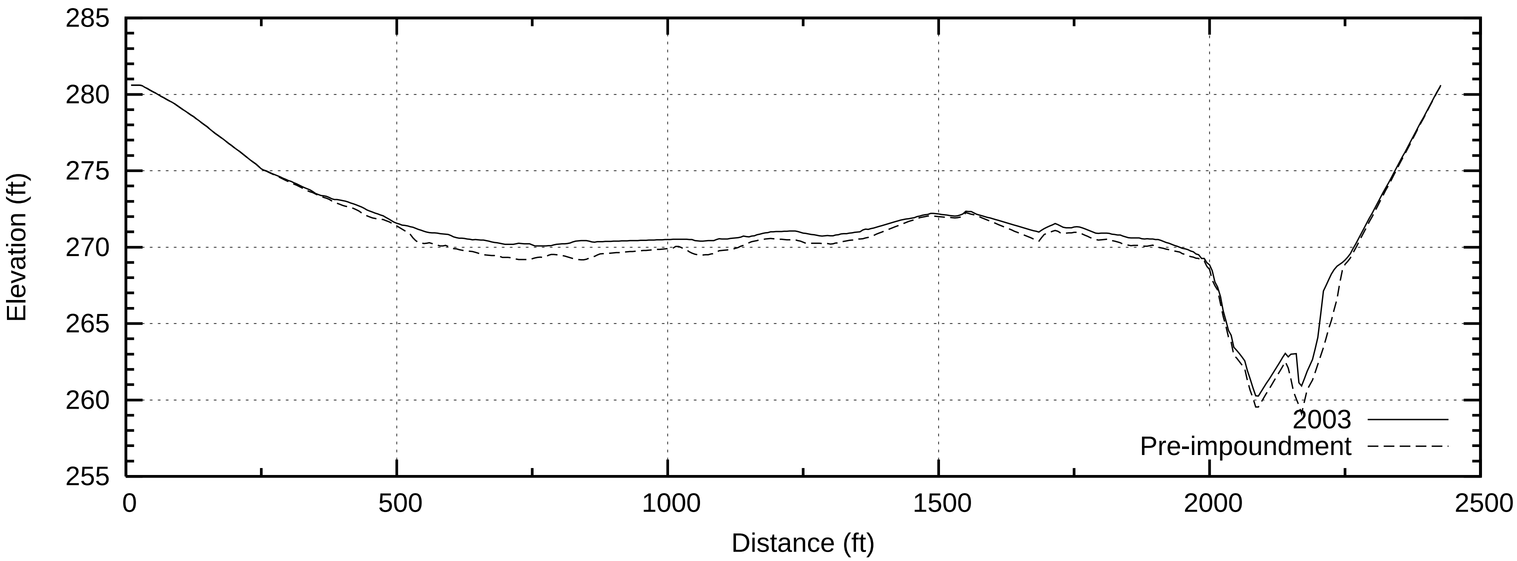
Appendix I

Lake Cherokee

Range Line SR15

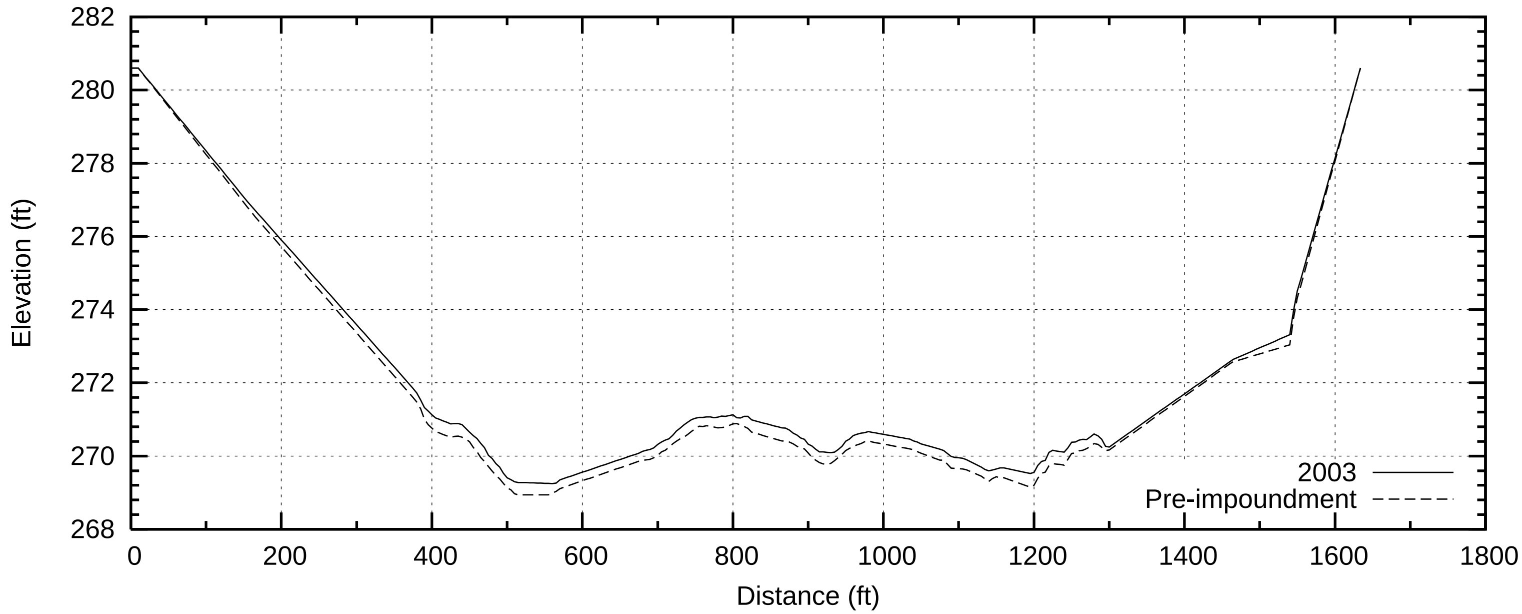


Range Line SR16

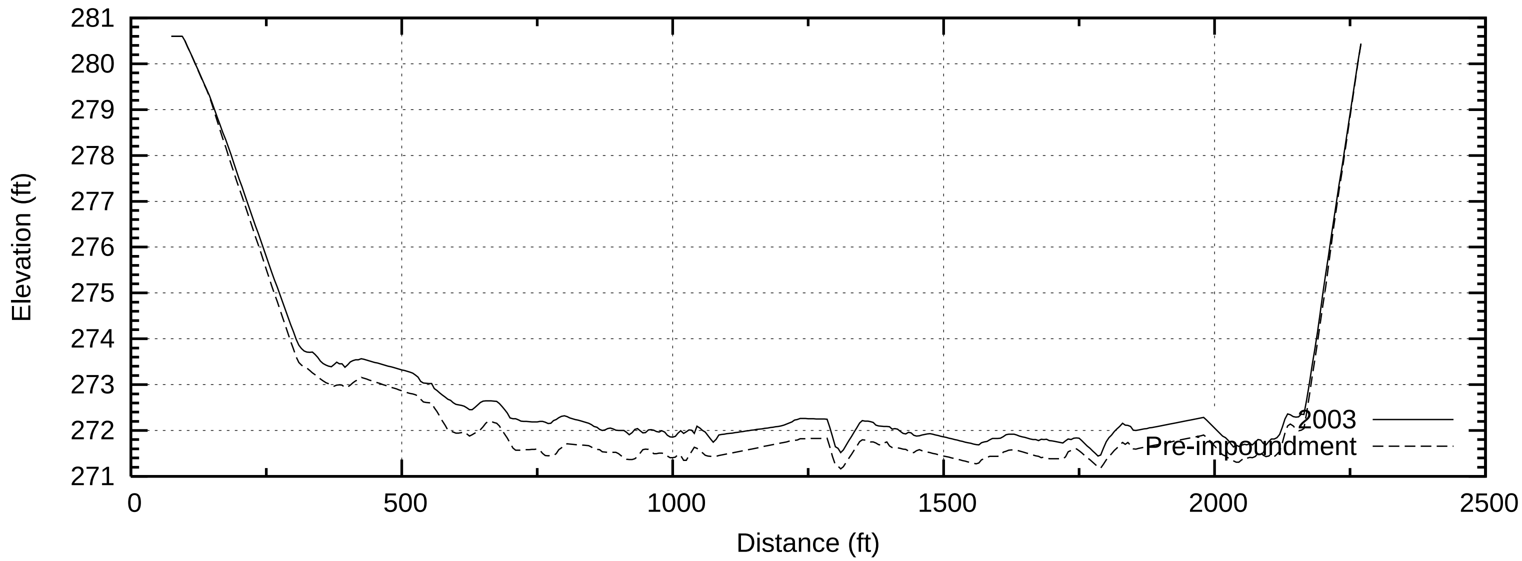


Lake Cherokee

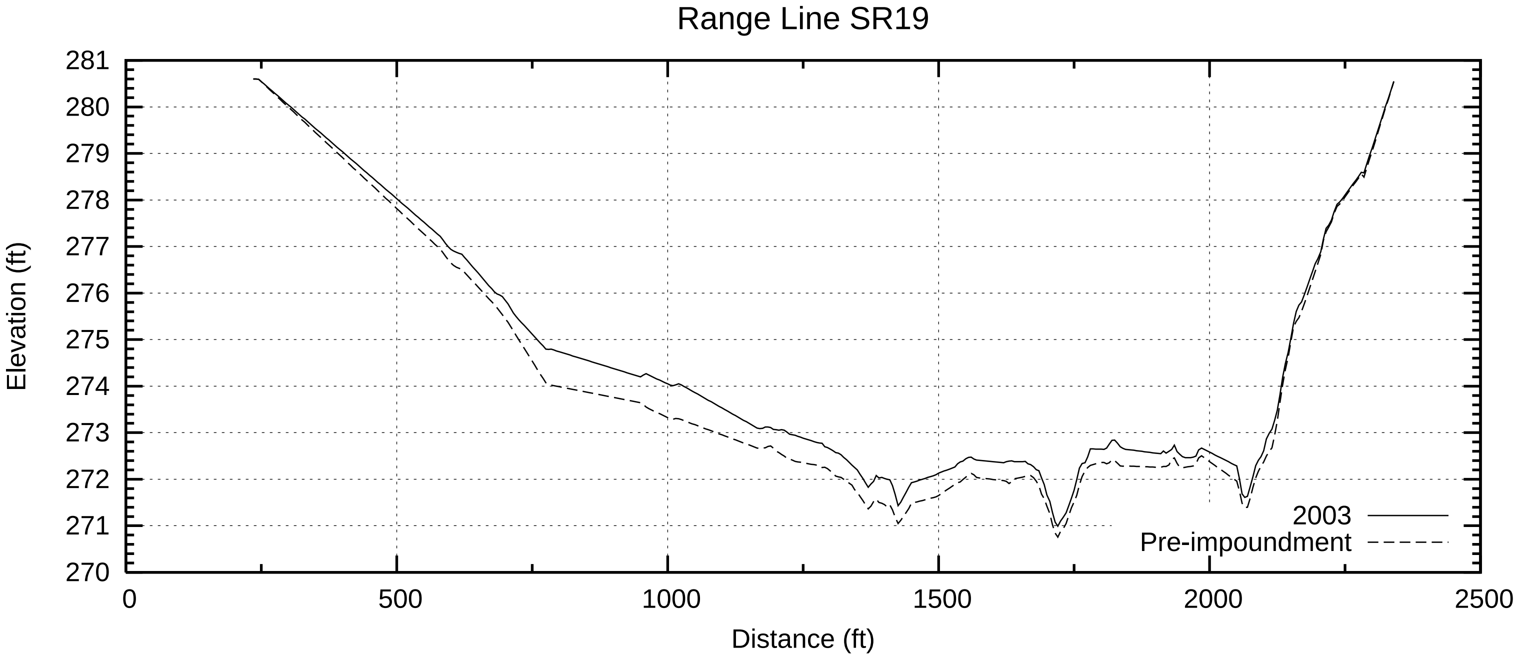
Range Line SR17

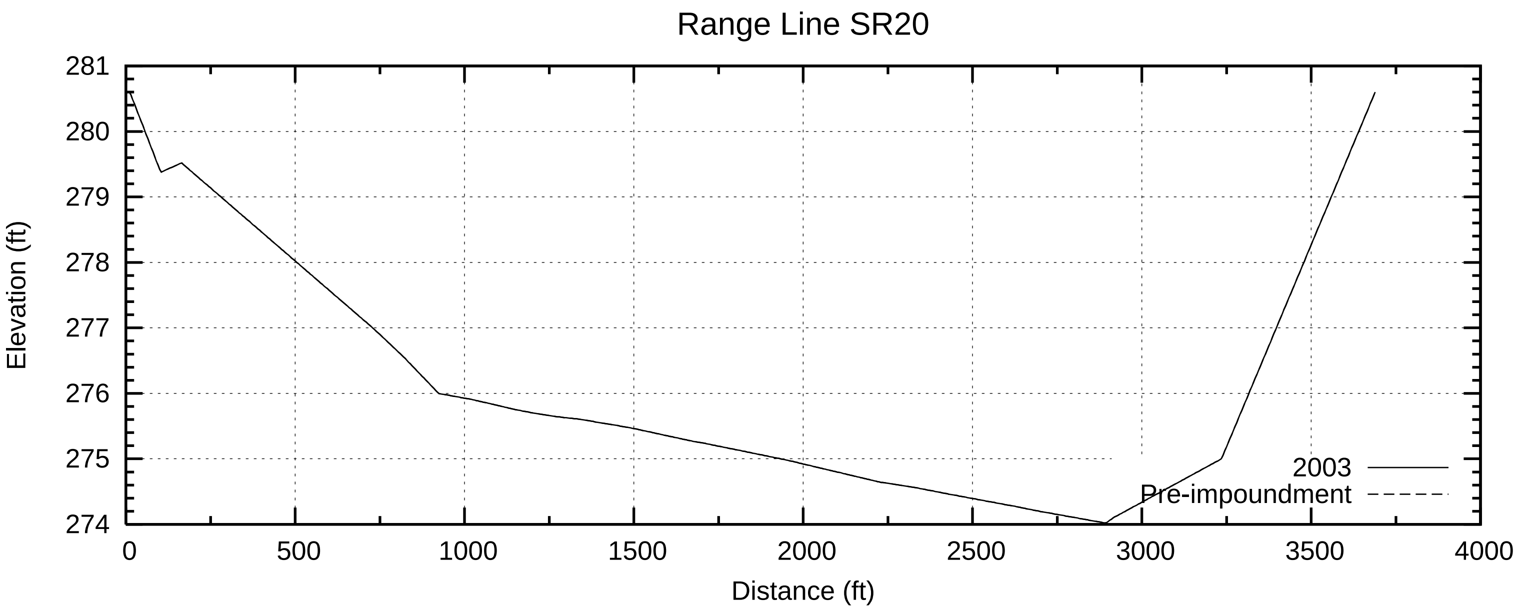


Range Line SR18

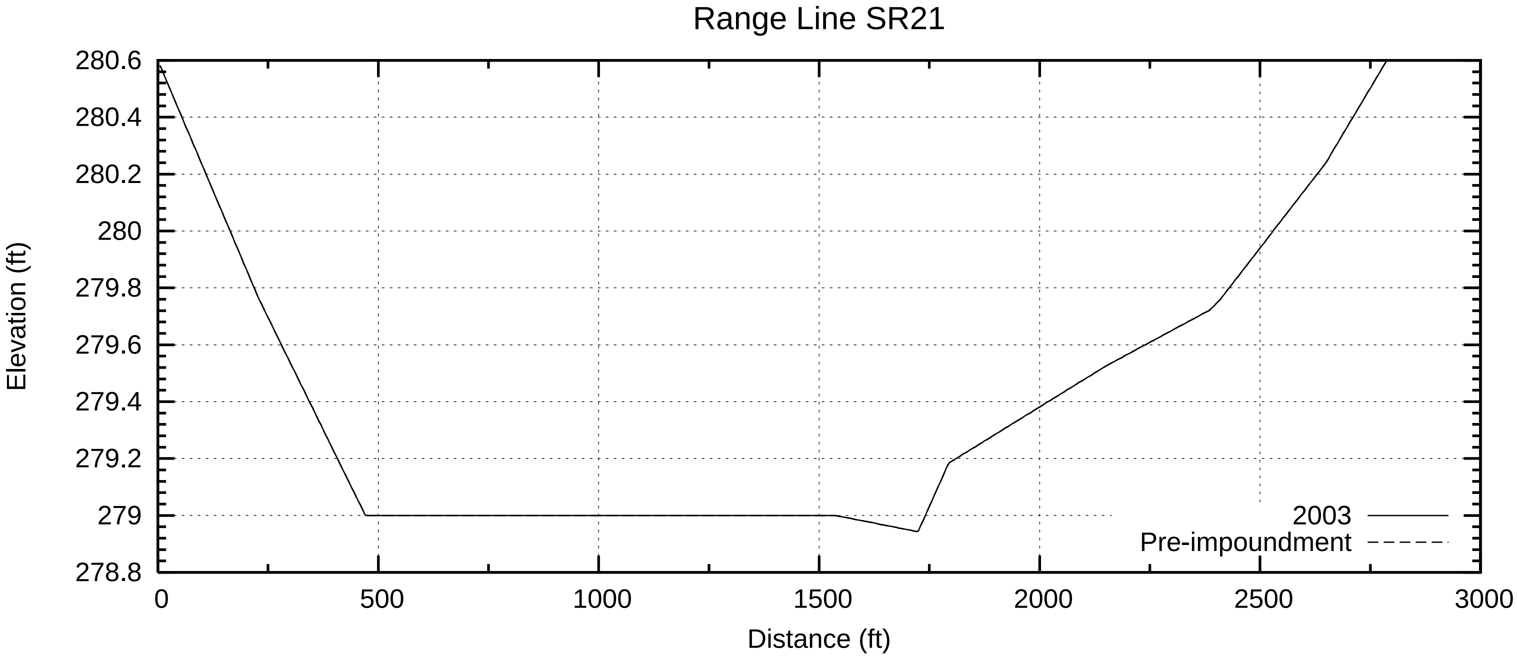


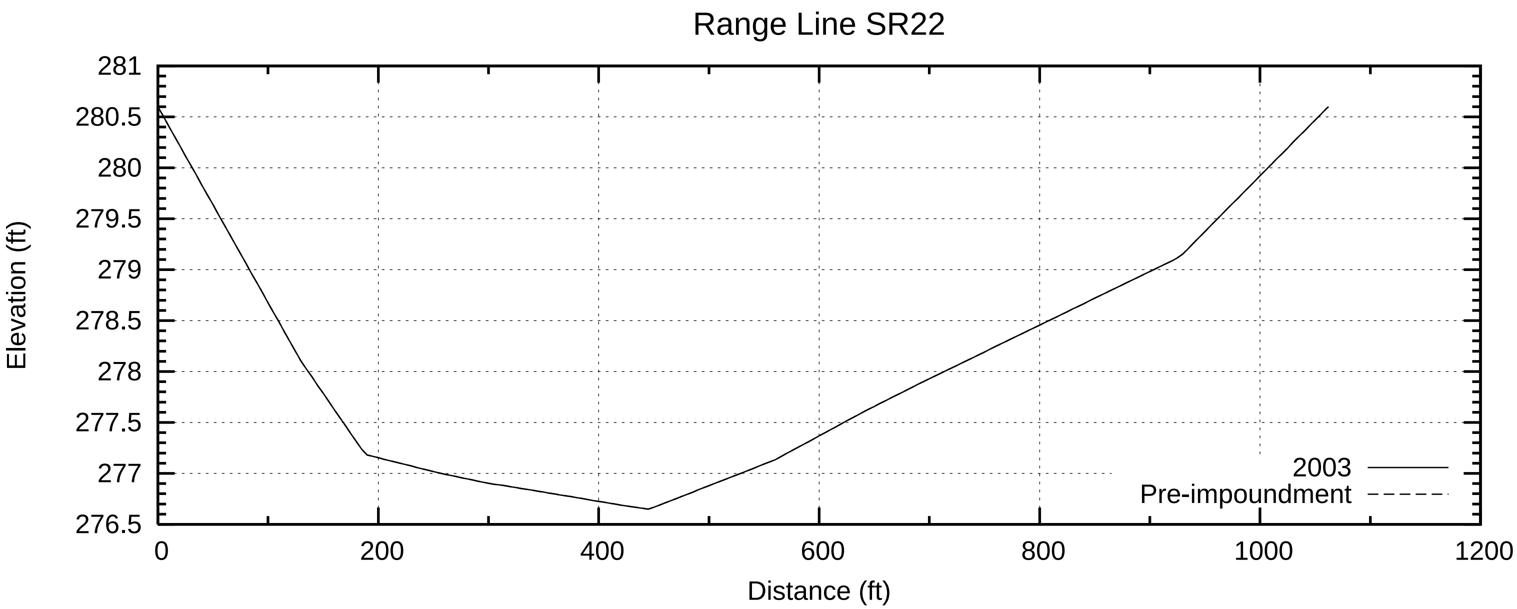
Lake Cherokee





Lake Cherokee

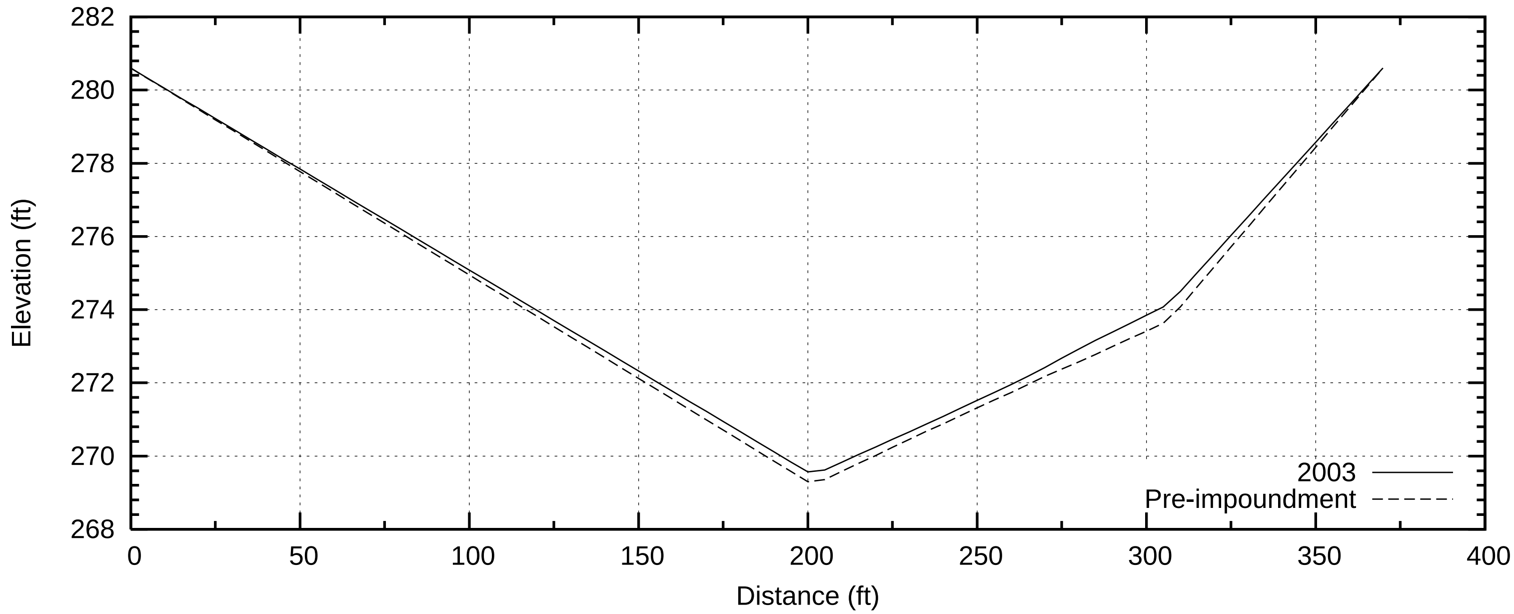




Appendix I

Lake Cherokee

Range Line SR23



