ANDERSON RANCH RESERVOIR
1998 SEDIMENTATION SURVEY

U.S. Department of the Interior
Bureau of Reclamation

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Anderson Ranch Reservoir in 1998 to develop a topographic map and compute a present storage-elevation relationship (area-capacity tables). The data were used to calculate reservoir capacity lost due to sediment accumulation since dam closure in 1945. The June 1998 underwater survey was conducted near reservoir elevation 4196 feet. The November 1998 aerial data was collected near reservoir elevation 4178 feet. The underwater survey used sonic depth recording equipment interfaced with a global positioning system (GPS) that gave continuous sounding positions throughout the underwater portion of the reservoir. The new topographic map of Anderson Ranch Reservoir was developed from the combined 1998 aerial and underwater measured topography.

As of June 1998, at top of controllable capacity elevation (feet) 4196.0, the surface area was 4,743 acres with a total capacity of 474,942 acre-feet. Since initial filling in December 1945, about 18,236 acre-feet of sediment have accumulated in Anderson Ranch Reservoir below elevation 4,196.0, resulting in a 3.70 percent loss in reservoir volume. Since December 1945, the estimated average annual rate of reservoir capacity lost to sediment accumulation is 346.7 acre-feet.

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1998 SEDIMENTATION SURVEY

by

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Denver, Colorado

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The Bureau of Reclamation's (Reclamation) Sedimentation and River Hydraulics Group of the Technical Service Center (TSC) prepared and published this report. Ronald Ferrari of TSC conducted the hydrographic survey with assistance from Mr. Charlie (Pete) Swan of the Pacific Northwest Region. The aerial data collection and analysis were conducted by Horizons, Inc. in Rapid City, South Dakota. Ronald Ferrari completed the data processing needed to generate the new topographic map and area-capacity tables. Sharon Nuanes of the TSC completed the final map development. Kent Collins of TSC performed the technical peer review of this documentation.

U.S. Department of the Interior
Mission Statement

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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INTRODUCTION

Anderson Ranch Dam, one of six principal features of the Boise Project, is located in Elmore County about 28 miles northeast of Mountain Home, Idaho on the South Fork of the Boise River (fig. 1). Additional principal features are Arrowrock Dam, Black Canyon Dam, Boise River Diversion Dam, Cascade Dam, and Deadwood Dam. Anderson Ranch Dam is the uppermost storage facility on the Boise system and is 42 miles upstream from Arrowrock Dam. Lucky Peak Dam, built by the Corps of Engineers, is located about 1 mile upstream from the Boise River Diversion Dam and backs water up to Arrowrock Dam. Anderson Ranch Dam and Reservoir are owned and operated by Reclamation and provide benefits in irrigation, power, and flood and silt control.

Anderson Ranch Dam was construction between 1941 through 1950 with first storage on December 15, 1945. A 3-foot parapet wall was added to the top of the dam to provide additional protection from waves splashing over the top when the reservoir is at or near maximum capacity, elevation (feet)[1] 4198.2. The dam is a rolled earth and rockfill structure whose dimensions are (fig. 2):

• Hydraulic height[2]	332 feet	• Structural height	456 feet
• Top width	40 feet	• Crest length	1,350 feet
• Crest elevation	4,206.0 feet	• Top of parapet wall	4,209.0 feet

The drainage area above Anderson Ranch Dam is 980 square miles, ranging from elevation 3,992.0, outlet sill elevation, to about 10,000 feet. Anderson Ranch Reservoir has an average width of 0.4 miles with a length, at elevation 3996.0, of around 19.3 miles that includes the main arm and lengths of all tributaries.

The Anderson Ranch Dam's spillway consists of a concrete-lined chute in the left abutment with two radial gates each 25 by 22 feet in size. The spillway crest is at elevation 4,174.0. The spillway gates provide controllable water storage to elevation 4196.0. The spillway provides a maximum discharge of 20,000 cubic feet per second (cfs) at maximum reservoir water surface elevation 4,198.2.

The outlet works, with an inlet elevation of 3,992.0, consists of a 20-foot-diameter concrete-lined tunnel in the left abutment with penstocks in the powerhouse and five 72-inch hollow-jet outlet valves. The outlet has a discharge capacity of 10,000 cfs.

The powerplant, located to the right of the spillway, consists of three 90-inch steel penstocks from the outlet pipes. The discharge capacity is 10,000 cfs at elevation 4,198.0. The powerplant has a current rated capacity of 40,000 kilowatts with the two installed generators.

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[1]Elevation levels are shown in feet.

[2]The definition of such terms as "hydraulic height," "structural height," etc. may be found in manuals such as Reclamation's *Design of Small Dams* and *Guide for Preparation of Standing Operating Procedures for Dams and Reservoirs*, or ASCE's *Nomenclature for Hydraulics*.

SUMMARY AND CONCLUSIONS

This Reclamation report presents the 1998 results of the survey of Anderson Ranch Reservoir. The primary objectives of the survey were to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships
- estimate storage depletion caused by sediment deposition since dam closure

Standard land surveying methods were used to establish the horizontal and vertical control points for the underwater and aerial surveys that were conducted in 1998. The aerial survey was flown in November of 1998 around reservoir water surface elevation 4178 and the underwater survey was conducted in June 1998 around reservoir water surface elevation 4196. The bathymetric survey was run using sonic depth recording equipment interfaced with a differential global positioning system (DGPS) capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates of the survey boat, as it was navigated along grid lines covering Anderson Ranch Reservoir. The positioning system provided information to allow the boat operator to maintain a course along these grid lines. Water surface elevations recorded by a Reclamation gauge during the time of collection were used to convert the sonic depth measurements to true reservoir bottom elevations.

The new Anderson Ranch Reservoir topographic maps are a combination of the aerial and underwater survey data. The 1998 reservoir surface areas at predetermined contour intervals were generated by a computer graphics program using the collected reservoir data. The 1998 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, 1985).

Tables 1 and 2 contain a summary of the Anderson Ranch Reservoir sedimentation and watershed characteristics for the 1998 survey. The 1998 survey determined that the reservoir has a total storage capacity of 474,942 acre-feet and a surface area of 4,743 acres at reservoir elevation 4,196.0. Since closure on December 15, 1945, the reservoir had an estimated volume change of 18,236 acre-feet below reservoir elevation 4,196.0. This volume represents a 3.70 percent loss in total capacity and an average annual loss of 346.7 acre-feet per year.

RESERVOIR OPERATIONS

Anderson Ranch Dam is a multiple-purpose structure that provides irrigation and power benefits, but also operates in conjunction with Arrowrock and Lucky Peak Reservoirs to provide downstream flood control. The June 1998 area-capacity tables show 474,942 acre-feet of total storage below elevation 4,196.0. The 1998 survey measured a minimum elevation of 3886.6. The following values are from the June 1998 area-capacity tables:

- 10,502 acre-feet of surcharge storage between elevation 4,196.0 and 4,198.2.
- 408,442 acre-feet of joint use storage between elevation 4,044.0 and 4,196.0.
- 4,632 acre-feet of conservation storage between elevation 4,039.6 and 4,044.0.
- 36,956 acre-feet of inactive storage between elevation 3,992.0 and 4,039.6.
- 24,912 acre-feet of dead storage below elevation 3,992.0.

The Anderson Ranch Reservoir inflow and end-of-month stage records in table 1, operation period December 1945 through June 1998, show the inflow and annual fluctuation since dam closure. The estimated average inflow into the reservoir for this operation period was 752,160 acre-feet per year. Since initial filling, the extreme storage fluctuations of Anderson Ranch Reservoir ranged from an elevation of 4,007.0 on March 10, 1993 to the maximum recorded elevation of 4,197.98 on June 11, 1983. The records show that in most years the reservoir fills to the near-full reservoir elevation and annually, while releasing irrigation and power supply water downstream, drops 50 or more feet in elevation.

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

The hydrographic survey equipment was mounted in the cabin of a 24-foot trihull aluminum vessel equipped with twin in-board motors. The hydrographic system contained on the survey vessel consisted of a global positioning system (GPS) receiver with a built-in radio and an omnidirectional antenna, a depth sounder, a helmsman display for navigation, a plotter, a computer, and hydrographic system software for collecting underwater data. Power to the equipment was supplied by an on-board generator.

The shore equipment included a second GPS receiver with a built-in radio and an omnidirectional antenna. The GPS receiver and antenna were mounted on a survey tripod over a known datum point. To obtain the maximum radio transmission range, known datum points with clear line-of-sight to the survey boat were selected. The power for the shore unit was provided by a 12-volt battery.

GPS Technology and Equipment

The hydrographic positioning system used at Anderson Ranch Reservoir was Navigation Satellite Timing and Ranging (NAVSTAR) GPS, an all-weather, radio-based, satellite navigation system that enables users to accurately determine three-dimensional position. The NAVSTAR system's primary mission is to provide passive global positioning and navigation for land-, air-, and sea-based strategic and tactical forces and is operated and maintained by the Department of Defense (DOD). The GPS receiver measures the distances between the satellites and itself and determines the receiver's position from intersections of the multiple-range vectors. Distances are determined by accurately measuring the time a signal pulse takes to travel from the satellite to the receiver.

The NAVSTAR system consists of three segments:

- The space segment is a network of 24 satellites maintained in a precise orbit about 10,900 nautical miles above the earth, each completing an orbit every 12 hours.

- The ground control segment tracks the satellites, determining their precise orbits. Periodically, the ground control segment transmits correction and other system data to all the satellites, and the data are then retransmitted to the user segment.

- The user segment includes the GPS receivers which measure the broadcasts from the satellites and calculate the position of the receivers.

The GPS receivers use the satellites as reference points for triangulating their position on earth. The position is calculated from distance measurements to the satellites that are determined by how long a radio signal takes to reach the receiver from the satellite. To calculate the receiver's position on earth, the satellite distance and the satellite's position in space are needed. The satellites transmit signals to the GPS receivers for distance measurements along with the data messages about their exact orbital location and operational status. The satellites transmit two "L" band frequencies (called L1 and L2) for the distance measurement signal. At least four satellite observations are required to mathematically solve for the four unknown receiver parameters (latitude, longitude, altitude, and time); the time unknown is caused by the clock error between the expensive satellite atomic clocks and the imperfect clocks in the GPS receivers. For hydrographic surveying, the altitude, Anderson Ranch's water surface elevation parameter was known, which realistically meant only three satellite observations were needed to track the survey vessel. During the Anderson Ranch Reservoir survey, the best available satellites were used for position calculations. Position accuracy was affected due to the canyon topography of Anderson Ranch Reservoir where at times the visibility of some of the satellites at one or both of the receivers was blocked.

