Volumetric and Sedimentation Survey of GIBBONS CREEK RESERVOIR

March 2008 Survey

Prepared by:

The Texas Water Development Board

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Texas Municipal Power Agency

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U.S. Army Corps of Engineers, Fort Worth District

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Executive Summary

In February of 2008, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Gibbons Creek Reservoir. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return measures the current bathymetric surface, while the combination of the three frequencies is analyzed for evidence of sediment accumulation throughout the reservoir. Sediment core samples were collected in selected locations and used both in interpreting the signal returns from the multi-frequency depth sounder and for validation of the sediment accumulation estimates. Additionally, the TWDB collected 19 temperature profiles in locations specified by the Texas Municipal Power Agency.

Gibbons Creek Dam and Reservoir are located on Gibbons Creek, a tributary of the Navasota River, in the Brazos River Basin 20 miles east of Bryan/ College Station, in Grimes County, Texas. Gibbons Creek Reservoir consists of two water bodies separated by a weir. Water surface elevations for Gibbons Creek Reservoir are measured and recorded by the Texas Municipal Power Agency at a gage located near the dam. The normal operating level of Gibbons Creek Reservoir is 247.0 feet, as measured at the dam. Based on a differential level measurement by the TWDB at 1:30 PM on March 14, 2008, the water surface elevation of the lake above the weir is 247.8 feet, at normal operating level. Bathymetric data collection for Gibbons Creek Reservoir occurred between March 20, 2008 and March 24, 2008. On March 20 and March 21 the water surface elevation of the reservoir ranged between 247.02 feet and 247.21 feet as measured below the weir. On March 24th the water surface elevation ranged between 247.42 feet and 247.50 feet as measured above the weir.

The results of the TWDB 2008 Volumetric Survey indicate that Gibbons Creek Reservoir has a capacity of 27,603 acre-feet and encompasses 2,576 acres at normal operating level. Below the weir, Gibbons Creek Reservoir has a capacity of 26,171 acre-feet and encompasses 2,328 acres at the normal operating level (247.0 feet). Above the weir, Gibbons Creek Reservoir has a capacity of 1,432 acre-feet and encompasses 248 acres at elevation 247.8 feet.

The results of the TWDB 2008 Sedimentation Survey indicate Gibbons Creek Reservoir has accumulated 938 acre-feet of sediment since impoundment in 1981, with 897 acre-feet of sediment located below the weir and 41 acre-feet of sediment located above the weir. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Gibbons Creek Reservoir loses approximately 35 acre-feet of capacity per year. The maximum sediment thickness observed in Gibbons Creek Reservoir was 2.9 feet.

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Note: *References to brand names throughout this report do not imply endorsement by the Texas Water Development Board*

Gibbons Creek Reservoir General Information

Gibbons Creek Dam and Reservoir are located on Gibbons Creek, a tributary of the Navasota River, in the Brazos River Basin, 20 miles east of Bryan/ College Station, in Grimes County, Texas. (Figure 1) Gibbons Creek Reservoir was built by and is owned and operated by the Texas Municipal Power Agency. Gibbons Creek Dam is a 1.25 mile long earthen dam constructed across the confluence of Gibbons and Sulphur Creeks, as well as several smaller tributaries.[1] Impoundment of Gibbons Creek Reservoir began in the spring of 1981. The original operating level of the reservoir was 245 feet. In 1991, the Texas Municipal Power Agency raised the operating level to its current elevation of 247 feet.[2]

The Texas Municipal Power Agency was created in 1975 by the Cities of Bryan, Denton, Garland, and Greenville to construct and manage the Gibbons Creek Steam Electric Station.[3] Gibbons Creek Reservoir primarily functions as a cooling pond for the Gibbons Creek Steam Electric Station, a lignite coal-fired power plant.[4] This 465-megawatt power plant began commercial production of electricity in 1983 and serves the Cities of Bryan, Denton, Garland, and Greenville, TX.[3,4]

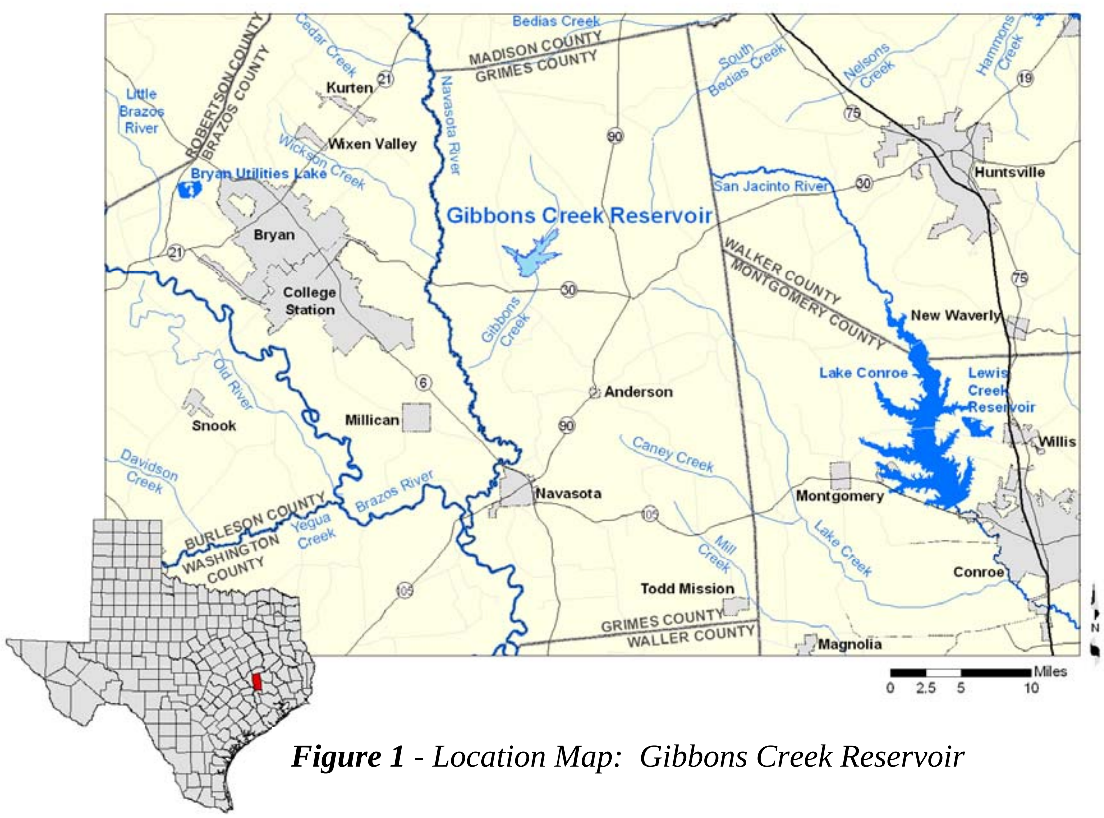

Figure 1 *- Location Map: Gibbons Creek Reservoir*

Water Rights

The water rights for Gibbons Creek Reservoir have been appropriated to the Texas Municipal Power Agency through Certificate of Adjudication No. 12-5311 and its amendment. A brief summary of each follows. The complete certificates are on file in the Records Division of the Texas Commission on Environmental Quality.

Certificate of Adjudication No. 12-5311 Priority Date: February 22, 1977

This certificate authorizes the Texas Municipal Power Agency to maintain an existing dam and reservoir on Gibbons Creek and impound therein a maximum of 26,824 acre-feet of water. The Texas Municipal Power Agency is also authorized to maintain an existing internal dam on Hog Creek to be used in conjunction with the dam creating Gibbons Creek Reservoir. The Texas Municipal Power Agency is authorized to divert, circulate, and re-circulate as much water as necessary, of which not more than 9,740 acre-feet of water per year may be consumptively used, for industrial (forced evaporative cooling and power plant operation) purposes.

Amendment to Certificate of Adjudication No. 12-5311A Granted: August 22, 1989

This amendment authorizes the Texas Municipal Power Agency to raise the normal maximum operating level of Gibbons Creek Reservoir two feet to 247 feet above mean sea level and impound therein a maximum of 32,084 acre-feet of water. The priority date of this amendment is March 9, 1989.

Volumetric and Sedimentation Survey of Gibbons Creek Reservoir

The Texas Water Development Board's (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. The Texas Water Code authorizes the TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In February of 2008, the TWDB entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Gibbons Creek Reservoir. This survey was performed using a single-beam multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return measures the current bathymetric surface, while the combination of the three frequencies, along with core samples for correlating the pre-impoundment surface with the signal return, is analyzed for evidence of sediment accumulation throughout the reservoir. Additionally, the TWDB collected 19 temperature profiles in locations specified by the Texas Municipal Power Agency.

Datum

Water surface elevations are recorded at Gibbons Creek Dam by the Texas Municipal Power Agency. The datum for this gage is assumed to be the National Geodetic Vertical Datum of 1929 (NGVD29) or mean sea level, however, there are no records confirming this. For this report, the TWDB referenced all volume and area calculations to the water levels recorded at the dam as provided by the Texas Municipal Power Agency. The horizontal datum used for this report is the North American Datum of 1983 (NAD83), and the horizontal coordinate system is State Plane Texas Central Zone (feet).

During the TWDB survey, the Texas Municipal Power Agency manually recorded the water surface elevations at the dam at 6:30 AM daily. The Texas Municipal Power Agency provided the TWDB with nine water level measurements. To determine water levels, the TWDB installed Solinst Levellogger pressure transducers in both the upper and lower waterbodies (Figure 2). Each transducer measured and recorded water depths (above the transducer) at 10 minute intervals over the course of the survey. Readings from each transducer were referenced to atmospheric pressure through use of a Solinst Barrologger, mounted on land adjacent to the Levelloggers (Figure 2). The elevation of the Levellogger installed within the lower pond was determined by averaging the nine calculated daily transducer elevations, each computed by subratcting the transducer depth reading at 6:30AM daily from the corresponding day’s water level reading provided by the Texas Municipal Power Agency. Water levels within the lower pond were determined by adding the transducer depth readings to the elevation of the Levellogger.

Elevations within the upper pond were established based on a differential level measurement made by the TWDB at 1:30 PM on March 14, 2008, when the Solinst Levelloggers were installed. With the differential level, the TWDB determined the difference in water surface elevations at the Levellogger locations was 0.8 feet. The water surface elevation in the upper pond at the time of the level measurement was determined by adding 0.8 feet to the lower pond water surface elevation (calculated based on the Gibbons Creek Dam readings as described above). The elevation of the upper pond transducer was established by subtracting the transducer's measured depth at the time of the level reading from the computed upper pond water surface elevation at the time of the level reading. Water levels within the upper pond were determined by adding the transducer depth readings to the elevation of the Levellogger.

TWDB Data Collection

Bathymetric Data

Bathymetric data collection for Gibbons Creek Reservoir occurred on March 21-22 and March 24 of 2008. On March 20 and March 21 the water surface elevation of the reservoir ranged between 247.02 feet and 247.21 feet, as measured below the weir. On March 24th the water surface elevation ranged between 247.42 feet and 247.50 feet, as measured above the weir. For data collection, the TWDB used a Specialty Devices, Inc., multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2008 survey, team members collected approximately 35,120 data points over cross-sections totaling nearly 57 miles in length. Figure 2 shows where data points were collected during the TWDB 2008 survey.

Temperature Profiles

At the request of the Texas Municipal Power Agency, 19 temperature profiles were collected within Gibbons Creek Reservoir at locations specified by the Texas Municipal Power Agency. The TWDB collected these profiles on June 9-11, 2008, using a Eureka Manta water quality probe. A 20th point requested by Texas Municipal Power Agency was not sampled because it was located behind a buoy line that the TWDB did not have permission to cross at the time of the sampling. Figure 2 shows the locations of each temperature reading. A complete analysis of the temperature profiles can be found in Appendix K.

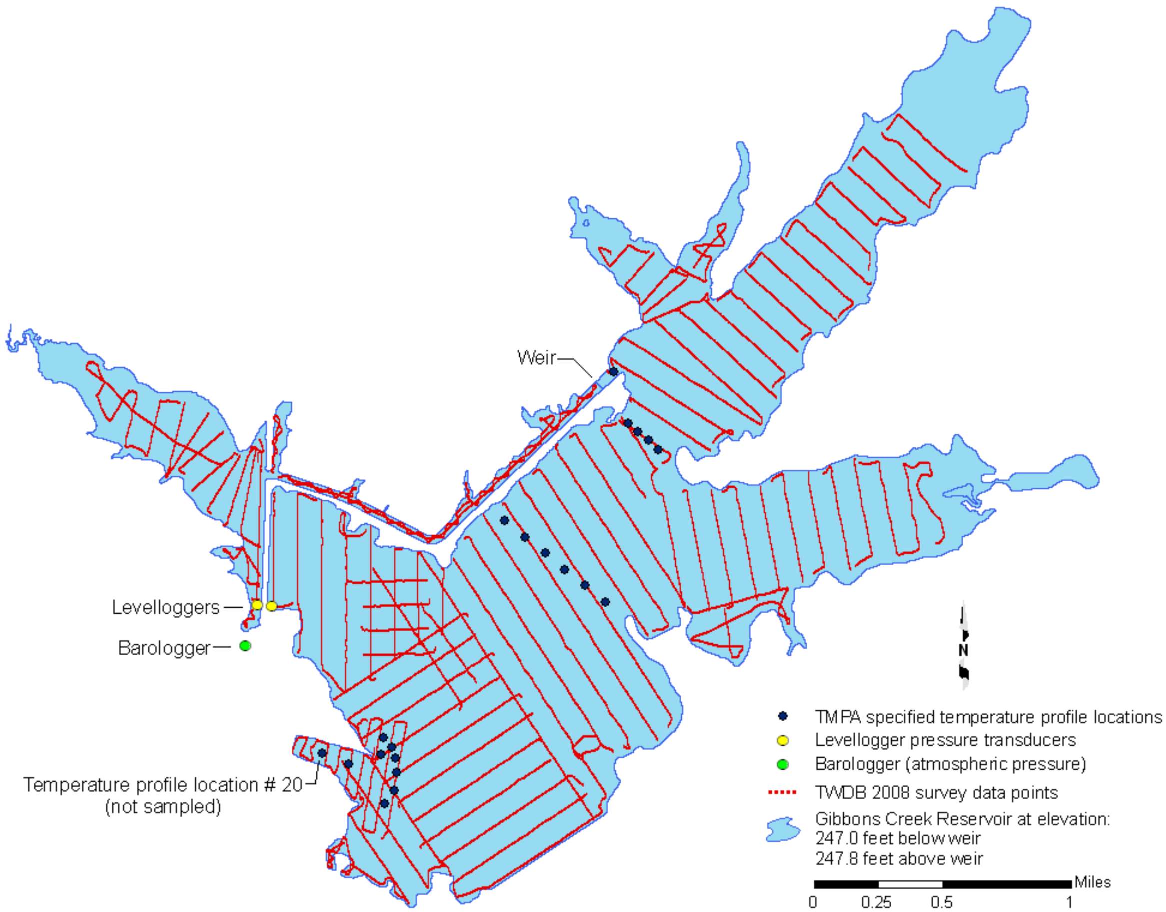

***Figure 2** - Bathymetric data points and temperature profiles collected during TWDB 2008 Survey.*

Data Processing

Model Boundaries

At the request of the Texas Municipal Power Agency, Elevation-Area-Capacity tables were calculated to elevation 251.0 feet, 4.0 feet above the normal operating level of the reservoir. To represent the surface topography at elevations above the normal operating level the Texas Municipal Power Agency provided the TWDB with a detailed line file containing elevation contours covering the majority of the reservoir vicinity.

Reservoir boundaries were digitized from aerial photographs, or digital orthophoto quarter-quadrangle images (DOQQs)[5,6], using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The quarter-quadrangles that cover Gibbons Creek Reservoir are Keith SW, Keith SE, Carlos NW, and Carlos NE. The Keith SW and

Carlos NW images were photographed on August 4, 2004, during which time the water surface elevation at Gibbons Creek Dam measured 247.5 feet according to the Texas Municipal Power Agency gage. The Keith SE and Carlos SE images were photographed on October 16, 2004, during which time the water surface elevation at Gibbons Creek Dam measured 246.1 feet according to the Texas Municipal Power Agency gage. The shoreline was digitized from the land water interface visible in the photos and elevations were assigned to the boundaries below the weir based on the gage readings. Based on the TWDB's differential level measurement at 1:30 PM on March 14, 2008, the boundaries above the weir were given an elevation 0.8 feet higher than those below the weir.

For an outer boundary encompassing the contour data provided by the Texas Municipal Power Agency and the boundaries digitized from the aerial photos, the TWDB used the digital hypsography[7] contour at elevation 260 feet. The 250 foot contour was also used in the areas where data was not available from the Texas Municipal Power Agency. The digital hypsography is available online from the Texas Natural Resources Information System Strategic Mapping Program (StratMap)[7], which provides digitized contour data derived from 1:24,000 scale U.S. Geological Survey topographic quadrangle maps. The 250 foot contour was manually altered so that it would not overlap or cross the boundary digitized from the 2004 DOQQs. The 260 foot contour was closed in the vicinity of the dam and does not reflect the actual elevations of this area. However, this does not affect area and capacity calculations, as these were only calculated to elevation 251 feet.

With reference to the data provided by the Texas Municipal Power Agency, the TWDB only used contours that were completely within the 260 foot hypsographic contour. Additionally, any contours with a "Layer" attribute of "DTM" were excluded from the lake model, as these tended to contradict the surrounding Texas Municipal Power Agency provided contours. All of the boundary files described above are illustrated in Figure 3.

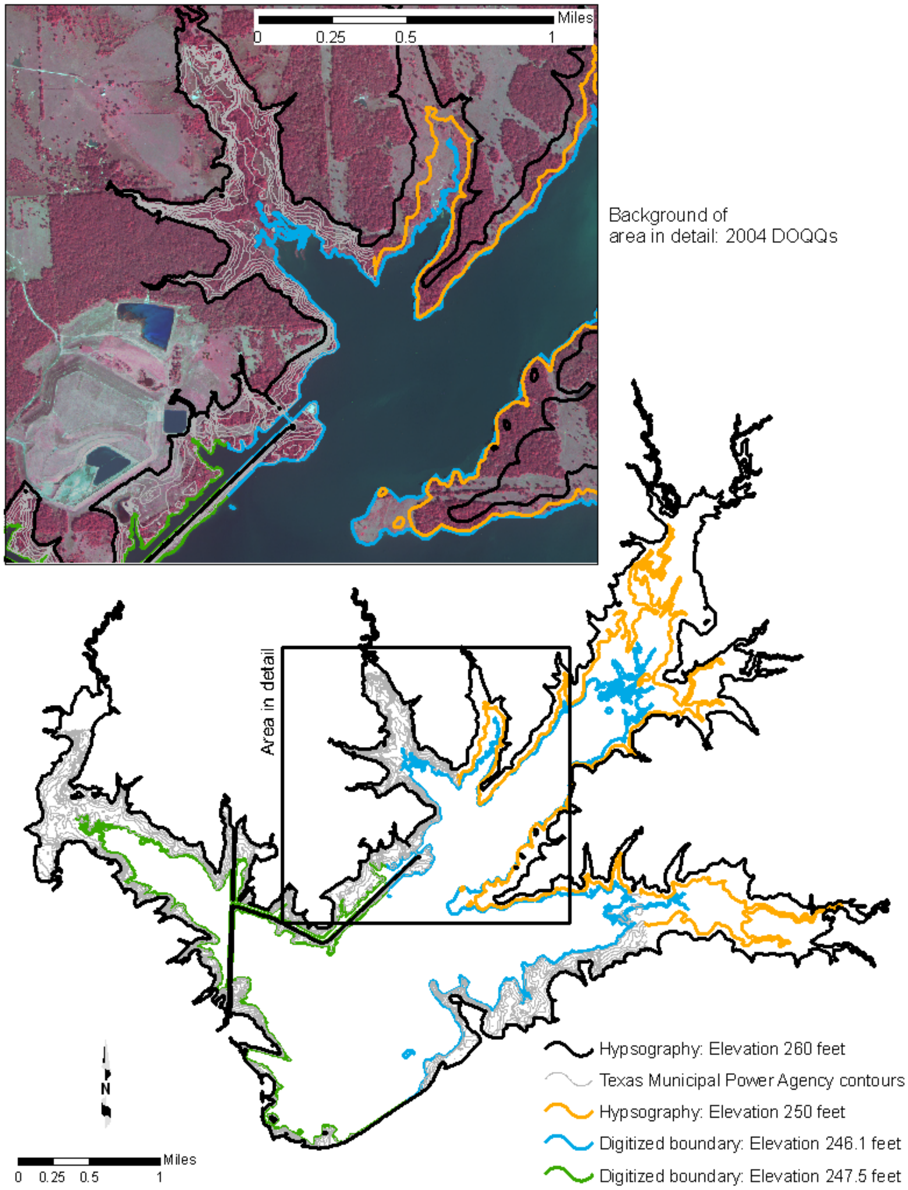

***Figure 3** - Model boundaries for Gibbons Creek Reservoir.*

Triangulated Irregular Network (TIN) Model

Upon completion of data collection, the raw data files collected by the TWDB were edited using HydroEdit and DepthPic to remove any data anomalies. HydroEdit is used to automate the editing of the 200 kHz frequency signal returns and determine the current bathymetric surface. DepthPic is used to display, interpret, and edit the multi-frequency data to correct any edits HydroEdit has flagged and to manually interpret the pre-impoundment surface. The water surface elevations at the times of each sounding are used to convert sounding depths to corresponding bathymetric elevations. For processing outside of DepthPic and HydroEdit, the sounding coordinates (X,Y,Z) were exported as a MASS points file. The TWDB also created additional MASS points files of interpolated and extrapolated data based on the sounding data. Using the “Self-Similar Interpolation” technique (described below), the TWDB interpolated bathymetric elevation and sediment thickness data located in-between surveyed cross sections. To better represent reservoir bathymetry in shallow regions, the TWDB used the “Line Extrapolation” technique (also described below).[8] The point files resulting from both the data interpolation and extrapolation were exported as MASS points files, and were used in conjunction with the sounding and boundary files in creating a Triangulated Irregular Network (TIN) model of the Gibbons Creek Reservoir bathymetry with the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithms use Delaunay’s criteria for triangulation to place a triangle between three non-uniformly spaced points, including the boundary vertices.[9] Once the TIN model was created up to elevation 260.0 feet, the 251.0 foot contour was extracted and used to create a second TIN model from which the area-capacity tables were calculated.

