RECLAMATION

Managing Water in the West

Lake Waha 2005 Survey

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

March 2006

Lake Waha
2005 Survey

Prepared by

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Lake Waha in 2005 to develop a topographic map and compute a present storage-elevation relationship (area-capacity tables). The underwater survey was conducted on July 13, 2005 between lake elevation 3383.2 and 3383.4 feet (project datum). The underwater survey used sonic depth recording equipment interfaced with a global positioning system (GPS) that gave continuous sounding positions throughout the underwater portions of the reservoir covered by the survey vessel. The above-water survey was conducted on October 18 and 19 of 2005 between lake elevation 3365.4 and 3365.7 feet (project datum). The above water survey used GPS and an autoscan reflectorless total station to measure ground positions from the lake water surface and above. The new topographic map of Lake Waha was developed from the combined above and below water data sets.

The surveys measured a minimum elevation of 3,294.3 feet and lake contours were developed from elevation 3,400 feet and below. All elevations shown in this report are based on the project water surface gage datum that appears tied to the National Geodetic Vertical Datum of 1929 (NGVD29) and 3.4 feet lower than the North American Vertical Datum of 1988 (NAVD88). The upper contour development was limited due to extensive tree growth around the reservoir. As of July 2005, at water surface elevation 3,400.0, the surface area was 91 acres with a total capacity of 5,561 acre-feet.

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INTRODUCTION

Lake Waha, located on Lake Creek, is a natural lake that also serves as offstream storage for the Lewiston Orchards Project. The lake is located about one mile southwest of the village of Waha and about 19 miles southeast of Lewiston, Idaho (figure 1). The natural lake, formed by a landslide, has no outlet. An estimated forty percent of stored water passes through a subsurface stratum into Sweetwater Creek with the remainder pumped 170-feet over a ridge to the West Fork of Sweetwater Creek and diverted into Sweetwater Canal.

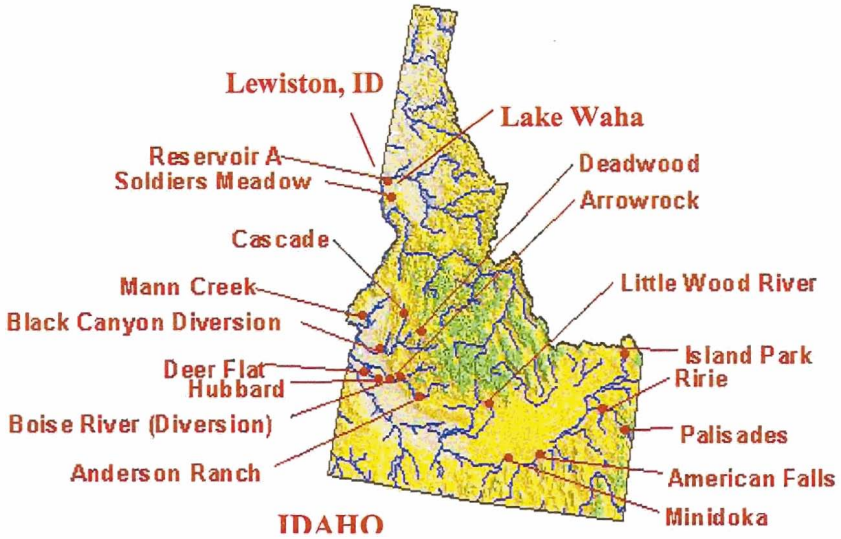

Figure 1 – Lake Waha location map

This Reclamation report presents the 2005 results of the survey of Lake Waha. The primary objectives of the survey were to gather data needed to:

- develop lake topography
- compute area-capacity relationships

A Real-time Kinematic (RTK) GPS control survey was conducted by the bathymetric survey crew to establish a temporary horizontal and vertical control point near the boat ramp (figure 2). The RTK GPS control survey was conducted with base set on the National Geodetic Survey (NGS) datum point "P402." The horizontal control was established in Idaho state plane coordinates, west zone, in the North American Datum of 1983 (NAD83) and the vertical in the North American Vertical Datum of 1988 (NAVD88). The survey determined the Reclamation water surface gage measurements were around 3.4 feet lower than NAVD88. All elevations in this report are referenced to the Reclamation project water surface gage that appears tied to the National Geodetic Vertical Datum of 1929 (NGVD29). Following is the control information for this survey. The survey began with base at "P402," moved to red cap "HS1-63," and then to temporary point "Sed-1" that is located near the boat ramp (figure 3).