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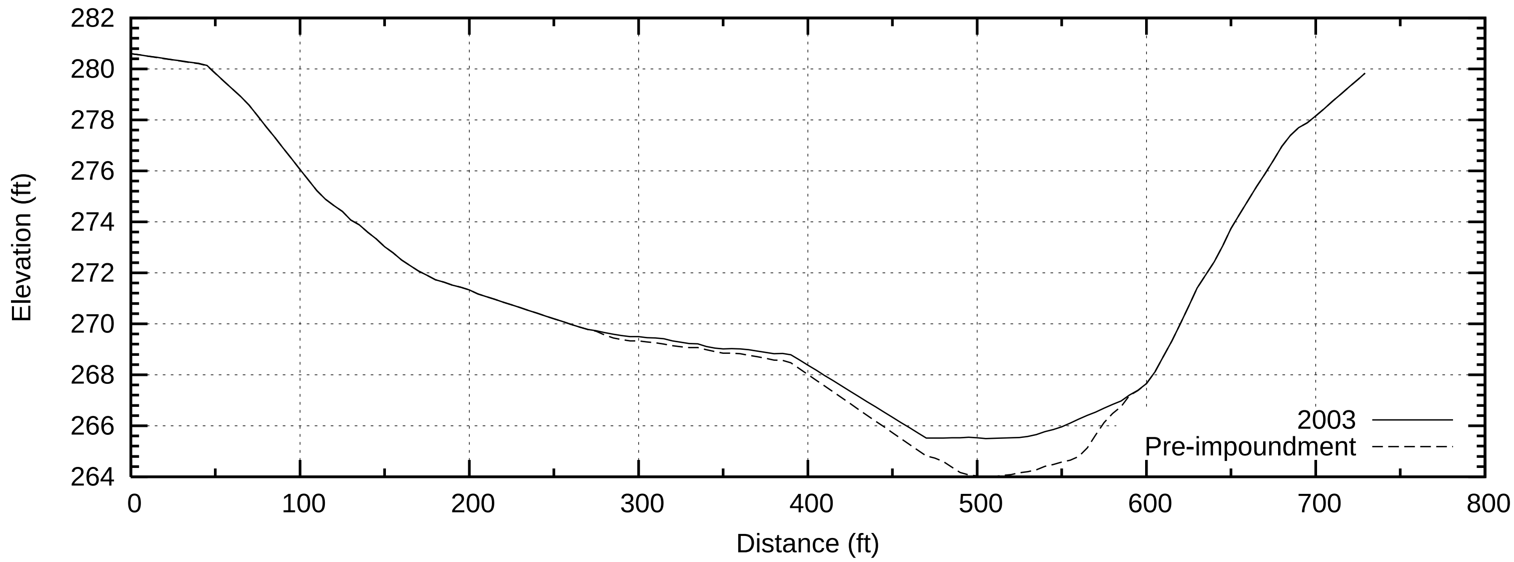

Lake Cherokee

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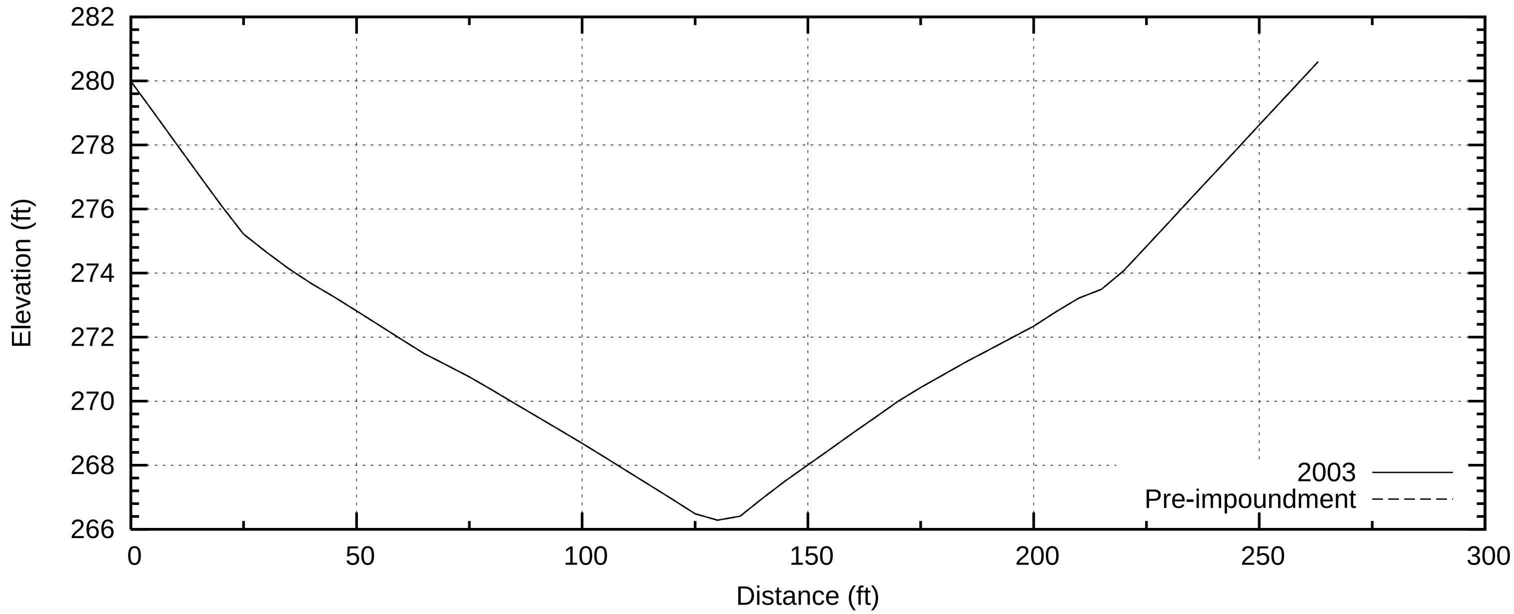

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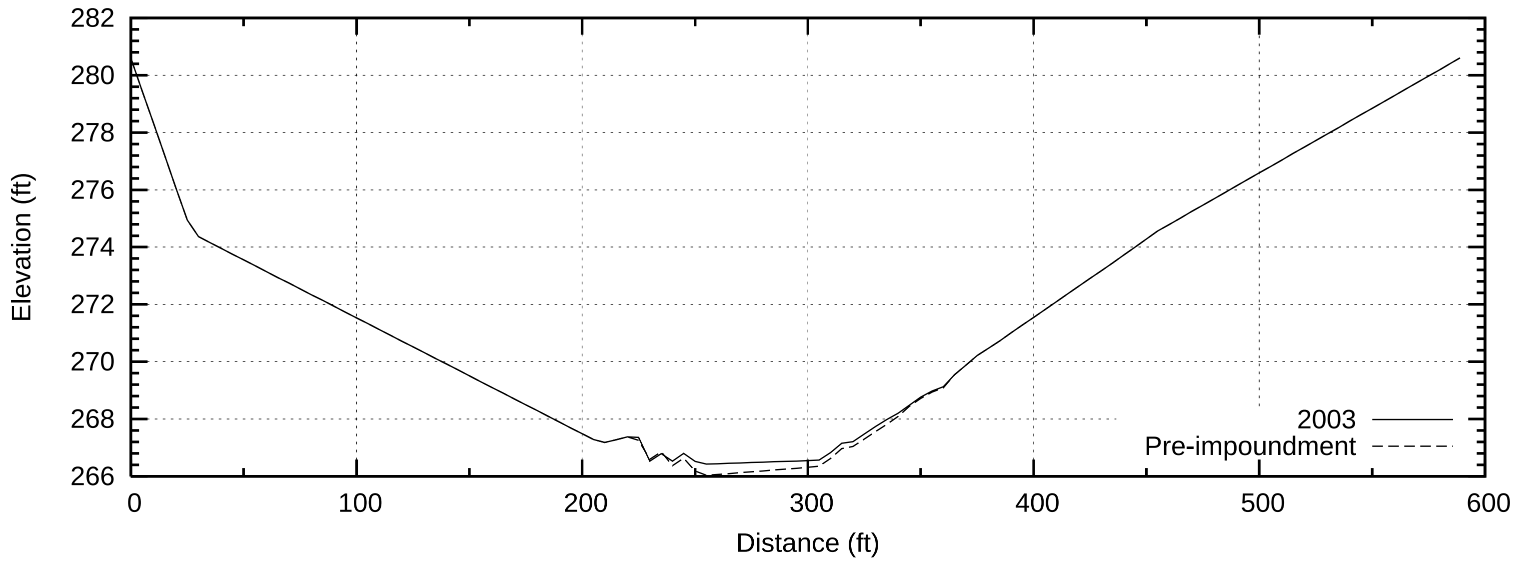
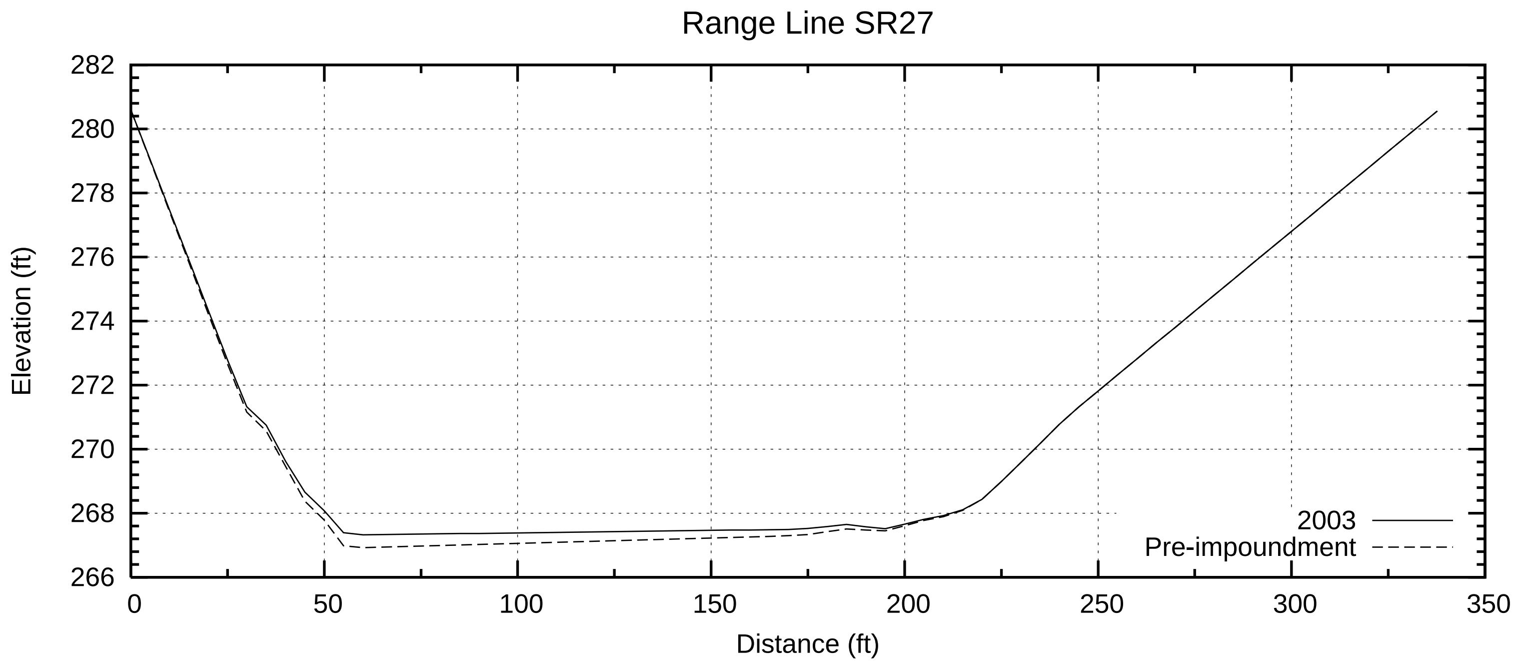
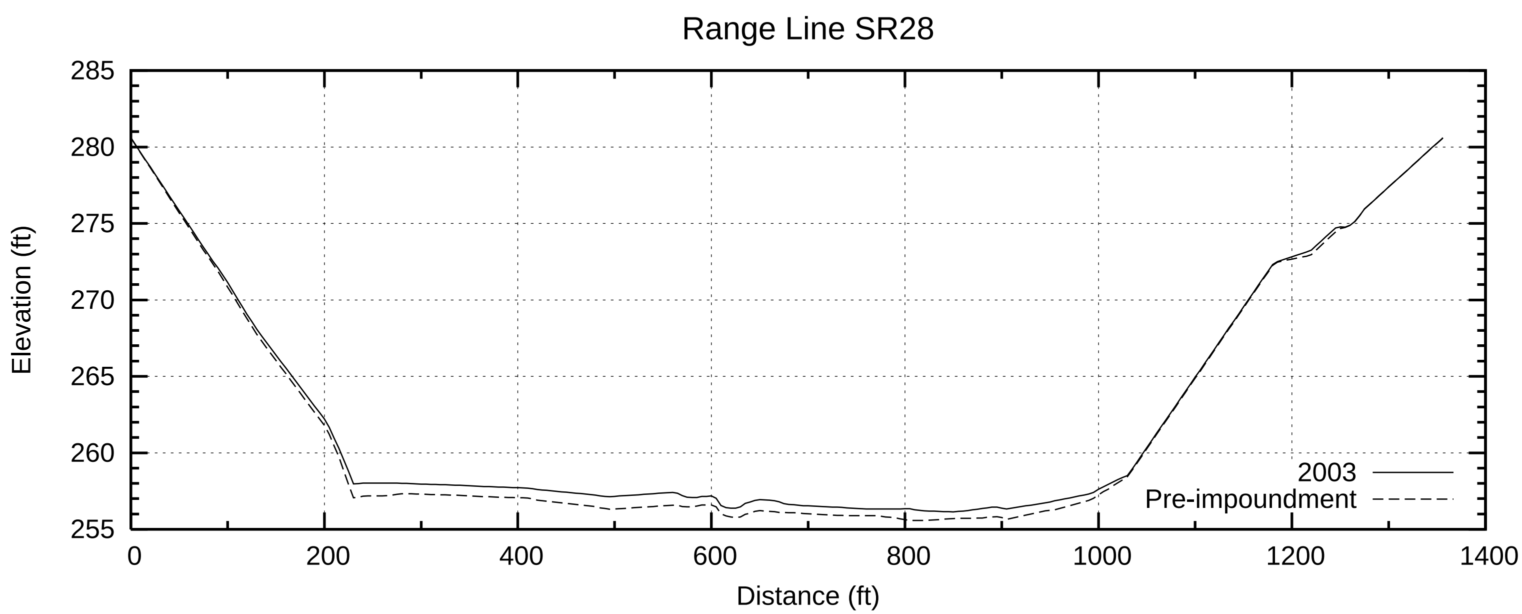


Appendix I

Lake Cherokee

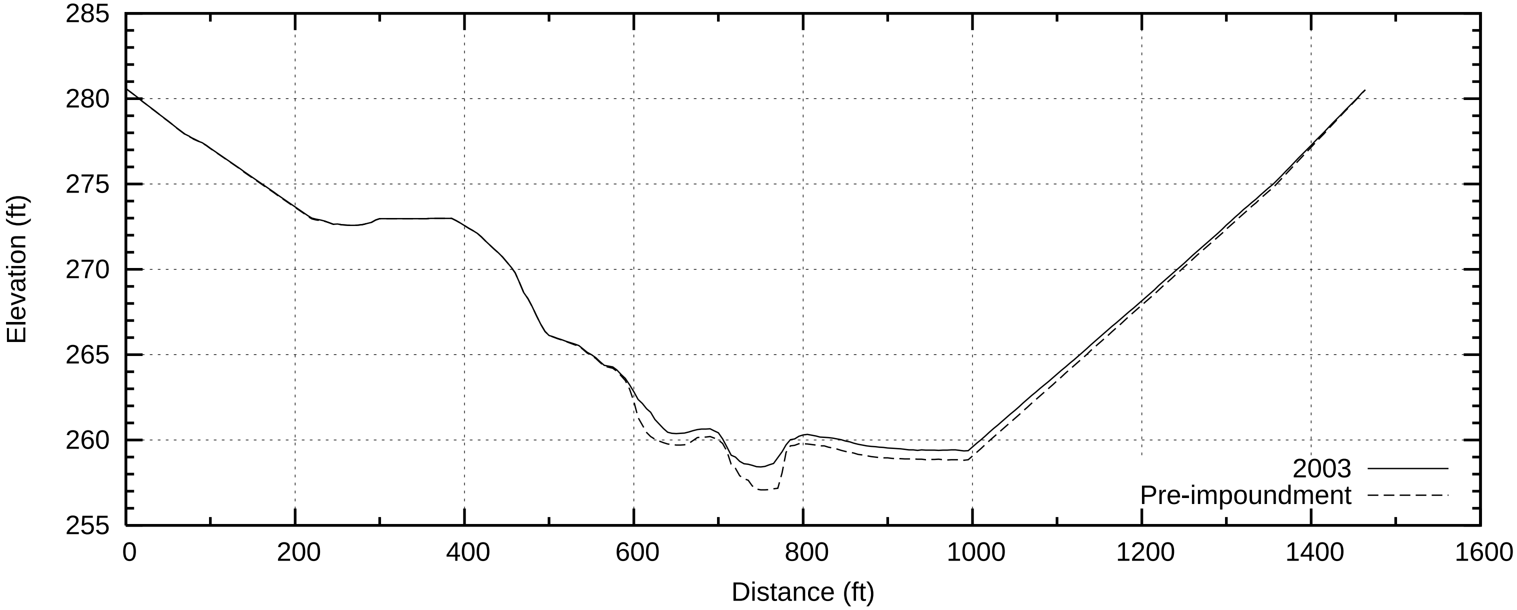




Appendix I

Lake Cherokee

Range Line SR29



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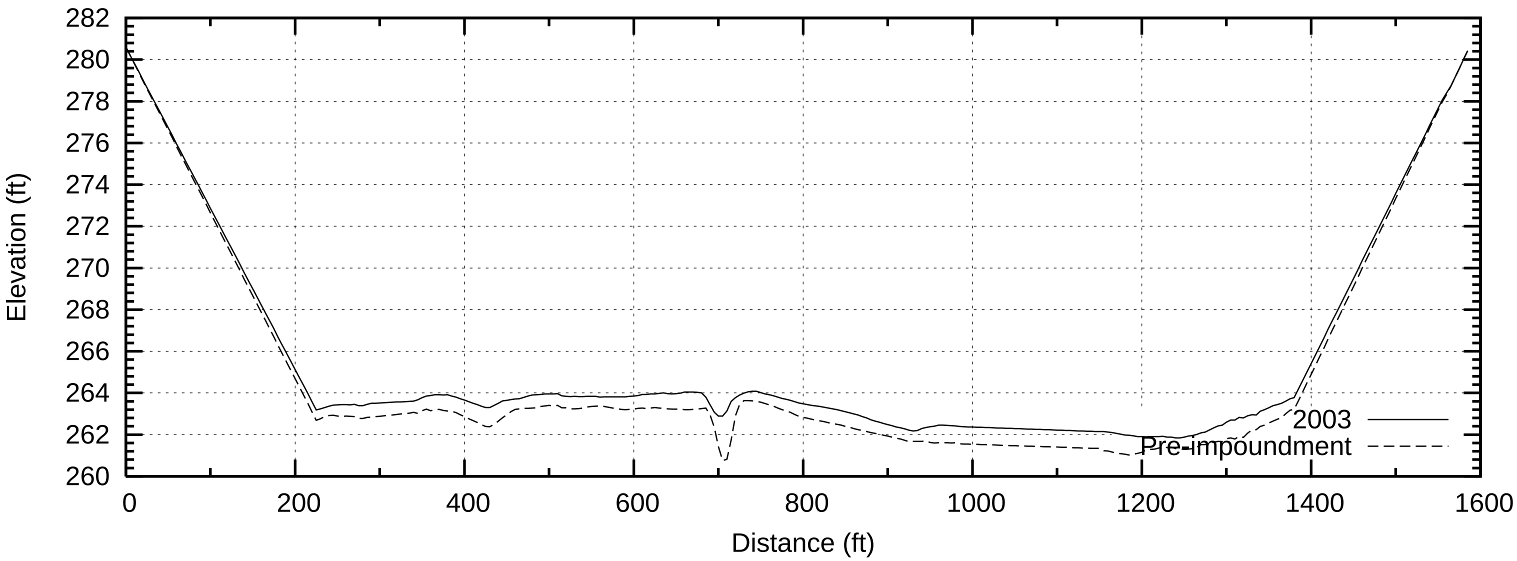

