HENRY HAGG LAKE
2001 SURVEY

U.S. Department of the Interior
Bureau of Reclamation

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE December 2001	3. REPORT TYPE AND DATES COVERED Final	
4. TITLE AND SUBTITLE Henry Hagg Lake 2001 Survey			5. FUNDING NUMBERS PR
6. AUTHOR(S) Ronald L. Ferrari			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bureau of Reclamation, Technical Service Center, Denver CO 80225-0007			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Bureau of Reclamation, Denver Federal Center, PO Box 25007, Denver CO 80225-0007			10. SPONSORING/MONITORING AGENCY REPORT NUMBER DIBR
11. SUPPLEMENTARY NOTES Hard copy available at Bureau of Reclamation Technical Service Center, Denver, Colorado			
12a. DISTRIBUTION/AVAILABILITY STATEMENT			12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Henry Hagg Lake in May 2001 to develop a topographic map and compute a present storage-elevation relationship (area-capacity tables). The underwater survey was conducted near lake elevation 279.1 feet (NGVD29). 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 topography was determined by aerial data collected on November 28, 1999 near lake elevation 268.5. The new topographic map of Henry Hagg Lake was developed from the combined 1999 aerial and 2001 underwater measured topography.

As of May 2001, at maximum water surface elevation (feet) 305.8, the surface area was 1,141acres with a total capacity of 64,812 acre-feet. The 2001 underwater survey measured greater surface areas than the original survey from reservoir elevation 255.0 and below. This resulted in the 2001 study computing a greater total reservoir capacity than the original computations. The 2001 analysis concluded these differences were due to under reporting of the original surface areas below elevation 260.0. The 2001 study measured an active capacity loss (elevation 235.3 to 305.8) of 352 acre-feet that could be attributed to sediment accumulation. Due to under reporting of the original surface areas, the 2001 study reported an increase of inactive storage (below elevation 235.3) of 2,580 acre-feet, resulting in a total net capacity increase of 2,228 acre-feet.

14. SUBJECT TERMS reservoir area and capacity/ sedimentation/ reservoir surveys/ sonar/ sediment distribution/ contour area/ reservoir area/ sedimentation survey/ global positioning system			15. NUMBER OF PAGES 16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UL	18. SECURITY CLASSIFICATION OF THIS PAGE UL	19. SECURITY CLASSIFICATION OF ABSTRACT UL	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

Henry Hagg Lake

2001 Survey

by

Ronald L. Ferrari

Sedimentation and River Hydraulics Group
Water Resources Services
Technical Service Center
Denver, Colorado

December 2001

ACKNOWLEDGMENTS

The Bureau of Reclamation's (Reclamation) Sedimentation and River Hydraulics Group of the Technical Service Center (TSC) prepared and published this report. The hydrographic survey was conducted by staff of the Reclamation's Ephrata Field Office under the guidance of Cory Stolsig. The underwater data editing was conducted by Cory Stolsig. Ron Ferrari of the TSC 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 the TSC performed the technical peer review of this documentation.

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to tribes.

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.

CONTENTS

TABLES

FIGURES

INTRODUCTION

Henry Hagg Lake, formed by Scoggins Dam, is located in Washington County on Scoggins Creek which is approximately 5 miles southwest of the city of Forest Grove and 25 miles west of Portland, Oregon (fig. 1). Scoggins Dam and Henry Hagg Lake are principal features of the Tualatin Project with the purpose of providing irrigation, recreation, flood and water quality control. The dam is owned by Reclamation who contracted with the Tualatin Valley Irrigation District for the operation and maintenance of the project facilities. The drainage area above Scoggins Dam is 40.6 square miles and all is considered sediment contributing.

Scoggins Dam was completed in 1975 with first storage in January of 1975. The dam is a rolled, zoned, earthfill structure whose dimensions are (fig. 2):

Hydraulic height[1]	111	feet	Structural height	151	feet
Top width	30	feet	Crest length	2,700	feet
Crest elevation	313.0	feet[2]			

The spillway is located on the left abutment and includes an inlet channel, gate structure of two 19- by 20.5 foot radial gates, a chute, and a stilling basin. The gates allow controlled spillway releases into a combined spillway and outlet works discharge channel. The spillway provides a maximum discharge of 14,100 cubic feet per second (cfs) at maximum reservoir elevation 305.8.

The outlet work is located at the left abutment and consists of an inlet channel, trashrack, upstream and downstream tunnels, and high-pressure gates to control the releases. The outlet works were designed to release a total of 355 cfs at reservoir elevation 260.3.

SUMMARY AND CONCLUSIONS

This Reclamation report presents the 2001 results of the survey of Henry Hagg Lake. The primary objectives of the survey were to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships

A static global positioning system (GPS) control survey was conducted to establish horizontal and vertical control points around the reservoir for the aerial survey that was conducted in November of 1999. The horizontal control was established in Oregon north state plane coordinates in the North American Datum of 1983 (NAD83). The vertical control for the established points was in the North

---

[1]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*.