Using Arc/Info software, volumes and areas are calculated from the TIN model for the entire reservoir at one-tenth of a foot intervals, from elevation 217.5 feet to elevation 251.0 feet. The Elevation-Capacity Tables and Elevation-Area Tables, updated for 2008, are presented in Appendices A through H. Separate Elevation-Capacity Tables and Elevation-Area Tables are presented for each of the following four scenarios:

1) *Appendix A, B*: the total reservoir capacity and area calculated up to elevation 251.0 feet
2) *Appendix C,D:* the capacity and area of the main body of the lake below the weir up to the normal operating level of 247.0 feet
3) *Appendix E,F:* the capacity and area of the reservoir above the weir up to the normal operating level of 247.8 feet
4) *Appendix G,H:* the total reservoir capacity and area of Gibbons Creek Reservoir up to the normal operating level.

The Elevation-Area-Capacity Curves are presented in Appendix I and J.

Within ArcGIS, the bathymetric TIN model (up to elevation 251.0 feet) was converted to a raster grid using a cell size of one foot by one foot. The raster was used to produce an Elevation Relief Map representing the topography of the reservoir bottom (Figure 4), a map showing shaded depth ranges for Gibbons Creek Reservoir (Figure 5), and a 2-foot contour map (Figure 6).

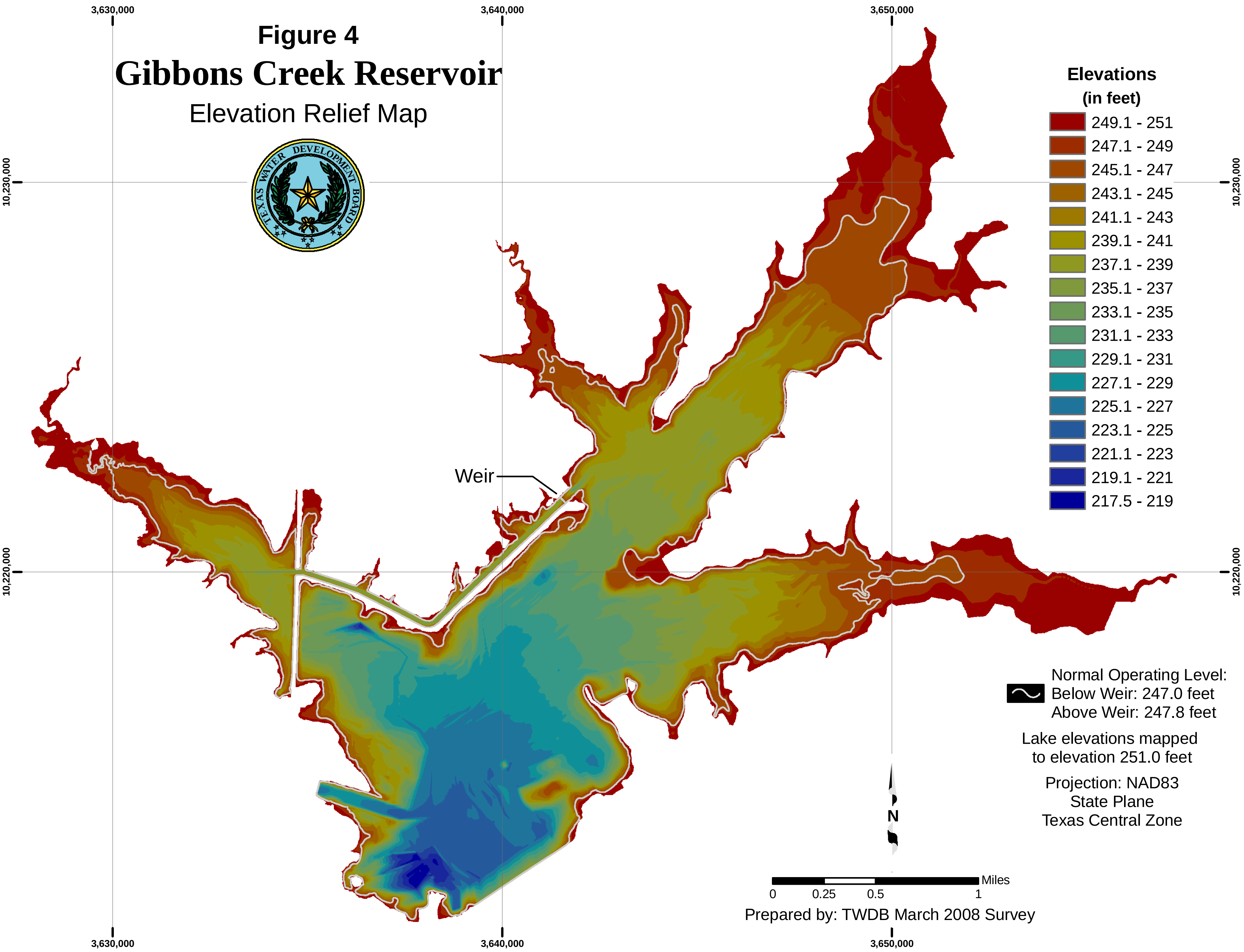

Figure 4
Gibbons Creek Reservoir
Elevation Relief Map
TEXAS WATER DEVELOPMENT BOARD
Elevations
(in feet)
249.1 - 251
247.1 - 249
245.1 - 247
243.1 - 245
241.1 - 243
239.1 - 241
237.1 - 239
235.1 - 237
233.1 - 235
231.1 - 233
229.1 - 231
227.1 - 229
225.1 - 227
223.1 - 225
221.1 - 223
219.1 - 221
217.5 - 219
Weir
Normal Operating Level:
Below Weir: 247.0 feet
Above Weir: 247.8 feet
Lake elevations mapped
to elevation 251.0 feet
Projection: NAD83
State Plane
Texas Central Zone
N
Miles
0
0.25
0.5
1
Prepared by: TWDB March 2008 Survey
3,630,000
3,640,000
3,650,000
10,230,000
10,220,000

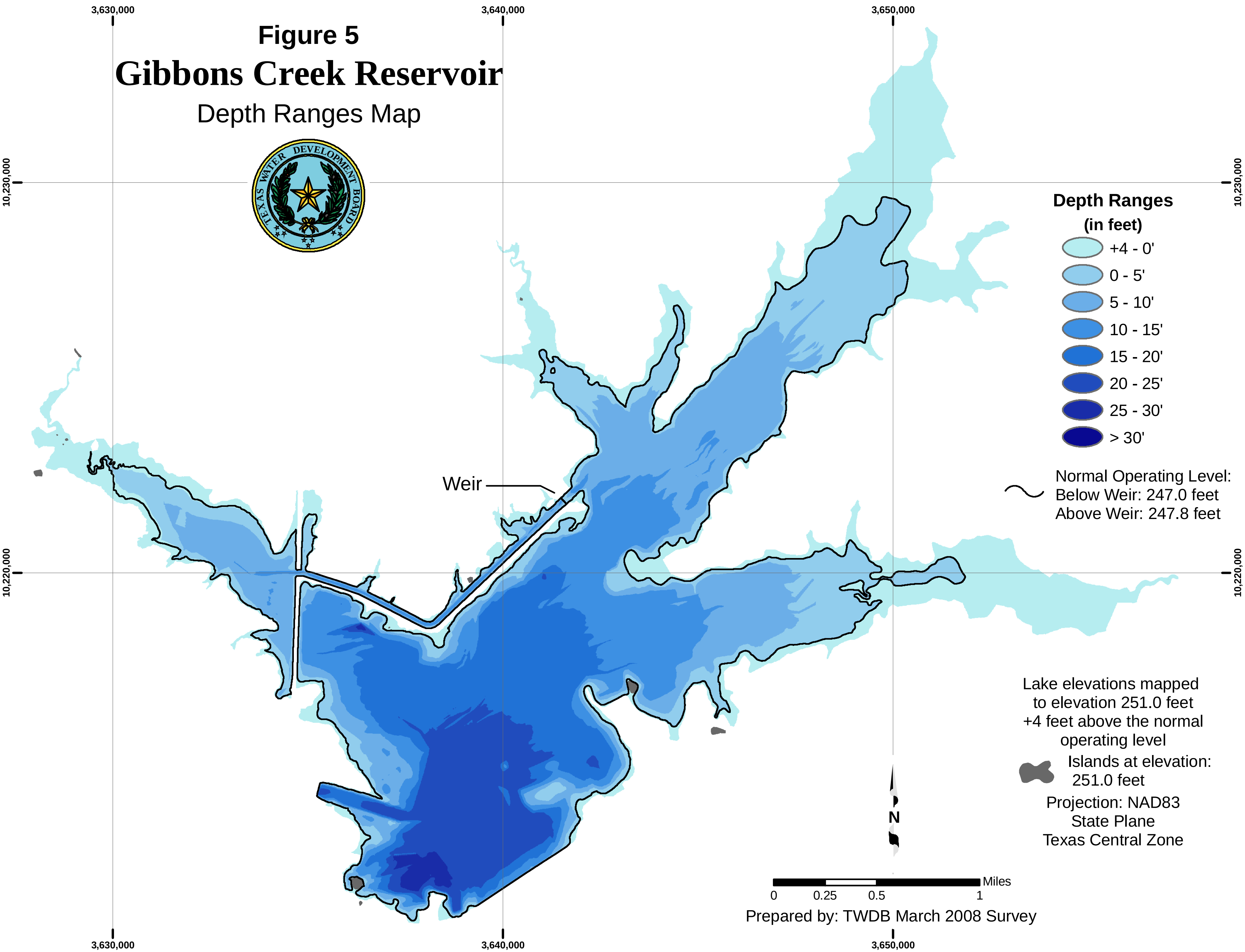
Figure 5
Gibbons Creek Reservoir
Depth Ranges Map
TEXAS WATER DEVELOPMENT BOARD
Weir
Depth Ranges
(in feet)
+4 - 0'
0 - 5'
5 - 10'
10 - 15'
15 - 20'
20 - 25'
25 - 30'
> 30'
Normal Operating Level:
Below Weir: 247.0 feet
Above Weir: 247.8 feet
Lake elevations mapped
to elevation 251.0 feet
+4 feet above the normal
operating level
Islands at elevation:
251.0 feet
Projection: NAD83
State Plane
Texas Central Zone
N
0
0.25
0.5
1
Miles
Prepared by: TWDB March 2008 Survey
3,630,000
3,640,000
3,650,000
10,230,000
10,220,000

Self-Similar Interpolation

A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. Also, if the surveyed cross sections are not perpendicular to the centerline of the submerged river channel (the location of which is often unknown until after the survey), then the TIN model is not likely to well-represent the true channel bathymetry.

To ameliorate these problems, a Self-Similar Interpolation routine (developed by the TWDB) was used to interpolate the bathymetry in between survey lines. The Self-Similar Interpolation technique effectively increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the reservoir topography.[8] In the case of Gibbons Creek Reservoir, the application of Self-Similar Interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 7). In areas where obvious geomorphic features indicate a high-probability of cross-section shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying the Self-Similar Interpolation technique are not likely to be valid; therefore, self-similar interpolation was not used in areas of Gibbons Creek Reservoir where a high probability of change between cross-sections exists.[8] Figure 7 illustrates typical results of the application of the Self-Similar Interpolation routine in Gibbons Creek Reservoir, and the bathymetry shown in Figure 7C was used in computing reservoir capacity and area tables (Appendices A-H).

Line Extrapolation

In order to estimate the bathymetry within the un-surveyed portions of Gibbons Creek Reservoir, the TWDB applied a line extrapolation technique[8] similar to the Self-Similar interpolation technique discussed above. The line extrapolation method is often used by the TWDB in extrapolating bathymetries in shallow coves near the upstream ends of reservoirs, where the water is often too shallow to allow boat passage. The method assumes that cross-sections within the “extrapolation area” have a “V-shaped” profile, with the deepest section located along a line drawn along the longitudinal axis of the area.

Elevations along this “longitudinal line” are interpolated linearly based on the distance along the line from the line’s start (nearest the reservoir interior) to the line’s end (where the line crosses the reservoir boundary). The elevations at points along each extrapolated cross-section are linearly interpolated from an elevation on the longitudinal line (at the intersection with the cross-section) and the elevation at the extrapolation area boundary. The line extrapolation method requires that the user specify the position of the longitudinal line and the elevation at the beginning of the longitudinal line. This elevation is usually assumed equivalent to the elevation of the TIN model near the beginning of the longitudinal line. Figure 7 illustrates the line extrapolation technique as applied to Gibbons Creek Reservoir.

The line extrapolation method for Gibbons Creek Reservoir was implemented using the 247.5-foot and 246.1-foot contours below the weir and the 248.3-foot and 246.9-foot contours above the weir (derived from the 2004 DOQQs), as well as the 250-foot contour (digital hypsography) as the bounding extents of the extrapolation areas. In Figure 7, the bathymetry was extrapolated to the 248.3-foot contour. The bathymetry between the extrapolated points and the 251-foot reservoir boundary was defined by the Texas Municipal Power Agency provided contours.

The assumption inherent in the line extrapolation method is that a V-shaped cross section is a reasonable approximation of the actual unknown cross-section within the extrapolated area. As of yet, the TWDB has been unable to test this assumption, and therefore can only assume that the results of the usage of the line extrapolation method are “more accurate” than those derived without line extrapolation. For the purpose of estimating the volume of water within Gibbons Creek Reservoir, the line extrapolation method is justified in that it produces a reasonable representation of reservoir bathymetry in the un-surveyed areas. The use of a V-shaped extrapolated cross-section likely provides a conservative estimate of the water volume in un-surveyed areas, as most surveyed cross-sections within Gibbons Creek Reservoir had shapes more similar to U-profiles than to V-profiles. The V-profiles are thus conservative in that a greater volume of water is implied by a U-profile than a V-profile. Further information on the line extrapolation method is provided in the HydroEdit User’s Manual.[8]

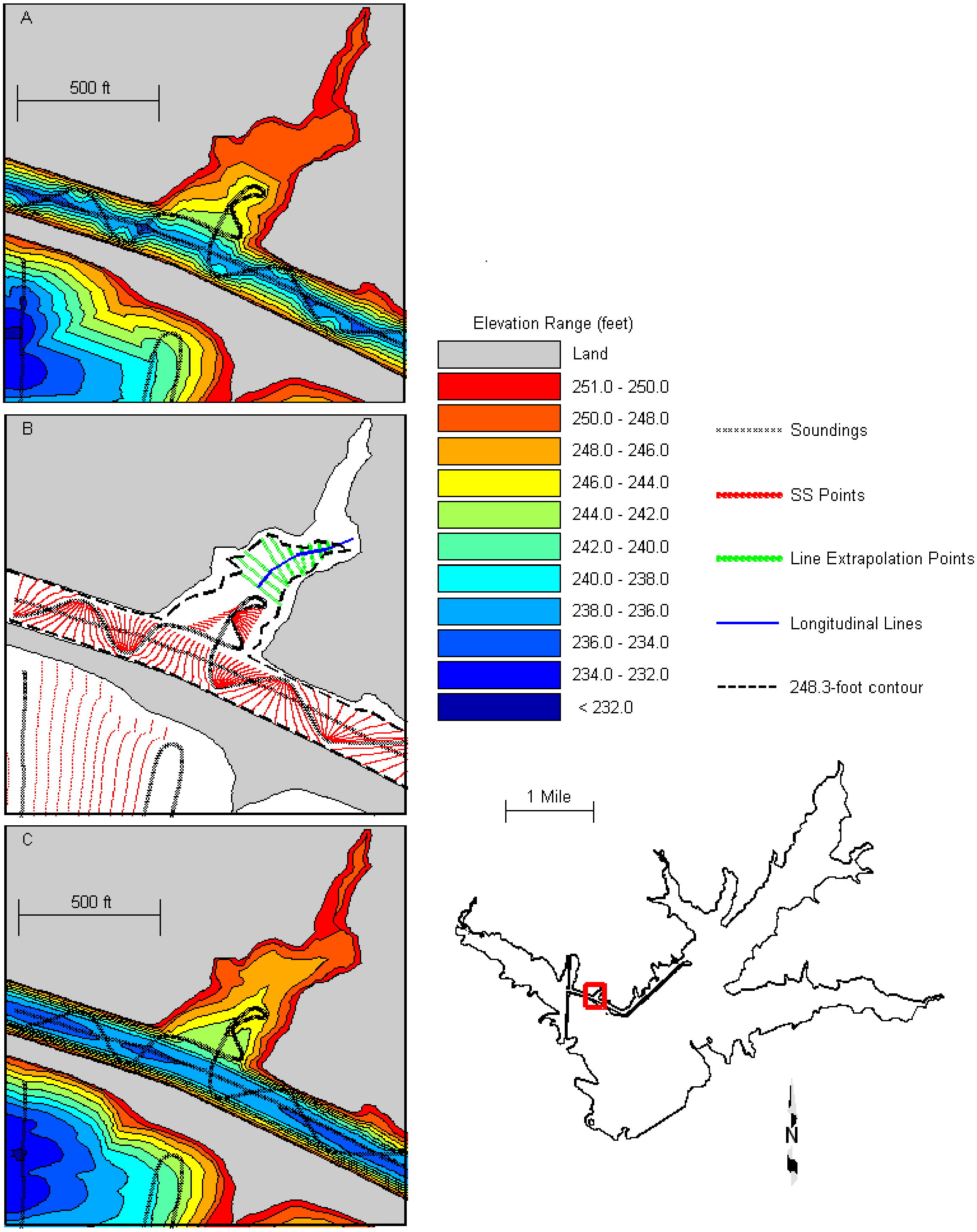

***Figure 7** - Application of the Self-Similar Interpolation and Line Extrapolation techniques to Gibbons Creek Reservoir sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black), interpolated points (red), and extrapolated points (green) with reservoir boundary shown at elevation 251.0 feet (black), C) bathymetric contours with the interpolated points. Note: In 7A the contours near the boundary bow out into the reservoir. This is an artifact of the TIN generation routine, rather than an accurate representation of the physical bathymetric surface. Inclusion of the interpolated points (7C) corrects this and smoothes the bathymetric contours.*

Survey Results

Volumetric Survey

The results of the TWDB 2008 Volumetric Survey indicate that the total capacity of Gibbons Creek Reservoir is 27,603 acre-feet at normal operating level, with a total surface area of 2,576 acres. In the main body of the reservoir below the weir, Gibbons Creek Reservoir has a capacity of 26,171 acre-feet and encompasses 2,328 acres at the normal operating level (247.0 feet). Above the weir, Gibbons Creek Reservoir has a capacity of 1,432 acre-feet and encompasses 248 acres at elevation 247.8 feet. The Amendment to Certificate of Adjudication 12-5311A, granted on August 22, 1989, authorizes the Texas Municipal Power Agency to store a maximum of 32,084 acre-feet at elevation 247.0 feet. Due to differences in the methodologies used in calculating the authorized capacity and the current capacity of Gibbons Creek Reservoir, comparison of these values is not recommended.

