RECLAMATION
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El Vado Reservoir
2007 Sedimentation Survey

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

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El Vado Reservoir
2007 Sedimentation Survey

prepared by

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Reclamation Report

This report was produced by the Bureau of Reclamation's Sedimentation and River Hydraulics Group (Mail Code 86-68240), PO Box 25007, Denver, Colorado 80225-0007, www.usbr.gov/pmts/sediment/.

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14. ABSTRACT

Reclamation surveyed El Vado Reservoir in June 2007 to develop updated reservoir topography and compute the present storage-elevation relationship (area-capacity tables). The underwater survey, conducted near water surface elevation 6,900 (project datum in feet), used sonic depth recording equipment interfaced with a real-time kinematic (RTK) global positioning system (GPS) that provided continuous sounding positions throughout the underwater portion of the reservoir covered by the survey vessel. Digitized reservoir contours from the U.S. Geological Survey quadrangle (USGS quad) maps were used to compute the reservoir areas and resulting capacities from elevation 6,902.0 through 6,912.0.

As of June 2007, at elevation 6,902.0, the surface area was 3,232 acres with a total capacity of 190,820 acre-feet. Since the January 1935 dam closure, about 7,382 acre-feet of change has occurred below elevation 6,902.0 due to sediment deposition, resulting in a 3.7 percent loss in reservoir volume. Unknowns in the detail and accuracy of the previous surveys introduce uncertainty to the sediment computation values. The 2007 study used the contour method for collection and analysis resulting in a larger computed reservoir volume than the 1984 study that used the range line method for collection and analysis.

15. SUBJECT TERMS

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Introduction

El Vado Dam, located on the Rio Chama in New Mexico, is about 10 miles southwest of the town of Tierra Amarilla, 78 miles northwest of Santa Fe, and 28 miles south of the Colorado-New Mexico state line (Figure 1). El Vado Dam, designated a New Mexico Civil Engineering Landmark, was built by the Middle Rio Grande Water Conservancy District in 1934-35 and rehabilitated by Reclamation in 1954-55. Reclamation installed new outlet works in 1965-66 to accommodate additional water for the San Juan-Chama Project that is diverted through Heron Reservoir, located upstream. The reservoir's primary purpose is to provide storage for supplemental irrigation to the Middle Rio Grande Valley and San Juan-Chama Project water for irrigation, municipal, and industrial use. The project also provides flood control, hydroelectric power, recreation, and fish and wildlife benefits.

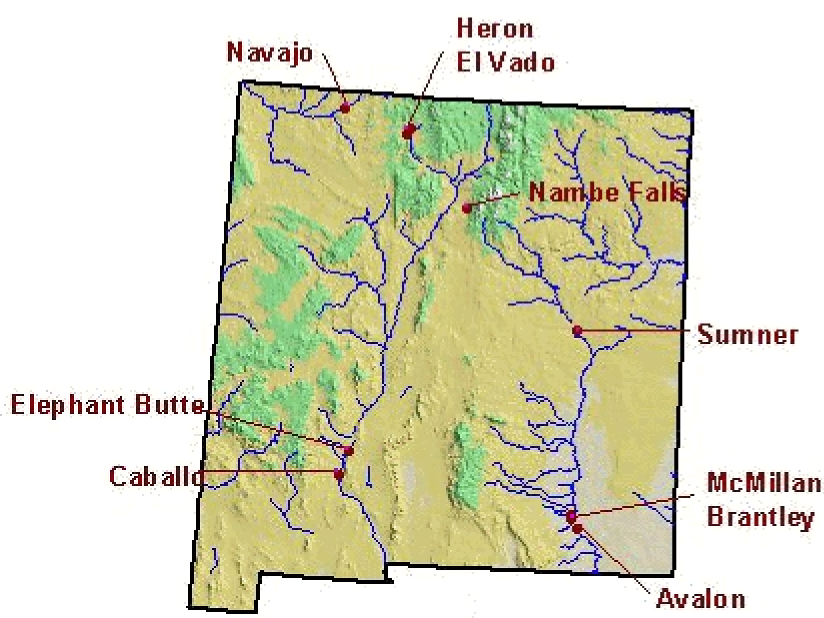

Figure 1 - Reclamation reservoirs located in New Mexico (Reclamation, 2008).

The dam, constructed between 1933 and 1935, has a rolled gravelfill and steel membrane. The embankment is compacted gravelfill with a rockfill zone at the downstream toe and a cobblefill zone downstream. The upstream face is covered with 0.25-inch-thick steel plate that is anchored to a cutoff wall at the toe and a steel parapet anchored to steel bracing set in concrete on the crest of the dam.

The dam's dimensions, in feet, are:

Hydraulic height[1]	156.5	Structural height	230
Crest length	1,326	Crest elevation[2]	6,914.5

An emergency spillway, located about one mile west of the dam, is an unlined channel with a fuseplug in a topographic saddle. The crest length is 630 feet at crest elevation 6,906.0 with a discharge capacity of 11,209 cubic-feet-per-second (cfs) at elevation 6,909.0. The service spillway is a gated crest structure with a 36- by 24-foot high radial gate, crest length of 36 feet, and chute length of 956 feet at crest elevation 6,879.0. The discharge capacity of the service spillway is 18,200 cfs at elevation 6,909.0. The river outlet works, constructed by Reclamation in 1965, is located at the west end of the dam in the right abutment. It consists of four 5- by 9-foot high pressure slide gates discharging through a 13-foot wide by 13- to 15-foot high horseshoe-shaped downstream tunnel section terminating in a concrete flip bucket in the right abutment. The discharge capacity at elevation 6,909.0 is 6,870 cfs. A bypass consists of a 14-inch pipe with a 14-inch high-pressure guard gate and 12-inch jet-flow gate valve that allow small outlet works releases at a capacity of 42 cfs at elevation 6,908.0. The hydroelectric powerplant consists of a 670-foot long penstock and a 96-inch diameter welded steel pipe extending from the valve chamber to the powerhouse with a maximum capacity of about 1,000 cfs.

El Vado Dam impounds natural drainage water from the Rio Chama and Boulder Creek along with diverted San Juan basin water released through Heron Reservoir, located upstream on the Rio Chama arm. The total drainage above El Vado Reservoir is 783 square miles bounded by the Continental Divide on the west and San Juan Mountains on the east. The basin can be divided into four subbasins: Boulder Creek drainage area flows directly into El Vado Reservoir and is 95 square miles (mi^2); Willow Creek drainage area is controlled by Heron Dam (closure in October 1970) and is 193 mi^2; Rio Chama drainage area is 492 mi^2; and the fourth subbasin is located west of El Vado Reservoir, drains into Stinking Lake and is considered non-contributing (Reclamation, 2004).

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[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] Elevations in feet. All elevations based on the original project datum established during construction. Add about 7.8 feet to match the National Geodetic Vertical Datum of 1929 (NGVD29) and 12.0 feet to match North American Vertical Datum of 1988 (NAVD88).

Summary and Conclusions

This Reclamation report presents the results of the June 2007 survey of El Vado Reservoir. The primary objectives of the survey were to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships
- estimate storage depletion due to sediment deposition

A control survey was conducted using the on-line positioning user service (OPUS) and RTK GPS to establish a horizontal and vertical control network near the reservoir for the hydrographic survey. OPUS is operated by the National Geodetic Survey (NGS) and allows users to submit GPS data files that are processed with known point data to determine positions relative to the national control network. Initially the GPS base was set over a NGS control point called "DAM" that is located on a high point on the right bank near the dam alignment. NGS rated this point as third order horizontal with the vertical rounded to the nearest foot. Coordinates were computed by an OPUS solution and from this base additional control points were established and checked during the survey.

The horizontal control for this study was in feet, New Mexico Central state plane coordinates, in the North American Datum of 1983 (NAD83). The vertical control, in feet, was tied to NAVD88 and the El Vado Dam project or construction (project) vertical datum. All elevations in this report are referenced to the project vertical datum that is 7.8 feet lower than NGVD29 and around 12.0 feet lower than NAVD88.

The June 2007 underwater survey was conducted near reservoir elevation 6,900, measured by the Reclamation gage at the dam. The bathymetric survey used sonic depth recording equipment interfaced with a RTK GPS for determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates as the survey boat navigated along grid lines covering El Vado Reservoir. The positioning system also provided information to allow the boat operator to maintain a course along these grid lines. The initial above-water topography was determined by digitizing contour lines from the USGS quads of the reservoir area. The water surface elevations recorded by Reclamation's reservoir gage and confirmed by RTK GPS measurements during the time of collection were used to convert the sonic depth measurements to reservoir bottom elevations.

El Vado Reservoir topographic map is a combination of the adjusted digitized contours and the 2007 underwater survey data. A computer graphics program generated the 2007 reservoir surface areas at predetermined contour intervals from the collected reservoir area. The 2007 area and capacity tables were produced by a computer program that used 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 summaries of the El Vado Reservoir and watershed characteristics for the 2007 survey. The 2007 survey determined that the reservoir has a total storage capacity of 213,090 acre-feet with a surface area of 3,517 acres at maximum water surface elevation 6,908.6 and a storage capacity of 190,820 acre-feet with a surface area of 3,232 acres at normal water surface elevation 6,902.0. Since closure in January 1935, the reservoir has an estimated volume change of 7,382 acre-feet below reservoir elevation 6,902.0. This volume change represents a 3.7 percent loss in total original capacity at this elevation. The unknown quality of the previous survey data introduces uncertainty into the volume change calculations as it is difficult to determine what portion is due to sediment deposition and what portion is due to differences in survey collection methods.

Control Survey Data Information

A control survey was conducted using OPUS and RTK GPS to establish a horizontal and vertical control network near the reservoir for the hydrographic surveys. OPUS is operated by the National Geodetic Survey (NGS) and allows users to submit GPS data files that are processed with known point data to determine positions relative to the national control network. Initially, the GPS base was set over a NGS control point called "DAM", located on a high point on the right bank near the dam. This point was rated as third order horizontal with the vertical rounded to the nearest foot. Accurate coordinates were obtained for the "DAM" point using OPUS and from this base additional points were established and checked during the June 2007 bathymetric survey, Figure 2.

The horizontal control, in NAD83, was tied to the New Mexico central state plane coordinate system in feet. The vertical control in feet was tied to NAVD88 and the El Vado Dam project vertical datum. All elevations in this report are referenced to the project vertical datum that is 7.8 feet lower than NGVD29 and about 12.0 feet lower than NAVD88. Following is the OPUS solution for NGS point "DAM" that was used for setting control for the 2007 bathymetric survey.

	NAD83/NAVD88		NAD27/NGVD29
North	2,035,143.10	North	2,035,077.12
East	1,497,633.14	East	357,387.20
Elevation	7,002.51	Elevation	6,998.41

Figure 2 - Temporary Point set near reservoir, June 2007.

The point data information was converted from NAD83/NAVD88 using the U.S. Army Corps of Engineers conversion program CORPSCON. For this location the difference between NAVD88 and NGVD29 was around 4.1 feet. During the 2007 hydrographic survey, RTK GPS water surface measurements, in NAVD88, measured the average shift to match the water surface gage readings to be around 11.9 to 12.0 feet, resulting in a 7.8 to 7.9 foot shift between the gage readings and NGVD29. This measured vertical difference agreed with several Reclamation references and control surveys that indicated the shift was 7.8 feet between NGVD29 and the project vertical datum (Reclamation, 2006).

Reservoir Operations

El Vado Reservoir is part of the Middle Rio Grande Project designed to provide storage for irrigation, municipal water, and flood control. The reservoir's primary purpose is to provide storage for supplemental irrigation to the Middle Rio Grande Valley and San Juan-Chama Project water for irrigation, along with municipal and industrial uses. The 2007 survey determined that the reservoir has a total storage capacity of 213,090 acre-feet with a surface area of 3,517 acres at maximum water surface elevation 6,908.6. The computations above elevation 6,902.0 were accomplished from the digitized above water contours from the

USGS quads around the reservoir area. The 2007 survey measured a minimum lake bottom elevation of 6,766. The following values are from the June 2007 capacity table:

- 22,270 acre-feet of surcharge pool storage between elevation 6,992.0 and 6,908.6
- 190,396 acre-feet of multiple use pool storage between elevation 6,775.0 and 6,902.0
- 424 acre-feet of dead pool storage below elevation 6,775.0.

The computed annual inflow and reservoir stage records for El Vado Reservoir are listed by water year in Table 1 for the available period starting in 1966. The inflow values were computed by the Upper Colorado Region for the 1984 analysis and are available through 1987. The values show the annual fluctuation with a computed average annual inflow of 287,731 acre-feet. The data shows the reservoir has not operated above elevation 6,902 since 1966. The USGS water resource records list the maximum recorded reservoir content at around 205,000 acre-feet in 1948, which would be about reservoir elevation 6,906. Table 1 shows a few years where the reservoir was drawn down near dead pool elevation 6,775. Since the 1984 survey the reservoir was drawn down to elevation 6,796.8 during the years 2002 and 2003.

Hydrographic Survey Equipment and Method

The hydrographic survey equipment was mounted in the cabin of a 24-foot trihull aluminum vessel equipped with twin in-board motors (Figure 3). The hydrographic system included a GPS receiver with a built-in radio, single and multibeam depth sounders, helmsman display for navigation, computer, and hydrographic system software for collecting the underwater data. An on-board generator supplied power to all the boat equipment. The shore equipment included a second GPS receiver with an external radio. The GPS receiver and antenna were mounted on a survey tripod over a known datum point and a 12-volt battery provided the power for the shore unit.

The Sedimentation and River Hydraulics Group uses RTK GPS with the major benefit being precise heights measured in real time to monitor water surface elevation changes. The basic output from a RTK receiver are precise 3-D coordinates in latitude, longitude, and height with accuracies on the order of 2 centimeters horizontally and 3 centimeters vertically. The output is on the GPS datum of WGS-84 that the hydrographic collection software converted into New Mexico’s state plane coordinates, central zone in NAD83. The RTK GPS system employs two receivers that track the same satellites simultaneously, just like with differential GPS.

Figure 3 - Survey Vessel with Mounted Instrumentation on El Vado Reservoir, New Mexico.

The El Vado Reservoir bathymetric survey was conducted from June 10 through June 16 of 2007 between water surface elevation 6,900.0 and 6,900.2 (project datum). The bathymetric survey was conducted using sonic depth recording equipment, interfaced with a RTK GPS, capable of determining sounding locations within the reservoir for the single beam collection. The survey system software continuously recorded reservoir depths and horizontal coordinates as the survey boat moved along closely-spaced grid lines covering the reservoir area. Most transects (grid lines) were run somewhat parallel to the upstream-downstream alignment of the reservoir at around 200-foot spacing. The survey vessel's guidance system gave directions to the boat operator to assist in maintaining the course along these predetermined lines. Data was collected along the shore by the survey vessel for the majority of the reservoir. During each run, the depth and position data were recorded on the laptop computer hard drive for subsequent processing.

The single beam depth sounder for the 2007 underwater data was calibrated by lowering a weighted cable below the boat with beads marking known depths. The collected data were digitally transmitted to the computer collection system through a RS-232 port. The single beam depth sounder also produced an analog hard-copy chart of the measured depths. These graphed analog charts were analyzed during post-processing, and when the analog charted depths indicated a difference from the computer recorded bottom depths, the computer data files were modified. The water surface elevations at the dam, recorded by a Reclamation gage, were used to convert the sonic depth measurements to true lake-bottom elevations.