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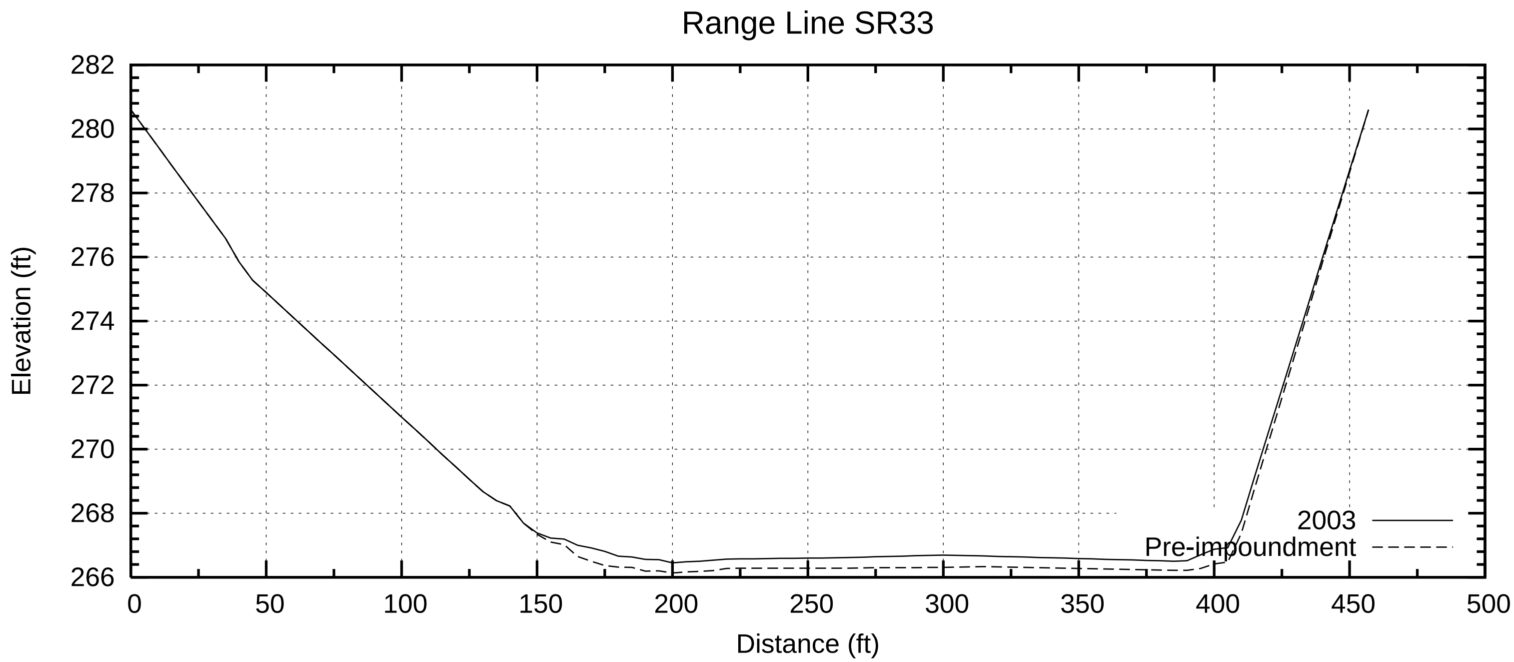

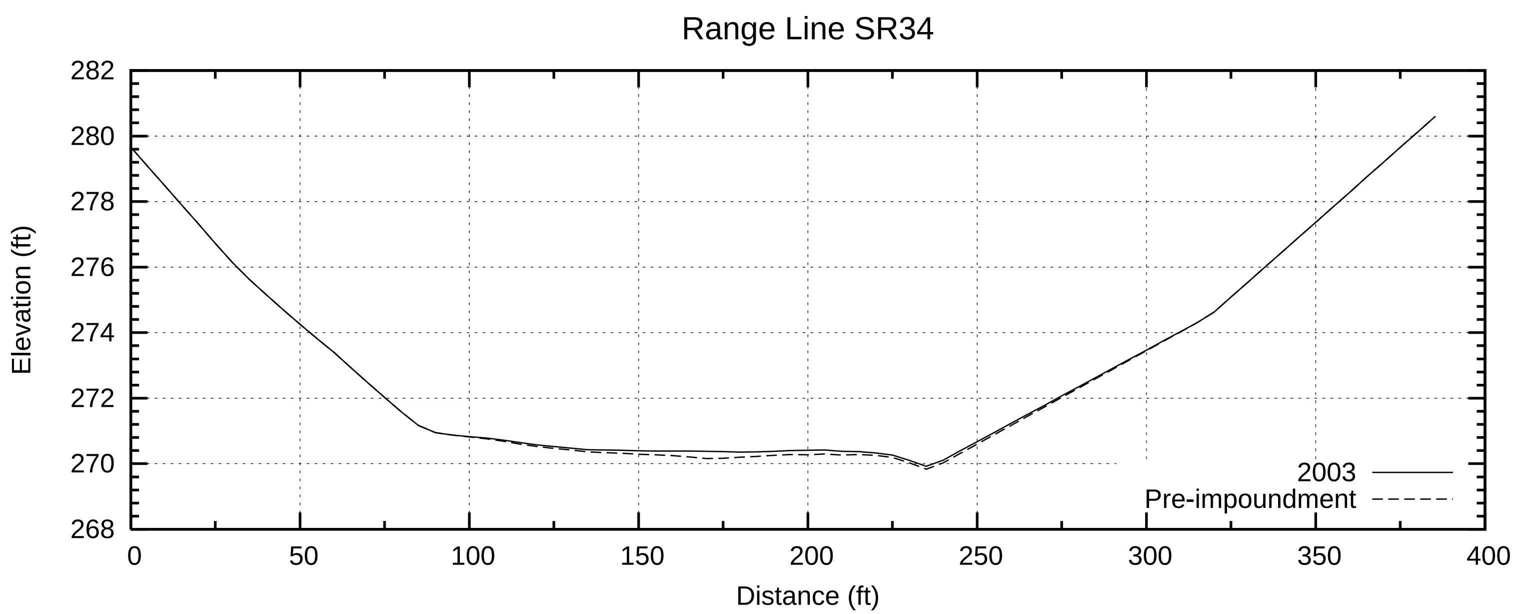

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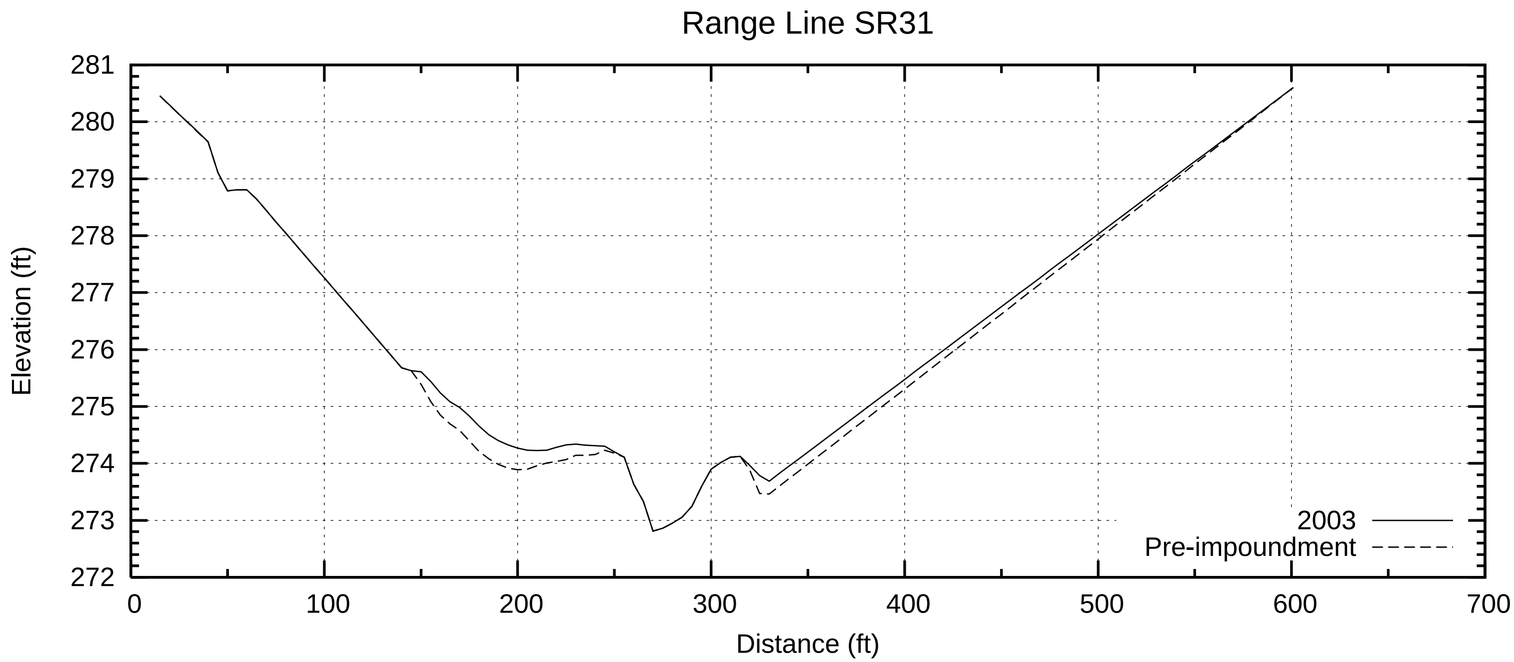

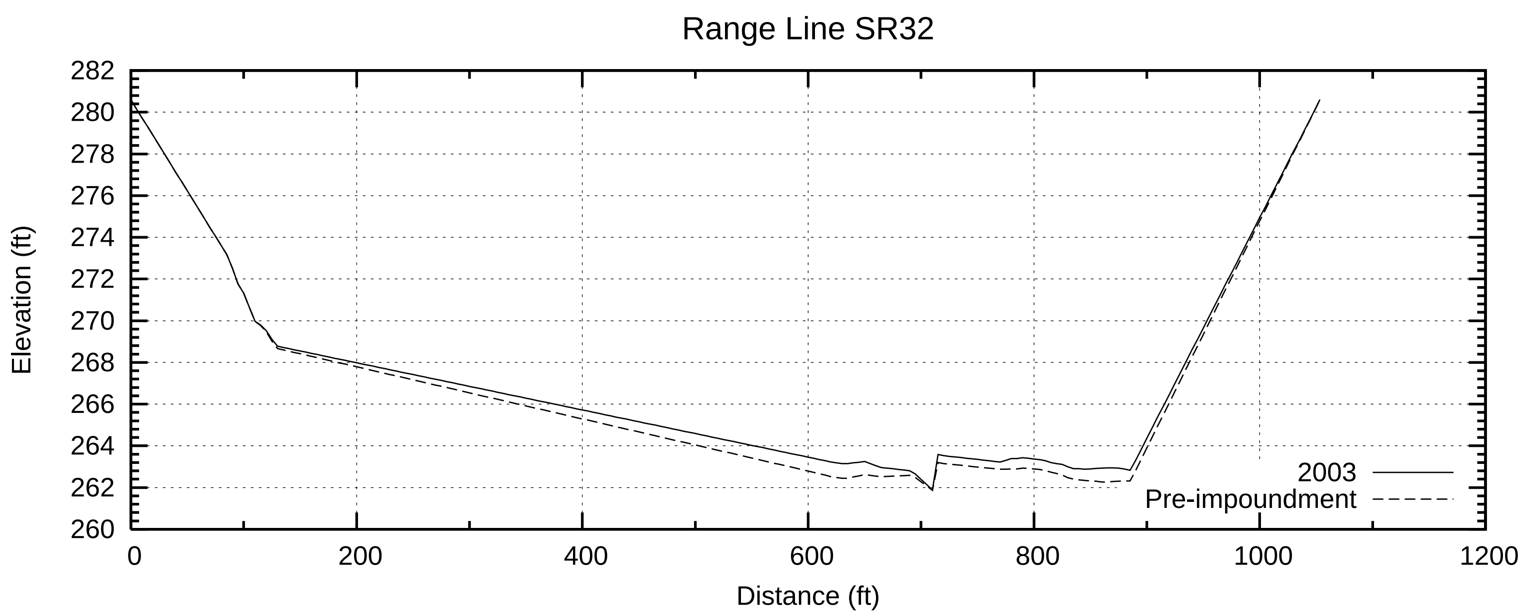

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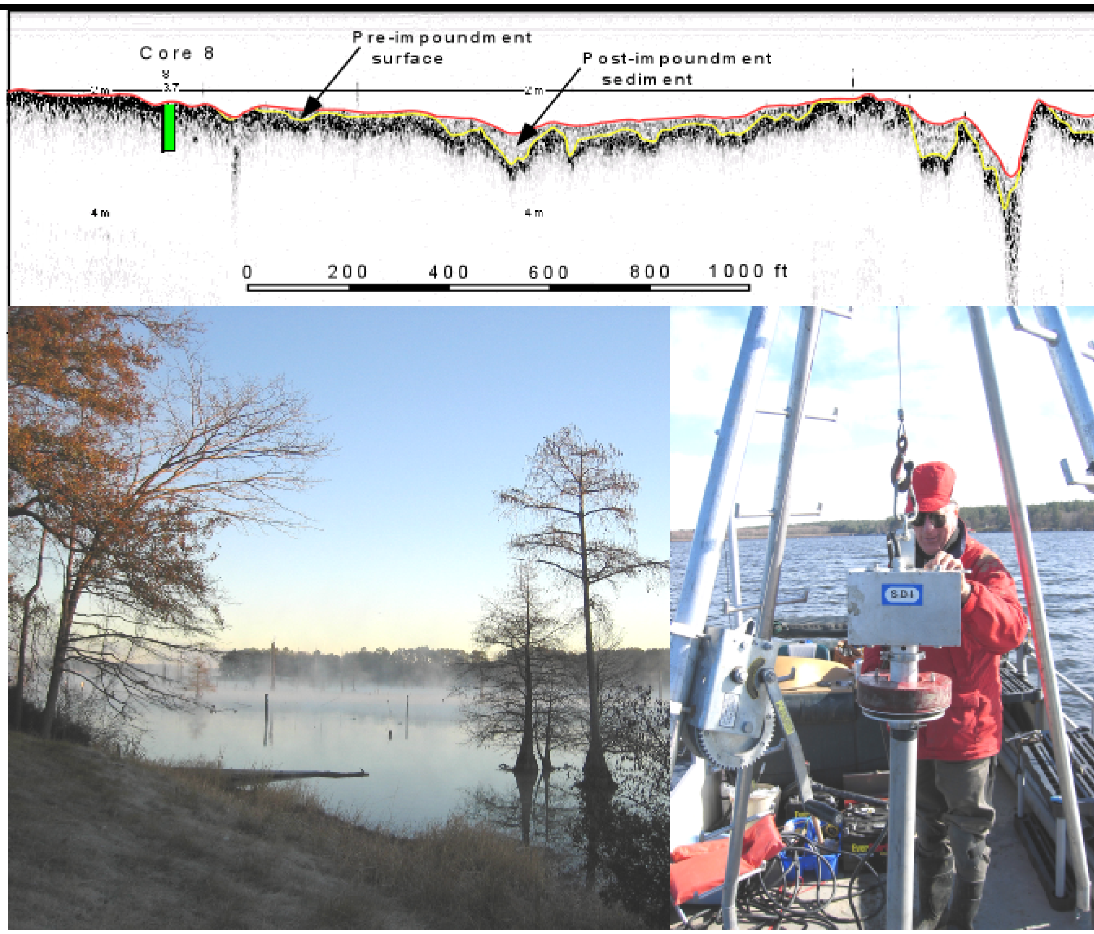
Sediment Thickness from Coring and Acoustic, Lake Cherokee, Rusk County, TX



By John A. Dunbar and Peter M. Allen

TWDB Contract No. 2003-483-499 **June, 2004**

EXECUTIVE SUMMARY

In November, 2003 the Texas Water Development Board (TWDB) conducted an acoustic survey of Lake Cherokee, in Rusk County, Texas to determine the volume of sediment in the reservoir. The goal of the study described in this report was to validate the TWDB's results by collecting core samples through the sediment at a number of locations along TWDB transects. We collected sediment cores at 8 locations in the reservoir using the vibracore technique, which produces continuous, undisturbed sediment samples. The cores ranged in length from 35 cm to 170 cm. The pre-impoundment surface was reached and sampled at all eight locations. Post-impoundment sediment at the core locations ranged in thickness from 0 to 25 cm. The cores were sub-sampled at 5 cm increments. The sub-samples were visually examined for evidence of the pre-impoundment surface and described. The sub-samples were also analyzed for water content and sediment shear strength. We found that the pre-impoundment surface was distinct and easily identified in all the cores. The post-impoundment sediment is a silty-clay, with high organic content and unusually high water continent (70-85%). Pre-impoundment materials range from nearly pure sand to clayey-sand. These sands are highly compacted, with shear strengths ranging up to 15 kg/cm^2 and have relatively low water content (20-30%). In all cases the pre-impoundment material contained intact terrestrial plant roots.

The correlation between the cores and the acoustic data was achieved in two ways. First, the core samples were collected at positions along acoustic profiles previously surveyed by the TWDB, so that the coring results could be directly compared with the TWDB data. Second, short acoustic records were collected at each core site, using an acoustic profiling system of the same make as that used by the TWDB. This system collects sub-bottom acoustic images at three discrete acoustic frequencies (200, 48, and 24 kilohertz (kHz)). The 200 kHz data show no visible distinction between the pre- and post-impoundment material. However, in the 48 and 24 kHz data, the post-impoundment layer appears light gray and the underlying pre-impoundment material is dark gray to black. The clearest image of the pre-impoundment surface is given by the 48 kHz data. Thicknesses estimated from the acoustic data agree with the core results to within 1 cm, assuming a sediment velocity of 1480 m/s (4,854 ft/s). The profiling results show that the post-impoundment layer produces a distinct acoustic response that is easily traced on acoustic profiles.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

In the November, 2003 the Texas Water Development Board (TWDB) conducted a survey of Lake Cherokee, Rusk County, Texas. The goal of this survey was to determine the volume of sediments that have accumulated in the reservoir since its impoundment in 1948. The approach used by the TWDB was to determine the sediment thickness by acoustic sub-bottom profiling along profiles spaced 500 ft apart throughout the lake. On these profiles the water bottom and the original lake bottom or pre-impoundment surface are identified and traced throughout. In the study described in this report we corroborate the TWDB's acoustic results by physical measurement of sediment thickness using the vibracoring method. The core samples were collected at points along selected TWDB acoustic profiles to validate the identification of the pre-impoundment surface and the speed of sound used to convert from acoustic transit time to sediment thickness.

3. PROCEDURES

The measurement of sediment thickness was done by collecting continuous, undisturbed cores using a vibracore device. The correlation between the cores and the acoustic data was achieved in two ways. First, the cores were collected along selected TWDB profiles, by positioning the coring vessel using differential GPS navigation. Because errors in vessel positioning during the original TWDB survey compound with errors in our positioning of the coring vessel along the same profile, the core locations may differ from the actual profile track line by 10 to 30 ft. Hence, to insure accurate co-location of acoustic and core data, short acoustic records were collected using the same model SDI profiling system as that owned by the TWDB, at each core site at the time the cores were collected. Because the survey boat remained anchored at the core site, these short records image the bottom at points only a few feet away from where the core tube penetrated the bottom.

2.1 Sediment Coring

A vibracoring system commercially available from SDI was used to core sediments within Lake Cherokee. Vibracoring is a common approach for obtaining undisturbed cores of unconsolidated sediment in saturated or nearly saturated conditions (Lanesky et al., 1979; Smith, 1984). The SDI vibracore uses a 1-HP motor that drives a pair of weights that are eccentrically mounted on two counter rotating shafts. The motor and vibrator mechanism are housed within a watertight aluminum chamber so it can be immersed in water. The chamber is connected to the top of a 76 cm (3 in.) diameter aluminum core tube. The vibracore driver is powered by two 12-volt batteries connected in series through a 125-ft power cord, thus limiting the depth of operation. Lengths of core tube 4 to 12 ft (1.2 to 3.7 m) long were used. The gantry is mounted on a 24 ft pontoon boat that has a 4 ft square “moon pool” cut into its deck (Figures 2-1).

