STORAGE CAPACITY OF FENA VALLEY RESERVOIR, GUAM, MARIANA ISLANDS, 1990

By Lenore Y. Nakama

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CONVERSION FACTORS

Multiply	By	To obtain
acre	0.4047	hectometer
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile per hour (mi/h)	1.609	kilometer per hour
pound per cubic foot (lb/ft^3)	16.0184	kilogram per cubic meter
square mile (mi^2)	2.590	square kilometer
ton per square mile per year [$(ton/mi^2)/yr$]	2.8449	megagram per square kilometer per year

Temperature is given in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) by using the equation:

$$°F = 1.8 \times °C + 32$$

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ABSTRACT

Fena Valley Reservoir, located in south-central Guam, was constructed in 1951 by the U.S. Navy to provide a dependable water-supply for both Navy personnel and local citizens. Analysis of bathymetric data collected during June 1990 indicates a total storage capacity for Fena Valley Reservoir of about 7,180 acre-feet, which is a loss of about 1,120 acre-feet, or 13.5 percent, with respect to the original design-survey estimate of 8,300 acre-feet. Sediment deposition appears to be greatest near the dam and at the mouth of the Imong River, where a delta is forming. Between 1949 and 1990, the largest relative declines in storage capacity (greater than 50 percent) have occurred at lower altitudes, significantly reducing unusable storage. The estimated suspended-sediment yield for the Fena Valley watershed, based on 40 years of sediment accumulation, is about 3,480 tons per square mile per year, considerably higher than the range (465 to 1,455 tons per square mile per year) estimated for three surrounding basins.

INTRODUCTION

Fena Valley Reservoir, located in south-central Guam, is the major source of domestic water supply for southern Guam (fig. 1). The dam regulating the flow of the Fena River is 85 ft in height, 1,050 ft in length, and has a spillway altitude of about 111 ft. The reservoir, which is under the management of the U.S. Navy Public Works Center, Guam, provides a daily water supply of about 35 acre-ft.

The total storage capacity of the reservoir, estimated during the original design-survey done in 1949, was 8,300 acre-ft when filled to spillway altitude. Measurements of the reservoir bathymetry in 1973 (Kennedy Engineers, Inc., 1974) and 1979 (Curtis, 1984) indicated that the storage capacity of the reservoir had been reduced by about 5 percent because of sediment accumulation. Because updated data on changes in the storage capacity of the reservoir is useful in the assessment of the potential water supply, the U.S. Geological Survey entered into a cooperative agreement with the U.S. Navy in 1990 to determine the storage capacity of Fena Valley Reservoir.

Purpose and Scope

This report describes the results of a study to determine the storage capacity of Fena Valley Reservoir. Depths below the water surface were measured in June 1990 to identify changes in the topography of Fena Valley Reservoir. Contours above the water-surface altitude were based on data collected during the 1973 reservoir survey (Kennedy Engineers, Inc., 1974).

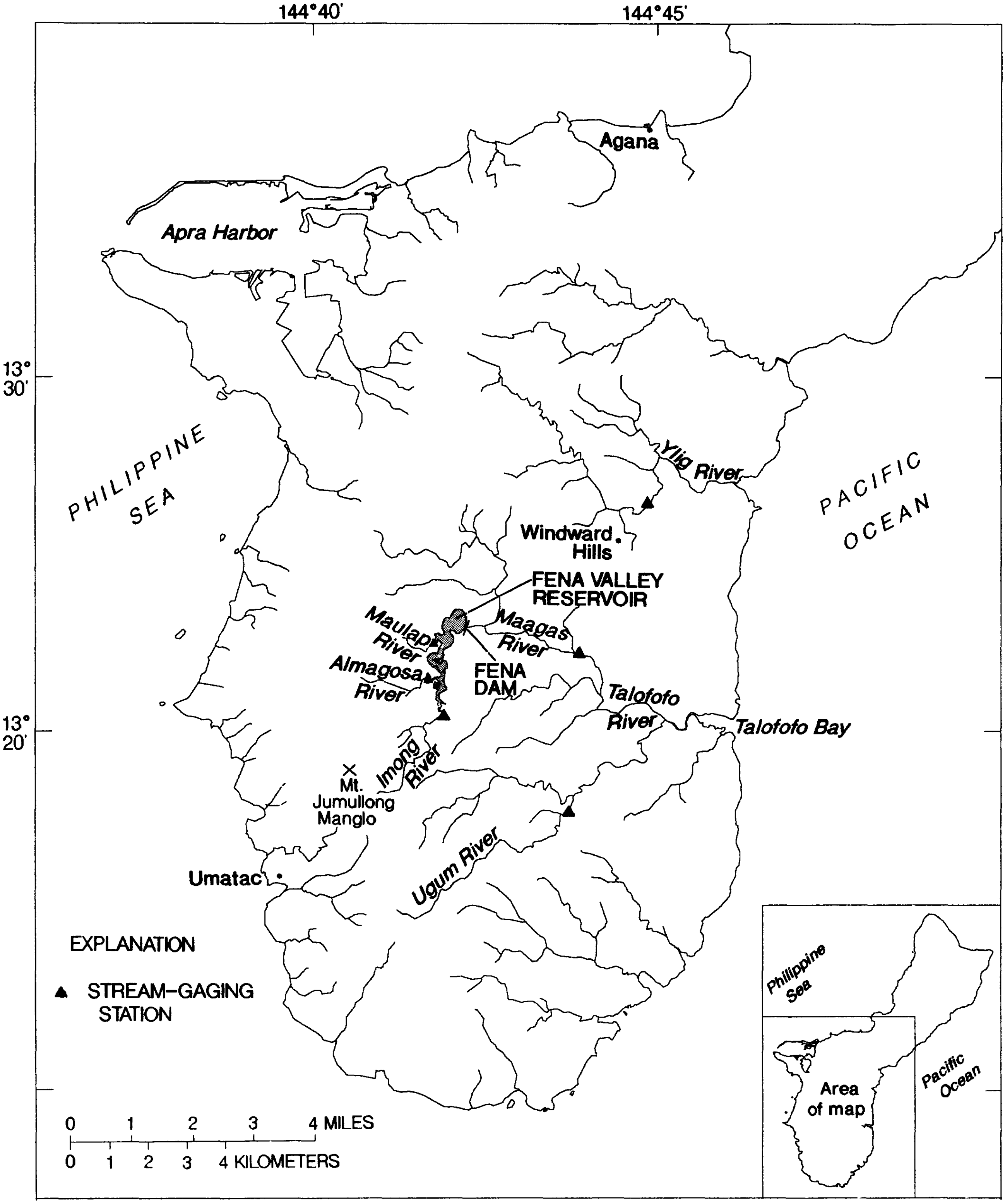

Figure 1. Location of Fena Valley Reservoir and nearby stream-gaging stations.