In 2001, the Sedimentation Group began utilizing an integrated multibeam hydrographic survey system. The system consists of a single transducer mounted on the center bow or forward portion of the boat. From the single transducer a fan array of narrow beams generates a detailed cross section of bottom geometry as the survey vessel passes over the areas mapped. The system transmits 80 separate 1-1/2 degree slant beams resulting in a 120-degree swath from the transducer. The 200 kHz high-resolution multibeam echosounder system measures the relative water depth across the wide swath perpendicular to the vessel's track.

Figure 4 illustrates the swath of the sea floor that is about 3.5 times as wide as the water depth below the transducer.

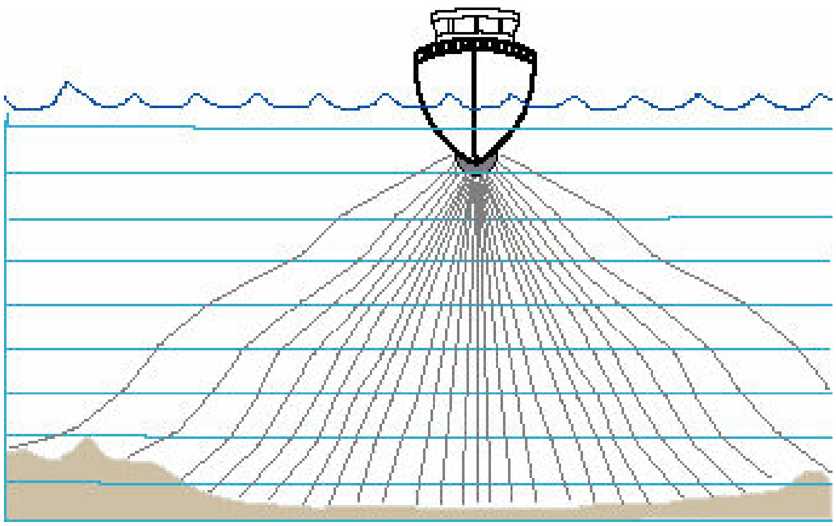

Figure 4 - Multibeam Collection System.

The multibeam system is composed of several instruments all in constant communication with a central on-board notebook computer. The components include the RTK GPS for positioning; a motion reference unit to measure the heave, pitch, and roll of the survey vessel; a gyro to measure the yaw or vessel attitude; and a velocity meter to measure the speed of sound through the vertical profile of the reservoir water. The multibeam sounder was calibrated by lowering an instrument that measured the sound velocity through the reservoir water column. The individual depth soundings were adjusted by the speed of sound of the measurements which can vary with density, salinity, temperature, turbidity, and other conditions. With proper calibration, the data processing software utilizes all the incoming information to provide an accurate, detailed x,y,z data set of the lake bottom.

Due to weather and time issues, the multibeam system was utilized on El Vado Reservoir during the last two days of collection only, June 15 and 16 of 2007. The multibeam surveyed areas mainly included the main channel from the dam upstream to the Rio Chama River, a few of the side coves, and the area around the mouth of the Boulder Creek. The collection concentrated on the deeper portions of the reservoir to provide more detailed mapping than what was provided by the single beam coverage. Figure 5 shows the reservoir areas covered by the multibeam and single beam collection systems along with the location of the sediment range lines.

The multibeam soundings, combined with the single beam soundings created a detailed data set of around 1,870,000 x,y,z points representing the reservoir for this study. The multibeam survey system software continuously recorded reservoir depths and horizontal coordinates as the survey vessel moved along closely-spaced grid lines covering the reservoir area. Most transects (grid lines) were run parallel to the reservoir alignment with the multibeam swaths overlapping in the deeper areas to provide full bottom coverage of the areas surveyed. The multibeam system could have provided more detailed bottom coverage throughout the reservoir, but time and budget did not allow for the rest of the reservoir to be surveyed by this method. Even though the multibeam data provided more detail of the reservoir bottom versus the single beam data set, a comparison of the surface area and volume computation results in common areas covered found the differences were not significant between the two methods.

The underwater collected data was processed using the hydrographic system software that was also used during the data collection. The analysis applied all measurements such as vessel location and corrections for the roll, pitch, and yaw effects. The other corrections included applying the sound velocity through the reservoir water column and converting all depth data points to elevations using the measured water surface elevation at the time of collection. To make it more manageable, the massive amount of multibeam data was filtered into 5-foot cells or grids of the reservoir area surveyed by the multibeam system. The multibeam data was combined with the single beam data to produce the x,y,z data set used for El Vado Reservoir map development. Additional information on collection and analysis procedures is included in *Engineering and Design: Hydrographic Surveying* (Corps of Engineers, January 2002) and *Reservoir Survey and Data Analysis* (Ferrari and Collins, 2006).

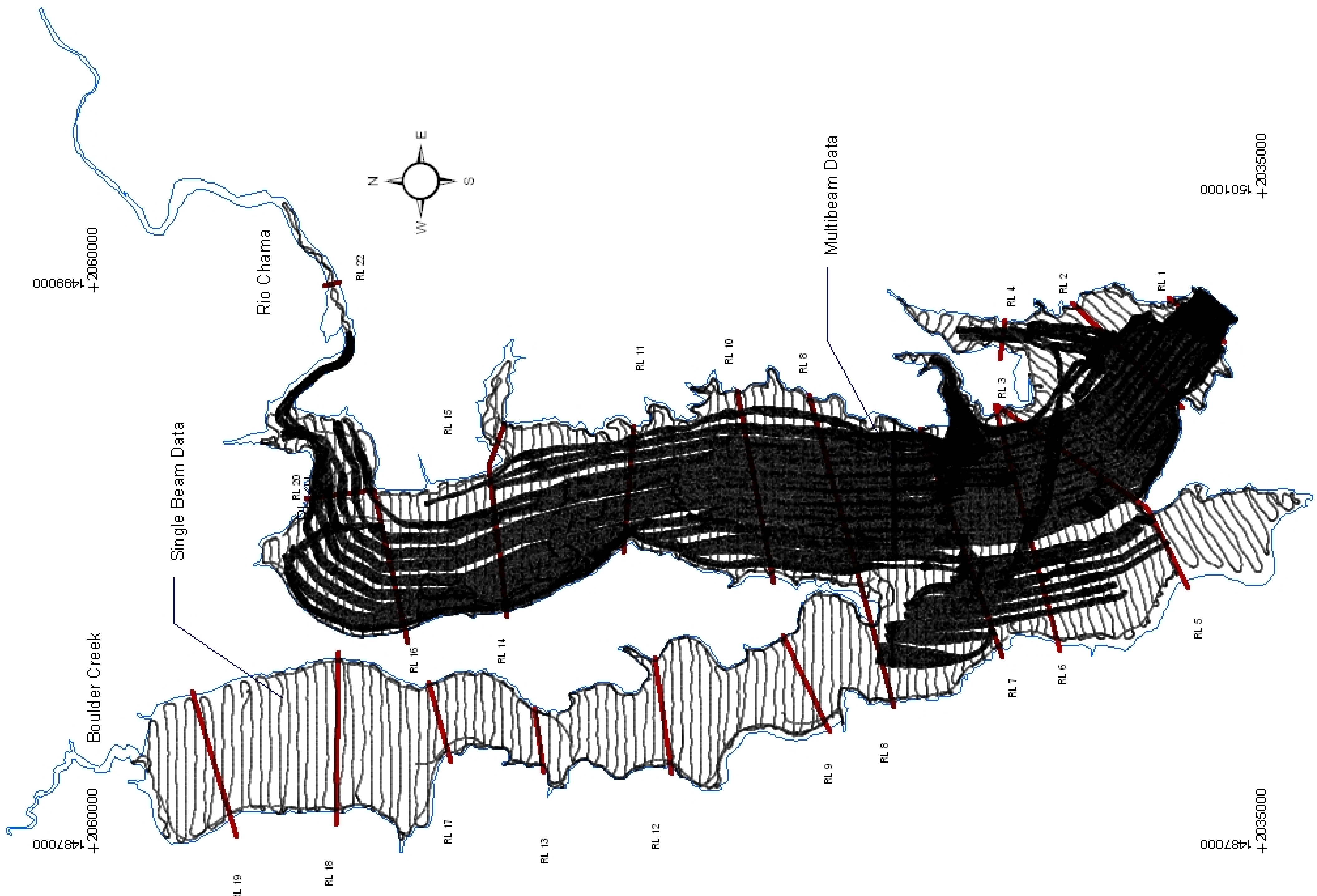

Figure 5 - El Vado Reservoir 2007 survey data points.

Reservoir Area and Capacity

Topography Development

The topography of El Vado Reservoir was developed from 2007 bathymetric survey data and digitized contours from the USGS quad maps. The USGS quad contours, labeled elevation 6,910 and 6,920 were developed from aerial photography dated 1976. These contours represent elevations in NGVD29 and were converted to project vertical elevations 6,902 and 6,912 respectfully. The 6,902 clip was slightly adjusted to ensure all 2007 underwater data was enclosed within the polygon. The modified elevation 6,902 contour was assigned a more precise elevation of 6,902.0 and was used as a hard boundary for the 2007 developed contours, allowing contour mapping within the reservoir area outlined by this hardclip contour only. The hardclip was used during the triangular irregular network (TIN) development to prevent interpolation outside the enclosed polygon. The 6,902.0 contour was selected for the hardclip boundary since it was the closest data available to represent the measured water surface during the 2007 underwater survey, elevation 6,900.

Contours for the reservoir below elevation 6,902.0 were developed from the TIN generated within ARCGIS. A TIN is a set of adjacent non-overlapping triangles computed from irregularly spaced points with x,y coordinates and z values. A TIN is 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 all the data points are connected to their nearest neighbors to form triangles. This method preserves all the collected data points. The TIN method is described in more detail in the ARCGIS user’s documentation, (ESRI, 2007).

The linear interpolation option of the ARCGIS TIN and CONTOUR commands was used to interpolate contours from the El Vado Reservoir TIN. The surface areas of the enclosed contour polygons at one-foot increments were computed from for elevations 6,766.0 through 6,902.0. The surface area of the modified digitized 6,902.0 contour was less than one percent different from the surface area used for the 1984 study at the same elevation. Since the digitized surface area was so close to the 1984 survey result, and because there were no visual signs of change of this contour due to a sediment delta, it was decided to assume no change and use the 1984 surface area for this study. For computing the capacity above elevation 6,902, the measured surface area of the digitized USGS quad contour elevation 6,912 was used. The reservoir contour topography at 2-foot intervals from elevation 6,902.0 and below is presented in Figures 6 and 7. The ARCGIS software developed contours directly from the TIN using all the enclosed data points, resulting in a jagged representation of the contours. For presentation purposes the contour lines were smoothed using the smooth line option within ARCMAP. The smoothing process did not affect the reported surface areas since they were computated directly from the TIN using all the data points.

Lateral Distribution

Profiles of the 21 previously surveyed sedimentation range lines were developed during this study to provide a visual representation of the lateral sediment deposition change since the 1944 and 1984 surveys (Figures 9 through 29). The location of the range lines along with the data points collected during this study are presented on Figure 5 and on Figure 8 of the 1984 contour and range line maps. The range line locations were visually determined from the reservoir sedimentation range system maps developed for the 1984 study, drawing number 163-518-4988. The digital range line plots were recreated by digitizing the 1944 and 1984 sedimentation range plots presented in an April, 1987 memorandum forwarding the results of the 1984 survey to the Albuquerque Area Office (Reclamation, 1987). It appears the 1944 and 1984 cross section profiles are plotted from left to right bank looking downstream.

Using tools within ARCGIS the 2007 cross sections were located and profiles were developed by cutting lines through the surveyed data points. The routine stored the nearest data points along the projected range lines. These stored points within 10 feet of the projected range line alignment. The point density of each profile depended on available data near the cross section.

The Range Line plots provided valuable insight into changes in lateral sediment distribution over time. Range Lines 1, 2, 3, 4, 6, 7, 8, 10, 11, 14, 15, 16, 20, and 22 (located on the Rio Chama reach of the reservoir) indicated that little to no change has occurred since 1984 due to sediment deposition. Range lines 6, 7, and 8 also extended into the Boulder Creek reach of the reservoir. The survey of range line 20 and 22, located in the upper reach of the Chama area, showed an increase in area due to erosion of the previous measured sediment deposits. The river scoured the previously deposited sediments in these upper range lines during periods of low reservoir content since 1984 and clear water releases from Lake Heron.

Range lines 5, 6, 7, 8, 9, 12, 13, 17, 18, and 19 are located on Boulder Creek arm of the reservoir and show a similar pattern to the Rio Chama arm, little to no change. Range lines 12 and 18 measured a slight change since the 1984 survey, but not a significant change considering the time period between surveys. Overall the sediment range line plots illustrate why the 2007 computed surface areas and resulting capacity are similar to the 1984 study results. The 2007 study actually measured a slight increase in capacity, likely due to the greater detail compared to the 1984 study. The 1984 study utilized a range line survey and a mathematical method to compute changes in the surface areas between the range lines.

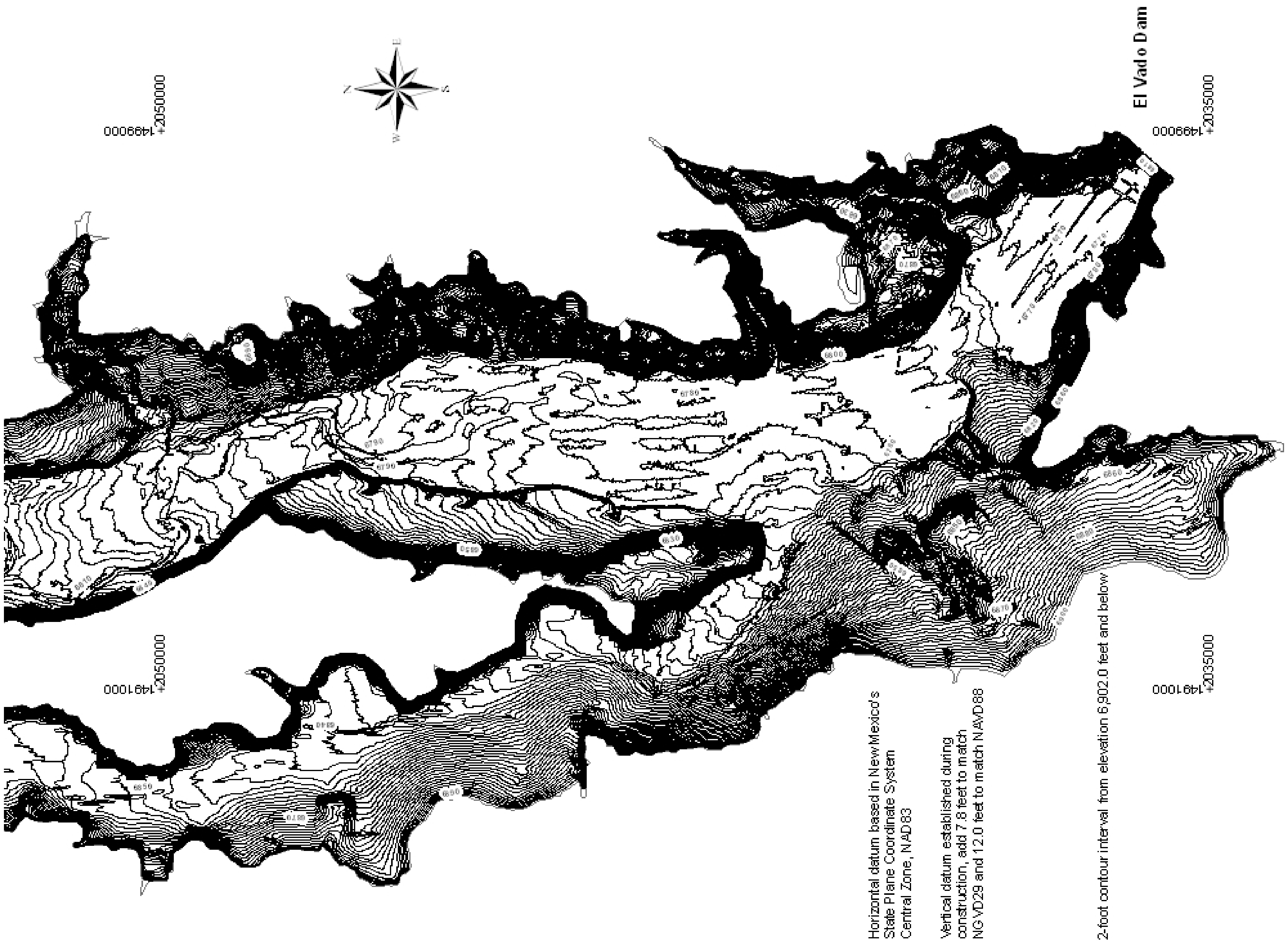

Figure 6 - El Vado Reservoir Contour Map, 1 of 2.