The GPS receiver's absolute position is not as accurate as it appears in theory because of the function of range measurement precision and the geometric position of the satellites. Precision is affected by several factors--time, because of the clock differences, and atmospheric delays caused by the effect on the radio signal of the ionosphere. Geometric dilution of precision (GDOP) describes the geometrical uncertainty and is a function of the relative geometry of the satellites and the user. Generally, the closer together in angle two satellites are from the receiver, the greater the GDOP. GDOP is broken into components: position dilution of precision (x,y,z) (PDOP), and horizontal dilution of precision (x,y) (HDOP). The components are based only on the geometry of the satellites. The PDOP and HDOP were monitored at the survey vessel's GPS receiver during the Anderson Ranch Reservoir Survey, and for the majority of the time they were less than 3, which is within the acceptable limits of horizontal accuracy for Class 1 and 2 level surveys (Corps of Engineers, 1991).

An additional and larger error source in GPS collection is caused by false signal projection, called selective availability (S/A). The DOD implements S/A to discourage the use of the satellite system as a guidance tool by hostile forces. Positions determined by a single receiver when S/A is active can have errors of up to 100 meters.

A method of collection to resolve or cancel the inherent errors of GPS (satellite position or S/A, clock differences, atmospheric delay, etc.) is called differential GPS (DGPS). DGPS was used during the Anderson Ranch Reservoir survey to determine positions of the moving survey vessel in real time. DGPS determines the position of one receiver in reference to another and is a method of increasing position accuracies by eliminating or minimizing the uncertainties. Differential positioning is not concerned with the absolute position of each unit but with the relative difference between the positions of two units, which are simultaneously observing the same satellites. The inherent errors are mostly canceled because the satellite transmission is essentially the same at both receivers.

At a known geographical benchmark, one GPS receiver is programmed with the known coordinates and stationed over the geographical benchmark. This receiver, known as the master or reference unit, remains over the known benchmark, monitors the movement of the satellites, and calculates its apparent geographical position by direct reception from the satellites. The inherent errors in the satellite position are determined relative to the master receiver's programmed position and the necessary corrections or differences are transmitted to the mobile GPS receiver on the survey vessel. For the Anderson Ranch Reservoir, position corrections were determined by the master receiver and transmitted via a ultra-high frequency (UHF) radio link every 3 seconds to the survey vessel mobile receiver. The survey vessel's GPS receiver used the corrections along with the satellite information it received to determine the vessel's differential location. Using DGPS results in positional accuracies of 1 to 2 meters for the moving vessel compared to positional accuracies of 100 meters with a single receiver. During the post-processing of the Anderson Ranch Reservoir collected data, some positioning errors were found requiring removal or adjusting of the collected data points. It was concluded that the errors occurred when the two receivers were not simultaneously observing the same satellites due to the reservoir canyon topography. The system used for this survey didn't allow the monitoring of the PDOP and HDOP at the reference GPS receiver. Recent upgrade of the GPS receivers and software should eliminate this error occurring in the future. The removal and adjustment of the collected data had very little effect on the total reservoir computed surface areas, less than 0.1 percent.

The TSC mobile and reference GPS units are identical in construction and consist of a 6-channel L1 coarse acquisition (C/A) code continuous parallel-tracking receiver, an internal modem, and a UHF radio transceiver. The differential corrections from the reference station to the mobile station are transmitted using the industry standard Radio Technical Commission for Maritime Services (RTCM) message protocol via the UHF radio link. The programming to the mobile or reference GPS unit is accomplished by entering necessary information via a notebook computer. The GPS collection system has the capability to collect data in 1927 or 1983 North American Datums (NAD) in the surveyed area's state plane coordinate system's zone. For Anderson Ranch Reservoir, the data were collected in Idaho's 1983 NAD west state plane zone.

Survey Method and Equipment

The Anderson Ranch Reservoir hydrographic survey collection was conducted on June 24 through June 28, 1998 at around water surface elevation 4,196. The bathymetric survey was run using sonic depth recording equipment interfaced with a DGPS capable of determining sounding locations within the reservoir. The survey system software continuously recorded reservoir depths and horizontal coordinates as the survey boat moved across close-spaced grid lines covering the reservoir area. Most of the transects (grid lines) were run in a perpendicular direction to the original river thalweg at 300-foot spacing. Data were also collected along the shore as the boat traversed to the next 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. A graphic plotter was used in the field to track the boat and ensure adequate coverage during the collection process.

The 1998 underwater data were collected by a depth sounder that was calibrated by lowering a deflector plate below the boat by cables with known depths marked by beads. The depth sounder was calibrated by adjusting the speed of sound, which can vary with density, salinity, temperature, turbidity, and other conditions. The collected data were digitally transmitted to the computer collection system via an RS-232 port. The depth sounder also produces an analog hard-copy chart of the measured depths. These graphed analog charts were printed for all survey lines as the data were collected and recorded by the computer. The charts were analyzed during post-processing, and when the analog charted depths indicated a difference from the recorded computer bottom depths, the computer data files were modified. The water surface elevations at the dam, recorded by a Reclamation gage at 15-minute intervals, were used to convert the sonic depth measurements to true lake-bottom elevations.

RESERVOIR AREA AND CAPACITY

Topography Development

Using ARC/INFO the topography of Anderson Ranch Reservoir was developed from the combined 1998 aerial and underwater data. ARC/INFO is a software package for development and analysis of geographic information system (GIS) layers and development of interactive GIS applications (ESRI, 1992). GIS technology provides a means of organizing and interpreting large data sets.

The 5-foot reservoir contours for elevation 4180 through 4270 were provided by the aerial contractor as a data exchange format (DXF) file. The underwater contours of the reservoir were developed by using the elevation 4180 contour as a boundary around the edge of the underwater data set. This polygon that enclosed the data set was assigned an elevation of 4180.0 and was used to perform a clip such that interpolation was not allowed to occur outside of this boundary. This clip was performed using the hardclip option of the ARC/INFO CREATETIN command.

Contours for the reservoir below elevation 4180.0 were computed from the underwater data set using the triangular irregular network (TIN) surface modeling package within ARC/INFO. 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. Elevation contours are then interpolated along the triangle elements. The TIN method is discussed in greater detail in the ARC/INFO V7.0.2 *Users Documentation,* (ESRI, 1992).

The linear interpolation option of the ARC/INFO TINCONTOUR command was used to interpolate contours from the Anderson Ranch Reservoir TIN. In addition, the contours were generalized by weeding out vertices along the contours. This generalization process improved the presentability of the resulting contours by removing very small variations in the contour lines. This generalization had no bearing on the computation of surface areas and volumes for Anderson Ranch Reservoir since the areas were calculated from the developed TIN.

ARC/INFO V7.0.2 GIS software was used to digitize the USGS quad features such as the dam, roads and the reservoir contour water surface elevation 4196.0. The digitized features were transformed to Idaho's NAD 1983 west state plane coordinates using the ARC/INFO PROJECT command. The contour topography at 5-foot intervals is presented on figures 3 through 13 (drawing numbers 4-D-2244 through 4-D-2254).

Development of 1998 Contour Areas

The 1998 contour surface areas for Anderson Ranch Reservoir were computed at 5-foot increments, from elevation 3890.0 to 4,175.0, using the Anderson Ranch Reservoir TIN discussed above. The 1998 survey measured the minimum reservoir elevation at 3886.6 feet. These calculations were performed using the ARC/INFO VOLUME command. This command computes areas at user-specified elevations directly from the TIN and takes into consideration all regions of equal elevation. The enclosed surface areas for the 5-foot reservoir contour increments of elevation 4,180.0 through 4,210.0 were measured from the provided DXF aerial contour file.

1998 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). Surface areas at 5-foot contour intervals from minimum reservoir elevation 3,886.6 to elevation 4,210.0 were used as the control parameters for computing the Anderson Ranch Reservoir capacity. The 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 Anderson Ranch Reservoir. 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 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. Final area equations are derived by differentiating the capacity equations, which are of second order polynomial form:

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

where:

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

Results of the 1998 Anderson Ranch Reservoir area and capacity computations are listed in table1 and columns 4 and 5 of table 2. On table 2, columns 2 and 3 list the original interpolated surface areas and visual capacity. A separate set of 1998 area and capacity tables has been published for the 0.1 and 1-foot elevation increments (Bureau of Reclamation 1998). A description of the computations and coefficients output from the ACAP85 program is included with these tables. Both the original and 1998 area-capacity curves are plotted on figure 14. As of June 1998, at elevation 4,196.0, the surface area was 4,743 acres with a total capacity of 474,942 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Figure 14 is a plot of Anderson Ranch Reservoir's original area data versus the 1998 measured areas. This illustrates the difference between the original and the 1998 measured surface areas. It must be noted that the original surface areas for the intermediate elevations were interpolated from areas measured from 50-foot contour topography which was used to develop the original capacity values.

Since Anderson Ranch Dam closure in December 1945, the measured total volume change at reservoir elevation 4,496.0 was estimated to be 18,236 acre-feet. The estimated average annual rate of capacity lost for this time period (52.6 years) was 346.7 acre-feet per year. The storage loss in terms of percent of original storage capacity was 3.70 percent. Tables 1 and 2 contain the Anderson Ranch Reservoir sediment accumulation and water storage data based on the 1998 resurvey.

The sediment computation values must be questioned due to the interpolation of reservoir area and resulting capacity values from 50-foot contour intervals, but the resulting value of 346.7 acre-feet per year appears reasonable when compared to other reservoirs in the region. A resurvey of Anderson Ranch Reservoir should be considered in the future if major sediment inflow events are observed, or if the average annual rate of sediment accumulation requires further clarification.

