US Army Corps of Engineers ®
Omaha District

Tri-Lakes Sedimentation Studies Area-Capacity Report Revised: July 2011

Tri-Lakes Report for Bear Creek, Chatfield, and Cherry Creek Lakes near Denver, Colorado

Chatfield Dam - July 2010

Prepared by:
Engineering Division
Hydrologic Engineering Branch
Sedimentation and Channel Stabilization Section

M.R.B. Sediment Memorandum 23a

U.S. ARMY CORPS OF ENGINEERS

NORTHWESTERN DIVISION

OMAHA – KANSAS CITY – PORTLAND – SEATTLE – WALLA WALLA DISTRICTS

The U.S. Army Corps of Engineers Missouri River Basin (M.R.B.) Sediment Memoranda Program was established for the development of practical sediment engineering for rational evaluation, regulation, and utilization of fluvial sediment phenomena. It was implemented as a comprehensive, Missouri River basin-wide program for coordination of studies of sediment problems in the overall basin program for flood control and allied purposes as well as for continuity and perspective in the planning and design of individual projects. The program includes both investigations for the development of sediment transport theory and observation of existent and occurring phenomena for the purpose of developing the applications of theory to practical problems, developing empirical relationships and providing aids to judgment.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The purpose of the Tri-Lakes Report is to document changes in the storage capacity of the Tri-Lakes between the original and subsequent surveys. The Tri-Lakes are located in the Denver metro area and consist of Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake.

Gross storage capacity in Bear Creek Lake has decreased from the original capacity of 78,101 acre-feet in 1980 to 77,293 acre-feet in 2009, the year of the latest sediment range line survey. This amounts to a total storage reduction of 808 acre-feet, or an average depletion rate of 27.9 acre-feet per year. The original projected storage depletion rate for Bear Creek Lake was approximately 20 acre-feet per year. The Bear Creek Lake flood control pool storage capacity has decreased from of 28,762 acre-feet in 1980 to 28,514 acre-feet in 2009, an average of 8.6 acre-feet per year.

Gross storage capacity in Chatfield Lake has decreased from the original capacity of 351,378 acre-feet in 1977 to 349,454 acre-feet in 2010, the year of the latest sediment range line survey. This amounts to a total storage reduction of 1,924 acre-feet, or an average depletion rate of 58.3 acre-feet per year. The original projected storage depletion rate for Chatfield Lake was approximately 200 acre-feet per year. The Chatfield Lake flood control pool storage capacity has decreased from 206,856 acre-feet in 1977 to 205,985 acre-feet in 2010, an average of 26.4 acre-feet per year.

Gross storage capacity in Cherry Creek Lake has decreased from the original capacity of 248,318 acre-feet in 1950 to 243,757 acre-feet in 2009 (the 2009 sediment range line survey is a composite of data collected in 2006, 2007, and 2009). This amounts to a total storage reduction of 4,561 acre-feet, or an average depletion rate of 77.3 acre-feet per year. The original projected storage depletion rate for Cherry Creek Lake was approximately 151 acre-feet per year. The Cherry Creek Lake flood control pool storage capacity has decreased from 80,638 acre-feet in 1950 to 79,294 acre-feet in 2009, an average of 22.8 acre-feet per year.

Although deposition has not significantly impacted storage capacity, sediment related impacts within the Tri-Lakes have occurred. Impacted areas include the Plum Creek tributary arm within Chatfield Lake and potential long term impacts from the Hayman fire of 2002.

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1 Introduction

1.1 Purpose

The U.S. Army Corps of Engineers Tri-Lakes Project is made up of three separate reservoirs including Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake, located in the metropolitan Denver, Colorado area. The purpose of this report is to document geomorphic conditions and trends for each reservoir. The nature, extent, and quantification of sediment accumulation are specifically detailed in this report. Presented in the report are project statistical data, cross section data, pool elevation records, and capacity and sediment depletion data. The report presents historical data in a format, which may be used in subsequent studies to predict future conditions for the three reservoirs. However, forecasting based on the existing data is not the purpose of this report and is not included in this investigation.

1.2 Scope of Work

The scope of work for this report was to compile all pertinent sediment information concerning Bear Creek, Chatfield, and Cherry Creek Lakes in a single document. The report is to be used as a reference document that analyzes the data to determine trends in geomorphic changes over the historical record.

1.3 Authorization

The report was prepared under the requirements of Engineering Manual EM 1110-2-4000; "Sedimentation Investigations of Rivers and Reservoirs" dated 31 October 1995. The funding for this report is through the USACE Omaha District Operation and Maintenance budget.

1.4 Sediment Related Problems

The Tri-Lakes are all located in upper reaches of the South Platte River basin. Bear Creek Lake and Cherry Creek Lake have experienced normal sediment loading that is less than originally projected; therefore making the projected life expectancy of each reservoir longer than originally projected. Chatfield Lake's projected life expectancy is also greater than originally projected, although Chatfield Lake has had sedimentation problems with the tributary arm of Plum Creek. In the late 1980's and early 1990's Plum Creek experienced a large influx of sediment, which settled around the Titan Road Bridge and in the Plum Creek delta of Chatfield Lake. This aggradation of the riverbed changed the location of the channel endangering the recreational facilities in the Plum Creek arm of Chatfield Lake. The aggradation of the riverbed decreased the flood conveyance capacity under the Titan Road Bridge. Several studies were conducted around 1990 to determine the future of the Titan Road Bridge. Since 1990, the Titan Road Bridge has been replaced and a grade control structure has been built upstream of the bridge. The Plum Creek arm continues to be the source of the majority of the sediment entering Chatfield Lake. One other source of sediment upstream along Plum Creek is an operating gravel pit.

In 2006, there were public concerns that there may have been excessive deposition into Chatfield Lake due to increased erosion potential after the Hayman Forest Fire of June 2002 which burned nearly 138,000 acres in the South Platte River Basin. Analysis of the average bed elevations for the six cross sections surveyed in June 2006 did not show any additional or unexpected sediment deposition in Chatfield Lake. In several cross sections, annual deposition rates decreased, due in part to the severe drought within the basin. Much of the sediment runoff and deposition from the Hayman Fire of 2002 may have been captured by Cheesman Reservoir located upstream of Chatfield Dam. A sedimentation problem could develop if sediments deposited in Cheesman Reservoir were to be transported into Chatfield Reservoir. Please refer to "Chatfield Lake Reconnaissance Report with Hayman Fire Sedimentation Assessment," August 2007, Omaha District, U. S. Army Corps of Engineers, for the full report.

2 General Information

2.1 Study Area

The Tri-Lakes Project is made up of three separate reservoirs, Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake, located in the metropolitan Denver, Colorado area, see Figure 2-1. The purpose of the Tri-Lakes Project is to protect the Denver metropolitan area from the South Platte River floodwaters that have plagued the area for more than 100 years. Although the Corps of Engineers built the dams primarily for the purpose of flood control, each project offers multi-purpose features, including outstanding recreational opportunities for those interested in boating, camping, skiing, horseback riding, fishing, hiking, and nature study.

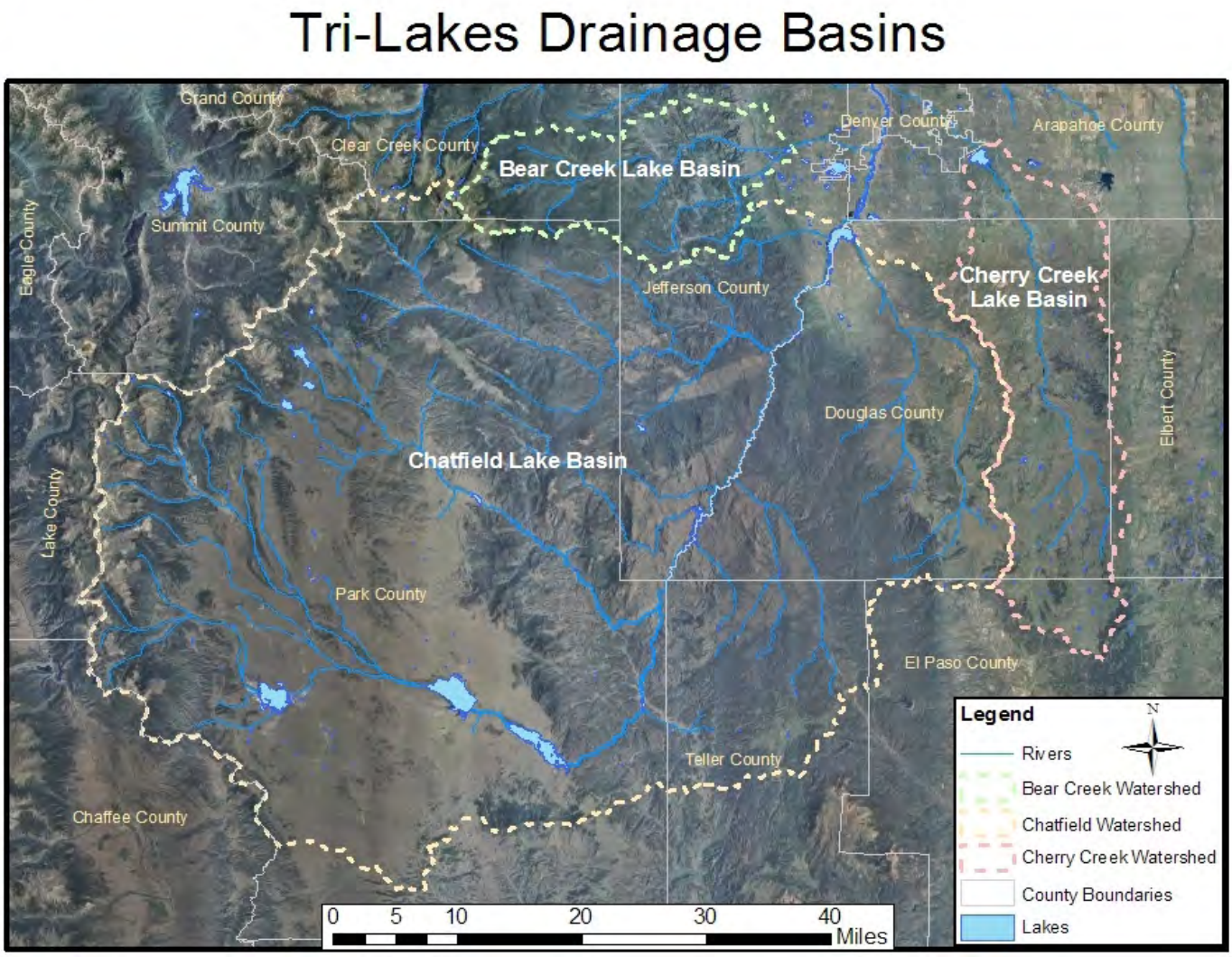


Figure 2-1. Tri-Lakes Project Basins Location

2.2 Geography & Topography

The geography and topography of each of the Tri-lakes basins are similar, due to their proximity to one another. The Bear Creek and Chatfield basins are a mixture of high plain and mountain areas, while the Cherry Creek basin is mostly high plain. More detailed descriptions of each basin follow.

2.2.1 Bear Creek

Bear Creek is a left bank tributary of the South Platte River near Morrison, a suburb of Denver, Colorado, see Figure 2-2. The basin drains a total of 236 square miles, of which 90 percent is made up of the terrain found in the Rocky Mountain foothills located west of Denver. The remaining 10 percent of the basin is characterized by high plains and rolling foothills and is separated from the mountains by a prominent hogback ridge that crosses the basin near the Morrison area. The mountains are heavily forested; the terrain below the hogback is mostly grassland with some urban development.

The basin is elongated and narrow at the upstream end and wider at the midpoint of the basin toward the downstream end, approximately 36 miles long and has a maximum width of about 13 miles. Stream flow originates near Summit Lake on the Mount Evans plateau. The flow moves easterly picking up contributions from numerous small tributaries along the way through the Arapahoe National Forest. At Morrison, Colorado, the flow breaks out of the confinement of a canyon and spreads through the foothills region.

The 52-square mile Turkey Creek drainage joins Bear Creek approximately two miles downstream from Morrison. Turkey Creek is the only major tributary into Bear Creek.

2.2.2 Chatfield

The South Platte River originates along the eastern slope of the Continental Divide and flows in a southeasterly direction through the South Park Meadow Area to Eleven Mile Canyon Reservoir as shown in Figure 2-3. Below Eleven Mile Canyon Dam, the South Platte enters a much narrower valley and the surrounding terrain becomes considerably steeper. This stretch includes Cheesman Reservoir. Several major tributaries enter the South Platte River between Eleven Mile Canyon and the foothills including Tarryall Creek and the North Fork South Platte River. Plum Creek is a right bank tributary that joins the South Platte River just upstream of the dam in the reservoir.

The drainage area upstream from Chatfield Lake contains 3,018 square miles, most of which is rugged mountainous terrain. The basin has a round shape, approximately 120 miles long and has a maximum width of about 90 miles. The lower section of the basin, elevation 5,500 to 7,000 feet, is a mixture of high plains and rolling foothills vegetated largely by grassland with some forested areas. The bulk of the watershed is comprised of mountainous terrain that begins approximately 10 miles upstream from the project. The terrain includes high mountain peaks ranging up to 13,000 feet and steep mountain valleys. The area is heavily forested and is liberally covered with normal forest duff. The headwaters region of the South Platte River is located along the western edge of the basin; it is comprised of about 270 square miles of extremely steep terrain. Elevations in the headwaters region range from 9,500 feet to over 14,000 feet along the Continental Divide.

2.2.3 Cherry Creek

Cherry Creek is a right bank tributary of the South Platte River, see Figure 2-4. It enters the South Platte River in the highly developed business and industrial area of downtown Denver. The basin drains a 410-square mile area located south of Denver. Cherry Creek Dam is located about 11.4 miles upstream from the mouth of Cherry Creek and controls 386 square miles of the basin's drainage area. The watershed is oblong in shape with a basin length of approximately 44 miles and an average width of approximately 9 miles.

The Cherry Creek basin, upstream from Franktown, Colorado, has steep to moderately rolling topography. Sharp topographic relief characterizes a narrow belt across the central part of the basin, immediately upstream from Franktown. Canyon walls and mesa fronts, 200 to 400 feet high, are common in this belt. In the reach from near Franktown to near Parker, Colorado, Cherry Creek courses through a broad valley bordered by steep to rolling ridges and hills. Downstream from Parker, the upland area consists of rolling hills. Vegetation in undeveloped areas is limited to groves of large cottonwoods and low shrubby growth bordering the creek channel. The basin elevation varies from about 7700.0 feet at the source of Cherry Creek to about 5170.0 feet at its confluence with the South Platte River.

2.3 Climate

Due to the topography of the Bear Creek, Cherry Creek, and South Platte River basins, remarkable climatic differences occur within each basin area. In describing the climate of these basins it is helpful to make two subdivisions: 1) the high plains and foothills and 2) the mountains and valleys. The climate of the high plains and foothills around the Denver metropolitan area is substantially different than the climate of the mountains and valleys west of the Front Range. Characteristics of these two climates are discussed below.

The climate of the plains is distinctly continental. Situated a long distance from any moisture source and separated from the Pacific Ocean source by a high mountain barrier, the plains area experiences light rainfall, low relative humidity, a large daily range in temperature, high daytime temperatures in summer, a few protracted cold spells in winter, moderately high wind movement, and a high percentage of sunshine. The mean annual temperature in the plains and foothills is about 50 degrees Fahrenheit. Temperatures of 100 degrees, or over, have been observed at all stations in the region, and daytime temperatures of 95 degrees, or higher, are common in the summer. In the foothills portion of the area, summer afternoon temperatures are frequently lowered by afternoon cloudiness and thunderstorms over and near the mountains. Cold air masses from the north can be abrupt and severe, intensified by the high altitude. However, many of the cold air masses out of Canada that spread southward over the Northern Great Plains are too shallow to reach the area's altitude and move off over the lower plains to the east. The lowest temperatures observed in the plains and foothills region have ranged from 30 to 40 degrees below zero. The mean annual precipitation averages about 14 to 17 inches, the amounts increasing with proximity to the mountains. Over 70 percent of the annual precipitation falls in the six-month period from April through September, much of it from the intense isolated summer thunderstorms. Winter snowfall averages from 3 to 5 feet on the plains, and from 5 to 7 feet in the foothills.

The climatic variations between mountain weather stations are substantially greater than between plains weather stations. The weather pattern in general is lower temperatures and increased precipitation and wind movement with increased altitude. However, local conditions can change this pattern quite markedly. The diurnal range in temperature is low on the mountain slopes and high in the valleys. At the mountain peaks the average annual temperature is less than 32 degrees. Readings of zero or lower are much more common than on the plains, although minimum temperatures of record are about the same. The daytime temperatures decrease with increasing elevation, while the minimum temperatures are a function of cold air drainage. The rainfall in the mountain areas depends largely on the elevation and exposure to moisture bearing winds. On the eastern slopes of the Front Range the precipitation pattern resembles that of the plains. At the higher elevations west of the Front Range snowfall is more prevalent. Snow survey data collected by the National Resource Conservation Service Office in Fort Collins indicate that there is no general snowpack accumulation in the Bear Creek basin. During the winter, snow normally accumulates to a few inches, drifts considerably, and then melts. This process generally repeats itself several times during the winter season. The variable climatic conditions existing throughout this region are shown in Table 2-1,

which presents precipitation, snowfall, and temperature data for selected weather stations, maintained by the National Climactic Data Center (NCDC), located near the Tri-Lakes Project dam sites.

Table 2-1. Temperature, Precipitation, and Snowfall for Weather Stations Located near the Tri-Lakes Project Dams

Climate Measure	Bear Creek	Chatfield	Cherry Creek
NCDC Weather Gage	Evergreen, CO	Castle Rock, CO	Cherry Creek Reservoir, CO
Average Temperature (°F)	44.4	47.5	49.8
Average Annual Precipitation (in.)	18.7	17.3	16.7
Average Annual Total Snowfall (in.)	83.6	60.7	52.2
Years of Record	42	48	52
Gage Elevation (ft)	7000	6250	5650

Data is from the Western Regional Climate Center at www.wrcc.dri.edu, accessed 28 July 2011.