Sedimentation Survey

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret sediment distribution and accumulation throughout Gibbons Creek Reservoir. Figure 7 shows the thickness of sediment throughout the lake. The TWDB collected sediment core samples at five locations throughout Gibbons Creek Reservoir, and at each location duplicate core samples were retrieved. Upon collection, one un-processed core sample from each location was provided to the Texas Municipal Power Agency. The TWDB analyzed the remaining core samples to aid in interpreting the multi-frequency acoustic data. All sediment cores were collected on June 10-11, 2008 using a Specialty Devices, Inc. VibraCore system. A complete description of the sediment measurement methodology and sample results is presented in Appendix L.

The results of the TWDB 2008 Sedimentation Survey indicate Gibbons Creek Reservoir has accumulated 938 acre-feet of sediment since impoundment in 1981, with 897 acre-feet of sediment present in the main body of the lake downstream from the weir. The estimated pre-impoundment capacity of the reservoir is therefore 28,363 acre-feet, computed as the sum of the current measured reservoir capacity plus the measured accumulated sediment volume. Based on this measured sediment volume and assuming a constant rate of sediment accumulation, Gibbons Creek Reservoir loses approximately 35 acre-feet of capacity per year. The maximum sediment thickness observed in Gibbons Creek Reservoir was 2.9 feet.

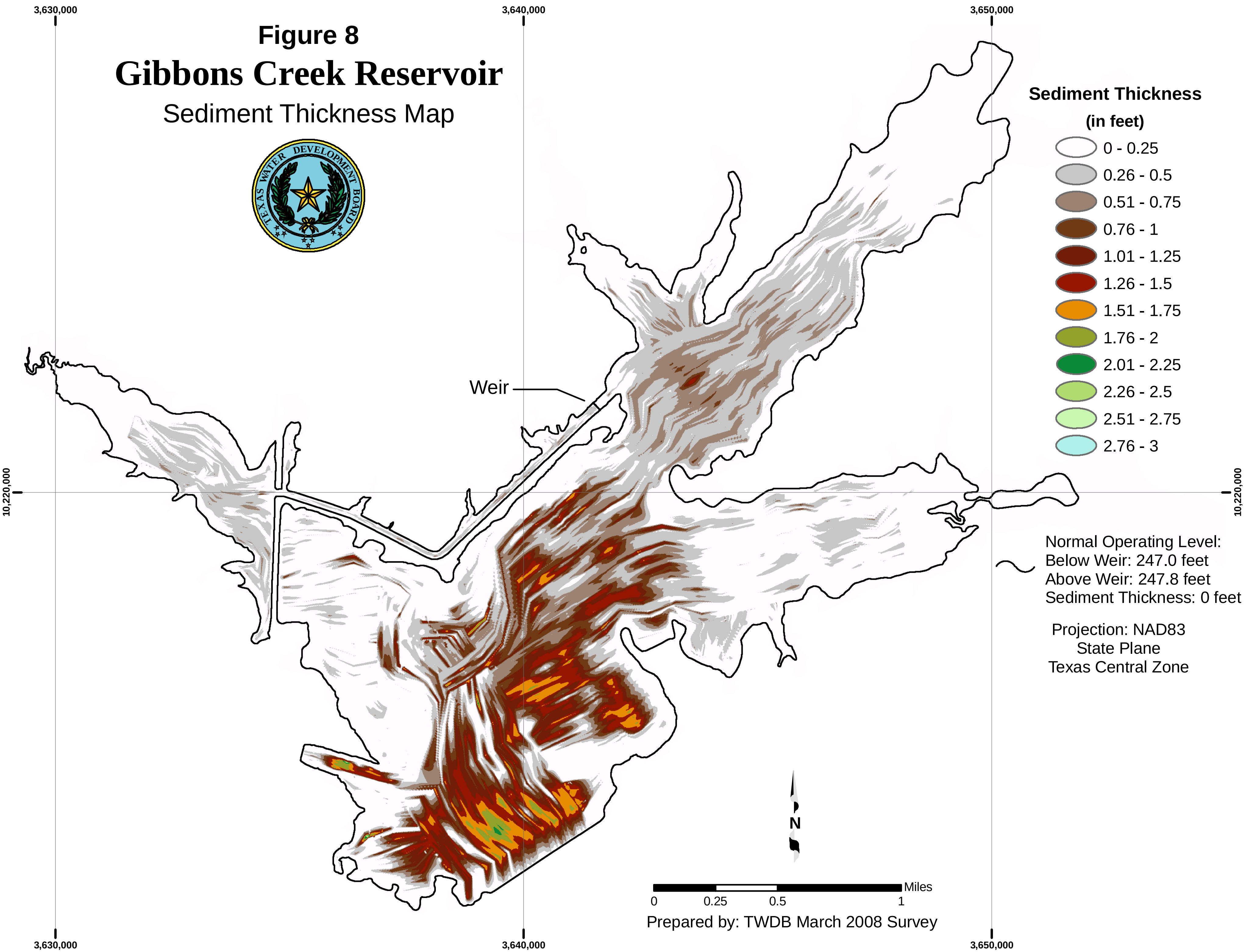
Figure 8
Gibbons Creek Reservoir
Sediment Thickness Map
TEXAS WATER DEVELOPMENT BOARD
Sediment Thickness
(in feet)
0 - 0.25
0.26 - 0.5
0.51 - 0.75
0.76 - 1
1.01 - 1.25
1.26 - 1.5
1.51 - 1.75
1.76 - 2
2.01 - 2.25
2.26 - 2.5
2.51 - 2.75
2.76 - 3
Weir
Normal Operating Level:
Below Weir: 247.0 feet
Above Weir: 247.8 feet
Sediment Thickness: 0 feet
Projection: NAD83
State Plane
Texas Central Zone
N
Miles
0
0.25
0.5
1
Prepared by: TWDB March 2008 Survey
3,630,000
3,640,000
3,650,000
10,220,000

TWDB Contact Information

More information about the Hydrographic Survey Program can be found at:

http://www.twdb.state.tx.us/assistance/lakesurveys/volumetricindex.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

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Or

Jason Kemp
Team Leader, TWDB Hydrographic Survey Program
Phone: (512) 463-2465
Email: Jason.Kemp@twdb.state.tx.us

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Appendix A

Gibbons Creek Reservoir

TOTAL RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

MARCH 2008 SURVEY

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
217	0	0	0	0	0	0	0	0	0	0
218	0	0	0	1	1	1	1	2	2	3
219	3	4	4	5	6	7	7	8	9	10
220	12	13	14	15	17	18	20	21	23	25
221	26	28	30	32	34	36	38	40	42	45
222	47	49	52	54	56	59	62	64	67	70
223	72	75	78	81	84	88	91	95	99	103
224	108	113	119	126	133	141	150	160	171	183
225	195	209	224	240	258	276	295	315	336	358
226	381	406	431	457	483	511	539	568	598	628
227	660	692	725	760	794	830	867	905	943	983
228	1,024	1,067	1,110	1,155	1,200	1,247	1,294	1,343	1,393	1,443
229	1,495	1,547	1,600	1,654	1,710	1,766	1,823	1,881	1,940	1,999
230	2,060	2,121	2,183	2,247	2,310	2,375	2,441	2,507	2,575	2,643
231	2,712	2,782	2,853	2,925	2,998	3,071	3,145	3,220	3,295	3,371
232	3,448	3,526	3,604	3,684	3,764	3,846	3,928	4,012	4,096	4,181
233	4,268	4,355	4,443	4,532	4,622	4,713	4,804	4,897	4,990	5,084
234	5,179	5,275	5,371	5,469	5,567	5,666	5,766	5,868	5,970	6,073
235	6,176	6,281	6,387	6,493	6,600	6,709	6,818	6,928	7,038	7,150
236	7,263	7,376	7,491	7,606	7,722	7,839	7,958	8,077	8,197	8,319
237	8,443	8,568	8,696	8,825	8,956	9,089	9,223	9,359	9,496	9,635
238	9,776	9,918	10,062	10,207	10,353	10,501	10,650	10,801	10,953	11,106
239	11,260	11,416	11,573	11,732	11,891	12,052	12,214	12,378	12,543	12,709
240	12,876	13,045	13,215	13,387	13,560	13,734	13,909	14,086	14,264	14,443
241	14,623	14,804	14,986	15,169	15,353	15,538	15,724	15,911	16,099	16,288
242	16,479	16,670	16,862	17,056	17,251	17,447	17,644	17,842	18,041	18,242
243	18,443	18,645	18,848	19,053	19,258	19,464	19,671	19,879	20,089	20,299
244	20,510	20,722	20,935	21,149	21,363	21,579	21,796	22,013	22,231	22,450
245	22,670	22,892	23,114	23,337	23,561	23,786	24,013	24,241	24,471	24,702
246	24,936	25,171	25,417	25,665	25,913	26,162	26,413	26,664	26,917	27,170
247	27,425	27,681	27,938	28,196	28,456	28,717	28,980	29,244	29,510	29,778
248	30,047	30,320	30,595	30,872	31,151	31,432	31,715	31,999	32,284	32,571
249	32,860	33,151	33,443	33,737	34,033	34,331	34,630	34,932	35,235	35,541
250	35,849	36,177	36,506	36,837	37,169	37,503	37,839	38,176	38,515	38,855
251	39,197									

Appendix B

Gibbons Creek Reservoir

TOTAL RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

AREA IN ACRES

MARCH 2008 SURVEY

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
217	0	0	0	0	0	0	0	0	0	1
218	1	1	1	2	2	3	3	4	5	5
219	6	6	7	7	8	8	9	10	10	11
220	11	12	13	14	14	15	16	16	17	17
221	18	18	19	19	20	20	21	21	22	22
222	23	23	24	25	25	26	26	27	27	28
223	29	29	30	31	32	33	35	38	41	45
224	50	56	63	71	78	85	93	104	113	123
225	133	144	156	166	176	187	196	205	215	227
226	238	248	256	264	271	278	285	293	302	310
227	319	328	337	345	353	362	372	382	393	405
228	417	428	439	449	460	472	482	492	501	509
229	518	528	539	548	557	566	575	584	592	601
230	609	618	626	635	643	652	661	670	679	688
231	696	705	714	722	729	736	743	750	758	765
232	773	782	790	800	810	820	829	839	849	859
233	868	876	885	895	903	912	920	928	937	945
234	953	962	970	979	988	996	1,006	1,016	1,025	1,034
235	1,043	1,052	1,060	1,069	1,078	1,086	1,095	1,104	1,112	1,122
236	1,131	1,139	1,148	1,158	1,167	1,177	1,187	1,198	1,213	1,227
237	1,244	1,265	1,285	1,302	1,318	1,335	1,350	1,366	1,381	1,396
238	1,414	1,430	1,445	1,458	1,472	1,486	1,498	1,511	1,524	1,538
239	1,551	1,565	1,578	1,591	1,603	1,615	1,628	1,641	1,655	1,668
240	1,681	1,695	1,709	1,722	1,736	1,749	1,761	1,773	1,784	1,795
241	1,805	1,815	1,825	1,835	1,845	1,855	1,864	1,875	1,887	1,898
242	1,908	1,919	1,931	1,943	1,955	1,966	1,976	1,986	1,997	2,007
243	2,017	2,028	2,038	2,047	2,057	2,067	2,077	2,087	2,097	2,106
244	2,116	2,125	2,134	2,143	2,152	2,161	2,169	2,178	2,187	2,196
245	2,206	2,215	2,226	2,237	2,249	2,261	2,275	2,289	2,305	2,323
246	2,344	2,456	2,467	2,477	2,488	2,499	2,509	2,520	2,531	2,542
247	2,553	2,564	2,577	2,590	2,603	2,620	2,636	2,652	2,668	2,685
248	2,724	2,742	2,759	2,784	2,800	2,816	2,832	2,848	2,864	2,881
249	2,897	2,914	2,931	2,949	2,967	2,985	3,005	3,025	3,046	3,069
250	3,267	3,284	3,300	3,316	3,333	3,349	3,364	3,380	3,396	3,411
251	3,428									

Appendix C

Gibbons Creek Reservoir

RESERVOIR CAPACITY TABLE - Below Weir

TEXAS WATER DEVELOPMENT BOARD — MARCH 2008 SURVEY

CAPACITY IN ACRE-FEET — Normal Operating Level 247.0 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
217	0	0	0	0	0	0	0	0	0	0
218	0	0	0	1	1	1	1	2	2	3
219	3	4	4	5	6	7	7	8	9	10
220	12	13	14	15	17	18	20	21	23	25
221	26	28	30	32	34	36	38	40	42	45
222	47	49	52	54	56	59	62	64	67	70
223	72	75	78	81	84	88	91	95	99	103
224	108	113	119	126	133	141	150	160	171	183
225	195	209	224	240	258	276	295	315	336	358
226	381	406	431	457	483	511	539	568	598	628
227	660	692	725	760	794	830	867	905	943	983
228	1,024	1,067	1,110	1,155	1,200	1,247	1,294	1,343	1,393	1,443
229	1,494	1,547	1,600	1,654	1,710	1,766	1,823	1,881	1,940	1,999
230	2,060	2,121	2,183	2,247	2,310	2,375	2,441	2,507	2,575	2,643
231	2,712	2,782	2,853	2,925	2,998	3,071	3,145	3,220	3,295	3,371
232	3,448	3,526	3,604	3,684	3,764	3,846	3,928	4,012	4,096	4,181
233	4,268	4,355	4,443	4,532	4,622	4,713	4,804	4,897	4,990	5,084
234	5,179	5,275	5,371	5,469	5,567	5,666	5,766	5,867	5,970	6,072
235	6,176	6,281	6,387	6,493	6,600	6,708	6,817	6,927	7,037	7,149
236	7,261	7,374	7,488	7,603	7,718	7,835	7,952	8,070	8,189	8,310
237	8,432	8,556	8,682	8,809	8,938	9,068	9,199	9,332	9,465	9,600
238	9,737	9,874	10,013	10,153	10,295	10,437	10,581	10,725	10,871	11,018
239	11,166	11,315	11,465	11,617	11,769	11,923	12,078	12,234	12,391	12,549
240	12,708	12,869	13,030	13,193	13,357	13,522	13,689	13,856	14,024	14,192
241	14,362	14,532	14,703	14,875	15,048	15,221	15,396	15,571	15,747	15,923
242	16,101	16,279	16,459	16,639	16,821	17,003	17,186	17,370	17,555	17,741
243	17,928	18,115	18,304	18,493	18,683	18,873	19,065	19,257	19,450	19,644
244	19,839	20,034	20,230	20,427	20,625	20,824	21,023	21,223	21,423	21,625
245	21,827	22,030	22,233	22,438	22,644	22,850	23,058	23,267	23,477	23,689
246	23,902	24,118	24,341	24,566	24,792	25,020	25,248	25,477	25,707	25,938
247	26,171									

Appendix D

Gibbons Creek Reservoir

RESERVOIR AREA TABLE - Below Weir

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

MARCH 2008 SURVEY
Normal Operating Level 247.0 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
217	0	0	0	0	0	0	0	0	0	1
218	1	1	1	2	2	3	3	4	5	5
219	6	6	7	7	8	8	9	10	10	11
220	11	12	13	14	14	15	16	16	17	17
221	18	18	19	19	20	20	21	21	22	22
222	23	23	24	25	25	26	26	27	27	28
223	29	29	30	31	32	33	35	38	41	45
224	50	56	63	71	78	85	93	104	113	123
225	133	144	156	166	176	187	196	205	215	227
226	238	248	256	264	271	278	285	293	302	310
227	319	328	337	345	353	362	372	382	393	405
228	417	428	439	449	460	472	482	492	501	509
229	518	528	539	548	557	566	575	584	592	601
230	609	618	626	635	643	652	661	670	679	688
231	696	705	714	722	729	736	743	750	758	765
232	773	782	790	800	810	820	829	839	849	859
233	868	876	885	895	903	912	920	928	937	945
234	953	962	970	979	988	996	1,006	1,016	1,025	1,034
235	1,043	1,051	1,060	1,068	1,077	1,085	1,093	1,101	1,110	1,119
236	1,127	1,135	1,143	1,151	1,159	1,168	1,177	1,187	1,201	1,214
237	1,229	1,249	1,265	1,279	1,293	1,307	1,319	1,332	1,344	1,356
238	1,370	1,384	1,396	1,407	1,418	1,429	1,440	1,451	1,462	1,474
239	1,486	1,498	1,509	1,521	1,531	1,542	1,553	1,564	1,576	1,587
240	1,599	1,611	1,623	1,635	1,646	1,656	1,666	1,675	1,684	1,692
241	1,700	1,707	1,715	1,723	1,731	1,738	1,746	1,754	1,763	1,772
242	1,780	1,789	1,799	1,809	1,819	1,829	1,837	1,846	1,854	1,863
243	1,871	1,879	1,887	1,894	1,903	1,910	1,918	1,927	1,935	1,943
244	1,951	1,959	1,966	1,974	1,981	1,988	1,995	2,003	2,010	2,017
245	2,025	2,033	2,042	2,051	2,061	2,072	2,083	2,096	2,109	2,125
246	2,144	2,233	2,245	2,255	2,266	2,277	2,287	2,297	2,307	2,317
247	2,328									

Appendix E

Gibbons Creek Reservoir

RESERVOIR CAPACITY TABLE - Above Weir

TEXAS WATER DEVELOPMENT BOARD — MARCH 2008 SURVEY

CAPACITY IN ACRE-FEET — Normal Operating Level 247.8 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
234	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	1	1	1	1
236	2	2	3	3	4	5	6	7	8	9
237	10	12	14	16	18	21	24	27	31	35
238	39	43	48	53	58	64	70	76	82	88
239	94	101	108	115	122	129	137	144	152	160
240	168	176	185	193	202	211	221	230	240	250
241	261	271	282	293	305	316	328	340	352	365
242	377	390	403	417	430	444	458	472	486	500
243	515	529	544	559	575	590	606	622	638	654
244	671	687	704	721	737	755	772	789	807	825
245	843	861	879	898	916	935	954	973	993	1,012
246	1,032	1,052	1,072	1,093	1,114	1,135	1,156	1,178	1,199	1,222
247	1,244	1,266	1,289	1,312	1,336	1,360	1,384	1,408	1,432	

Appendix F

Gibbons Creek Reservoir

RESERVOIR AREA TABLE - Above Weir

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

MARCH 2008 SURVEY
Normal Operating Level 247.8 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
234	0	0	0	0	0	0	0	0	0	0
235	0	0	1	1	1	1	2	2	3	3
236	4	5	6	7	8	9	10	11	12	13
237	15	17	20	23	26	28	31	34	37	41
238	43	46	49	51	54	56	58	60	62	64
239	65	67	69	70	72	73	75	77	78	80
240	82	84	86	88	90	92	95	98	100	103
241	105	108	110	112	114	116	118	121	124	126
242	128	130	132	134	135	137	139	141	142	144
243	146	149	151	153	155	156	158	160	161	163
244	164	166	167	169	171	172	174	175	177	179
245	180	182	183	185	187	189	191	193	195	197
246	200	202	204	207	209	212	214	217	219	222
247	225	227	230	233	236	238	241	244	248	

Appendix G

Gibbons Creek Reservoir

TOTAL RESERVOIR CAPACITY TABLE - Normal Operating Level

TEXAS WATER DEVELOPMENT BOARD
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

