PILOT BUTTE RESERVOIR

1995 SEDIMENTATION SURVEY

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation surveyed the underwater area of Pilot Butte Reservoir on June 29, 1995, to compile field data for developing a topographic map and computing a present storage-elevation relationship (area-capacity tables). The data were also used to calculate the volume of reservoir capacity lost because of sediment accumulation since dam closure in December 1926. The bathymetric survey used sonic depth recording equipment interfaced with a GPS (global positioning system) that gave continuous sounding positions throughout the reservoir. The underwater topography was developed by a computer graphics program using the collected data. The above-water topography was determined by digitizing contour lines from the USGS quad (United States Geological Survey quadrangle) map of the reservoir area. The USGS quad was developed from aerial photography obtained in 1948 and photorevised in 1978. The new topographic map of Pilot Butte Reservoir is a combination of the digitized contours and the 1995 underwater measured topography.

As of June 29, 1995, at top of active conservation elevation (ft) 5,460.0, the surface area was 901 acres with a total capacity of 33,721 acre-feet and an active capacity of 29,918 acre-feet. Since initial filling in December 1926, about 3,853 acre-feet of sediment have accumulated in Pilot Butte Reservoir, resulting in a 10.2-percent loss in reservoir volume. Since 1926, the average annual rate of reservoir capacity lost because of sediment accumulation is 56.2 acre-feet.

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by

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Denver, Colorado

July 1996

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INTRODUCTION

Pilot Butte Dam, Reservoir, and Powerplant are features of the Riverton Unit of the Pick-Sloan Missouri Basin Program. Additional major Riverton Unit features are Bull Lake Dam, Pilot Butte Powerplant, and the Wind River Diversion Dam. Pilot Butte Dam, located in Fremont County of west-central Wyoming, is located near the town of Morton in the Wind River Valley about 22 miles northwest of Riverton, Wyoming (fig. 1).

Pilot Butte is an off-channel reservoir and obtains Wind River water through the Wyoming Canal diverted by the Wind River Diversion Dam. The drainage area above the dam is 8.5 square miles ranging from elevation (ft) 5,410, top of inactive pool, to elevation 5,988 at one point along the northeast boundary. The Wyoming Canal traverses the basin, crossing just above the reservoir and separating the drainage into two areas. The larger area, above the canal, is 5.8 square miles; and the smaller area, surrounding the reservoir, is 2.7 square miles, 1.4 square miles of which is covered by the reservoir. The reservoir's original total capacity was reported as 36,900 acre-feet at reservoir elevation 5460.0 (Bureau of Reclamation, 1981).

Pilot Butte Dam was constructed between 1922 through 1926, and storage began in December 1926. The reservoir is formed by three zoned earthfill dike embankments (fig. 2) whose dimensions are:

	Embankments		
	No. 1	No. 2	No. 3
Hydraulic height*	offstream	offstream	offstream
Structural height (ft)	51	25	12
Top width (ft)	19.4	26	12
Crest length (ft)	1,300	1,200	3,400
Crest elevation (ft)	5469.5	5469.5	5467.0

Pilot Butte Dam is equipped with an uncontrolled, concrete-lined, open channel spillway which has a capacity of 500 cubic feet per second at maximum water surface elevation 5,461.3. The spillway, located in the right abutment of the main embankment, has a crest length of 100 feet with a crest elevation of 5,460.0. The outlet works is a concrete conduit through the foundation near the center of the main embankment controlled by three 4.8- by 6-foot slide gates. The capacity is 1,000 cubic feet per second at elevation 5,460.0.

Pilot Butte Powerplant is located at the drop from the Wyoming Canal into Pilot Butte Reservoir. The capacity is 1,600 kilowatts developed by two 800-kilowatt units operating at a maximum head of 105 feet.

* The definition of terms such as "structural height," "hydraulic 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 (Bureau of Reclamation) report presents the 1995 results of the first extensive survey of Pilot Butte Reservoir. The primary objectives of the survey were to gather data needed to:

- develop underwater topography
- compute area-capacity relationships
- estimate storage depletion caused by sediment deposition since closure of Pilot Butte Dam.

The bathymetric survey was run using sonic depth recording equipment interfaced with a DGPS (differential global positioning system) capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates as the survey boat was navigated along close spaced grid lines covering the reservoir area. The positioning system provided information to allow the boat operator to maintain course along these grid lines. Water surface elevations recorded by a Reclamation gage during the time of collection were used to convert the sonic depth measurements to true reservoir bottom elevations.