Cores were collected by lowering the vibrator with core tube attached to the bottom by hand winch, switching on the vibrator, and allowing the tube to slowly vibrate into the bottom. The vibration causes the sediment to liquefy in a region a few millimeters thick near the tube wall, allowing the tube to slide into the sediment with little drag. This results in less disturbance and compaction of the sediment cores than occurs with gravity-driven drop coring devices. Core catchers made of thin sheet aluminum are attached inside of the leading end of the core tube. They allow the core to slide into the tube, but prevent it from sliding back out of the tube during retrieval. When the core had reached the point of refusal, the vibrator was turned off and the core was winched out of the bottom. On deck, the retrieved cores were capped top and bottom with rubber end-caps and stored upright during transport.

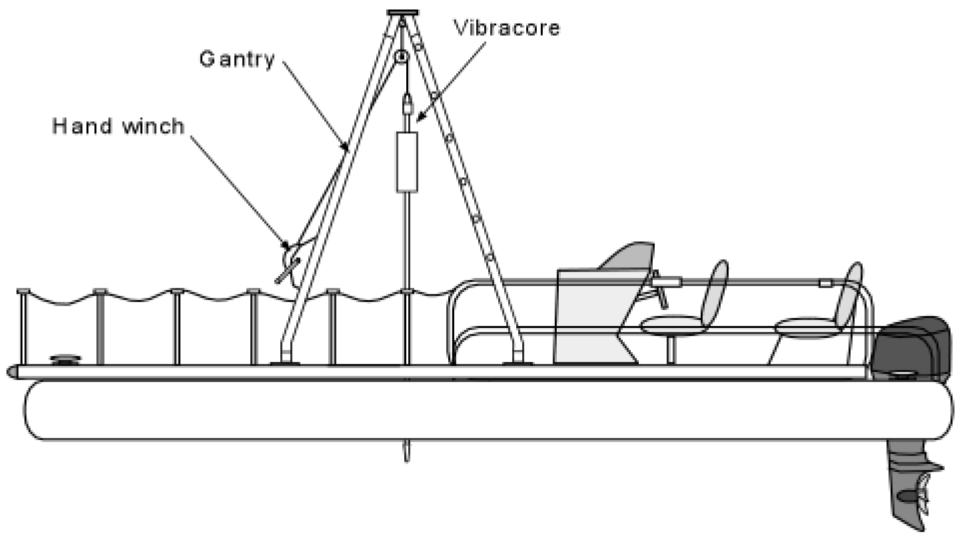

Figure 2-1. Coring boat with gantry. Schematic diagram of 24 ft coring boat and vibracoring system.

2.2 Core analysis:

The main goal of our core analysis was to determine the thickness of the post-impoundment sediment present in each core. In this analysis, we relied on visual examination of the sampled material, and measurements of the sediment water content and sediment shear strength versus depth in the cores. After the cores were brought back from the field, they were sub-sampled by cutting the core tube and sediment into 5-cm long slices using a pipe cutter. The sediment within each 5-cm slice was placed into pre-weighed containers, dried for 48 hours at 106º C, reweighed and stored for further analysis. The wet and dry weights of the samples were used to compute water content profiles along the cores. During the sub-sampling operation the strength of the sediment was determined using a pocket penetrometer that measures the force required to drive a 2.5 cm diameter disk into the sediment. These tests were performed on the top of each 5 cm sample, while the sample was confined in the core tube.

2.3 Discriminating Between Pre- and Post-impoundment materials

We determined the depth to the pre-impoundment surface in each core based on the following evidence: (1) a visual examination of the core for in place terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which would be expected on or just below the pre-impoundment surface, but not in the post-impoundment sediment and (2) variations in the physical properties of the sediment, particularly sediment water content and shear strength. Sediments deposited in reservoirs typically have water contents that range from 50 to 80% at the water bottom and decrease with burial to 30 to 40% at depths of several meters. Soils, in contrast, typically have water contents of 20 to 30% when saturated. The shear strength of reservoir sediments (as measured with penetration devices) typically ranges from 0 to 2 kg/cm^2. The shear strength of saturated clay-rich soils typically ranges from 3 to over 10 kg/cm^2.

2.4 Acoustic Profiling

The acoustic profiling system used in this study is the same SDI profiler model as that used by the TWDB in its sediment surveys. The system images the bottom and sub-bottom sediments with acoustic transducers with central frequencies of 200, 48, and 24 kHz. During acquisition, the system collects traces using each transducer independently in a rapid, round-robin succession. The high-frequency signals provide a sharp image of low-density mud at the water bottom, whereas the low-frequency signals penetrate many meters into the bottom to image the base of sediment fill, even in areas of high sediment accumulation. For the present study, the sound source was suspended over the side of the coring boat, adjacent to the coring gantry. Short acoustic records were collected at each core site. During post survey processing of the acoustic data, the core locations, and depths to the pre-impoundment surface were read into the acoustic processing program. The program posts core diagrams that show the interpreted post-impoundment sediment thickness on the acoustic data at the point of closest approach of the profile to the core location.

3. Results

Eight cores were collected in Lake Cherokee at locations spaced along its length (Figure 3-1). A summary of core locations, core lengths, and the interpreted depth to the pre-impoundment surface are given in Table 3-1. Tables describing the results of the physical analysis of cores from each site are given in Appendix A. Water content and shear strength versus depth in the cores are shown along side the visual description of the core material in Figures 3-2 to 3-9. The interpreted tops to the pre- and post-impoundment intervals on co-located acoustic profiles are also shown in Figures 3-2 to 3-9.

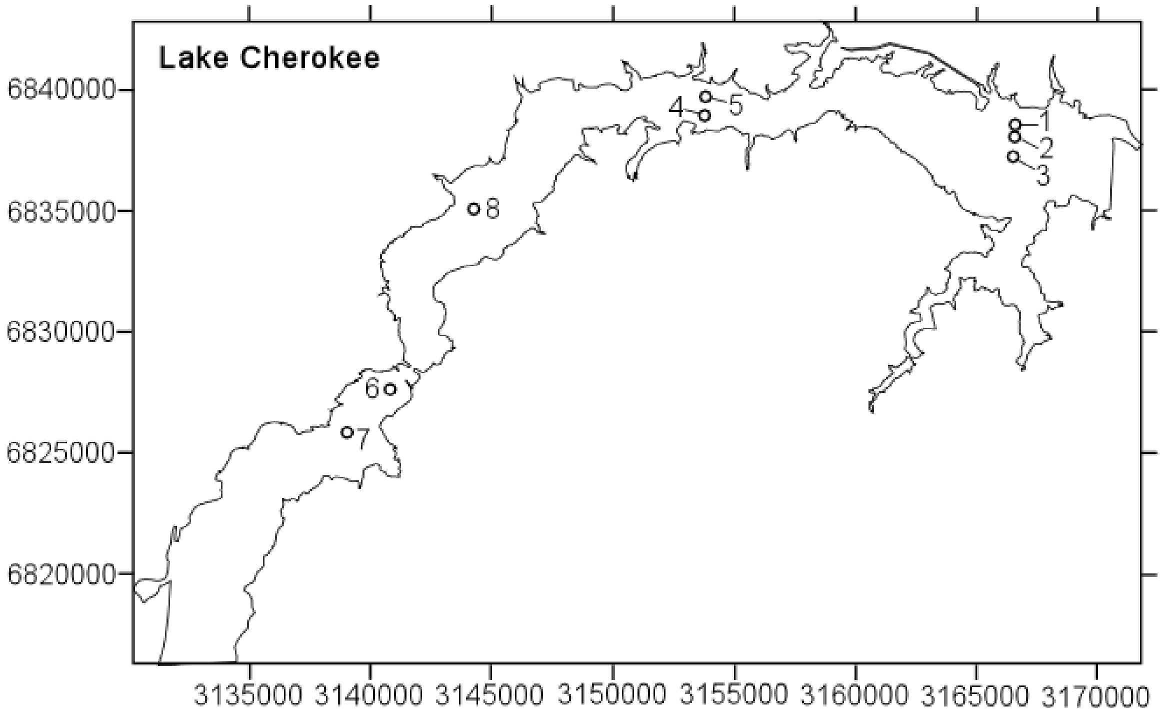

Figure 3-1. Map showing core locations in Lake Cherokee (circles). Map coordinates are Texas State Plane, North Central Zone, NAD 83, feet.

Table 3-1. Summary of sediment cores collected in Lake Cherokee. The core locations are given in Texas State Plane, North Central Zone, NAD 83, feet. Survey line numbers refer to acoustic profiles collected during the November, 2003 TWDB survey of Lake Cherokee that are closest to each core location.

Core ID	Easting (ft)	Northing (ft)	Length (cm)	Depth to pre-impoundment (cm)	TWDB Survey Line No.
CKE1	3166610.9	6838535.7	42	20	10
CKE2	3166598.6	6838031.6	170	25	10
CKE3	3166539.2	6837238.1	35	15	10
CKE4	3153784.0	6838936.0	38	15	62
CKE5	3153831.8	6839686.9	145	10	62
CKE6	3140811.8	6827655.5	82	10	111
CKE7	3139029.0	6825896.2	59	15	116
CKE8	3144277.2	6835057.9	78	0	92

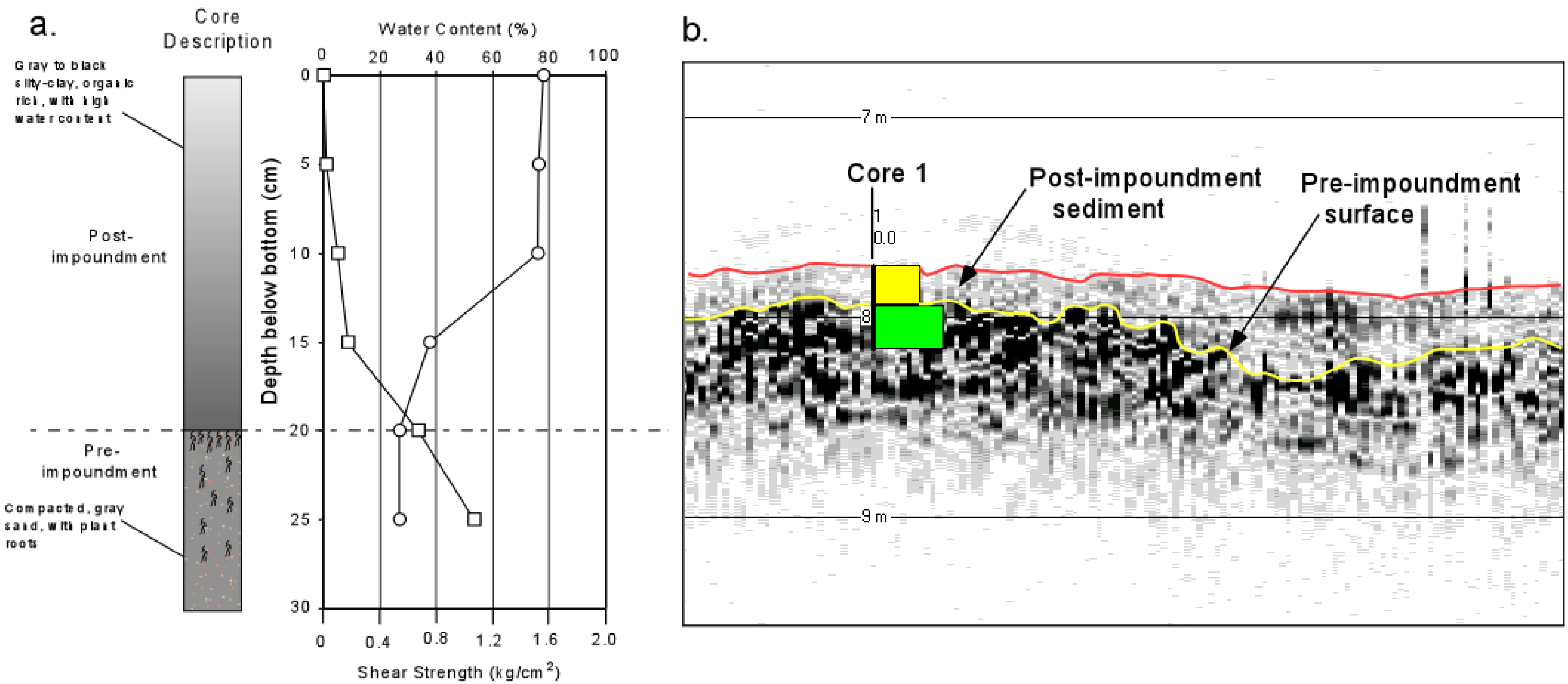

Figure 3-2. Core and acoustic results for site CKE1. (a) Physical analysis of Core 1, showing 20 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface. In the core diagrams yellow represents post-impoundment fill and green represents cored interval of pre-impoundment material. The location of core CKE1 is shown in Figure 3-1.

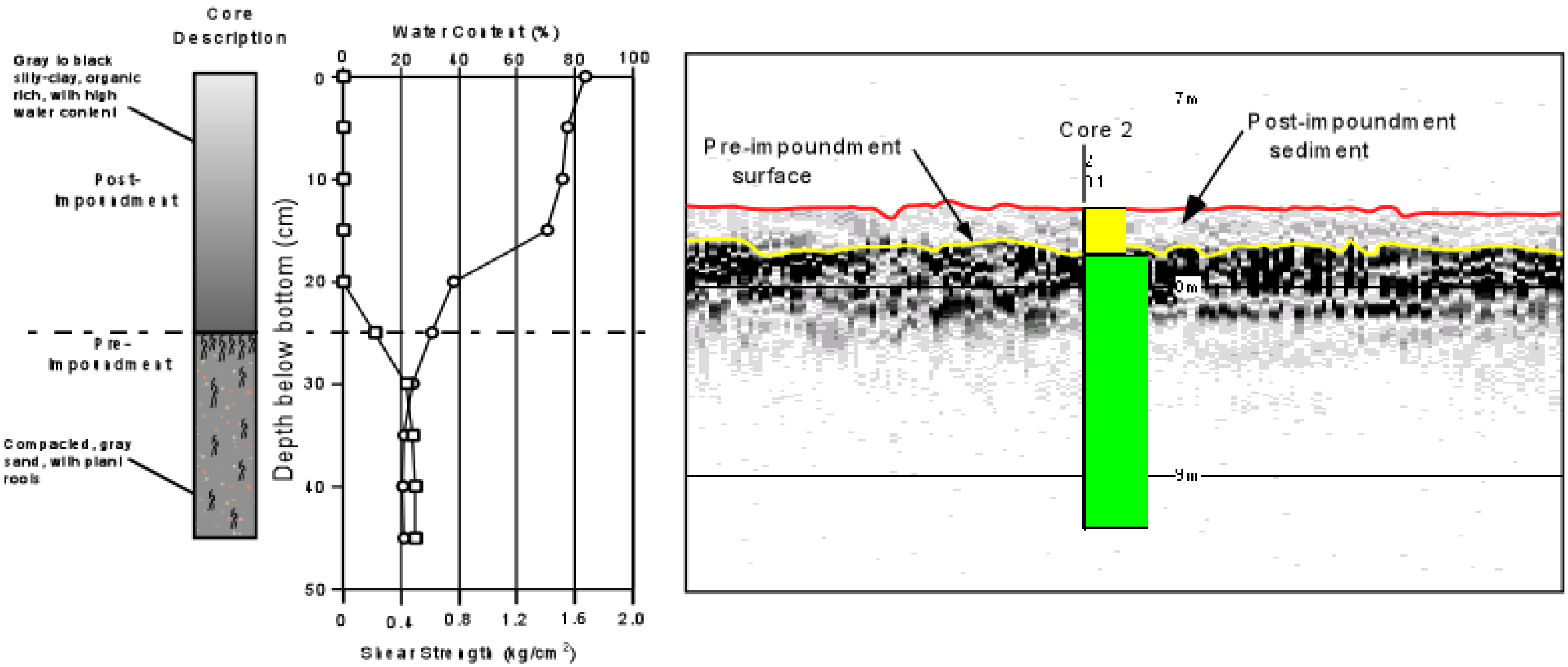

Figure 3-3. Core and acoustic results for site CKE2. (a) Physical analysis of Core 2, showing 25 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

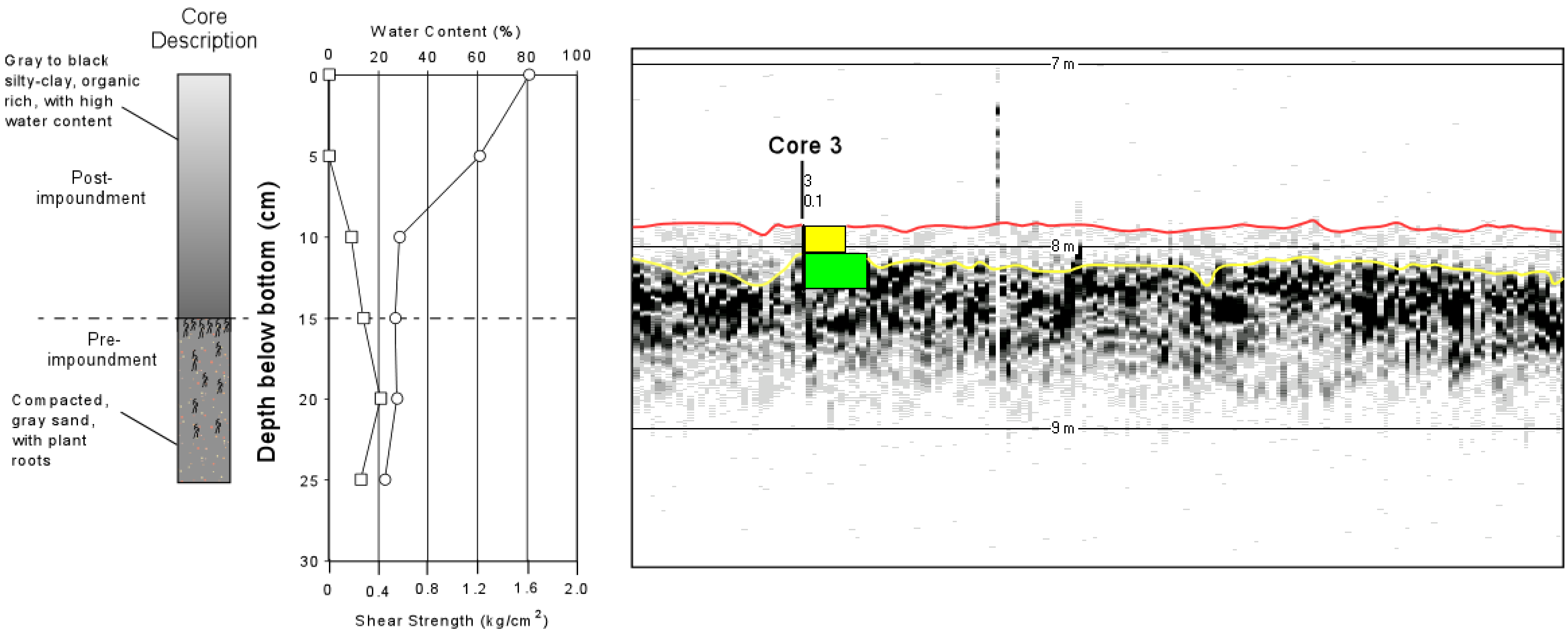

Figure 3-4. Core and acoustic results for site CKE3. (a) Physical analysis of Core 3, showing 15 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