A new topographic map of the reservoir was developed and analyzed to determine the present reservoir storage capacity. Stage-surface area and stage-capacity curves that establish the existing relation between reservoir stage, surface area, and capacity were developed. Areas of major sediment deposition were identified by comparing the 1990 topographic map with older topographic maps. The 1990 storage capacity of the reservoir was evaluated in relation to storage capacities determined from previous investigations, and the estimated suspended-sediment yield for the Fena Valley watershed was compared with suspended-sediment yields computed for adjacent basins.

Description of the Study Area

The climate of Guam is uniformly warm and humid throughout the year. Average annual rainfall is about 95 in. About 65 percent of the annual rainfall usually occurs during the rainy season from July through November. In contrast, only 15 percent of the annual precipitation usually occurs during the dry season from January to May. From February through April, monthly rainfall totals less than 4 in. in 3 out of 4 years on the average (Ward and others, 1965). December and June are transitional months; climatic conditions are variable from year to year. Typhoons generally occur during the rainy season and frequently bring daily rainfall of 6 to 10 in. and winds in excess of 75 mi/h.

The watershed for the Fena Valley Reservoir is located in the volcanic uplands of southern Guam (Tracey and others, 1964). All of the Fena Valley Reservoir watershed lands are under the jurisdiction of the U.S. Navy. The drainage area above the dam is 5.88 mi^2. Altitude of the land surface in the Fena watershed ranges from about 111 ft at the dam spillway to 1,282 ft at Mt. Jumullong Manglo on the western drainage divide.

Dense tropical forests and a variety of grasses grow on overland slopes that range from less than 15 percent to greater than 50 percent. The land surface is characteristically steep and highly-dissected in the volcanic terrain that underlies about 87 percent of the total watershed area. Gentler slopes are associated with areas where limestones rest unconformably on the volcanic rocks at higher altitudes in the watershed. Runoff is rapid on the predominantly clay soils that are found throughout the watershed (U.S. Soil Conservation Service, 1988). The watershed is relatively undisturbed, except for areas where occasional wildfires occur. The areas of bare soil that result from the wildfires are susceptible to erosion and contribute to the sediment load carried in the streams.

Three main rivers, the Almagosa, the Imong, and the Maulap drain 75 percent of the Fena Valley watershed (fig. 1). Annually, the combined discharge of the three rivers averages about 15,000 acre-ft. Rainfall in the region is highly seasonal, and this is reflected in the records of monthly runoff and reservoir stage (fig. 2). During the dry season, water levels in the reservoir decline gradually, as average daily withdrawals generally exceed the volume of runoff available for reservoir recharge. With the onset of the

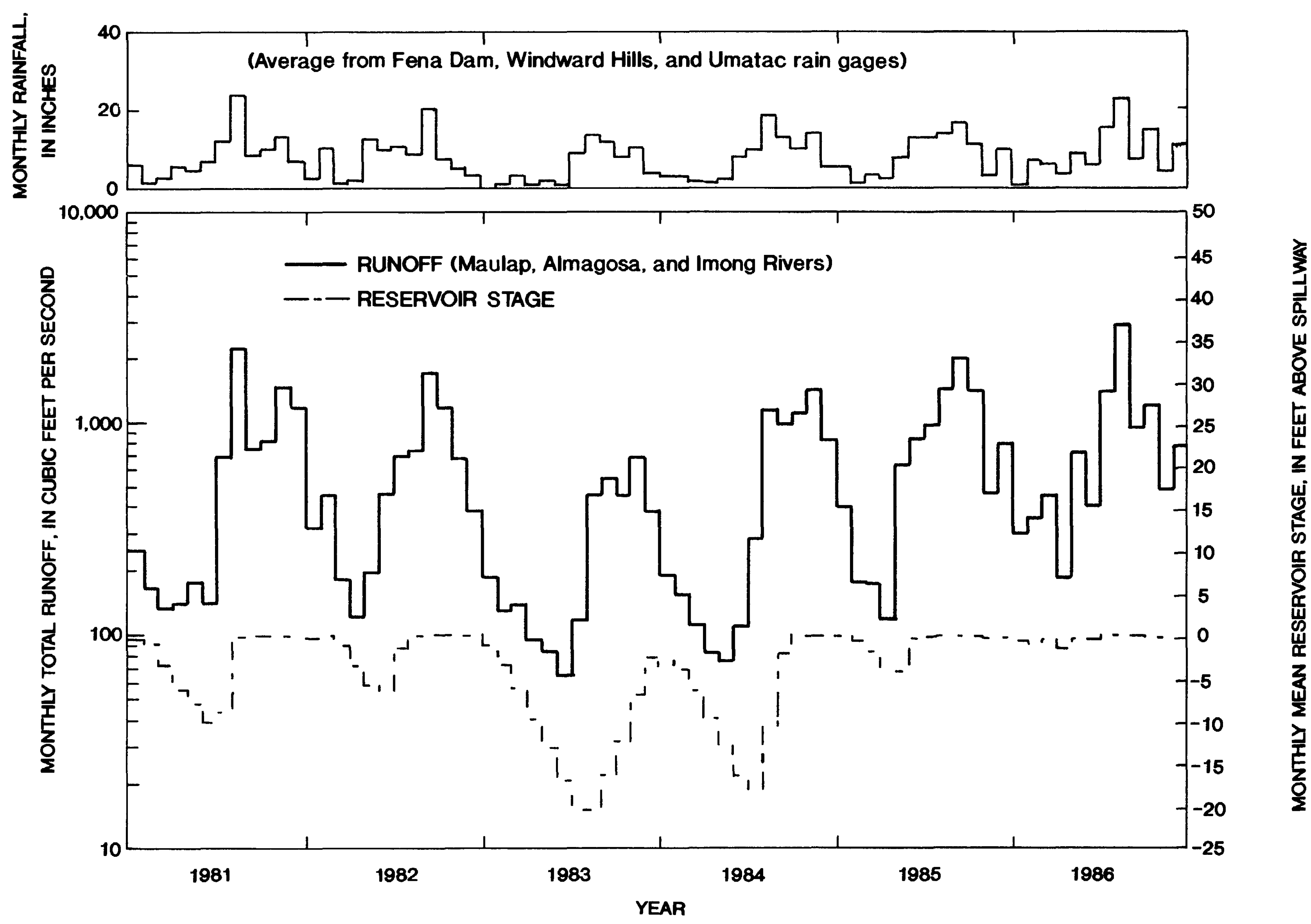

Figure 2. Monthly rainfall, monthly total runoff, and monthly mean stage of Fena Valley Reservoir, 1981-86.

wet season, generally in mid-June, increases in precipitation, runoff, and reservoir water levels occur. In most years, wet-season runoff is adequate for complete replenishment of the reservoir.