2.4 Survey History

Corps of Engineers personnel performed the original surveys of the sediment range lines. Subsequent surveys were performed by both the Corps of Engineers and independent survey firms contracted by the Corps of Engineers. Survey dates are listed in Table 2-2.

Table 2-2. Survey Years for Tri-Lakes Reservoirs

Lake	Survey Years
Bear Creek	1980, 1987, 1996-7[a], 2009
Chatfield	1977, 1991, 1998, 2006 (reconnaissance), 2010
Cherry Creek	1950, 1961, 1965, 1974, 1988, 2009[b]

[a] The overbanks were surveyed in December 1996 and the underwater portion in 1997.

[b] 2009 survey is a composite of data collected in 2006, 2007, and 2009

The survey data collected during 1982 through 1984 at each reservoir is not included in the analysis of this report. The data from these years were deemed to be unreliable due to unresolved survey errors. The Cherry Creek survey conducted in 1997 is not included in this report due to erroneous data at ranges CC-01 to CC-04.

The original sediment range line surveys collected overbank data to the farthest permanent sediment monument on either side of the reservoir. However, overbank data for some subsequent surveys were only collected to the sediment monument nearest to the water's edge. These shortened surveys used the previous survey overbank data for use in calculating reservoir area-capacity curves. The flood control and surcharge pools are affected most by this procedure. Reporting sediment changes between survey periods where range line overbanks were copied from previous surveys will not accurately reflect sediment aggradation or degradation for these survey periods. Changes in storage that cannot be calculated due to limited survey extents are identified in the summary tables.

2.4.1 Cross Section Labeling System

Two letters and a number designate the sediment range lines. The letters indicate the reservoir with the following designations: Bear Creek (BC), Chatfield (CH), and Cherry Creek (CC). The numbering begins at the first cross section upstream from the dam and increases upstream. For example, the first cross section upstream of the dam at Bear Creek Lake is BC-01. Range line location maps and cross sections are provided for each reservoir in Sections 3-5.

2.4.2 New Survey Metadata

2.4.2.1 Bear Creek

The 2009 survey was completed by Omaha District staff. Hydrographic and land surveys were collected in state plane coordinate system, NAD 83, Colorado Central Zone and vertical data in NGVD29. Data was then converted to Omaha XY (station-elevation) format to run area-capacity programs.

Brief Metadata: Bear Creek

Survey Date:	Data collected during June 2009
Surveyor:	USACE Omaha District, Hydrologic Engineering Branch, Sedimentation & Channel Stabilization Section
Horizontal Datum:	Colorado State-Plane Coordinate System NAD83, Zone 0502.
Vertical Datum:	Survey data was collected in NAVD88 and converted to NGVD29 using CORPSCON 6.0.1 software
Units:	U.S. Survey Feet
Accuracy:	3rd Order Horizontal & Vertical per EM 1110-2-1003

2.4.2.2 Chatfield

The 2010 survey was completed by Omaha District staff. Both hydrographic and land survey data were collected for all twenty-two (22) previously established cross sections at Chatfield Lake.

Brief Metadata: Chatfield

Survey Date:	Data collected 19-30 July 2010
Surveyor:	USACE Omaha District, Hydrologic Engineering Branch, Sedimentation & Channel Stabilization Section
Horizontal Datum:	Colorado State-Plane Coordinate System NAD 83, Zone 0502.
Vertical Datum:	Survey data was collected in NAVD88 and converted to NGVD29 using CORPSCON 6.0.1 software
Units:	U.S. Survey Feet
Accuracy:	3rd Order Horizontal & Vertical per EM 1110-2-1003

2.4.2.3 Cherry Creek

The 2009 survey data presented in this report is a composite of data collected in 2006, 2007, and 2009. Cross sections CC-01 through CC-06 were completed in 2006 by in-house personnel. A contractor surveyed cross sections CC-07 through CC-11 and CC-13 in 2007. The hydrographic surveys completed during the 2006 survey were determined to be inaccurate and these sections, CC-01 to CC-04, were resurveyed in 2009 by in-house personnel. Note the CC-12 cross section was completely destroyed; survey data from 1988 was used for this cross section to run the area-capacity program for the latest survey.

Brief Metadata: Cherry Creek

Survey Date:	Data collected in 2006 (In-House), 2007 (A-E Contract), and 2009 (In-House)
Surveyor:	In-House: USACE Omaha District, Hydrologic Engineering Branch, Sedimentation & Channel Stabilization Section Contract Work: Ayres & Associates, Inc., Fort Collins, Colorado
Horizontal Datum:	Colorado State-Plane Coordinate System NAD83, Zone 0502.
Vertical Datum:	Survey data was collected in the ***Local Project Datum***.
Units:	U.S. Survey Feet
Accuracy:	3rd Order Horizontal & Vertical per EM 1110-2-1003

A detailed Cherry Creek basin survey was performed using LiDAR mapping, flown on 12 February 2009 by Woolpert, Inc., Englewood, Colorado. The LiDAR data was provided to the Sedimentation and Channel Stabilization Section for comparison to the range line surveys. The LiDAR dataset was collected using vertical datum NAVD88.

The Cherry Creek Dam was built using elevations in a Local Project Vertical Datum. Based on a September 2010 survey, conducted by the USACE Omaha District Surveys & Mapping Section, the Local Project Datum is approximately 1.27 feet above the NGVD29 datum and 1.76 feet below the NAVD88 datum. The NAVD88 datum is approximately 3.02 feet above the NGVD29 datum at Cherry Creek Dam, see Figure 2-2. Table 2-3 compares range line monument elevations as surveyed using the three datums. Any conversions between datums should be coordinated through the USACE Omaha District Surveys Section to ensure accuracy, these values are approximations. Elevations in this report for Cherry Creek are reported in the Local Project Datum.

The elevations on the Cherry Creek staff gage, which is located on the downstream side of the intake structure, are in Local Project Datum plus approximately 0.20 feet (1.47 feet above NGVD29 datum and 1.56 feet below NAVD88 datum). This 0.20 feet difference corresponds closely to the settlement observed in the upstream end of the conduits at the intake since original construction. If the staff gage is used to monitor pool elevation, subtract 0.20 feet from the elevation to approximate the elevation in Local Project Datum.

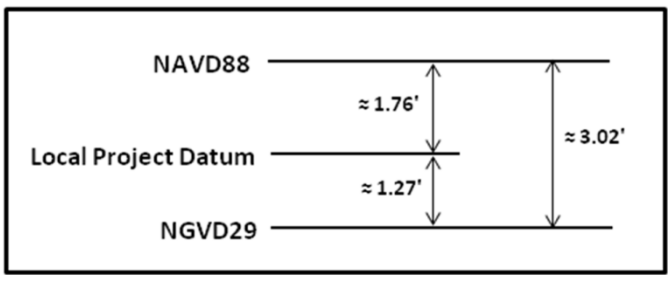


***Figure** 2-2. The Local Project Datum for Cherry Creek Relative to NAVD88 and NGVD29*

Table 2-3. The Range Line Monument Elevations in NGVD29, Local, and NAVD88 Datum

Range Number	Bank	Station	Elevation - Datum			Difference between NAVD88 and Local Datum	Description
			NGVD29	Local	NAVD88		
CC-01	RT	124+71	5585.37	5586.97	5588.40	1.43	Steel Pin
CC-02	LT	31+16	5602.09	5603.84	5605.12	1.28	Brass Cap
CC-02	RT	122+44	5560.75	5562.38	5563.77	1.39	Brass Cap
CC-03	LT	42+28	5582.42	5584.26	5585.45	1.19	Brass Cap
CC-03	RT	107+81	5587.80	5589.56	5590.83	1.27	Brass Cap
CC-04	LT	59+93	5563.93	5565.55	5566.95	1.40	1" Iron Pipe
CC-04	RT	115+67	5590.82	5592.62	5593.84	1.22	Brass Cap
CC-05	LT	61+54	5582.20	5584.39	5585.22	0.83	3/4" Rebar
CC-05	RT	114+62	5571.09	5572.99	5574.11	1.12	1" Iron Pipe
CC-06	LT	76+04	5568.64	5570.47	5571.66	1.19	Brass Cap
CC-06	RT	106+50	5562.78	5564.56	5565.81	1.25	5/8" Rebar
CC-07	LT	92+33	5577.07	5578.76	5580.10	1.34	Brass Cap
CC-07	RT	108+57	5603.56	5605.33	5606.58	1.25	1" Iron Pipe
CC-08	LT	78+81	5587.67	5589.66	5590.69	1.03	1.5" Iron Pipe
CC-08	RT	98+03	5587.35	5589.43	5590.38	0.95	Brass Cap
CC-09	LT	78+81	5617.26	5619.28	5620.29	1.01	Brass Cap
CC-09	RT	100+03	5598.69	5600.79	5601.71	0.92	1" Iron Pipe
CC-10	LT	82+17	5637.09	5639.06	5640.11	1.05	Brass Cap
CC-10	RT	101+00	5614.55	5616.52	5617.58	1.06	2" Iron Pipe
CC-11	LT	84+38	5639.00	5640.94	5642.03	1.09	1" Iron Pipe

2.5 Source & Distribution of Deposits

The primary source of sediment deposited in the project comes from watershed sheet, rill, and gully erosion. An additional and non-quantified source of sediment is from shoreline erosion. As a shoreline erodes, the eroded material generally moves to lower elevations. While this erosion increases the capacity at higher reservoir elevations, storage capacity allocated for specific purposes at lower elevations is reduced. In all the Tri-Lakes, most of the incoming sediment is transported via the inflowing rivers. A delta forms at the junction of the river and the lake where the majority of sediment drops out into the lake. Initially, the delta grows in both the downstream and upstream direction. Most of the growth is in the downstream direction. As the delta matures, a stable slope is established at the headwaters and the delta then progresses into the reservoir. In the reservoir, sediment generally settles in the low spots, filling in the old channel, and smoothing out any roughness in the topography.

2.6 Area-Capacity

An investigation of the Tri-Lakes area-capacity is described in Sections 3 through 5 for each lake individually. Descriptions of the computational methods follow.

2.6.1 Computations

Surface-area and capacity computations were performed for all survey data utilizing one of the two versions of the Omaha District's Reservoir Area-Capacity Analysis software. The original software was a package of four programs written in FORTRAN developed by the Omaha District in the 1960s and 1970s. The program set includes SATOVOL, SACHELM, VOLRATIO, and SAREACAP. The program AreaCapacity, developed by WEST Consultants, Inc. in August 2000, is a Windows® based graphical user interface integrating the four original programs. A synopsis of this procedure can be found in Appendix A.

General procedures for executing the area-capacity programs can be found in the manuals "Reservoir Area-Capacity Analysis (on the Microcomputer)," August 1992, Omaha District, U. S. Army Corps of Engineers; and "User's Manual AreaCapacity Computer Program," August 2000, Omaha District, U. S. Army Corps of Engineers.

Data output files containing results from the execution of area-capacity programs as well as cross section data input files are stored in the USACE Omaha District Sedimentation and Channel Stabilization Section.

2.6.2 Area-Capacity Tables

Area-capacity tables computed at 1.0-foot increments are located in Appendices B, C, and D for Bear Creek, Chatfield, and Cherry Creek, respectively. The tables computed at 0.01-foot increments are available at the following address:

US Army Corps of Engineers
Omaha District
Attn: CENWO-ED-HF Larry Morong
1616 Capitol Avenue, Suite 9000
Omaha, Nebraska 68102-4901