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RESERVOIR SEDIMENT
DATA SUMMARY

Anderson Ranch Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM Boise River	3. STATE Idaho
	4. SEC. 1 TWP. 1 N RANGE 8 E	5. NEAREST P.O. Mountain Home	6. COUNTY Elmore
	7. LAT 43° 21' 31" LONG 115° 26' 45"	8. TOP OF DAM ELEVATION 4,209.0[1]	9. SPILLWAY CREST EL 4174.0[2]

RESERVOIR	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, AC	13. ORIGINAL CAPACITY, AF	14. GROSS STORAGE ACRE- FEET	15. DATE STORAGE BEGAN
	a. SURCHARGE	4198.2	--	10,504	503,682	
	b. FLOOD CONTROL					12/45
	c. POWER					
	d. JOINT USE	4196.0	4,720	418,191	493,178	16. DATE NORMAL OPERATION BEGAN
	e. CONSERVATION	4044.0	1,170	4,987	74,987	
	f. INACTIVE	4039.6	1,100	41,000	70,000	
	g. DEAD	3992.0	625	29,000	29,000	12/45
	17. LENGTH OF RESERVOIR 19.3[3] MILES			AVG. WIDTH OF RESERVOIR 0.4 MILES		

BASIN	18. TOTAL DRAINAGE AREA 980 SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 11.7[4] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 980 SQUARE MILES	23. MEAN ANNUAL RUNOFF 14.4[5] INCHES
	20. LENGTH MILES AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF 752,160[6] ACRE-FEET
	21. MAX. ELEVATION 10000 MIN. ELEVATION 3992	25. ANNUAL TEMP. MEAN 52°F RANGE -23°F to 108°F[4]

SURVEY DATA

26. DATE OF SURVEY	27. PER. YRS.	28. ACCL. YRS.	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVAL	31. SURFACE AREA, AC.	32. CAPACITY ACRE-FEET	33. C/I RATIO AF/AF
12/45			Contour	50-ft	4,720[7]	493,178[7]	.65
6/98	52.6	52.6	Contour (D)	5-ft	4,743[8]	474,942[8]	.63

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIP.	35. PERIOD WATER INFLOW, ACRE FEET			WATER INFLOW TO DATE, AF	
		a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	a. MEAN ANN.	b. TOTAL
6/98	11.7[4]	752,160[9]	1,679,000	38,811,680	752,160	38,811,680

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SEDIMENT DEPOSITS TO DATE, AF		
	a. TOTAL	b. AV. ANN.	c. /MI.²-YR.	a. TOTAL	b. AV. ANNUAL	c. /MI.²-YR.
6/98	18,236[10]	346.7	.35	18,236	346.7	.35

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42. SEDIMENT	
		a. PERIOD	b. TOTAL TO	a. AV.	b. TOTAL TO	a.	b.
6/98				0.0703[10]	3.70[10]		

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE BY RESERVOIR ELEVATION											
		3992-3886	4039.6-3992	4080-4039.6	4120-4080	4160-4120	4196-4160					
6/98	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
		22.2	22.4	15.7	20.0	18.5	1.2					

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-105	105-110	110-115	115-120	120-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														

Table 1. - Reservoir sediment data summary (page 1 of 2).

45. RANGE IN RESERVOIR OPERATION[6]							
YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1946	4,065.8	3,992.0	766,250	1947	4,099.4	3,994.8	645,380
1948	4,101.4	3,994.4	604,140	1949	4,101.3	3,994.6	648,690
1950	4,157.5	4,028.9	842,330	1951	4,196.4	4,143.8	963,690
1952	4,197.0	4,063.0	1,072,140	1953	4,195.7	4,128.3	751,950
1954	4,196.8	4,132.6	716,850	1955	4,190.7	4,132.9	495,620
1956	4,196.0	4,107.7	1,114,660	1957	4,195.9	4,133.3	822,070
1958	4,196.0	4,127.0	906,120	1959	4,195.8	4,164.7	551,420
1960	4,196.0	4,158.3	574,530	1961	4,160.7	4,098.4	375,710
1962	4,196.4	4,058.4	698,590	1963	4,197.8	4,162.4	615,020
1964	4,196.1	4,151.1	592,220	1965	4,196.6	4,128.1	1,305,010
1966	4,195.9	4,149.7	473,030	1967	4,196.4	4,118.2	708,000
1968	4,185.0	4,149.4	461,890	1969	4,195.8	4,132.3	951,260
1970	4,196.0	4,157.4	--	1971	4,196.9	4,139.4	1,230,000
1972	4,196.1	4,146.1	1,679,000	1973	4,194.4	4,157.0	471,000
1974	4,195.6	4,129.9	1,126,000	1975	4,193.0	4,152.8	898,000
1976	4,195.4	4,152.2	730,000	1977	4,178.2	4,080.8	226,000
1978	4,196.0	4,080.8	795,000	1979	4,196.0	4,146.8	408,000
1980	4,196.0	4,141.2	747,000	1981	4,196.9	4,162.9	516,000
1982	4,197.5	4,142.4	1,193,000	1983	4,195.8	4,143.6	1,264,800
1984	4,196.8	4,144.7	1,057,470	1985	4,195.7	4,153.8	605,650
1986	4,195.7	4,154.9	1,040,050	1987	4,185.6	4,102.6	327,380
1988	4,146.2	4,093.4	380,350	1989	4,194.0	4,096.5	615,200
1990	4,167.2	4,123.6	402,240	1991	4,142.5	4,079.2	340,000
1992	4,090.6	4,040.6	251,190	1993	4,195.8	4,007.9	717,280
1994	4,168.1	4,064.9	294,190	1995	4,196.5	4,051.6	893,660
1996	4,195.8	4,159.5	999,660	1997	4,195.9	4,106.4	1,270,600
1998	4,196.0	4,172.8	676,390				

46. ELEVATION - AREA - CAPACITY DATA FOR **1998 CAPACITY**[11]								
ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
3886	0	0	3890	4.0	8	3900	20.8	132
3910	45.9	458	3920	100.8	1,187	3930	166.5	2,516
3940	232.6	4,496	3950	283.9	7,090	3960	336.6	10,173
3970	412.4	13,915	3980	496.5	18,458	3990	564.1	23,770
3992	578	24,912	4000	638.2	29,771	4010	716.2	36,555
4020	798.5	44,126	4030	905.6	52,619	4039.6	1,023	61,868
4040	1,028.4	62,278	4050	1,158.7	73,226	4060	1,311.8	85,575
4070	1,490.6	99,600	4080	1,674.7	115,411	4090	1,906.0	133,291
4100	2,175.0	153,659	4110	2,425.2	176,653	4120	2,629.7	202,026
4130	2,802.1	229,179	4140	3,078.0	258,425	4150	3,349.4	290,628
4160	3,589.0	325,337	4170	3,878.0	362,615	4180	4,199.4	403,058
4190	4,218.6	447,002	4196	4,743	474,942	4198.2	4,804	485,444
4200	4,853.6	494,136	4206	5,012	523,735	4210	5,114.7	543,988

47. REMARKS AND REFERENCES

1 Top parapet wall is elevation 4209.0. Roadway elevation is 4206.0.
2 Spillway sill elevation is 4174.0 of radial gates.
3 Length main arm = 13.3 miles. Length of all tributaries = 6.0 miles.
4 Bureau of Reclamation Project Data Book, 1981. Reported value for all of Boise Project.
5 Calculated using mean annual runoff value of 752,160 AF, item 24.
6 Computed inflows from 12/45 through 6/98. Missing data for water year 1970.
7 The original areas interpolated from 50-foot contour topography. Volume at el. 4196 was 493,178 AF reported as visually capacity, 2/15/46.
8 Surface area & capacity at el. 4196.0. Surface areas at 5-foot intervals measured from 1998 aerial and underwater survey data. Capacity computed by ACAP program.
9 Inflow values in acre-feet and maximum and minimum elevations in feet by water year from 12/45 through 6/98. Inflow estimate not available for 1970.
10 Question as to true original capacity since surface areas from 50-foot contour topography.
11 Capacities computed by Reclamation's ACAP computer program.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE September 1999

Table 1. - Reservoir sediment data summary (page 2 of 2).

1	2	3	4	5	6	7	8
Elevations (feet)	Original Area (acres)	Original Capacity (acre-feet)	1998 Area (acres)	1998 Capacity (acre-feet)	Measured Sediment Volume (acre-feet)	Percent of Computed Sediment	Percent Reservoir Depth
4210			5115	543988			
4206			5012	523735			
4200			4854	494136			
4199		507534	4826	489296	18238	100.0	
4198.2		503683	4804	485444	18239	100.0	
4196	4720	493178	4743	474942	18236	100.0	100.0
4190	4540	465258	4568	447002	18256	100.1	98.1
4180	4200	421437	4219	403058	18379	100.8	94.8
4170	3920	380975	3878	362615	18360	100.7	91.6
4160	3600	343350	3589	325337	18013	98.8	88.4
4150	3380	308079	3350	290628	17451	95.7	85.2
4140	3140	275071	3078	258425	16646	91.3	81.9
4130	2870	244690	2802	229179	15511	85.1	78.7
4120	2700	216665	2630	202026	14639	80.3	75.5
4110	2510	190515	2425	176653	13862	76.0	72.3
4100	2260	166473	2175	153659	12814	70.3	69.0
4090	1960	145129	1906	133291	11838	64.9	65.8
4080	1720	126407	1675	115411	10996	60.3	62.6
4070	1540	109849	1491	99600	10249	56.2	59.4
4060	1370	95095	1312	85575	9520	52.2	56.1
4050	1205	82084	1159	73226	8858	48.6	52.9
4044	1148	74987	1082	66500	8487	46.5	51.0
4040	1110	70462	1028	62278	8184	44.9	49.7
4039.6	1100	70000	1023	61868	8132	44.6	49.5
4030	1000	59876	906	52619	7257	39.8	46.5
4020	900	50324	798	44126	6198	34.0	43.2
4010	785	41809	716	36555	5254	28.8	40.0
4000	685	34327	638	29771	4556	25.0	36.8
3992	625	29000	578	24912	4088	22.4	34.2
3990			564	23770			33.5
3980			496	18458			30.3
3970			412	13915			27.1
3960			337	10173			23.9
3950			284	7090			20.6
3940			233	4496			17.4
3930			167	2516			14.2
3920			101	1187			11.0
3910			46	458			7.7
3900			21	132			4.5
3890			4	8			1.3
3886			0	0			0.0

1 Elevation of reservoir water surface.
2 Original areas interpolated from areas at 50-foot contour intervals.
3 Original reservoir capacity computed visually.
4 Reservoir surface area from 1998 survey.
5 1998 calculated reservoir capacity computed using ACAP.
6 Measured sediment volume = column (3) - column (5).
7 Measured sediment expressed in percentage of total sediment 18,236 acre-feet.
8 Depth of reservoir expressed in percentage of total depth (310.0 feet).