MARCH 2008 SURVEY
Normal Operating Level below weir 247.0 feet
Normal Operating Level above weir 247.8 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
217	0	0	0	0	0	0	0	0	0	0
218	0	0	0	1	1	1	1	2	2	3
219	3	4	4	5	6	7	7	8	9	10
220	12	13	14	15	17	18	20	21	23	25
221	26	28	30	32	34	36	38	40	42	45
222	47	49	52	54	56	59	62	64	67	70
223	72	75	78	81	84	88	91	95	99	103
224	108	113	119	126	133	141	150	160	171	183
225	195	209	224	240	258	276	295	315	336	358
226	381	406	431	457	483	511	539	568	598	628
227	660	692	725	760	794	830	867	905	943	983
228	1,024	1,067	1,110	1,155	1,200	1,247	1,294	1,343	1,393	1,443
229	1,494	1,547	1,600	1,654	1,710	1,766	1,823	1,881	1,940	1,999
230	2,060	2,121	2,183	2,247	2,310	2,375	2,441	2,507	2,575	2,643
231	2,712	2,782	2,853	2,925	2,998	3,071	3,145	3,220	3,295	3,371
232	3,448	3,526	3,604	3,684	3,764	3,846	3,928	4,012	4,096	4,181
233	4,268	4,355	4,443	4,532	4,622	4,713	4,804	4,897	4,990	5,084
234	5,179	5,275	5,371	5,469	5,567	5,666	5,766	5,867	5,970	6,072
235	6,176	6,281	6,387	6,493	6,600	6,709	6,818	6,928	7,038	7,150
236	7,263	7,376	7,491	7,606	7,722	7,839	7,958	8,077	8,197	8,319
237	8,443	8,568	8,696	8,825	8,956	9,089	9,223	9,359	9,496	9,635
238	9,776	9,918	10,062	10,207	10,353	10,501	10,650	10,801	10,953	11,106
239	11,260	11,416	11,573	11,732	11,891	12,052	12,214	12,378	12,543	12,709
240	12,876	13,045	13,215	13,387	13,560	13,734	13,909	14,086	14,264	14,443
241	14,623	14,804	14,986	15,169	15,353	15,538	15,724	15,911	16,099	16,288
242	16,478	16,670	16,862	17,056	17,251	17,447	17,644	17,842	18,041	18,241
243	18,442	18,645	18,848	19,052	19,257	19,464	19,671	19,879	20,088	20,298
244	20,509	20,721	20,934	21,148	21,363	21,578	21,795	22,012	22,230	22,449
245	22,669	22,890	23,112	23,335	23,560	23,785	24,012	24,240	24,470	24,701
246	24,934	25,170	25,414	25,659	25,906	26,154	26,404	26,655	26,907	27,160
247	27,414	27,437	27,460	27,483	27,506	27,530	27,554	27,578	27,603	

Appendix H

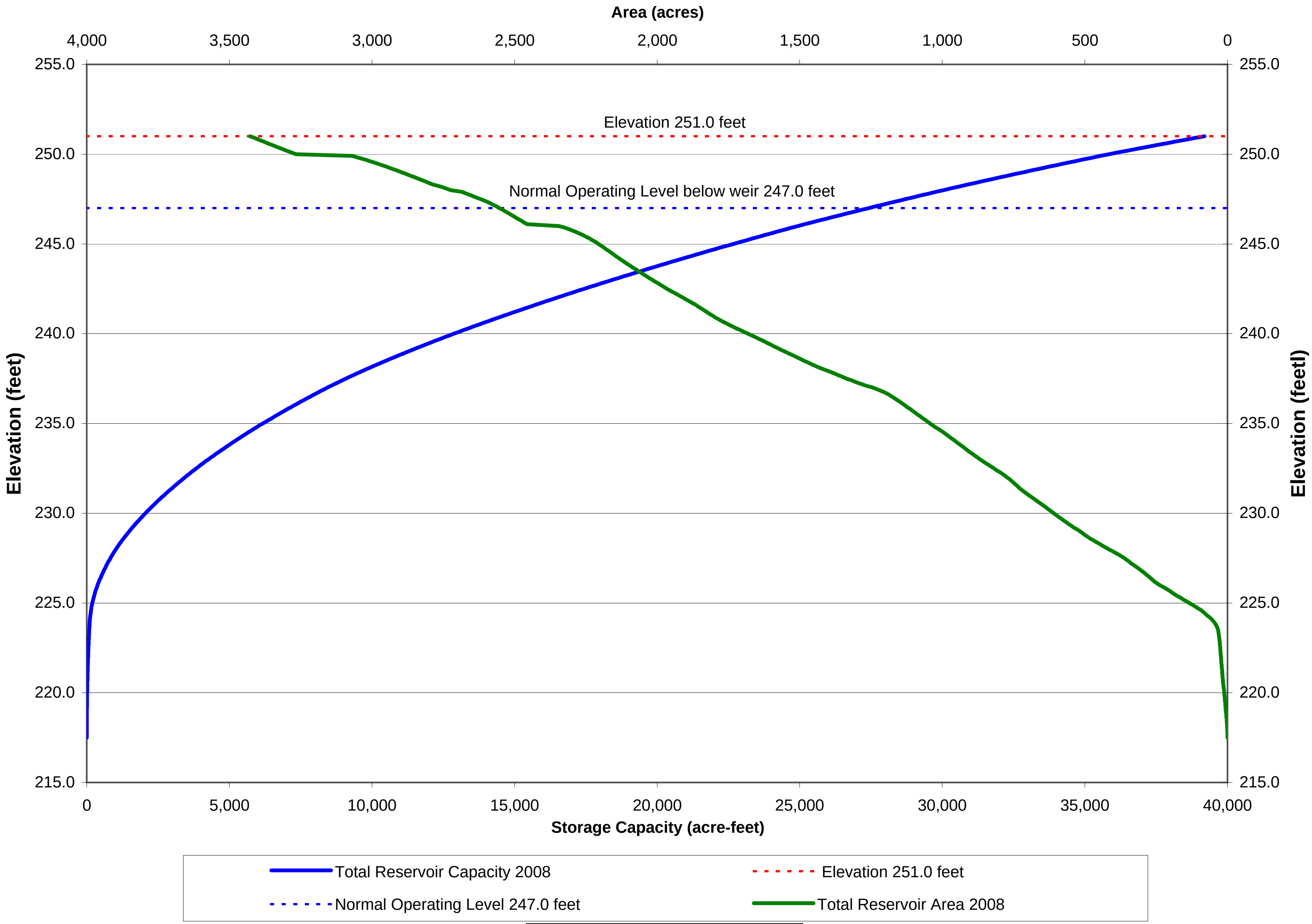
Gibbons Creek Reservoir

TOTAL RESERVOIR AREA TABLE - Normal Operating Level

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

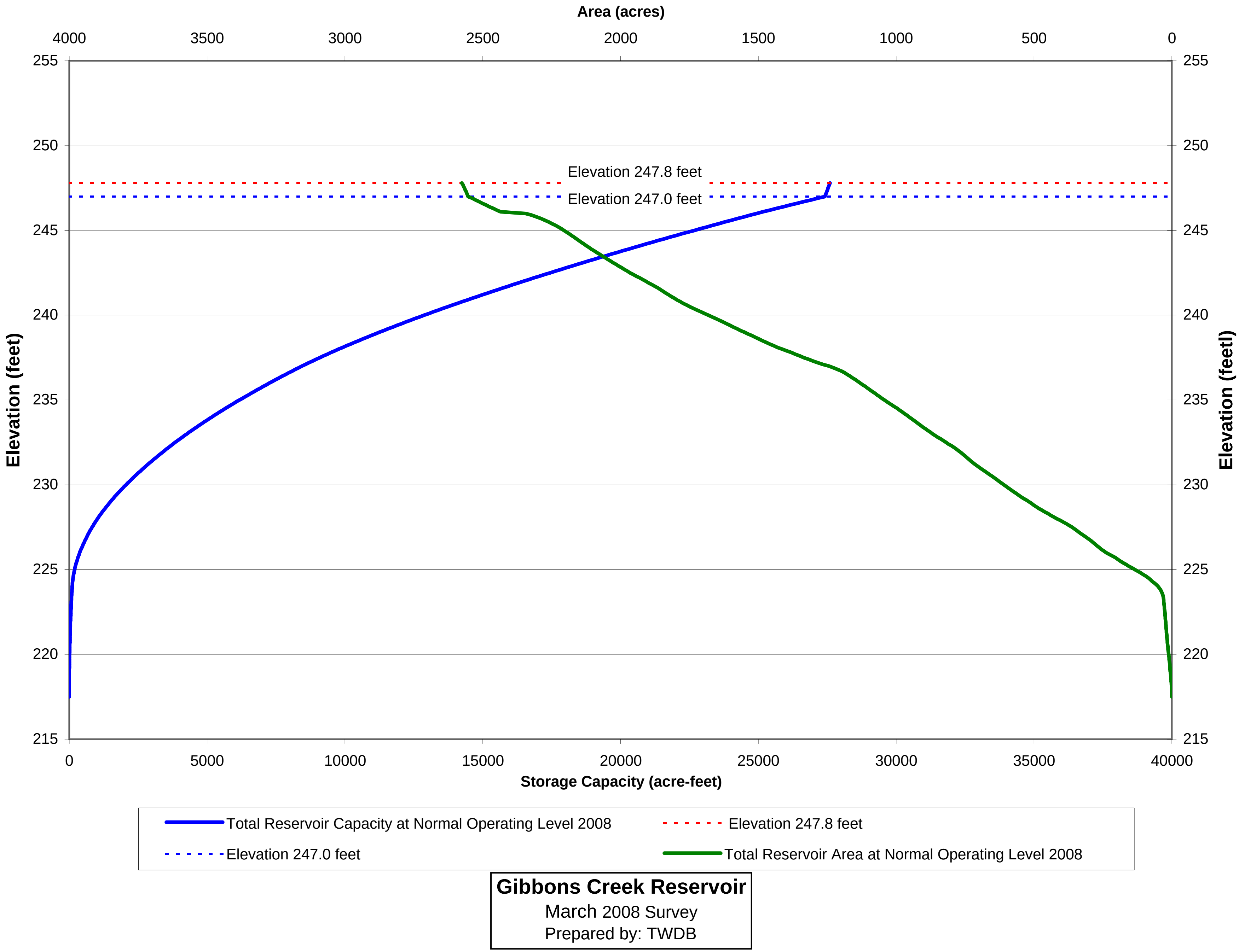
MARCH 2008 SURVEY
Normal Operating Level below weir 247.0 feet
Normal Operating Level above weir 247.8 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
217	0	0	0	0	0	0	0	0	0	1
218	1	1	1	2	2	3	3	4	5	5
219	6	6	7	7	8	8	9	10	10	11
220	11	12	13	14	14	15	16	16	17	17
221	18	18	19	19	20	20	21	21	22	22
222	23	23	24	25	25	26	26	27	27	28
223	29	29	30	31	32	33	35	38	41	45
224	50	56	63	71	78	85	93	104	113	123
225	133	144	156	166	176	187	196	205	215	227
226	238	248	256	264	271	278	285	293	302	310
227	319	328	337	345	353	362	372	382	393	405
228	417	428	439	449	460	472	482	492	501	509
229	518	528	539	548	557	566	575	584	592	601
230	609	618	626	635	643	652	661	670	679	688
231	696	705	714	722	729	736	743	750	758	765
232	773	782	790	800	810	820	829	839	849	859
233	868	876	885	895	903	912	920	928	937	945
234	953	962	970	979	988	996	1,006	1,016	1,025	1,034
235	1,043	1,052	1,060	1,069	1,078	1,086	1,095	1,104	1,112	1,122
236	1,131	1,139	1,148	1,158	1,167	1,177	1,187	1,198	1,213	1,227
237	1,244	1,265	1,285	1,302	1,318	1,335	1,350	1,366	1,381	1,396
238	1,414	1,430	1,445	1,458	1,472	1,486	1,498	1,511	1,524	1,538
239	1,551	1,565	1,578	1,591	1,603	1,615	1,628	1,641	1,655	1,668
240	1,681	1,695	1,709	1,722	1,736	1,748	1,761	1,773	1,784	1,795
241	1,805	1,815	1,825	1,835	1,845	1,855	1,864	1,875	1,887	1,897
242	1,908	1,919	1,931	1,943	1,955	1,966	1,976	1,986	1,996	2,007
243	2,017	2,028	2,037	2,047	2,057	2,067	2,076	2,086	2,096	2,106
244	2,115	2,125	2,134	2,143	2,151	2,160	2,169	2,178	2,187	2,196
245	2,205	2,215	2,225	2,236	2,248	2,261	2,274	2,289	2,304	2,322
246	2,343	2,435	2,449	2,462	2,476	2,488	2,501	2,514	2,526	2,539
247	2,553	2,555	2,558	2,561	2,564	2,567	2,569	2,572	2,576	



Gibbons Creek Reservoir
March 2008 Survey
Prepared by: TWDB

Appendix I: Area and Capacity Curves: to elevation 251.0 feet



Appendix J: Area and Capacity Curves: to normal operating level

Appendix K

Hydrographic Survey of Gibbons Creek Reservoir (Texas)

Temperature Profile Data Collection Report

Prepared by Jordan Furnans Ph.D., P.E.
Texas Water Development Board
May 15, 2009

Introduction

As part of its volumetric and sedimentation survey of Gibbons Creek Reservoir, Texas, the Texas Water Development Board (TWDB) was contracted to collect 20 temperature vs. depth profiles within the lake, at locations specified by the Texas Municipal Power Agency (TMPA). The TWDB collected 19 of these profiles on June 9-11, 2008, using a Eureka Manta water quality probe. The TWDB was unable to collect a temperature profile at TMPA site #12 because it was located behind a buoy line, and the TWDB was unable to obtain permission to travel behind the buoys at the time of the sampling. This appendix contains the collected temperature profiles in tabular and graphical format, and describes how the data were collected. The TWDB also provides recommendations as to how additional temperature profiles/measurements in alternative locations and at alternative times might lead to improved understanding of the water temperature distribution in Gibbons Creek Reservoir.

Data Collection Performed By:

Jordan Furnans, Ph.D., P.E.
Jason Kemp, Team Lead
Tony Connell
Texas Water Development Board

Basic Temperature Profiling Methodology

The TWDB used a Eureka Manta water quality multiprobe (Figure K1) for all temperature measurements. The Manta multiprobe is manually lowered over the side of the survey vessel to depths determined by the probe user. All data from the unit are displayed on a computer screen on the survey vessel, and the probe user manually selects the depths and times at which each data measurement is recorded. The TWDB attempted to collect data at 1-foot intervals from the water surface to the reservoir bed, with an additional measurement collected within 6 inches from the reservoir bed. In instances where 1-foot increments were insufficient to capture temperature gradients, shorter depth increments were used. Upon reaching a desired depth, the TWDB held the probe steady for 10 seconds before recording the data; this stabilization time allows the probe sensors time to adjust from the potentially different readings recorded at the previous depth/location.

Figure K1 – The Eureka Manta Multiprobe used by the TWDB in measuring temperature profiles in Gibbons Creek Reservoir. (Photo Source: www.EurekaEnvironmental.com)

For each measurement, the TWDB would navigate to the measurement location using a Trimble ProXRS or Ag132 GPS system, differentially corrected to Ominstar Level 1 (positional accuracy ±1.0 m). At the location, the TWDB anchored the survey vessel and set the location as a target point in the GPS system. The TWDB then set the GPS to continuously navigate to the target point, thus forcing the GPS system to continuously display the distance between the current location and the target point. While collecting the profile data, the TWDB monitored the GPS system to verify that the "distance to target point" was not increasing, therefore indicating that the anchor was holding the survey vessel in place at the desired sampling location. In instances where the GPS system indicated significant boat drift during the data collection, the collected data were deleted, the survey vessel position was re-established at the desired location, anchor was laid, and measurements were re-collected. Following this procedure, the TWDB ensures that the temperature profiles were collected in the immediate vicinity (±20 feet) of the locations specified by TMPA. Coordinates of each sampling location are provided in Table K1 and displayed on Figure K2.

Table K1 – Temperature Profile Sampling Information – Gibbons Creek Reservoir

Point	Latitude	Longitude	Date	Time
1	30.6262704027	-96.0555678245	6/9/2008	14:48
2	30.6272283117	-96.0568370570	6/9/2008	15:04
3	30.6281862065	-96.0581063144	6/9/2008	15:16
4	30.6291440871	-96.0593755966	6/9/2008 6/10/2008	15:37 09:39
5	30.6301019535	-96.0606449035	6/9/2009	16:03
6	30.6310598057	-96.0619142353	6/9/2008	16:23
7	30.6363267184	-96.0535856812	6/9/2008 6/10/2008	16:36 09:10
8	30.6358101692	-96.0529734989	6/9/2008 6/10/2008	16:50 09:00
9	30.6352936167	-96.0523613231	6/9/2008 6/10/2008	17:19 08:51
10	30.6347770609	-96.0517491538	6/9/2008 6/10/2008	17:53 08:40
11	30.6392864928	-96.0544598033	6/10/2008	09:20
12	30.6183141949	-96.0744696723	DNS**	DNS**
13	30.6176764959	-96.0727694311	6/10/2008	10:01
14	30.6170667553	-96.0696219010	6/10/2008	10:18
15	30.6181453728	-96.0706105571	6/10/2008	10:35
16	30.6178872422	-96.0697030912	6/11/2008	12:09
17	30.6160938863	-96.0698699932	6/11/2008	12:01
18	30.6153443212	-96.0705149543	6/11/2008	12:15
19	30.6185200043	-96.0699009792	6/11/2008	11:55
20	30.6190743141	-96.0703789766	6/11/2008	11:33

** Point 12 was inaccessible on the sampling day

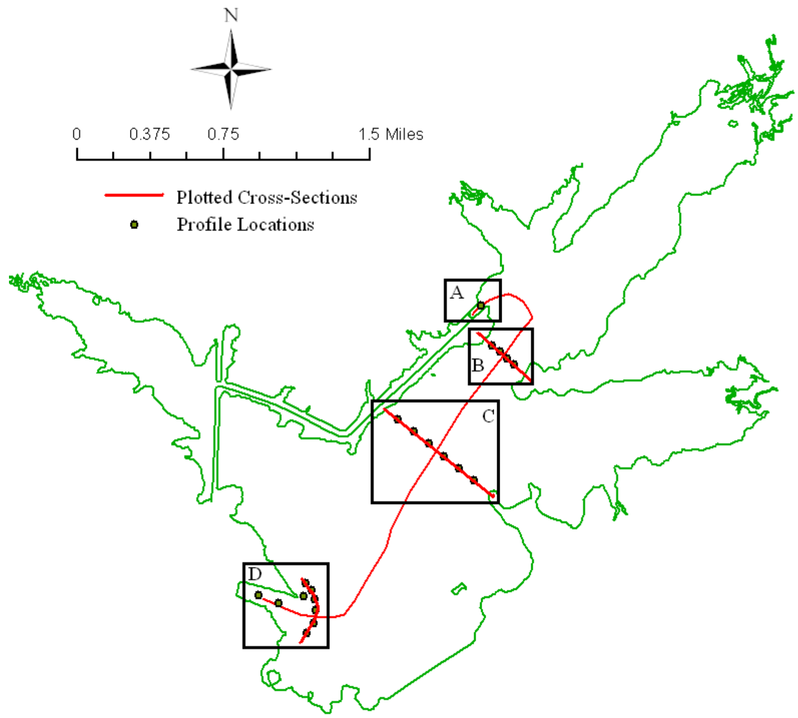


Figure K2 – Gibbons Creek Reservoir Map Showing Temperature Profile Locations and Plotted Cross-Sections. Insets are shown in Figures K3-K6.

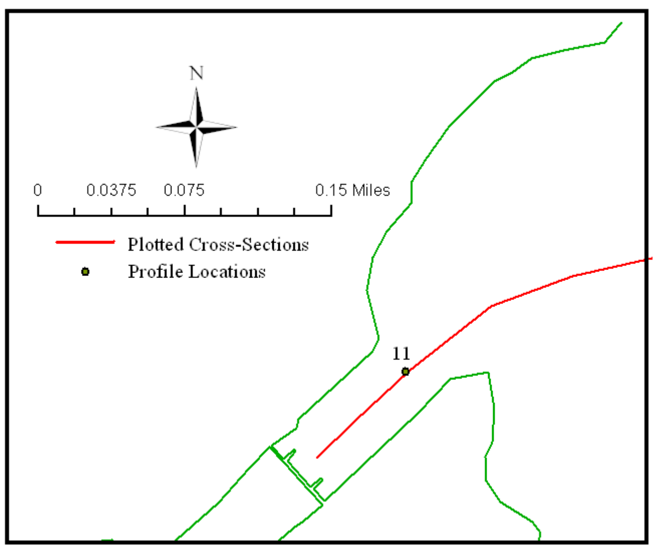


Figure K3 – Gibbons Creek Reservoir Map – Inset "A" showing temperature profile location 11.