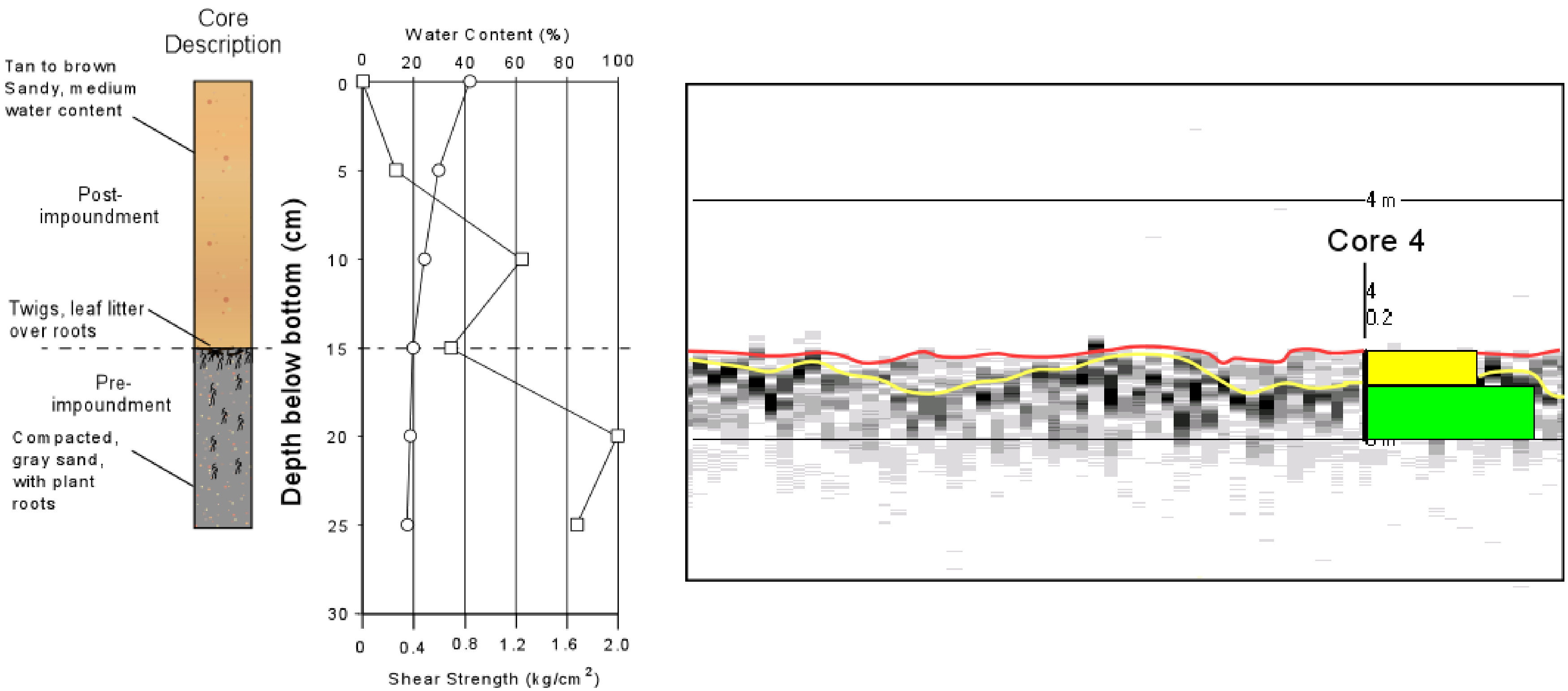

Figure 3-5. Core and acoustic results for site CKE4. (a) Physical analysis of Core 4, showing 15 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

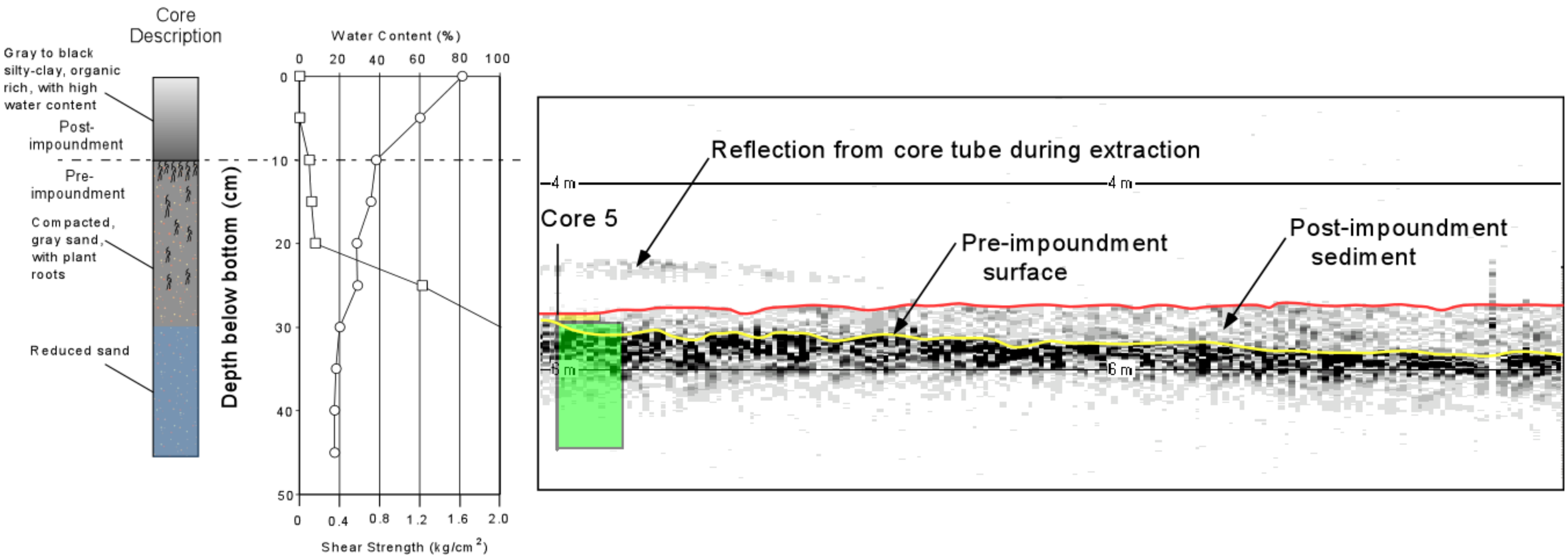

Figure 3-6. Core and acoustic results for site CKE5. (a) Physical analysis of Core 5, showing 10 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

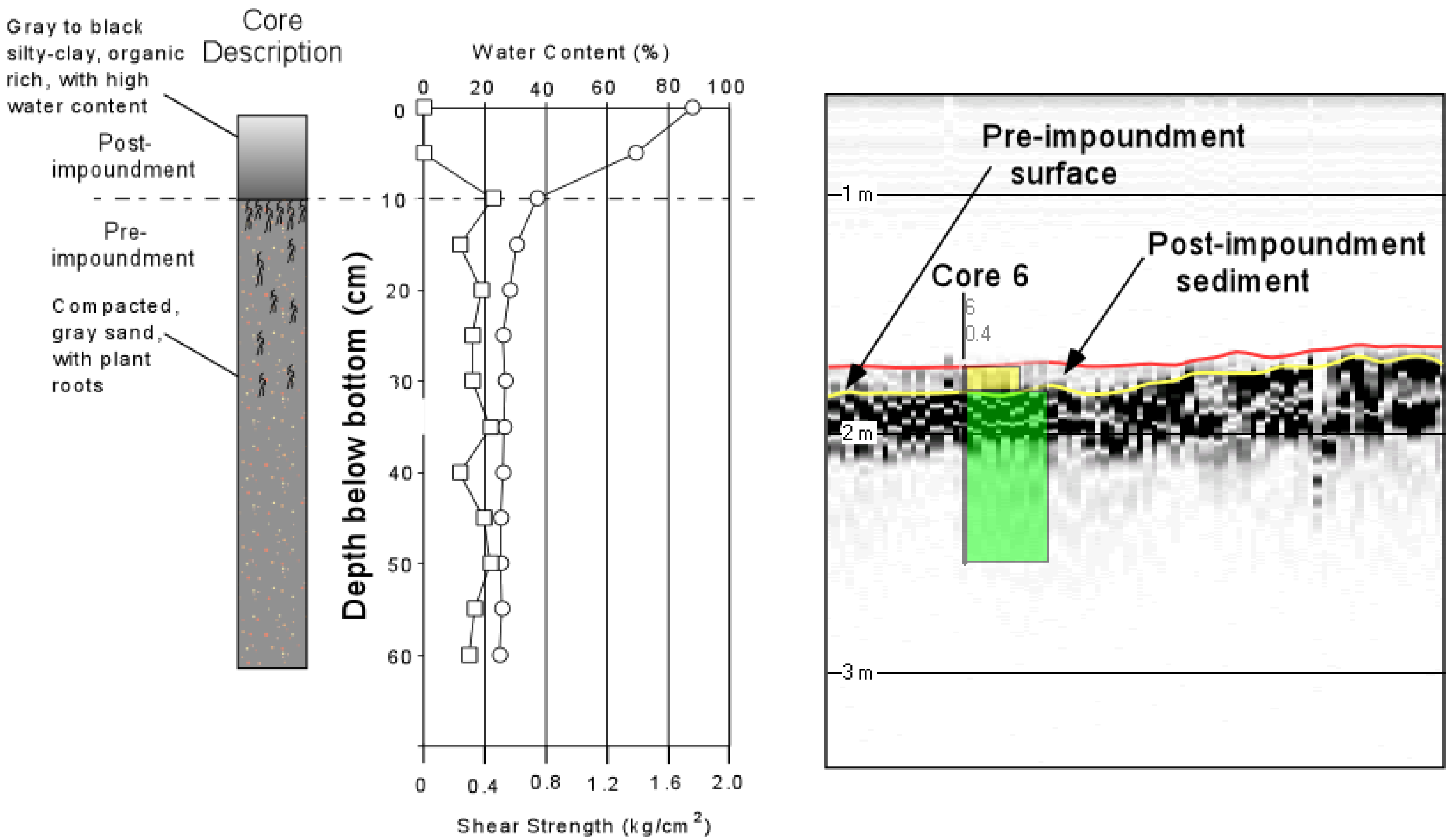

Figure 3-7. Core and acoustic results for site CKE6. (a) Physical analysis of Core 6, showing 10 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

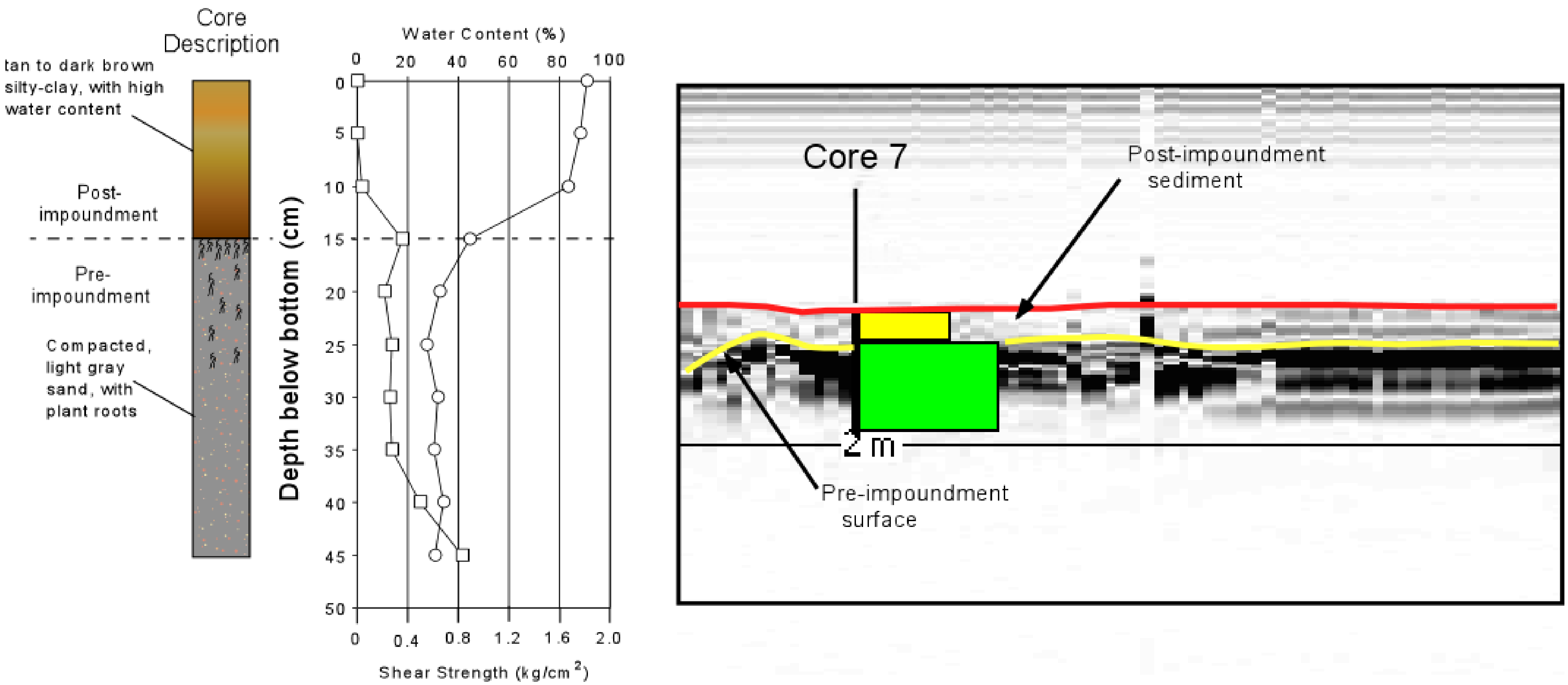

Figure 3-8. Core and acoustic results for site CKE7. (a) Physical analysis of Core 7, showing 15 cm of post-impoundment sediment over pre-impoundment. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface.

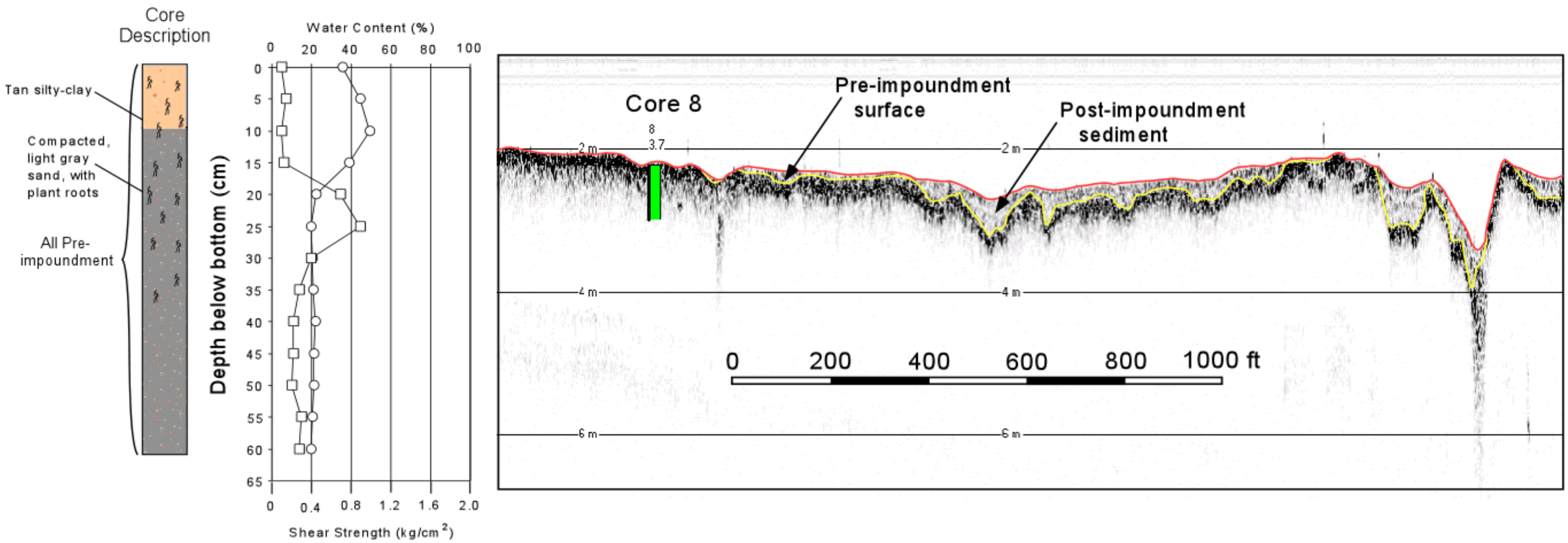

Figure 3-9. Core and acoustic results for site CKE8. (a) Physical analysis of Core 8, showing essentially no post-impoundment sediment over pre-impoundment at the core site. (b) Short acoustic profile showing only the 48 kHz acoustic signal. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface. Extended profile through Lake Cherokee Core site CKE8. Only the 48 kHz acoustic data are shown. On the acoustic data, the red line marks the water bottom and the yellow line marks the interpreted pre-impoundment surface. In the core diagrams yellow represents post-impoundment fill and green represents cored interval of pre-impoundment material. At the site of the core there is no post-impoundment sediment. Elsewhere along the profile the post-impoundment interval reaches a thickness of 60 cm.

4. Discussion

The goal of this study was to identify the pre-impoundment surface in a series of cores and on co-located acoustic data in support of the November, 2003 TWDB survey of Lake Cherokee. Two aspects of our results stand out as noteworthy. First, in the cores the layer of post-impoundment sediment fill is unusually thin (0 to 25 cm) for reservoirs of this age. This is partly an artifact of where the cores were collected. In many cases the sites that were pre-selected for coring from the TWDB's acoustic data could not be reached with the coring boat because of stumps and other obstructions. Alternate core locations were selected based on access to the site, rather than specific sediment targets. Somewhat thicker sediment accumulations (50 to 60 cm) with the same acoustic character are seen on the profiles at other points (Figure 3-9). Still, the amount of sedimentation is lower than is found in reservoirs of comparable age in the Backland Prairie, for example. We attribute this to the relatively small contributing watershed surface area (170 mi^2) for a reservoir of this size and the sandy soils that dominate the watershed.

The second noteworthy finding is that the pre-impoundment surface and the post-impoundment sediment column is best imaged on the 48 kHz data. The 200 kHz signal scatters efficiently in both the post- and pre-impoundment material to the extent that the two material types are not distinguishable on the 200 kHz records. In contrast, the post-impoundment sediment scatters the 48 and 24 kHz signals much less efficiently than the pre-impoundment material. Hence, the two materials are distinct on both the 48 and 24 kHz records, but the pre-impoundment surface is more sharply imaged on the 48 kHz data.

5. CONCLUSIONS

The main conclusions of our study are listed below.

1. The post impoundment fill in Lake Cherokee has high water continent (70-85%) and low shear strength throughout. At the core sites the post-impoundment layer is relatively thin, ranging in thickness from 0 to 25 cm thick.

2. The post-impoundment layer is acoustically distinct from the pre-impoundment material, appearing light gray on the 48 kHz single frequency acoustic displays. The underlying pre-impoundment materials appear dark gray to black on the same displays.

6. REFERENCES

Lanesky, D.E., B.W. Logan, R.G. Brown, and A.C. Hine, 1979. A new approach to portable vibracoring underwater and on land. Journal of Sedimentary Petrology, 49, 654-657.

Smith, D.G., 1984. Vibracoring fluvial and deltaic sediments: Tips on improving penetration and recovery. Journal of Sedimentary Petrology, 54, 660-663.

Appendix A

Cherokee Core 1

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	0.44	5.63	1.59	77.8	0	Dark gray to black
2	5	10	0.44	6.83	1.97	76.1	0.1	mud
3	10	15	0.44	4.97	1.54	75.7	0.5	
4	15	20	0.45	8.44	5.43	37.7	0.9	Pre-impoudment
5	20	25	0.45	6.71	5.03	26.8	3.4	Dark brown, roots
6	25	30	0.43	9.23	6.87	26.8	5.4	

Cherokee Core 2

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	8.5	218.5	43.36	83.4	0	Soupy, silty-clay,
2	5	10	8.42	247.95	62.45	77.4	0	gray to black
3	10	15	8.27	220.59	60.09	75.6	0	
4	15	20	8.18	204.29	66.53	70.2	0	
5	20	25	8.58	280.17	177.26	37.9	0	twigs, leaf fragments
6	25	30	8.12	298.65	209.6	30.7	1.1	pre-impouundment
7	30	35	8.32	339.05	260	23.9	2.2	gray sand, plant roots
8	35	40	8.33	297.26	236.51	21.0	2.4	
9	40	45	8.48	281.7	225.2	20.7	2.5	
10	45	50	8.15	283.84	226.59	20.8	2.5	

Cherokee Core 3

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	0.65	7.54	1.99	80.6	0	black mud
2	5	10	0.43	13.31	5.49	60.7	0	mass of twigs
3	10	15	0.44	9.48	6.9	28.5	0.9	Pre-impoundment
4	15	20	0.45	8.18	6.12	26.6	1.4	brown, roots
5	20	25	0.44	11.82	8.71	27.3	2.1	
6	25	30	0.43	13.72	10.74	22.4	1.3	

Cherokee Core 4

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	0.44	8.24	4.98	41.8	0	tan, sandy-clay
2	5	10	0.44	13.98	9.95	29.8	1.3	
3	10	15	0.44	15.09	11.58	24.0	6.3	
4	15	20	0.43	23.2	18.75	19.5	3.5	twigs, leaf fragments
5	20	25	0.45	22.15	18.16	18.4	10.1	pre-impoundment
6	25	30	0.45	20.04	16.65	17.3	8.5	roots

Cherokee Core 5

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	8.48	163.3	37.98	80.9	0	Dark brown to black
2	5	10	8.07	222.62	93.6	60.1	0	organic material
3	10	15	8.28	340.69	214.17	38.1	0.5	pre-impoundment
4	15	20	8.59	358.28	233.58	35.7	0.6	Dark gray to black
5	20	25	8.77	364.74	262.76	28.6	0.8	sand with roots
6	25	30	8.09	341.01	244.36	29.0	6.2	
7	30	35	8.4	394.95	317.25	20.1	10.2	
8	35	40	8.06	217.61	179.46	18.2	15	
9	40	45	8.46	226.74	189.07	17.3	10.5	
10	45	50	8.46	224.78	186.89	17.5	15	

Cherokee	Core 6							x=
Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg)	Comment 1
1	0	5	7.97	145.54	24.86	87.7	0	Dark brown-Black
2	5	10	8.12	205.37	68.81	69.2	0	Mud
3	10	15	8.54	379.43	242.55	36.9	2.3	pre-impoundment
4	15	20	8.46	357.74	252.1	30.2	1.2	Gray pure sand with
5	20	25	8.42	373.44	270.67	28.2	1.9	no roots
6	25	30	8.45	338.4	253.39	25.8	1.6	
7	30	35	8.07	386.9	285.86	26.7	1.6	
8	35	40	8.29	384.25	285.02	26.4	2.2	
9	40	45	8.01	388.38	289.96	25.9	1.2	
10	45	50	8.33	318.74	240.57	25.2	2	
11	50	55	8.2	394.61	297.95	25.0	2.2	
12	55	60	8.21	346.06	260	25.5	1.7	
13	60	65	8.59	279.07	212.22	24.7	1.5	