Table 2 Summary of 1998 survey results

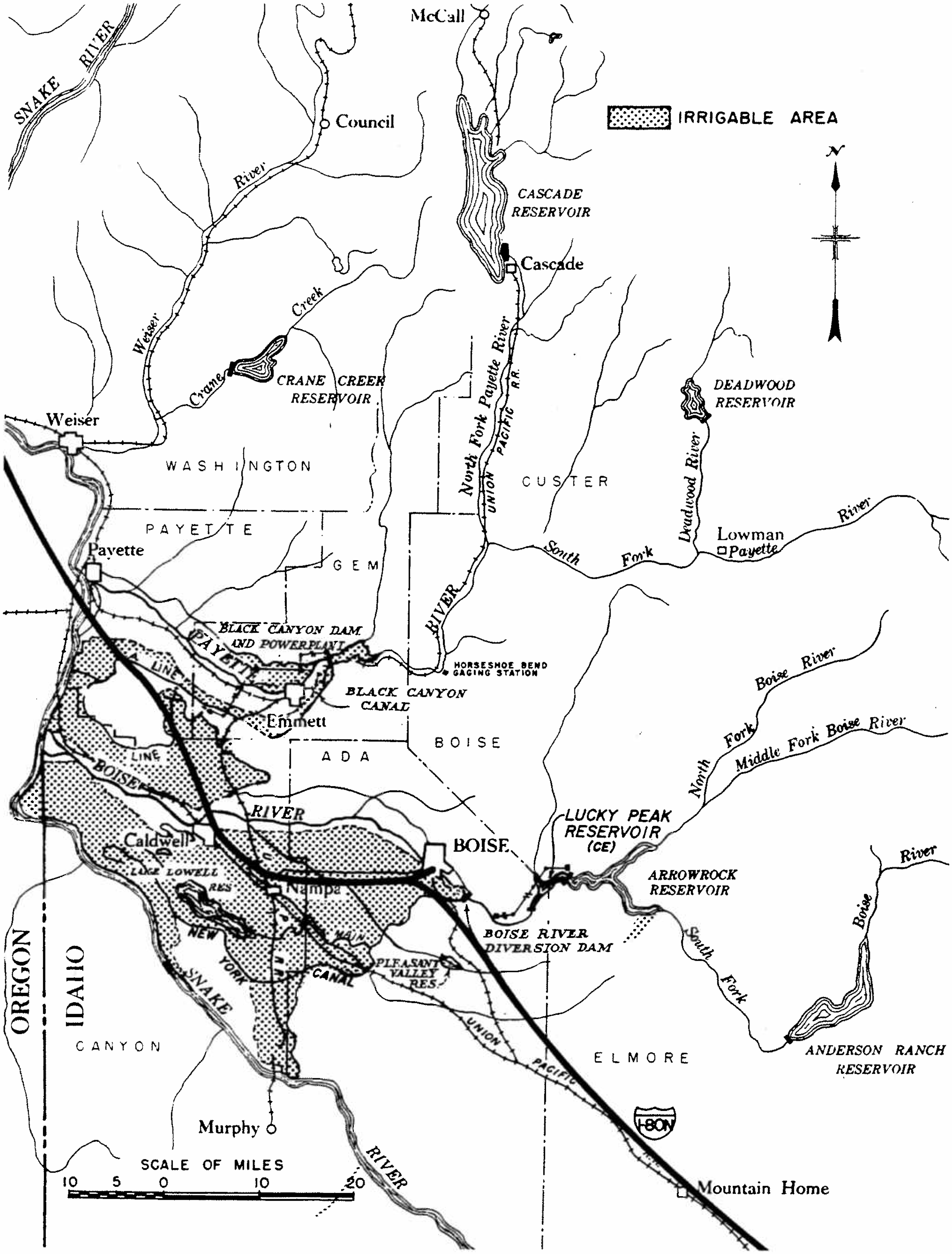


Figure 1. - Anderson Ranch Reservoir location map.