Previous Investigations

Three previous investigations of the Fena Valley Reservoir storage capacity have been made, in 1949, 1973, and 1979. The methods and results of those investigations are described below.

Preconstruction Survey (1949)

The original design-survey was made in 1949 by Frederic R. Harris, Inc. (written commun., 1949). Information is not available on the methods of surveying or on the volumetric computation. According to preconstruction estimates, the surface area of the reservoir, when filled to spillway altitude, would be 197 acres and the storage capacity would be 8,300 acre-ft. In the 1949 topographic map, a bay near the Almagosa River is on the east side of the river instead of the west, and a small island in the bay is not shown.

1973 Survey

In 1973, a topographic map was developed from new aerial photographs and supplemented with more than 500 lake soundings (Kennedy Engineers, Inc., 1974). The configuration of the shoreline generally was the same as that mapped in 1949; however, the discrepancies noted above were absent. Analysis of the 1973 map indicated that the reservoir surface area occupied 196 acres and had a storage capacity of about 7,500 acre-ft when filled to spillway altitude. A decrease in reservoir storage capacity of about 5 percent, or 500 acre-ft, was reported; apparently, the original 1949 estimate of storage capacity was recomputed, and the number used for comparison was 8,000 acre-ft. The 1974 report shows revised stage-surface area and stage-capacity curves for 1949. The report does not document the reasons for the recomputations or the methods applied.

1979 Survey

A complete resurvey of Fena Valley Reservoir topography was done in 1979 (Curtis, 1984). Thirty monuments were established around the perimeter of the reservoir to allow for later comparative surveys. A sonic sounder was used to record depths along 32 cross sections of the reservoir. Analysis of this topographic map indicated that the surface area of the reservoir was 195 acres with a storage capacity of 7,863 acre-ft when filled to spillway altitude. A decrease in capacity of about 5 percent, or 440 acre-ft, from the original 1949 estimate of 8,300 acre-ft was reported. The 1979 report shows unrevised stage-surface area and stage-capacity curves for 1949 and 1973.

DATA COLLECTION

For consistency, the same cross sections used in the 1979 study were used for the present reservoir survey. However, none of the monuments used to establish cross-section endpoints during the 1979 reservoir survey were recovered. The rebar used for construction of the monuments probably had corroded under the harsh climatic conditions. Temporary monuments were established in 1990 that corresponded to locations of the 1979 monuments, as indicated on the map developed during the 1979 study. The sinuate shape of the shoreline, with numerous spits and embayments, aided in the identification of proximate cross-section endpoint locations (fig. 3). The temporary monuments established for the present study are believed to be located to within 25 ft of those established in 1979.

A tagline between cross-section endpoints was used for recording distance increments and for navigation. From June 22 through June 28, 1990, continuous measurements of depth below the water surface were recorded for 30 cross sections of the reservoir using a fathometer, an instrument that uses sonic pulses to determine depth. Cross sections between endpoints 27 and 28, 27 and 30, and 29 and 30 were not navigable because of water levels that fluctuated between 11.1 ft and 11.6 ft below spillway altitude during the data-collection period; these cross sections were surveyed by differential levelling. A general description of this technique can be found in Moffitt and Bouchard (1987).

Before measuring along each cross section, the fathometer was calibrated. Depths recorded by the fathometer were compared with depth readings taken manually using a measuring tape, and the difference between the two readings was used to correct the graphical record. Adjustments ranged from 0.5 to 3.8 ft and averaged 2.3 ft. The adjusted data are believed to be a reasonably accurate representation of the reservoir-bottom contours.

RESERVOIR STORAGE CAPACITY, 1990

After correction for reservoir stage at the time the data were collected, altitudes below the water surface were plotted for each cross section and manually interpolated to develop a new topographic map of the Fena Valley Reservoir (fig. 3). For comparative purposes, the map base developed for the original 1949 topographic map was used for the 1990 topographic map; all spatial data are referenced to the north and east of an arbitrary datum on a grid spacing of 1,000 ft.

The most recent aerial photographs available for the establishment of the shoreline configuration were taken during the 1973 reservoir survey, in which aerial photogrammetric techniques were used to determine the shoreline configuration and reservoir surface area. Therefore, contours above the water surface altitude were derived from the 1973 map. Tape-measured distances between cross-section endpoints were compared with those measured on the 1973 map. Differences between the two sets of distance readings ranged from 0 to 13 percent and averaged 4 percent, indicating little change in reservoir width at the surveyed sections since 1973.