larry.j.morong@usace.army.mil

Figure 2-3. Bear Creek Lake Drainage Basin

Chatfield Lake Drainage Basin

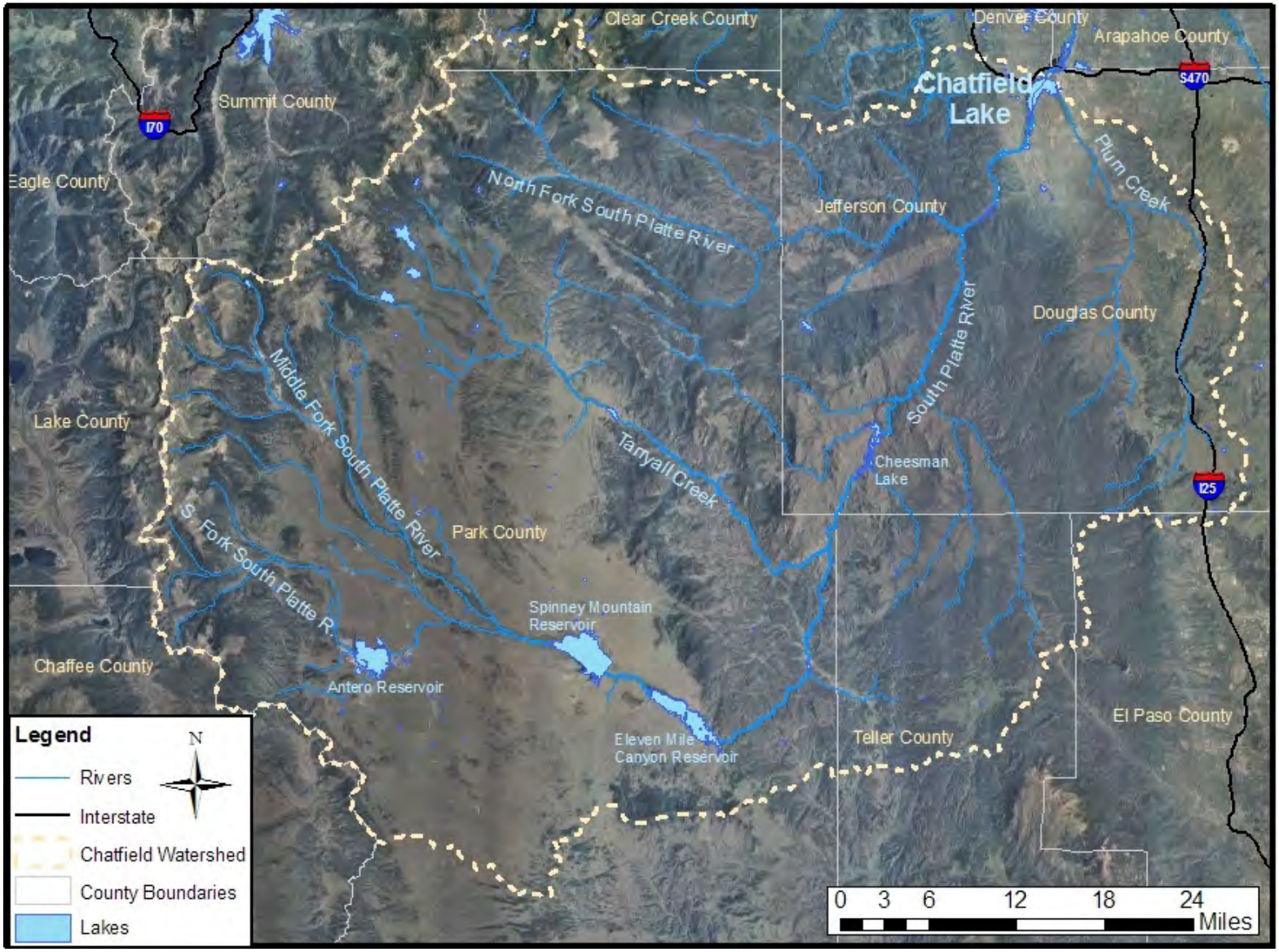


Figure 2-4. Chatfield Lake Drainage Basin

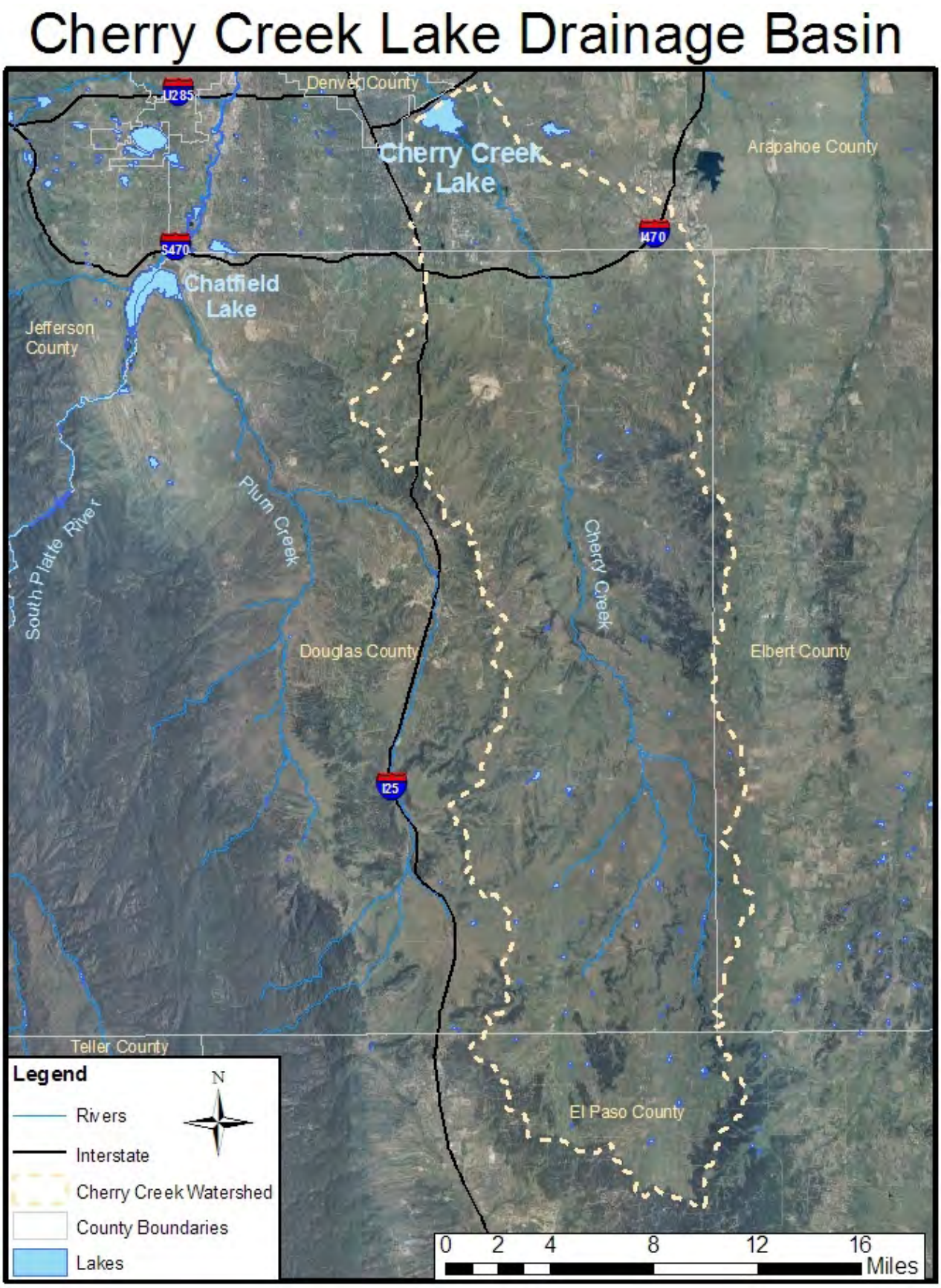


Figure 2-5. Cherry Creek Lake Drainage Basin

Table 2-4. Summary of Engineering Data for the Tri-Lakes Projects

ITEM NO	SUBJECT	BEAR CREEK	CHATFIELD	CHERRY CREEK
	GENERAL			
1	Location of dam	3 mi S.W. of Denver, CO.	8 mi S. of Denver, CO.	10 mi S.E. of Denver, CO.
2	River & river mile	Bear Creek @ R.M. 8	South Platte River @ R.M. 321	Cherry Creek @ R.M. 11.4
3	Drainage area	236 square miles	3,018 square miles	386 square miles
4	Reservoir length	0.5 mi @ Elev 5558	2.0 mi @ Elev 5430	1.5 mi @ Elev 5550
5	Location of Damtender	At Chatfield Dam	On site	At Chatfield Dam
6	Travel time to Missouri River	2 weeks	2 weeks	2 weeks
7	Max. discharge of record	8,600 cfs July 1896	110,000 cfs June 1965	58,000 cfs June 1965
8	Project cost[A]	$61,700,000.00	$101,130,000	$14,670,000
	DAM AND EMBANKMENT			
9	Top of dam	5689.5 ft	5527.0 ft	5645.0 ft
10	Length of dam	5,300 ft-main/2,100 ft-South	13,136 ft	14,300 ft
11	Height of dam	179.5 ft-main/65 ft South	147 ft	141 ft
12	Stream Bed	5,510 ft	5,380 ft	5,504 ft
13	Abutment formation	Clay-shale-siltstone-sandstone	Sandy overburden	Sandstone-clay-silt
14	Type of fill	Rolled earth	Rolled earth	Rolled earth
15	Fill quantity in cubic yards	11,346,000 main, 770,000 South	14,650,000	13,000,000
16	Date of closure	July 1977	August 1973	October 1948
17	Date of initial fill (base F.C.)	May 1979	June 1979	March 1960
	SPILLWAY			
18	Discharge capacity	153,500 cfs @ Elev 5684.5	188,000 cfs @ Elev 5521.6	38,350 cfs @ Elev 5636.2
19	Crest elevation	5667.0 ft	5500.0 ft	5610.6 ft[B]
20	Width	800 ft	500 ft	67 ft
21	Gates, number, size, type	Ungated earth channel	Ungated converging chute	Ungated earth channel
	RESERVOIR	**ELEVATION & AREA**		
22	Maximum pool	5684.5 ft 1,167 acres[C]	5521.6 ft 5,987 acres	5636.2 ft 4,522 acres
23	Top of flood control pool	5635.5 ft 711 acres	5500.0 ft 4,782 acres	5598.0 ft 2,638 acres
24	Top of multipurpose pool	5558.0 ft 107 acres	5432.0 ft 1,412 acres	5550.0 ft 840 acres
25	Top of inactive pool	5528.0 ft 16 acres	5385.0 ft 10 acres	none
	STORAGE ZONES	**ELEVATION & CAPACITY**		
26	Surcharge	5635.5-5684.5 46,495 ac ft	5500.0-5521.6 116,393 ac-ft	5598.0-5636.2 133,404 ac-ft
27	Flood control	5558.0-5635.5 28,514 ac-ft	5432.0-5500.0 205,985 ac-ft	5550.0-5598.0 79,294 ac-ft
28	Multipurpose	5528.0-5558.0 1,771 ac-ft	5385.0-5432.0 27,060 ac-ft	5504.0-5550.0 12,558 ac-ft
29	Inactive	5510.0-5528.0 53 ac-ft	5377.0-5385.0 16 ac-ft	none
30	Gross (top of F.C. pool)	30,338 ac-ft	233,061 ac-ft	91,852 ac-ft
	OUTLET WORKS			
31	Number and size - conduits	1 - 7 ft circular - upstream 1 - 7x10.5 ft - downstream	2 - 11x16 ft oval conduit	2 - 8x12 ft oval conduit 1 - 12 ft circular conduit
32	Conduit length	1690 ft Ungated drop inlet - Elev 5558	1280 ft	679.5 ft
33	Number - size - type gates	2 - 3x6 ft hydraulic slide 2 - 1x1 ft slide - gate on gate	2- 6x13.5 ft hydraulic slide 2 - 2x2 ft slide - gate on gate 1 - 72 in butterfly	5 - 6x9 ft hydraulic slide
34	Discharge capacity	2,160 cfs @ Elev 5667.0	8,400 cfs @ Elev 5500.0	8,100 cfs @ Elev 5598.0
35	**POWER INSTALLATION**	none	none	none

[A] 1980 dollars Elevations reported in NGVD29

[B] Top of Flood Control Pool is elevation 5598.0, which was the original spillway crest elevation. Due to sloughing of the spillway side slopes, spillway crest elevation is 5610.6 ft.

[C] Capacity only calculated to elevation 5680.0

3 Bear Creek Lake

3.1 Background

Bear Creek Lake is located three miles southwest of Denver, Colorado. The lake is located in Jefferson County. A map of Bear Creek Lake, including its sediment range lines, is shown in Figure 3-1.

Bear Creek Dam is a rolled earth structure, the main dam is 5,300 feet long and 179.5 feet high and the south dam is 2,100 feet long and 65 feet high. Bear Creek Lake was closed in July 1977 and initial filling was completed in May 1979. The lake covers approximately 106 acres at the multi-purpose pool elevation of 5,558.0 feet. The originally estimated long term average annual depletion rate for the lake was 20 acre-feet.

A road was built in the area of range BC-08 between 1987 and 1997. Due to the embankment, the 2009 range lines show a considerable increase in elevation from the original survey in this area. The 1987 and 1997 surveys did not cover the outer extents of all the range lines for the overbank and used 1980 data to complete the lines for the area-capacity programs to reach comparable survey elevations. Due to the data repetition, the 1987 and 1997 data in the flood control and surcharge pools are not reflective of the changes and are not reported. Note the 2009 survey covered the entire length of the range lines.

3.2 Surface Area

Figure 3-2 is a plot of elevation versus surface area for all survey years. Table 3-1 shows the reservoir surface area by elevation. The surface area at the top of the Bear Creek multipurpose pool (5558.0 feet) decreased three acres between 1980 and 1997, and increased one acre between 1997 and 2009 for a total decrease of two acres. Shoreline erosion increases the surface area while delta growth decreases the surface area of the lake. The overall decrease is likely due to delta growth.

Table 3-1. Bear Creek Lake Surface Area by Storage Pool

	Top of Pool	Surface Area (acres)			
Storage Pool	**Elevation**	**1980**	**1987**	**1997**	**2009**
Flood Control	5635.5	717	*	*	711
Multipurpose	5558.0	109	107	106	107

*Survey data did not reach this elevation.

3.3 Capacity Changes

Figure 3-3 is a plot of the elevation versus reservoir capacity curve for all survey years. Table 3-2 presents the reservoir capacity by storage pool and Table 3-3 presents the rate of change by elevation. Gross storage (elevation 5510.0 – 5684.5 feet) decreased 808 acre-feet (1.03%) between 1980 and 2009. Storage in the flood control pool (elevation 5558.0 – 5635.5 feet) decreased 248 acre-feet (0.86%) between 1980 and 2009. Storage in the multipurpose pool (elevation 5528.0 – 5558.0 feet) decreased 121 acre-feet (6.40%) between 1980 and 2009. Storage in the inactive pool (elevation 5510.0 – 5528.0 feet) decreased 19 acre-feet (26.39%) between 1980 and 2009.

The total storage depletion rate between survey years 1980 and 2009 is 27.9 acre-feet per year, while the storage depletion rate up to the multipurpose pool (elevation 5558.0 feet) is 4.8 acre-feet per year. The original projected total storage depletion rate was approximately 20 acre-feet per year.

Table 3-2. Bear Creek Lake - Reservoir Storage Capacity by Storage Pool

Storage Pool	Reservoir Capacity (ac-ft)				Change in Reservoir Capacity (ac-ft)				Depletion Rate (ac-ft/yr)	Percent Lost per Year
	1980	1987	1997	2009	1980-1987	1987-1997	1997-2009	1980-2009	1980-2009	1980-2009
Surcharge 5635.5-5684.5	47,375	*	*	46,495	*	*	*	-880	-30.3	-0.06%
Flood Control 5558.0-5635.5	28,762	*	*	28,514	*	*	*	-248	-8.6	-0.03%
Multipurpose 5528.0-5558.0	1,892	1,909	1,824	1,771	17	-85	-53	-121	-4.2	-0.22%
Inactive 5510.0-5528.0	72	65	58	53	-7	-7	-5	-19	-0.7	-0.91%
Gross Storage 5510.0-5684.5	**78,101**	*	*	**77,293**	*	*	*	**-808**	**-27.9**	**-0.04%**

*Survey data did not reach this elevation.

Note: Bear Creek elevations are reported in vertical datum NGVD29.

Table 3-3. Bear Creek Lake – Cumulative Reservoir Capacity Changes

Top of Pool	1980	1987			1997			2009		
	Capacity (ac-ft)	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original
Surcharge 5684.5	78,101	*	*	*	*	*	*	77,293	-27.9	99.0%
Flood Control 5635.5	30,726	*	*	*	*	*	*	30,338	-13.4	98.7%
Multipurpose 5558.0	1,964	1,974	1.40	100.5%	1,882	-4.8	95.8%	1,824	-4.8	92.9%
Inactive 5528.0	72	65	-1.00	90.3%	58	-0.8	80.6%	53	-0.7	73.6%

*Survey data did not reach this elevation.

Note: Bear Creek elevations are reported in vertical datum NGVD29.

3.4 Profile Plots

Figure 3-4 compares the average bed elevation of each survey year for both the flood control and multipurpose pool levels. Figure 3-5 compares the thalweg profile of each survey year. The areas with the most deposition are between the dam and range line BC-03 and between BC-05 and BC-06, where the thalweg increased by approximately 4.3 feet and 2.1 feet respectively since 1980.

3.5 Sediment Volume

Figure 3-6 represents the change in reservoir capacity by segment from sedimentation and erosion between 1980 and 2009. The volume of sediment that entered the reservoir between surveys is represented by the reservoir capacity depletion as shown in Table 3-4.

Table 3-4. Total Sediment Change and Capacity Depletion in Bear Creek Lake

Survey Period	Total Sediment Aggradation or Capacity Depletion (ac-ft)	Rate of Change (ac-ft/yr)
1980-2009	**808**	**27.9**

3.6 Area-Capacity Tables

Area-capacity tables computed at 1.0-foot increments are located in Appendix B. The capacity tables computed at 0.01-foot increments are available from the USACE Omaha District Sedimentation and Channel Stabilization Section.

3.7 Cross Section Data

Cross sectional plots are shown in Figures 3-7 through 3-19. The plots do not show the entire surveyed cross section, only the lower elevation portion where sedimentation is occurring is plotted to magnify the changes. Plots of the full cross sections are available from the USACE Omaha District Sedimentation and Channel Stabilization Section. Note that only one survey has been completed for cross sections BC-12 and BC-13, downstream of the dam for degradation monitoring.

3.8 Engineering Form 1787 – Reservoir Sediment Data Summary

Engineering Form 1787, “Reservoir Sedimentation Data Summary” is presented in Appendix E. The purpose of this form is to provide a means for the uniform documentation of pertinent Bear Creek Lake sedimentation data.