The 1995 underwater surface areas at predetermined 2-foot contour intervals were generated by a computer program using the collected data. The above-water reservoir areas were measured from the digitized USGS quad (U.S. Geological Survey 7.5-minute quadrangle) map of Pilot Butte Reservoir. The new topographic map of Pilot Butte Reservoir is a combination of the digitized and underwater measured topography (fig. 3). The 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.

Table 1 contains a summary of the Pilot Butte Reservoir watershed characteristics for the 1995 survey. The 1995 survey determined that the reservoir has a storage capacity of 33,721 acre-feet and a surface area of 901 acres at reservoir elevation (ft) 5,460.0. Since closure in 1926, the reservoir has accumulated a sediment volume of 3,853 acre-feet below reservoir elevation 5,460.0. This volume represents a 10.2-percent loss in capacity and an average annual loss of 56.2 acre-feet.

RESERVOIR OPERATIONS

The reservoir is primarily an irrigation facility with surcharge storage (the following values from June 1995 area-capacity tables):

- 1,271 acre-feet of surcharge storage between elevations 5,460.0 and 5,461.4.

- 29,918 acre-feet of active conservation storage between elevations 5,410.0 and 5,460.0.

- 665 acre-feet of inactive storage between elevations 5,407.5 and 5,410.0.

- 3,138 acre-feet of dead storage below elevation 5,407.5.

Pilot Butte Reservoir is an off-channel reservoir that receives its inflow from Wind River diversions into the Wyoming Canal. A structure in the Wyoming Canal permits flow to continue down the Wyoming Canal to an open channel into Pilot Butte Reservoir or into the penstock of the Pilot Butte Powerplant. Available records for years 1950 through June 1995 show that the average inflow into the reservoir was 212,761 acre-feet per year. The inflow and end-of-month stage records in table 1 show the extreme annual fluctuation of the reservoir. The available records show Pilot Butte Reservoir operation ranging from elevation 5,410.0 in 1965 to maximum elevation of 5,459.4 in 1977 and 1989.

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

The hydrographic survey equipment was mounted in the cabin of a 24-foot tri-hull aluminum vessel equipped with twin in-board motors. The hydrographic system contained on the survey vessel consisted of a GPS (global positioning system) receiver with a built-in radio and omnidirectional antenna, a dual frequency depth sounder, a helmsman display for navigation, a plotter, a computer, and hydrographic system software for collecting the 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. The power for the shore units was provided by a 12-volt battery.

GPS Technology and Equipment

The positioning system used at Pilot Butte Reservoir was NAVSTAR (NAVigation Satellite Timing and Ranging) 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 DOD (Department of Defense). 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 that is maintained in precise orbits, 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, which are then retransmitted to the user segment.

- The user segment is 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 for the distance measurement signal called L1 and L2. 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, Pilot Butte's water surface elevation parameter was known, which realistically meant only three satellite observations were needed to track the survey vessel. During the Pilot Butte Reservoir survey, the best six available satellites were used for position calculations.

The GPS receiver's absolute position is not as accurate as it appears in theory because of the function of range measurement precision and 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 by the ionosphere. GDOP (geometric dilution of precision) describes the geometric 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: PDOP is position dilution of precision (x,y,z), and HDOP is horizontal dilution of precision (x,y). The components are based only on the geometry of the satellites. The PDOP and HDOP were monitored during the Pilot Butte 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.

An additional and larger error source of GPS collection is caused by false signal projection, called S/A (selective availability). 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 DGPS (differential GPS). DGPS was used during the Pilot Butte 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 Pilot Butte Reservoir, position corrections were determined by the master receiver and transmitted via a UHF (ultra-high frequency) 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 resulted in positional accuracies of 1 to 2 meters for the moving vessel compared to positional accuracies of 100 meters with a single receiver.

The TSC (Technical Service Center) mobile and reference GPS units are identical in construction and consist of a 6-channel L1 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 RTCM (Radio Technical Commission for Maritime Services) 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 TSC's GPS system has the capability of establishing or confirming the land base control points by using notebook computers for logging data and post-processing software. The GPS collection system has the capability of collecting the data in 1927 or 1983 NAD (North American Datums) in the surveyed area's state plane coordinate system zone. For Pilot Butte Reservoir, the collected data were in Wyoming's 1927 NAD west central state plane zone.