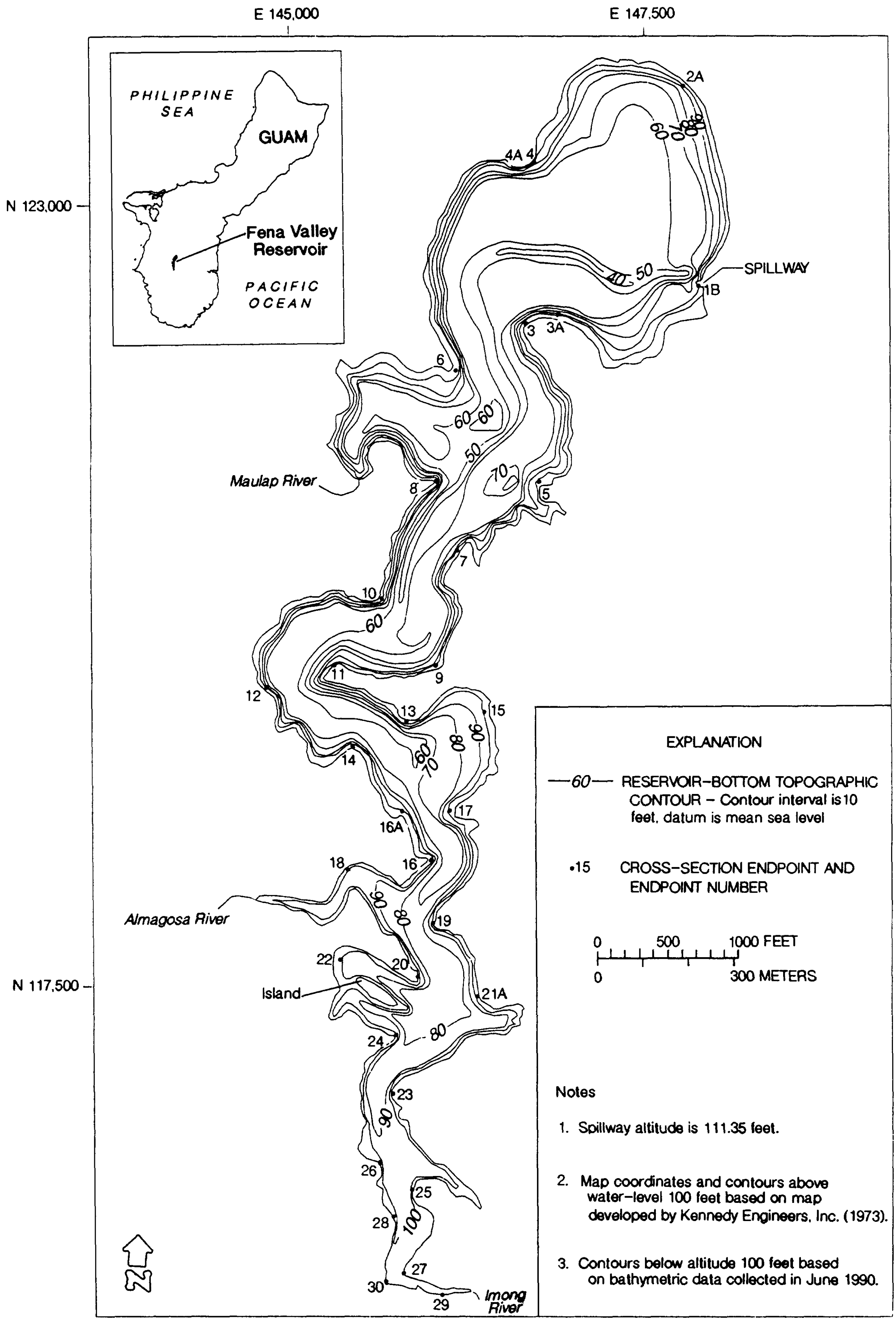

Figure 3. Topography of Fena Valley Reservoir, 1990, and cross-section endpoint locations.

Reservoir surface areas were determined at each of the 10-ft contours using a geographic information system. The increment of storage between each 10-ft contour was computed by multiplying the average of the areas at the two altitudes by the altitude difference (Linsley and Franzini, 1972). The storage capacity at the spillway altitude was computed by summing the increments of storage below altitude 111.35 ft (table 1).

Table 1.--*Summary of surface areas and corresponding volumes used to compute storage capacity of Fena Valley Reservoir*

[ft, feet; acre-ft, acre-feet]

Altitude (ft)	Surface area (acre)	Altitude difference (ft)	Incremental volume (acre-ft)	Cumulative volume (acre-ft)
40	1.0	1.0	1.0	1.0
50	8.0	10.0	45.0	46.0
60	55.0	10.0	315.0	361.0
70	97.0	10.0	760.0	1,121.0
80	122.0	10.0	1,095.0	2,216.0
90	145.0	10.0	1,335.0	3,551.0
100	168.0	10.0	1,565.0	5,116.0
111.35	196.0	11.35	2,065.7	7,181.7

Because the 1973 study indicated that the 1949 storage capacity had been over-estimated by about 300 acre-ft, storage capacity was recomputed in 1990 using the original 1949 topographic map. The errors in the mapped shoreline were resolved. On the basis of the revised 1949 topographic map, 1949 storage capacity was recomputed to be about 8,390 acre-ft. Because of uncertainties associated with the 1973 estimate of storage capacity in 1949, the original 1949 storage capacity estimate of 8,300 acre-ft is probably more accurate.

Analysis of the data indicate that the current storage capacity of the reservoir at the spillway altitude is about 7,180 acre-ft, which represents a loss of about 1,120 acre-ft (28 acre-ft/yr), or 13.5 percent, with respect to the original design-survey estimate of 8,300 acre-ft. Stage-surface area and stage-capacity curves summarizing the current relations between reservoir stage, surface area, and storage capacity are shown in figure 4. Interpolated ratings for reservoir surface area and reservoir capacity in 1990 are given in tables 2 and 3 (at end of report).

SEDIMENT ACCUMULATION

A comparison of the 1990 topographic map with those developed in 1949, 1973, and 1979 indicates that sediment deposition appears to be greatest near the dam and at the mouth of the Imong River, where a delta is forming. Between 1949 and 1990, the largest relative declines in storage capacity have occurred below the altitude of the lower inlet (66 ft), substantially reducing the volume of water held in unusable storage (table 4).