Figure 2 - Temporary point near boat ramp, "Sed-1"

Figure 3 - Red cap marker "HS1-63" overlooking Lake Waha

CONTROL SURVEY DATA INFORMATION

NGS control point "P402"

46/20/19.01895 (latitude)
116/53/10.50906 (longitude)
1,570.548 feet[1] (ellipsoid elevation)

The above position information was converted to Idaho state plane coordinates, west zone, using the Corp of Engineer's program Corpscon.

NAD83/NAVD88

1,705,062.46941
2,337,681.30559
1,629.23

NAD27/NGVD29

1,705,084.39505
213,255.21339
1,625.87

Difference NAVD88 – NGVD29 = 3.36 feet

With the GPS base set over NGS point P402, the observation coordinates for the red cap point HS1-63, overlooking Lake Waha, were measured.

Existing Red Cap (on road overlooking Lake Waha) **"HS1-63"**

1,659,132.626 N
2,349,557.350 E
3,585.272

Base Moved to HS1-63

Sed-1, Cap near boat ramp

1658049.670N
2348440.530E
3392.347

[1]Elevation in feet. All elevations shown in this report are based on the project water surface gage datum that appears tied to the National Geodetic Vertical Datum of 1929 (NGVD29) and 3.4 feet lower than the North American Vertical Datum of 1988 (NAVD88).

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

The hydrographic survey equipment was mounted in a large aluminum vessel, with outboard motor, supplied by the Snake River Area Office. The hydrographic system included a GPS receiver with a built-in radio, a depth sounder, a helmsman display for navigation, a computer, and hydrographic system software for collecting the underwater data. The shore equipment included a second GPS receiver with an external radio. The GPS receiver and antenna were mounted on a survey tripod over the known datum point "Sed-1" located near the boat ramp. Batteries supplied power to all the equipment.

The Sedimentation and River Hydraulics Group uses RTK GPS with the major benefit being precise heights measured in real time to monitor water surface elevation changes. The basic outputs from RTK receiver are precise 3D coordinates in latitude, longitude, and height with accuracies on the order of two centimeters horizontally and three centimeters vertically. The output is on the GPS datum of WGS-84 that the hydrographic collection software converted into Idaho's NAD83 state plane west zone coordinates. The RTK GPS system employs two receivers that track the same satellites simultaneously just like with differential GPS.

Lake Waha hydrographic survey was conducted on July 13, 2006 between water surface elevation 3,383.2 and 3.383.4 (Reclamation hourly gage readings). The bathymetric survey was run using sonic depth recording equipment, interfaced with RTK GPS, capable of determining sounding locations within the lake. The survey system software continuously recorded lake depths and horizontal coordinates as the survey boat moved across closely spaced grid lines covering the lake area. Most of the transects (grid lines) were run in a east-west alignment on the lake at around 100-foot spacing. Data was also collected along the shore as the boat traversed between transects. The survey vessel's guidance system gave directions to the boat operator to assist in maintaining the course along these predetermined lines. During each run, the depth and position data were recorded on the notebook computer hard drive for subsequent processing. The collection was affected at times by problems with GPS geometry and vessel motor problems. Due to the vessel outboard problems, data was collected with the boat in motion most of the time affecting shallow water collection. This was not a major factor since above water data was collected after underwater collection when the lake elevation was eighteen feet lower.

During processing, all GPS data with bad geometry was removed. This left some gaps in the data set, but did not appear to have a major impact on contour development and volume computations. Figure 4 is a plot of the above and below water data sets. Calibration of the depth sounder was obtained by dropping a velocity probe in the lake and obtaining speed of sound reading every foot from one foot below the water surface to the bottom of the lake. The depth sounder velocity was set at 4,800 feet per second and the corrections were applied during processing. The GPS base was set over the temporary point "Sed-1" for the underwater collection with elevations tied to NAVD88. RTK GPS water surface measurements, during the collection, were compared to hourly gage readings and found to have a difference of around 3.4 feet. All collected data results for this study were tied to the gage readings by lowering the NAVD88 elevation data 3.4 feet.

The above water data was collected on October 18 and 19 of 2005 between water surface elevation 3,365.4 and 3,365.7. The ground survey crew used an autoscan reflectorless total station that scanned out to 1,600 feet. The instrument was set at different locations and overlapping data was obtained for redundancy checking during analysis. RTK GPS data was collected along the shore and was used to further check the scanner data set. During analysis, the data was adjusted in 200-foot increments relative to the setup points. To remove the tree and brush shots, a TIN model was developed in AutoCAD and edited as an ASCII data file of actual ground elevation points. The elevations were collected in NAVD88 and were reduced by 3.4 feet during analysis to match the project vertical datum. The positions of the above water data are plotted on figure 5.