Survey Method and Equipment

The Pilot Butte Reservoir hydrographic survey collection took 1 day and was conducted on June 29, 1995, at water surface elevation 5,454.0. 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. The majority of the transects were run in a mostly north-south direction. Data were also collected along the shore as the boat traversed to the next transect. Transects were also run in a mostly east-west direction to provide additional data for complete contour development. The survey vessel's guidance system gave directions to the boat operator to assist in maintaining course along these predetermined grid lines. During each run, the depth and position data were recorded on the notebook computer hard drive for subsequent processing by TSC personnel. The underwater data set includes about 8,661 data points. A graph plotter was used in the field to track the boat and ensure adequate coverage during the collection process. The water surface elevation recorded by a Reclamation gage during the time of collection was used to convert the sonic depth measurements to true lake bottom elevations.

The hydrographic survey crew used a benchmark as the control point for the shore station site that was previously verified by personnel from Reclamation's Cody Office. The shore unit was set over a Reclamation 4-inch brass cap marked CSSA, which is located at the north shore of the reservoir. This point was selected because it had known coordinates, was accessible, was located near the reservoir, and was on a hill overlooking the reservoir. The location allowed for good radio transmission from the known reference survey point to the mobile survey vessel throughout the reservoir. During post processing of the collected data, all points without differential correction were removed.

Prior to data collection, the depth sounder 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.

RESERVOIR AREA AND CAPACITY

Topography Development

The topography of Pilot Butte Reservoir was developed from collected underwater data and from a USGS quad (USGS 7.5-minute quadrangle map). The upper contours of Pilot Butte Reservoir were developed by digitizing the reservoir water surface contour line from the USGS quad map that covered the Pilot Butte Reservoir area. The measured surface area of this contour was 836 acres. This measured surface area compares to the original reservoir water surface elevation of 5,454.0 feet. In the 1995 study, the USGS Pilot Butte Reservoir water surface contour was assumed to be elevation 5,454.0. The USGS quad map was dated 1959 and was photorevised in 1978. ARC/INFO V7.0.2 geographic information system software was used to digitize the USGS quad contours. The digitized contours were transformed to Wyoming's NAD 1927 west central state plane coordinates using the ARC/INFO PROJECT command.

Contours for elevations below 5,454.0 feet were computed from collected underwater data using the TIN (triangular irregular network) surface modeling package within ARC/INFO. The underwater survey data were collected in the Wyoming west central zone state plane coordinates in NAD 1927. The collected underwater data ranged in elevation from 5,386.6 to 5,450.6 feet. 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 know as Delaunay's criteria for triangulation. Triangles are formed between all data points including all boundary points. This method preserves all collected survey points. The method requires that a circle drawn through the three nodes of a triangle will contain no other point. This requirement means that sample points are connected to their nearest neighbors to form triangles. Elevation contours are then interpolated along the triangle elements. The TIN method is discussed in great detail in the ARC/INFO V7.0.2 user documentation.

The elevation 5,454.0-foot contour that was digitized from the USGS quad map was used to perform a clip of the Pilot Butte Reservoir TIN such that interpolation was not allowed to occur outside of the 5,454.0-foot contour. This clip was performed using the hardclip option of the ARC/INFO CREATETIN command. In creating the TIN, points that fell within a set distance of each other were weeded out to eliminate flat triangular elements. Flat triangles occur where all three points making up a triangle have the same elevation. Elimination of redundant points helped to improve the performance of the contouring process as well as helped to create more continuous contours in the lower elevations of the reservoir.

The linear interpolation option of the ARC/INFO TINCONTOUR command was used to interpolate contours from the Pilot Butte 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 little bearing on the computation of surface areas and volumes for Pilot Butte Reservoir. The contour topography at 5-foot intervals is presented on figure 3.

Development of 1995 Contour Areas

The 1995 contour surface areas for Pilot Butte Reservoir were computed in 2-foot intervals from elevation 5,388.0 to 5,454.0 using the Pilot Butte Reservoir TIN discussed above. The 1995 survey measured the minimum reservoir elevation as 5,386.4 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.