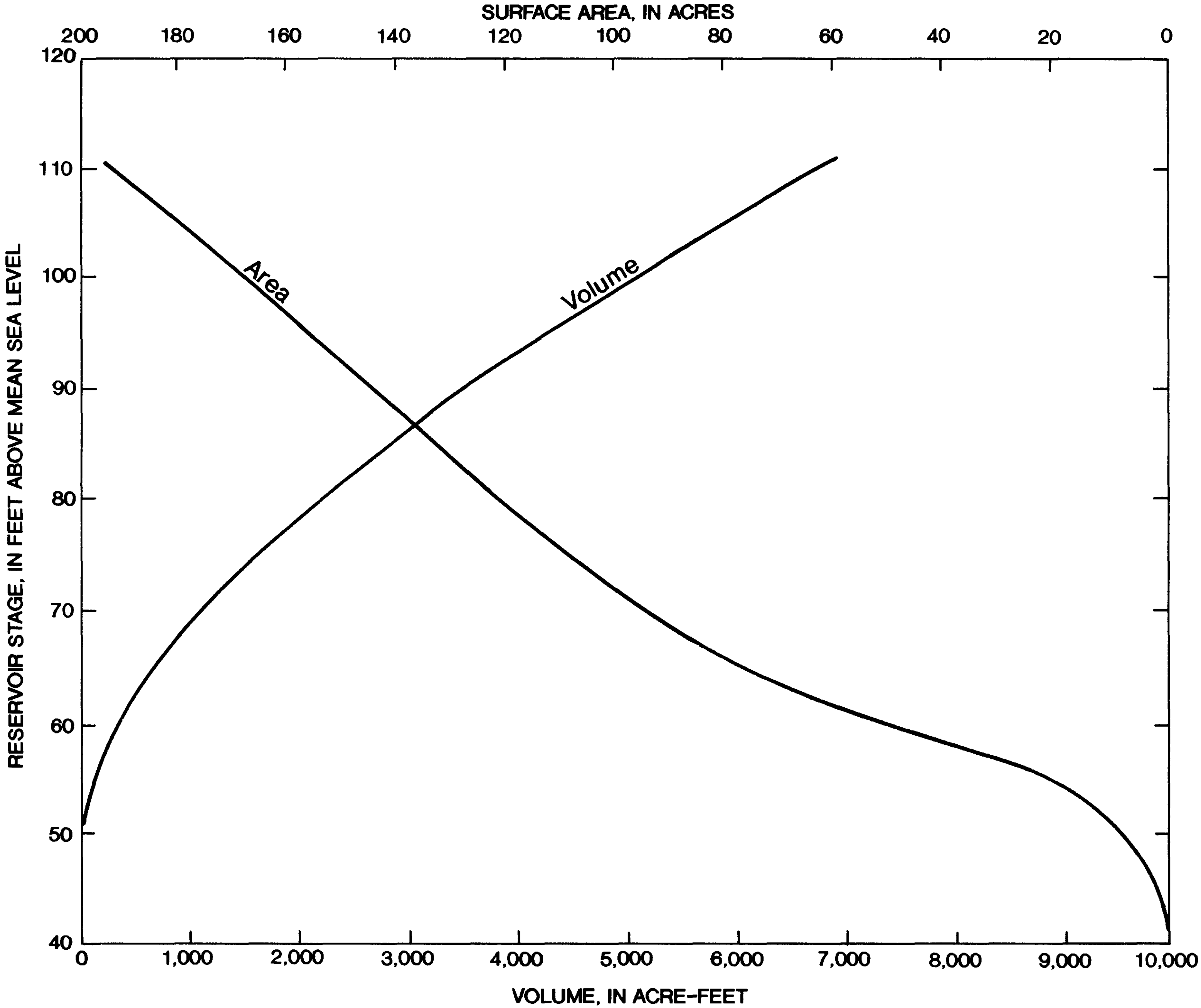

Figure 4. Stage-surface area and stage-capacity curves for Fena Valley Reservoir, 1990.

Table 4.--*Comparison of storage capacity at selected altitudes for Fena Valley Reservoir for years 1949 and 1990*

[ft, feet; acre-ft, acre-feet]

Altitude (ft)	Reservoir storage capacity (acre-ft) 1949	1990	Difference between 1949 and 1990 (percent)
111.35	8,300	7,182	13.5
100	6,280	5,116	18.5
90	4,630	3,551	23.3
80	3,150	2,216	29.7
70	1,940	1,121	42.2
60	960	361	62.4
50	260	46	82.3

The rate of sediment accumulation cannot be addressed on the basis of the storage capacities and losses in storage capacity computed for Fena Valley Reservoir in 1949, 1973, 1979, and 1990. An explanation could not be found for the apparent increase in storage capacity between 1973 and 1979; the reservoir was not flushed during this 6-year interval (Ralph Mesa, U.S. Navy Public Works Center, Guam, oral commun., 1990). Different map bases used for the 1973 and 1979 topographic maps are not likely to explain the difference in the estimates. Differences in methodology, such as the total number of width and depth measurements, and the accuracy of those measurements, probably have a greater effect.

On the basis of the period of record for the Imong River stream gage (1961-90), cumulative annual runoff increased at a fairly linear rate (fig. 5); because erosion and sediment yield are, in part, functions of runoff, it is likely that the rate of sediment accumulation remained constant also. If the 1979 storage-capacity estimate of 7,863 acre-ft is disregarded, then the loss in storage capacity has decreased at a relatively linear rate (fig. 6). Conversely, sediment accumulation has increased at a relatively linear rate with respect to the original storage capacity of 8,300 acre-ft. However, it is not possible to address changes in the rate of sediment accumulation between the different surveys because of the large degree of uncertainty.

Regional suspended-sediment yields were compared using the results of a previous investigation of stream sedimentation in southern Guam (Shade, 1983). Because reservoir sediment data were not collected in 1990, sediment data collected during the 1979 reservoir survey (Curtis, 1984) were used to estimate the amount of total suspended sediment (assumed to be 85 percent of total load) and the assumed bulk density of the suspended sediment (37.5 lb/ft^3). These values were used in the analysis by Shade (1983).

The 1,118 acre-ft reduction in Fena Valley Reservoir storage capacity during the last 40 years is a result of at least 1,118 acre-ft of deposited sediment derived from 5.57 mi^2 of watershed area. Assuming that 85 percent of

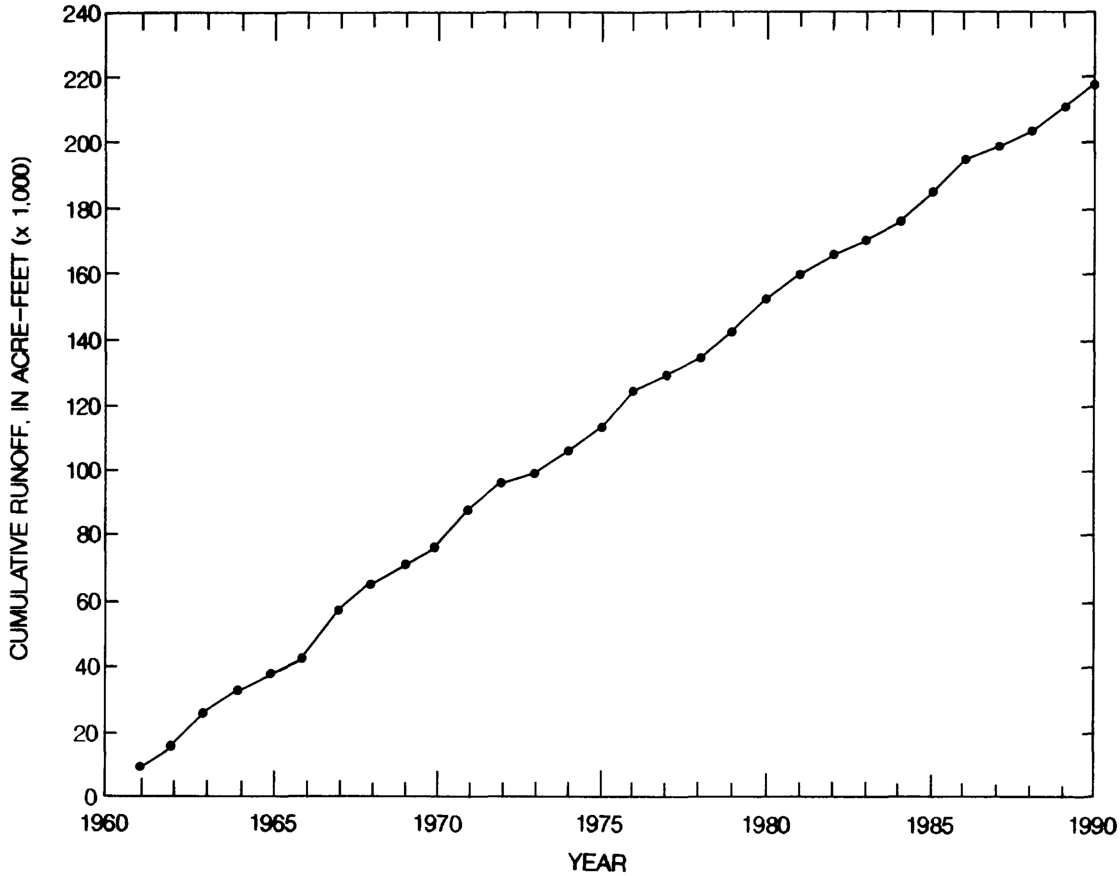

Figure 5. Cumulative runoff in the Imong River, 1961-90.