RESERVOIR AREA AND CAPACITY

Topography Development

The 2005 Lake Waha map is a combination of the above and below water survey data. A computer graphics program, using the 2005 collected reservoir data, generated the lake surface areas at one-foot contour intervals. The 2005 area and capacity tables were produced by a computer program that uses measured contour surface areas and a curve-fitting technique to compute area and capacity at prescribed elevation increments (Bureau of Reclamation, 2005).

The mapping was completed using ArcGIS software (ESRI, 2005). The surveyed points developed a triangular irregular network (TIN) of Lake Waha such that interpolation was not allowed to occur outside a hardclip polygon that enclosed the data. A TIN is a set of adjacent non-overlapping triangles computed from irregularly spaced points with x,y coordinates and z values. TIN was designed to deal with continuous data such as elevations. The TIN software uses a method known as Delaunay's criteria for triangulation where triangles are formed among all data points within the polygon clip. The method requires that a circle drawn through the three nodes of a triangle will contain no other point, meaning that sample points are connected to their nearest neighbors to form triangles using all collected data. This method preserves all collected survey points. Contours for the lake below elevation 3,400.0 were developed from the underwater data set using the TIN surface-modeling package within ARCGIS. The upper contour, elevation 3,400.0, was limited due to the tree and ground vegetation that surrounded the reservoir, figures 6 and 7. The contour topography at 5-foot intervals is presented on figure 8.

Development of 2005 Contour Areas

The 2005 contour surface areas for Lake Waha were computed at 2- and 5-foot increments from elevation 3,295.0 to 3,400.0. The 2005 underwater survey measured a minimum reservoir bottom elevation of 3,294.3. These calculations were performed using the ARC surface area and volume command. This command computes areas at user-specified elevations directly from the TIN and takes into consideration all regions of equal elevation.