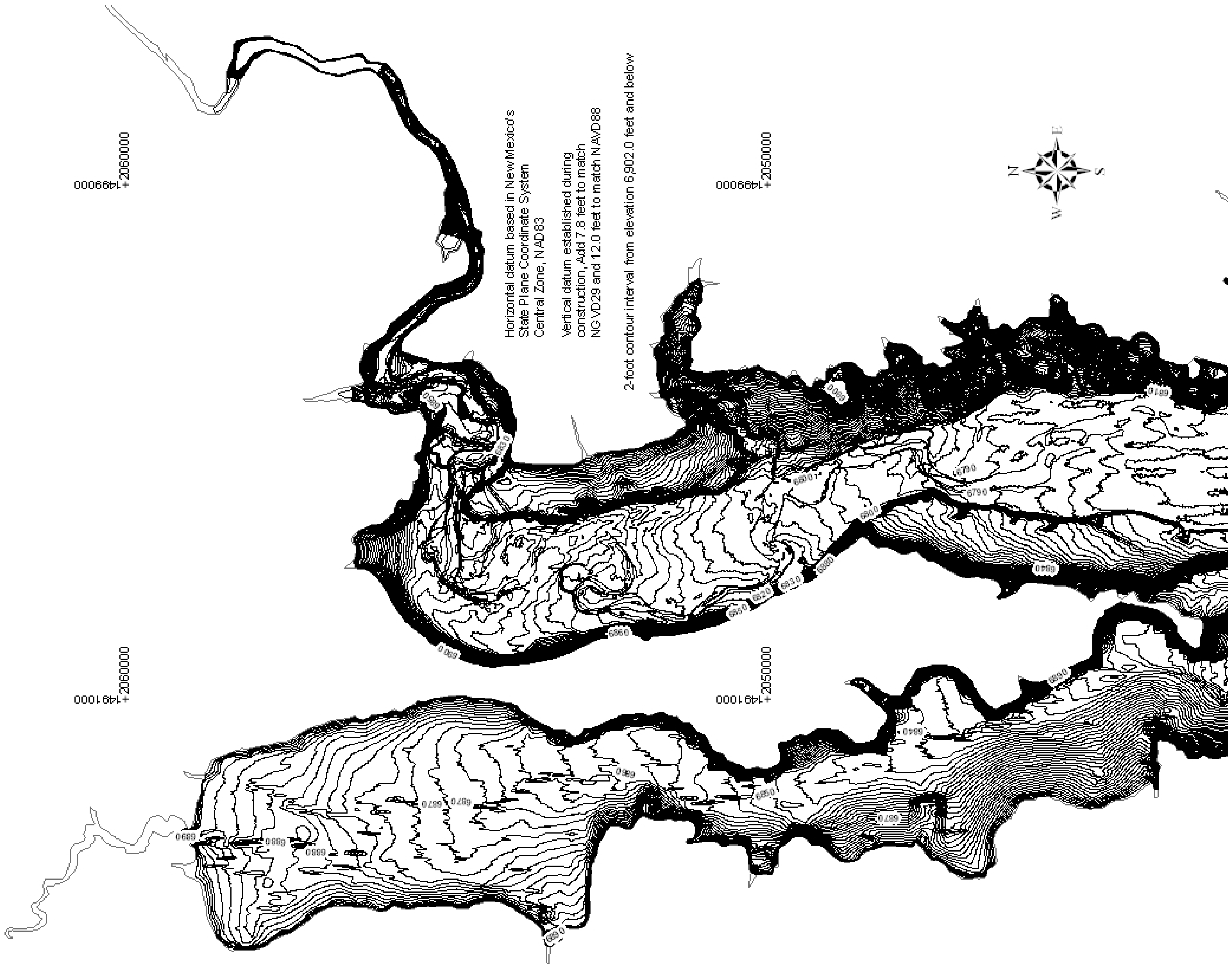

Figure 7 - El Vado Reservoir Contour Map, 2 of 2.

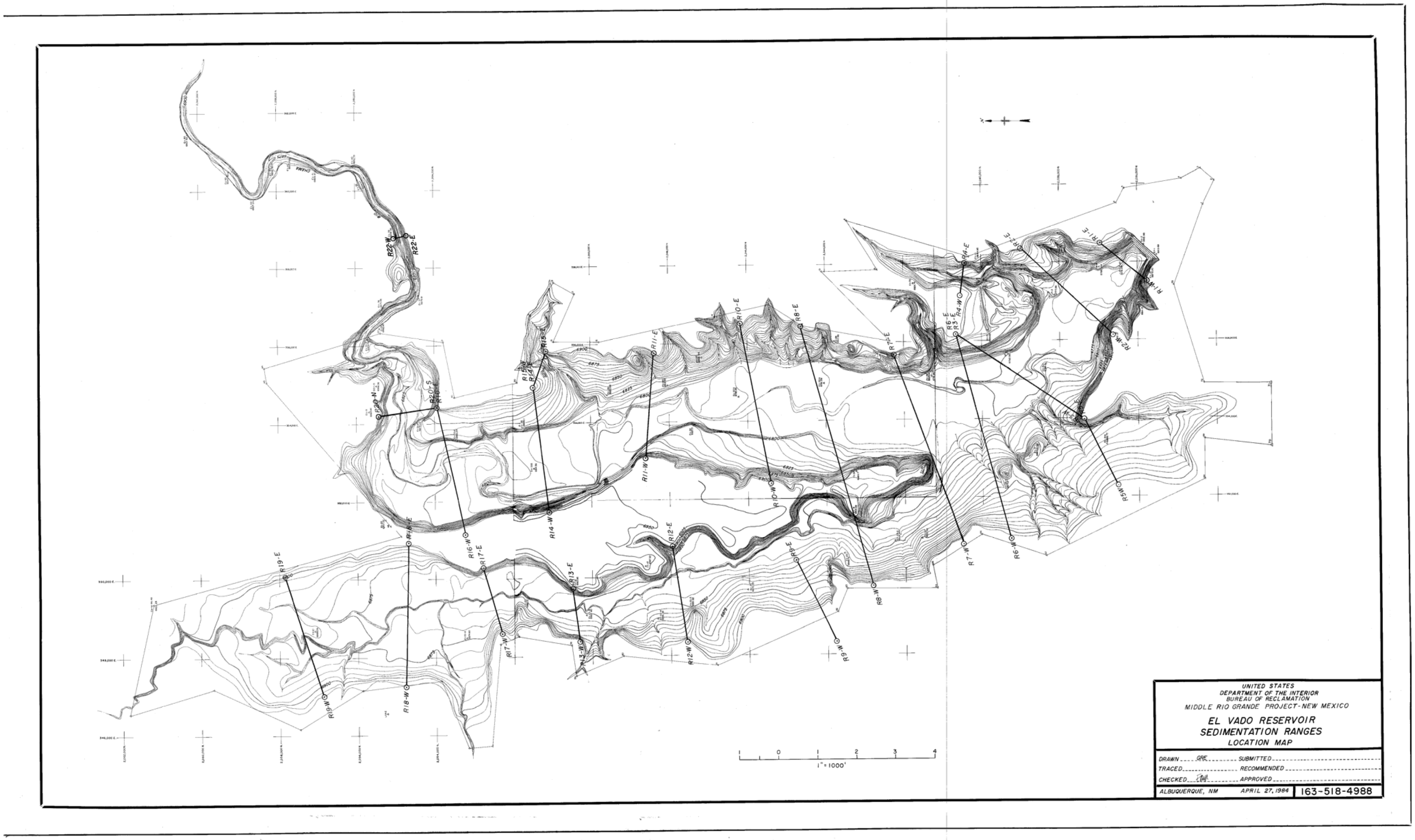

Figure 8 - El Vado Reservoir Sedimentation Ranges Developed in 1984.

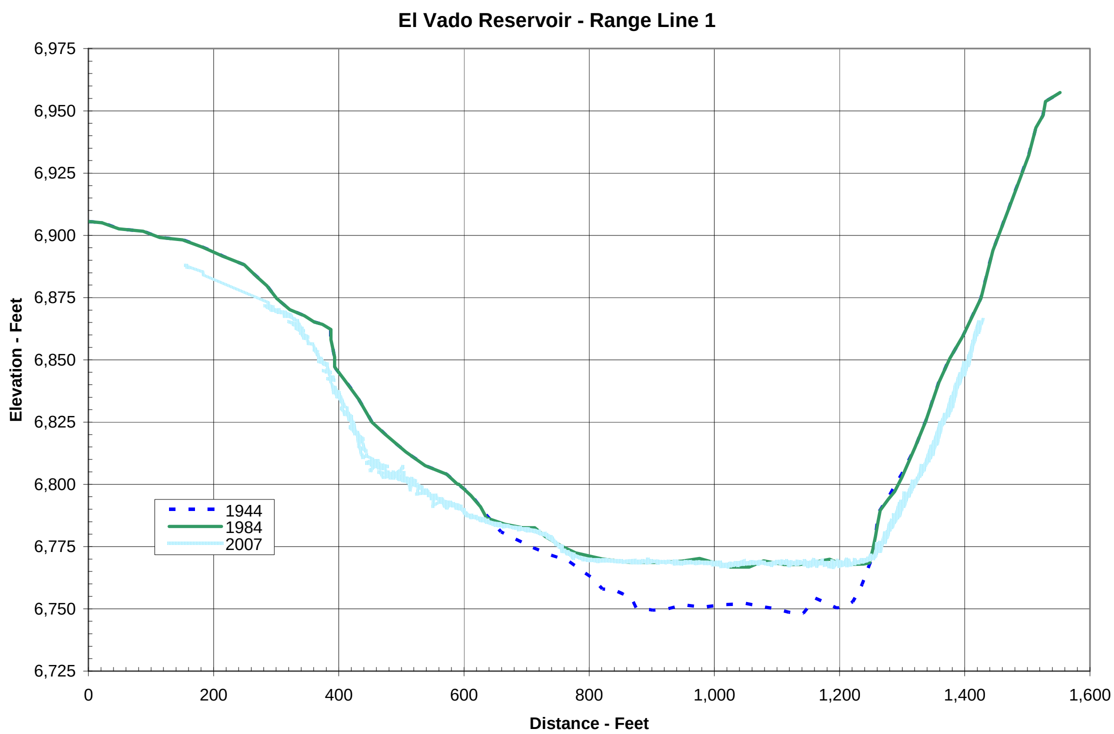

Figure 9 - Range Line 1, Rio Chama.

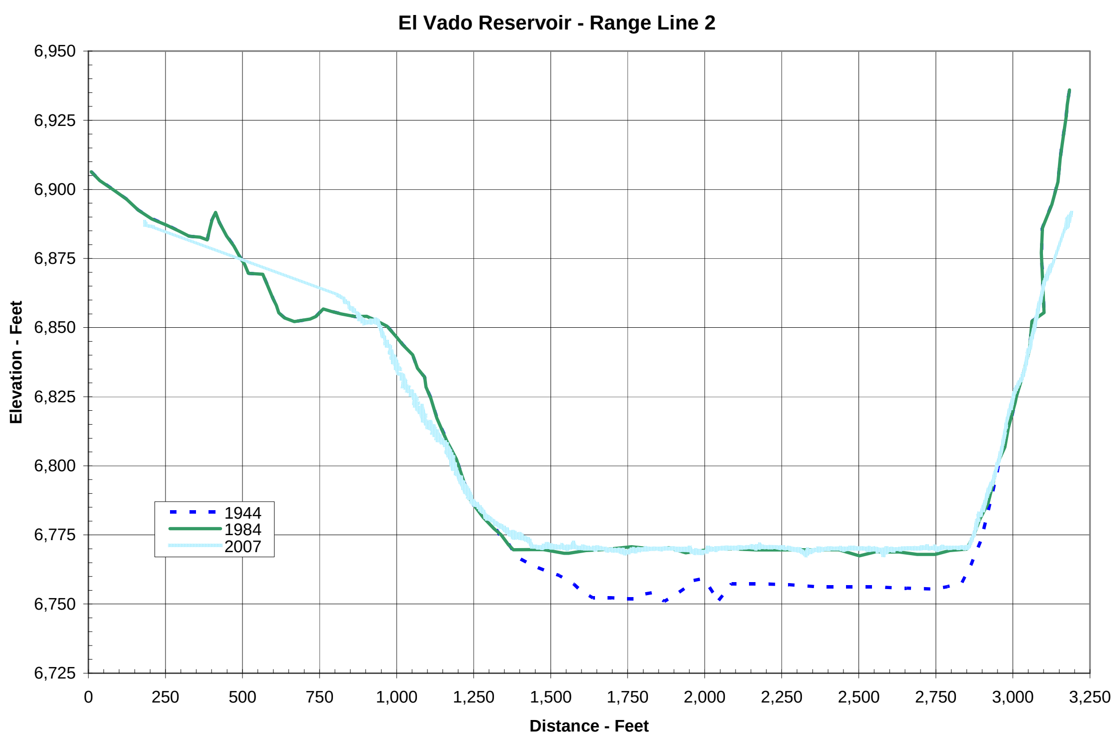

Figure 10 - Range Line 2, Rio Chama.

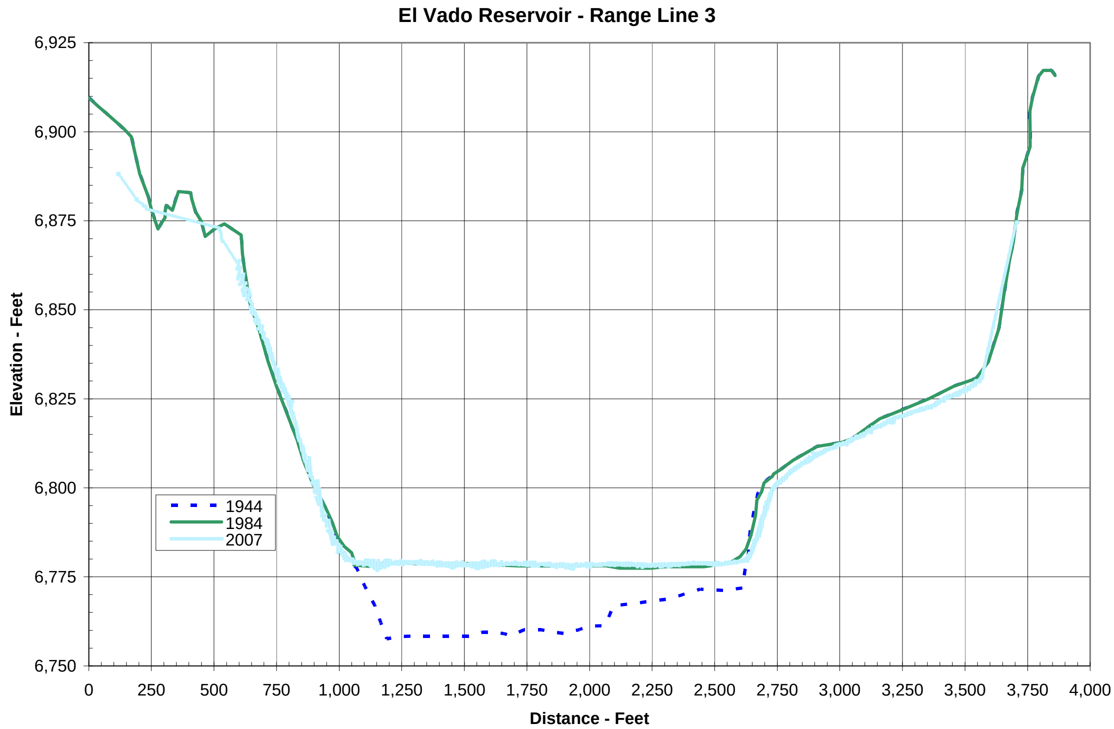

Figure 11 - Range Line 3, Rio Chama.