Space intentionally left blank due to security concerns

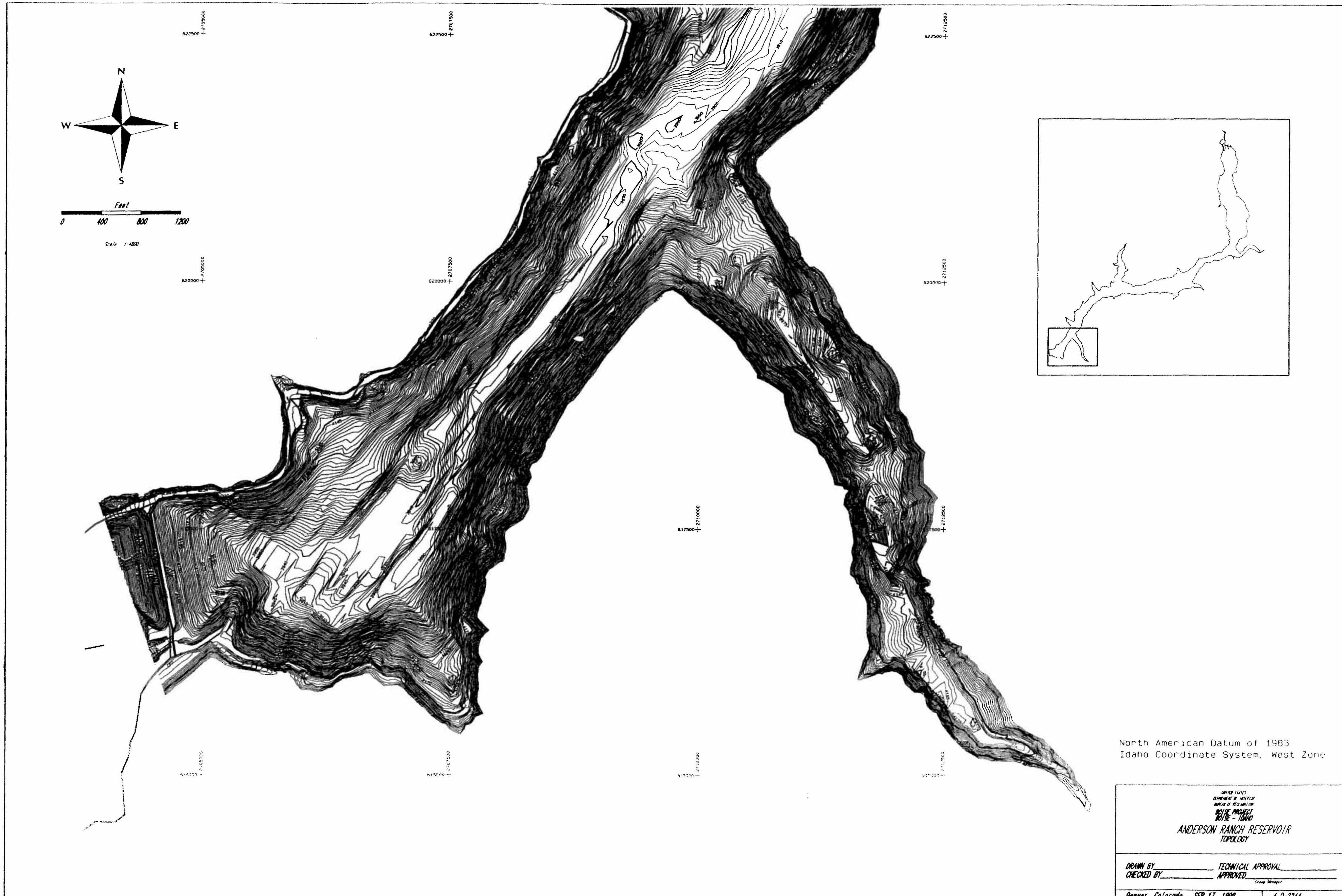


Figure 3. - Anderson Ranch Reservoir topographic map. No. 4-D-2244

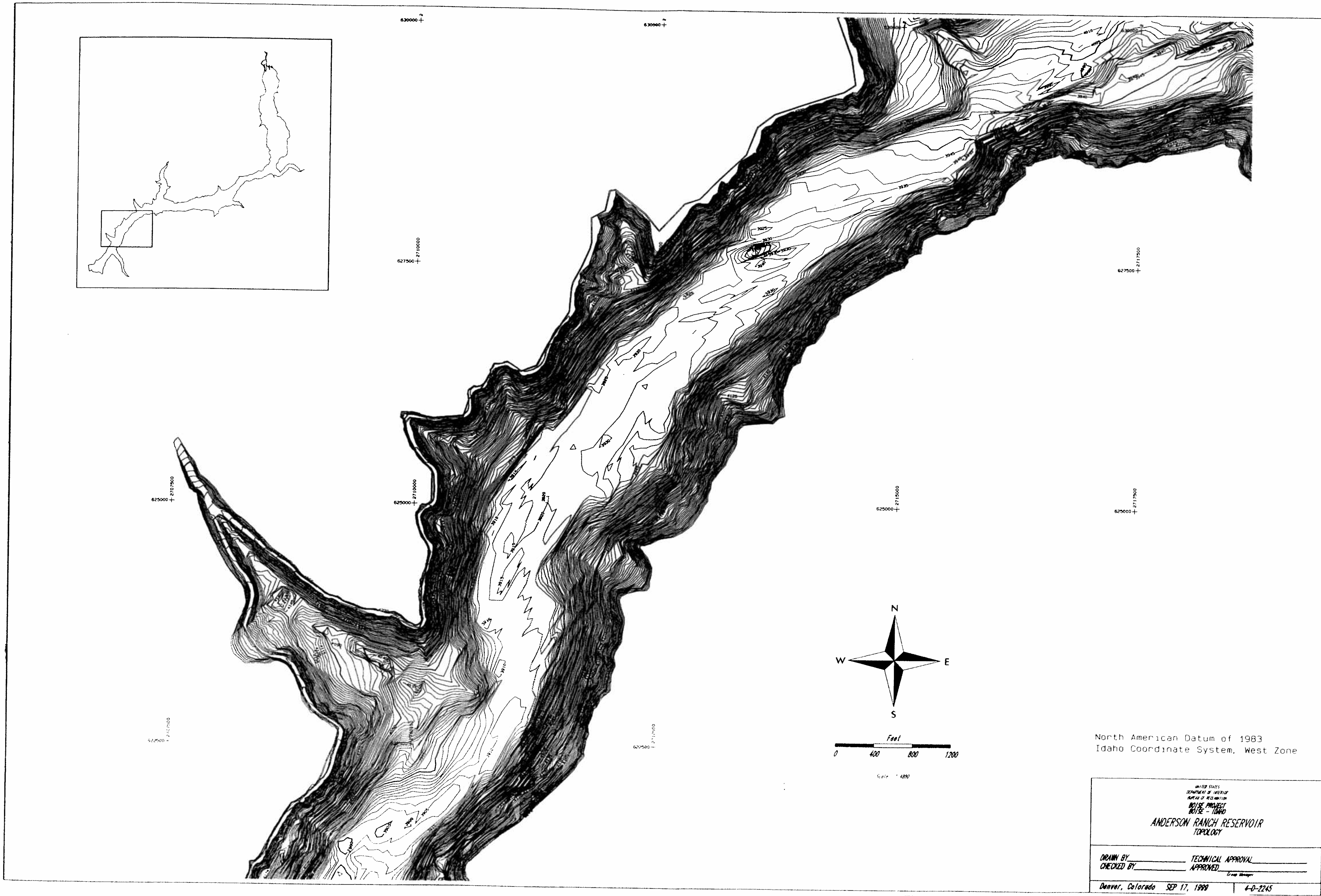


Figure 4. - Anderson Ranch Reservoir topographic map, No. 4-D-2245