[2]Elevation levels are shown in feet. All elevations shown in this report are based on the original project datum established by U.S. Bureau of Reclamation which are tied to the National Geodetic Vertical Datum of 1929. It is 3.49 feet lower than North American Vertical Datum of 1988.

American Vertical Datum of 1988 (NAVD88). This study determined that for the established control points the average elevations in NAVD88 were around 3.49 feet higher than the Reclamation project construction datum that was tied to the National Geodetic Vertical Datum of 1929 (NGVD29). All elevations in this report are referenced to NGVD29.

The aerial survey was flown in fall of 1999 around reservoir water surface elevation 268.5 and the underwater survey was conducted in May of 2001 around reservoir water surface elevation 279.1. 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 Henry Hagg Lake. The positioning system provided information to allow the boat operator to maintain a course along these grid lines. Water surface elevations recorded by the lake's gauge (NGVD29) during the time of collection were used to convert the sonic depth measurements to true reservoir bottom elevations.

The new Henry Hagg Lake topographic maps are a combination of the aerial and underwater survey data with the developed aerial contours being used for elevation 271.5 and above. The 2001 reservoir surface areas at predetermined contour intervals were generated by a computer graphics program using the collected reservoir data. The 2001 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 Henry Hagg Lake watershed characteristics for the original and 2001 surveys. The original reported values of the reservoir, at elevation 305.8, was a total storage capacity of 62,584 acre-feet with a surface area of 1,157 acres. The 2001 survey determined that the reservoir has a total storage capacity of 64,812 acre-feet and a surface area of 1,141 acres at reservoir elevation 305.8. The 2001 study measured an active capacity loss (from elevation 235.3 to 305.8) of 352 acre-feet that could be attributed to sediment accumulation. Due to under reporting of the original surface areas, the 2001 study reported an increase of inactive storage of 2,580 acre-feet below elevation 235.3. This resulted in a total net reservoir capacity increase of 2,228 acre-feet from elevation 305.8 and below.

RESERVOIR OPERATIONS

Henry Hagg Lake operates for the Tualatin Project to provide irrigation water, recreation, and flood and water quality control. The May 2001 area-capacity tables show 64,812 acre-feet of total storage below elevation 305.8. The 2001 survey measured the minimum lake bottom elevation to be 185.0 compared to the original reported elevation of 195.0. Comparisons of the original and 2001 area and capacity values are provided on column 6 and 7 of table 2. The following values are from the May 2001 area-capacity tables:

- 2,596 acre-feet of surcharge storage between elevation 303.5 and 305.8.
- 20,334 acre-feet of joint use storage between elevation 283.5 and 303.5.
- 32,989 acre-feet of active conservation storage between elevation 235.3 and 283.5.
- 2,620 acre-feet of inactive storage between elevation 229.0 and 235.3.
- 6,273 acre-feet of dead storage below elevation 229.0.

The Henry Hagg Lake inflow and end-of-month stage records in table 1, operation period January 1975 through May 2001, show the inflow and annual fluctuation since dam closure. The estimated average inflow into the reservoir for this operation period was 84,160 acre-feet per year. Since initial filling, the extreme storage fluctuations of Henry Hagg Lake ranged from elevation 237.2 in 1976 and a maximum recorded elevation of 304.7 in 1995.

RESERVOIR AREA AND CAPACITY

Topography Development

Using ARC/INFO the topography of Henry Hagg Lake was developed from the combined 1999 aerial and 2001 underwater survey 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 271.5 through 321.5 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 281.5 contour as a boundary around the edge of the underwater data set. This polygon enclosed the data set, was assigned an elevation of 281.5, 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 281.5 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 Henry Hagg Lake TIN. In addition, the contours were generalized by eliminating certain 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 Henry Hagg Lake since the areas were calculated from the developed TIN. The areas of the enclosed contour polygons developed from the aerial survey data were computed for elevations 271.5 through elevation 321.5.

The contour topography for the Henry Hagg Lake area is presented on figures 3 and 4 (drawing number 417-D-803 and 417-D-804). The 5-foot contours from elevations 271.5 and above were imported from the aerial data. The 5-foot contours from elevation 265.0 below were developed and imported from the underwater data. The map features such as the dam and roads were imported from the USGS quad maps.

Development of 2001 Contour Areas

The 2001 contour surface areas for Henry Hagg Lake were computed at 1-foot increments, from elevation 185.0 to 281.0, using the Henry Hagg Lake TIN discussed above. 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 271.5 through 321.5 were measured from the provided DXF contour files developed by the aerial contractor.