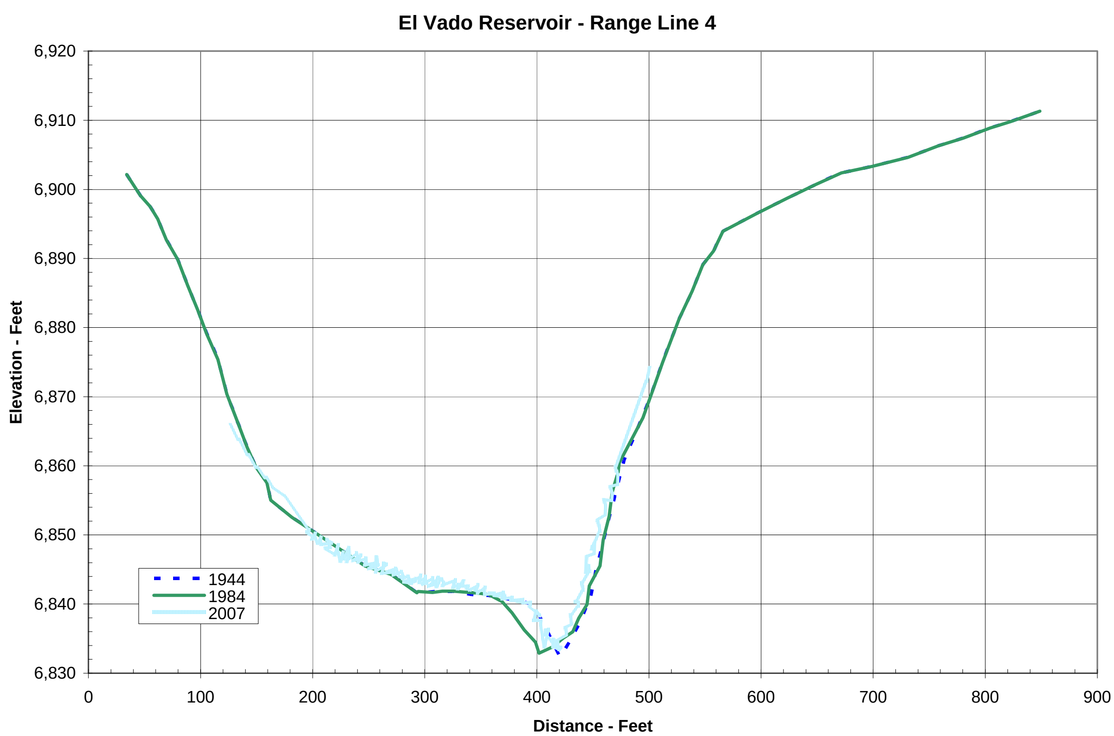

Figure 12 - Range Line 4, Rio Chama.

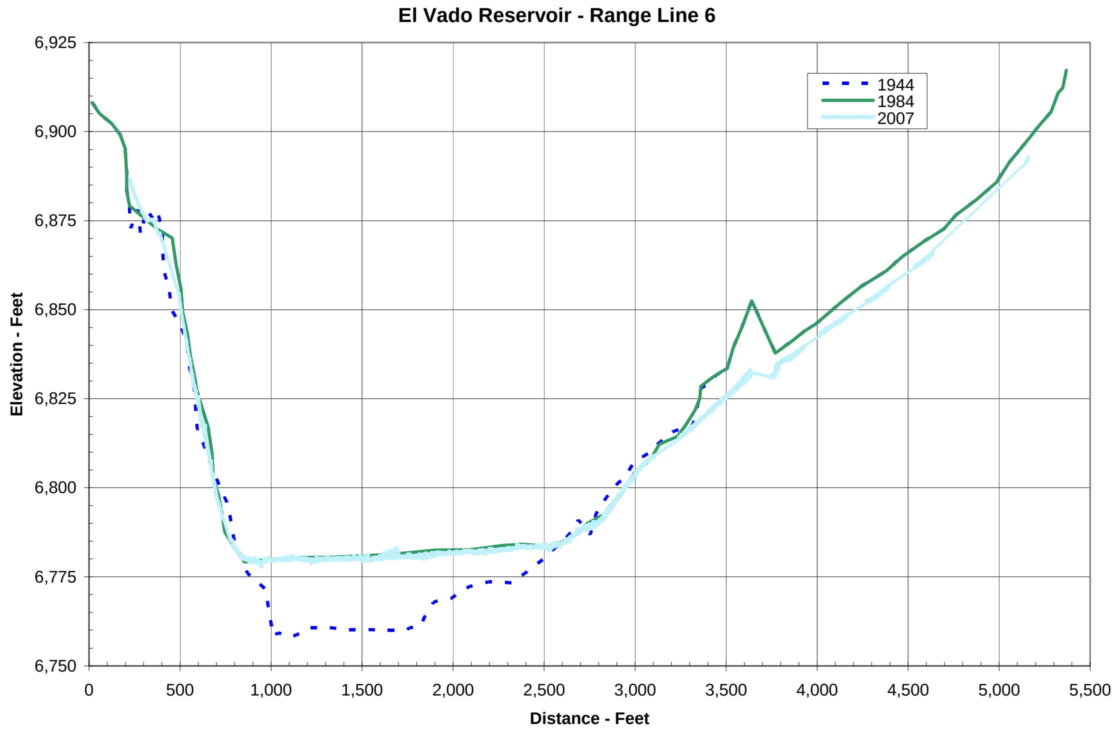

Figure 13 - Range Line 6, Rio Chama and Boulder Creek.

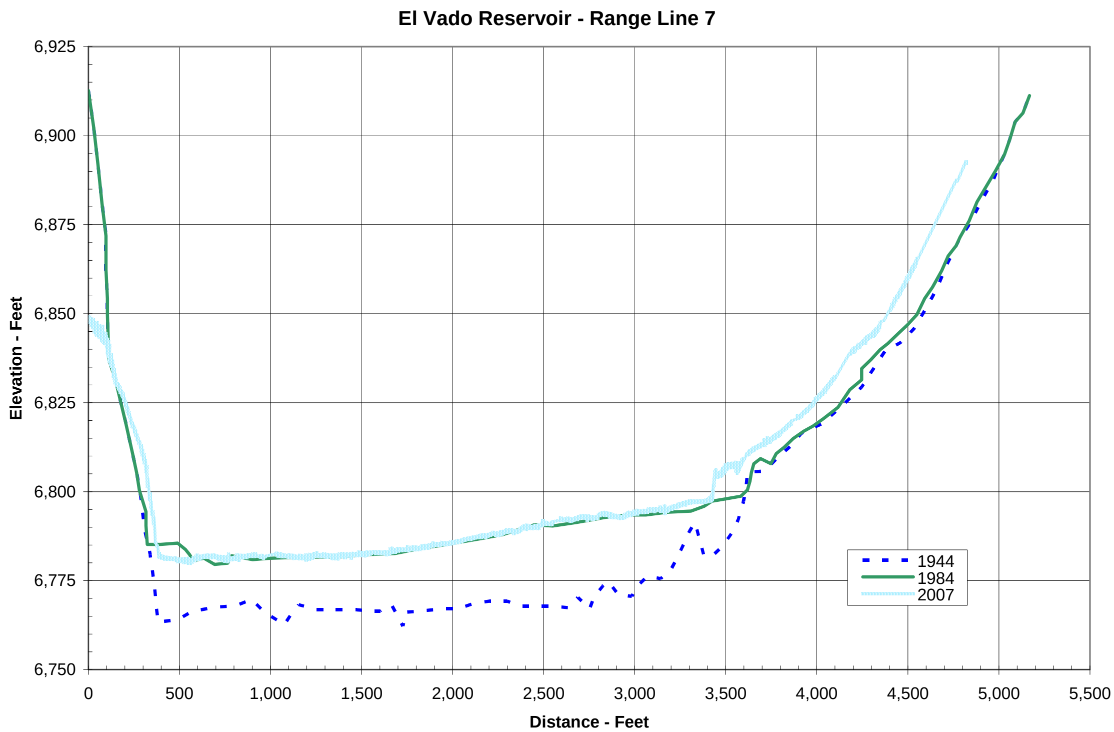

Figure 14 - Range Line 7, Rio Chama and Boulder Creek.

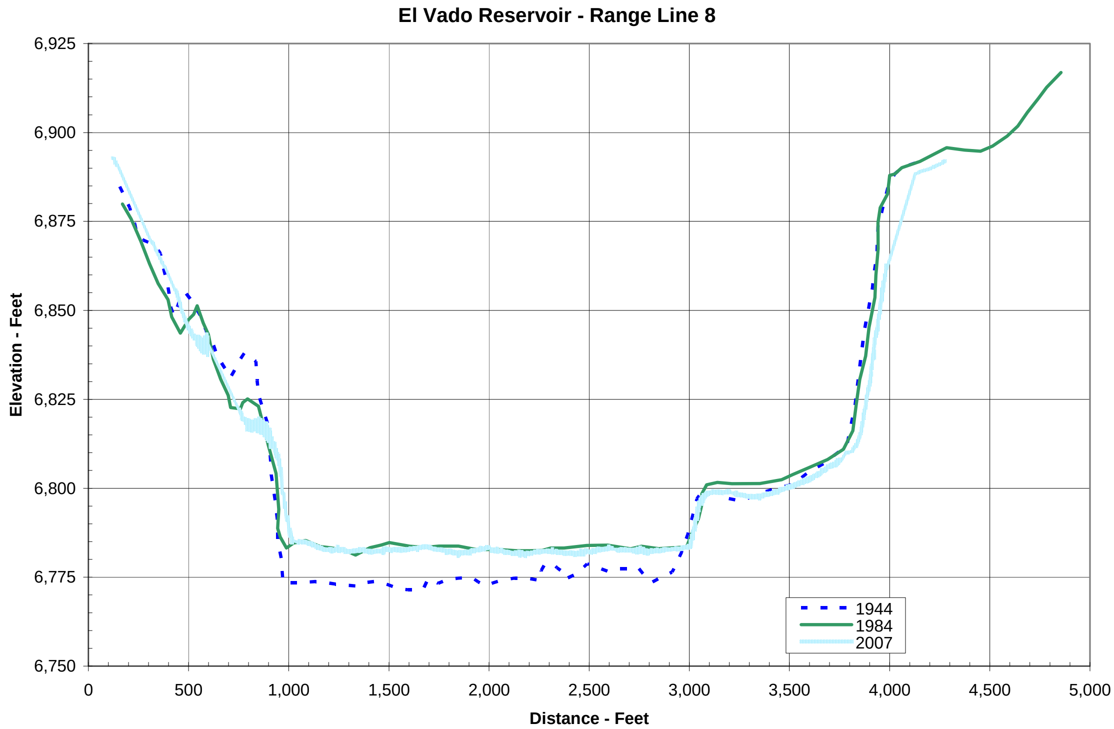

Figure 15 - Range Line 8, Rio Chama and Boulder Creek.

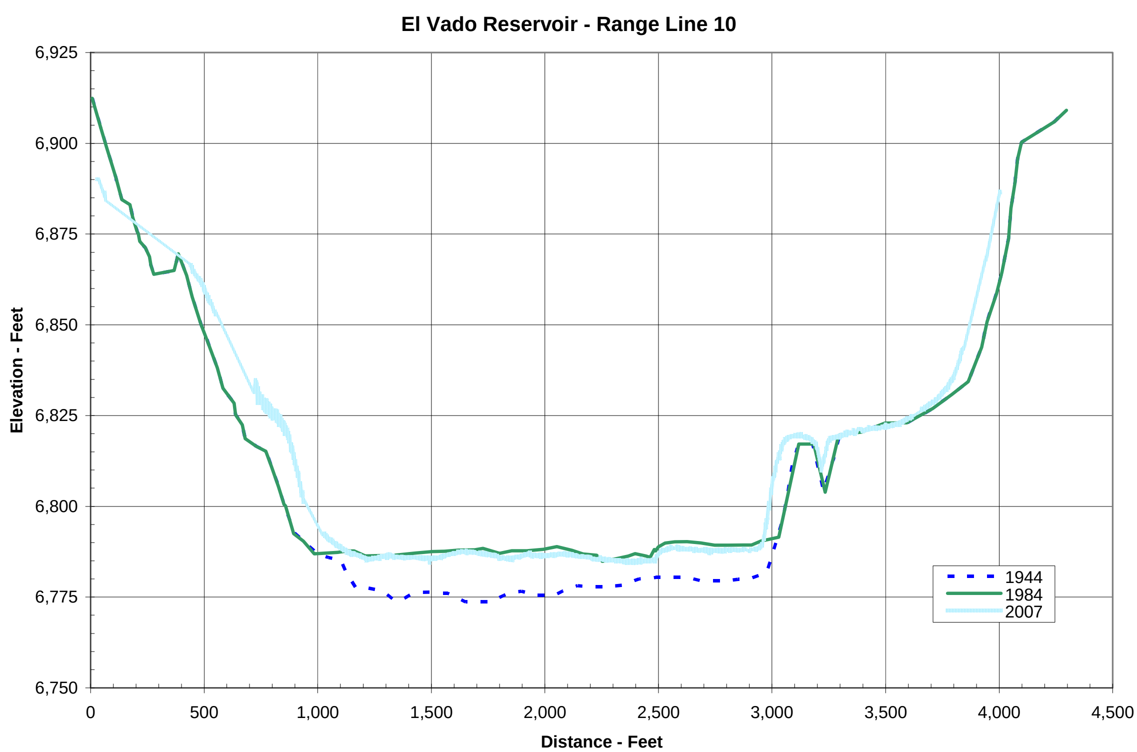

Figure 16 - Range Line 10, Rio Chama.