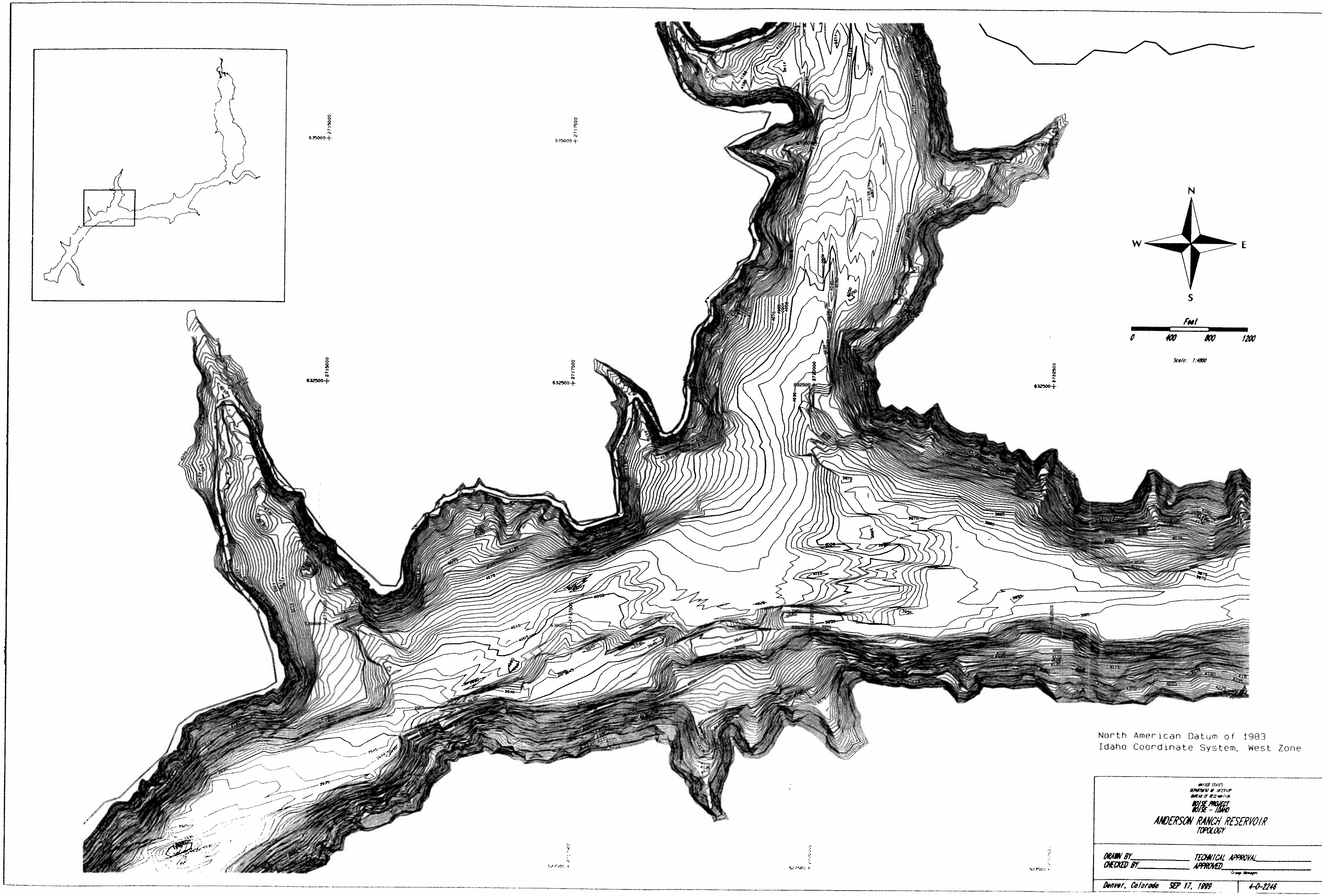


Figure 5. - Anderson Ranch Reservoir topographic map. No. 4-D-2246

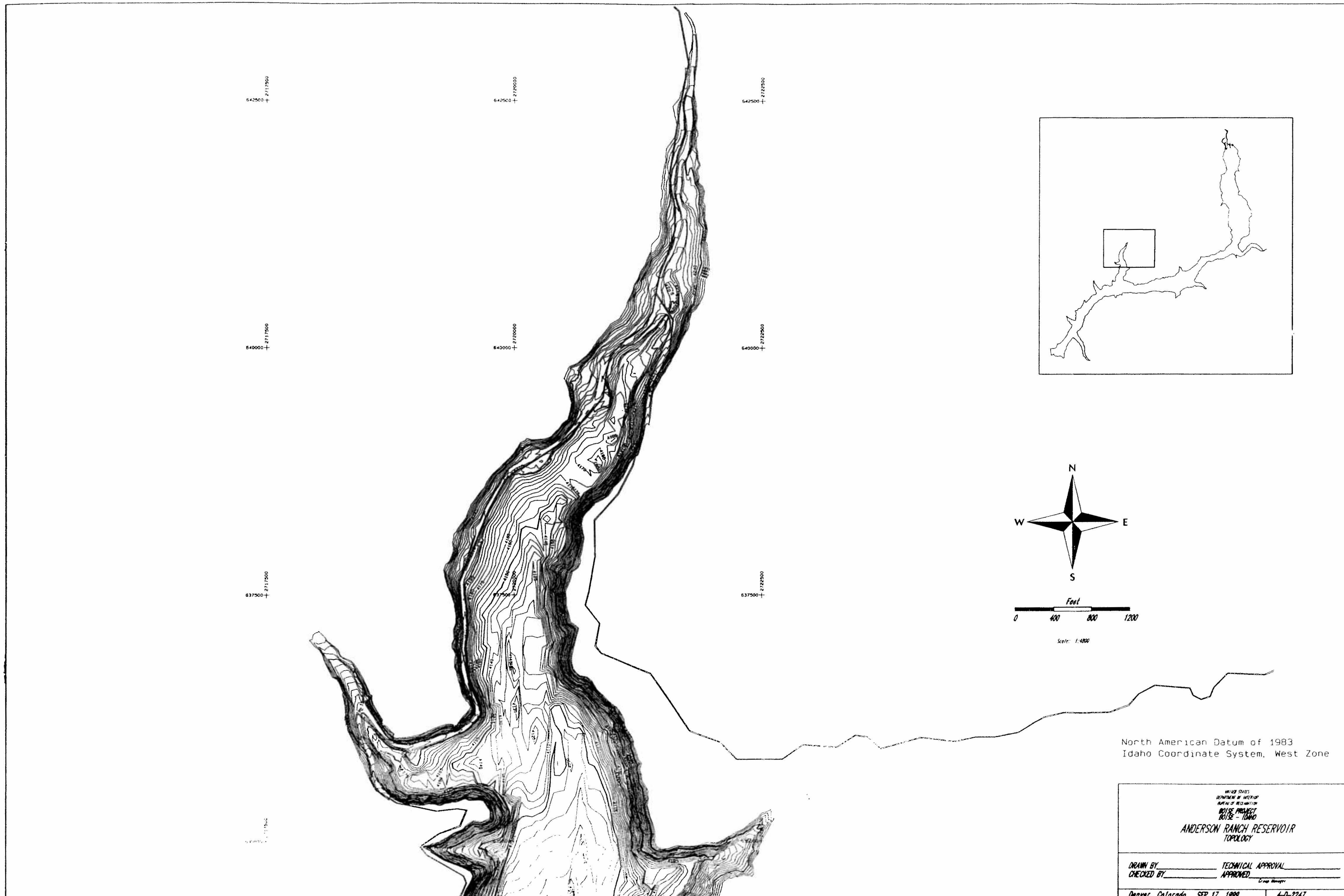


Figure 6. - Anderson Ranch Reservoir topographic map, No. 4-D-2247

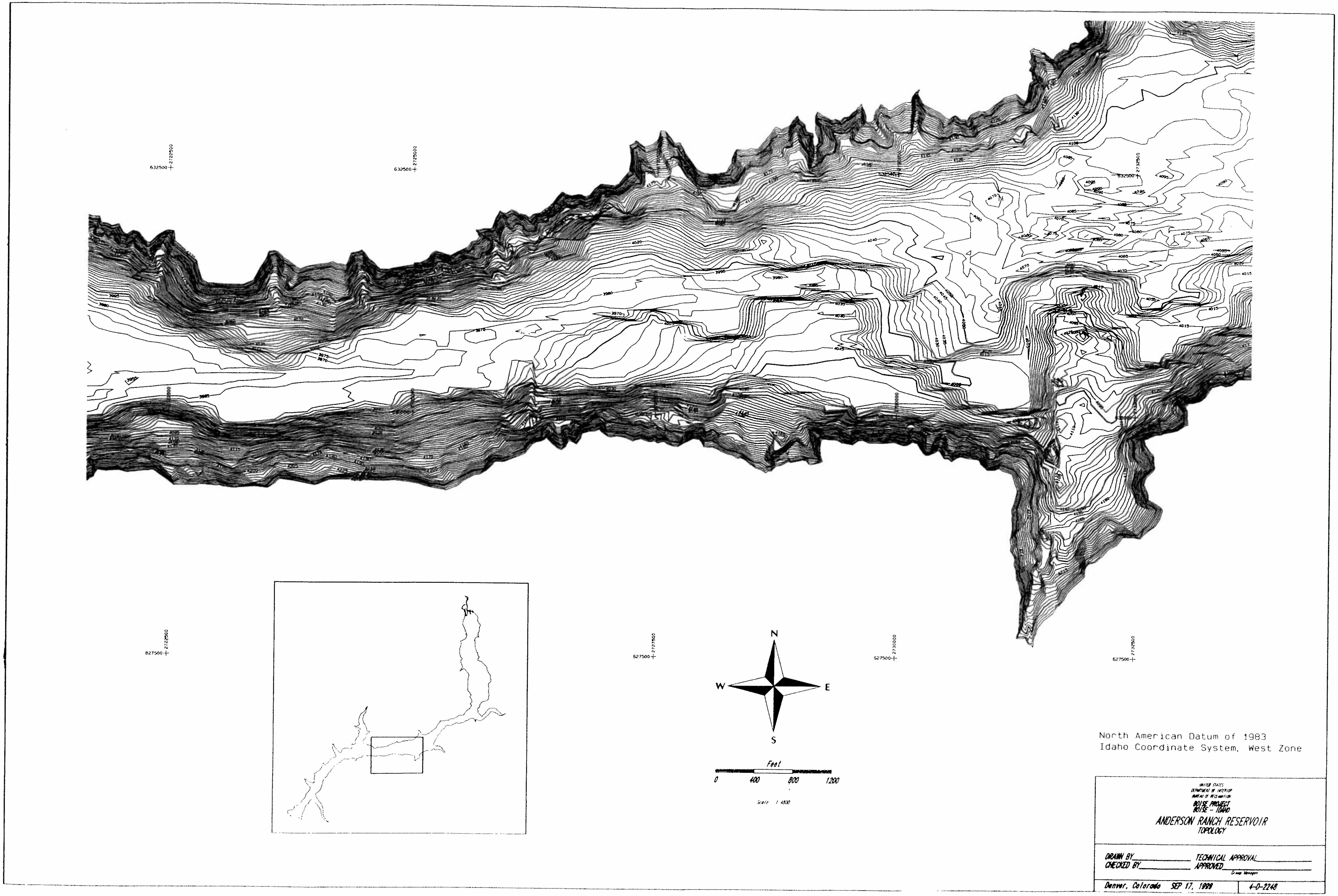
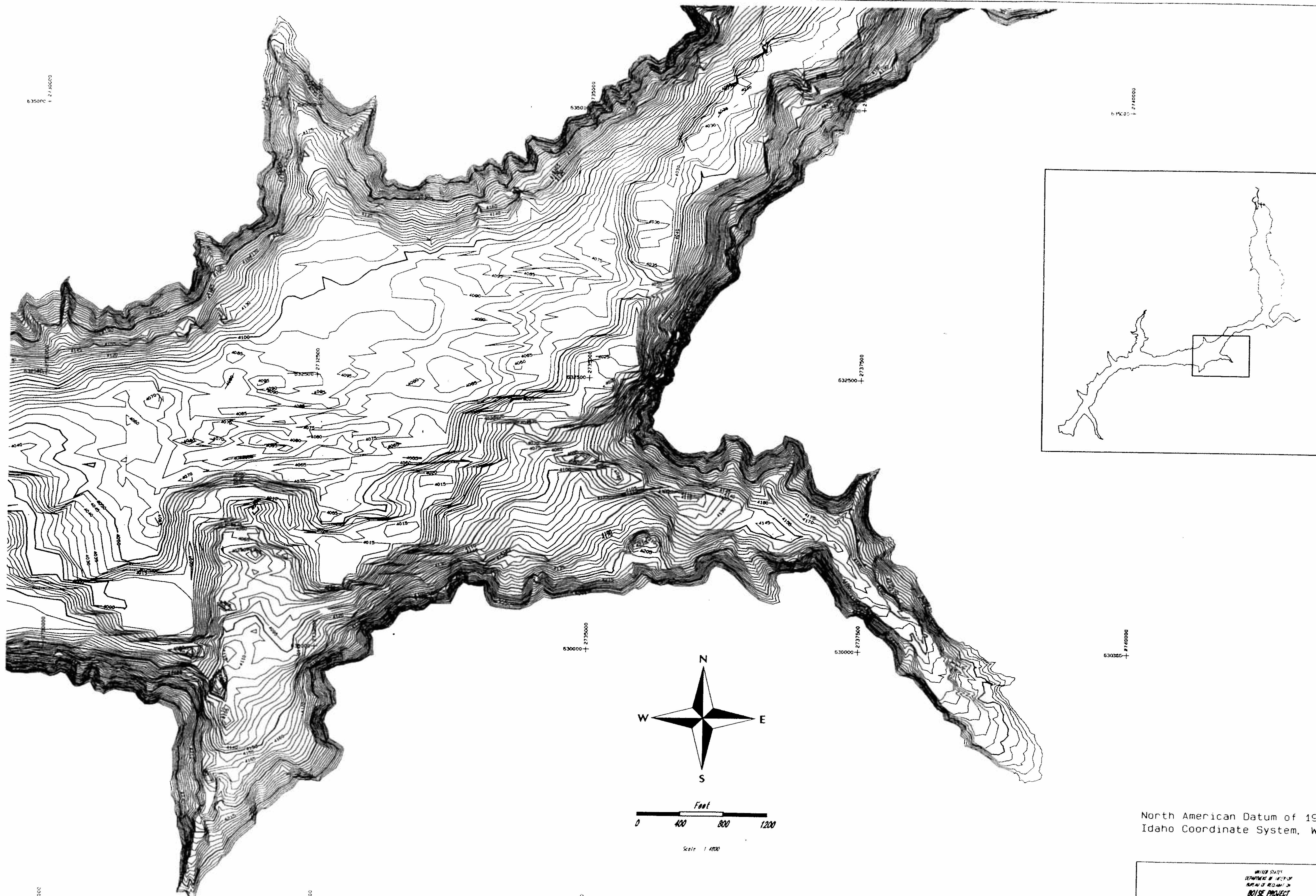