2001 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 reservoir elevation 185.0 to elevation 270.0 from the underwater survey results and from elevation 271.5 to elevation 321.5 from the aerial survey results were used as the control parameters for computing the Henry Hagg Lake 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 Henry Hagg Lake. 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 2001 Henry Hagg Lake area and capacity computations are listed in table 1 and columns 4 and 5 of table 2. On table 2, columns 2 and 3 list the original surface areas and capacities. A separate set of 2001 area and capacity tables has been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation 2001). A description of the computations and coefficients output from the ACAP85 program is included with these tables. Both the original and 2001 area-capacity curves are plotted on figure 5. As of May 2001, at elevation 305.8, the surface area was 1,141 acres with a total capacity of 64,812 acre-feet.

STUDY CONCLUSIONS

The area and capacity plots on figure 5 and values on table 2 illustrate the differences of Henry Hagg Lake's original and 2001 study results. As illustrated on column 7 of table 2, the 2001 underwater survey measured larger surface areas than what was originally reported for reservoir elevation 255.0 and below. It is concluded these differences were due to under reporting of the original surface areas and not due to a vertical datum shift, dredging, or scouring of the reservoir bottom. Conversations with regional personnel familiar with the operation of Henry Hagg Lake confirmed a reconnaissance survey conducted after completion of the reservoir measured depths deeper than the original reported bottom elevation 195 and no dredging of the reservoir has occurred since dam closure. The reservoir is located in an area with heavy vegetation growth which would have made it difficult to survey the original river channel area prior to dam construction.

The 2001 study measured slightly smaller surface areas for reservoir elevation 260.0 and above than what was originally reported. This resulted in an active capacity loss (elevation 235.3 to 305.8) of 352 acre-feet that could be attributed to sediment accumulation. A portion of this difference could also be attributed to the different survey methods or a slight shift in the vertical datum, but the general conclusion is the majority of the difference is due to sediment accumulation. A 1999 geological field investigation, conducted near reservoir elevation of 253, concluded that sediment accumulation had not exceeded the original pre-reservoir sediment yield estimate of 20 acre-feet per year (Bureau of Reclamation, 2000). The geological field investigation estimated sediment within the reservoir to be 250 acre-feet exposed and about 250 acre-feet submerged for a total of 500 acre-feet. This equated to a sediment yield rate of 19.2 acre-feet per year since dam closure in 1974. The above water sediment deposition was estimated by inspection and mapping of the three main streams from elevation 253 and above. The sediment accumulation below the water surface was based on estimates of the submerged deposited areas.

The general conclusion is that the 2001 study provides an accurate measurement of the present condition of Henry Hagg Lake. The 1999 aerial survey provided above water mapping detail to account for the sediment deposition along with the upper reservoir changes due to shoreline erosion. For future planning a sediment yield rate of 20 acre-feet per year may be used. A resurvey of Henry Hagg Lake should be considered in the future if major sediment inflow events are observed, if the average annual rate of sediment accumulation needs to be further clarified, and if location of the sediment deposition is needed..

REFERENCES

American Society of Civil Engineers, 1962. ***Nomenclature for Hydraulics***, ASCE Headquarters, New York.

Bureau of Reclamation, 1981. ***Project Data,*** Denver Office, Denver CO.

Bureau of Reclamation, 1985. Surface Water Branch, ***ACAP85 User's Manual***, Technical Service Center, Denver CO.

Bureau of Reclamation, 1987(a). ***Guide for Preparation of Standing Operating Procedures for Bureau of Reclamation Dams and Reservoirs***, U.S. Government Printing Office, Denver, CO.

Bureau of Reclamation, 1987(b). ***Design of Small Dams***, U.S. Government Printing Office, Denver CO.

Bureau of Reclamation, July 2000. ***Geologic Report on Sediment Accumulation and Distribution in Henry Hagg Lake Tualatin Valley Irrigation District Washington County, Oregon.*** Pacific Northwest Region, Boise, ID.

Bureau of Reclamation, May 2001. Denver Office, ***Henry Hagg Lake Area and Capacity Tables, Tualatin Project***, Pacific Northwest Region, Boise, ID.

Corps of Engineers, October 1994. Engineer and Design - ***Hydrographic Surveying***, EM 1110-2-1003 (FR), Department of the Army, Washington DC (www.usace.army.mil/inet/usace.docs/eng-manuals/em.htm).

Environmental Systems Research Institute , Inc. (ESRI), 1992. ***ARC Command References***.