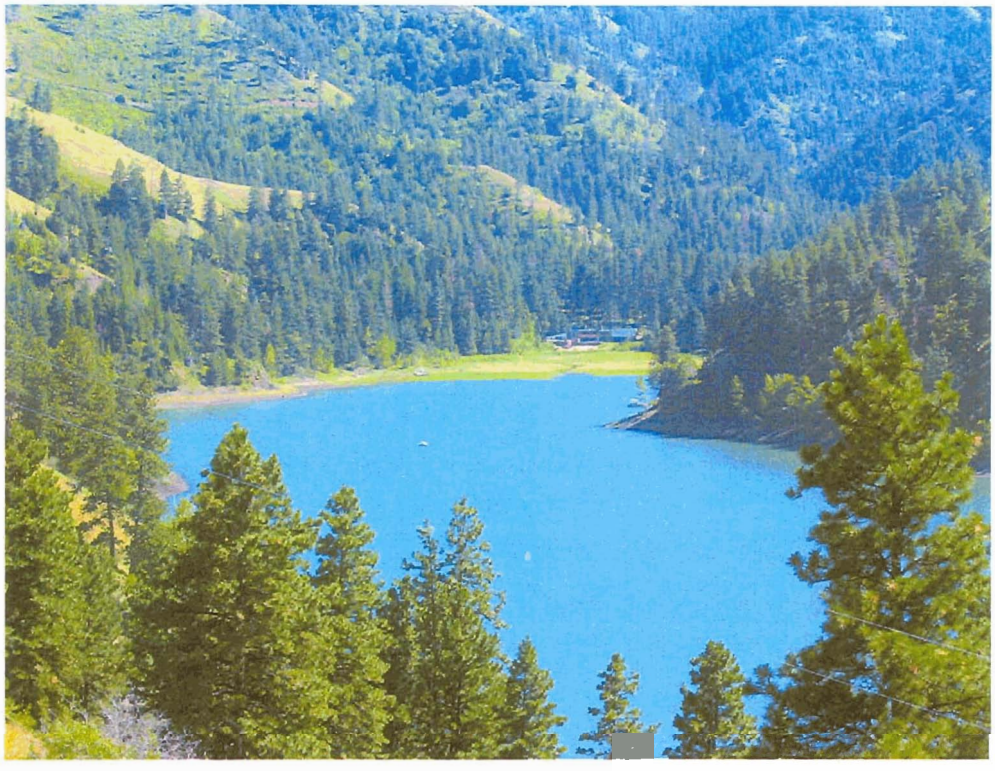

Figure 6 – Upper Lake Waha view from road

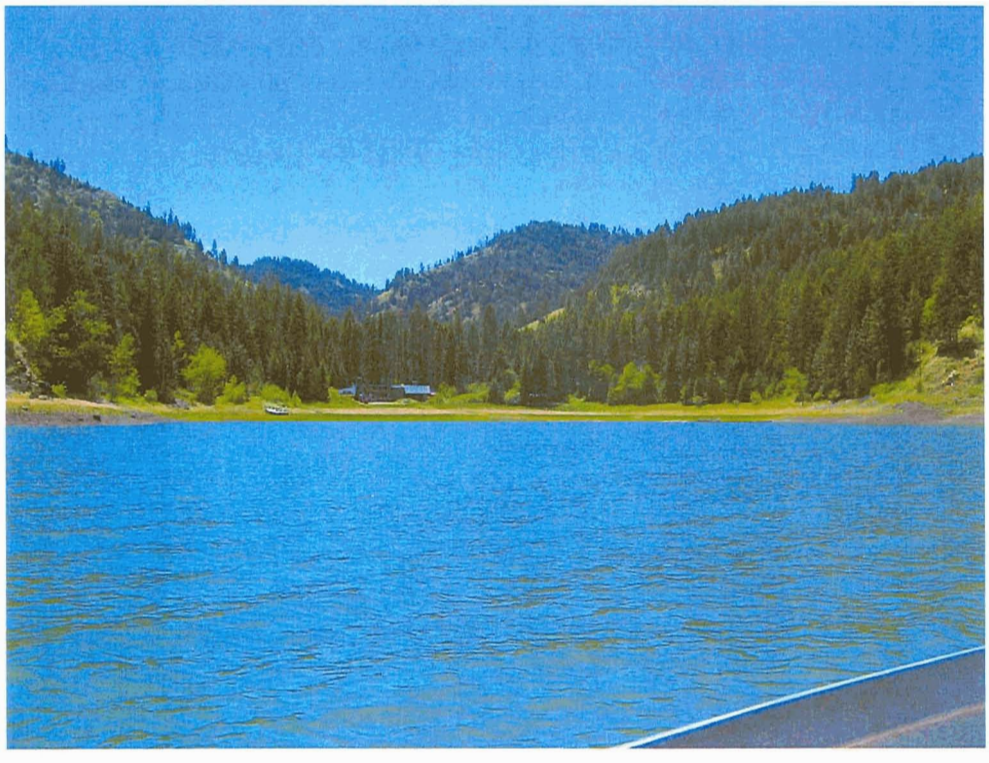

Figure 7 – Upper Lake Waha view from survey vessel

2005 Storage Capacity

The storage-elevation relationships based on the measured surface areas were developed using the area-capacity computer program ACAP85 (Bureau of Reclamation, 1985). The 2005 surveyed surface areas at 2- and 5-foot contour intervals from reservoir elevation 3,295.0 to elevation 3,400.0 were used as the control parameters for computing the 2005 Lake Waha capacity.

The ACAP85 program can compute an area and capacity at elevation increments 0.01- to 1.0-foot by linear interpolation between the given contour surface areas. The program begins by testing the initial capacity equation over successive intervals to ensure that the equation fits within an allowable error limit. The error limit was set at 0.000001 for Lake Waha. The capacity equation is then used over the full range of intervals fitting within this allowable error limit. For the first interval at which the initial allowable error limit is exceeded, a new capacity equation (integrated from a basic area curve over that interval) is utilized until it exceeds the error limit. Thus, the capacity curve is defined by a series of curves, each fitting a certain region of data. By differentiating the capacity equations, which are of second order polynomial form, the final area equations are derived:

$$y = a_1 + a_2x + a_3x^2$$

where:

y = capacity
x = elevation above a reference base
a_1 = intercept
a_2 and a_3 = coefficients

Results of the Lake Waha area and capacity computations are listed in table 1. A separate set of 2005 area and capacity tables has been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation, July 2005). A description of the computations and coefficients output from the ACAP85 program is included with these tables. The 2005 area-capacity curves are also plotted on figure 9. As of July 2005, at elevation 3,400.0, the surface area was 90.6 acres with a total capacity of 5,561 acre-feet.

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Lake Waha
2005 Survey Summary