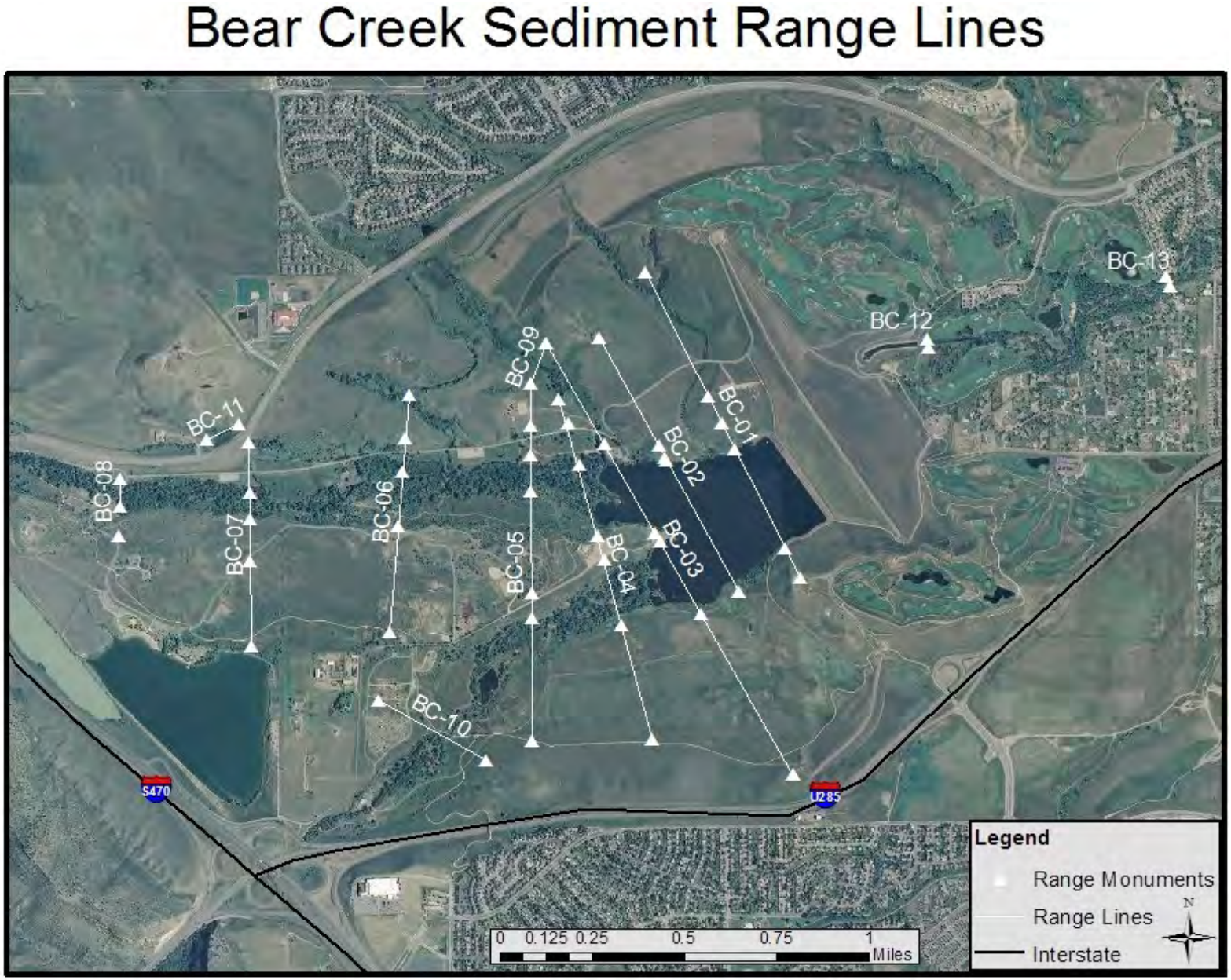


Figure 3-1. Bear Creek Lake with Sediment Range Line Locations

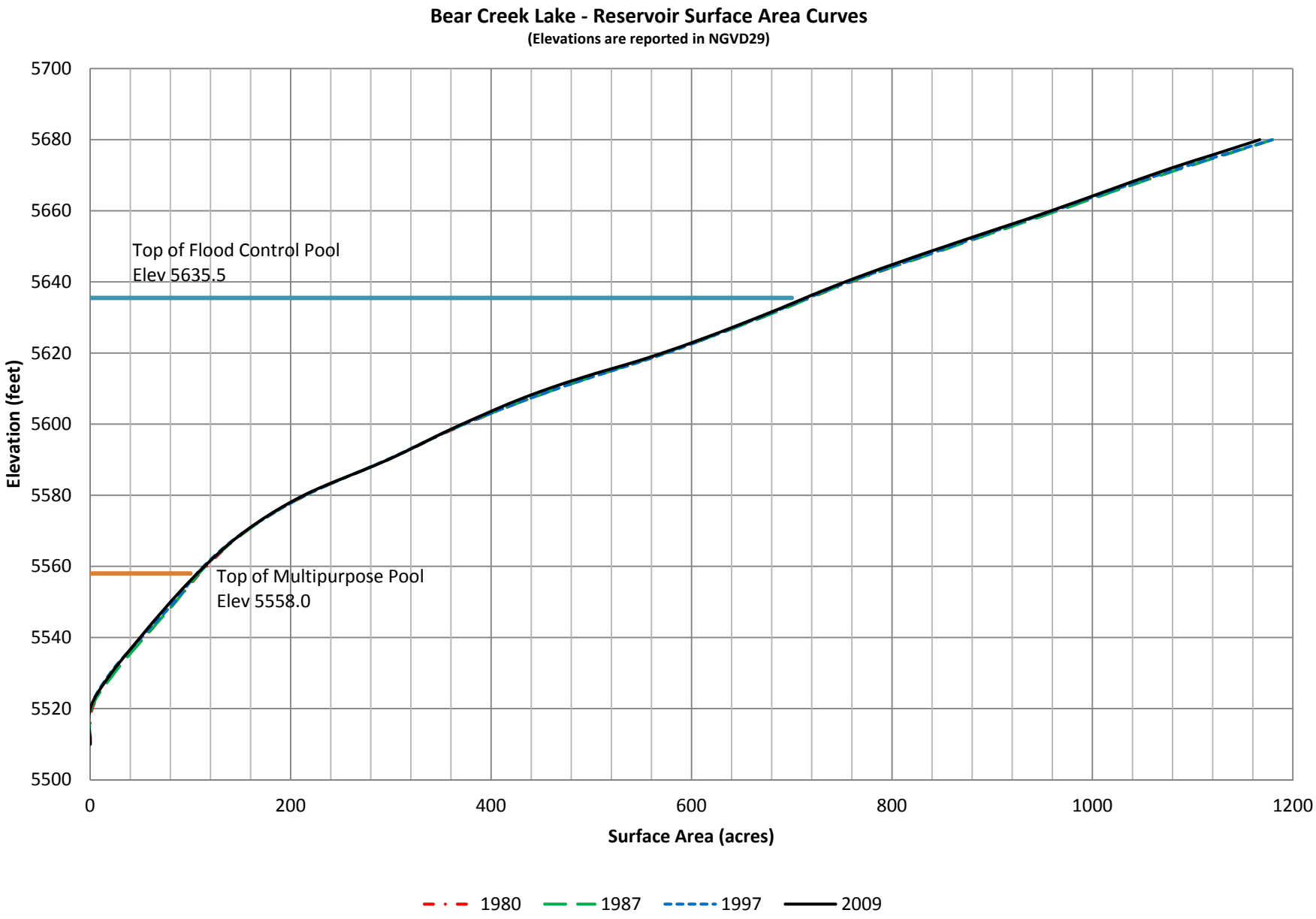


Figure 3-2. Bear Creek Lake – Reservoir Surface Area Curves

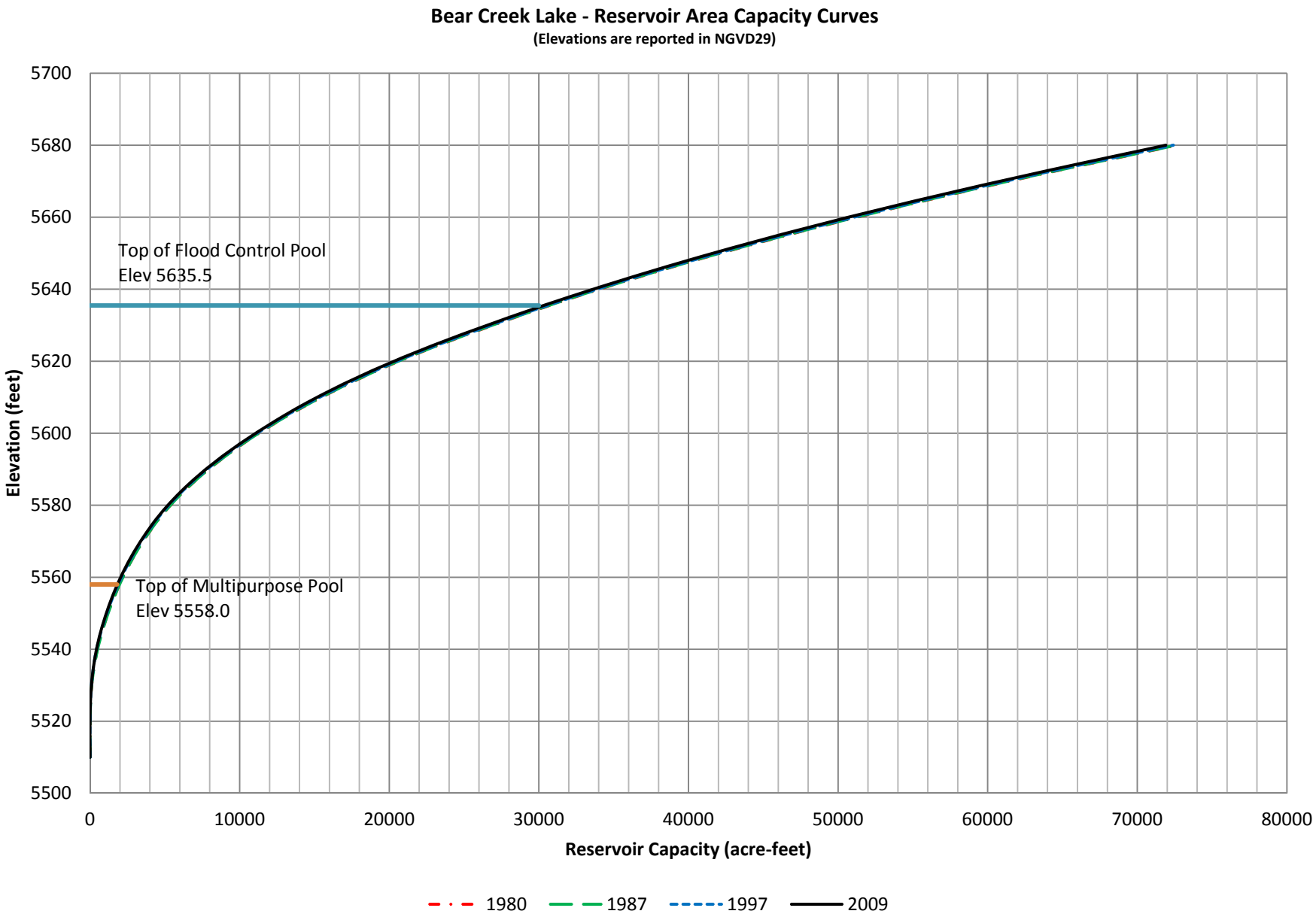


Figure 3-3. Bear Creek Lake – Reservoir Area Capacity Curves

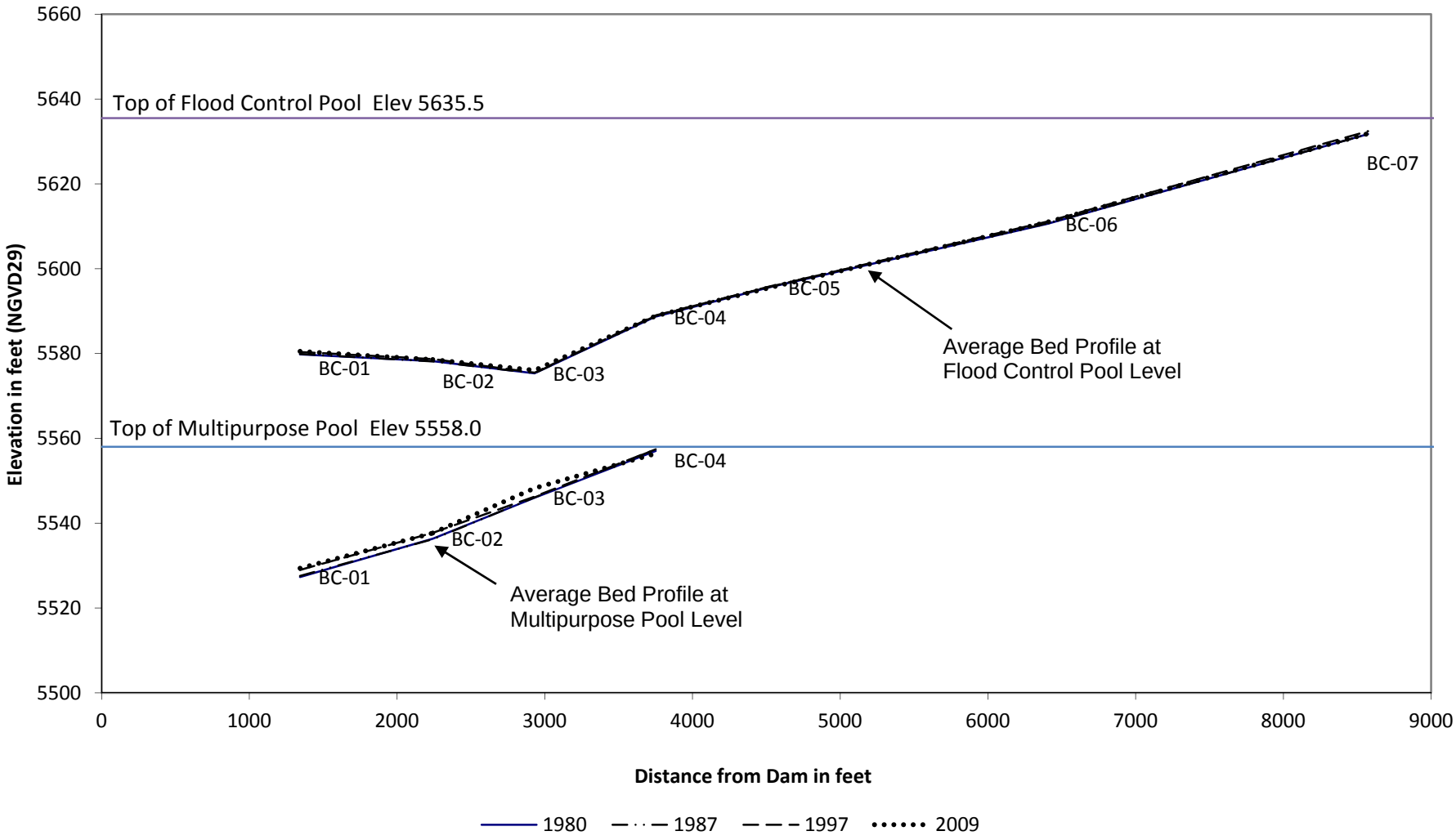


Figure 3-4. Bear Creek Lake - Average Bed Profiles for the Flood Control Pool and Multipurpose Pool