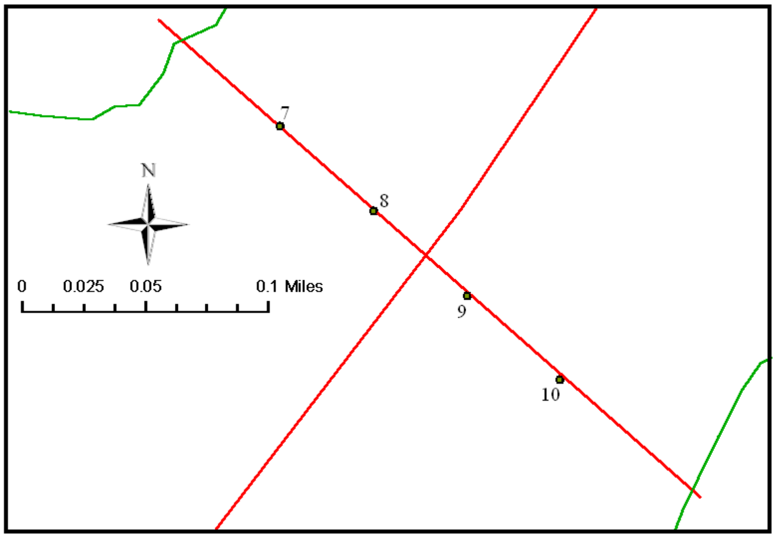


Figure K4– Gibbons Creek Reservoir Map – Inset "B" showing temperature profile locations 7, 8, 9, and 10

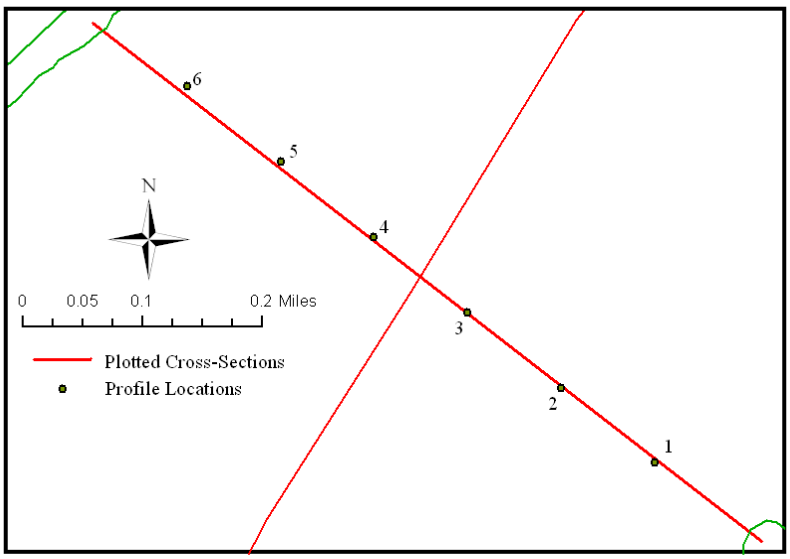


Figure K5– Gibbons Creek Reservoir Map – Inset "C" showing temperature profile locations 1, 2, 3, 4, 5 and 6.

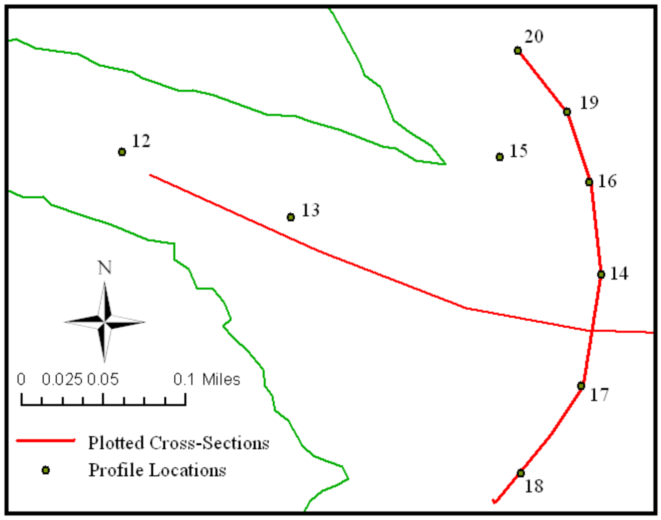
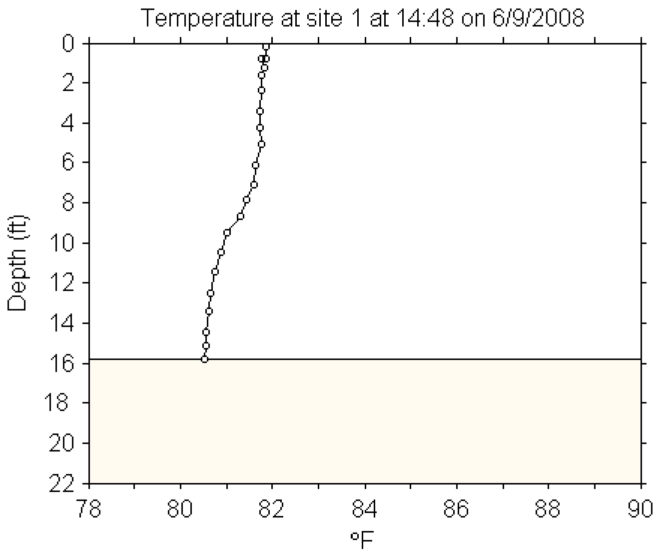
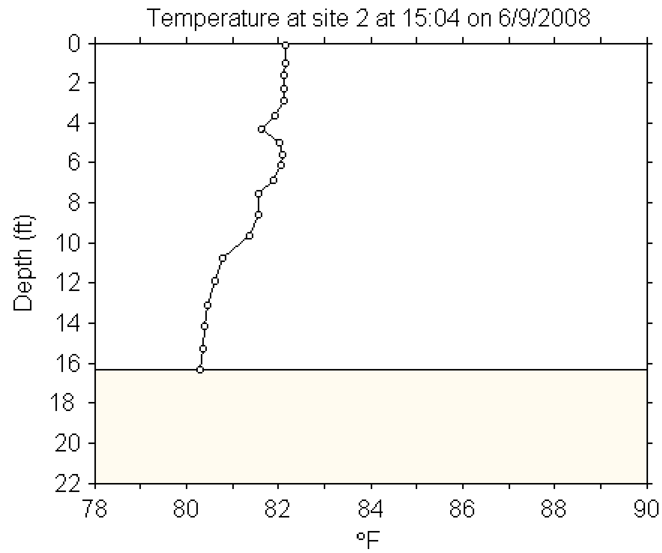
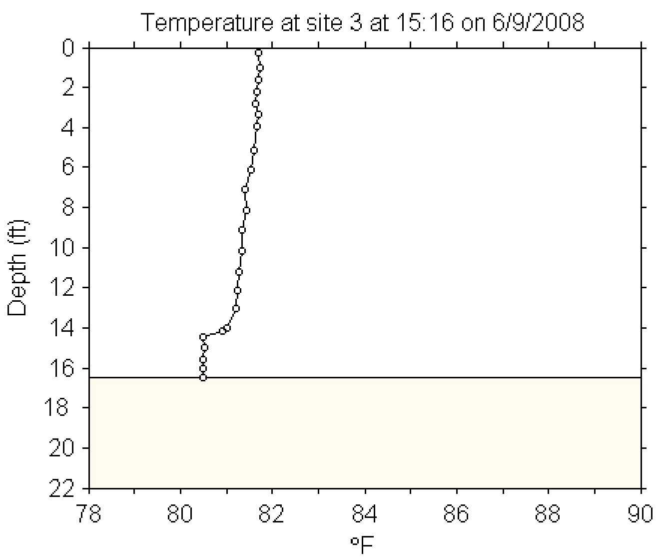


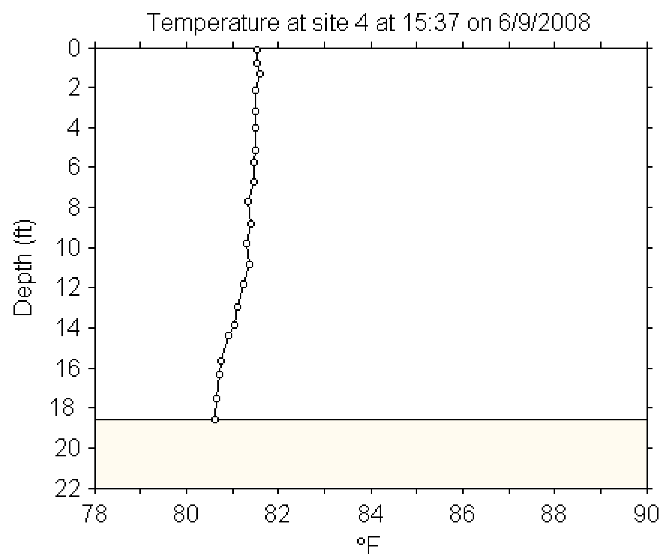
Figure K6– Gibbons Creek Reservoir Map – Inset "D" showing temperature profile locations 12, 13, 14, 15, 16, 17, 18, 19, and 20.

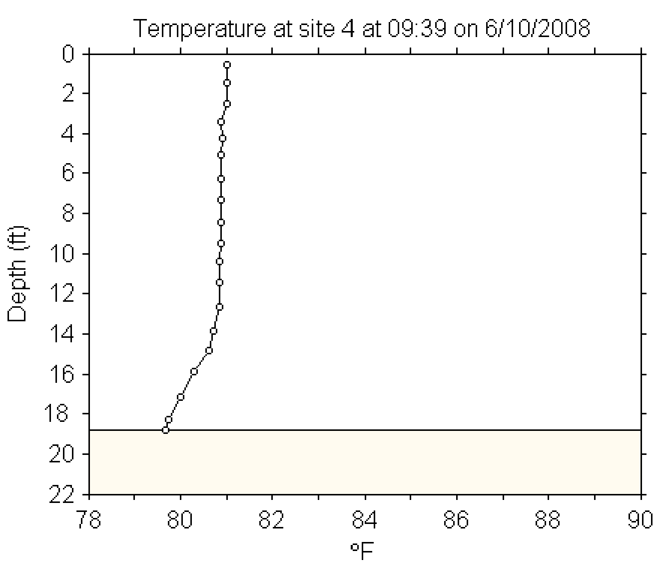
On the following pages, temperature profiles are plotted versus depth for each sampling event listed in Table K1. Each plot is shown with identical axes to allow for quick visual comparison between the data. The content of each plot is provided on the plot title at the top of each figure. Figures K7-K11 show interpolated temperature profiles along cross-sections connecting the sampled locations. The cross-section locations are shown in Figures K2-K6. Figures K12-K14 are approximated surface maps of temperature data. The temperatures shown on each map in areas between survey locations are only interpolated data and are not necessarily reflective of the true temperature distributions within Gibbons Creek Reservoir. Figure K12 depicts surface temperatures, whereas bottom temperatures are shown in Figure K13. Figure K14 shows temperature stratification, defined as the difference between the surface and bottom temperatures. The data collected during this project are insufficient in spatial extent to accurately represent the distribution of temperatures within Gibbons Creek Reservoir. The scenarios presented in Figures K12-K14 are one possible interpretation of the collected data. The exact temperature distributions between sampling point #11 and points #7-#10 (boxed area in Figures K12-K14) are unknown.