Elevations (feet)	2005.0 Surface Area (acres)	2005 Capacity (acre-feet)	Percent of Reservoir Depth
3400	90.6	5561	100.0
3398	89.0	5381	98.1
3396	87.3	5205	96.2
3395	86.4	5118	95.3
3394	85.5	5032	94.3
3392	83.8	4863	92.4
3390	82.2	4697	90.5
3388	80.8	4534	88.6
3386	79.3	4373	86.8
3385	78.6	4294	85.8
3384	77.9	4216	84.9
3382	76.6	4062	83.0
3380	75.3	3910	81.1
3378	73.8	3761	79.2
3376	72.5	3614	77.3
3375	71.9	3542	76.3
3374	71.4	3471	75.4
3372	70.3	3329	73.5
3370	69.2	3189	71.6
3368	68.2	3052	69.7
3366	67.1	2917	67.8
3365	66.6	2850	66.9
3364	66.1	2783	65.9
3362	65.1	2652	64.0
3360	64.1	2523	62.2
3358	63.1	2396	60.3
3356	62.2	2271	58.4
3355	61.7	2209	57.4
3354	61.2	2147	56.5
3352	60.1	2026	54.6
3350	59.1	1907	52.7
3348	58.0	1790	50.8
3346	56.8	1675	48.9
3345	56.3	1618	48.0
3344	55.7	1562	47.0
3342	54.5	1452	45.1
3340	53.2	1344	43.2

Table 1 - Summary of 2005 survey results.

Lake Waha
2005 Survey Summary (Continued)

Elevations	2005.0 Surface Area	2005 Capacity	Percent of Reservoir
(feet)	(acres)	(acre-feet)	Depth
3338	51.6	1239	41.3
3336	50.1	1138	39.5
3335	49.2	1088	38.5
3334	48.3	1039	37.6
3332	46.6	944	35.7
3330	44.5	853	33.8
3328	42.3	767	31.9
3326	40.8	684	30.0
3325	40.1	643	29.0
3324	39.5	603	28.1
3322	38.0	526	26.2
3320	36.3	451	24.3
3318	34.5	381	22.4
3316	32.3	314	20.5
3315	31.1	282	19.6
3314	29.8	252	18.6
3312	26.6	195	16.7
3310	22.3	146	14.9
3308	17.9	106	13.0
3306	13.6	75	11.1
3305	11.9	62	10.1
3304	10.4	51	9.2
3302	7.8	33	7.3
3300	5.9	19	5.4
3298	4.1	9	3.5
3296	2.4	2	1.6
3295	1.0	1	0.7
3294.3	0.0	0	0.0

Table 1 (Continued) - Summary of 2005 survey results.

Horizontal datum based on Idaho's State Plane Coordinate System, West Zone. (NAD83).

Vertical datum based on water surface project datum established by U.S. Bureau of Reclamation in NGVD29, 3.4 feet less than NAVD83.