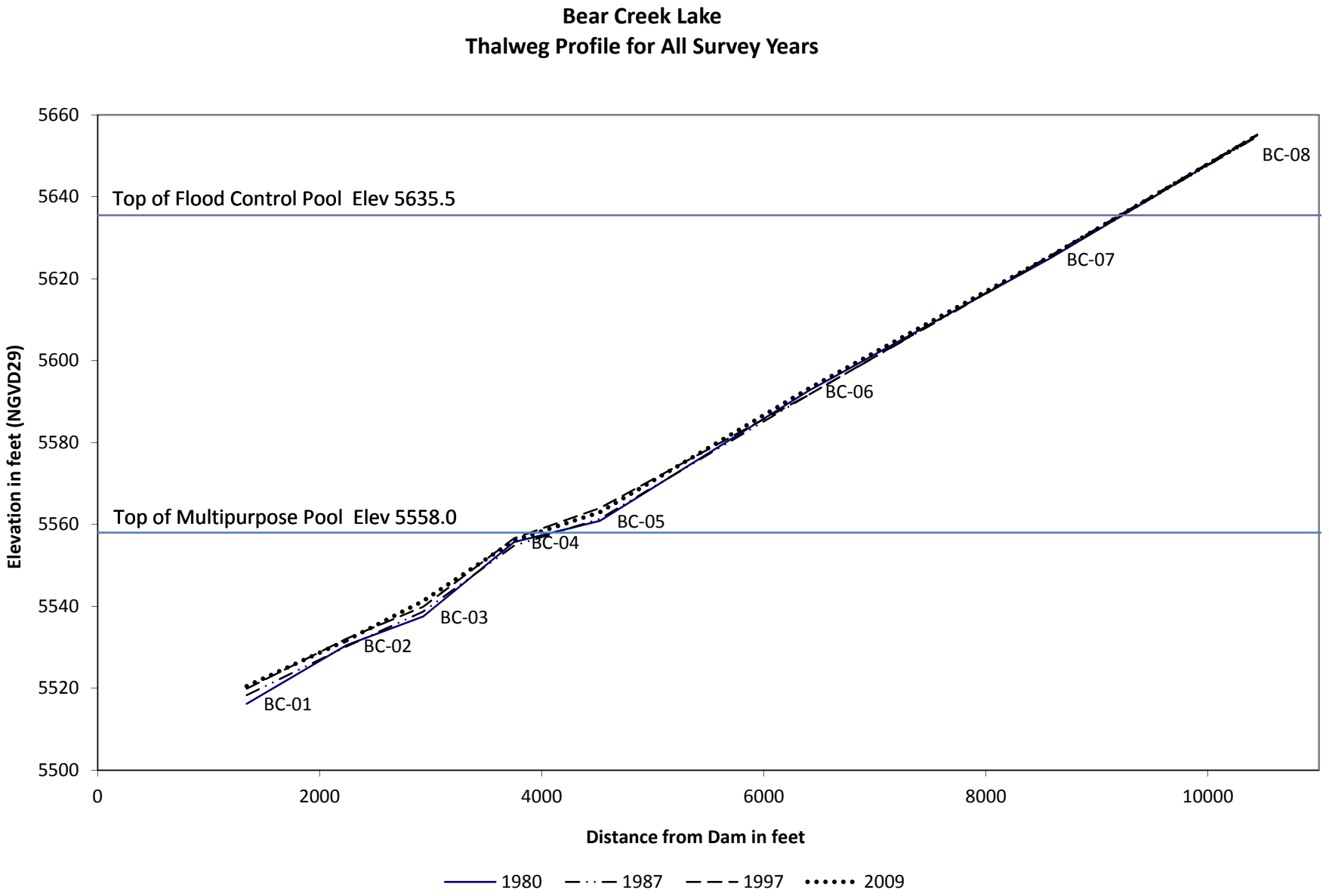


Figure 3-5. Bear Creek Lake - Thalweg Profiles

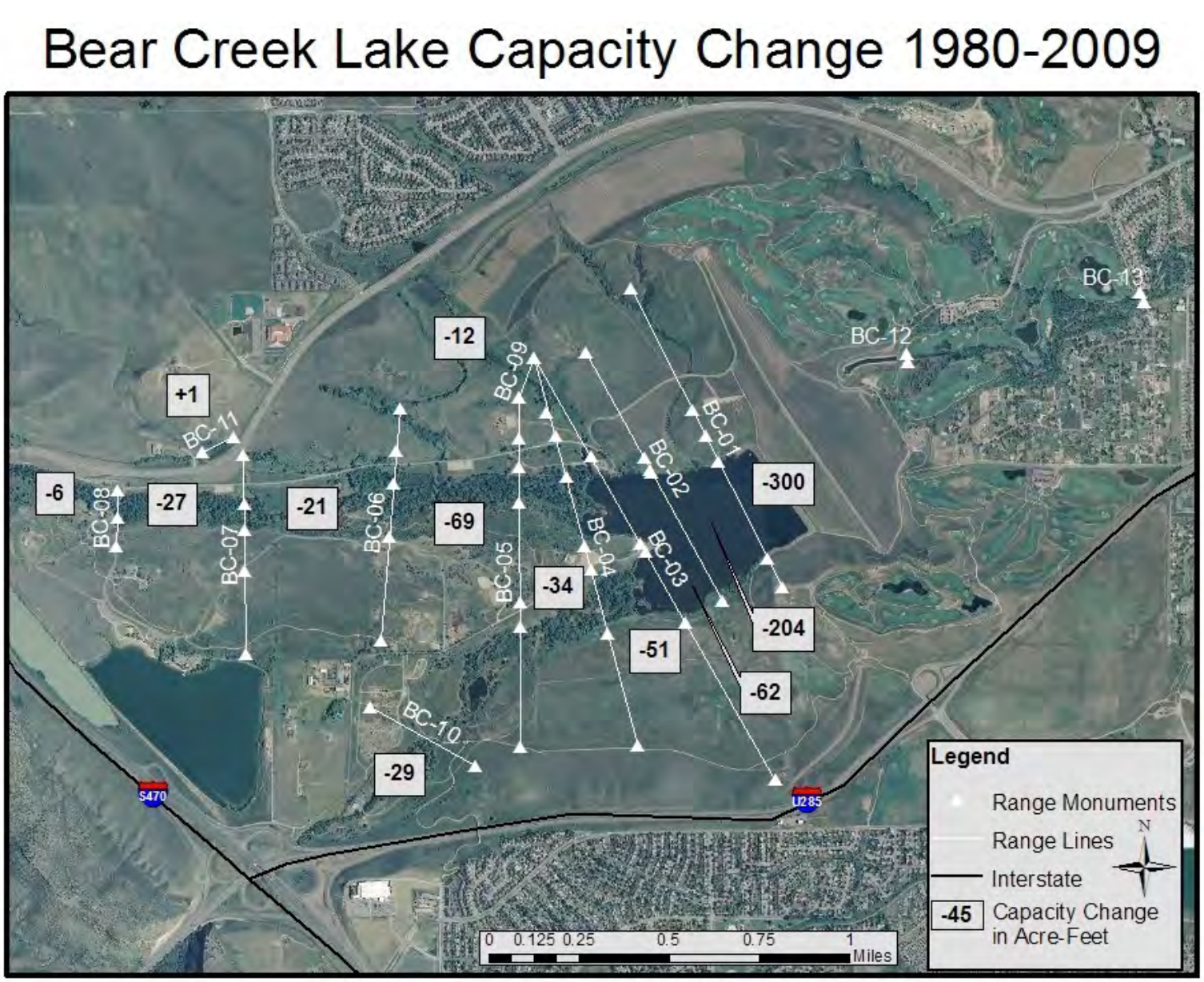
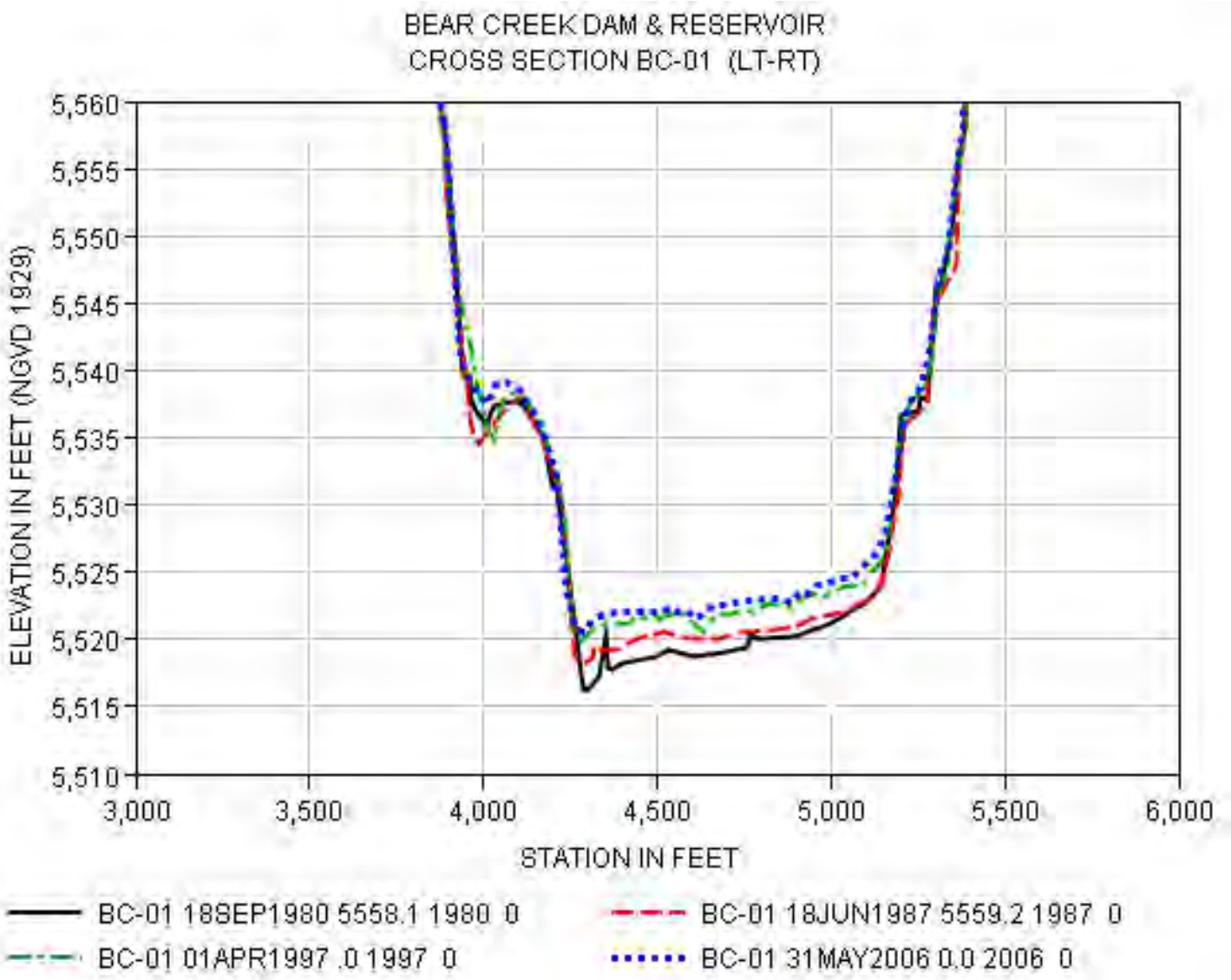
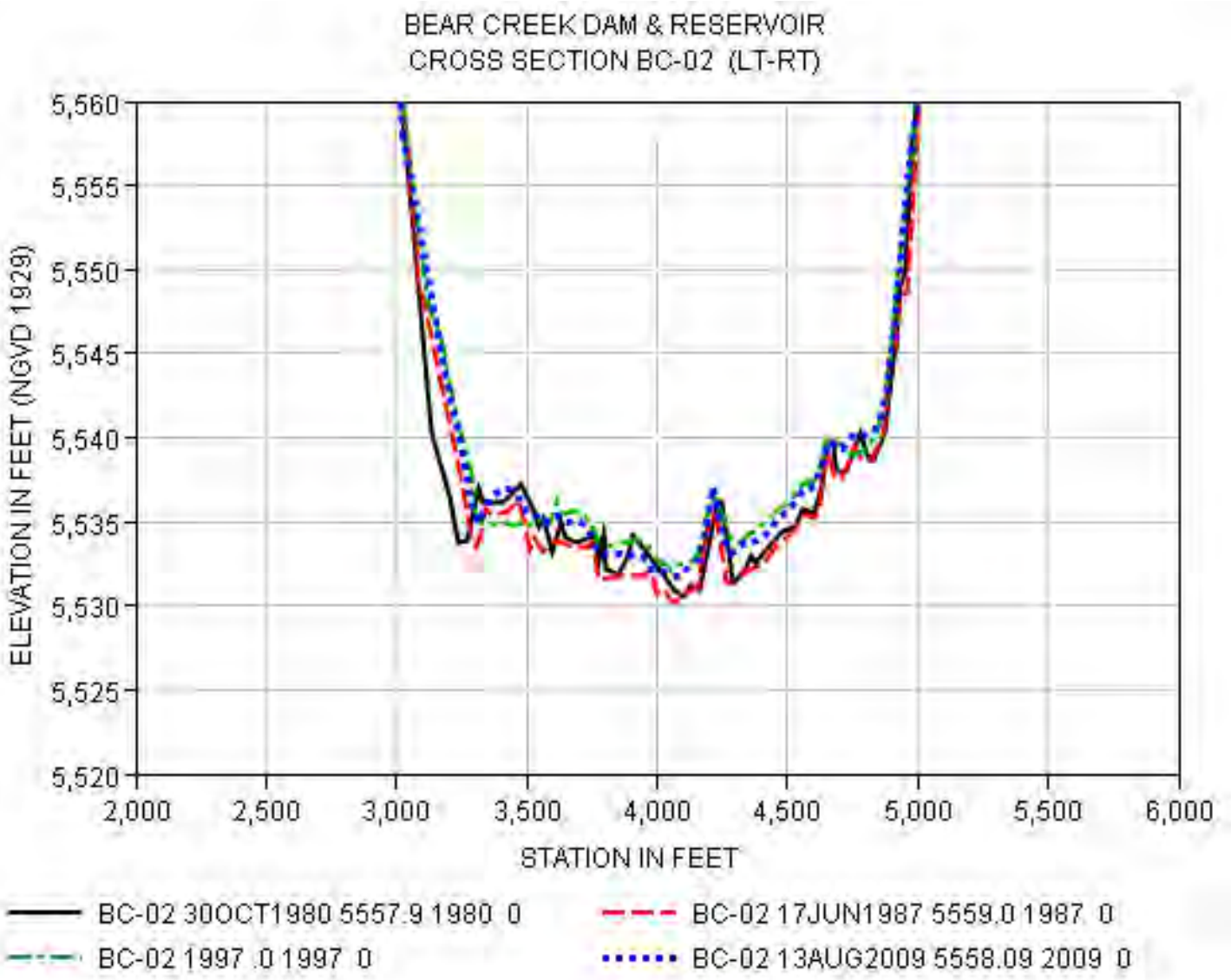


Figure 3-6. Change in Capacity by Segment of Bear Creek Lake



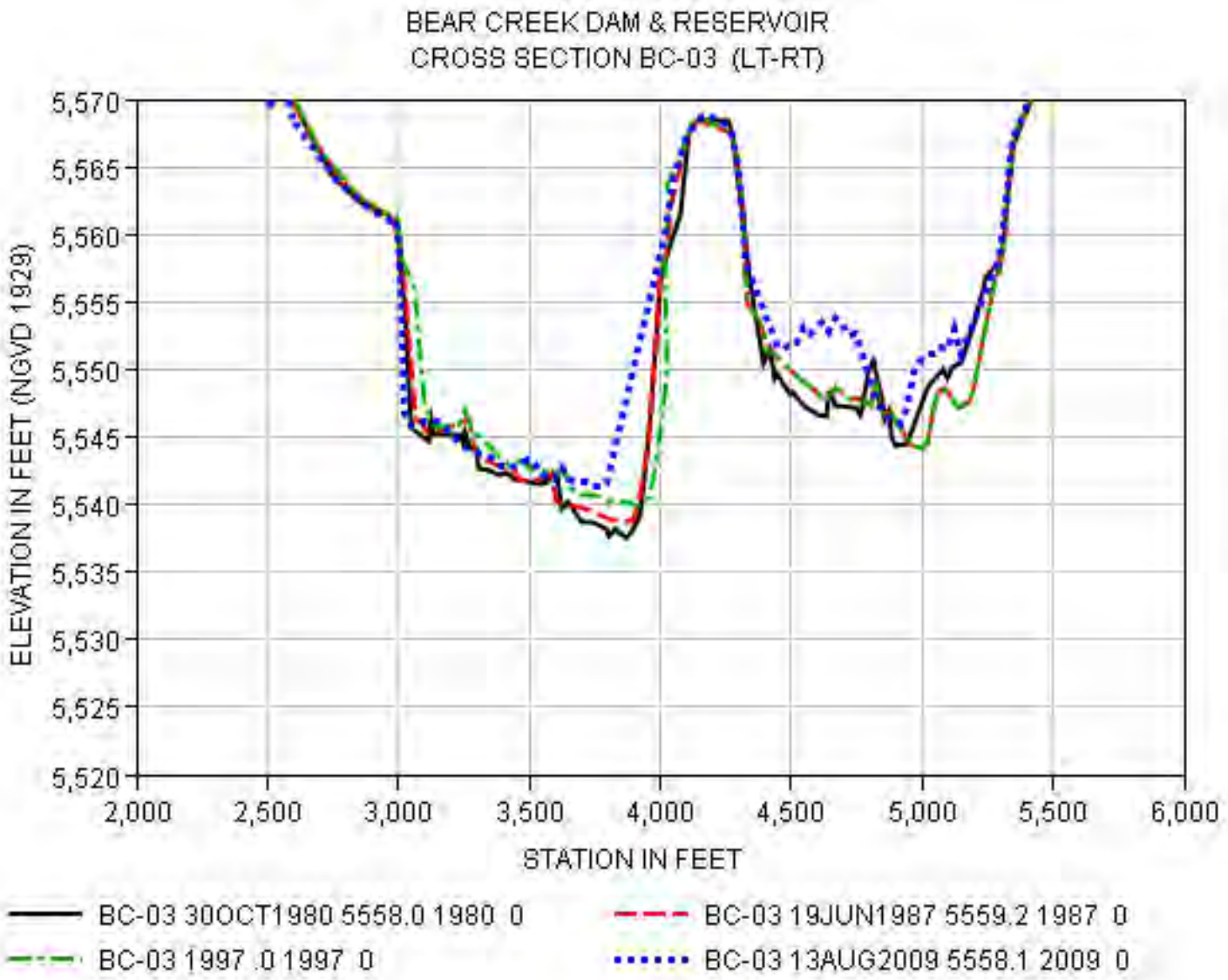
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-7. Sediment Range Line BC-01 Cross Section



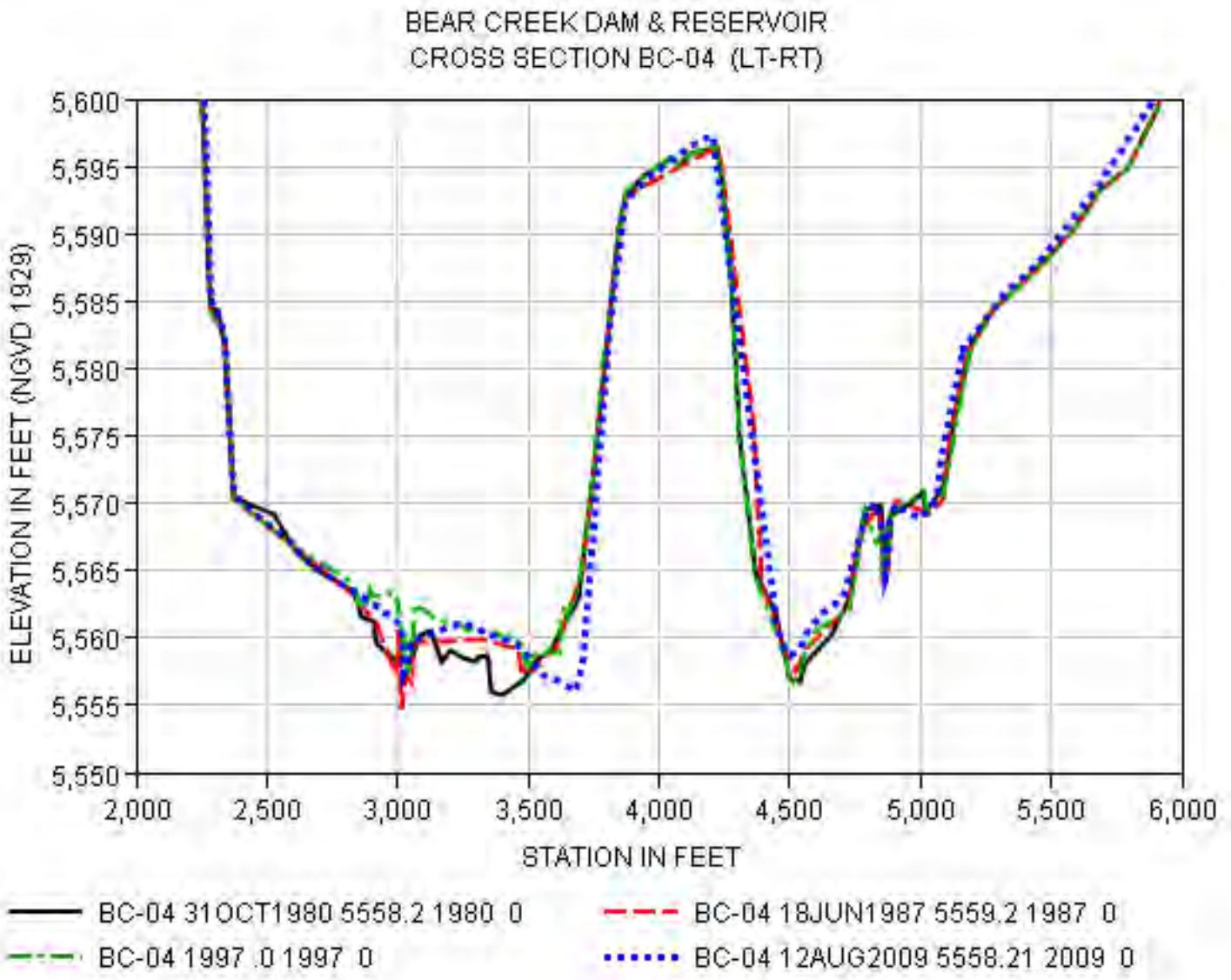
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-8. Sediment Range Line BC-02 Cross Section



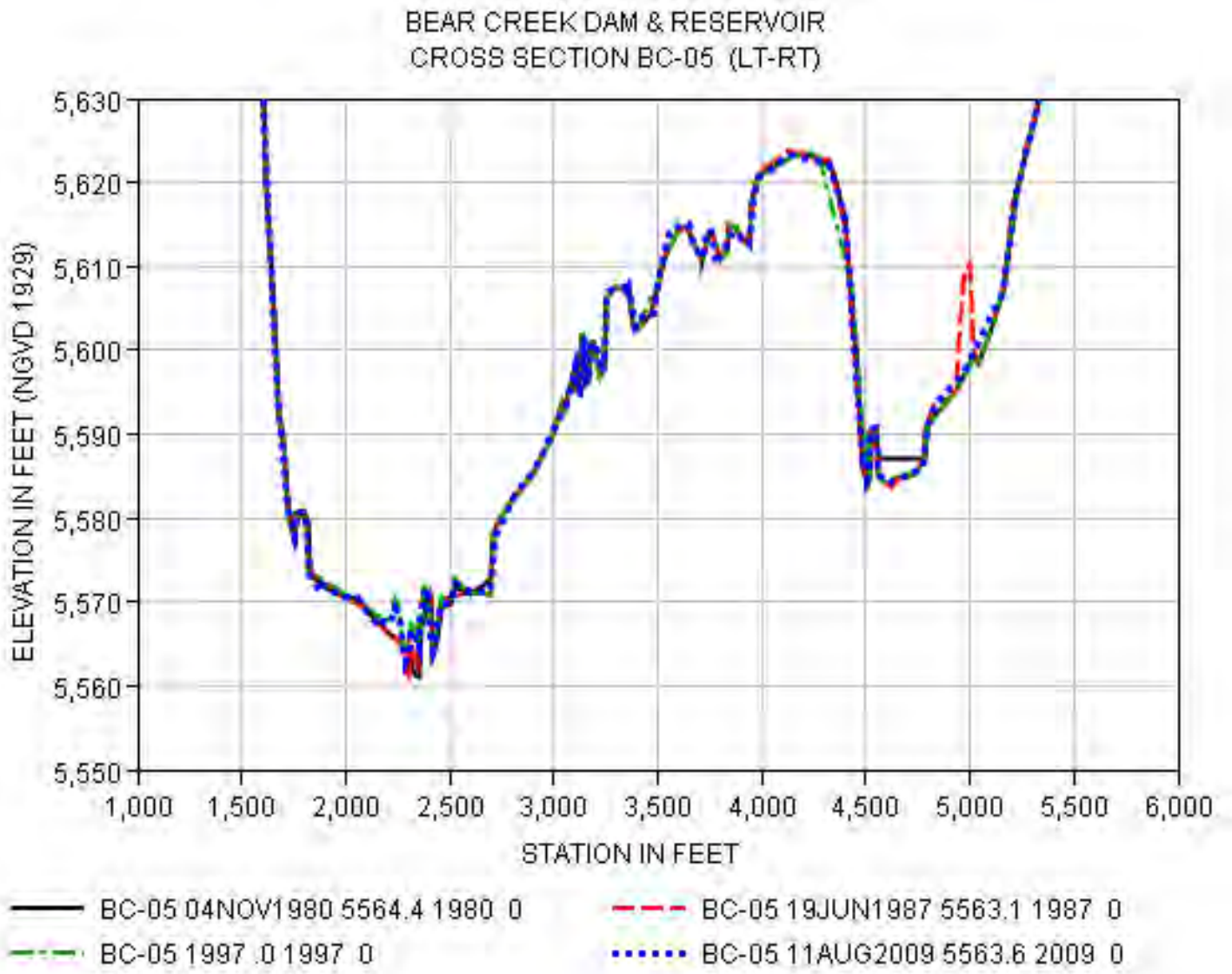
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-9. Sediment Range Line BC-03 Cross Section