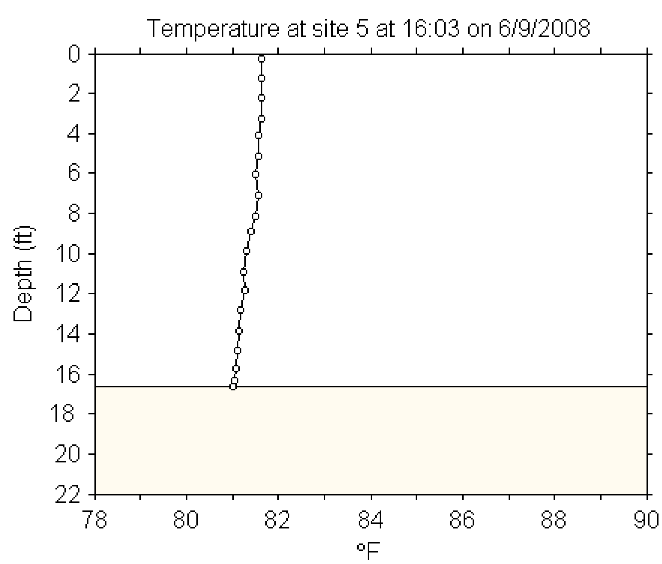

Temperature at site 1 at 14:48 on 6/9/2008
Depth (ft)
°F

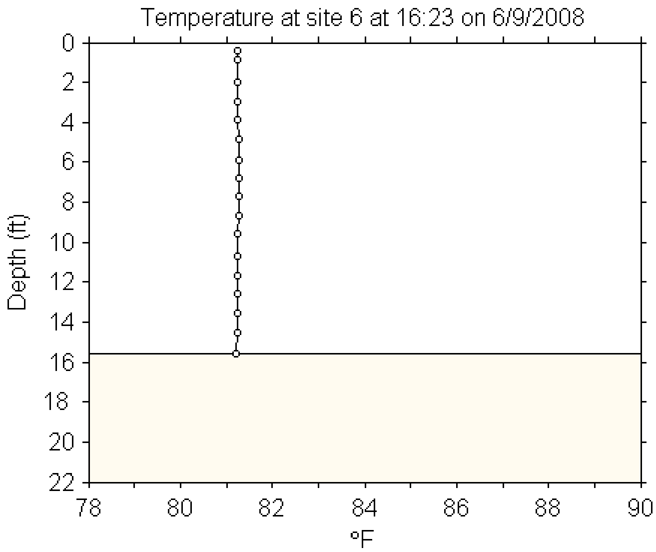

Temperature at site 2 at 15:04 on 6/9/2008
Depth (ft)
°F

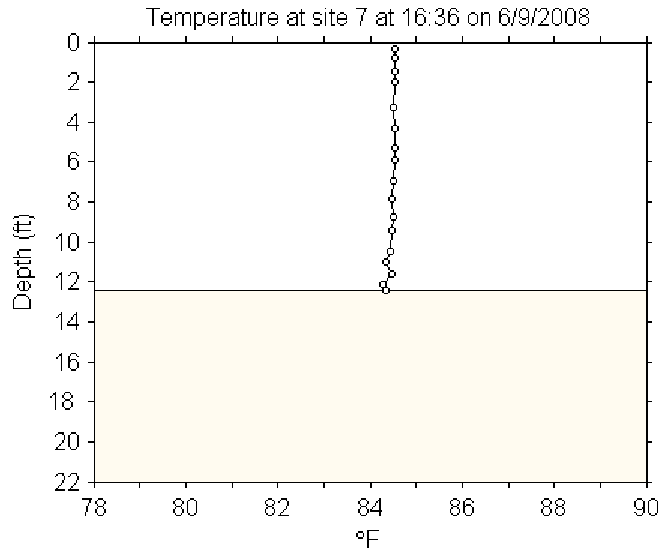

Temperature at site 3 at 15:16 on 6/9/2008
Depth (ft)
°F

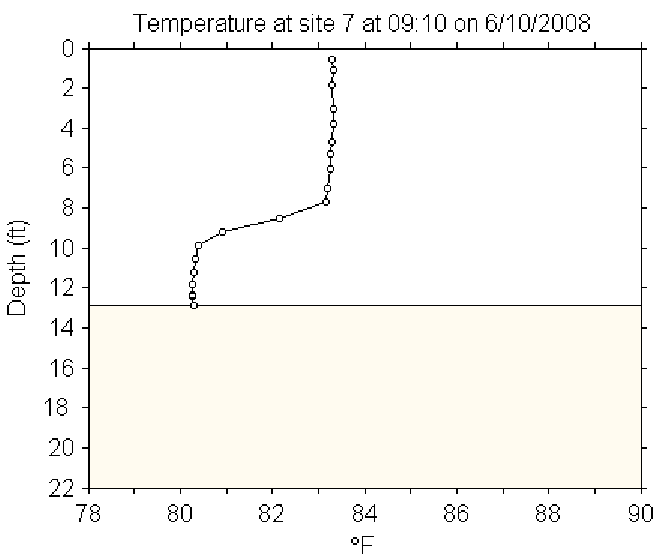

Temperature at site 4 at 15:37 on 6/9/2008
Depth (ft)
°F

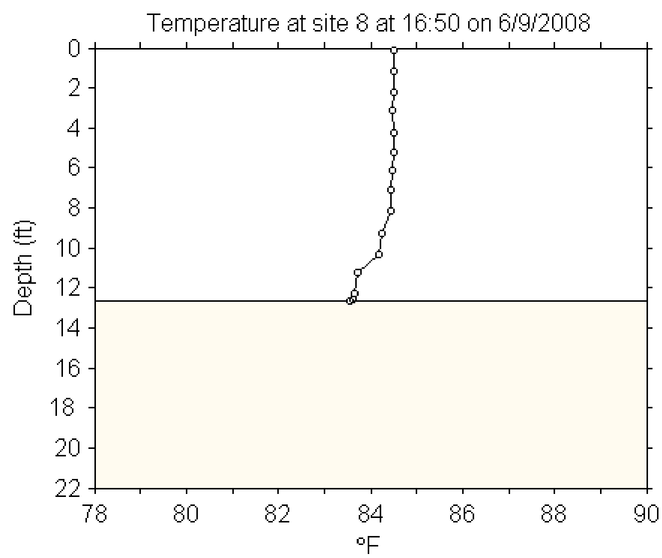

Temperature at site 4 at 09:39 on 6/10/2008
Depth (ft)
°F

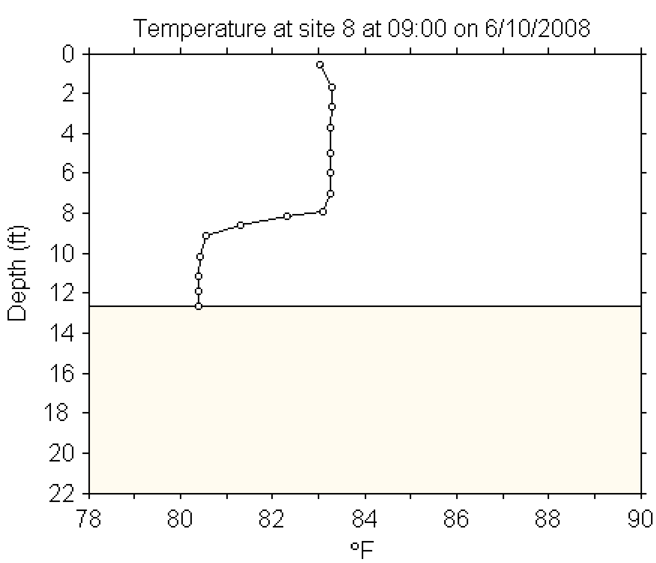

Temperature at site 5 at 16:03 on 6/9/2008
Depth (ft)
°F

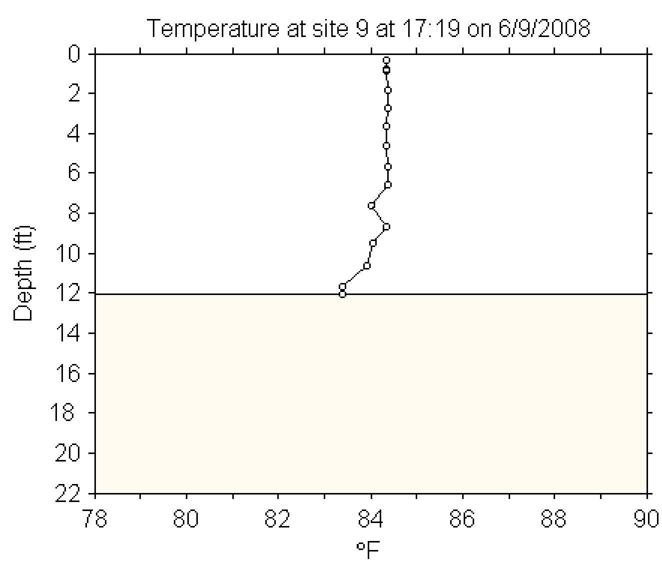

Temperature at site 6 at 16:23 on 6/9/2008
Depth (ft)
°F

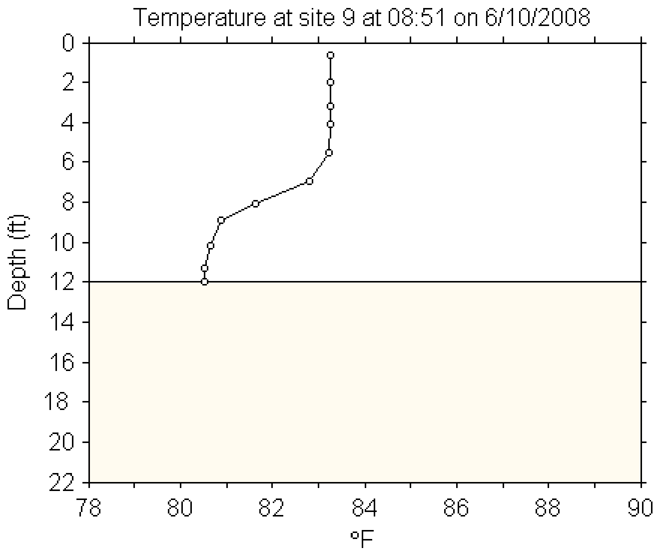

Temperature at site 7 at 16:36 on 6/9/2008
Depth (ft)
°F

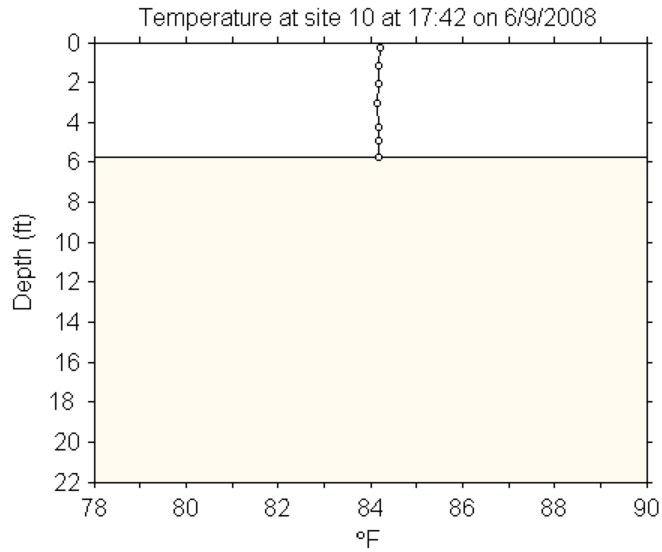

Temperature at site 7 at 09:10 on 6/10/2008
Depth (ft)
°F

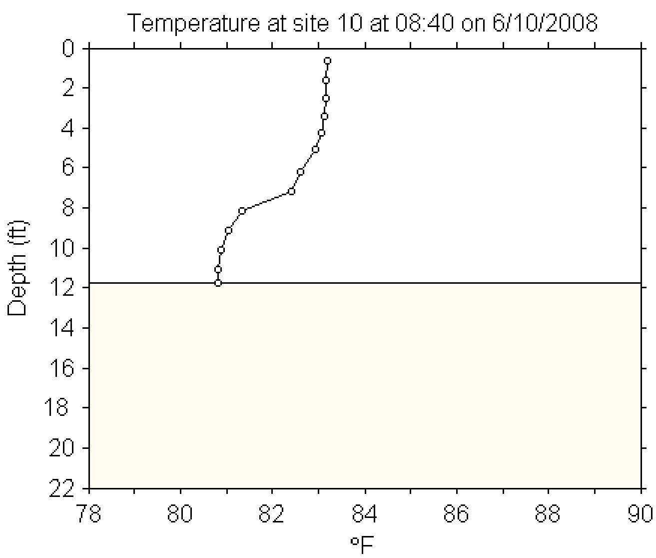

Temperature at site 8 at 16:50 on 6/9/2008
Depth (ft)
°F

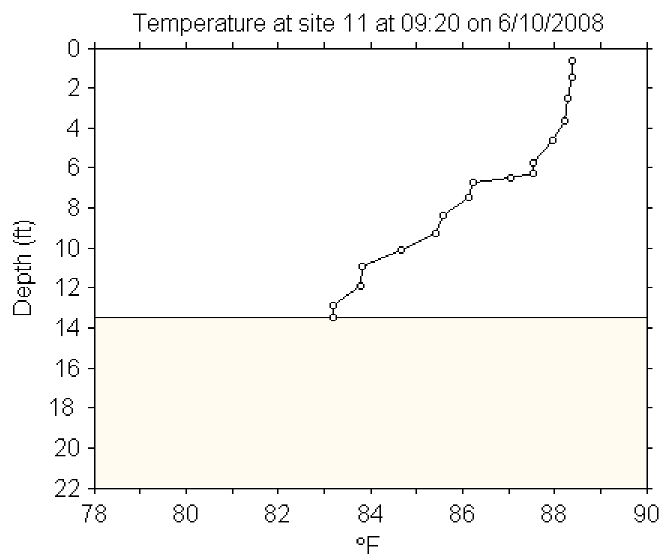

Temperature at site 8 at 09:00 on 6/10/2008
Depth (ft)
°F

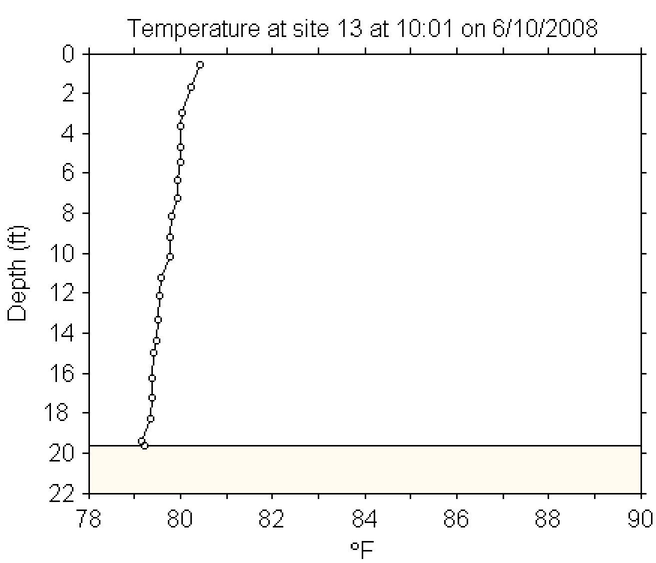

Temperature at site 9 at 17:19 on 6/9/2008
Depth (ft)
°F

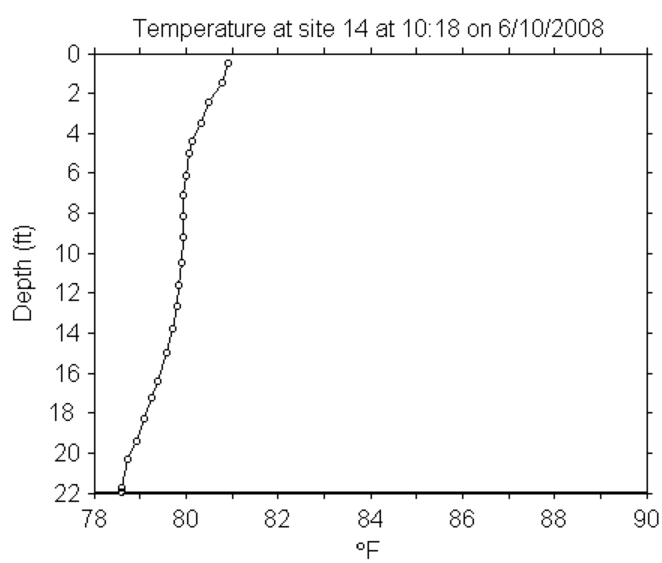

Temperature at site 9 at 08:51 on 6/10/2008
Depth (ft)
°F

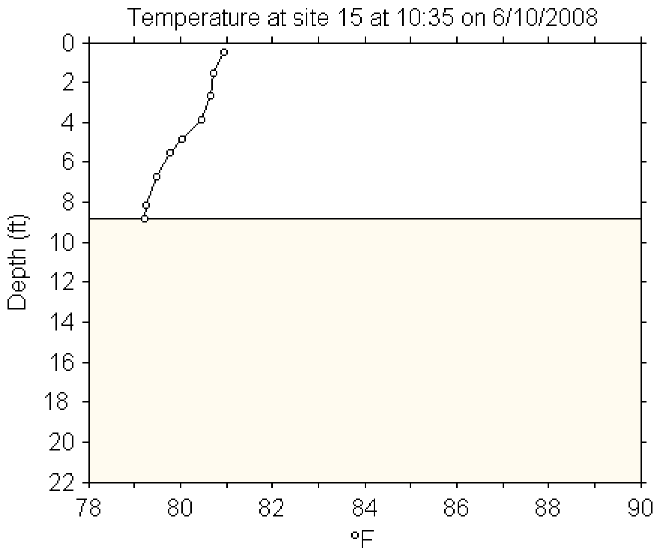

Temperature at site 10 at 17:42 on 6/9/2008
Depth (ft)
°F

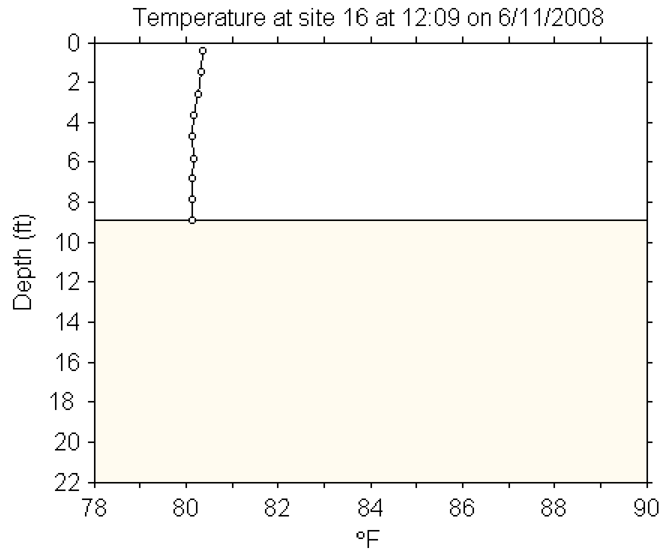

Temperature at site 10 at 08:40 on 6/10/2008
Depth (ft)
°F

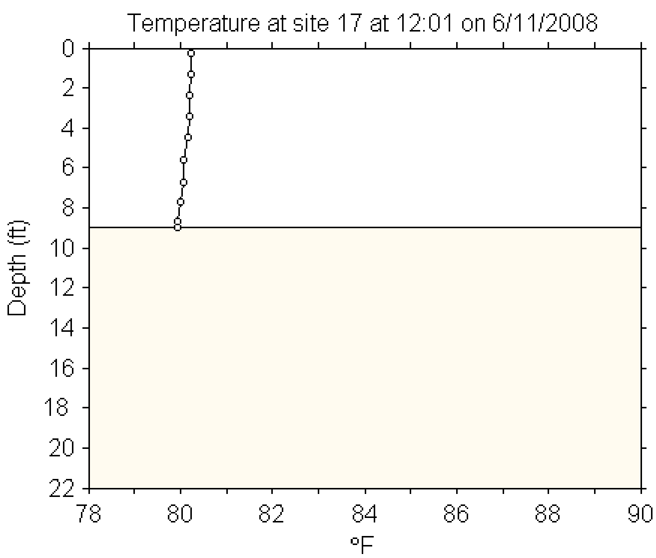

Temperature at site 11 at 09:20 on 6/10/2008
Depth (ft)
°F

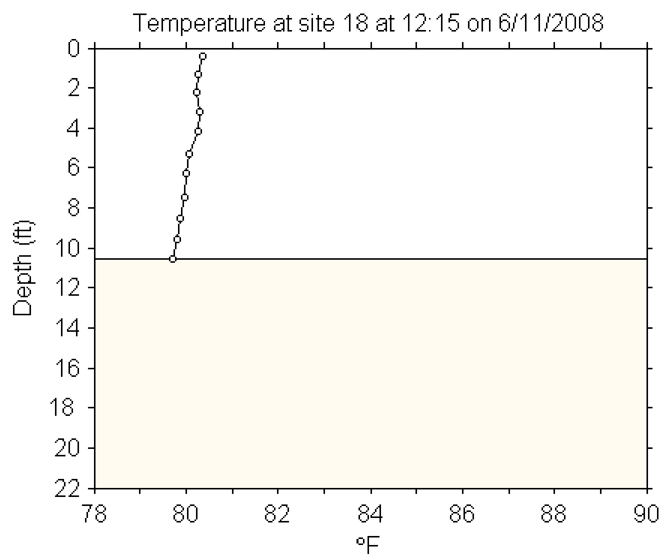

Temperature at site 13 at 10:01 on 6/10/2008
Depth (ft)
°F

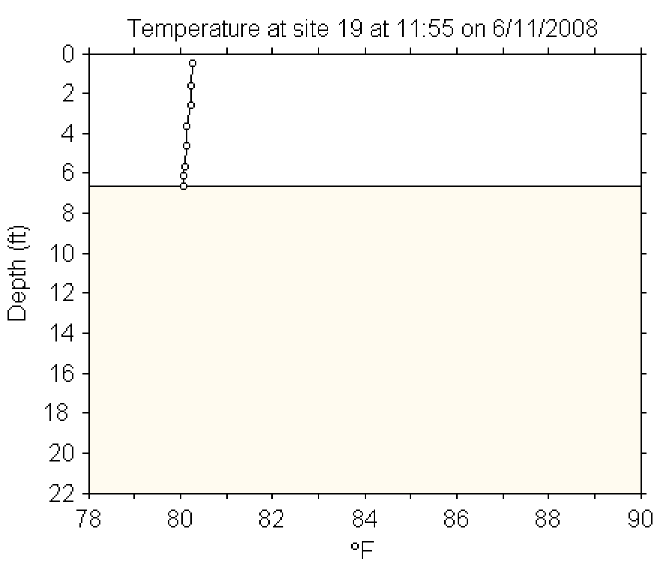

Temperature at site 14 at 10:18 on 6/10/2008
Depth (ft)
°F

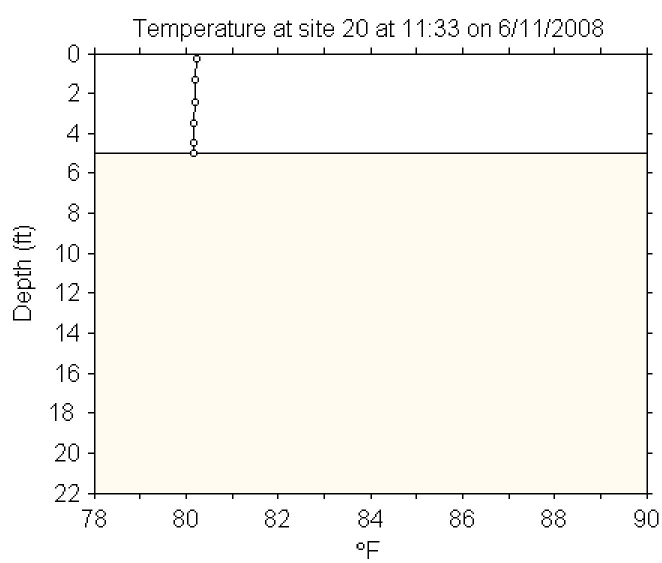

Temperature at site 15 at 10:35 on 6/10/2008
Depth (ft)
°F


Temperature at site 16 at 12:09 on 6/11/2008
Depth (ft)
°F


Temperature at site 17 at 12:01 on 6/11/2008
Depth (ft)
°F


Temperature at site 18 at 12:15 on 6/11/2008
Depth (ft)
°F


Temperature at site 19 at 11:55 on 6/11/2008
Depth (ft)
°F


Temperature at site 20 at 11:33 on 6/11/2008
Depth (ft)
°F

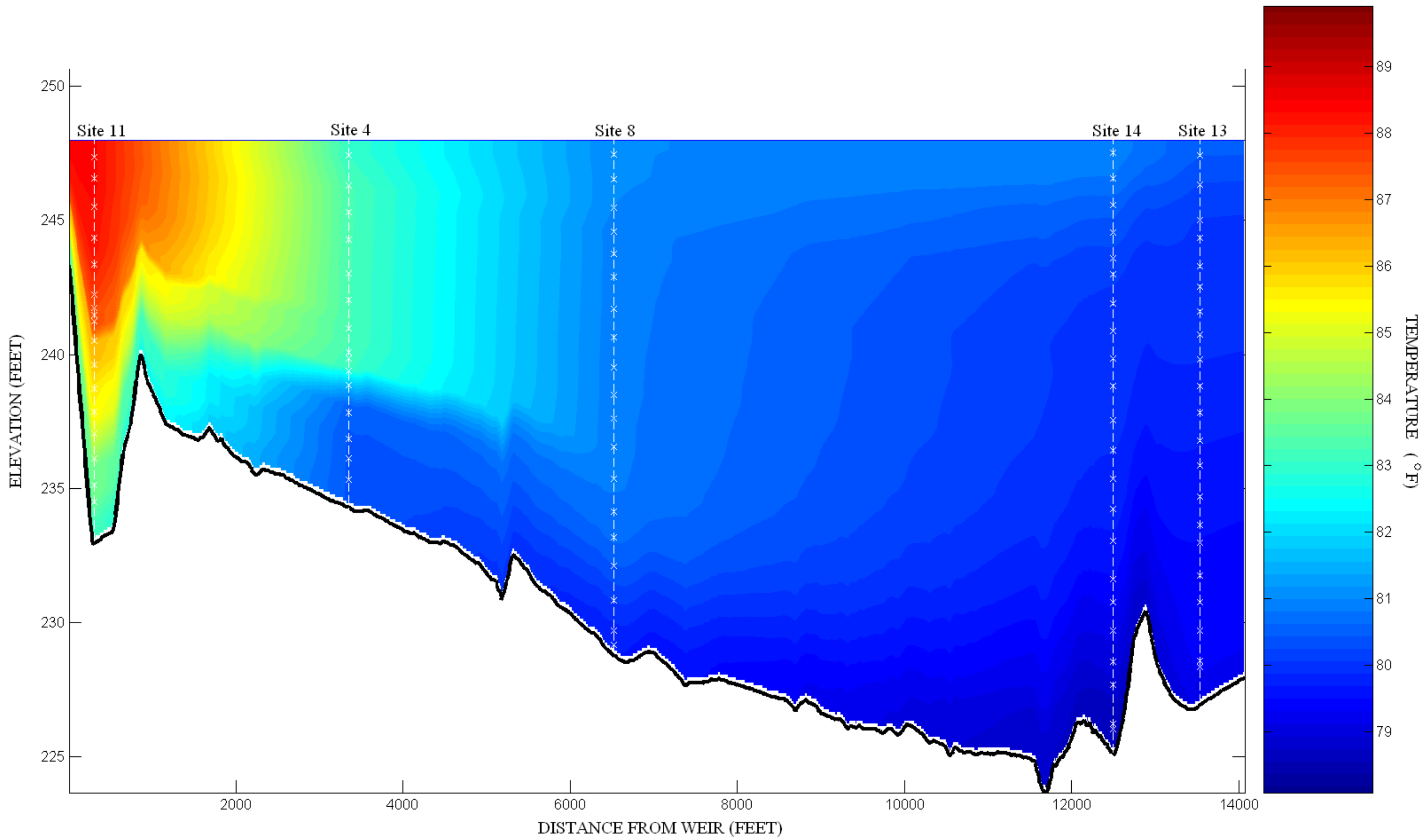


Figure K7 – Temperature Profile from Weir to TMPA Water Intake – Gibbons Creek Reservoir – 6/10/2008 0900 HRS. Profile location is depicted in Figure K2, and bathymetry is derived from the 2008 TWDB Volumetric and Sedimentation Survey. Dashed white lines and "X"s indicate sampling locations/depths.