Cherokee	Core 7							
Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg/25)	Comment 1
1	0	5	0.44	7.87	1.13	90.7	0	Dark brown-Black
2	5	10	0.44	10.59	1.66	88.0	0	Mud
3	10	15	0.44	13.79	2.66	83.4	0.2	twigs, leaf fragments
4	15	20	0.64	25.31	14.39	44.3	1.8	Pre-impoundment
5	20	25	0.43	15	10.23	32.7	1.1	Gray pure sand with
6	25	30	0.43	20.51	15.01	27.4	1.4	plant roots
7	30	35	0.45	13.66	9.44	31.9	1.3	
8	35	40	0.44	16.43	11.58	30.3	1.4	
9	40	45	0.43	18.83	12.53	34.2	2.5	
10	45	50	0.44	16.14	11.31	30.8	4.2	

Cherokee Core 8

Sample	Top (cm)	Bot (cm)	Cont. wt (gr)	Wet wt. (gr)	Dry wt. (gr)	Wat Cont. (%)	Pen. At Top (kg/25)	Comment 1
1	0	5	8.66	373.73	244.11	35.5	0.5	Pre-impoundment
2	5	10	8.56	327.37	186.13	44.3	0.7	Pebble-size lithic
3	10	15	8.51	321.75	166.99	49.4	0.5	framgnets
4	15	20	8.64	387.61	240.5	38.8	0.6	Uniform gray sand
5	20	25	8.66	354.29	277.78	22.1	3.5	plant roots
6	25	30	8.43	358.02	289.26	19.7	4.5	
7	30	35	8.59	330.81	264.85	20.5	2	
8	35	40	8.81	382.48	304.91	20.8	1.4	
9	40	45	8.55	345.56	272.39	21.7	1.1	
10	45	50	8.76	350.08	278.58	20.9	1.1	
11	50	55	8.56	352.56	280.3	21.0	1	
12	55	60	8.58	390.6	312.18	20.5	1.5	
13	60	65	8.01	284.79	230.59	19.6	1.4	

Figure 5

LAKE CHEROKEE

Location of Survey Data and Core Samples

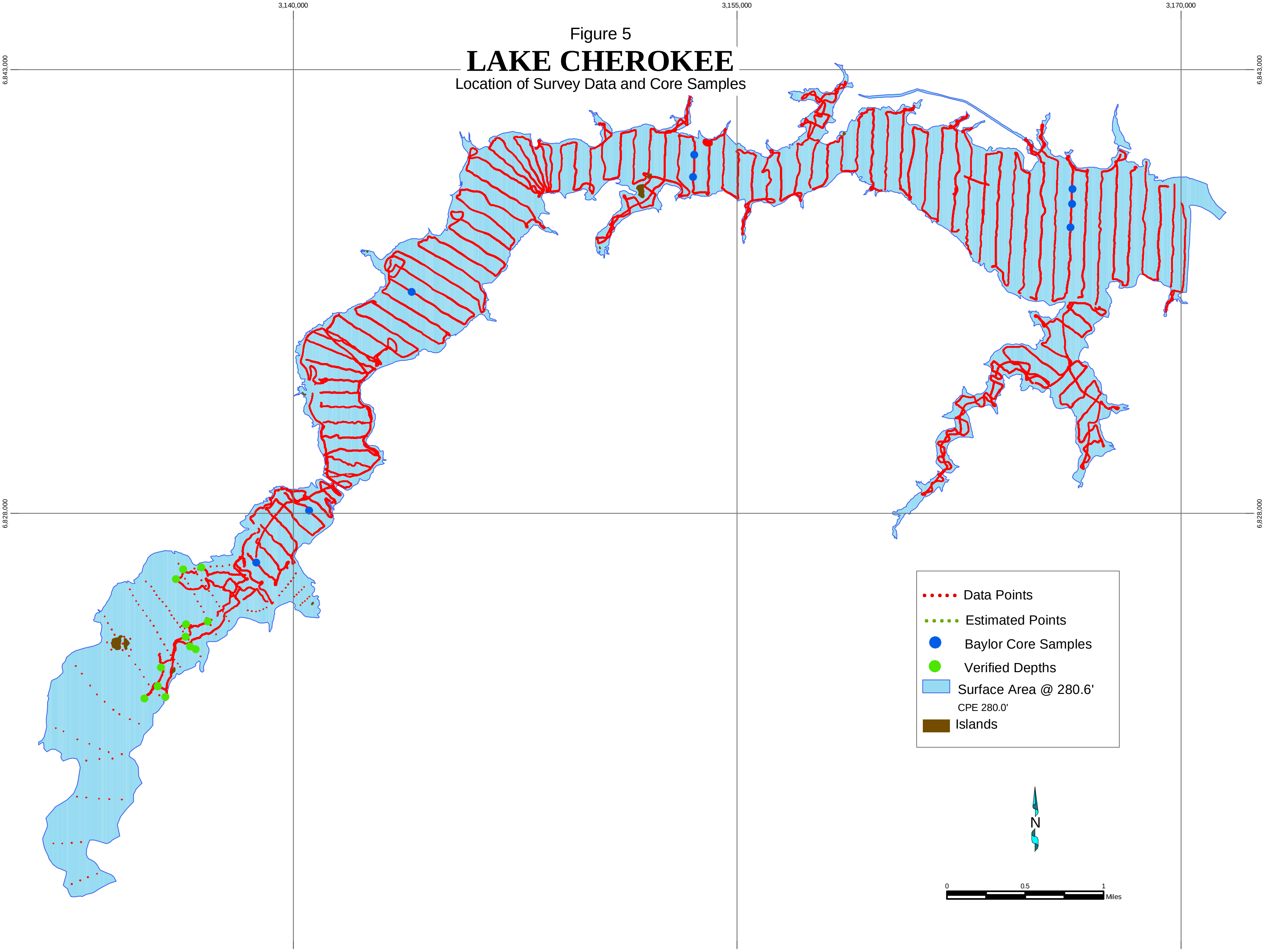

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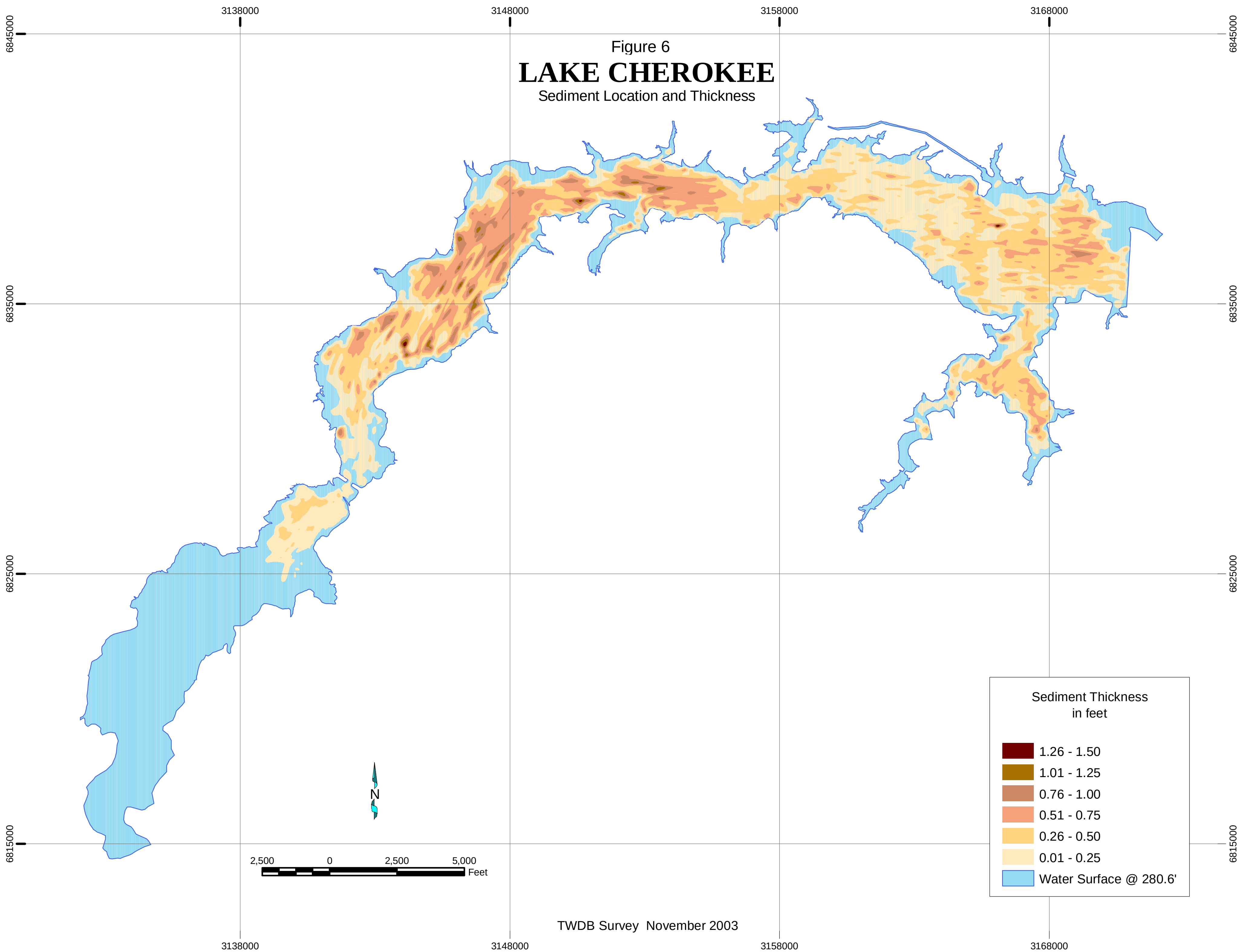
Figure 6

LAKE CHEROKEE

Sediment Location and Thickness



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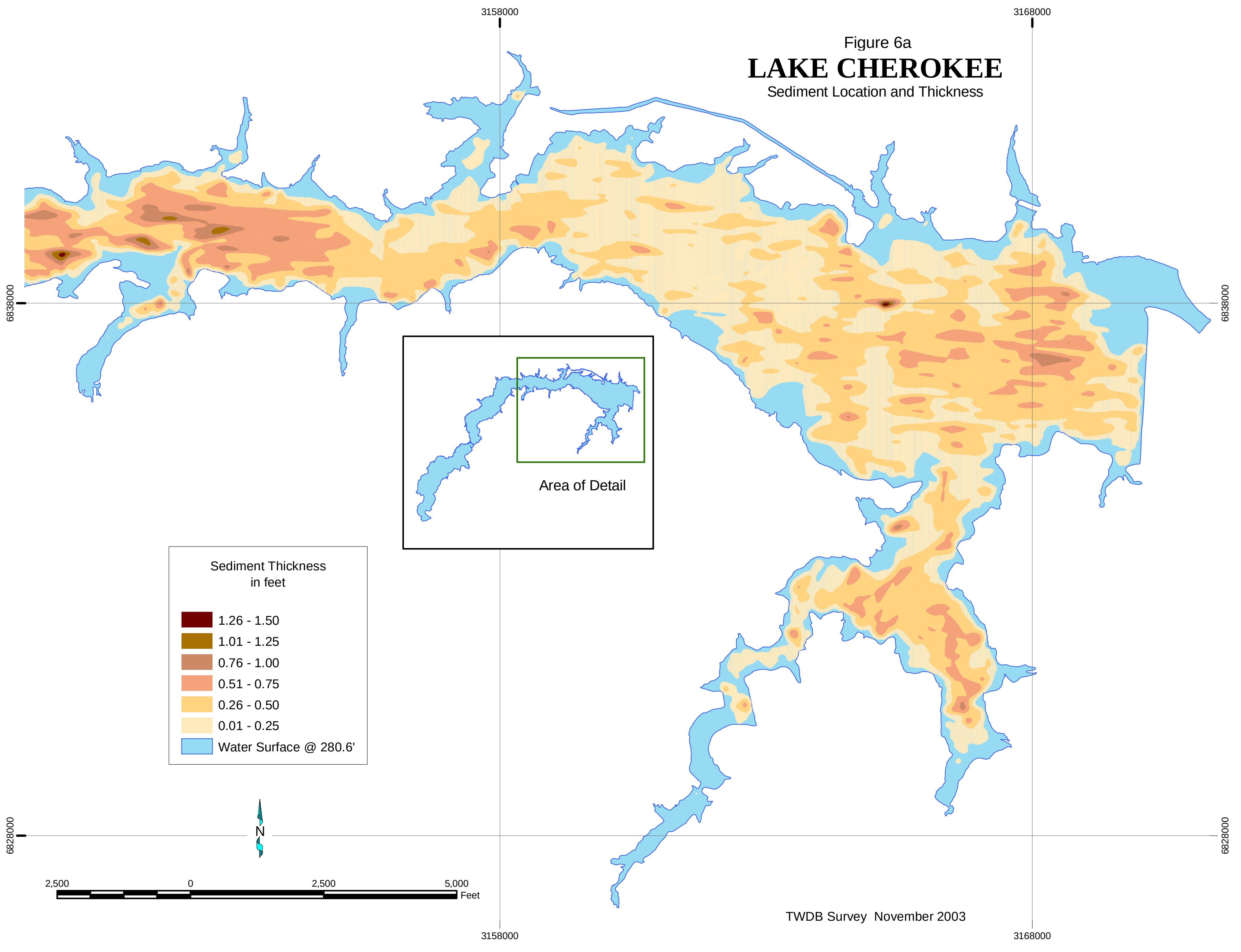
Figure 6a
LAKE CHEROKEE
Sediment Location and Thickness
3158000
3168000
6838000
6828000
Area of Detail
Sediment Thickness
in feet
1.26 - 1.50
1.01 - 1.25
0.76 - 1.00
0.51 - 0.75
0.26 - 0.50
0.01 - 0.25
Water Surface @ 280.6'
N
2,500
0
2,500
5,000
Feet
TWDB Survey November 2003

Figure 6b

LAKE CHEROKEE

Sediment Location and Thickness

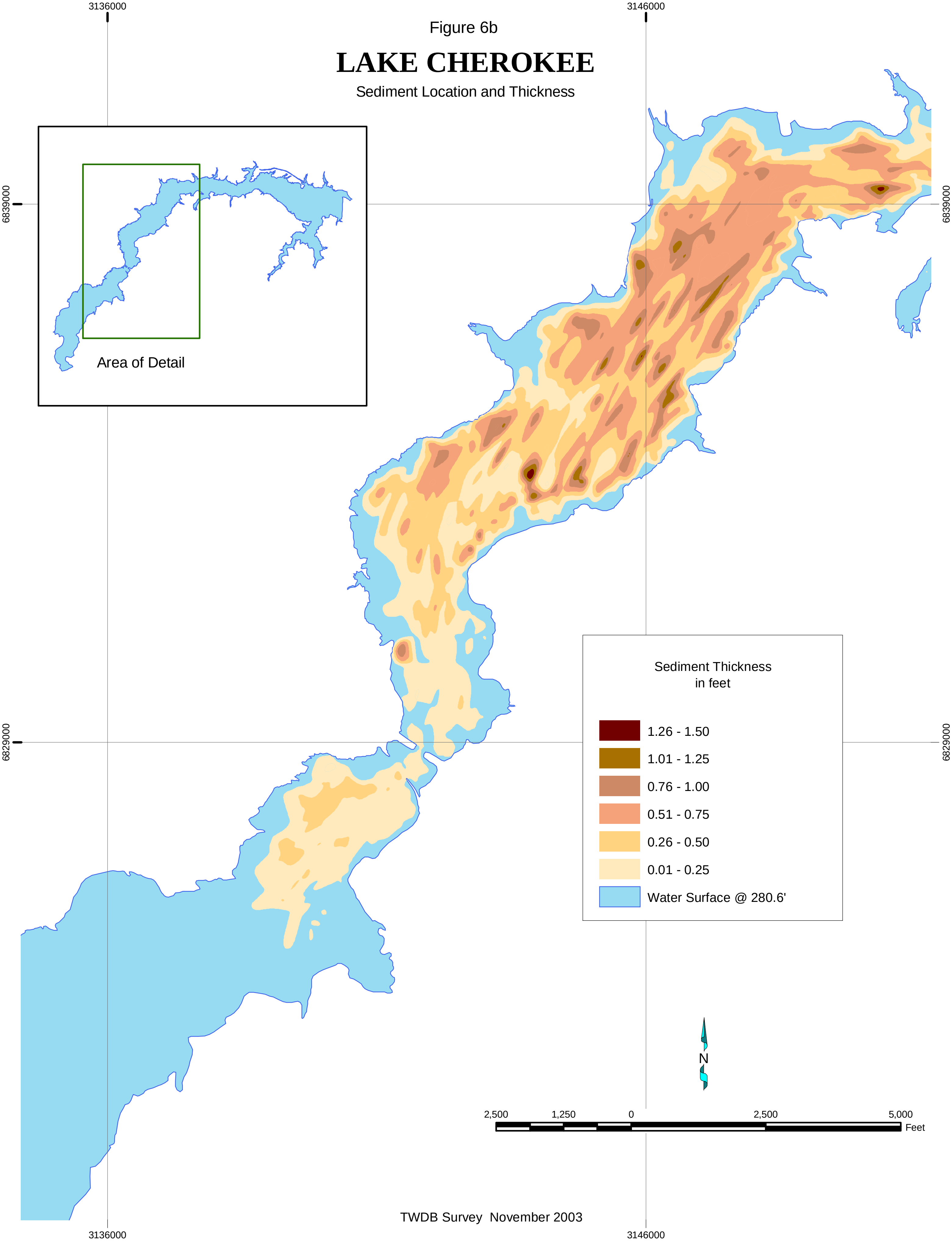

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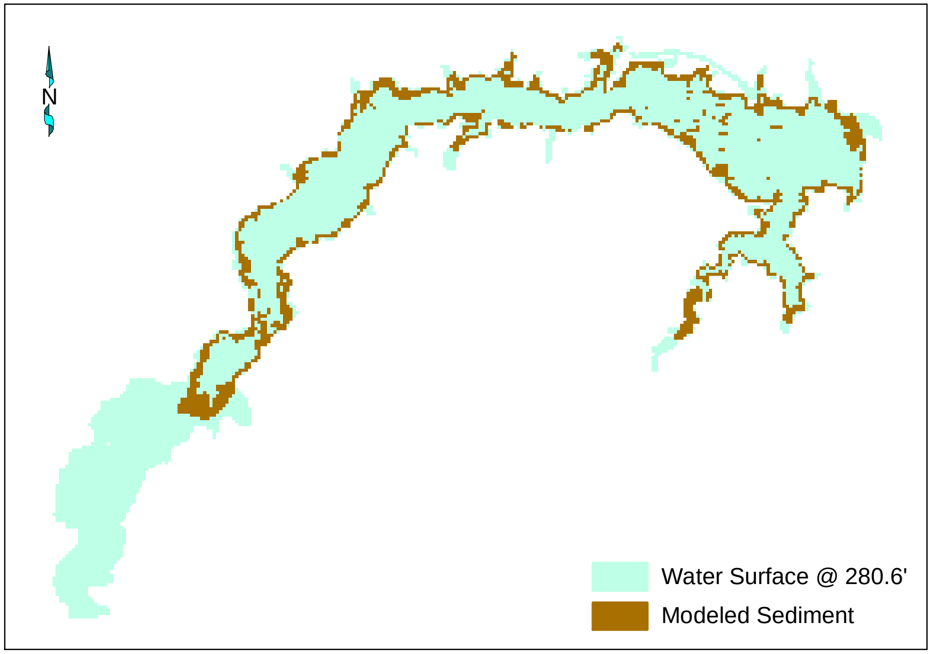
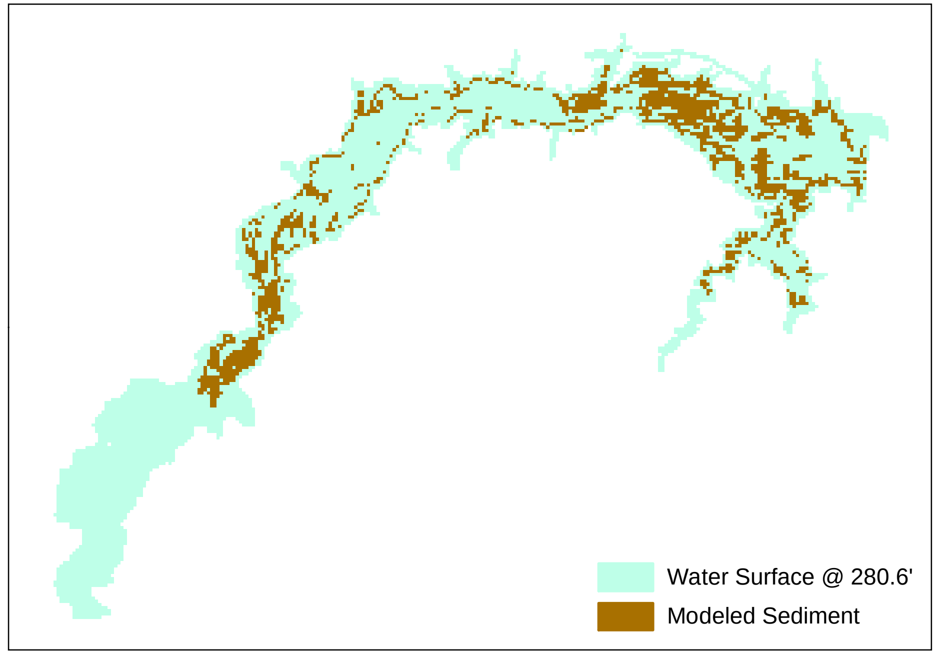
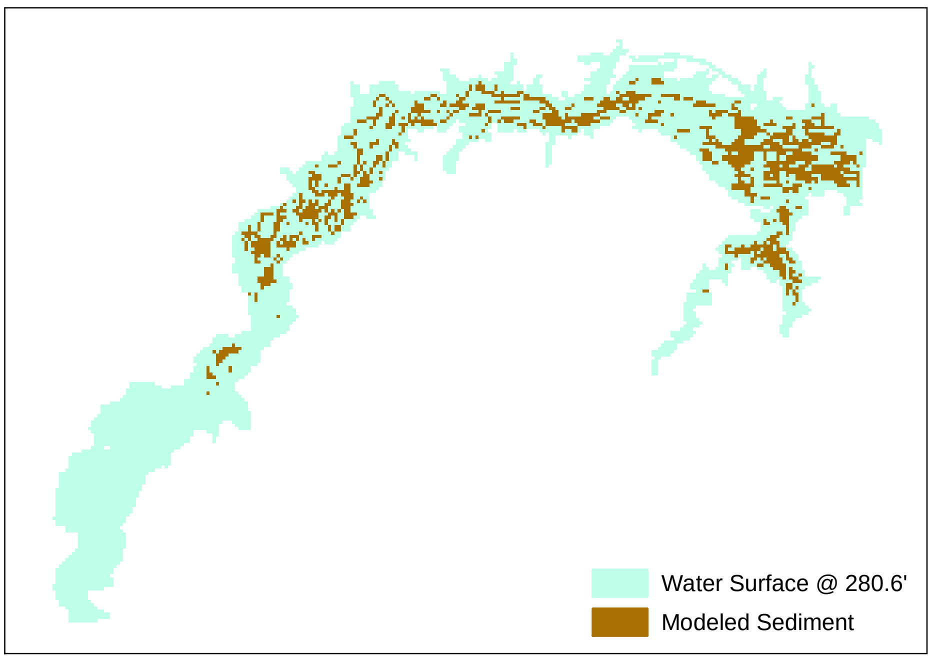
Figure 7a