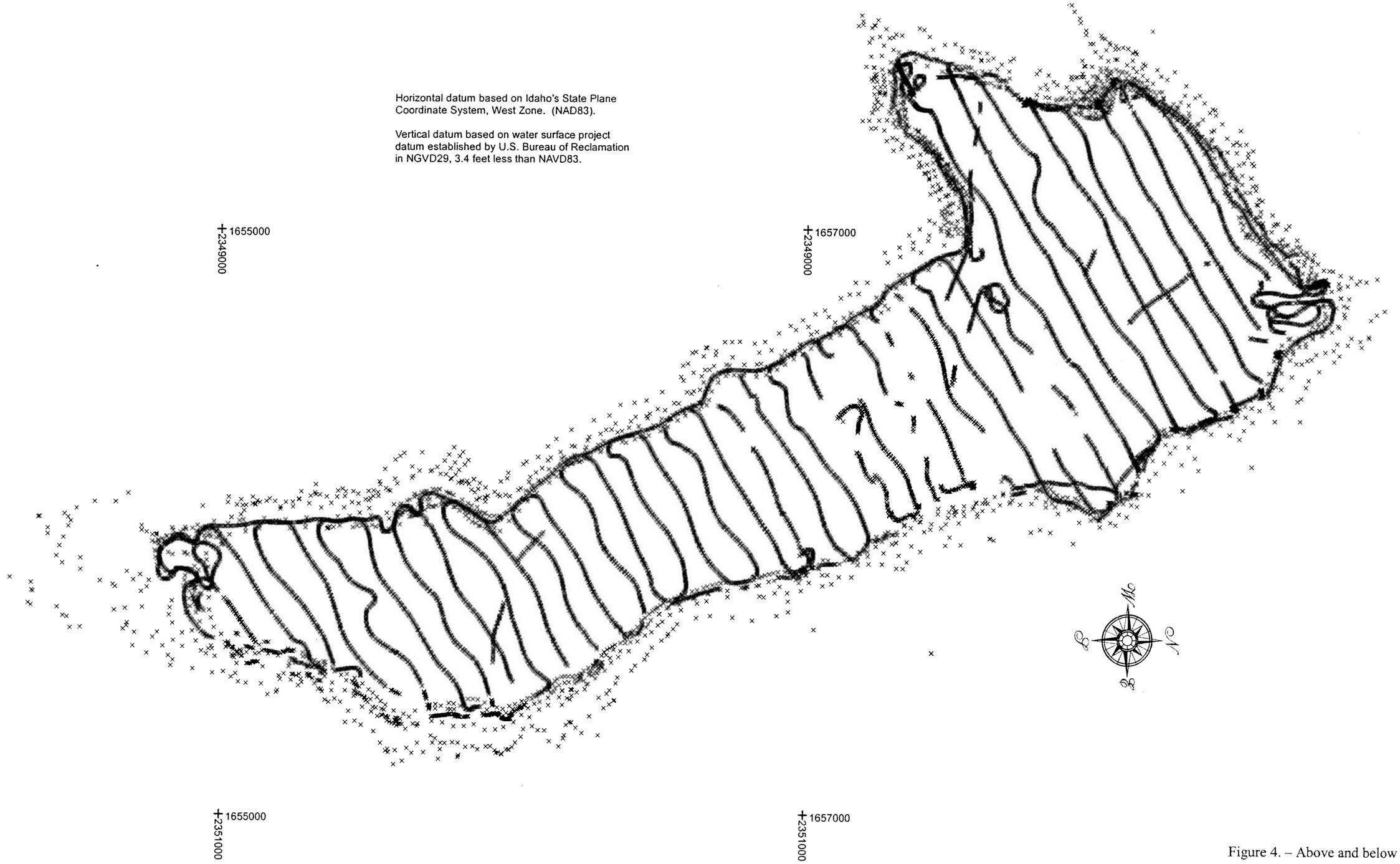

Figure 4. – Above and below water data

Horizontal datum based on Idaho's State Plane Coordinate System, West Zone. (NAD83).

Vertical datum based on water surface project datum established by U.S. Bureau of Reclamation in NGVD29, 3.4 feet less than NAVD83.