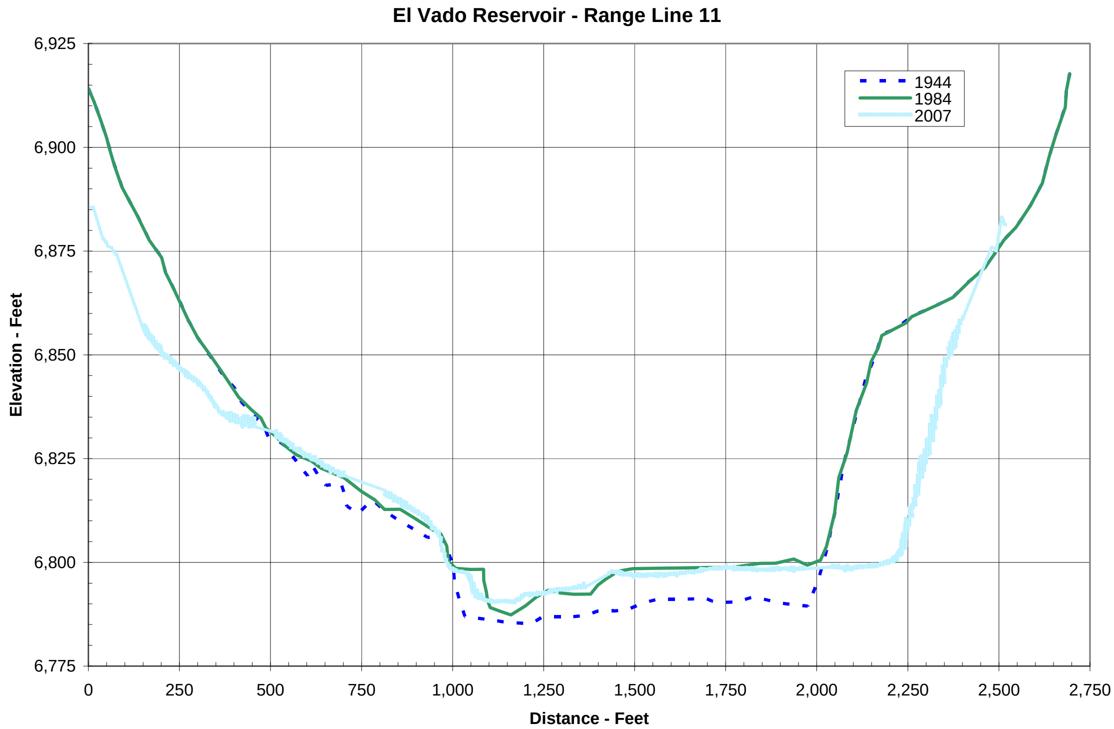

Figure 17 - Range Line 11, Rio Chama.

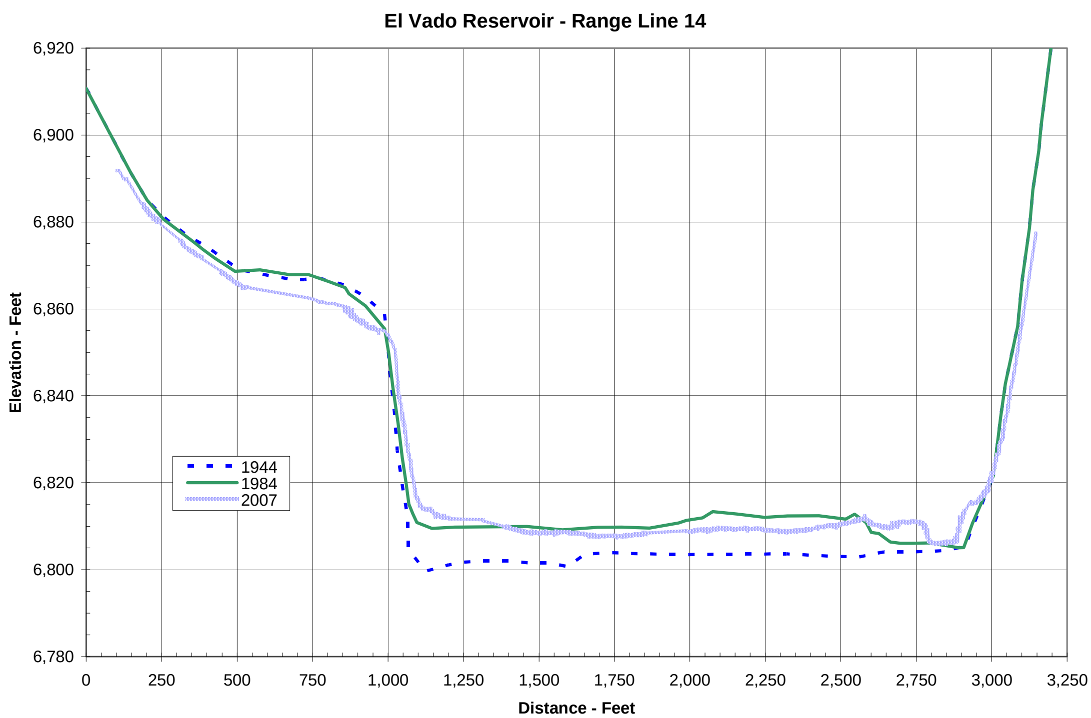

Figure 18 - Range Line 14, Rio Chama.

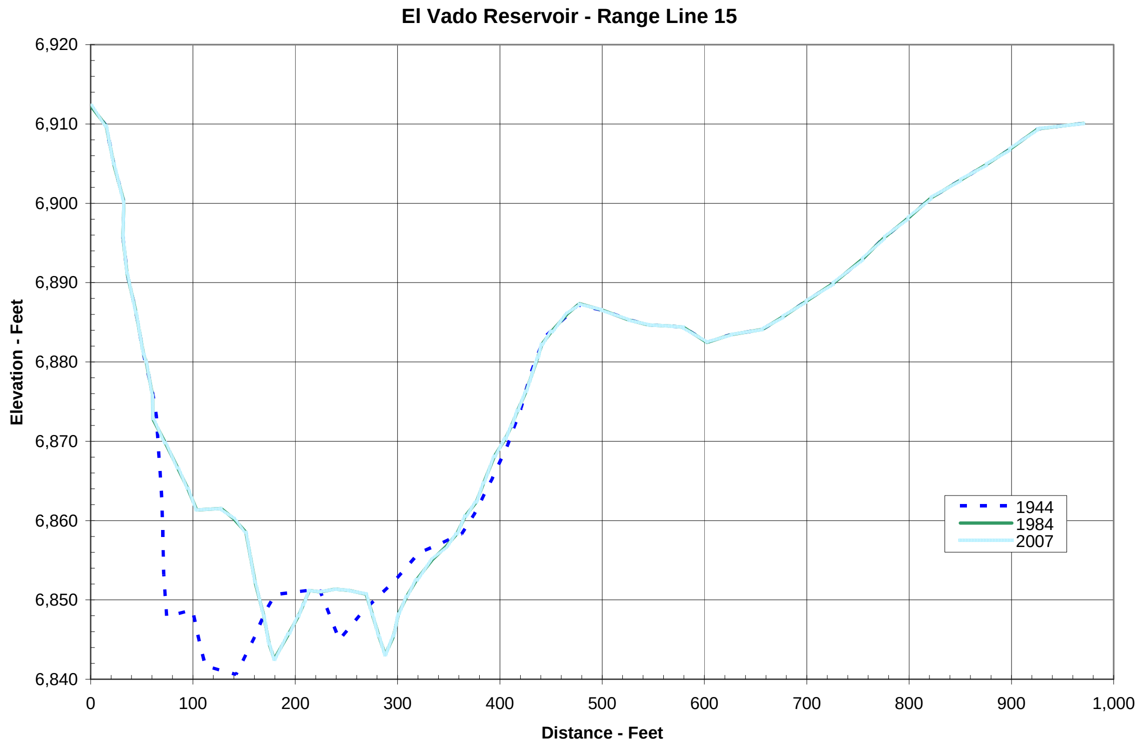

Figure 19 - Range Line 15, Rio Chama.

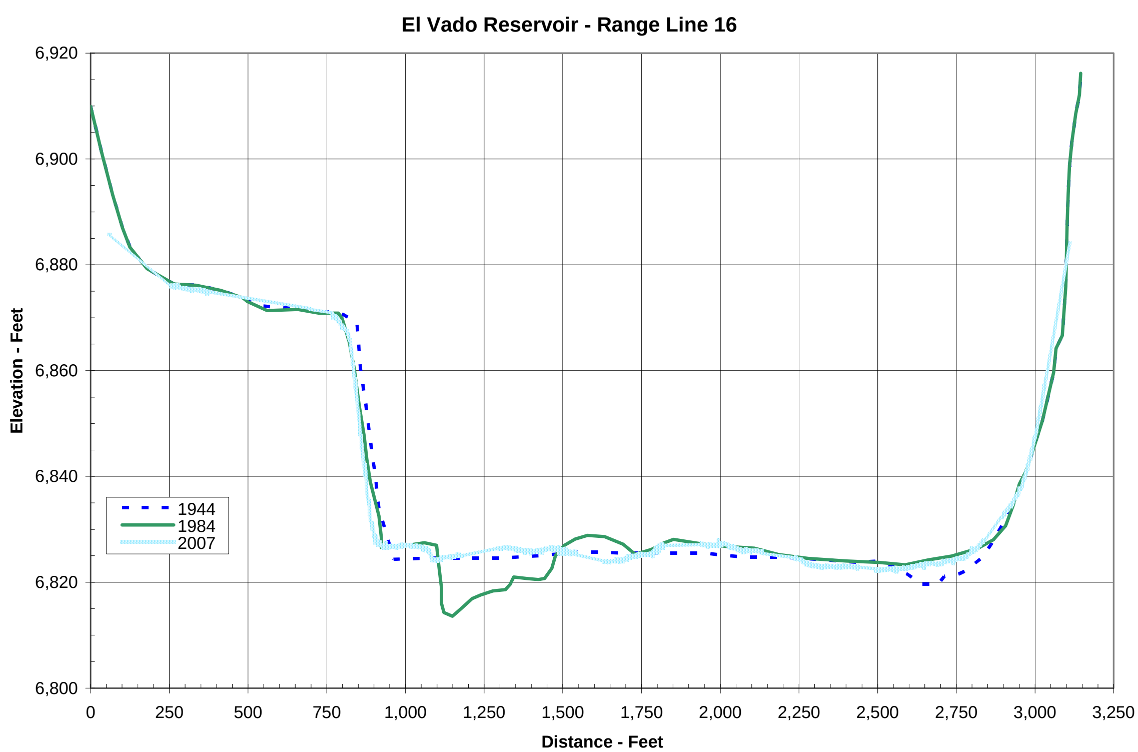

Figure 20 - Range Line 16, Rio Chama.

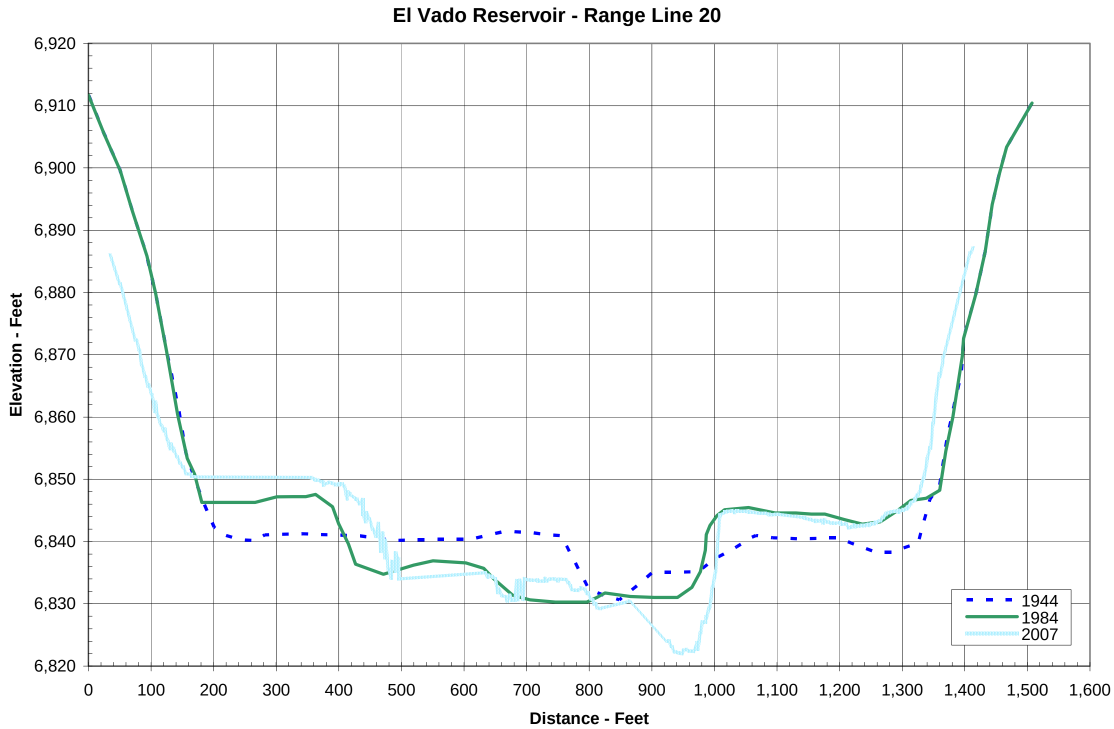

Figure 21 - Range line 20, Rio Chama.

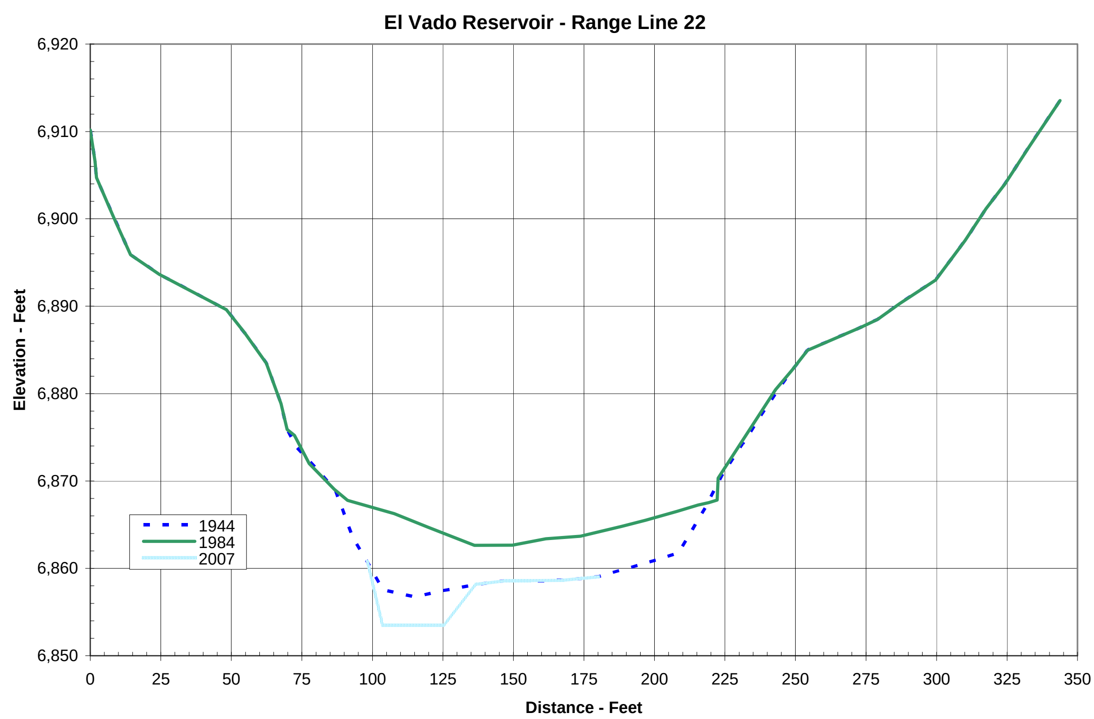

Figure 22 - Range line 22, Rio Chama.