RESERVOIR SEDIMENT
DATA SUMMARY

Henry Hagg Lake
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM Scoggins Creek	3. STATE Oregon
	4. SEC. 20 TWP. 1 S RANGE 4 W	5. NEAREST P.O. Forest Grove	6. COUNTY Washington
	7. LAT 45° 28' 25" LONG 123° 11' 51"	8. TOP OF DAM ELEVATION 313.0	9. SPILLWAY CREST EL 283.5[1]

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	305.8	1,157	2,633	62,584	
	b. FLOOD CONTROL					1974
	c. POWER					
	d. JOINT USE	303.5	1,132	20,603	59,951	16. DATE NORMAL OPERATION BEGAN
	e. CONSERVATION	283.5	938	33,035	39,348	
	f. INACTIVE	235.3	411	2,329	6,313	
	g. DEAD	229.0	328	3,984	3,984	4/75
	17. LENGTH OF RESERVOIR 2.46 MILES			AVG. WIDTH OF RESERVOIR 0.6 MILES		

BASIN			
	18. TOTAL DRAINAGE AREA 40.6 SQUARE MILES		22. MEAN ANNUAL PRECIPITATION 44.4[2] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 40.6 SQUARE MILES		23. MEAN ANNUAL RUNOFF 38.9[3] INCHES
	20. LENGTH MILES	AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF 84,160[4] ACRE-FEET
	21. MAX. ELEVATION 3,464	MIN. ELEVATION 284	25. ANNUAL TEMP. MEAN 53°F RANGE -4°F to 108°F[2]

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
1/75			Contour (D)	5-ft	1,157[5]	62,584[5]	.39
5/01	26.4	26.4	Contour (D)	5-ft	1,141[6]	64,812[6]	.41

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
5/01		84,160[7]	159,150	2,221,870	84,160	2,221,870

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.
5/01	[8]					

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT^3)	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.
5/01				[9]	[9]		

26. DATE OF SURVEY	43. DESIGNATION RANGE BY RESERVOIR ELEVATION											
	185.0-229.0		229.0-235.3		235.3-283.5		283.5-303.5		303.5-305.8			
	TOTAL CAPACITY CHANGE WITHIN ELEVATION RANGE DESIGNATION											
	+2289		+291		-46		-269		-37			

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[7]

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
				1975	303.5	244.9	77,010
1976	303.5	237.2	99,710	1977	285.6	269.8	19,250
1978	303.4	268.8	98,490	1979	303.5	272.7	51,980
1980	302.3	272.9	78,390	1981	303.4	273.2	74,240
1982	302.4	273.0	125,000	1983	303.5	274.1	132,400
1984	303.4	272.3	78,650	1985	303.5	271.7	65,930
1986	303.5	271.3	62,430	1987	303.5	271.0	77,110
1988	303.6	266.1	54,960	1989	303.6	268.9	66,930
1990	303.5	260.1	73,100	1991	303.5	269.8	70,550
1992	303.5	265.1	44,260	1993	303.5	260.5	63,810
1994	303.5	270.8	49,280	1995	304.7	266.3	114,880
1996	303.5	272.5	159,150	1997	303.4	273.2	128,290
1998	303.4	271.2	94,340	1999	303.5	263.7	147,620
2000	303.5	253.2	91,280	2001	278.6	257.0	22,830

46. ELEVATION - AREA - CAPACITY DATA FOR **2001 CAPACITY**[9]

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
185.0	0	0	190.0	2.1	5	195.0	6.7	27
200.0	40.2	119	205.0	101.5	490	210.0	155.4	1,135
215.0	211.4	2,051	220.0	278.2	3,274	225.0	341.0	4,823
229.0	383	6,273	230.0	393.5	6,661	235.0	445.7	8,759
235.3	449.0	8,893	240.0	498.0	11,117	245.0	542.1	13,721
250.0	582.8	16,534	255.0	638.4	19,582	260.0	693.8	22,916
265.0	746.1	26,517	270.0	790.8	30,316	271.5	799.4	31,554
276.5	851.2	35,680	281.5	901.1	40,061	283.5	920	41,882
286.5	948.2	44,684	291.5	995.2	49,543	296.5	1,045.8	54,645
301.5	1,096.8	60,002	303.5	1,117	62,216	305.8	1,141	64,812
306.5	1,147.9	65,613	311.5	1,195.6	71,472	316.5	1,241.5	77,565
321.5	1,289.4	83,892						

47. REMARKS AND REFERENCES

[1] Bottom of radial gates.
[2] Bureau of Reclamation Project Data Book, 1981.