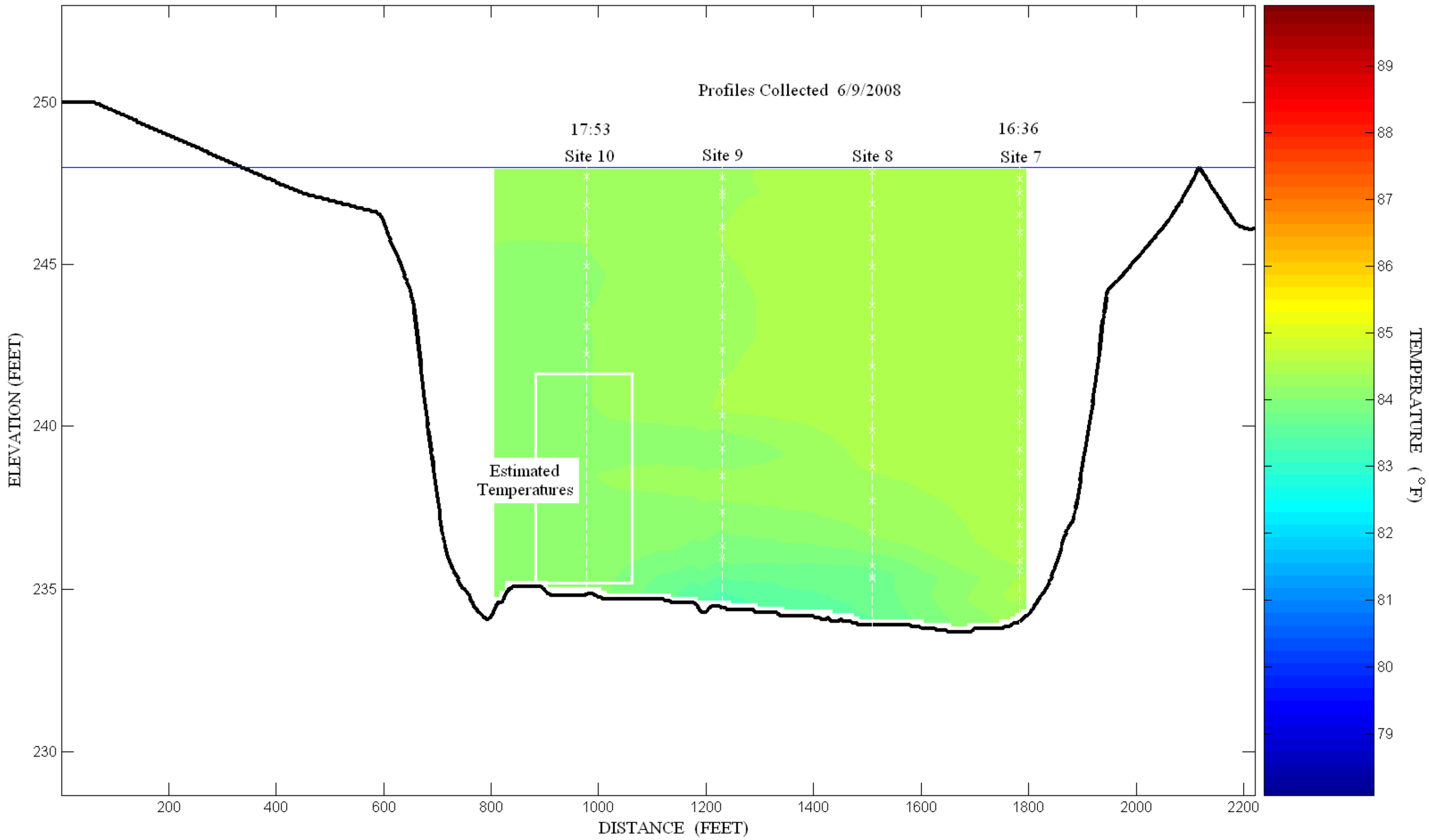


Figure K8 – Temperature Profile Between Site #7 and Site #10 – Gibbons Creek Reservoir – 6/09/2008 1700 HRS. Profile location is depicted in Figure K2, and bathymetry is derived from the 2008 TWDB Volumetric and Sedimentation Survey. Dashed white lines and "X"s indicate sampling locations/depths. Temperatures at depths greater than 6 ft for Site 10 are estimated for display purposes only.

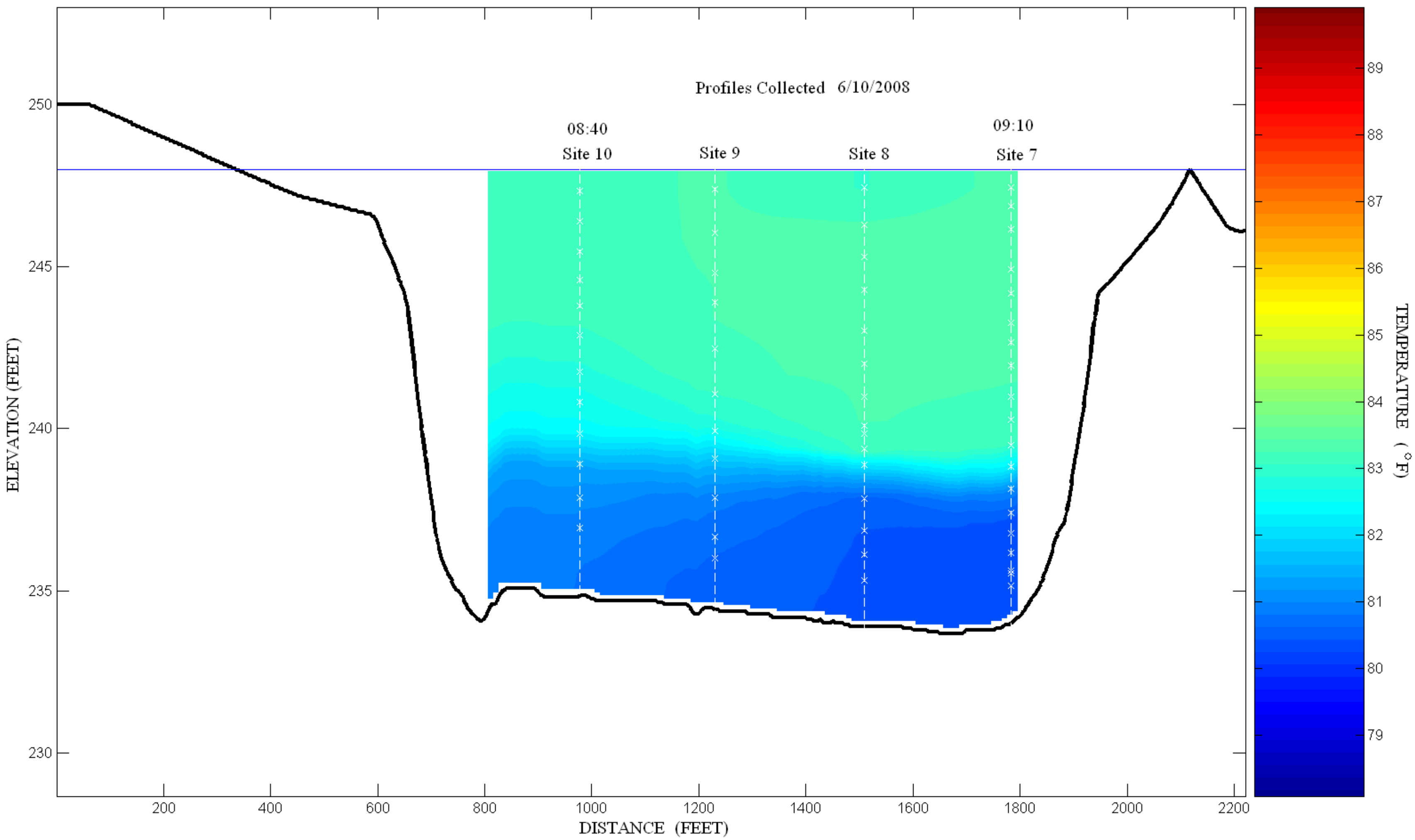


Figure K9 – Temperature Profile Between Site #7 and Site #10 – Gibbons Creek Reservoir – 6/10/2008 0900 HRS. Profile location is depicted in Figure K2, and bathymetry is derived from the 2008 TWDB Volumetric and Sedimentation Survey. Dashed white lines and "X"s indicate sampling locations/depths.

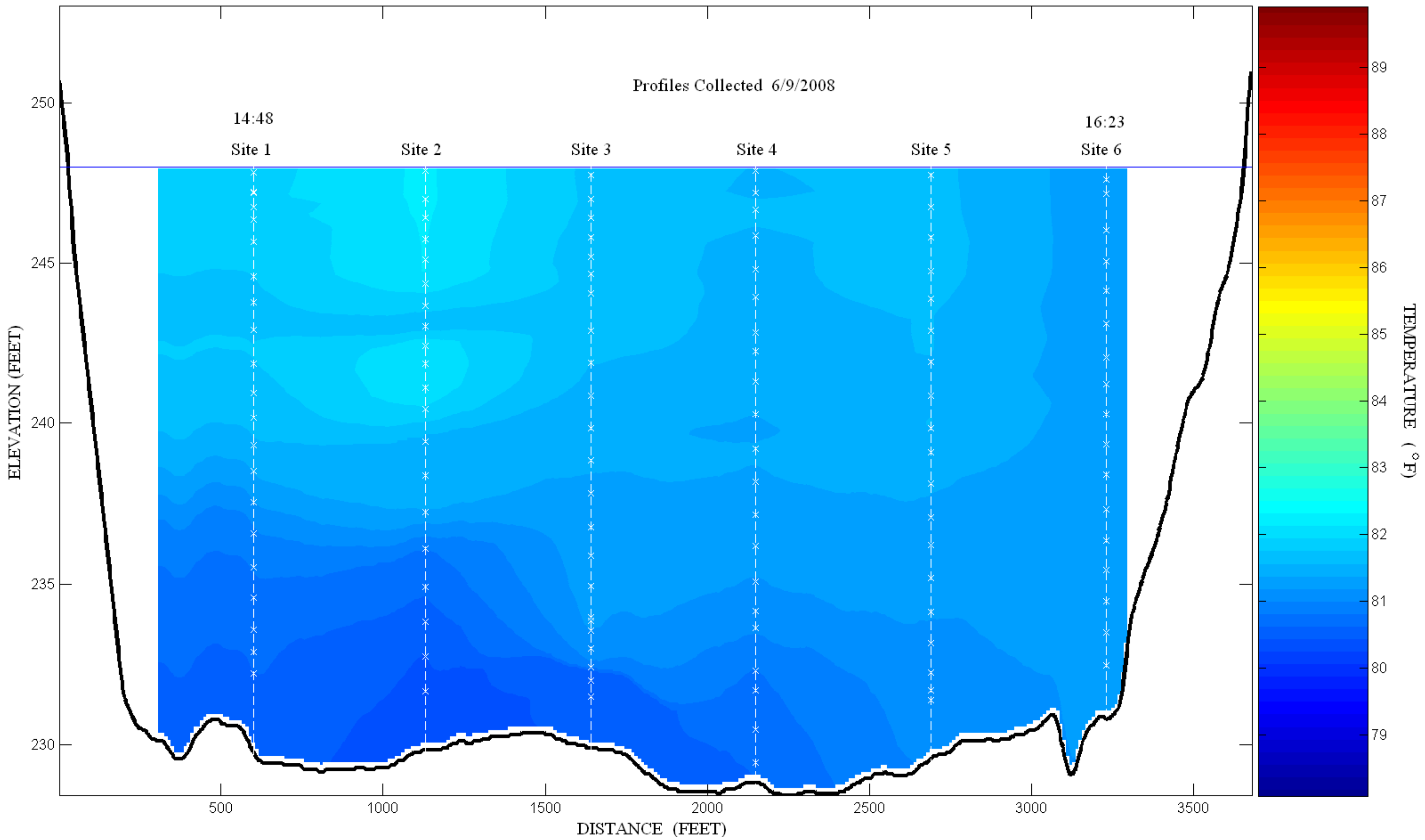


Figure K10 – Temperature Profile Between Site #1 and Site #6 – Gibbons Creek Reservoir – 6/9/2008 1500 HRS. Profile location is depicted in Figure K2, and bathymetry is derived from the 2008 TWDB Volumetric and Sedimentation Survey. Dashed white lines and "X"s indicate sampling locations/depths.

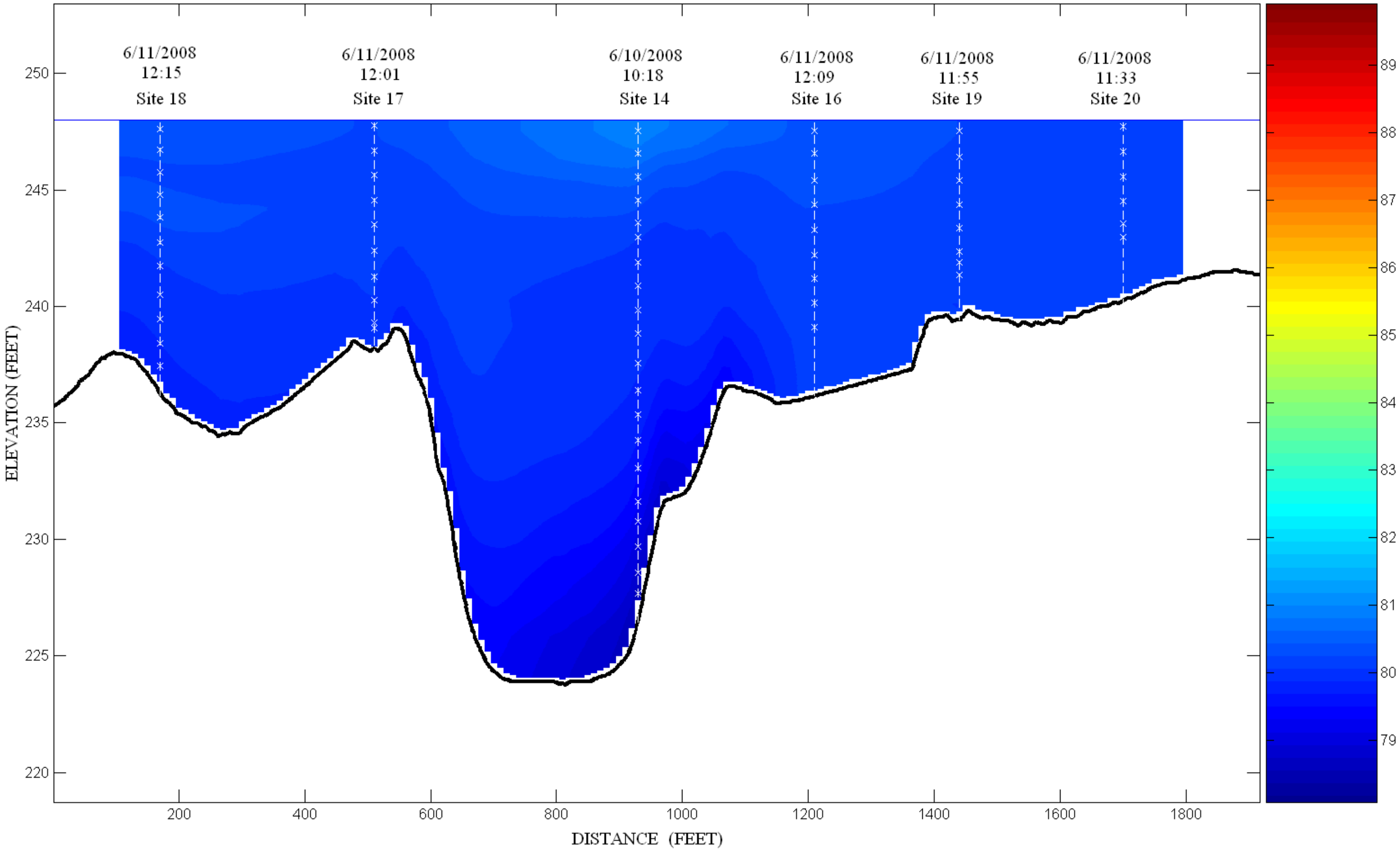


Figure K11 – Temperature Profile Between Site #18 and Site #20 – Gibbons Creek Reservoir – 6/11/2008 1200 HRS. Profile location is depicted in Figure K2, and bathymetry is derived from the 2008 TWDB Volumetric and Sedimentation Survey. Dashed white lines and "X"s indicate sampling locations/depths. Note: data for site 14 was collected on 6/10/2008 at 10:18 AM.

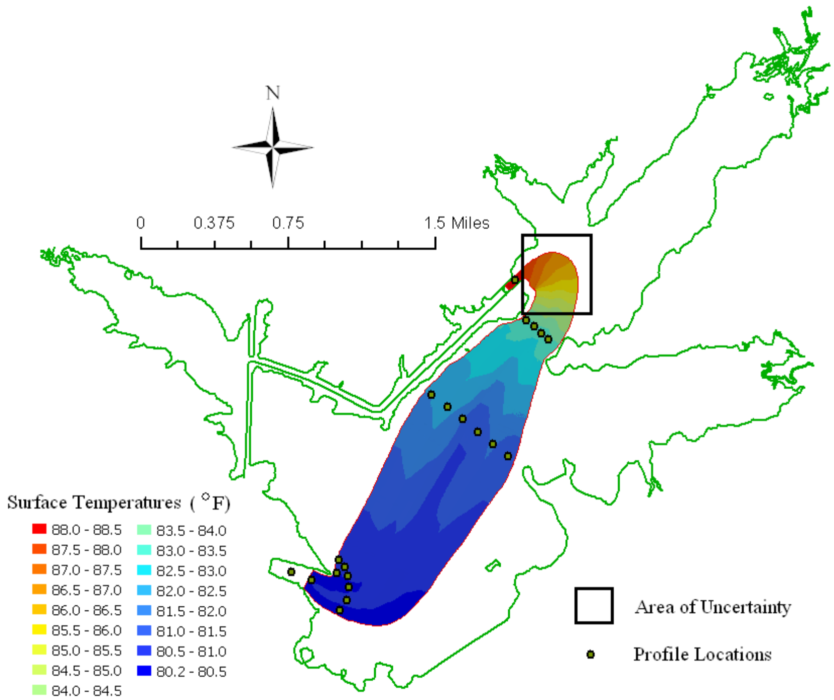


Figure K12 – Approximate surface temperature distribution within Gibbons Creek Reservoir, June 2008. Note: Display colors are different than those shown in Figure K13.

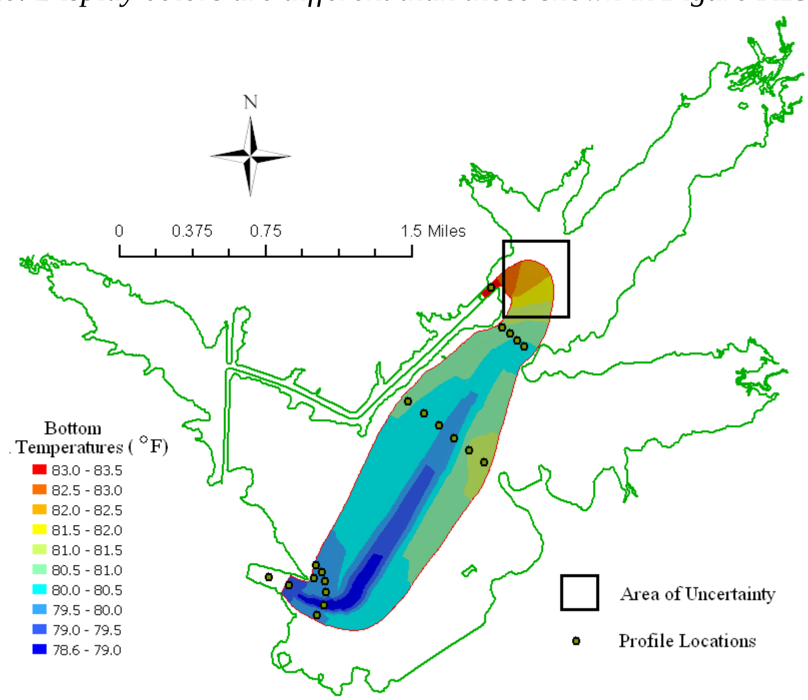


Figure K13 – Approximate bottom temperature distribution within Gibbons Creek Reservoir, June 2008. Note: Display colors are different than those shown in Figure K12.