1995 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 2-foot contour intervals from minimum reservoir elevation 5,386.5 to elevation 5,554.0 were used as the control parameters for computing the Pilot Butte Reservoir capacity. The original surface area of 901 acres at maximum conservation storage elevation 5,460.0 was used as the maximum control parameter. The program can compute an area and capacity at elevation increments of 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, which was set at 0.000001 for Pilot Butte Reservoir. This 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) tests the fit until it also 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 1995 Pilot Butte Reservoir area and capacity computations are listed in table 1 and columns (4) and (5) of table 2. Listed in columns (2) and (3) of table 2 are the original surface areas and recomputed capacity values. A separate set of 1995 area and capacity tables has been published for the 0.01-, 0.1-, and 1-foot elevation increments (Bureau of Reclamation, 1995). A description of the computations and coefficients output from the ACAP85 program is included with these tables. Both the original and 1995 area-capacity curves are plotted on figure 4. As of June 1995, at elevation 5,460.0, the surface area was 901 acres with a total capacity of 33,721 acre-feet and an active capacity of 29,918 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Sediments have accumulated in Pilot Butte Reservoir to a total volume of 3,853 acre-feet since dam closure in December 1926. This volume is calculated at spillway crest elevation 5,460.0. It must be noted that the 1995 underwater survey was conducted at water surface elevation 5,454.0 and the final product relied on a USGS quad map for the above water topography and the original surface areas above elevation 5,454.0 for computing the 1995 reservoir capacity. Column (6) of table 2 gives the measured sediment volume by elevation and illustrates that the majority of the deposit is located in the lower elevations of the reservoir.

Of the total deposited sediment of 3,853 acre-feet, 2,235 acre-feet was deposited in the inactive pool storage areas and 1,618 acre-feet in the active pool storage areas. The average annual rate of sediment deposition between closure and June 1995 (68.5 years) was 56.2 acre-feet per year. The storage loss in terms of percent of original storage capacity was 10.2 percent. Tables 1 and 2 contain the Pilot Butte Reservoir sediment accumulation and water storage data based on the 1995 resurvey.

REFERENCES

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

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

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

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

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

Bureau of Reclamation, Denver Office, *Pilot Butte Reservoir Area and Capacity Tables, Riverton Unit*, Great Plains Region, Denver, CO, June 1995.

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

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

RESERVOIR SEDIMENT
DATA SUMMARY

Pilot Butte Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM offstream[1]	3. STATE Wyoming
	4. SEC. 33 TWP. 3N RANGE 1E	5. NEAREST P.O. Riverton	6. COUNTY Fremont
	7. LAT 43° 11′ 39″ LONG 108° 45′ 20″	8. TOP OF DAM ELEVATION 5,467	9. SPILLWAY CREST EL. 5,460

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	5,461.4	915	1,271[2]	38,845[2]	
	b. FLOOD CONTROL					12/1926
	c. POWER					
	d. WATER SUPPLY					16. DATE NORMAL OPERATION BEGAN
	e. IRRIGATION					
	f. CONSERVATION	5,460	901	31,536[2]	37,574[2]	
	g. INACTIVE	5,410	345	6,038[2]	6,038[2]	
	17. LENGTH OF RESERVOIR 2.3 MILES			AVG. WIDTH OF RESERVOIR 0.6 MILES		

BASIN	18. TOTAL DRAINAGE AREA 8.5 SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 9[3] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 8.5 SQUARE MILES	23. MEAN ANNUAL RUNOFF [1,4] INCHES
	20. LENGTH MILES AV. WIDTH MILES	24. MEAN ANNUAL INFLOW 212,761 [1,5] ACRE-FEET
	21. MAX. ELEVATION 5,988 MIN. ELEVATION 5,410 55-MIN.	25. ANNUAL TEMP. MEAN 44°F[3] RANGE 101°F to -42°F[3] 103°F,[44]

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
	12/1926			Contour (D)	5-ft	901[6]	37,574[6]	0.18
	6/29/95	68.5	68.5	Contour (D)	2-ft	901[6,7]	33,721[6]	0.16

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
6/29/95	9	212,761[5]	296,698[5]	9,733,840[5]	212,761[5]	9,733,840[5]

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.
6/29/95	3,853	56.2	6.6	3,853	56.2	6.6

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42. SEDIMENT INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.
6/29/95				0.150[8]	10.2[8]		

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, CREST ELEVATION										
		95.0-80.0	80.0-70.0	70.0-60.0	60.0-50.0	50.0-40.0	40.0-20.0	20.0-Crest			
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION										
6/95		3.2	24.0	14.4	16.4	20.7	19.4	1.9			