Figure 7. - Anderson Ranch Reservoir topographic map. No. 4-D-2248



North American Datum of 1983
Idaho Coordinate System, West Zone

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOISE PROJECT
BOISE - IDAHO

ANDERSON RANCH RESERVOIR
TOPOLOGY

DRAWN BY______ TECHNICAL APPROVAL______
CHECKED BY______ APPROVED______
Group Manager

Denver, Colorado SEP 17, 1999 | 4-0-2249

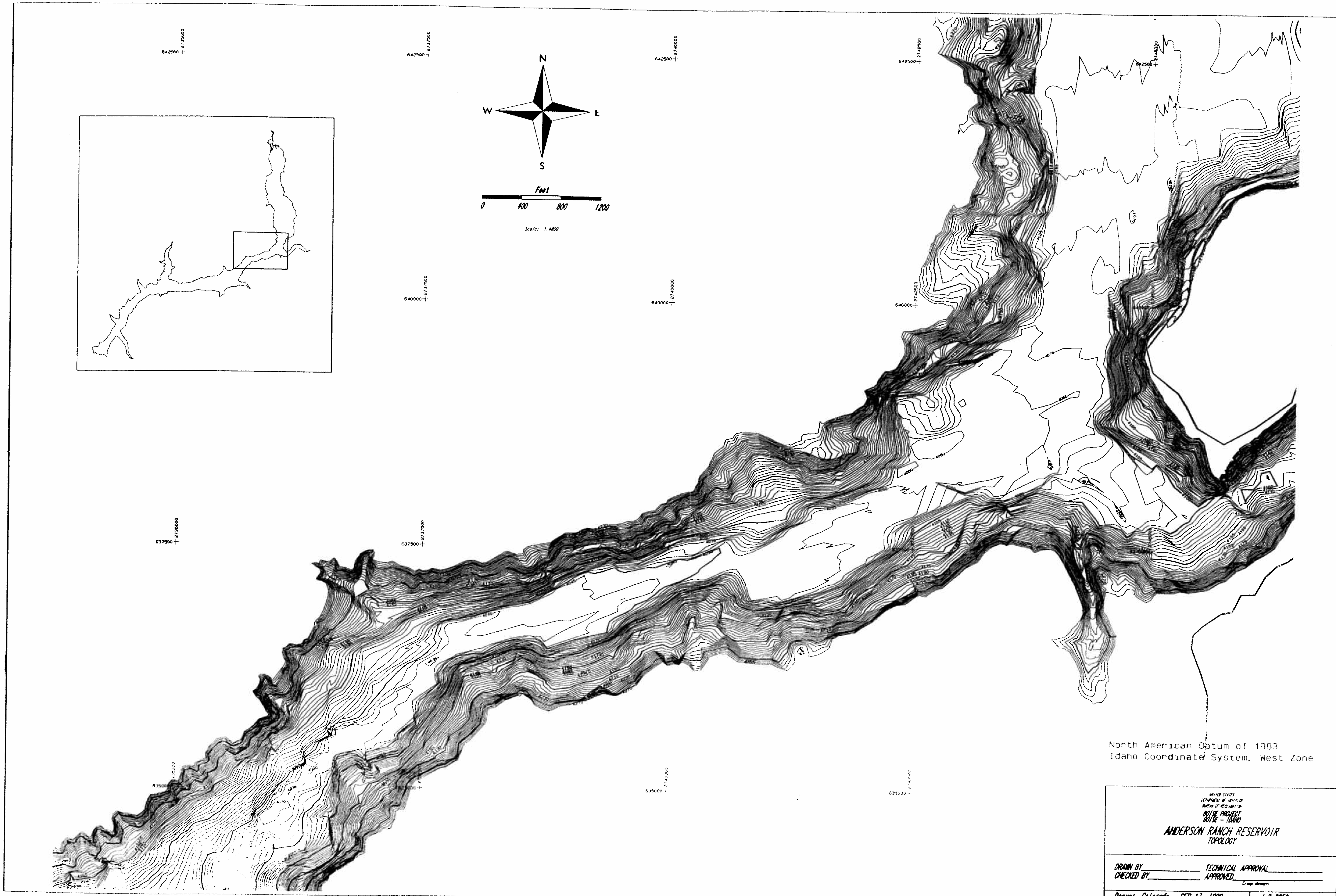


Figure 9. - Anderson Ranch Reservoir topographic map, No. 4-D-2250

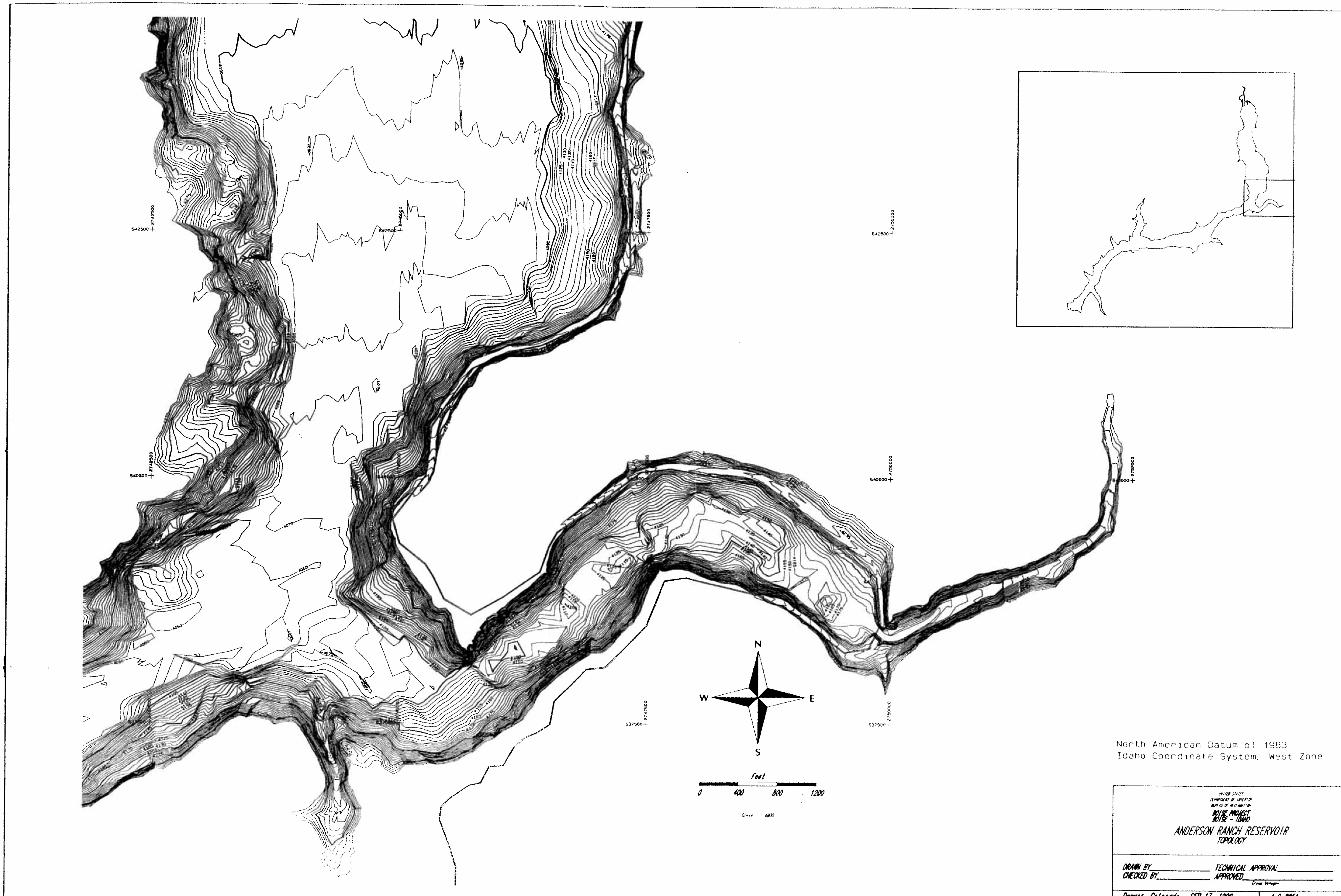