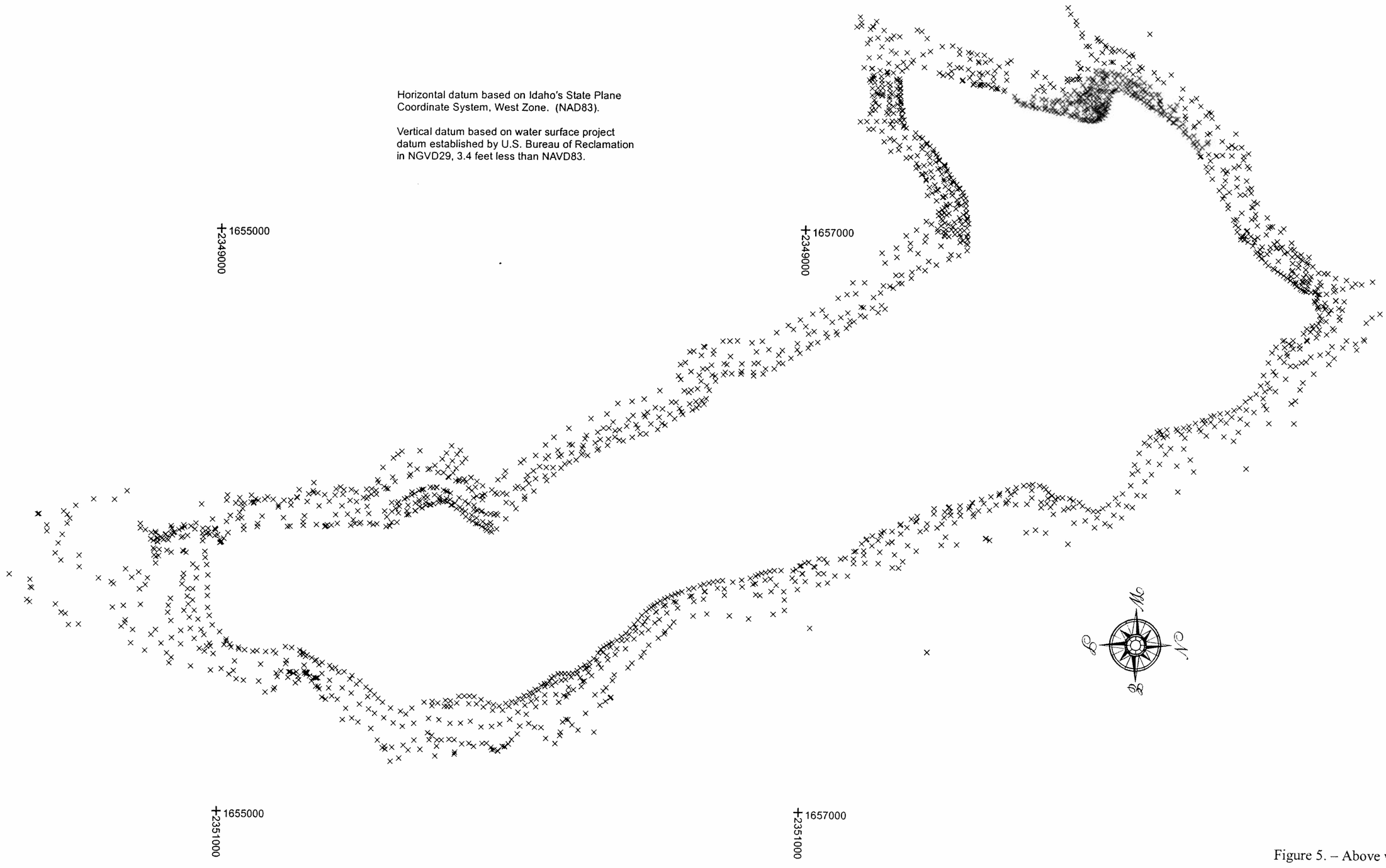

Figure 5. – Above water data set

Horizontal datum based on Idaho's State Plane Coordinate System, West Zone. (NAD83).

Vertical datum based on water surface project datum established by U.S. Bureau of Reclamation in NGVD29, 3.4 feet less than NAVD83.