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														

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

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.[9]	MIN. ELEV.[9]	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1950	5451.2	5418.1	221,529	1951	5450.7	5411.0	228,253
1952	5445.3	5410.4	268,114	1953	5457.6	5419.6	259,754
1954	5453.0	5421.0	285,891	1955	5457.6	5417.0	247,317
1956	5455.2	5410.4	257,733	1957	5455.7	5418.5	234,447
1958	5456.3	5420.7	263,253	1959	5451.9	5418.6	234,480
1960	5453.6	5417.9	255,289	1961	5456.6	5421.1	210,069
1962	5456.8	5421.9	268,238	1963	5458.5	5422.5	259,207
1964	5459.2	5410.1	249,139	1965	5459.2	5410.0	224,190
1966	5458.2	5425.5	264,469	1967	5457.5	5412.0	247,640
1968	5457.1	5421.6	267,078	1969	5457.6	5424.4	273,838
1970	5457.9	5432.5	239,394	1971	5451.8	5417.3	186,319
1972	5453.5	5426.0	296,698	1973	5457.4	5438.2	188,848
1974	5456.9	5429.6	195,918	1975	5455.3	5438.9	168,730
1976	5451.9	5429.3	192,766	1977	5459.4	5424.9	120,770
1978	5458.5	5423.4	187,679	1979	5452.8	5428.5	171,997
1980	5457.0	5425.7	201,372	1981	5458.2	5422.8	183,545
1982	5457.5	5431.6	195,417	1983	5458.6	5447.6	166,026
1984	5457.3	5445.0	203,391	1985	5457.6	5436.1	183,500
1986	5458.5	5441.0	204,085	1987	5459.3	5420.5	170,196
1988	5458.3	5426.2	183,205	1989	5459.4	5445.4	185,614
1990	5455.6	5439.1	184,192	1991	5457.9	5436.2	160,312
1992	5457.9	5435.1	160,956	1993	5458.0	5438.5	168,881
1994	5455.8	5427.9	151,325	1995	5455.9	5453.3	62,772[10]

46. ELEVATION - AREA - CAPACITY DATA FOR **1995 CAPACITY**

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
5386	0	0	5388	41	24	5392	101.2	317
5396	145.2	812	5400	187.7	1,479	5404	223.5	2,303
5408	258.8	3,267	5410	277.9	3,803	5412	297.2	4,378
5416	341.1	5,652	5420	394.8	7,120	5424	455.2	8,819
5428	513.9	10,756	5432	573.2	12,931	5436	625.0	15,329
5440	671.8	17,922	5444	721.3	20,704	5448	770.8	23,691
5452	814.0	26,860	5454	836.0	28,510	5460	901	33,721

47. REMARKS AND REFERENCES

[1] Wind River diverted via Wyoming Canal.

[2] Original capacity recomputed by Bureau of Reclamation program ACAP.

[3] Reclamation *Project Data Book*, 1981.

[4] Off-channel reservoir, inflows regulated from Wind River diversions.

[5] Calculated, unregulated, monthly inflows for available records, water years 1950 through June 1995.

[6] Surface area and capacity at elevation 5460.0, spillway crest. Area and capacity calculated by Bureau of Reclamation program ACAP.

[7] 1995 survey determined surface areas from underwater collected depths and digitized USGS contours. From measured surface area of 836 acres, USGS digitized contour was assumed to be elevation 5454.0. 901 acres at elevation 5460.0 from original measured values, which assumed no area change.

[8] Average annual and total sediment deposits divided by 37,574 acre-feet, original capacity at elevation 5460.0.

[9] Maximum and minimum end-of-month water surface elevations.

[10] For water year 1995, from October 1994 through June 1995.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE March 1996

Table 2. - Summary of 1995 survey results.

(1) Elevation (ft)	(2) Original Area (acres)	(3) Original Capacity (acre-ft)	(4) 1995 Area (acres)	(5) 1995 Capacity (acre-ft)	(6) Measured sediment Volume (acre-ft)	(7) Measured Sediment (%)	(8) Reservoir Depth (%)
5460.0	901.0	37,574	901	33,721	3,853	100.0	100.0
5456.0	858.0	34,055	(858)	30,204	3,851	99.9	95.3
5454.0	836.0	32,361	836.0	28,510	3,851	99.9	92.9
5452.0	815.0	30,710	814.0	26,860	3,850	99.9	90.6
5448.0	772.0	27,537	770.8	23,691	3,846	99.8	85.9
5444.0	728.0	24,540	721.3	20,704	3,836	99.6	81.2
5440.0	686.0	21,703	671.8	17,922	3,781	98.1	76.5
5436.0	643.0	19,056	625.0	15,329	3,727	96.7	71.8
5432.0	599.0	16,572	573.2	12,931	3,641	94.5	67.0
5428.0	556.0	14,261	513.9	10,756	3,505	91.0	62.3
5424.0	514.0	12,121	455.2	8,819	3,302	85.7	57.6
5420.0	470.0	10,153	394.8	7,120	3,033	78.7	52.9
5416.0	426.0	8,361	341.1	5,652	2,709	70.3	48.2
5412.0	375.0	6,758	297.2	4,378	2,380	61.8	43.5
5410.0	345.0	6,038	277.9	3,803	2,235	58.0	41.2
5408.0	(325)	5,367	258.8	3,267	2,100	54.5	38.8
5407.5	(320)	5,206	(254)	3,138	2,068	53.7	37.6
5404.0	(286)	4,145	223.5	2,303	1,842	47.8	34.1
5400.0	(246)	3,080	187.7	1,479	1,601	41.6	29.4
5396.0	(207)	2,174	145.2	812	1,362	35.3	24.7
5392.0	(168)	1,262	101.2	317	945	24.5	20.0
5388.0	(128)	833	41.0	24	809	21.0	15.3
5386.0	(108)	596	0.0	0	596	15.5	12.9
5384.0	(89)	399	-	-	399	10.4	10.6
5380.0	(49)	123	-	-	123	3.2	5.9
5376.0	(10)	5	-	-	5	0.1	1.2
5375.0	0	0	-	-	0	0.0	0.0