[3] Calculated using mean annual runoff value of 84,160 AF, item 24, 1/75-5/01.
[4] Computed annual inflows from 1/75 through 5/01.
[5] Original reported surface area and capacity at el. 3,05.8. A reconnaissance survey after completion of the reservoir found depths deeper then the original report bottom elevation of 195.0.
[6] Surface area & capacity at el. 305.8.
[7] Inflow values in acre-feet and maximum and minimum elevations in feet by water year from 1/75 through 5/01. Some months of missing records.
[8] Total sediment deposition values could not be computed with available data. The 2001 underwater survey measured greater surface areas from reservoir elevation 255.0 and below than what was originally reported. The 2001 analysis concluded these differences were due to under reporting of the original surface areas and not a vertical datum shift, dredging, or scouring since dam closure. The 2001 study measured an active capacity loss (elevation 235.3 to 305.8) of 352 acre-feet that can be attributed to sediment accumulation. The 2001 survey could not verify the sediment deposition in the inactive zone, below elevation 235.3, due to the under reporting of the original capacity.
[9] Due to under reporting of the original surface areas, the 2001 study measured an increase of inactive and dead storage of 2,580 acre-feet. This resulted in an net capacity increase of 2,228 acre-feet from reservoir elevation 305.8 feet and below.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE December 2001

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

1	2	3	4	5	6	7	8
Elevations	Reservoir	Original	Original	2001	2001	Change in	Change in
	Allocation	Area	Capacity	Area	Capacity	Area	Capacity
(feet)		(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
321.5				1289.4	83892		
316.5				1241.5	77565		
311.5				1195.6	71472		
306.5				1147.9	65613		
305.8	**Surcharge**	1157	62584	1141.0	64812	-16.0	2228
303.5	**Joint**	1132	59951	1117.0	62216	-15.0	2265
301.5		1111	57708	1096.8	60002	-14.2	2294
296.5		1057	52288	1045.8	54645	-11.2	2357
291.5		1008	47125	995.2	49543	-12.8	2418
286.5		966	42203	948.2	44684	-17.8	2481
283.5	**Conservation**	938	39348	920.0	41882	-18.0	2534
281.5		919	37492	901.1	40061	-17.9	2569
276.5		872	33014	851.2	35680	-20.8	2666
271.5		826	28775	799.4	31554	-26.6	2779
270.0		809	27548	790.8	30361	-18.2	2813
265.0		753	23642	746.1	26517	-6.9	2875
260.0		700	20017	693.8	22916	-6.2	2899
255.0		635	16678	638.4	19582	3.4	2904
250.0		576	13659	582.8	16534	6.8	2875
245.0		530	10894	542.1	13721	12.1	2827
240.0		471	8385	498.0	11117	27.0	2732
235.3	**Inactive**	411	6313	449.0	8893	38.0	2580
235.0		407	6190	445.7	8759	38.7	2569
230.0		341	4318	393.5	6661	52.5	2343
229.0	**Dead**	328	3984	383.0	6273	55.0	2289
225.0		271	2789	341.0	4823	70.0	2034
220.0		191	1640	278.2	3274	87.2	1634
215.0		133	833	211.4	2051	78.4	1218
210.0		82	311	155.4	1135	73.4	824
205.0		21	67	101.5	490	80.5	423
200.0		6	10	40.2	119	34.2	109
195.0		0	0	6.7	27	6.7	27
190.0		0	0	2.1	5	2.1	5
185.0		0	0	0.0	0	0.0	0
1		**Elevation of reservoir water surface.**					
2		**Top elevation of reservoir allocation zone.**					
3		**Original reported reservoir surface area.**					
4		**Original reported reservoir capacity.**					
5		**Reservoir surface area from 2001 survey.**					
6		**2001 Reservoir capacity computed using ACAP.**					
7		**Change in surface area, 2001 measured area minus original area.**					
8		**Change in capacity, 2001 computed capacity minus original capacity.**					

Table 2 - Summary of 2001 survey results.