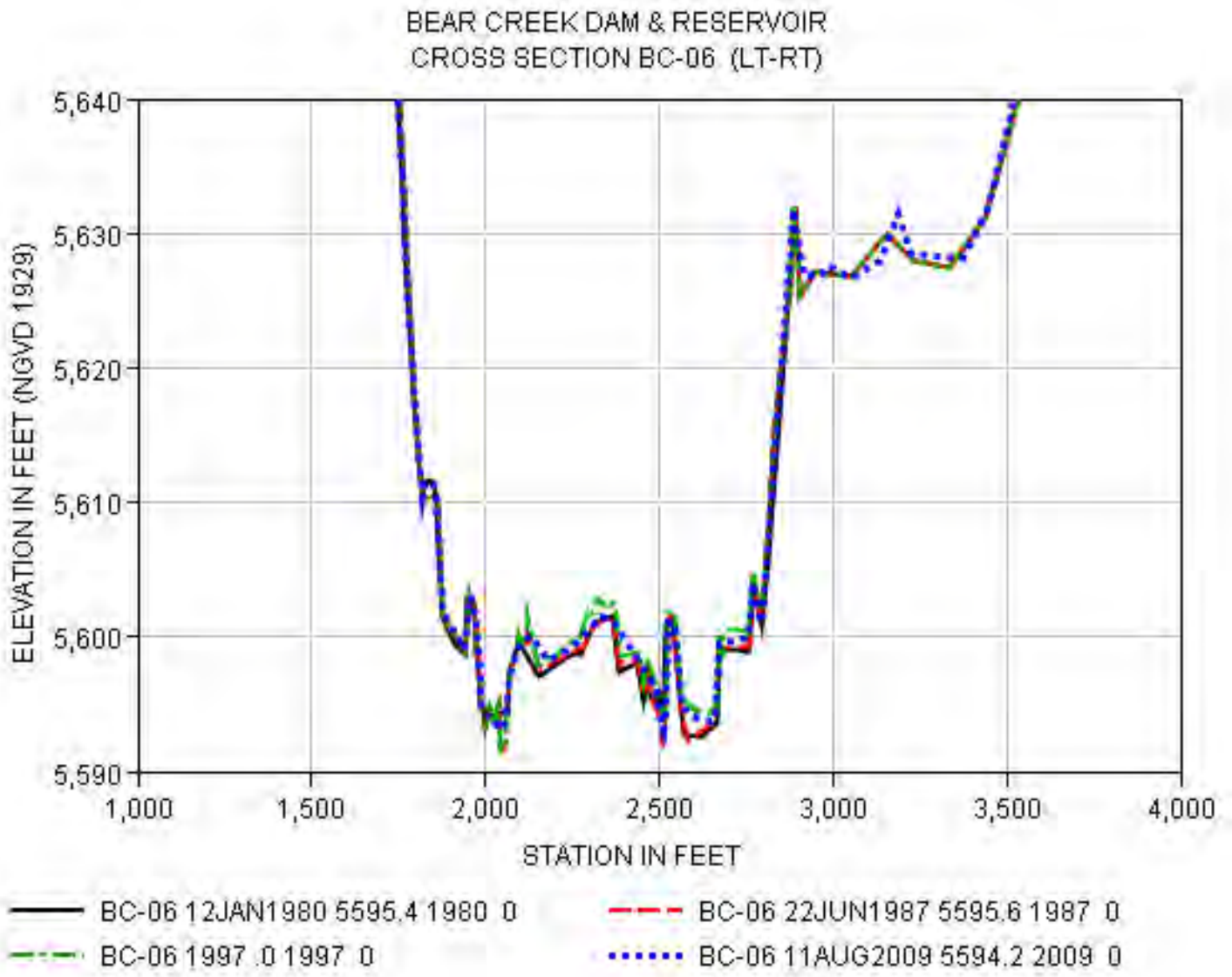
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-10. Sediment Range Line BC-04 Cross Section



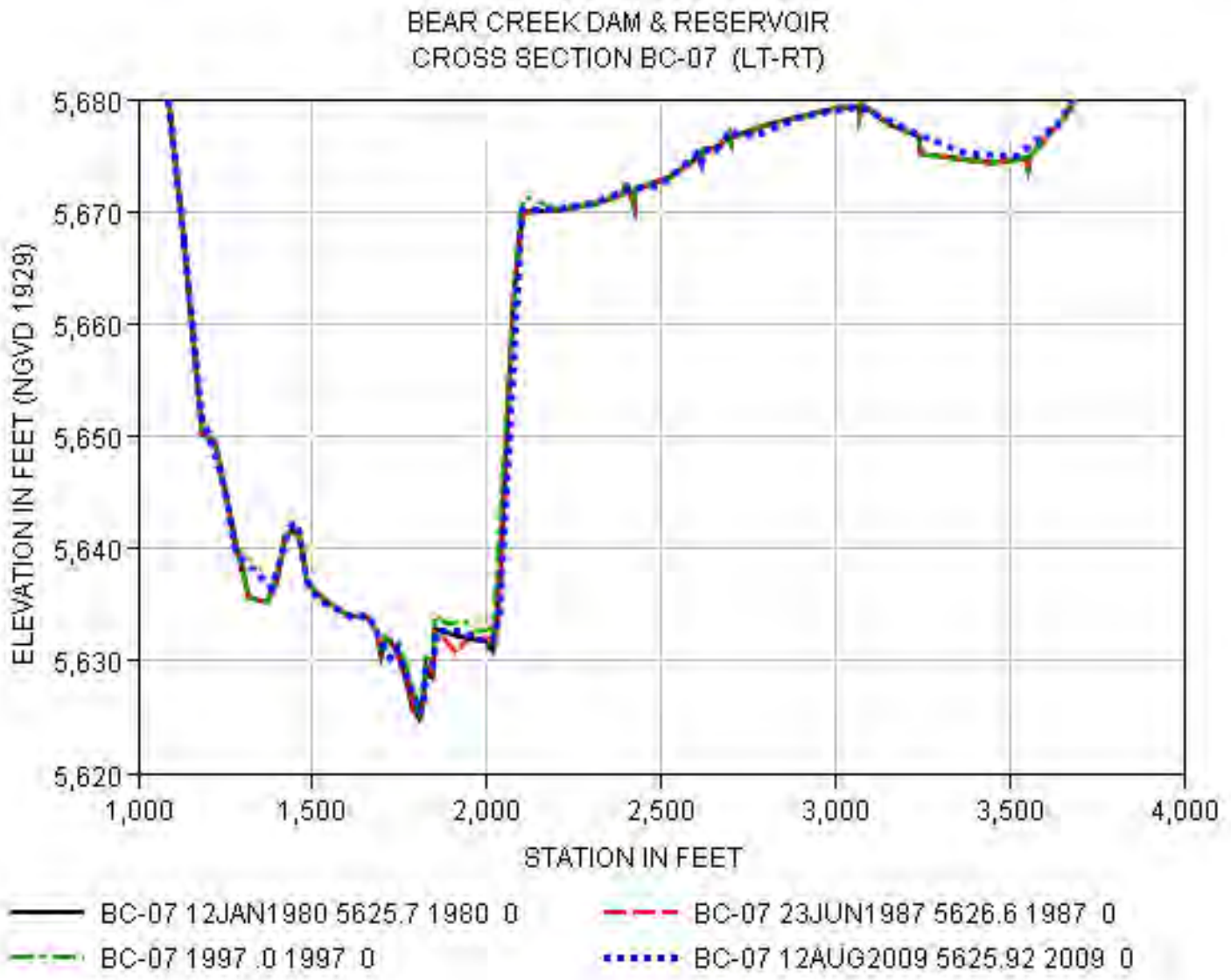
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-11. Sediment Range Line BC-05 Cross Section



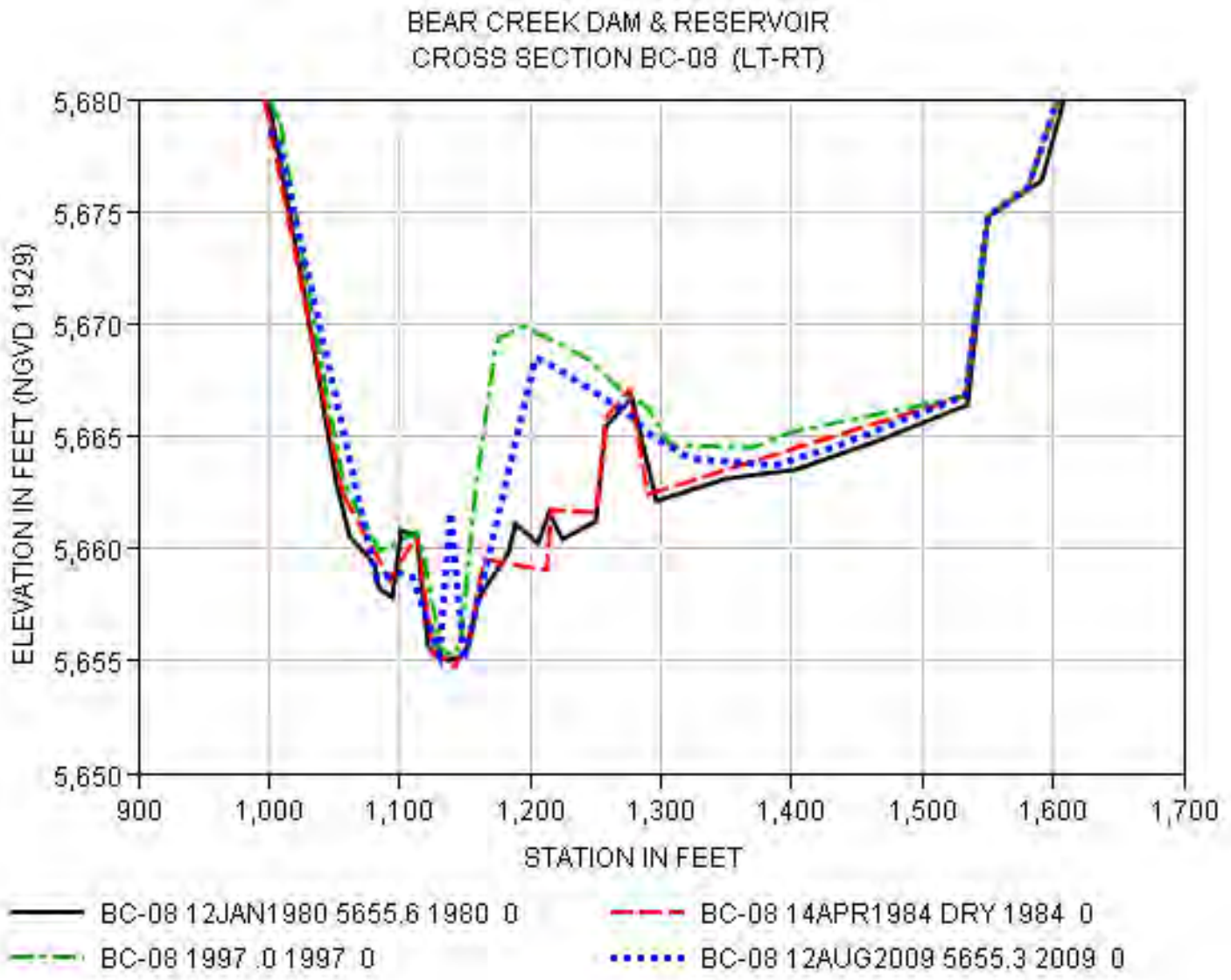
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-12. Sediment Range Line BC-06 Cross Section



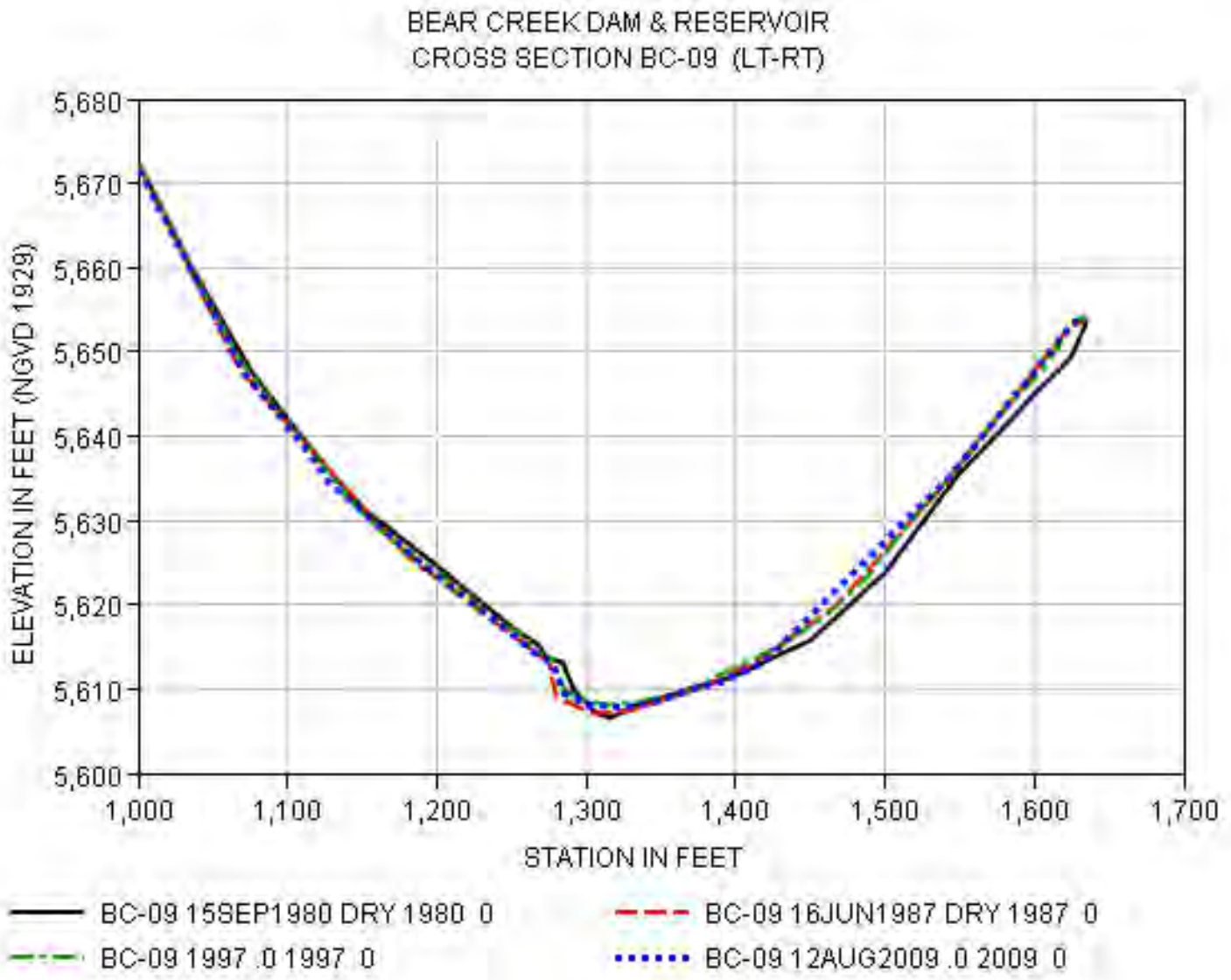
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-13. Sediment Range Line BC-07 Cross Section



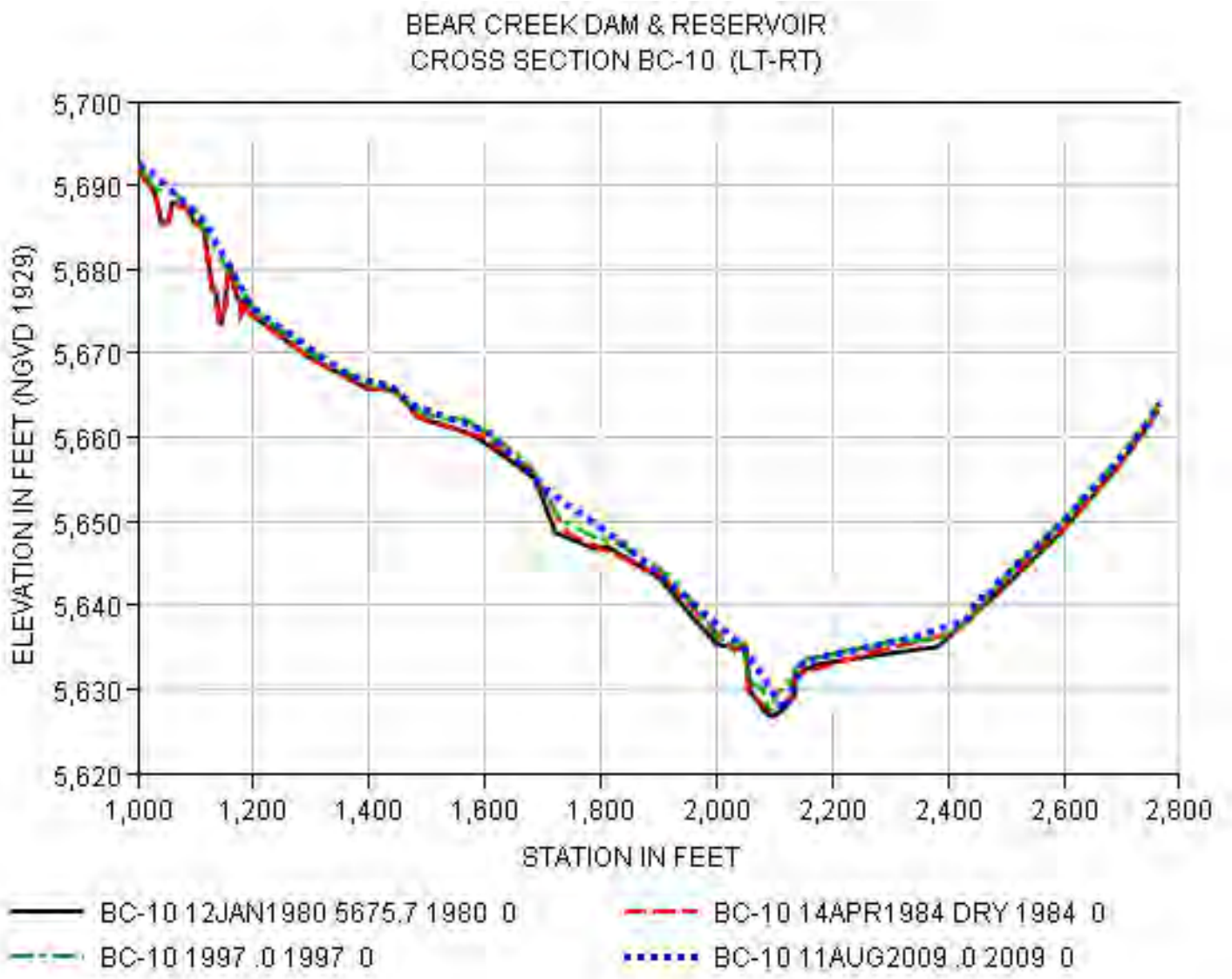
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-14. Sediment Range Line BC-08 Cross Section