(1) Elevation of reservoir water surface.
(2) Original reservoir surface area.
(3) Original calculated reservoir capacity computed using Reclamation's computer program ACAP from original measured surface areas.
(4) Reservoir surface area from 1995 survey.
(5) 1995 calculated reservoir capacity computed using ACAP.
(6) Measured sediment volume = column (3) - column (5).
(7) Measured sediment expressed in percentage of total sediment of 3,853 acre-feet at elevation 5460.0.
(8) Depth of reservoir expressed in percentage of total depth (85 ft).

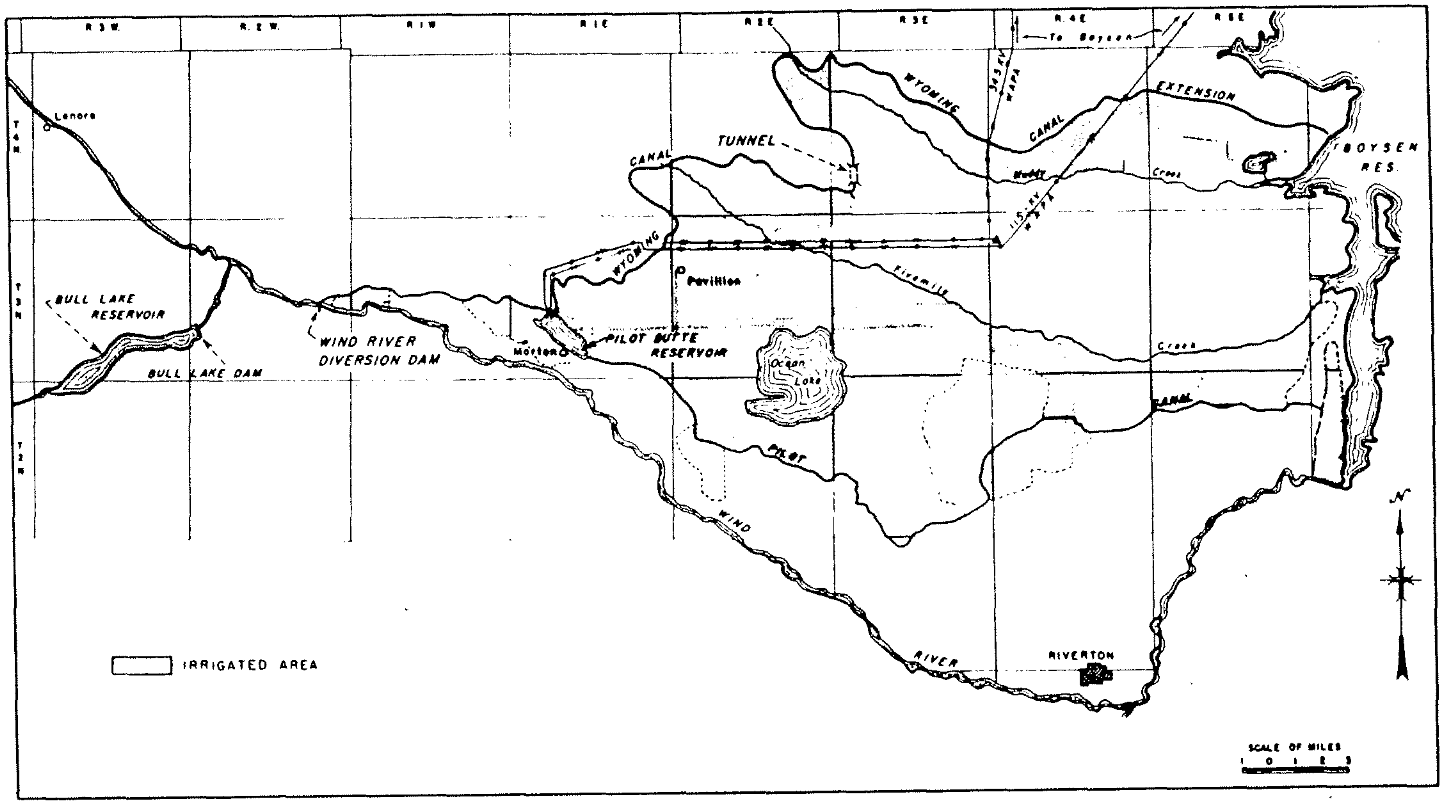

Figure 1. - Pilot Butte Reservoir location map.

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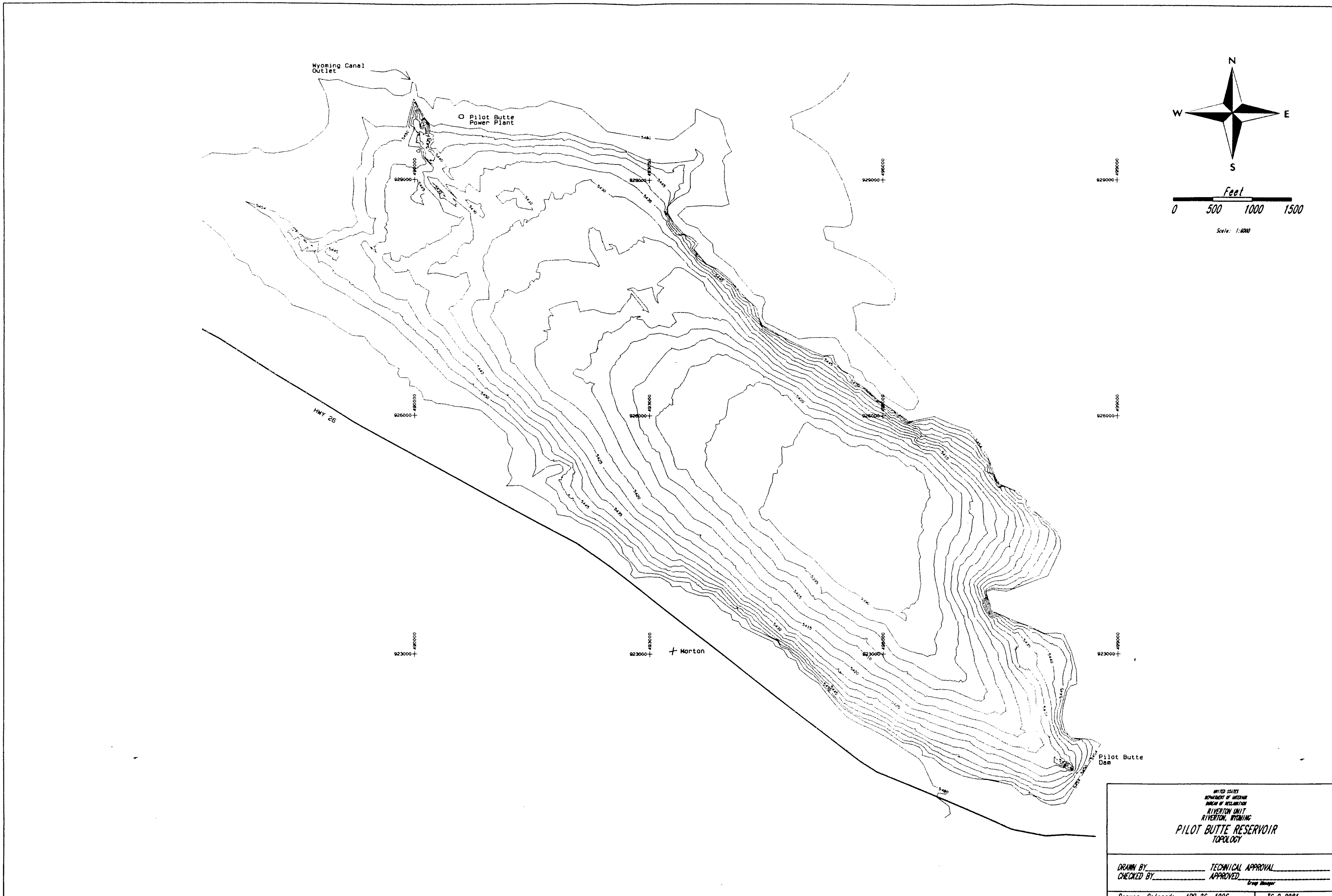

Figure 3. - Pilot Butte Reservoir topographic map.