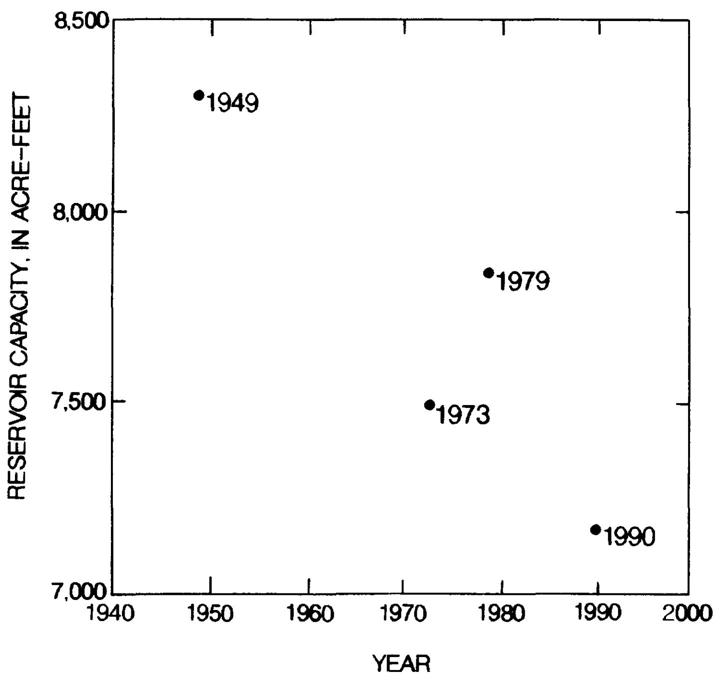

Figure 6. Computed storage capacity of Fena Valley Reservoir, 1949, 1973, 1979, and 1990.

the total accumulated sediment was transported in suspension, and assuming a bulk density of 37.5 lb/ft^3, the mean annual suspended-sediment yield for the watershed is about 3,480 $(ton/mi^2)/yr$. This estimate of suspended-sediment yield is much higher than the range of suspended-sediment yields [465 to 1,455 $(ton/mi^2)/yr$] estimated for the Ylig, Ugum, and Talofofo River basins (fig. 1) using the flow-duration sediment-rating-curve method (Shade, 1983). In an identical application using Curtis' estimate of sediment accumulation in Fena Valley Reservoir (1984), Shade (1983) reported that estimated suspended-sediment yield for the Fena Valley watershed [1,750 $(ton/mi^2)/yr$] was also somewhat higher than suspended-sediment yield estimates for the three surrounding basins.

SUMMARY

The Fena Valley Reservoir, located in south-central Guam, was constructed in 1951 to provide a dependable water supply for U.S. Navy personnel and local citizens. A preconstruction topographic survey of the site in 1949 indicated a storage capacity of 8,300 acre-feet when filled to the spillway altitude of 111.35 feet. Bathymetric surveys done in 1973 and 1979 indicated that the storage capacity of the reservoir had been reduced by about 5 percent since 1951. The loss in storage capacity is attributed to the accumulation of sediment in the reservoir.

On the basis of data collected in 1990, the storage capacity of Fena Valley Reservoir is about 7,180 acre-ft, which represents a loss of about 1,120 acre-ft (28 acre-ft/yr), or 13.5 percent, with respect to the original design-survey estimate of 8,300 acre-ft. Deposition appears to be greatest near the dam and at the mouth of the Imong River, where a delta is forming. Between 1949 and 1990, the largest relative declines in storage capacity (greater than 50 percent) have occurred at lower altitudes in the deepest parts of the reservoir, significantly reducing the unusable part of the total storage capacity. The estimated suspended-sediment yield for the Fena Valley watershed, based on 40 years of sediment accumulation, is about 3,480 $(ton/mi^2)/yr$. This rate is considerably higher than the range (465 to 1,455 $(ton/mi^2)/yr$ estimated for three surrounding basins using the flow-duration sediment-rating-curve method.

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Table 2.--Rating table for surface area of Fena Valley Reservoir, 1990

[ft, feet]