5-foot contour interval

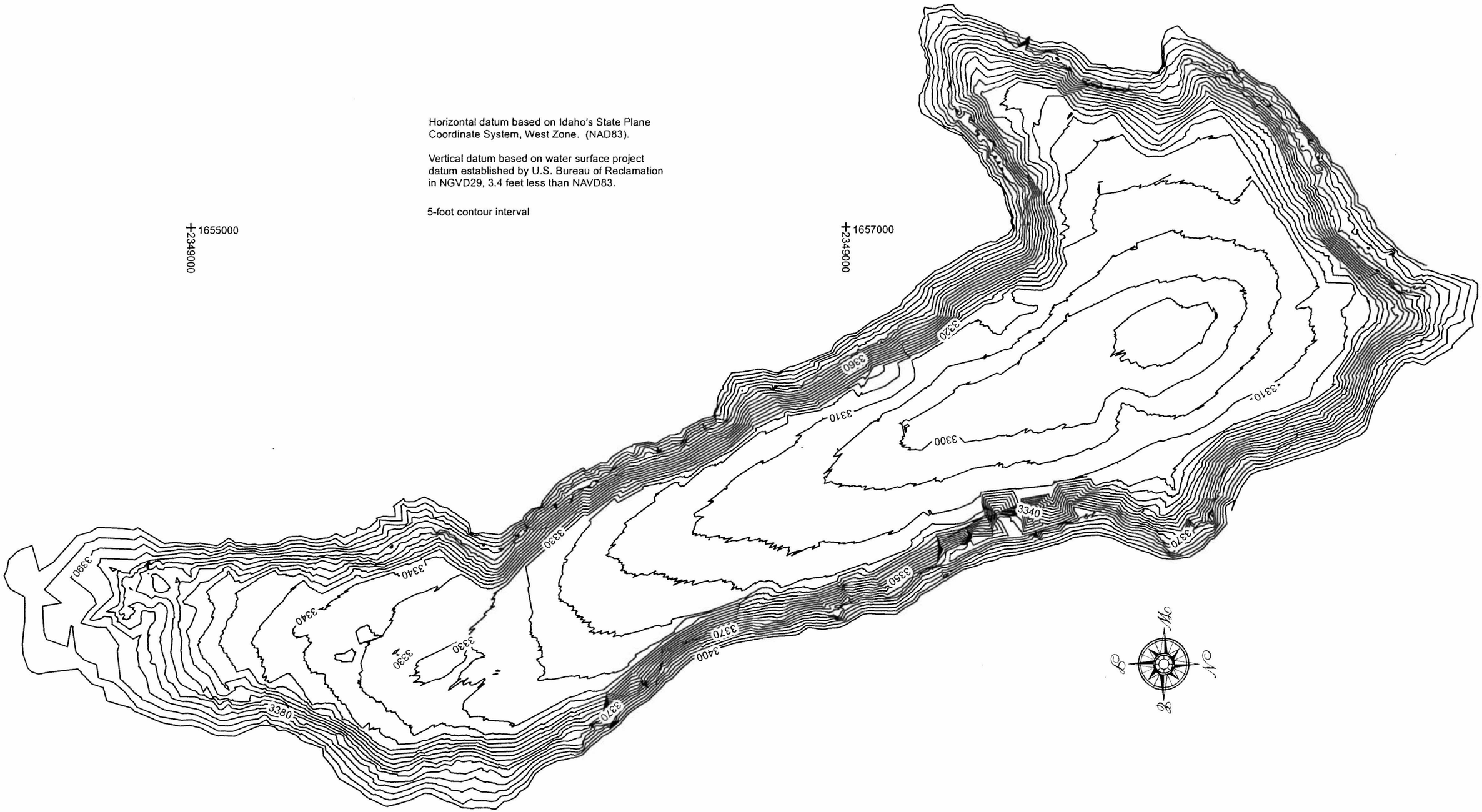

Figure 8. – Lake Waha topographic map

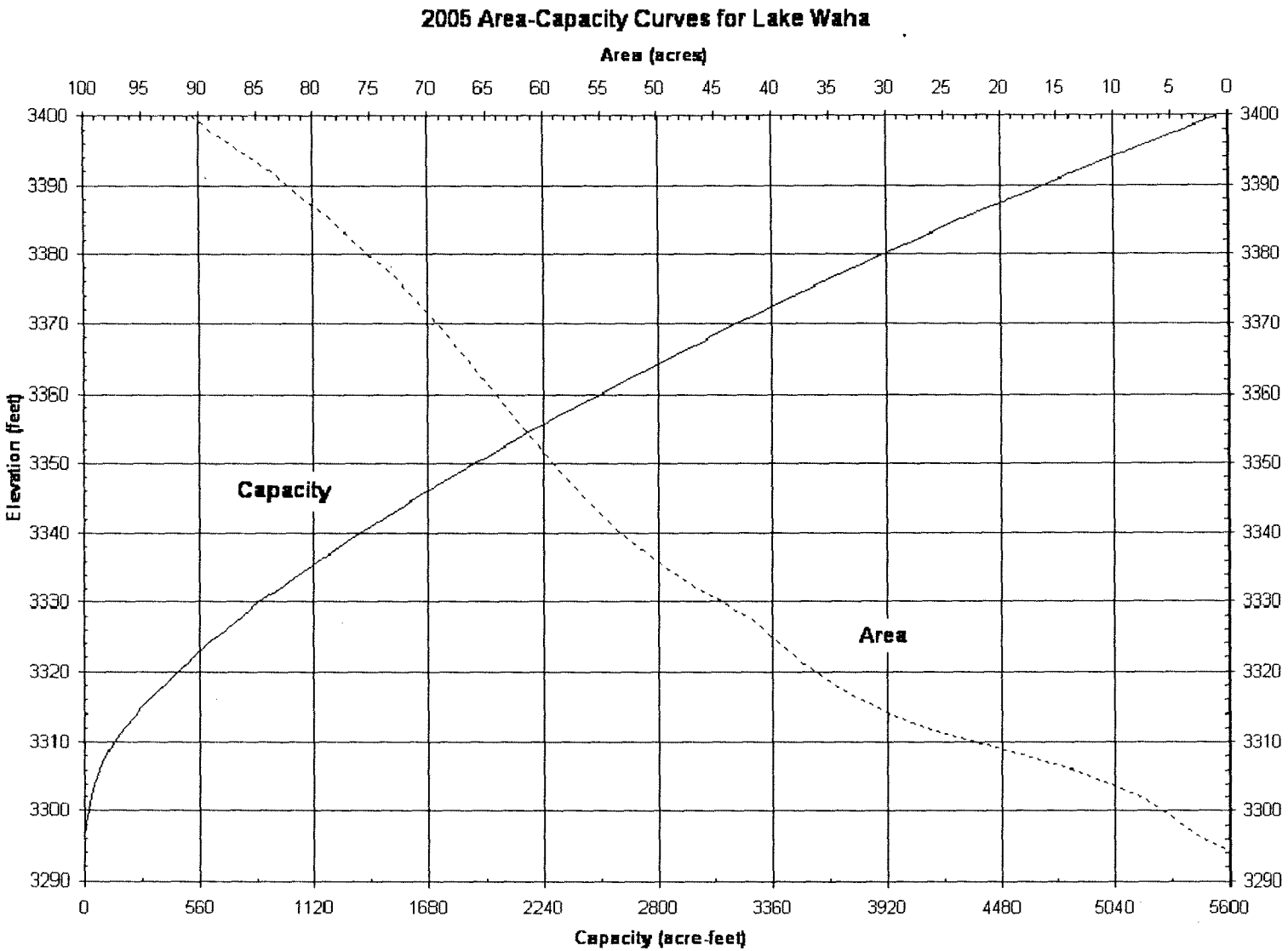

Figure 9 – Lake Waha Area and Capacity Curves