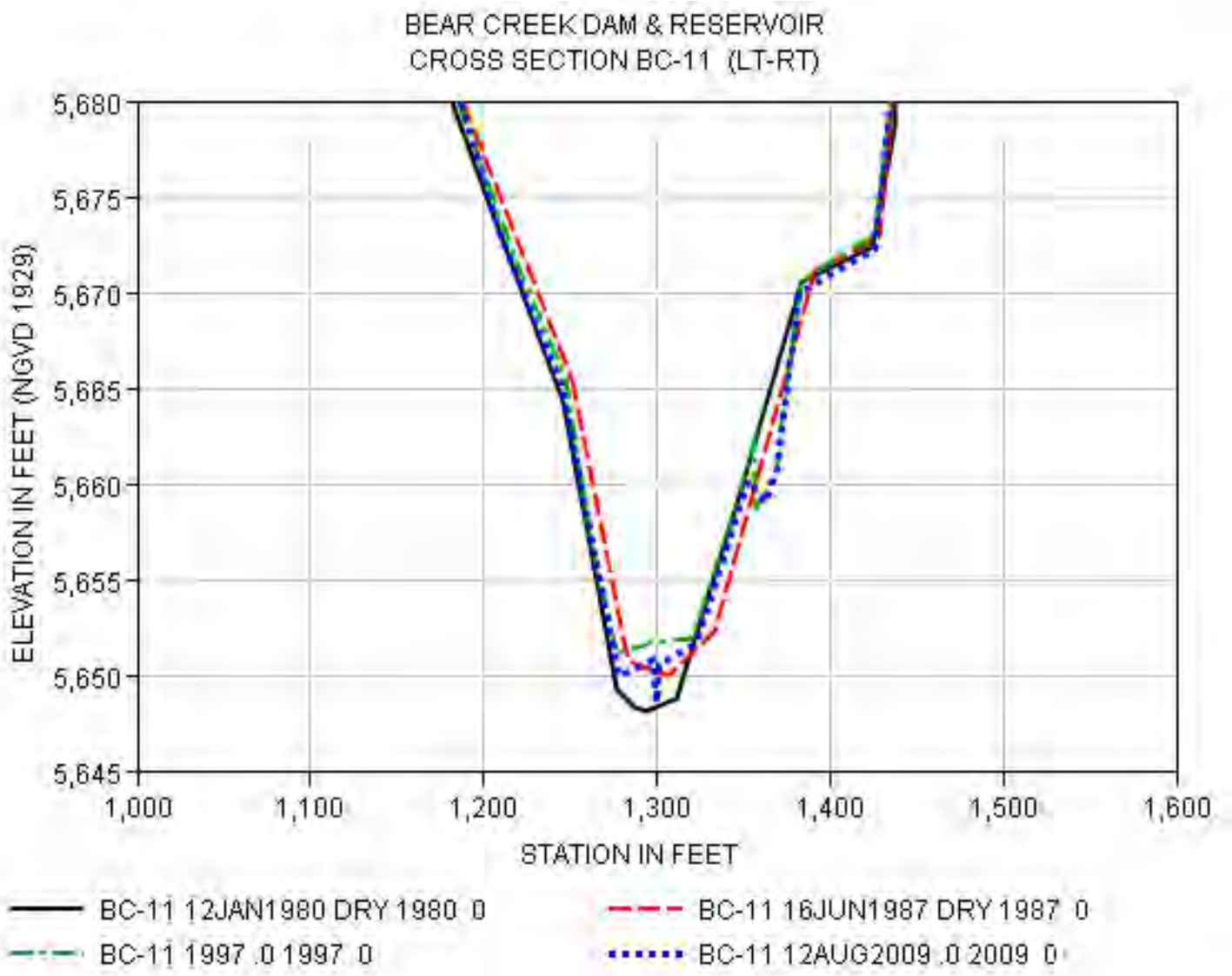
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-15. Sediment Range Line BC-09 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-16. Sediment Range Line BC-10 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 3-17. Sediment Range Line BC-11 Cross Section

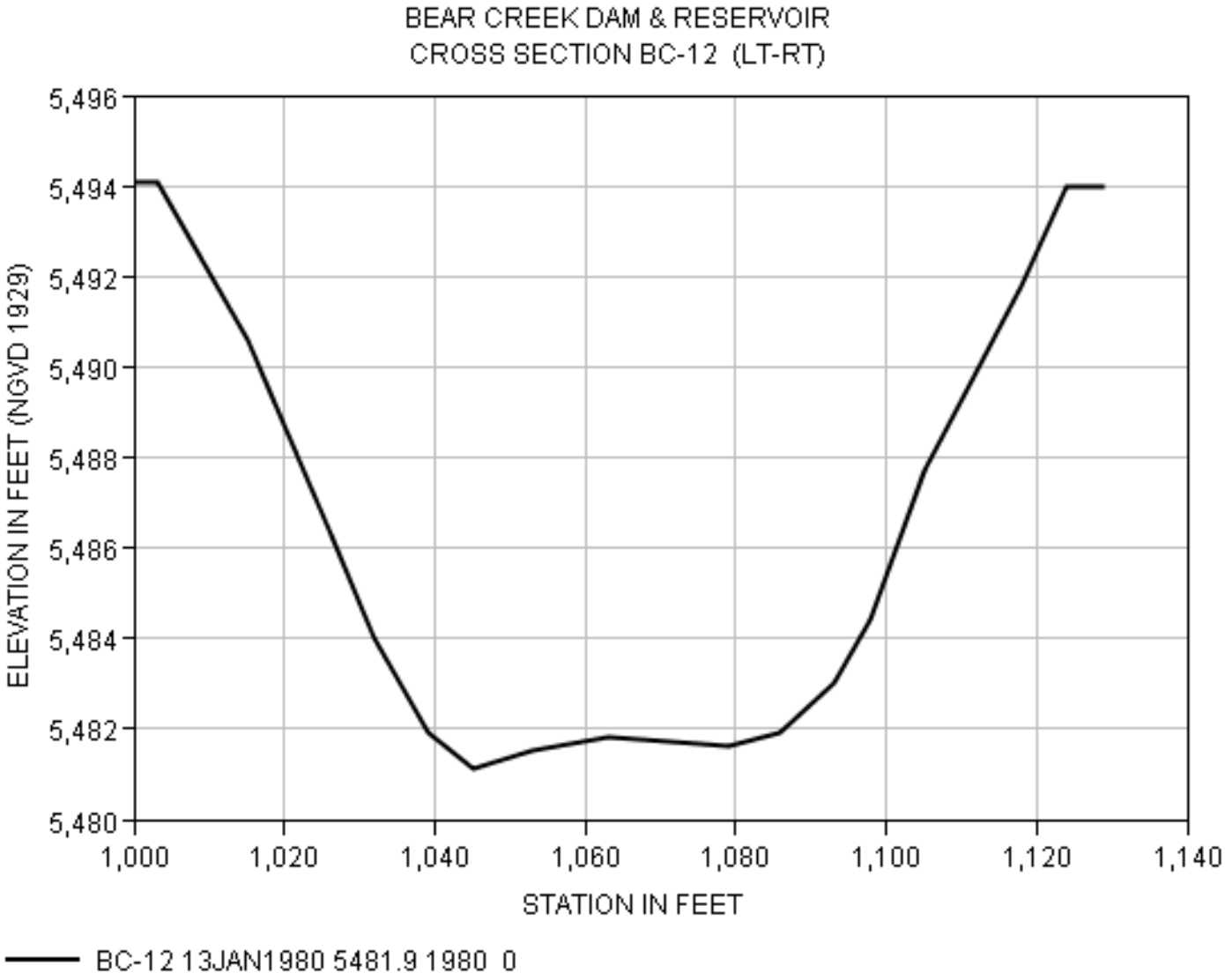


Figure 3-18. Sediment Range Line BC-12 Cross Section

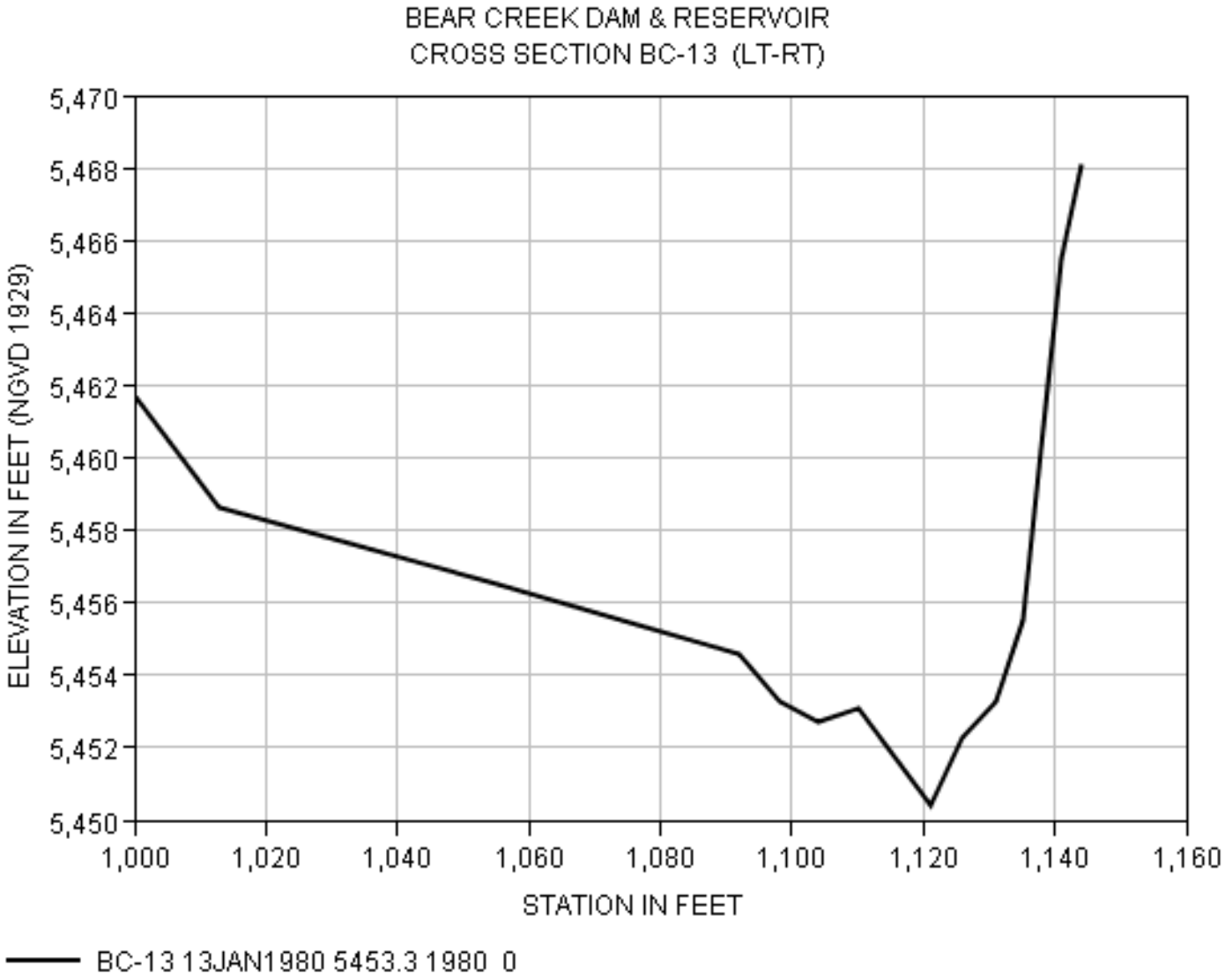


Figure 3-19. Sediment Range Line BC-13 Cross Section

4 Chatfield Lake

4.1 Background

Chatfield Lake is located on the South Platte River at the confluence of Plum Creek about eight miles upstream from downtown Denver, Colorado. The lake is located in portions of Arapahoe, Douglas, and Jefferson Counties. A map of Chatfield Lake, including its sediment ranges, is shown in Figures 4-1 and 4-2. Chatfield Dam is a rolled earth structure 13,136 feet long and 147 feet high. The lake covers 1,429 acres at the multi-purpose pool elevation of 5432.0 feet. The original estimated long term average annual depletion rate for the lake was 200 acre-feet with 59 acre-feet originating from the Plum Creek drainage basin.

Plum Creek flows into the east arm of Chatfield Lake. The Plum Creek basin drains a total of 324 square miles. In the late 1980's and early 1990's Plum Creek experienced a large influx of sediment causing excess aggradation and delta buildup in the Plum Creek tributary arm of Chatfield Lake. This aggradation changed the location of the channel endangering the recreational facilities in the Plum Creek arm of Chatfield Lake. The aggradation has also decreased the flood conveyance capacity of the Titan Road Bridge, located approximately three miles upstream of the lake's multipurpose pool elevation. A 1989 internal draft report stated that there was only three feet of clearance at the Titan Road Bridge in 1989. Several studies were conducted around the early 1990's to determine the future of the Titan Road Bridge. Since 1990, the Titan Road Bridge has been replaced and a grade control structure has been built upstream of the bridge. The Plum Creek arm continues to be the source of the majority of the sediment entering Chatfield Lake. One sediment source upstream Plum Creek is a currently operating gravel pit.

The 1991 and 1998 surveys did not cover the outer extents of all the range lines for the overbank and used 1977 data to complete the lines for the area-capacity programs to reach comparable survey elevations. Due to the data repetition, the 1991 and 1998 data in the flood control and surcharge pools are not reflective of the changes and are not reported. Note the 2010 survey covered the entire length of the range lines.

4.2 Surface Area

Figure 4-3 is a plot of elevation versus surface area for all survey years. Table 4-1 shows the reservoir surface area by elevation. The surface area at the top of the Chatfield Lake multipurpose pool (5432.0 feet) decreased by 32 acres between 1977 and 2010. Shoreline erosion increases the surface area while delta growth decreases the surface area of the lake. The decrease in this case is likely due to delta growth at the multipurpose level.

Table 4-1. Reservoir Surface Area by Elevation for Chatfield Lake

Storage Pool	Top of Pool Elevation	Surface Area (acres)			
		1977	1991	1998	2010
Flood Control	5500	4,774	*	*	4,782
Multipurpose	5432	1,444	1,438	1,429	1,412

*Survey data did not reach this elevation.

4.3 Capacity Changes

Figure 4-4 is a plot of the elevation versus reservoir capacity curve for all survey years. Table 4-2 presents reservoir capacity by storage pool and Table 4-3 presents the rate of change by elevation. Gross storage (elevation 5377.0 – 5521.6 feet) decreased 1,924 acre-feet (0.55%) between 1977 and 2010. In the flood surcharge pool

(elevation 5500.0 – 5521.6), storage decreased 53 acre-feet (0.05%) between 1977 and 2010. Storage in the exclusive flood control pool (elevation 5432.0 – 5550.0 feet) decreased 871 acre-feet (0.42%) between 1977 and 2010. Storage in the multipurpose pool (elevation 5385.0 – 5432.0 feet) decreased 987 acre-feet (3.52%) between 1977 and 2010. Storage in the inactive pool (elevation 5377.0 – 5385.0 feet) decreased 13 acre-feet (44.83%) between 1977 and 2010.

The total storage depletion rate between survey years 1977 and 2010 is 58.3 acre-feet per year, while the storage depletion rate up to the multipurpose pool level is 30.3 acre-feet per year. The original projected total storage depletion rate was approximately 200 acre-feet per year.

Table 4-2. Chatfield Lake - Reservoir Storage Capacity by Storage Pool

Storage Pool	Reservoir Capacity (ac-ft)				Change in Reservoir Capacity (ac-ft)				Depletion Rate (ac-ft/yr)	Percent Lost per Year
	1977	1991	1998	2010	1977-1991	1991-1998	1998-2010	1977-2010	1977-2010	1977-2010
Surcharge 5521.6 - 5500.0	116,446	*	*	116,393	*	*	*	-53	-1.6	-0.001%
Flood Control 5500.0 - 5432.0	206,856	*	*	205,985	*	*	*	-871	-26.4	-0.01%
Multipurpose 5432.0 - 5385.0	28,047	27,596	27,405	27,060	-451	-191	-345	-987	-29.9	-0.11%
Inactive 5385.0 - 5377.0	29	28	23	16	-1	-5	-7	-13	-0.4	-1.36%
Gross Storage 5521.6-5377.0	**351,378**	*	*	**349,454**	*	*	*	**-1,924**	**-58.3**	**-0.02%**

*Survey data did not reach this elevation.