Water level (ft)	Surface area (acres) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Difference in area per foot
40.0	1.000	1.030	1.060	1.090	1.120	1.150	1.180	1.210	1.240	1.270	.300
41.0	1.300	1.335	1.370	1.405	1.440	1.475	1.510	1.545	1.580	1.615	.350
42.0	1.650	1.690	1.730	1.770	1.810	1.850	1.890	1.930	1.970	2.010	.400
43.0	2.050	2.095	2.140	2.185	2.230	2.275	2.320	2.365	2.410	2.455	.450
44.0	2.500	2.560	2.620	2.680	2.740	2.800	2.860	2.920	2.980	3.040	.600
45.0	3.100	3.170	3.240	3.310	3.380	3.450	3.520	3.590	3.660	3.730	.700
46.0	3.800	3.880	3.960	4.040	4.120	4.200	4.280	4.360	4.440	4.520	.800
47.0	4.600	4.690	4.780	4.870	4.960	5.050	5.140	5.230	5.320	5.410	.900
48.0	5.500	5.610	5.720	5.830	5.940	6.050	6.160	6.270	6.380	6.490	1.100
49.0	6.600	6.740	6.880	7.020	7.160	7.300	7.440	7.580	7.720	7.860	1.400
50.0	8.000	8.300	8.600	8.900	9.200	9.500	9.800	10.10	10.40	10.70	3.000
51.0	11.00	11.40	11.80	12.20	12.60	13.00	13.40	13.80	14.20	14.60	4.000
52.0	15.00	15.50	16.00	16.50	17.00	17.50	18.00	18.50	19.00	19.50	5.000
53.0	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	5.000
54.0	25.00	25.50	26.00	26.50	27.00	27.50	28.00	28.50	29.00	29.50	5.000
55.0	30.00	30.50	31.00	31.50	32.00	32.50	33.00	33.50	34.00	34.50	5.000
56.0	35.00	35.50	36.00	36.50	37.00	37.50	38.00	38.50	39.00	39.50	5.000
57.0	40.00	40.50	41.00	41.50	42.00	42.50	43.00	43.50	44.00	44.50	5.000
58.0	45.00	45.50	46.00	46.50	47.00	47.50	48.00	48.50	49.00	49.50	5.000
59.0	50.00	50.50	51.00	51.50	52.00	52.50	53.00	53.50	54.00	54.50	5.000
60.0	55.00	55.50	56.00	56.50	57.00	57.50	58.00	58.50	59.00	59.50	5.000
61.0	60.00	60.50	61.00	61.50	62.00	62.50	63.00	63.50	64.00	64.50	5.000
62.0	65.00	65.40	65.80	66.20	66.60	67.00	67.40	67.80	68.20	68.60	4.000
63.0	69.00	69.40	69.80	70.20	70.60	71.00	71.40	71.80	72.20	72.60	4.000
64.0	73.00	73.40	73.80	74.20	74.60	75.00	75.40	75.80	76.20	76.60	4.000
65.0	77.00	77.40	77.80	78.20	78.60	79.00	79.40	79.80	80.20	80.60	4.000
66.0	81.00	81.40	81.80	82.20	82.60	83.00	83.40	83.80	84.20	84.60	4.000
67.0	85.00	85.40	85.80	86.20	86.60	87.00	87.40	87.80	88.20	88.60	4.000
68.0	89.00	89.40	89.80	90.20	90.60	91.00	91.40	91.80	92.20	92.60	4.000
69.0	93.00	93.40	93.80	94.20	94.60	95.00	95.40	95.80	96.20	96.60	4.000
70.0	97.00	97.25	97.50	97.75	98.00	98.25	98.50	98.75	99.00	99.25	2.500
71.0	99.50	99.75	100.0	100.2	100.5	100.7	101.0	101.2	101.5	101.7	2.500
72.0	102.0	102.2	102.5	102.7	103.0	103.2	103.5	103.7	104.0	104.2	2.500
73.0	104.5	104.7	105.0	105.2	105.5	105.7	106.0	106.2	106.5	106.7	2.500
74.0	107.0	107.2	107.5	107.7	108.0	108.2	108.5	108.7	109.0	109.2	2.500
75.0	109.5	109.7	110.0	110.2	110.5	110.7	111.0	111.2	111.5	111.7	2.500
76.0	112.0	112.2	112.5	112.7	113.0	113.2	113.5	113.7	114.0	114.2	2.500
77.0	114.5	114.7	115.0	115.2	115.5	115.7	116.0	116.2	116.5	116.7	2.500
78.0	117.0	117.2	117.5	117.7	118.0	118.2	118.5	118.7	119.0	119.2	2.500
79.0	119.5	119.7	120.0	120.2	120.5	120.7	121.0	121.2	121.5	121.7	2.500
80.0	122.0	122.2	122.4	122.6	122.8	123.0	123.2	123.4	123.6	123.8	2.000
81.0	124.0	124.2	124.4	124.6	124.8	125.0	125.2	125.4	125.6	125.8	2.000
82.0	126.0	126.2	126.4	126.6	126.8	127.0	127.2	127.4	127.6	127.8	2.000
83.0	128.0	128.2	128.4	128.6	128.8	129.0	129.2	129.4	129.6	129.8	2.000
84.0	130.0	130.2	130.5	130.7	131.0	131.2	131.5	131.7	132.0	132.2	2.500

Table 2.--Rating table for surface area of Fena Valley Reservoir, 1990--Continued

Water level (ft)	Surface area (acres)										Difference in area per foot
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	
85.0	132.5	132.7	133.0	133.2	133.5	133.7	134.0	134.2	134.5	134.7	2.500
86.0	135.0	135.2	135.5	135.7	136.0	136.2	136.5	136.7	137.0	137.2	2.500
87.0	137.5	137.7	138.0	138.2	138.5	138.7	139.0	139.2	139.5	139.7	2.500
88.0	140.0	140.2	140.5	140.7	141.0	141.2	141.5	141.7	142.0	142.2	2.500
89.0	142.5	142.7	143.0	143.2	143.5	143.7	144.0	144.2	144.5	144.7	2.500
90.0	145.0	145.2	145.5	145.7	146.0	146.2	146.5	146.7	147.0	147.2	2.500
91.0	147.5	147.7	148.0	148.2	148.5	148.7	149.0	149.2	149.5	149.7	2.500
92.0	150.0	150.2	150.5	150.7	151.0	151.2	151.5	151.7	152.0	152.2	2.500
93.0	152.5	152.7	153.0	153.2	153.5	153.7	154.0	154.2	154.5	154.7	2.500
94.0	155.0	155.2	155.5	155.7	156.0	156.2	156.5	156.7	157.0	157.2	2.500
95.0	157.5	157.7	158.0	158.2	158.5	158.7	159.0	159.2	159.5	159.7	2.500
96.0	160.0	160.2	160.4	160.6	160.8	161.0	161.2	161.4	161.6	161.8	2.000
97.0	162.0	162.2	162.4	162.6	162.8	163.0	163.2	163.4	163.6	163.8	2.000
98.0	164.0	164.2	164.4	164.6	164.8	165.0	165.2	165.4	165.6	165.8	2.000
99.0	166.0	166.2	166.4	166.6	166.8	167.0	167.2	167.4	167.6	167.8	2.000
100.0	168.0	168.3	168.6	168.9	169.2	169.5	169.8	170.1	170.4	170.7	3.000
101.0	171.0	171.3	171.6	171.9	172.2	172.5	172.8	173.1	173.4	173.7	3.000
102.0	174.0	174.3	174.6	174.9	175.2	175.5	175.8	176.1	176.4	176.7	3.000
103.0	177.0	177.3	177.6	177.9	178.2	178.5	178.8	179.1	179.4	179.7	3.000
104.0	180.0	180.3	180.6	180.9	181.2	181.5	181.8	182.1	182.4	182.7	3.000
105.0	183.0	183.3	183.6	183.9	184.2	184.5	184.8	185.1	185.4	185.7	3.000
106.0	186.0	186.3	186.6	186.9	187.2	187.5	187.8	188.1	188.4	188.7	3.000
107.0	189.0	189.2	189.4	189.6	189.8	190.0	190.2	190.4	190.6	190.8	2.000
108.0	191.0	191.2	191.4	191.6	191.8	192.0	192.2	192.4	192.6	192.8	2.000
109.0	193.0	193.2	193.4	193.6	193.8	194.0	194.2	194.4	194.6	194.8	2.000
110.0	195.0	195.1	195.2	195.2	195.3	195.4	195.5	195.5	195.6	195.7	.800
111.0	195.8	195.8	195.9	196.0							