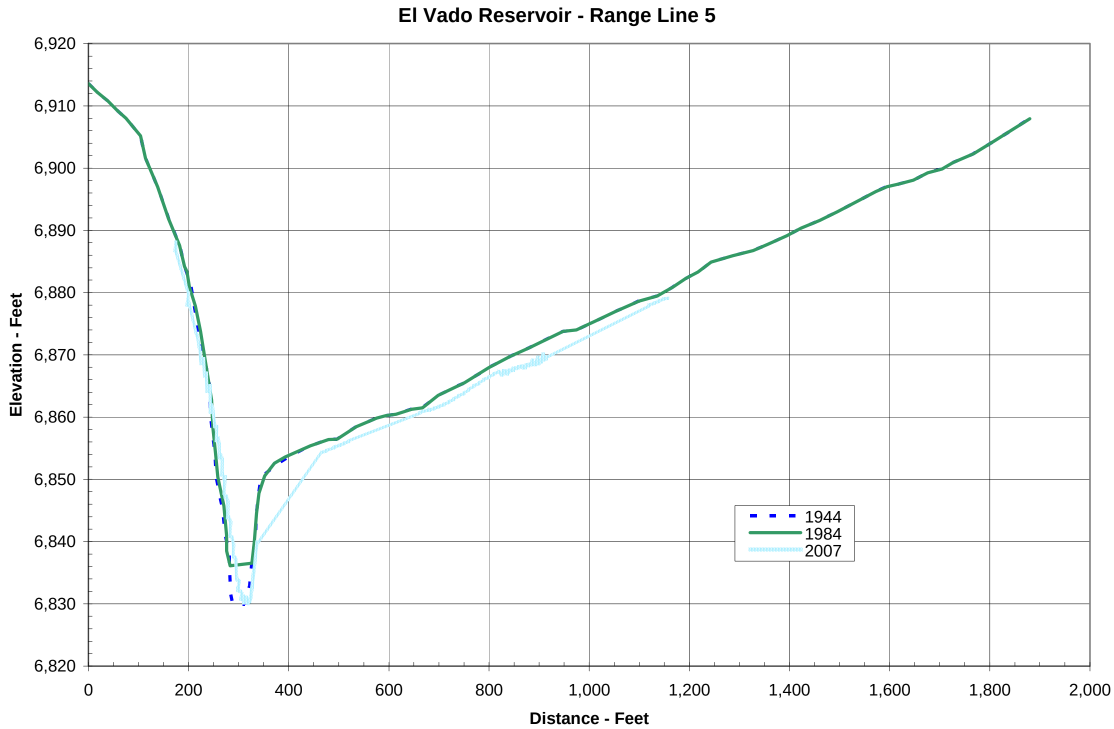

Figure 23 - Range Line 5, Boulder Creek.

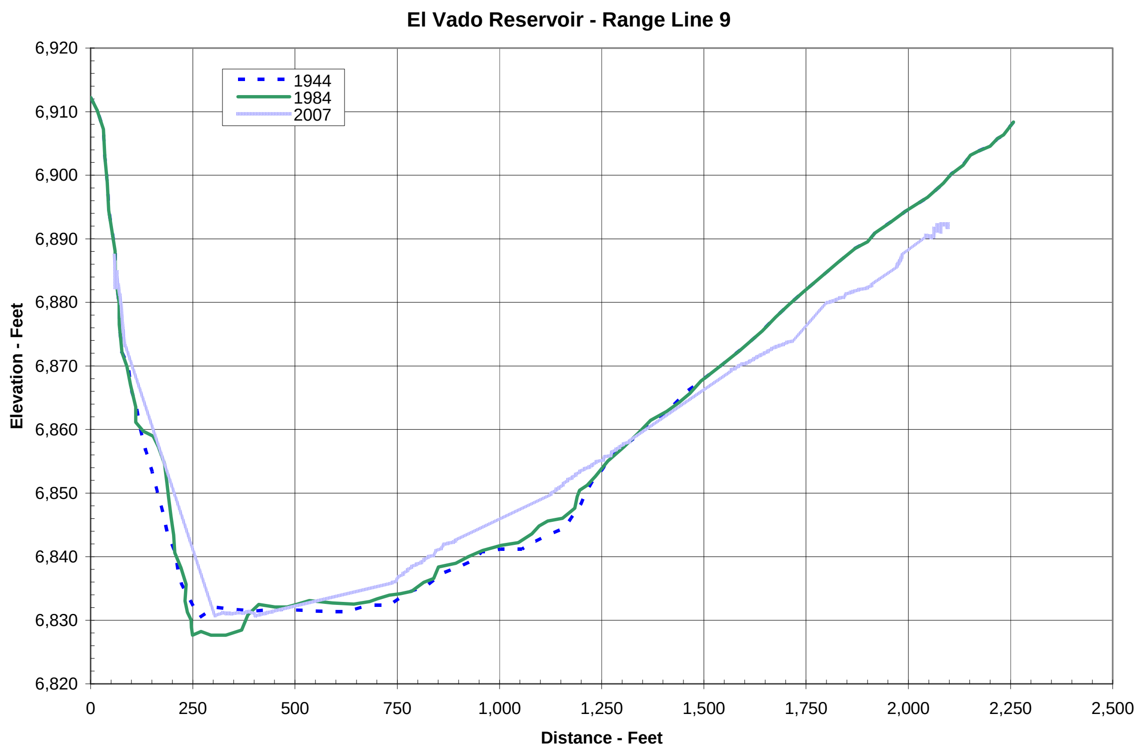

Figure 24 - Range Line 9, Boulder Creek.

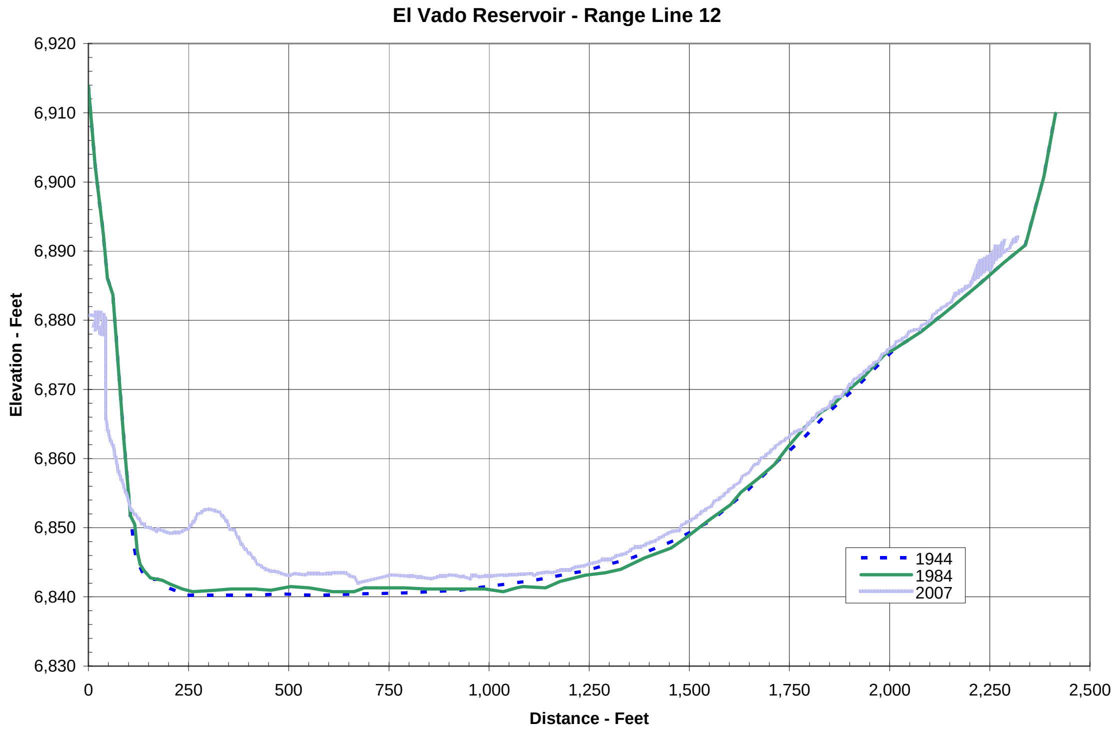

Figure 25 - Range Line 12, Boulder Creek.

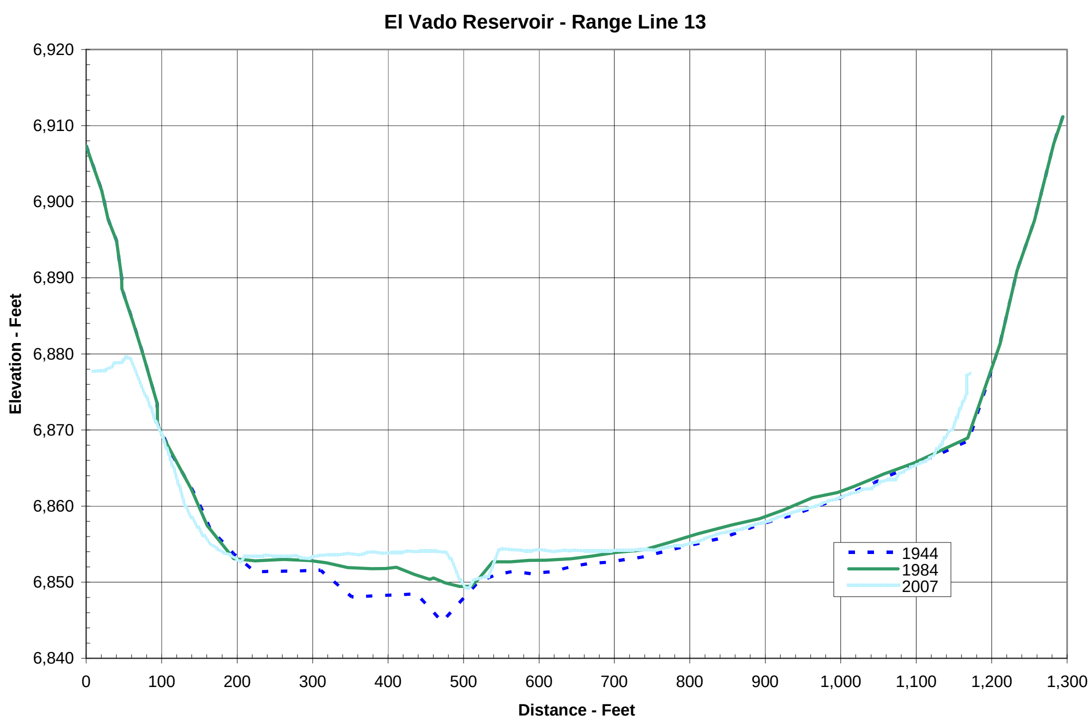

Figure 26 - Range Line 13, Boulder Creek.

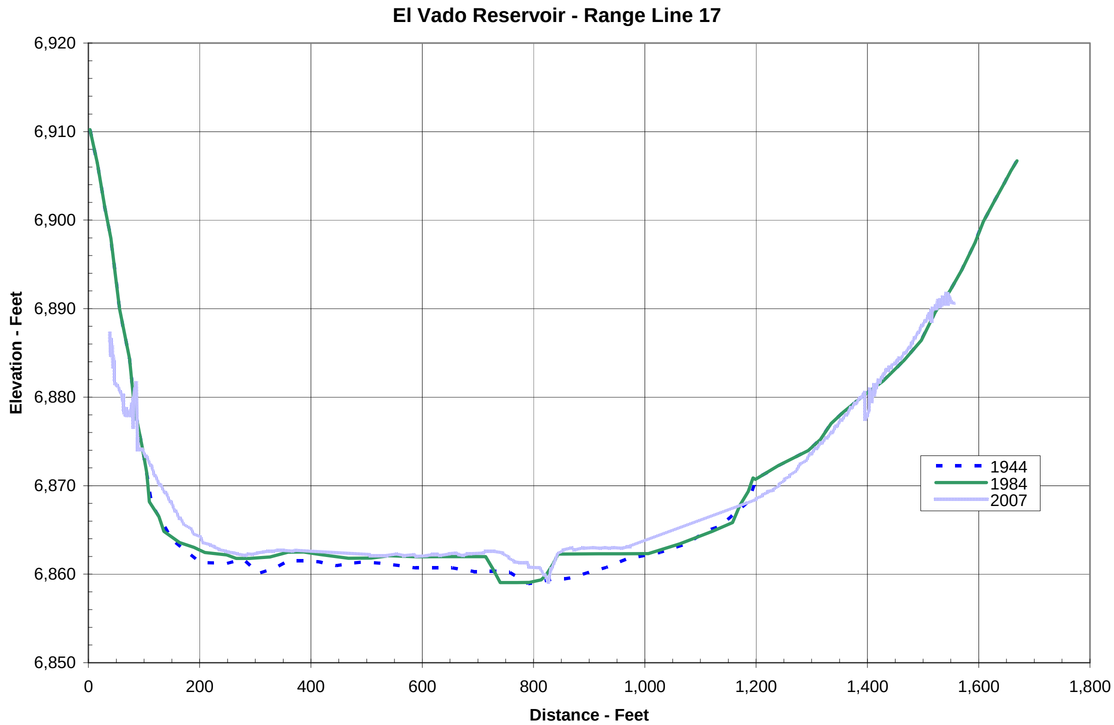

Figure 27 - Range line 17, Boulder Creek.

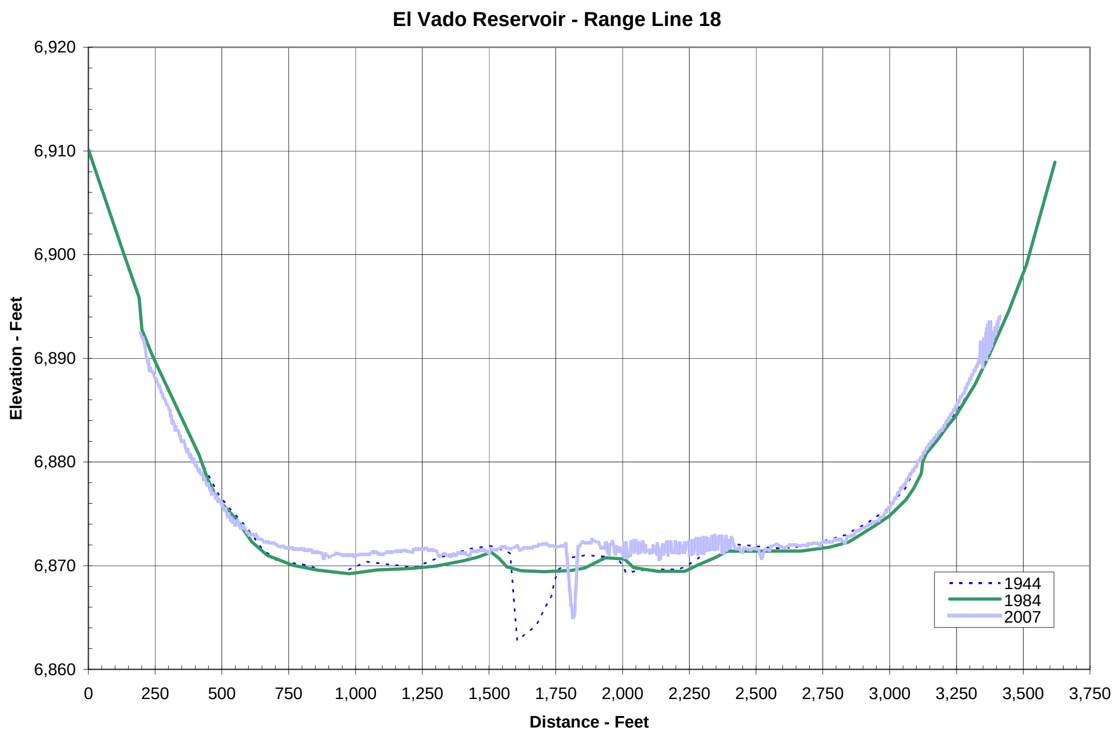

Figure 28 - Range line 18, Boulder Creek.