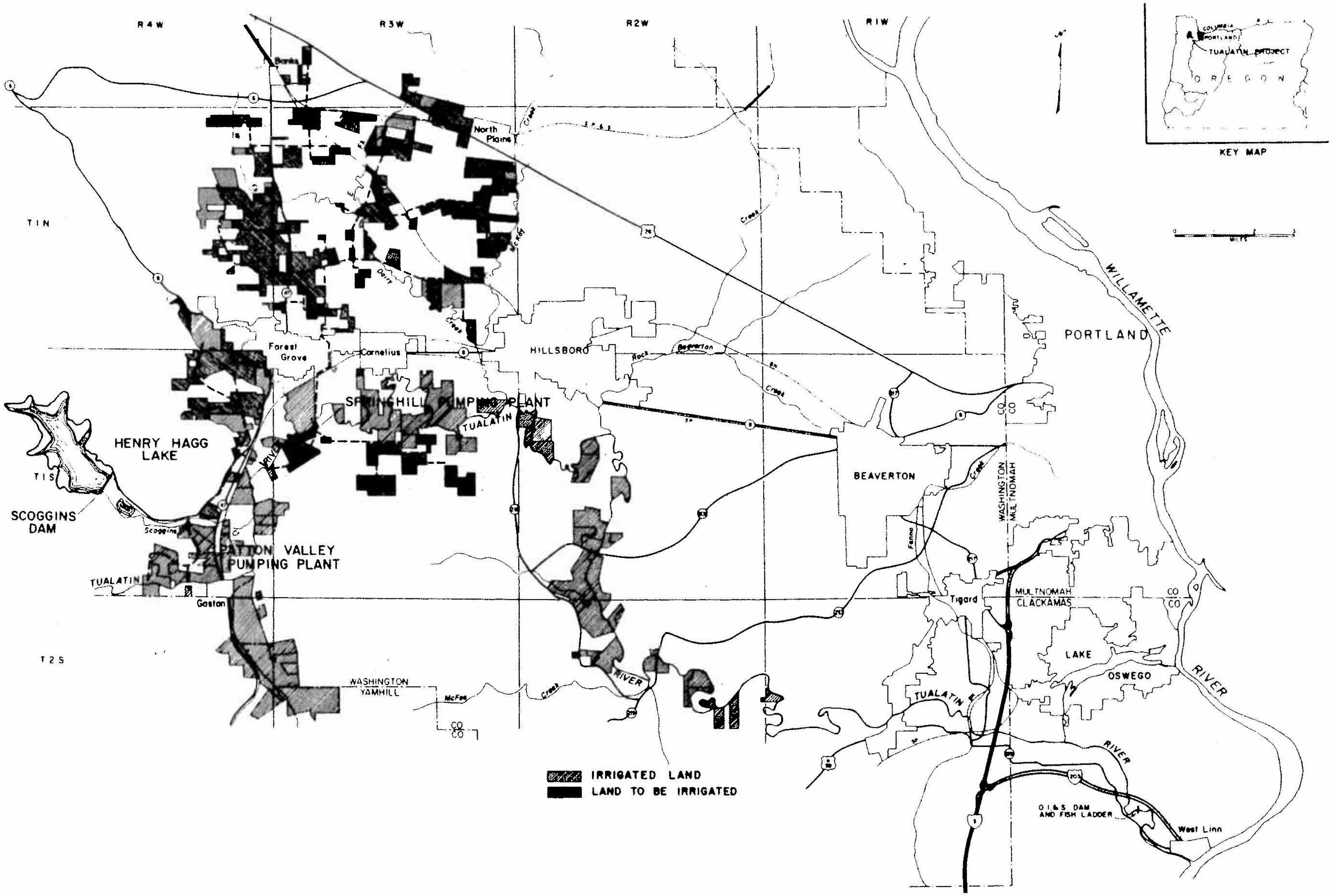

Figure 1. - Henry Hagg Lake location map.