Table 3.--Rating table for storage capacity of Fena Valley Reservoir, 1990

Water level (feet)	Storage capacity (acre-feet) (standard precision) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Difference in volume per foot
40.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.0
41.0	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	1.0
42.0	3.0	3.1	3.3	3.4	3.6	3.7	3.9	4.0	4.2	4.3	1.5
43.0	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.8	1.5
44.0	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	2.0
45.0	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.8	11.2	11.6	4.0
46.0	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	5.0
47.0	17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9	22.6	23.3	7.0
48.0	24.0	24.9	25.8	26.7	27.6	28.5	29.4	30.3	31.2	32.1	9.0
49.0	33.0	34.2	35.4	36.6	37.8	39.0	40.2	41.4	42.6	43.8	12.0
50.0	45.0	46.2	47.4	48.6	49.8	51.0	52.2	53.4	54.6	55.8	12.0
51.0	57.0	58.3	59.6	60.9	62.2	63.5	64.8	66.1	67.4	68.7	13.0
52.0	70.0	71.8	73.6	75.4	77.2	79.0	80.8	82.6	84.4	86.2	18.0
53.0	88.0	90.2	92.4	94.6	96.8	99.0	101	103	106	108	22.0
54.0	110	113	115	118	120	123	126	128	131	133	26.0
55.0	136	139	142	146	149	152	155	158	162	165	32.0
56.0	168	172	176	180	184	187	191	195	199	203	39.0
57.0	207	211	216	220	224	228	233	237	241	246	43.0
58.0	250	255	261	266	272	277	283	288	294	299	55.0
59.0	305	310	316	321	327	332	338	343	349	354	55.0
60.0	360	366	372	378	384	390	396	402	408	414	60.0
61.0	420	426	432	438	444	450	456	462	468	474	60.0
62.0	480	486	492	498	504	510	516	522	528	534	60.0
63.0	540	546	552	558	564	570	576	582	588	594	60.0
64.0	600	607	614	621	628	635	642	649	656	663	70.0
65.0	670	677	684	691	698	705	712	719	726	733	70.0
66.0	740	749	758	767	776	785	794	803	812	821	90.0
67.0	830	839	848	857	866	875	884	893	902	911	90.0
68.0	920	930	940	950	960	970	980	990	1000	1010	100
69.0	1020	1030	1040	1050	1060	1070	1080	1090	1100	1110	100
70.0	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	100
71.0	1220	1230	1240	1250	1260	1270	1280	1290	1300	1310	100
72.0	1320	1330	1340	1350	1360	1370	1380	1390	1400	1410	100
73.0	1420	1430	1440	1450	1460	1470	1480	1490	1500	1510	100
74.0	1520	1530	1540	1550	1560	1570	1590	1600	1610	1620	110
75.0	1630	1640	1650	1660	1670	1680	1700	1710	1720	1730	110
76.0	1740	1750	1760	1770	1780	1790	1810	1820	1830	1840	110
77.0	1850	1860	1870	1890	1900	1910	1920	1930	1950	1960	120
78.0	1970	1980	1990	2010	2020	2030	2040	2050	2070	2080	120
79.0	2090	2100	2110	2130	2140	2150	2160	2180	2190	2200	120
80.0	2210	2230	2240	2250	2260	2270	2280	2300	2310	2320	120
81.0	2330	2340	2350	2370	2380	2390	2400	2410	2430	2440	120
82.0	2450	2460	2470	2490	2500	2510	2520	2540	2550	2560	120
83.0	2570	2590	2600	2610	2620	2630	2640	2660	2670	2680	120
84.0	2690	2700	2720	2730	2740	2750	2770	2780	2790	2810	130

Table 3.--Rating table for storage capacity of Fena Valley Reservoir, 1990--Continued

Water level (feet)	Storage capacity (acre-feet) (standard precision)										Difference in volume per foot
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	
85.0	2820	2830	2850	2860	2880	2890	2900	2920	2930	2950	140
86.0	2960	2970	2990	3000	3020	3030	3040	3060	3070	3090	140
87.0	3100	3110	3130	3140	3160	3170	3190	3200	3220	3230	150
88.0	3250	3260	3280	3290	3310	3320	3340	3350	3370	3380	150
89.0	3400	3410	3430	3440	3460	3470	3490	3500	3520	3530	150
90.0	3550	3560	3580	3590	3610	3620	3640	3650	3670	3680	150
91.0	3700	3710	3730	3740	3760	3770	3790	3800	3820	3830	150
92.0	3850	3860	3880	3890	3910	3920	3940	3950	3970	3980	150
93.0	4000	4010	4030	4040	4060	4070	4090	4100	4120	4130	150
94.0	4150	4170	4180	4200	4210	4230	4250	4260	4280	4290	160
95.0	4310	4330	4340	4360	4370	4390	4410	4420	4440	4450	160
96.0	4470	4490	4500	4520	4530	4550	4570	4580	4600	4610	160
97.0	4630	4650	4660	4680	4690	4710	4730	4740	4760	4770	160
98.0	4790	4810	4820	4840	4850	4870	4890	4900	4920	4930	160
99.0	4950	4970	4980	5000	5020	5030	5050	5070	5080	5100	160
100.0	5110	5130	5150	5160	5180	5190	5210	5230	5240	5260	160
101.0	5270	5290	5310	5320	5340	5350	5370	5380	5400	5410	160
102.0	5430	5450	5460	5480	5490	5510	5530	5540	5560	5570	160
103.0	5590	5610	5620	5640	5650	5670	5690	5700	5720	5730	160
104.0	5750	5770	5780	5800	5810	5830	5850	5860	5880	5890	160
105.0	5910	5930	5940	5960	5980	5990	6010	6030	6050	6060	170
106.0	6080	6100	6120	6130	6150	6170	6190	6210	6220	6240	180
107.0	6260	6280	6300	6320	6340	6360	6380	6400	6420	6440	200
108.0	6460	6480	6500	6530	6550	6570	6590	6610	6640	6660	220
109.0	6680	6700	6720	6750	6770	6790	6810	6830	6860	6880	220
110.0	6900	6920	6940	6960	6980	7000	7020	7050	7070	7090	210
111.0	7110	7130	7150	7170							