Figure 10. - Anderson Ranch Reservoir topographic map. No. 4-D-2251

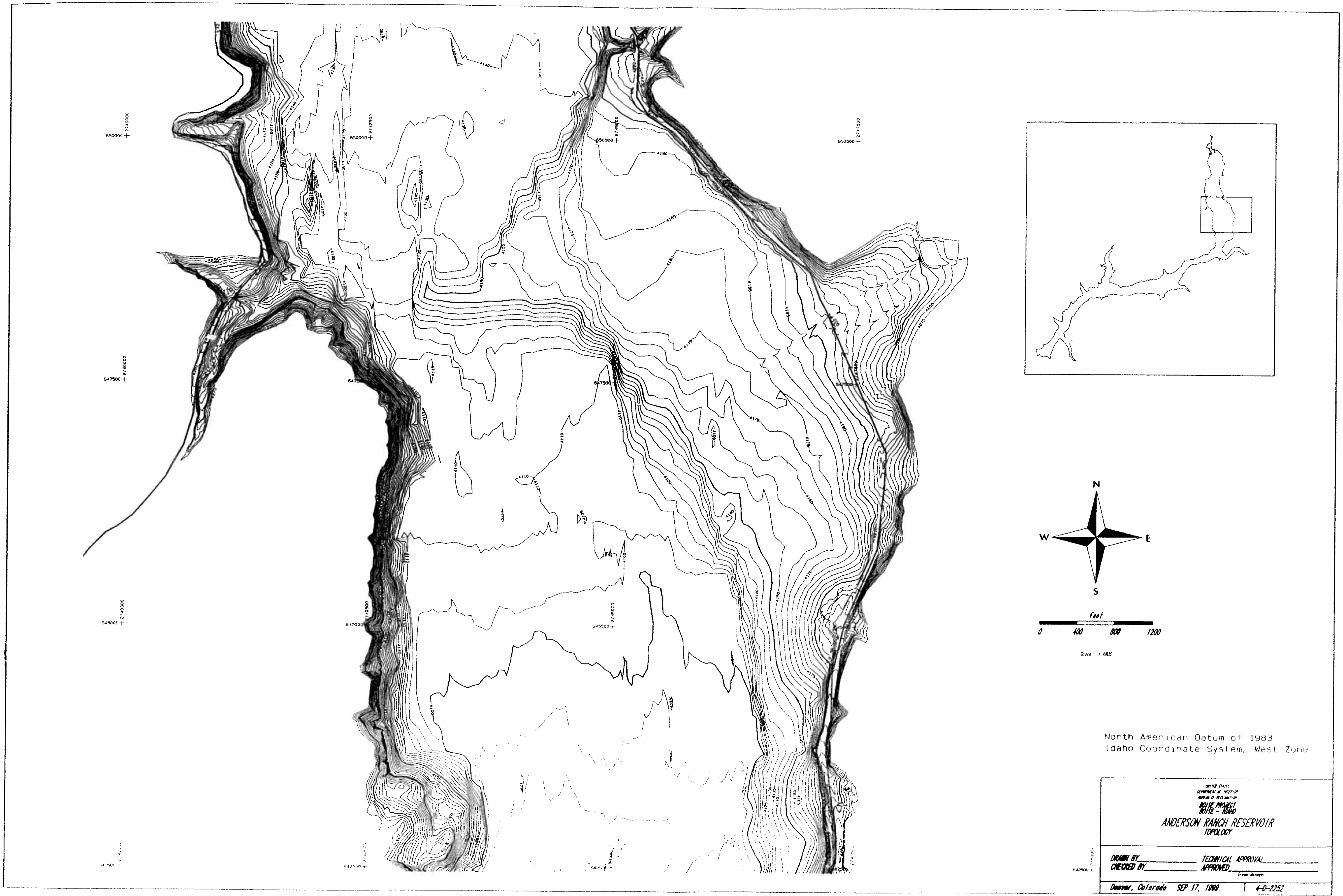


Figure 11. - Anderson Ranch Reservoir topographic map. No. 4-D-2252

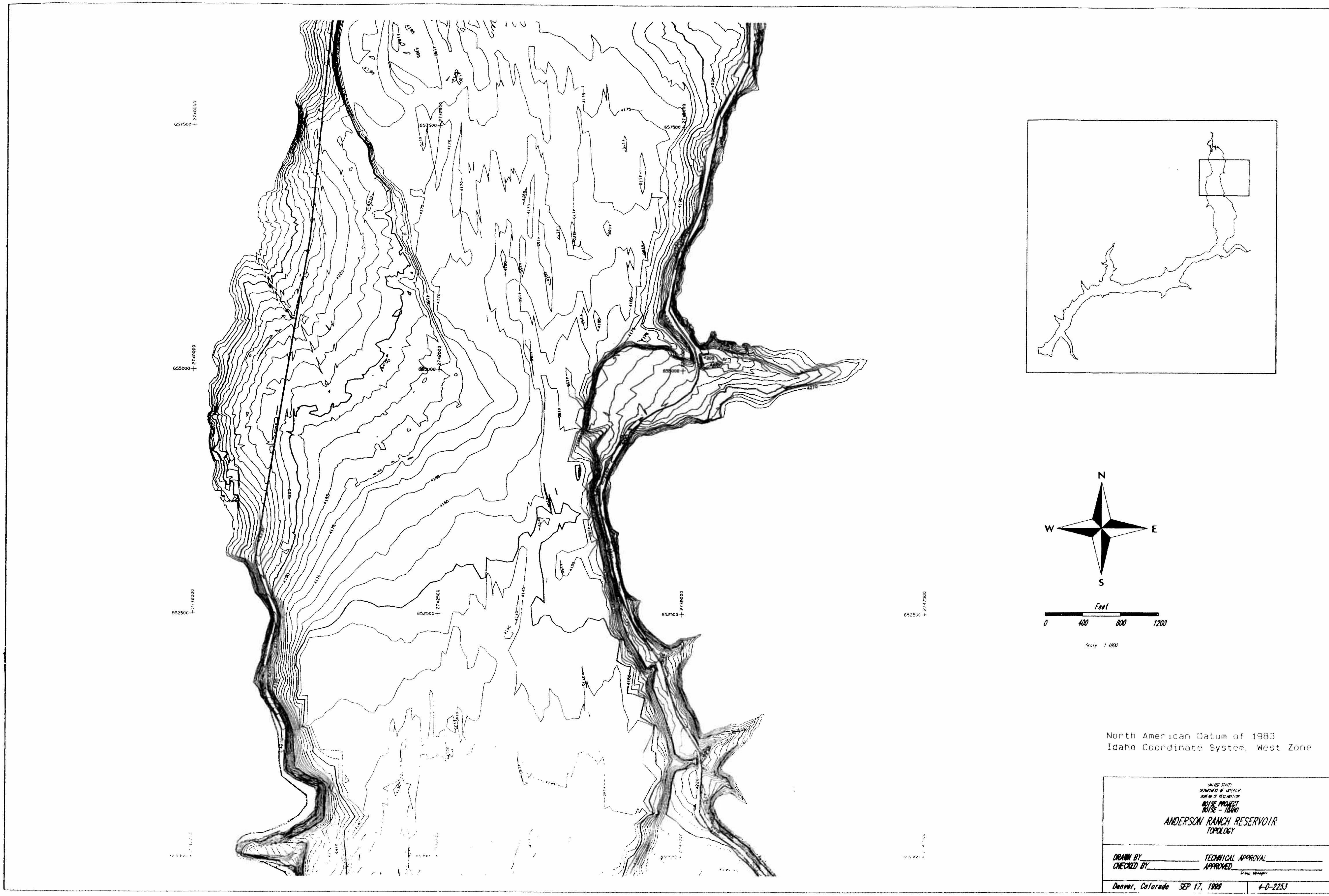


Figure 12. - Anderson Ranch Reservoir topographic map. No. 4-D-2253

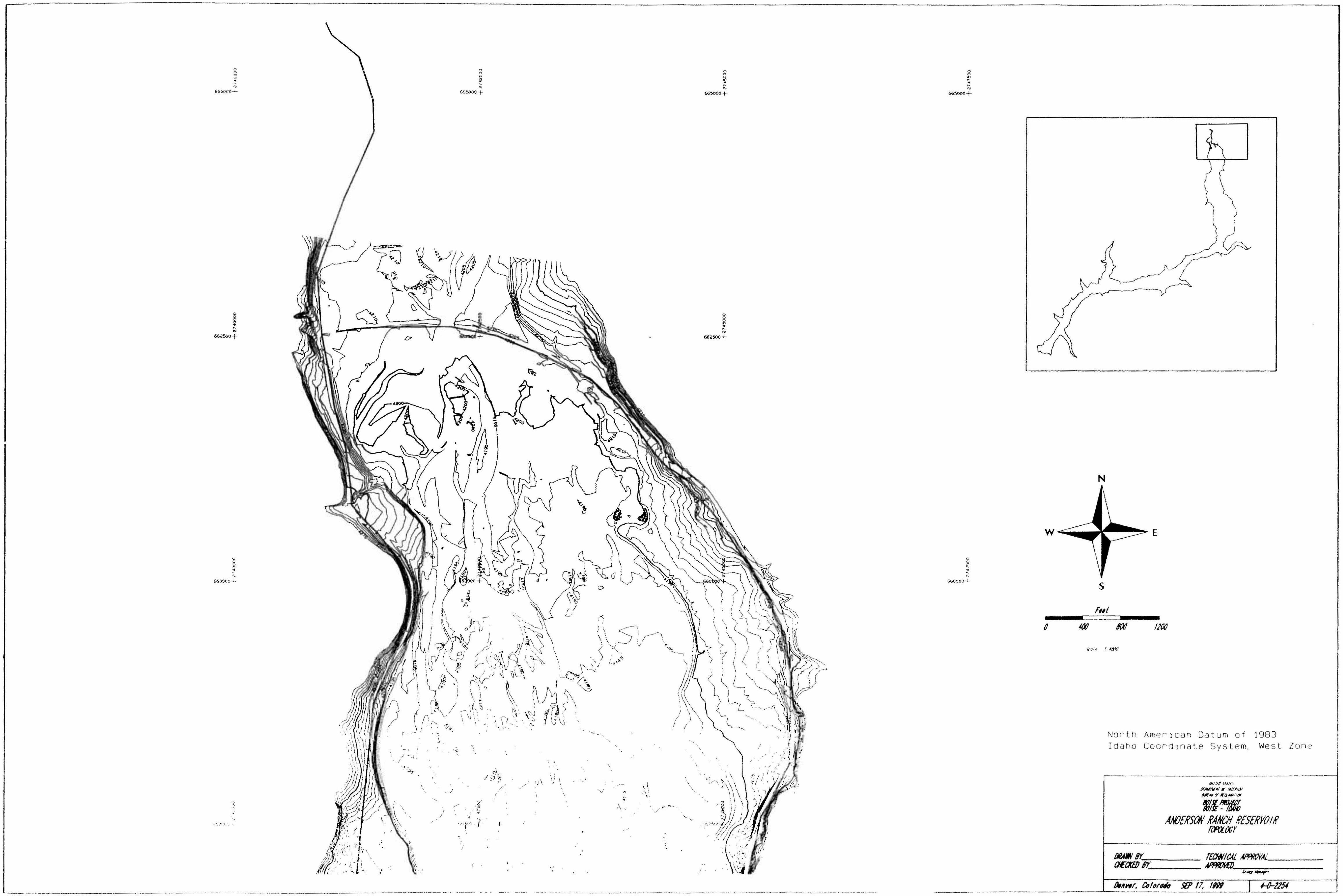


Figure 13. - Anderson Ranch Reservoir topographic map, No. 4-D-2254

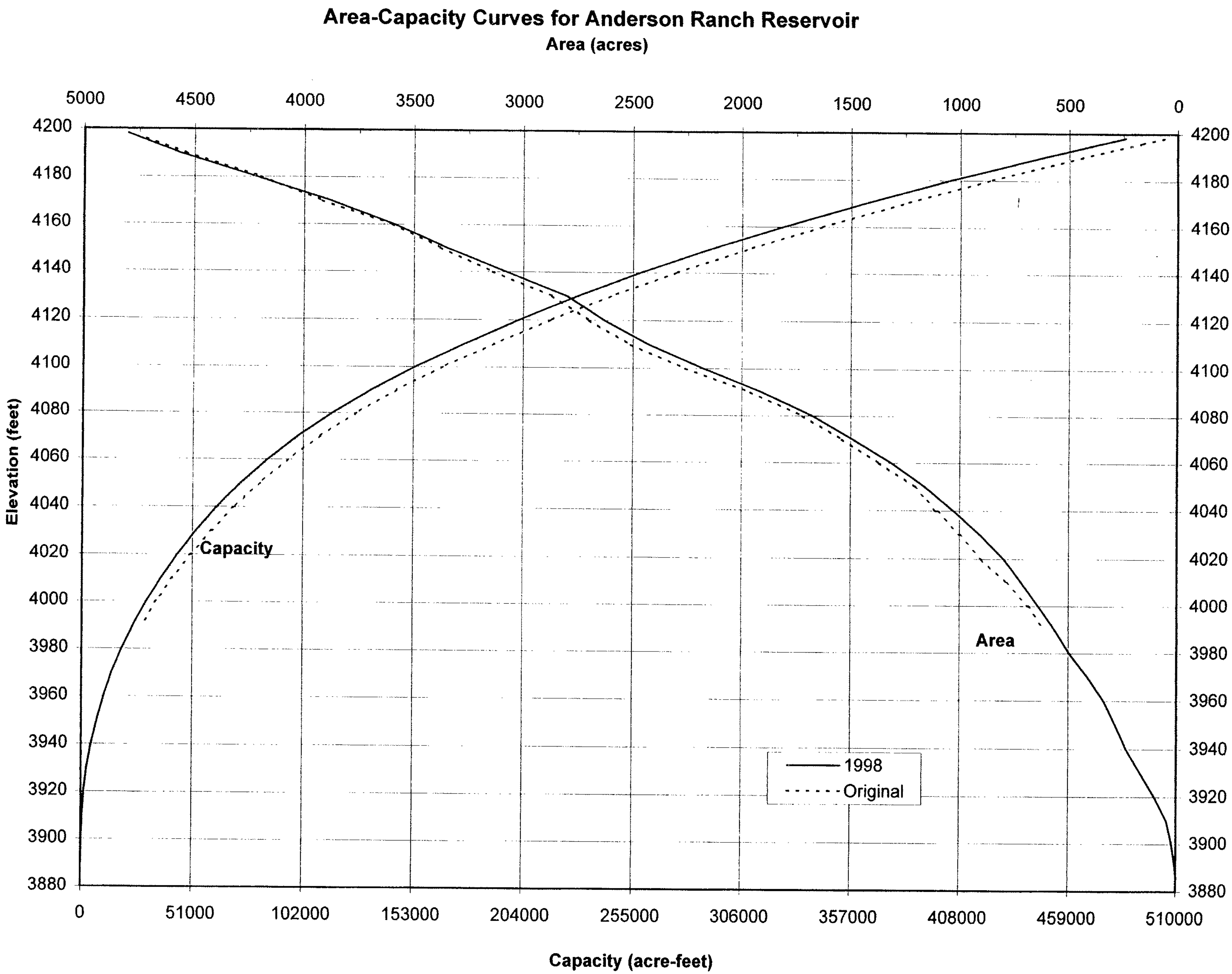


Figure 14. - 1998 area and capacity curves

RECLAMATION'S MISSION

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American Public.