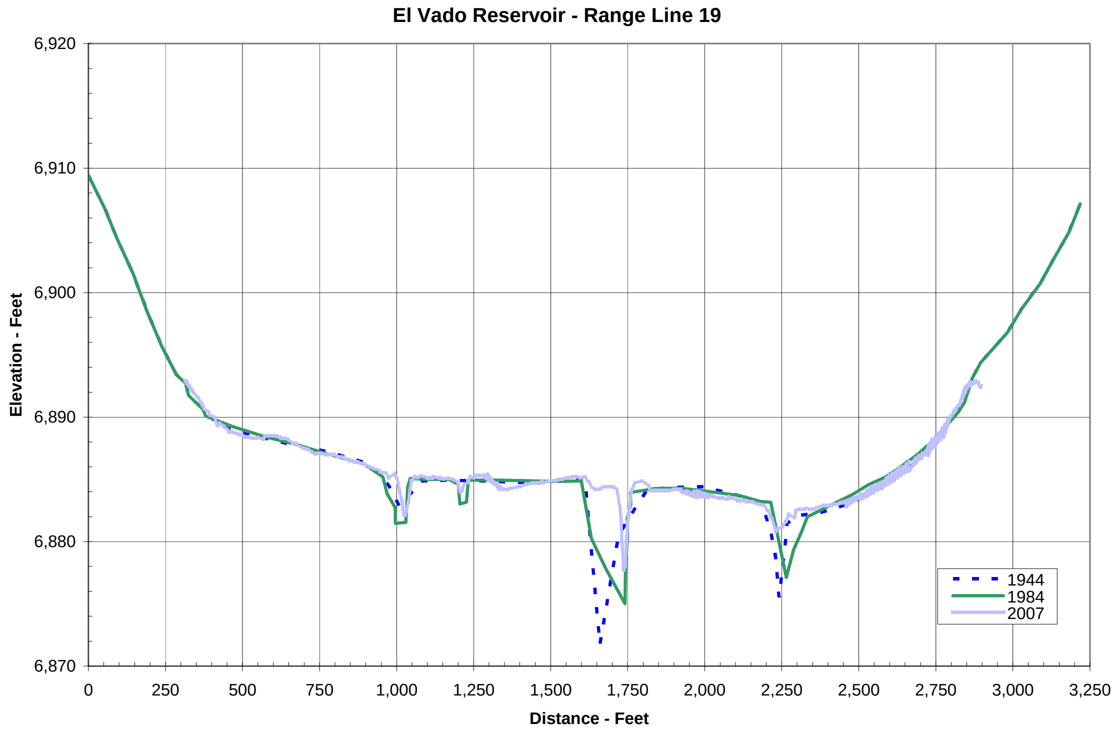

Figure 29 - Range line 19, Boulder Creek.

Development of the 2007 El Vado Reservoir Surface Areas

The 2007 surface areas for El Vado Reservoir were computed at 1-foot increments directly from the reservoir TIN from elevation 6,766.0 through 6,902.0. The TIN was developed from collected and interpolated data sets within the hardclip polygon created from the previously described digitized 6,902.0 contour. Surface area calculations were performed using ARCGIS commands that compute areas at user-specified elevations directly from the TIN. For the purpose of this study, the measured survey areas at 2- and 5-foot increments from elevation 6,766.0 through 6,900.0 were used in computing the new area and capacity tables. The 1984 surface area at elevation 6,902.0 was used since it appeared no significant change had occurred at this elevation since 1984.

Table 1 provides a summary of surveys that have been conducted on El Vado Reservoir including 1935 (original), 1944, 1967, 1984, and 2007 results. The area and capacity curves for all of these surveys are plotted on Figure 30. The table and plots show interesting results from all of these surveys. The 1967 results actually showed a slight increase in surface area at elevation 6,902.0 while the other survey results showed a similar surface area at the same elevation. There was limited literature available on the past surveys, but several located notes mentioned uncertainty in the results from previous surveys. The original surface areas were measured from developed contours that were later adjusted during the 1944 study. The 1984 El Vado Reservoir surface areas were computed using the range width ratio method that is explained in more detail in Chapter 9 of the Sedimentation Groups Erosion and Sedimentation Manual (Ferrari and Collins, 2006).

As part of the 2007 analysis, the USGS quad contours developed from 1970 aerial photographs of the reservoir area were digitized. The elevation 6,902 digitized contour was slightly adjusted to enclose all 2007 survey data, resulting in a computed surface area less than one percent different from the 1944 and 1984 results. For this study the 1984 surface area at elevation 6,902.0 was used. It was assumed the 1984 study measured the reservoir surface areas between ranges as presented in drawing number 163-518-4988, Figure 8. For computing reservoir data above elevation 6,902.0, the measured surface area of the digitized USGS quad contour 6,920 (elevation 6,912 in project datum) was used. This resulted in a 2007 computed volume of 22,270 acre-feet within the reservoir surcharge zone, slightly less than the previous published volume of 23,078 acre-feet within this same zone (Reclamation, 2006).

RESERVOIR SEDIMENT
DATA SUMMARY

El Vado Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

D	1. OWNER Middle Rio Grande Conservation District	2. STREAM Rio Chama	3. STATE New Mexico
A	4. SEC 1A TWP. 28N RANGE 2E	5. NEAREST P.O. Tierra Amarilla	6. COUNTY Rio Arriba
M	7. LAT 36 ° 35 ' # " LONG 106 ° 44 ' 00 "	8. TOP OF DAM ELEVATION 6914.5	9. SPILLWAY CREST EL 6879.0 [1]

	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, AC-FT	13. ORIGINAL CAPACITY, AC-FT	14. GROSS STORAGE ACRE-FEET	15 DATE STORAGE BEGAN
R	a. SURCHARGE	6,908.6 [2]		23,078	221,280	
E	b. FLOOD CONTROL					
S	c. Multiple Use					01/1935
E	d. JOINT USE					16 DATE NORMAL OPERATIONS BEGAN
R	e. CONSERVATION	6,902.0	3,320	193,583	198,202	
V	f. INACTIVE	6,775.0	349	4,619	4,619	
O	g. DEAD					
I / R	17. LENGTH OF RESERVOIR 11.7 [3] MILES		AVG. WIDTH OF RESERVOIR 0.4 MILES			

B	18. TOTAL DRAINAGE AREA 873 [4] SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 8 to 30 INCHES
A	19. NET SEDIMENT CONTRIBUTING AREA 602 [4] SQUARE MILES	23. MEAN ANNUAL RUNOFF INCHES
S	20. LENGTH 50 MILES AVG. WIDTH 17.4 MILES	24. MEAN ANNUAL INFLOW 287,731 [5] ACRE-FEET
I / N	21. MAX. ELEVATION 12,000± MIN. ELEVATION 6741.5	25. ANNUAL TEMP, MEAN 56 °F RANGE -20 °F to 108 °F [7]

SURVEY DATA

26. DATE OF SURVEY	27. PER. YRS	28. PER. YRS	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVALS	31. SURFACE AREA, AC.	32. CAPACITY ACRE - FEET	33. C/ RATIO AF/AF
1/1935 [2]			Contour (D)			198,202	0.69
1944			Range (D)	23	3,230	197,533	0.69
11/1967					3,380	196,500	0.68
6/1984	49.5	49.5	Range (D)	23	3,232	186,252	0.65
6/2007	23.0	72.5	Contour (D)	2-ft	3,232	190,820	0.66

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIPITATION	35. PERIOD WATER INFLOW, ACRE-FEET a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	36 WATER INFLOW TO DATE, AF a. MEAN ANN.	b. TOTAL
1944						
11/1967						
6/1984	8 to 30	287,731	544,130 [6]	13,954,950	287,731	13,954,950
6/2007						

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET a. TOTAL	b. AVG. ANN.	c. /MI.^{2}-YR.	38. TOTAL SEDIMENT DEPOSITS TO DATE, AF a. TOTAL	b. AVG. ANN.	c. /MI.^{2}-YR.
6/1984	11,950 [7]	241	0.401 [8]	11,950 [7]	241	0.401 [8]
6/2007	[9]			7,382	102	0.169

26. DATE OF SURVEY	39. AVG. DRY WT. (#/FT^3)	40. SED. DEP. TONS/MI.^{2}-YR a. PERIOD	b. TOTAL TO DATE	41. STORAGE LOSS, PCT. a. AVG. ANNUAL	b. TOTAL TO DATE	42 SEDIMENT INFLOW, PPM a. PER.	b. TOT.
6/1984				0.122	6.03		
6/2007				0.051	3.72		

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW AND ABOVE CREST ELEVATION									
	129-114	114-99	99-84	84-69	69-54	54-39	39-24	24.9	C-9	CR+11	11+23
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION										

26. DATE	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	105-	110-	115-	120-
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION													

Table 1 - Reservoir Sediment Data Summary (page 1 of 2).

45. RANGE IN RESERVOIR OPERATION [10]

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1966	6,819.1	6,758.6	230,790	1967	6,814.7	6,775.2	172,900
1968	6,812.0	6,775.0	237,230	1969	6,812.0	6,775.0	321,070
1970	6,812.0	6,775.1	199,430	1971	6,814.3	6,775.2	165,180
1972	6,812.3	6,775.3	162,440	1973	6,896.3	6,812.4	469,210
1974	6,893.0	6,845.8	174,506	1975	6,896.2	6,854.8	424,880
1976	6,898.4	6,852.2	272,130	1977	6,877.2	6,810.0	107,770
1978	6,858.8	6,813.9	300,060	1979	6,896.2	6,839.0	529,330
1980	6,877.2	6,864.4	544,130	1981	6,877.2	6,855.8	172,810
1982	6,878.5	6,866.2	475,450	1983	6,888.1	6,876.3	461,100
1984	6,885.6	6,877.6	461,500	1985	6,896.2	6,877.8	574,650
1986	6,899.9	6,897.8	568,580	1987	6,897.4	6,879.7	377,664
1988	6,900.0	6,877.7		1989	6,898.8	6,873.4	
1990	6,900.0	6,862.8		1991	6,898.3	6,870.1	
1992	6,900.2	6,868.0		1993	6,900.2	6,848.4	
1994	6,900.7	6,867.3		1995	6,897.3	6,853.9	
1996	6,893.3	6,837.2		1997	6,900.0	6,835.2	
1998	6,900.0	6,859.3		1999	6,900.2	6,854.8	
2000	6,900.0	6,826.1		2001	6,873.0	6,809.4	
2002	6,875.4	6,796.8		2003	6,892.8	6,796.8	
2004	6,878.3	6,824.4		2005	6,892.8	6,820.0	
2006	6,883.0	6,842.7		2007	6,900.2	6,842.6	

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

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
1984	**SURVEY**		6,765.0	0	0	6,770.0	56	129
6,775.0	84.1	480	6,780.0	144	1,051	6,785.0	346	2,275
6,790.0	477.3	4,333	6,795.0	548	6,897	6,800.0	617	9,810
6,805.0	701.4	13,106	6,810.0	788	16,828	6,815.0	880	20,992
6,820.0	969.9	25,619	6,825.0	1,073	30,725	6,830.0	1,169	36,328
6,835.0	1,259.9	42,399	6,840.0	1,373	48,982	6,845.0	1,473	56,098
6,850.0	1,578.4	63,727	6,855.0	1,668	71,843	6,860.0	1,797	80,506
6,865.0	1,949.9	89,873	6,870.0	2,111	100,026	6,875.0	2,296	111,044
6,880.0	2,493.1	123,017	6,885.0	2,655	135,887	6,890.0	2,853	149,658
6,895.0	3,026.6	164,358	6,900.0	3,170	179,849	6,902.0	3,232	186,252
2007	**SURVEY** [11]		6,766.0	0	0	6,770.0	38	41
6,775.0	92	424	6,780.0	165	1,006	6,785.0	386	2,422
6,790.0	497	4,667	6,795.0	557	7,310	6,800.0	631	10,273
6,805.0	715	13,633	6,810.0	809	17,437	6,815.0	903	21,718
6,820.0	985	26,448	6,825.0	1,082	31,598	6,830.0	1,200	37,314
6,835.0	1,296	43,552	6,840.0	1,399	50,276	6,845.0	1,517	57,569
6,850.0	1,630	65,436	6,855.0	1,739	73,849	6,860.0	1,856	82,830
6,865.0	2,000	92,464	6,870.0	2,166	102,868	6,875.0	2,369	114,202
6,880.0	2,563	126,565	6,885.0	2,744	139,820	6,890.0	2,927	154,009
6,895.0	3,051	168,983	6,900.0	3,136	184,452	6,902.0	3,232	190,820
6,905.0	3,361	200,710	6,908.6	3,517	213,090			

47. REMARKS AND REFERENCES

[1] Top of movable spillway gate, el. 6,902.0. All elvations tied to project datum. Add 7.8 ft to match NGVD29 and 12.0 ft to match NAVD88.

[2] Original capacity values adjusted using 1944 survey results. Questions on survey method and related accuracy of the different surveys. 1984 study projected 23,078 AF of capacity between elevation 6902.0 (Top Active Conservation Pool) to elevation 6908.6.

[3] 7.1 miles of Rio Chama arm + 4.6 miles of Boulder Creek arm = 11.7 miles.

[4] Removes Heron Reservoir drainage basin of 188 sq. miles and 83 sq. miles of non-contributing area. Heron Reservoir clousre in Oct. 1970.

[5] Beginning in 1972, inflow includes water released from Heron Reservoir which also stores transbasin diversions.

[6] Maximum annual from 1966-84.

[7] Loss below elevation 6,902.0. Uncertainty of validity of original and following values. Some studies considered 1944 most accurate.

[8] For weighted contributing area of 736.6 sq. miles.

[9] 2007 detailed contour survey computed a greater volume than 1984 range line survey. Range line comparisons (1984 and 2007) show minimum change between surveys.

[10] Data for calendar year with elevation being end-of month occurrence. Inflows are cumulative sums of computed inflows using a reservoir budget method.

[11] 2007 surface area and capacity values above elevation 6,902.0 computed using USGS quad contour results.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation DATE June 2008

Table 1 - Reservoir Sediment Data Summary (page 2 of 2).