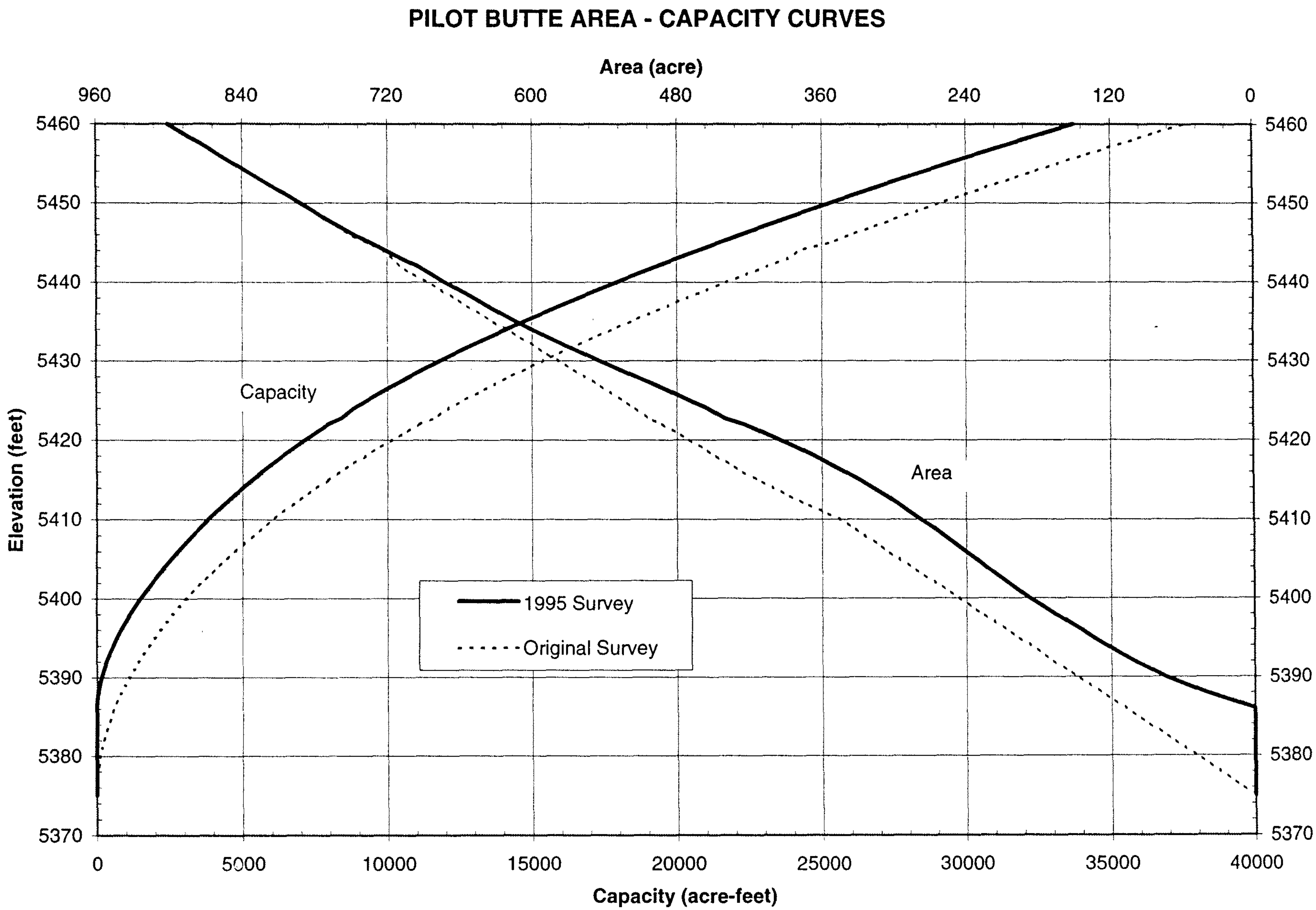

Figure 4. - Area and capacity curves—Pilot Butte Reservoir.

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.