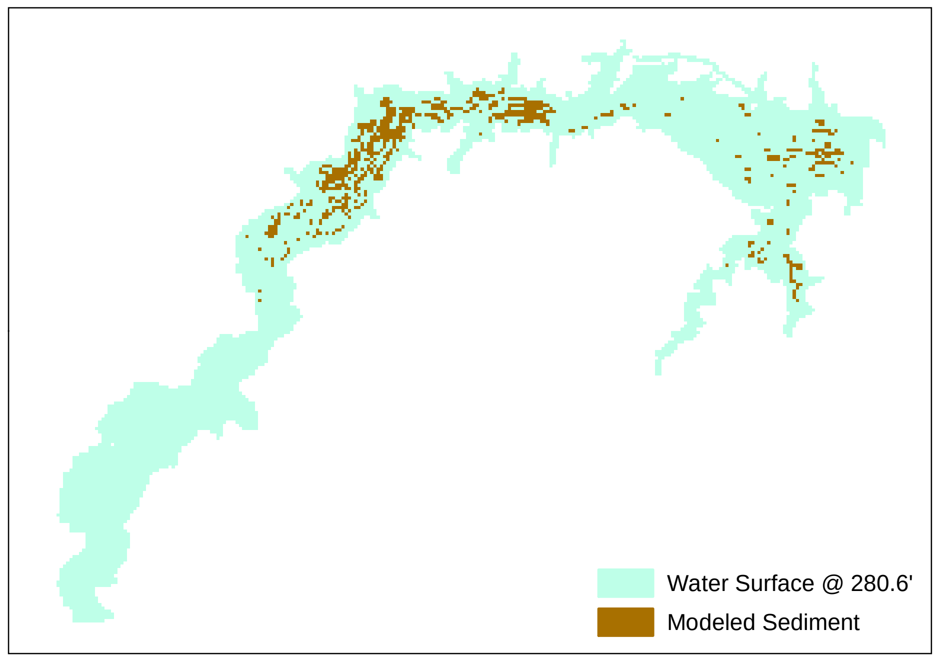
Sediment Depth Range 0.01 - 0.25 ft



Sediment Depth Range 0.25 - 0.50 ft



Sediment Depth Range 0.50 - 0.75 ft



Sediment Depth Range 0.75 - 1.0 ft

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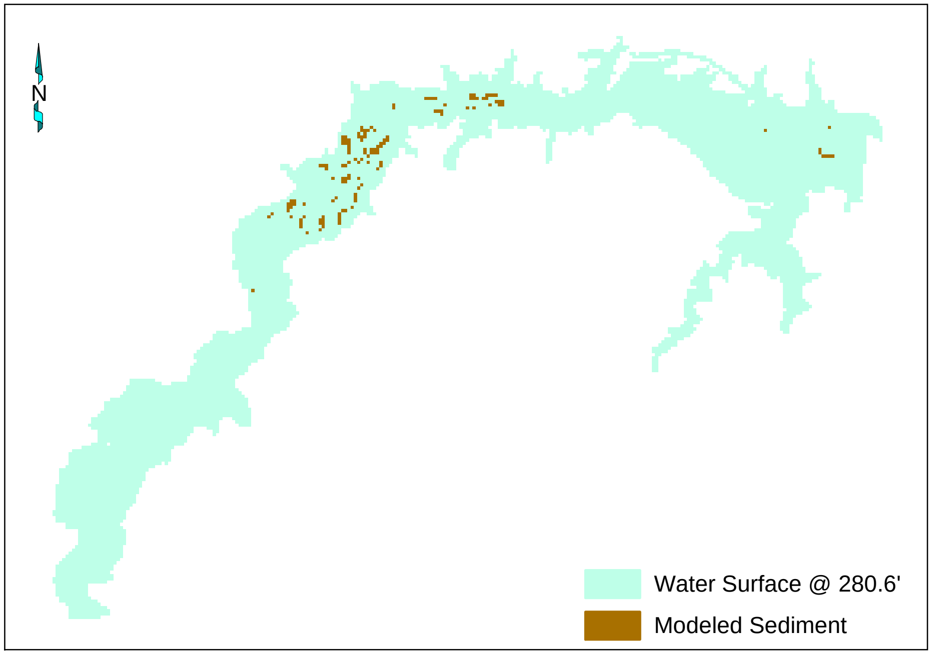
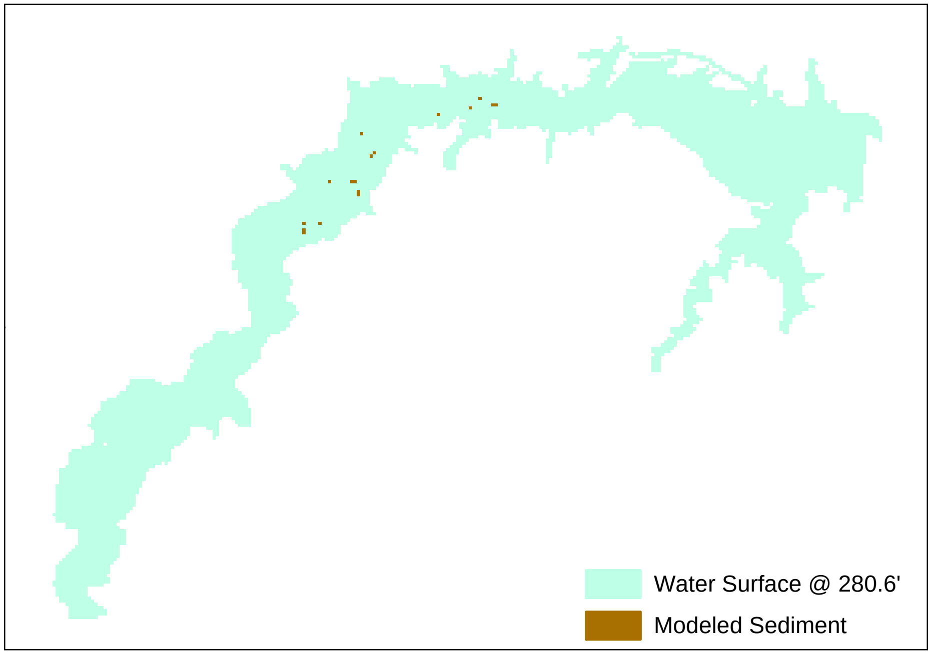
LAKE CHEROKEE

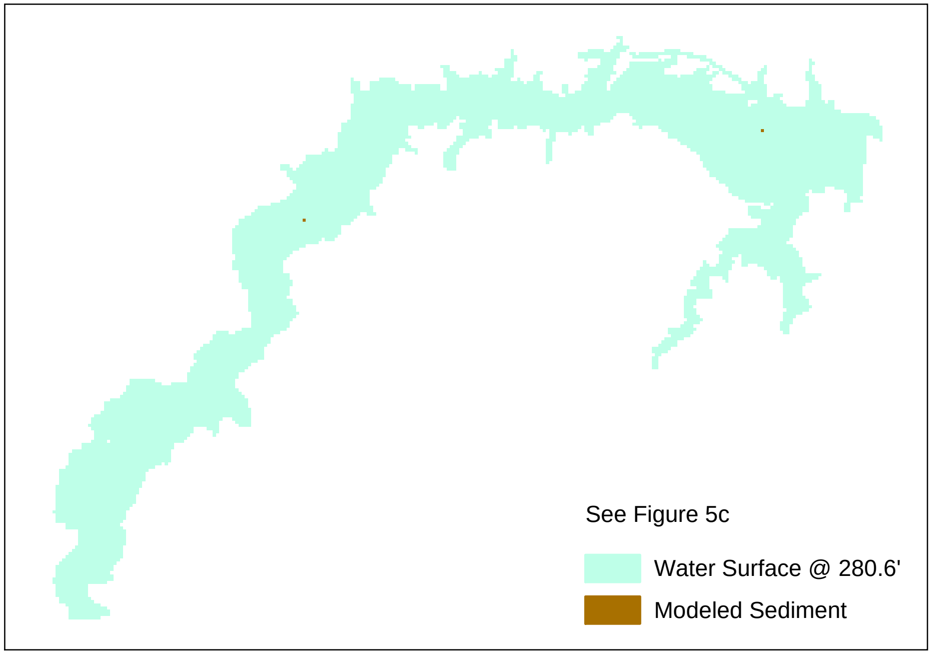
Figure 7b



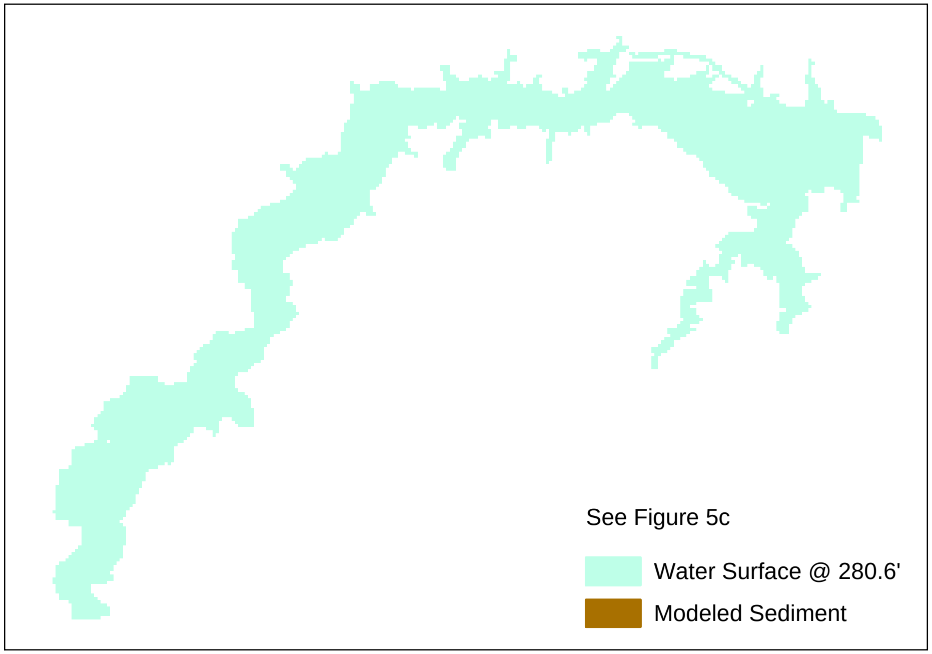
Sediment Depth Range 1.0 - 1.25 ft



Sediment Depth Range 1.25 - 1.50 ft



Sediment Depth Range 1.50 - 1.75 ft



Sediment Depth Range 1.75 - 2.0 ft

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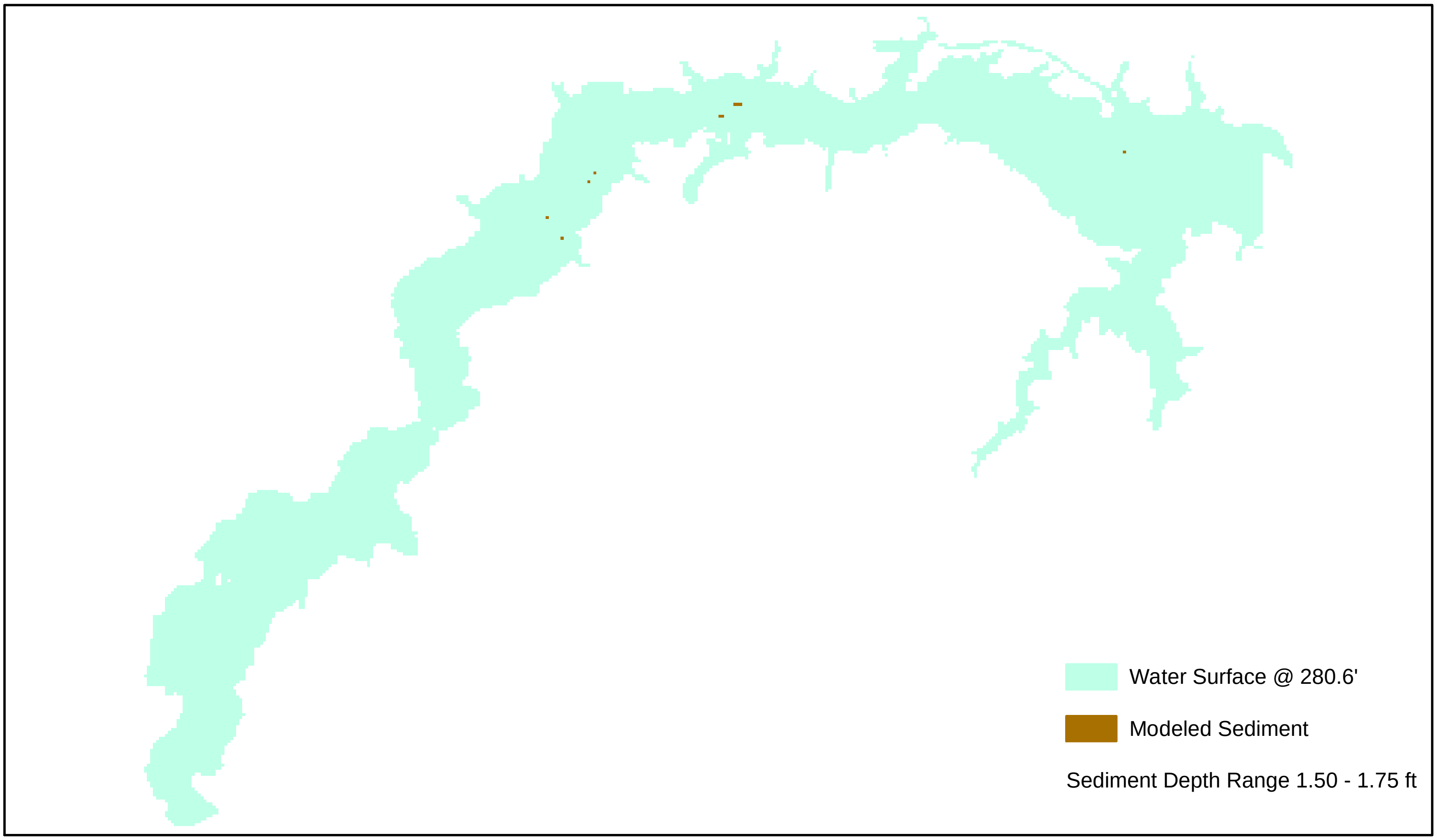
Figure 7c



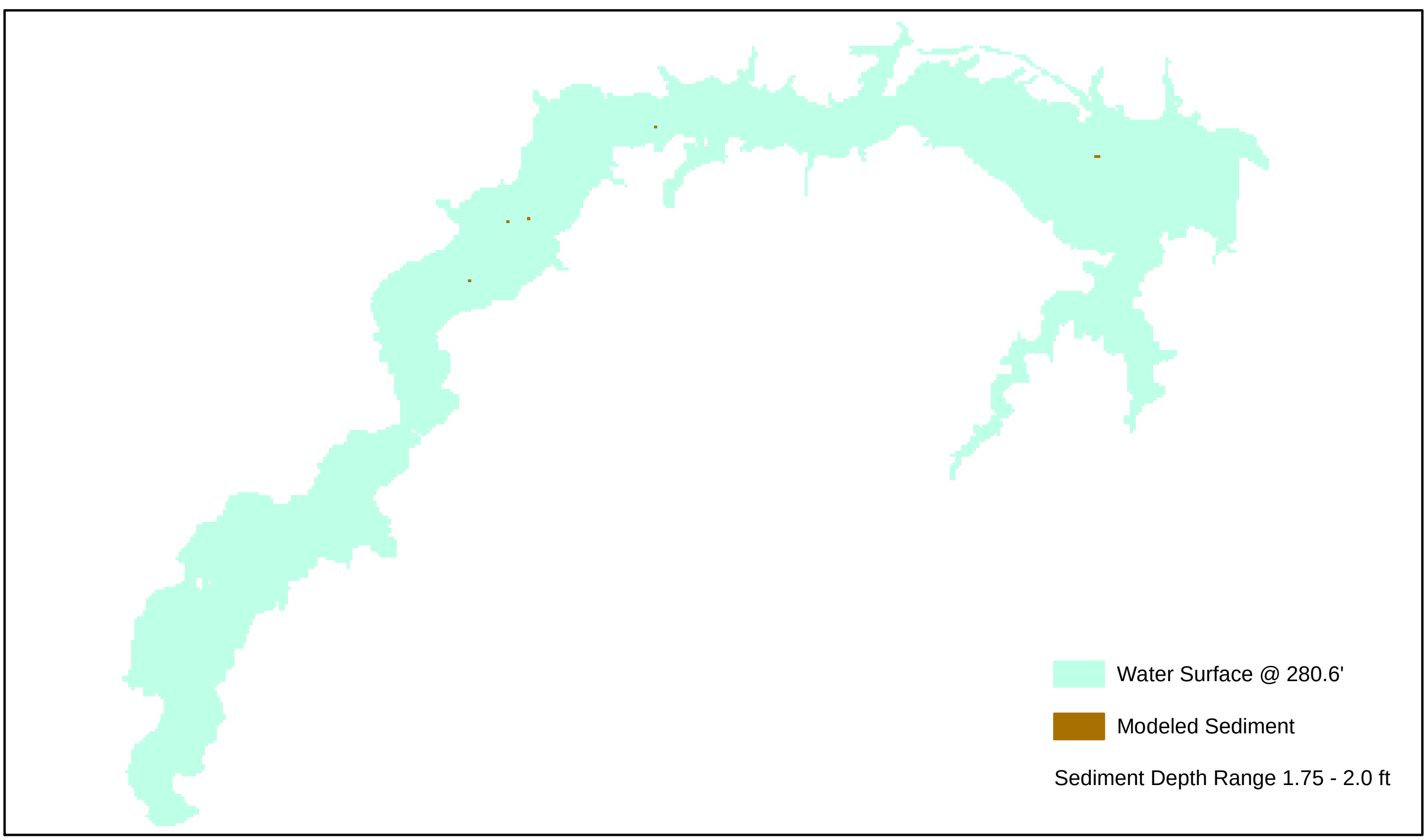


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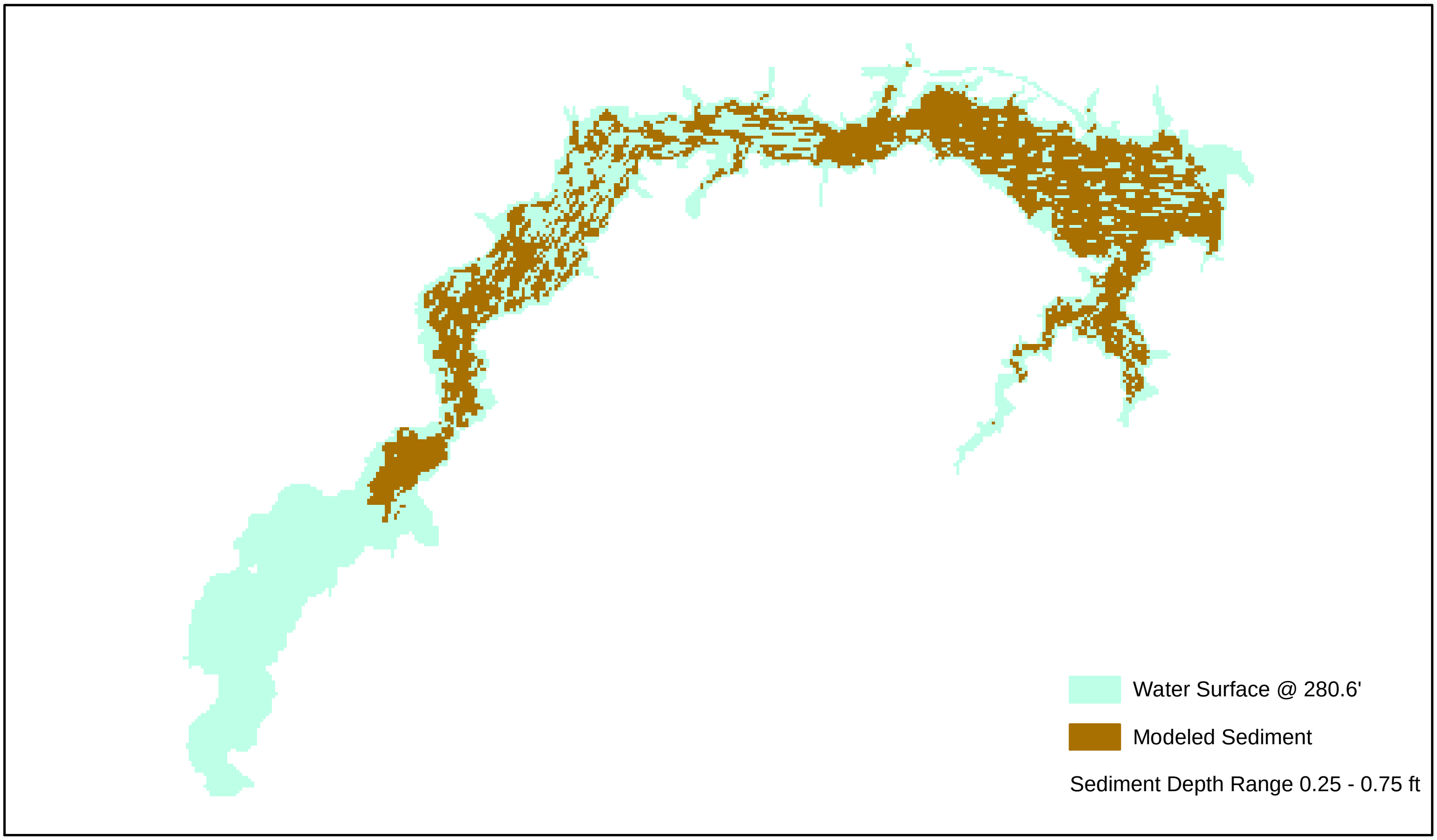
Figure 7d