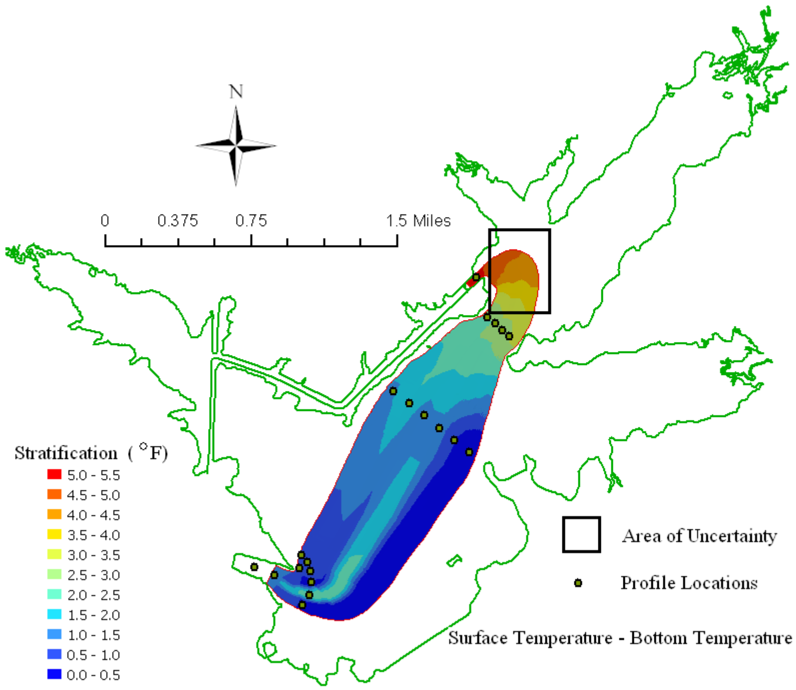


Figure K14 – Approximate temperature stratification map of Gibbons Creek Reservoir, June 2008. Stratification is defined as the surface temperature minus the bottom temperature.

Data Analysis & Summary

Based on the temperature data collected, there exists a thermal gradient between site #11 (near the weir) and site #13 (near the TMPA water intake). For the temperature profiles recorded in the afternoon, the water columns were generally well mixed, showing little stratification with depth. Greater stratification was observed within profiles collected in the morning, as nighttime cooling lowered the surface water temperatures. Stratification is highest at site #11 where discharge water from the TMPA facility mixes with underlying cooler water from the main body of Gibbons Creek Reservoir.

To fully determine the extent of mixing between the TMPA discharged water and the main body of Gibbons Creek Reservoir, greater numbers of sampling sites are necessary. Sites should be located in all portions of the reservoir in addition to those sites sampled and reported herein. In addition, locating automated sampling equipment at select locations may provide useful information as to the temporal fluctuations in temperature throughout the reservoir, either due to variations in TMPA facility discharges or due to diurnal heating/cooling of the water column.

Appendix L

Analysis of Sediment Accumulation Data from Gibbons Creek Reservoir

Executive Summary

The results of the Texas Water Development Board (TWDB) 2008 Sedimentation Survey indicate Gibbons Creek Reservoir has accumulated 938 acre-feet of sediment since impoundment in 1981. Based on this measured sediment volume and assuming a constant rate of sediment accumulation over the 27 years since impoundment, Gibbons Creek Reservoir loses approximately 35 acre-feet of capacity per year. The thickest sediment deposits are located below the weir in the main body of the reservoir. The maximum sediment thickness observed in Gibbons Creek Reservoir was 2.9 feet.

Introduction

This appendix includes the results of the sediment investigation using multi-frequency depth sounder and sediment core data collected by the TWDB. Through careful analysis and interpretation of the multi-frequency signal returns, it is possible to discern the pre-impoundment bathymetric surface, as well as the current surface and sediment thickness. Such interpretations are aided and validated through comparisons with sediment core samples which provide independent measurements of sediment thickness. The remainder of this appendix presents a discussion of the results from and methodology used in the core sampling and multi-frequency data collection efforts, followed by a composite analysis of sediment measured in Gibbons Creek Reservoir.

Data Collection & Processing Methodology

The TWDB conducted the bathymetric data collection for Gibbons Creek Reservoir on March 21-22 and March 24 of 2008. For all data collection efforts, the TWDB used a Specialty Devices, Inc. (SDI), multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, the depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2008 survey, team members collected approximately 35,120 data points over cross-sections totaling nearly 57 miles in length. Figure L1 shows where data points were collected during the TWDB 2008 Gibbons Creek Reservoir survey.

The TWDB collected sediment core samples at five locations throughout Gibbons Creek Reservoir where sounding data had been previously collected (Figure L1). All cores were collected with a custom-coring boat and SDI VibraCore system, and collection occurred on June 10-11, 2008. At each coring location, duplicate core samples were retrieved. Upon collection, one un-processed core sample from each location was provided to the Texas Municipal Power Agency. The TWDB analyzed the remaining core samples to aid in interpreting the multi-frequency acoustic data. The coordinates and a description of each core sample are provided in Table L1. Figure L2 shows the cross-section of sediment core G3-2. At this location, the TWDB collected 25.5 inches of sediment, with the upper sediment layer (Figure L2) having high water content, non cohesive sediment, and lacking organic matter. The pre-impoundment boundary was evident from this core at a distance of 7 inches above the core base, as indicated by the transition from large amounts of plant material and lower moisture content below this location to greatly increased moisture content above this location (Figure L2).

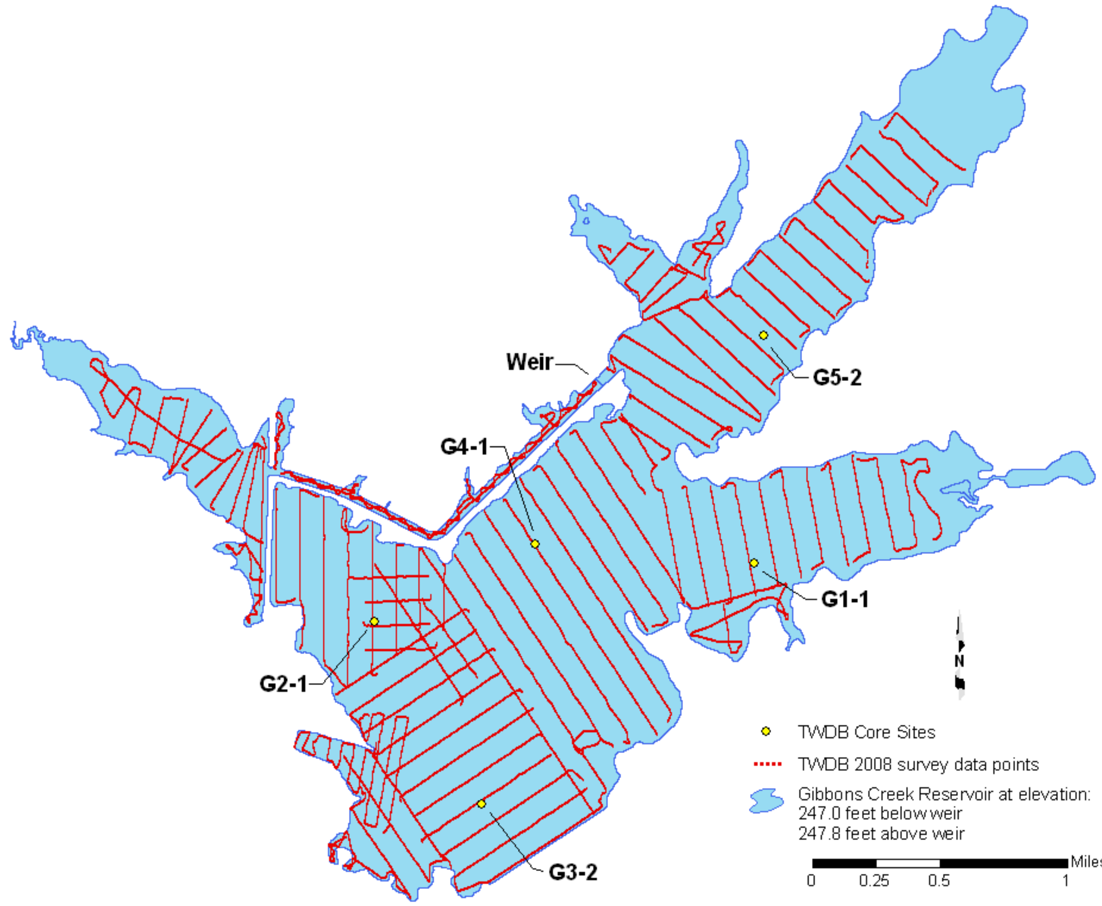


Figure L1 – TWDB 2008 survey data points and core sites for Gibbons Creek Reservoir.

Table L1 – Core Sampling Analysis Data – Gibbons Creek Reservoir

Core	Easting** (ft)	Northing** (ft)	Description
G1-1	3644779.69	10218077.82	2-3" very wet, loose sediment. 30" of sandy sediment with some plant material visible.
G2-1	3636911.84	10216884.89	4-5" very wet, non cohesive sediment. 25" of sandy sediment with some plant material visible.
G3-2	3639120.45	10213096.78	25.5" of gelatinous sediment with no plant material visible
G4-1	3640229.11	10218478.12	25" of very watery sediment with no plant material visible
G5-2	3644972.06	10222807.42	76" of gelatinous sediment with no plant material visible.

** Coordinates are based on NAD83 State Plane Texas Central system

Figure L2 – Sediment Core G3-2 from Gibbons Creek Reservoir, showing the pre-impoundment boundary 7 inches above the base of the core (left). The pre-impoundment boundary is marked by the change in sediment moisture content below and above the area 7 inches up from the core base.

All sounding data are processed using the DepthPic software, within which both the pre-impoundment and current bathymetric surfaces are identified and digitized manually. These surfaces are first identified along cross-sections for which core samples have been collected – thereby allowing the user to identify color bands in the DepthPic display that correspond to the sediment layer(s) observed in the core samples. This process is illustrated in Figure L3 where core sample G3-2 is shown with its corresponding sounding data. Core sample G3-2 contained 25.5 inches of sediment above the pre-impoundment boundary, as indicated by the yellow box in Figure L3. The top of the green box represents the pre-impoundment boundary identified in the core sample in Figure L2. The pre-impoundment surface is usually identified within the core sample by one of the following methods: (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 tend to occur on or just below the pre-impoundment surface, (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials, and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth.

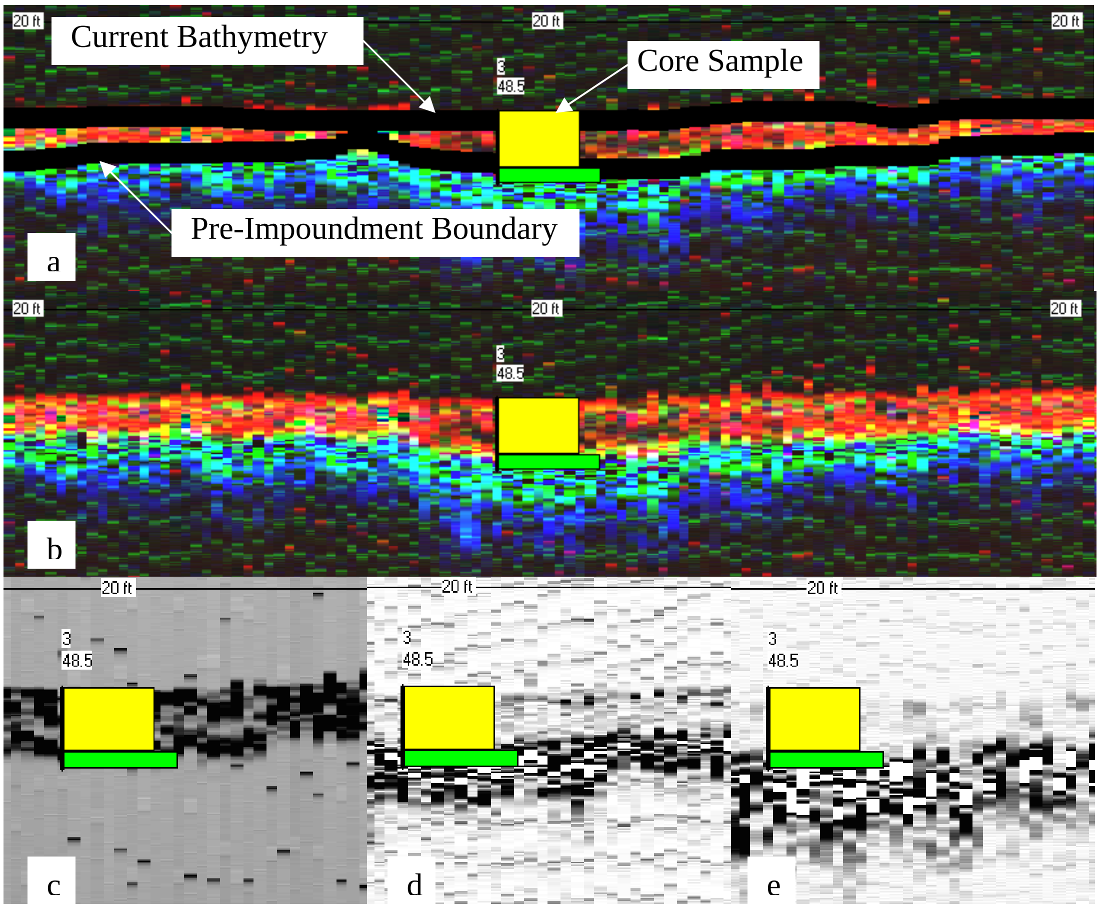


Figure L3 – Correlation of Core G3-2 and co-located acoustic records as viewed in DepthPic. (a) Composite display of 200, 50, and 24 kHz signals showing current bathymetric surface, pre-impoundment surface, and core sample. (b) Composite of three frequencies and core sample without bathymetric surfaces (c) 200 kHz frequency only with core sample (d) 50 kHz frequency (e) 24 kHz frequency. The post-impoundment sediment measured in Core G3-2 correlated well with the 50 and 24 kHz signal returns.

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer. The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample G3-2, it is clear that the sediment layer is bounded by the layers of red and yellow pixels. The pre-impoundment bathymetric surface for this cross-section is therefore identified by the transition to bright blue, green, and turquoise pixels or white and pink pixels in the DepthPic display. The current bathymetric surface is identified as the upper-most layer of red-yellow pixels. (Figure L3).

In analyzing data from cross-sections where core samples were not collected, the assumption is made that sediment layers may be identified in a similar manner as when core sample data is available. To improve the validity of this assumption, core samples are collected at regularly spaced intervals within the lake, or at locations where interpretation of the DepthPic display would be difficult without site-specific core data. For this reason, all sounding data is collected and reviewed before core sites are selected and cores are collected.

After manually digitizing the pre-impoundment surface from all cross-sections, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z-coordinates from DepthPic into text files suitable for use in ArcGIS. Within ArcGIS, the sounding points are then processed into TIN models following standard GIS techniques[1]. The accumulated sediment volume for Gibbons Creek Reservoir was calculated from a sediment thickness TIN model created in ArcGIS. Sediment thicknesses were computed as the difference in elevations between the current and pre-impoundment bathymetric surfaces. Sediment thicknesses were interpolated for locations between surveyed cross-sections using the TWDB Self-Similar Interpolation technique[2]. For the purposes of the TIN model creation, the TWDB assumed 0-feet sediment thicknesses at all the model boundaries (defined as the 251 foot contour extracted from the original TIN model up to elevation 260 feet, the 250 foot hypsographic contour, the 246.1 and 247.5 foot contours digitized from the aerial photography, and the Texas Municipal Power Agency contours – See Main Report section "Model Boundaries").

Results

The results of the TWDB 2008 Sedimentation Survey indicate Gibbons Creek Reservoir has accumulated 938 acre-feet of sediment since impoundment in 1981, with 897 acre-feet of sediment located below the weir and 41 acre-feet of sediment located above the weir. The thickest sediment deposits are located below the weir within the main body of the reservoir. The maximum sediment thickness observed in Gibbons Creek Reservoir was 2.9 feet. Figure L4 depicts the sediment thickness in Gibbons Creek Reservoir.

Based on the measured sediment volume in Gibbons Creek Reservoir and assuming a constant rate of sediment accumulation over the 27 years since impoundment, Gibbons Creek Reservoir loses approximately 35 acre-feet of capacity per year, with approximately 33.5 acre-feet lost per year below the weir and 1.5 acre-feet lost per year above the weir. To improve the sediment accumulation rate estimates, the TWDB recommends Gibbons Creek Reservoir be re-surveyed using similar methods in approximately 10 years or after a major flood event.

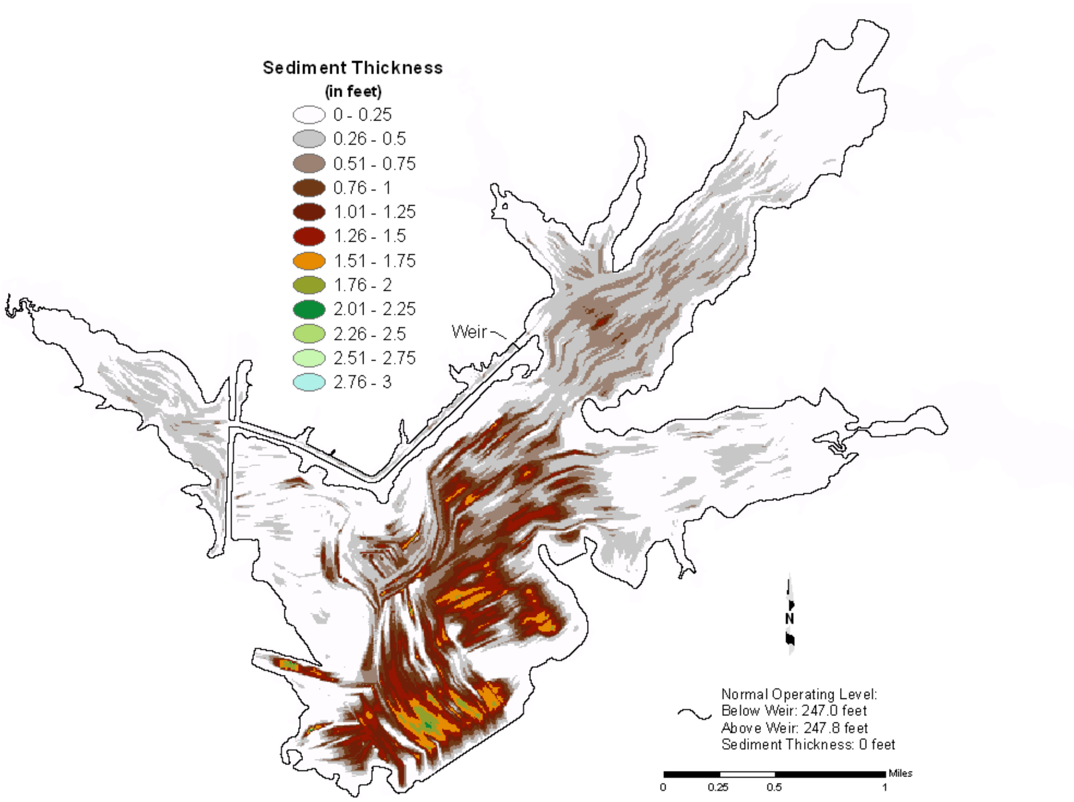


Figure L4 - Sediment thicknesses in Gibbons Creek Reservoir derived from multi-frequency sounding data.

References

1. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011

2. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."

Figure 6

CONTOURS
(in feet)

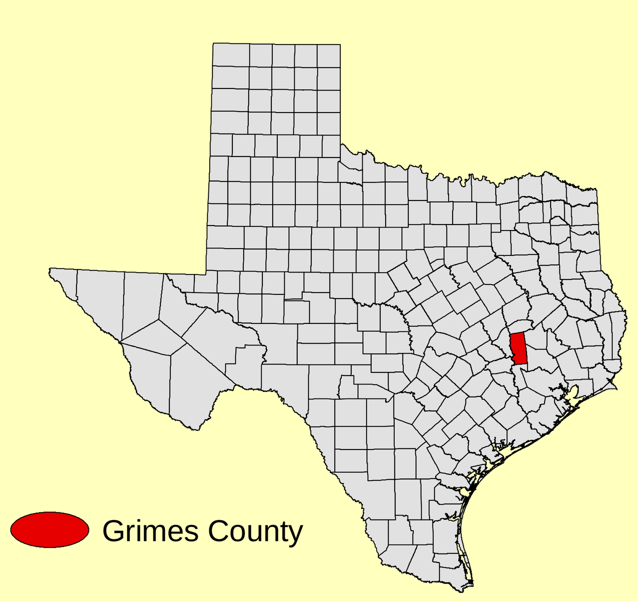
218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250

Gibbons Creek Reservoir at elevation: 251.0 feet

Islands at elevation: 251.0 feet

Normal Operating Level:
247.0 feet below weir
247.8 feet above weir

Projection: NAD83
State Plane
Texas Central Zone



This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Gibbons Creek Reservoir. The Texas Water Development Board makes no representations nor assumes any liability.