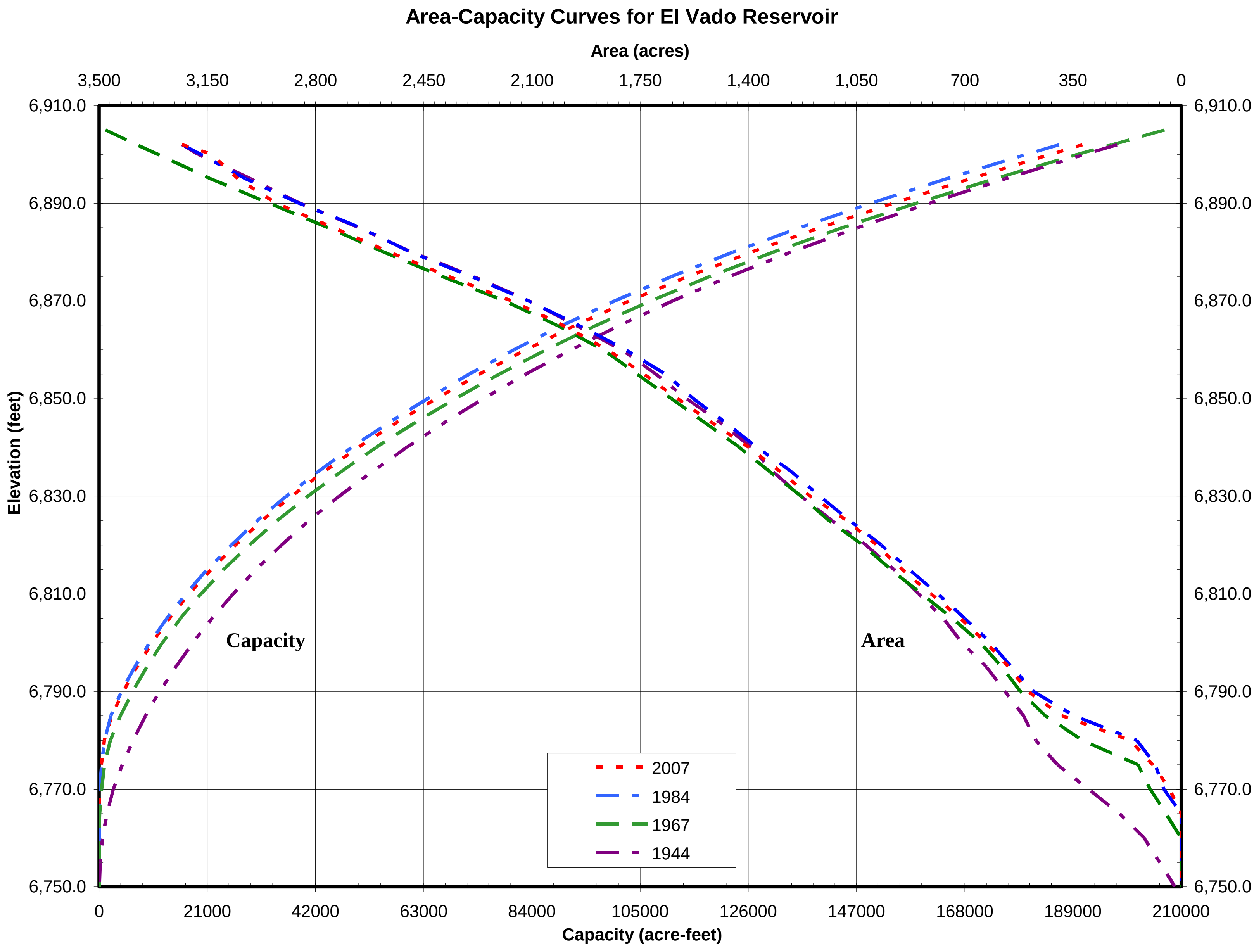

Figure 30 - El Vado Reservoir Area and Capacity Plots

2007 Storage Capacity

The storage-elevation relationships based on the measured surface areas were developed using the area-capacity computer program ACAP (Bureau of Reclamation, 1985). The ACAP program can compute the area and capacity at elevation increments from 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 El Vado Reservoir. The capacity equation is then used over the full range of intervals fitting within the 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. Through differentiation of the capacity equations, which are of second order polynomial form, final area equations are derived:

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

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

Results of the El Vado Reservoir area and capacity computations are listed in a separate set of 2007 area and capacity tables and have been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation, 2007). A description of the computations and coefficients output from the ACAP program is included with these tables. The original (1935), 1944, 1967, 1984, and 2007 area-capacity relationships are listed on Table 2. The curves for all surveys except for the original, due to limited data, are plotted on Figure 30. As of June 2007, at conservation use elevation 6,902.0, the surface area was 3,232 acres with a total capacity of 190,820 acre-feet.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15a	16	17
						1967				1984				2007	2007		
	1935					Sediment	1967			Sediment	1984			Sediment	Sediment	2007	
	Original	1944	1944	1967	1967	Volume	Percent	1984	1984	Volume	Percent	2007	2007	Volume	Volume	Percent	Percent
Elevation	Capacity	Area	Capacity	Area	Capacity	Since 1944	Computed	Area	Capacity	Since 1944	Computed	Area	Capacity	Since 1935	Since 1944	Computed	Reservoir
Feet	Ac-Ft	Acres	Ac-Ft	Acres	Ac-Ft	Ac-Ft	Sediment	Acres	Ac-Ft	Ac-Ft	Sediment	Acres	Ac-Ft	Ac-Ft	Ac-Ft	Sediment	Depth
6,908.6												3,517.0	213,090				
6,905.0				3,480	206,780							3,361.0	200,710				
6,902.0	198,202	3,230	197,533	3,380	196,500	1,033	100.0	3,232	186,252	11,281	100.0	3,232.0	190,820	7,382	6,713	100.0	100.0
6,900.0		3,180	191,154	3,310	189,810	1,344	130.1	3,170	179,849	11,305	100.2	3,135.9	184,452		6,702	99.8	98.8
6,895.0		3,010	175,719	3,140	173,690	2,029	196.4	3,027	164,358	11,361	100.7	3,050.8	168,983		6,736	100.3	95.7
6,890.0	161,750	2,850	161,019	2,950	158,470	2,549	246.8	2,853	149,658	11,361	100.7	2,926.6	154,009	7,741	7,010	104.4	92.6
6,885.0		2,660	147,155	2,760	144,210	2,945	285.1	2,655	135,887	11,268	99.9	2,743.7	139,820		7,335	109.3	89.5
6,880.0	135,053	2,490	134,286	2,580	130,850	3,436	332.6	2,493	123,017	11,269	99.9	2,562.8	126,565	8,488	7,721	115.0	86.4
6,875.0		2,290	122,285	2,390	118,430	3,855	373.2	2,296	111,044	11,241	99.6	2,369.4	114,202		8,083	120.4	83.3
6,870.0	112,194	2,110	111,253	2,190	107,000	4,253	411.7	2,111	100,026	11,227	99.5	2,166.3	102,868	9,326	8,385	124.9	80.2
6,865.0		1,960	101,044	2,020	96,490	4,554	440.9	1,950	89,873	11,171	99.0	2,000.3	92,464		8,580	127.8	77.2
6,860.0	92,808	1,810	91,649	1,870	86,770	4,879	472.3	1,797	80,506	11,143	98.8	1,856.4	82,830	9,978	8,819	131.4	74.1
6,855.0		1,700	82,825	1,760	77,690	5,135	497.1	1,668	71,843	10,982	97.3	1,738.7	73,849		8,976	133.7	71.0
6,850.0	75,979	1,600	74,618	1,650	69,160	5,458	528.4	1,578	63,727	10,891	96.5	1,629.8	65,436	10,543	9,182	136.8	67.9
6,845.0		1,490	66,886	1,540	61,180	5,706	552.4	1,473	56,098	10,788	95.6	1,517.2	57,569		9,317	138.8	64.8
6,840.0	61,183	1,390	59,680	1,430	53,770	5,910	572.1	1,373	48,982	10,698	94.8	1,399.2	50,276	10,907	9,404	140.1	61.7
6,835.0		1,320	52,912	1,330	46,880	6,032	583.9	1,260	42,399	10,513	93.2	1,295.7	43,552		9,360	139.4	58.6
6,830.0	46,183	1,230	46,603	1,230	40,480	6,123	592.7	1,169	36,328	10,275	91.1	1,200.2	37,314	8,869	9,289	138.4	55.6
6,825.0		1,130	40,729	1,140	34,540	6,189	599.1	1,073	30,725	10,004	88.7	1,082.2	31,598		9,131	136.0	52.5
6,820.0	34,886	1,020	35,358	1,030	29,110	6,248	604.8	970	25,619	9,739	86.3	985.1	26,448	8,438	8,910	132.7	49.4
6,815.0		930	30,455	940	24,180	6,275	607.5	880	20,995	9,460	83.9	903.0	21,718		8,737	130.2	46.3
6,810.0	25,788	850	26,005	840	19,730	6,275	607.5	788	16,828	9,177	81.3	808.6	17,437	8,351	8,568	127.6	43.2
6,805.0		770	21,904	740	15,770	6,134	593.8	701	13,106	8,798	78.0	714.8	13,633		8,271	123.2	40.1
6,800.0	17,987	710	18,191	650	12,290	5,901	571.2	617	9,810	8,381	74.3	631.0	10,273	7,714	7,918	118.0	37.0
6,795.0		630	14,805	580	9,240	5,565	538.7	548	6,897	7,908	70.1	557.4	7,310		7,495	111.6	34.0
6,790.0	11,793	570	11,765	520	6,510	5,255	508.7	477	4,333	7,432	65.9	496.7	4,667	7,126	7,098	105.7	30.9
6,785.0		510	9,015	440	4,100	4,915	475.8	346	2,275	6,740	59.7	386.4	2,422		6,593	98.2	27.8
6,780.0	6,924	470	6,577	320	2,190	4,387	424.7	144	1,051	5,526	49.0	165.0	1,006	5,918	5,571	83.0	24.7
6,775.0		400	4,472	140	1,060	3,412	330.3	84	480	3,992	35.4	92.4	424		4,048	60.3	21.6
6,770.0	3,182	300	2,765	100	490	2,275	220.2	56	129	2,636	23.4	38	41	3,141	2,724	40.6	18.5
6,765.0		200	1,502	50	130	1,372	132.8	0	0	1,502	13.3	0	0		1,502	22.4	15.4
6,760.0	855	120	691	0	0	691	66.9	0	0	691	6.1	0	0	855	691	10.3	12.3
6,755.0		70	210	0	0	210	20.3	0	0	210	1.9	0	0		210	3.1	9.3
6,750.0	23	20	23	0	0	23	2.2	0	0	23	0.2	0	0	23	23	0.3	6.2
6,740.0	0	0	0	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0.0	0.0

1	Reservoir water surface elevation tied to project or construction datum, add 7.8 feet to match NGVD29 and 12.0 feet to match NAVD88.
2	Original capacity readjusted based on corrections of original traverse in May 1944.
3	1944 reservoir surface area, measured by contour method. 1944 survey data used to adjust original 1935 upper contours, but accuracy is questionable.
4	1944 reported reservoir capacity.
5	1967 reservoir surface area.
6	1967 reported reservoir capacity.
7	1967 computed sediment volume, column (4) - column (6), Since 1944. Due to limited information on original data, 1944 considered original.
8	1967 measured sediment in percentage of total sediment (1,033 AF at elevation 6902.0). Maximum measured deposition (6,275 AF) at elevation 6,810.0.
9	1984 reservoir surface area.
10	1984 reported reservoir capacity.
11	1984 computed sediment volume, column (4) - column (10), Since 1944. Due to limited information on original data, 1944 considered original.
12	1984 measured sediment in percentage of total sediment (11,281 AF at elevation 6,902.0).
13	2007 measured reservoir surface area. 2007 surface areas at elevation 6,902.0 and 6,912.2 developed from USGS quad contours.
14	2007 reservoir capacity computed using ACAP.
15	2007 measured sediment volume, column (2) - column (14), Since 1935 (original survey).
15a	2007 measured sediment volume, column (4) - column (14), Since 1944. Due to limited information on original data, 1944 considered original.
16	2007 measured sediment in percentage of total sediment (6,713 AF at elevation 6,902.0). Maximum measured deposition (9,404 AF) at elevation 6,840.0.
17	Depth of reservoir expressed in percentage of total depth, 162.0 feet, from water surface 6,902.0.

Table 2 - Summary of 2007 Survey Results.

2007 Reservoir Analyses

Results of the 2007 El Vado Reservoir area and capacity computations are listed in Table 1 and columns 13 and 14 of Table 2. Column 2 in Table 2 lists the original capacity values that were adjusted from the 1944 resurvey results. There was limited information on the original reservoir survey, but it was assumed it consisted of 10-foot contour intervals developed from a plane table survey. Columns 3 and 4 list the 1944 survey area and capacity values. The 1944 survey was conducted to correct the original survey and was considered the base for comparisons with the 1967, 1984, and 2007 resurveys showing the sediment deposition pattern. Column 15a lists the capacity differences between the 1944 and 2007 survey results that are due to sediment deposition and methods of collection. Figure 30 is a plot of the El Vado Reservoir surface area and capacity values for the 1944, 1967, 1984, and 2007 surveys, illustrating the differences and reservoir area and capacity patterns.

Table 1 shows the total capacity at elevation 6,902.0 for all known surveys along with the computed differences. The total reservoir capacity in 2007 is 7,382 acre-feet less than the original (1935) volume at reservoir elevation 6,902.0. It must be noted that the 2007 area and capacity tables were generated assuming no surface area change since the 1984 survey at elevation 6,902.0. Assuming no change at elevation 6,902.0 is probably not entirely accurate, but any loss due to sediment deposition above this elevation is not significant since the range line comparison plots show little to no change of the upper range lines. For the 2007 study, the USGS quad contour 6,912 (labeled 6,920 on the USGS quad) was digitized to compute the surface area and was used to calculate the area and capacity of the reservoir from elevation 6,902.0 to 6,912.0. This computation method resulted in a smaller surcharge capacity than previous publications, but no information on how the previous capacity was computed could be located. On the Chama arm, the comparison plots measured scour of the previously deposited sediments in the upper reservoir that occurred during low reservoir drawdown and clean water releases from Heron Reservoir. Questions as to the accuracy of these USGS digitized surface areas can only be answered with a detailed aerial survey of the reservoir area.

During the planning phase for El Vado Reservoir, the original estimated 100 year sediment accumulation for was around 30,100 acre-feet at elevation 6,902.0, an average annual loss of 301 acre-feet. Table 1 list the sediment computation results of the 1984 and 2007 surveys that measured an average annual loss of 241 and 102 acre-feet respectfully. The 2007 survey measured a larger reservoir capacity than the 1984 survey, resulting in a much lower computed average annual loss. It is assumed much of the computed differences are due to the accuracy differences between the survey methods along with sediment deposition.

During the 2007 analysis limited files and notes on the details of the previous surveys were located. The May 1944 survey found errors in the original boundary survey and topography which necessitated the resurvey and adjustments of the original upper elevation topography. This adjustment resulted in corrected original capacities for comparison with the 1944 and subsequent surveys. In May and June of 1944 a plane table survey of the original reservoir boundary was conducted and 22 sediment ranges were established. Depth soundings were collected along the newly established sediment ranges and the original capacity based on the adjusted original contours was recomputed to be 198,202 acre-feet at elevation 6902.0. During the 1984 survey, the range lines were resurveyed and the differences used to compute the change of the original surface areas between the range lines, resulting in a computed 1984 reservoir capacity of 186,252 at elevation 6902.0.

For the 2007 analysis, the hard copies of the range lines plots were digitized for comparisons between the three surveys. As seen from these plots, Figures 9 through 29, there was little or no change between the 1984 and 2007 surveys for the majority of the range lines. A few of the range lines located in the upper Chama reach actually showed a gain in volume due to scouring of the previously deposited sediments. This is the reach were Heron Reservoir is located, which began trapping sediment for a large portion of this part of the basin after dam closure in 1970. For the Boulder Creek area only a few of the range lines indicated a small change in 2007 due to sediment deposition since 1984. If the 1984 range line computation method could have been recreated using the 2007 range line data, only a very slight loss of total reservoir capacity would likely have been computed between 1984 and 2007. The method utilized in the 1984 computations only analyses the data at each range line and mathematically computes the surface area change between the range line locations. The 2007 study used the contour method were survey data was collection throughout the reservoir area, providing detailed topography of the current reservoir geometry and current reservoir volume.

The results of the 2007 El Vado Reservoir study provide up-to-date surface area and capacity information for the entire reservoir. Besides obtaining information along the previous established sediment range line alignments, the 2007 survey collected detailed data between these ranges throughout the reservoir area that was covered by the survey vessel. The resulting data set produced up-to-date reservoir information and represents the area and capacity of El Vado Reservoir as of June 2007. To compute the annual sediment inflow values more accurately, a future survey using the contour or similar method should be conducted. Overall, the range line comparison plots indicated that little sediment has deposited within the reservoir area since 1944 with an even smaller rate of deposition since the 1984 survey. A resurvey should be scheduled no sooner than the year 2027 unless a significant change in the sediment basin runoff is noted. An example of such change would be if a large basin fire occurred upstream of El Vado Reservoir.

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