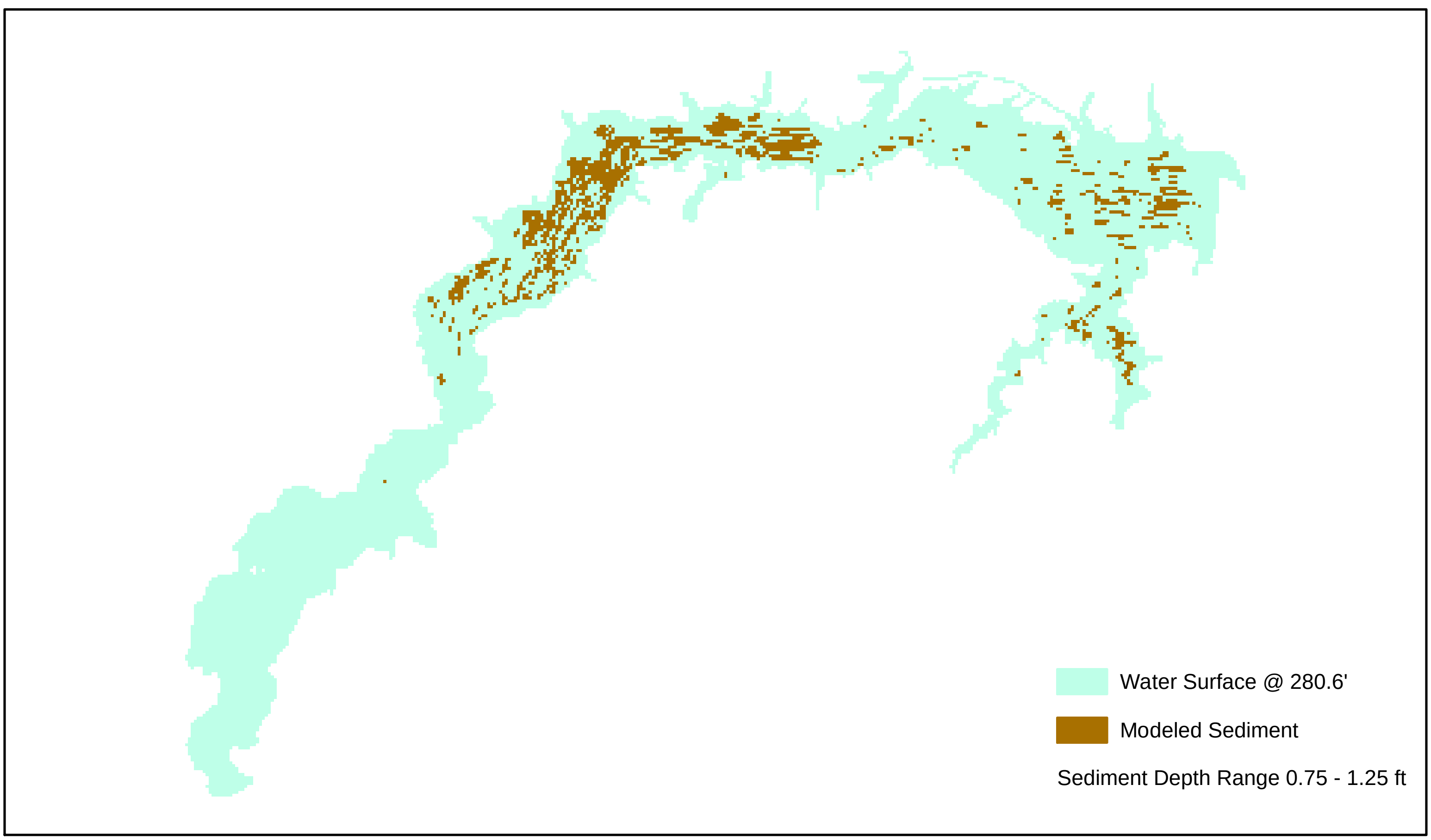


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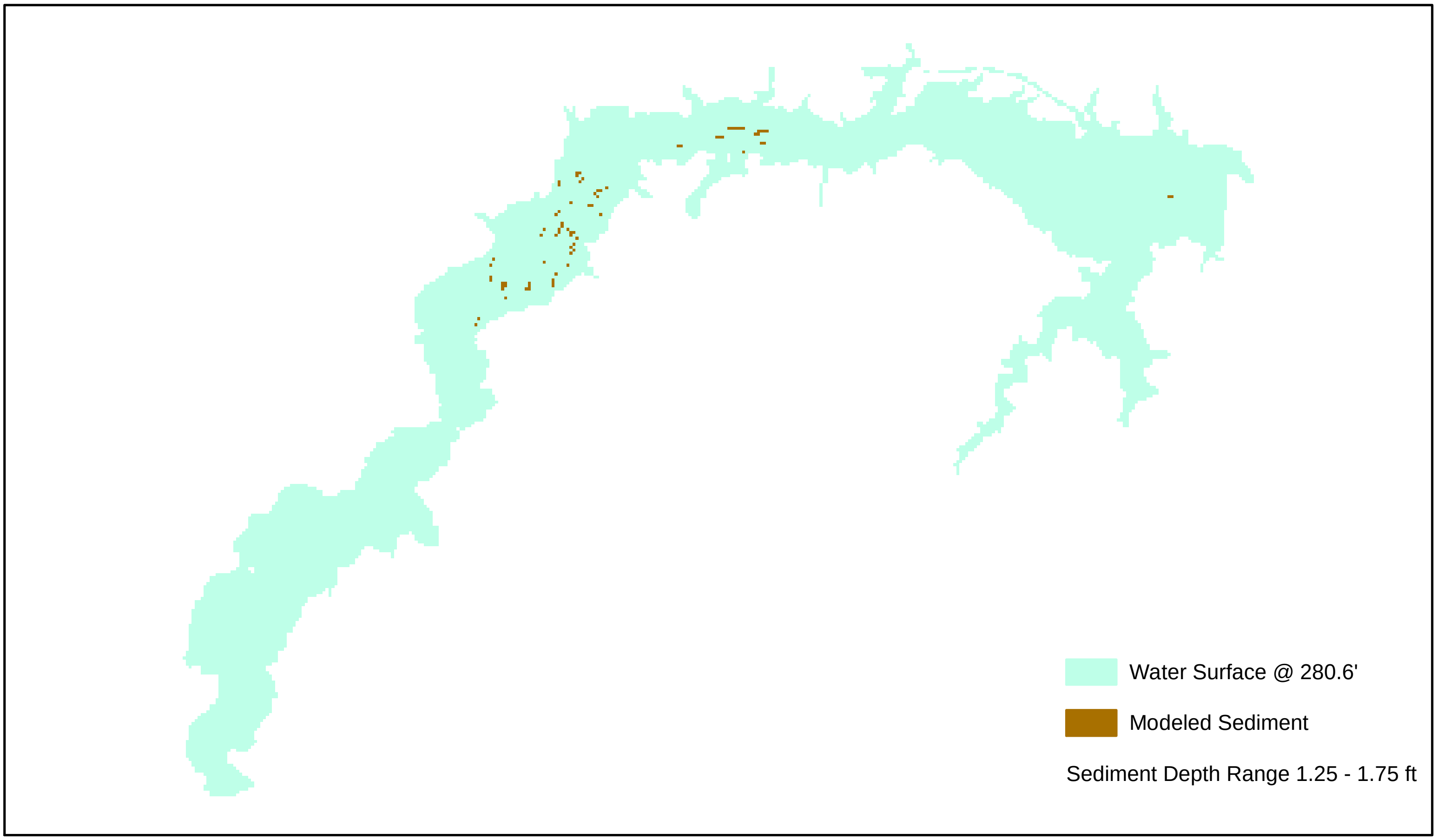
Figure 7e



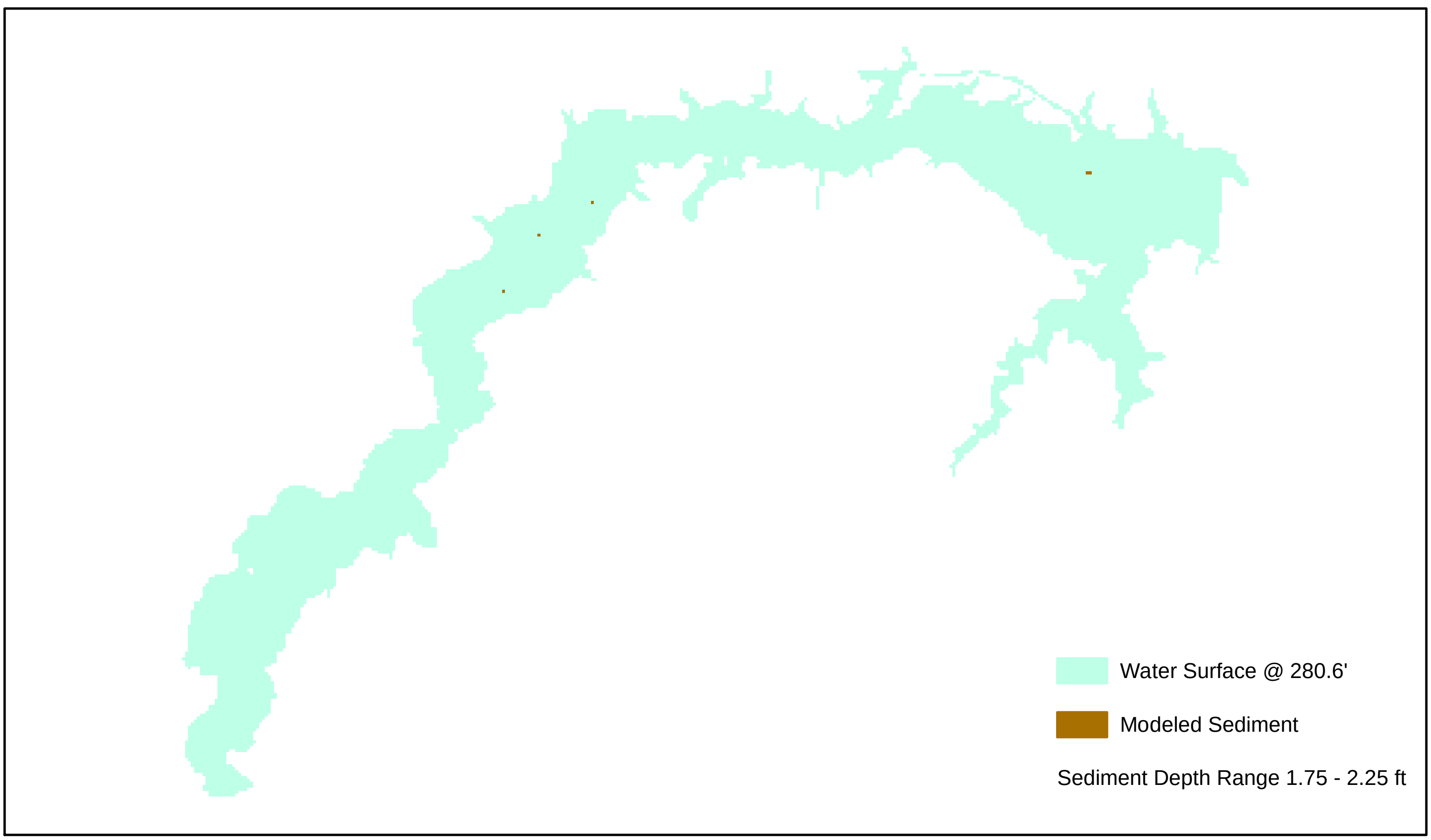
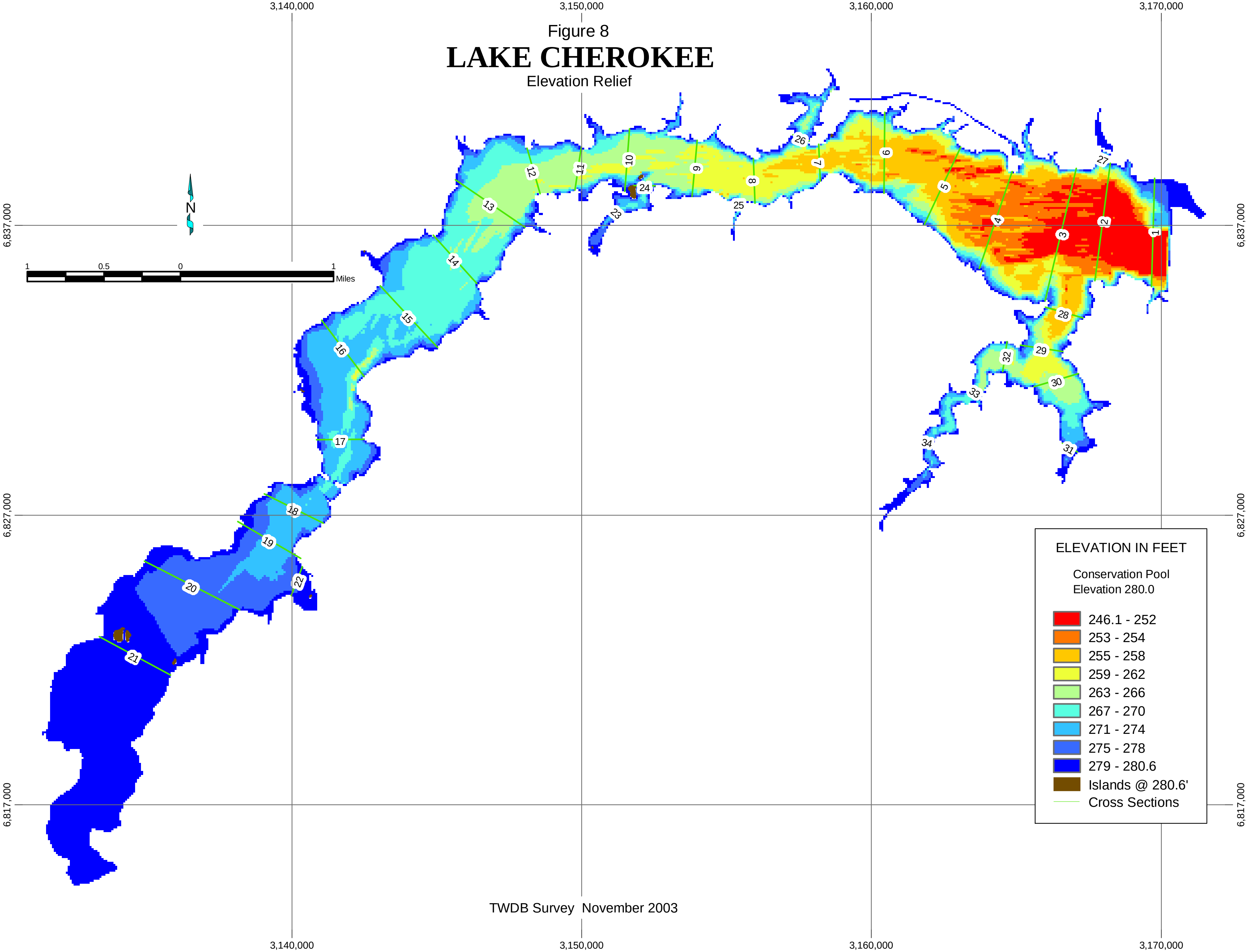


Figure 8

LAKE CHEROKEE

Elevation Relief



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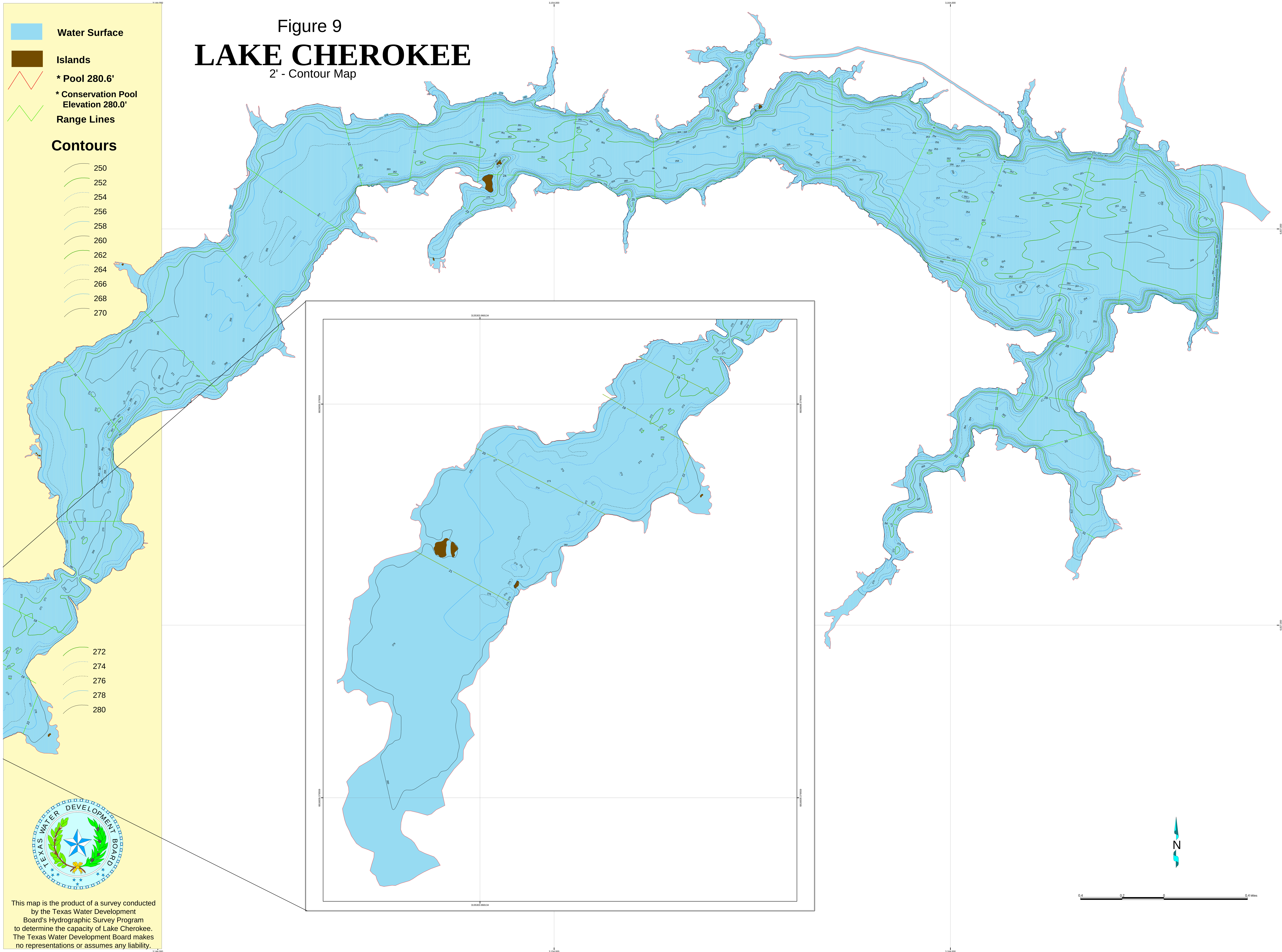

Prepared by : TEXAS WATER DEVELOPMENT BOARD NOVEMBER 2003