Space intentionally left blank due to security concerns

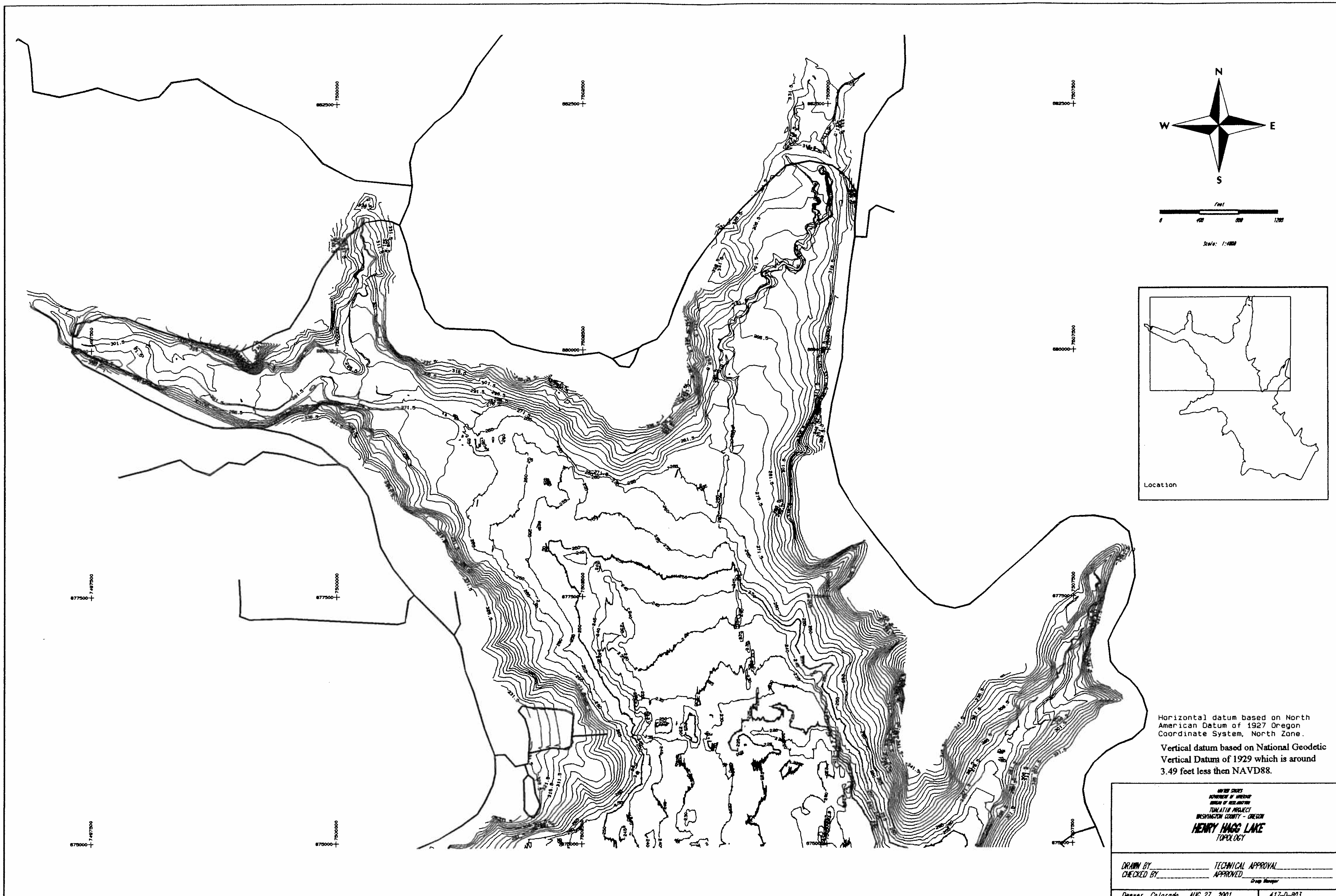

Figure 3. - Henry Hagg Lake topographic map, No. 417-D-803.

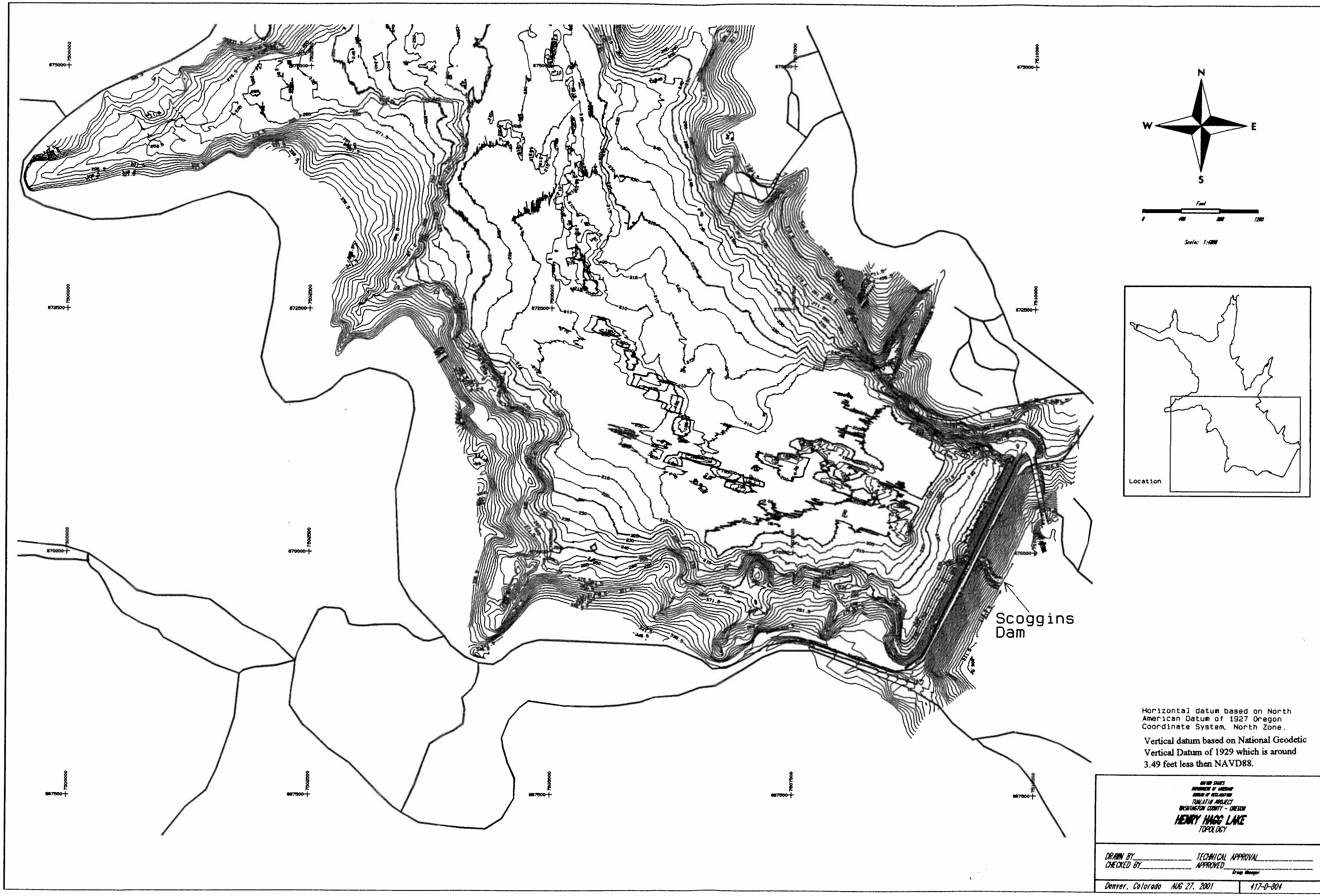

Figure 4. - Henry Hagg Lake topographic map, No. 417-D-804.

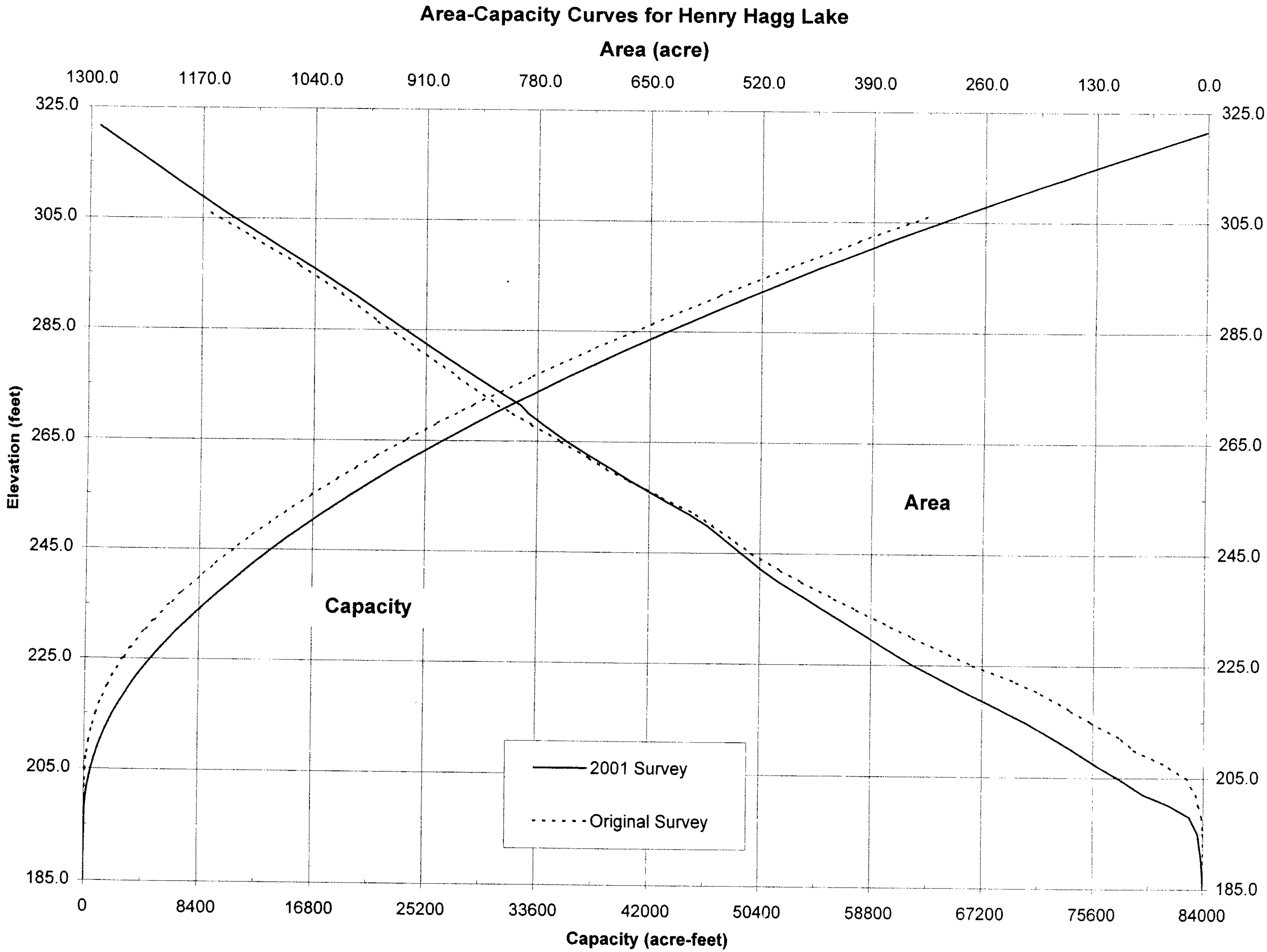

Figure 5. - 2001 area and capacity curves