Note: All elevations are reported in vertical datum NGVD 1929.

Table 4-3. Chatfield Lake – Cumulative Reservoir Capacity Changes

Top of Pool	1977	1991			1998			2010		
	Capacity (ac-ft)	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/ yr)	Percent of Original
Surcharge 5521.6	351,378	*	*	*	*	*	*	349,454	-58.3	99.5%
Flood Control 5500.0	234,932	*	*	*	*	*	*	233,061	-56.7	99.2%
Multipurpose 5432.0	28,076	27,624	-32.3	98.4%	27,428	-30.9	97.7%	27,076	-30.3	96.4%
Inactive 5385.0	29	28	-0.1	96.6%	23	-0.3	79.3%	16	-0.4	55.2%

*Survey data did not reach this elevation.

Note: All elevations are reported in vertical datum NGVD 1929.

4.4 Profile Plots

Figures 4-5 and 4-6 compare the average bed elevations of each survey year for both the flood control and multipurpose pool levels in the Plum Creek Arm and South Platte River Arm of the reservoir respectively. Figures 4-7 and 4-8 compare the thalweg profile of the reservoir arm of each survey year. The areas with the most deposition occurred in the vicinity of range lines CH-04 and CH-05 on the South Platte River Arm where the thalweg has increased by over 9 feet since 1977.

4.5 Sediment Volume

Figure 4-9 represents the change in reservoir capacity by segment from sedimentation and erosion between 1977 and 2010. The volume of sediment that entered the reservoir between surveys is represented by the reservoir capacity depletion as shown in Table 4-4.

Table 4-4. Total Sediment Change and Capacity Depletion in Chatfield Lake

Survey Period	Total Sediment Aggradation or Capacity Depletion (ac-ft)	Rate of Change (ac-ft/yr)
1977-2010	**1,924**	**58.3**

4.6 Area-Capacity Tables

Area-capacity tables computed at 1.0-foot increments are located in Appendix C. The capacity tables computed at 0.01-foot increments are available from the USACE Omaha District Sedimentation and Channel Stabilization Section.

4.7 Cross Section Data

Cross sectional plots are shown in Figures 4-10 through 4-33. The plots do not show the entire surveyed cross section, only the lower portion where sedimentation is occurring is plotted to magnify the changes. Plots of the full cross sections are available from the USACE Omaha District Sedimentation and Channel Stabilization Section.

Chatfield Lake is unique in the Tri-Lakes Projects due to the confluence of Plum Creek with the South Platte River upstream of the dam creating a v-shaped reservoir. Range lines are set on both streams with the upstream most range line on Plum Creek, CH-15, intersecting the South Platte range line CH-01 and connecting to the end points of the range lines CH-02, and CH-03, see Figure 4-2. For segment calculations the AreaCapacity program requires CH-01 to be split into two separate sections, CH-01 and CH-101; and CH-15 is required to be split in to two sections for the South Platte River Arm segment calculations in addition to the entire cross section used for the Plum Creek Arm segment calculation.

4.8 Engineering Form 1787 – Reservoir Sediment Data Summary

Engineering Form 1787, “Reservoir Sedimentation Data Summary” is presented in Appendix E. The purpose of this form is to provide a means for the uniform documentation of pertinent Chatfield Lake sedimentation data.

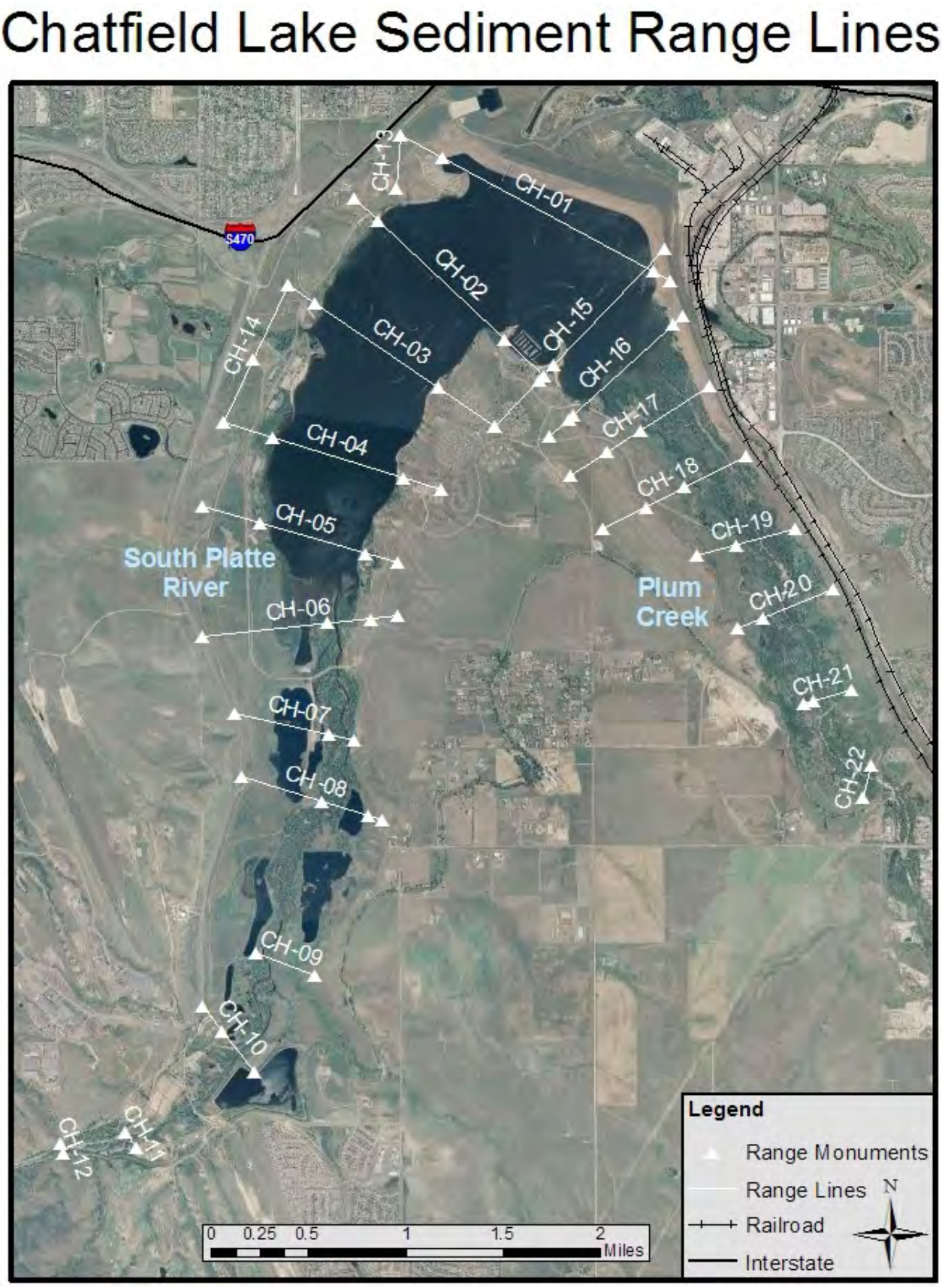


Figure 4-1. Chatfield Lake with Sediment Range Line Locations

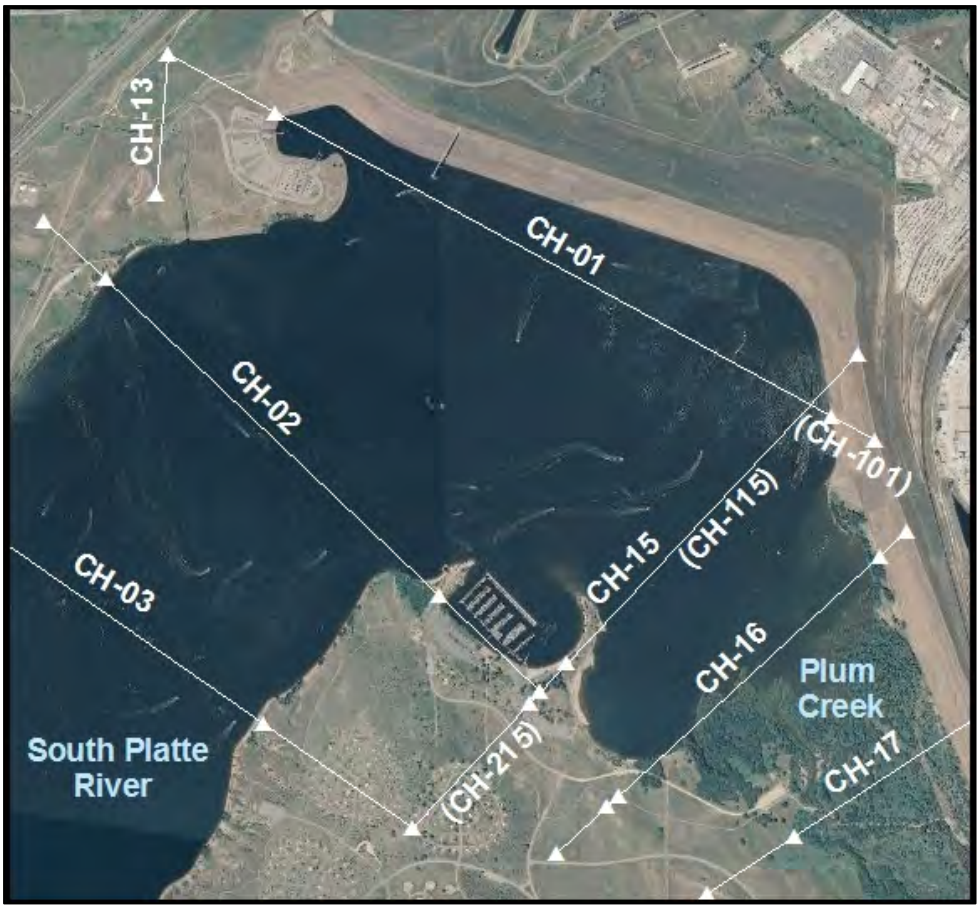


Figure 4-2. Detail of the Connecting Chatfield Lake Sediment Range Lines

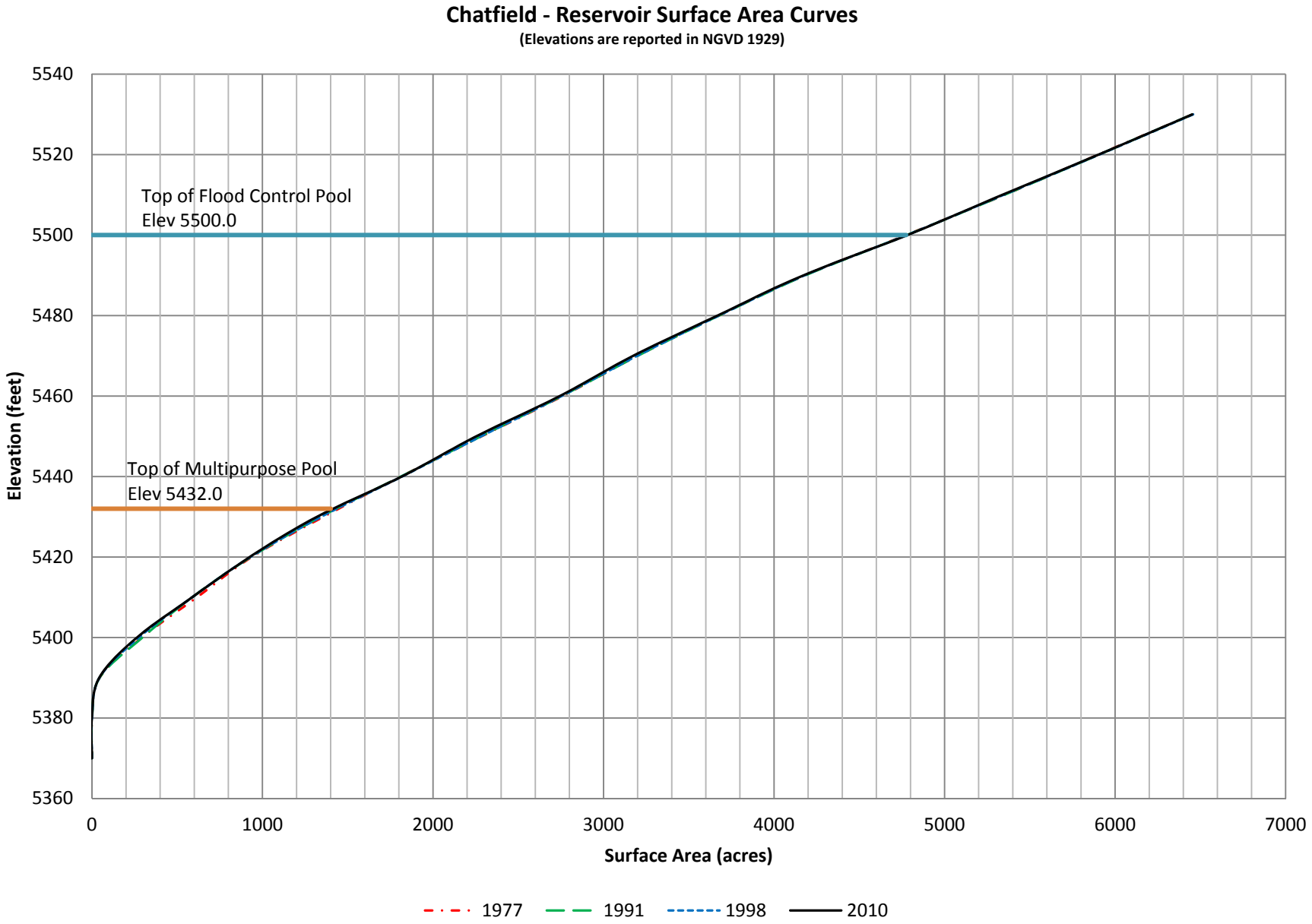


Figure 4-3. Chatfield Lake – Reservoir Surface Area Curves

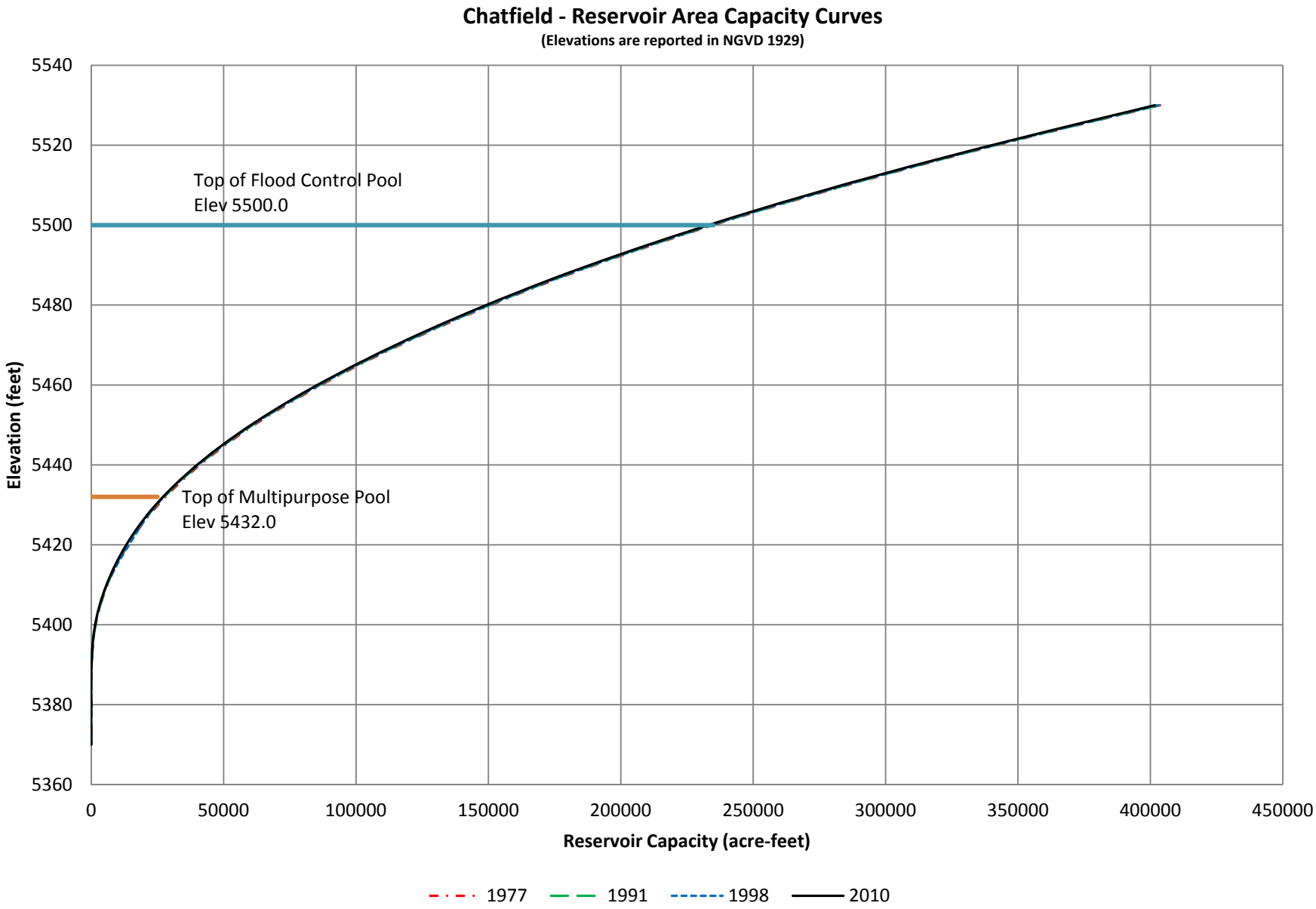


Figure 4-4. Chatfield Lake – Reservoir Area Capacity Curves

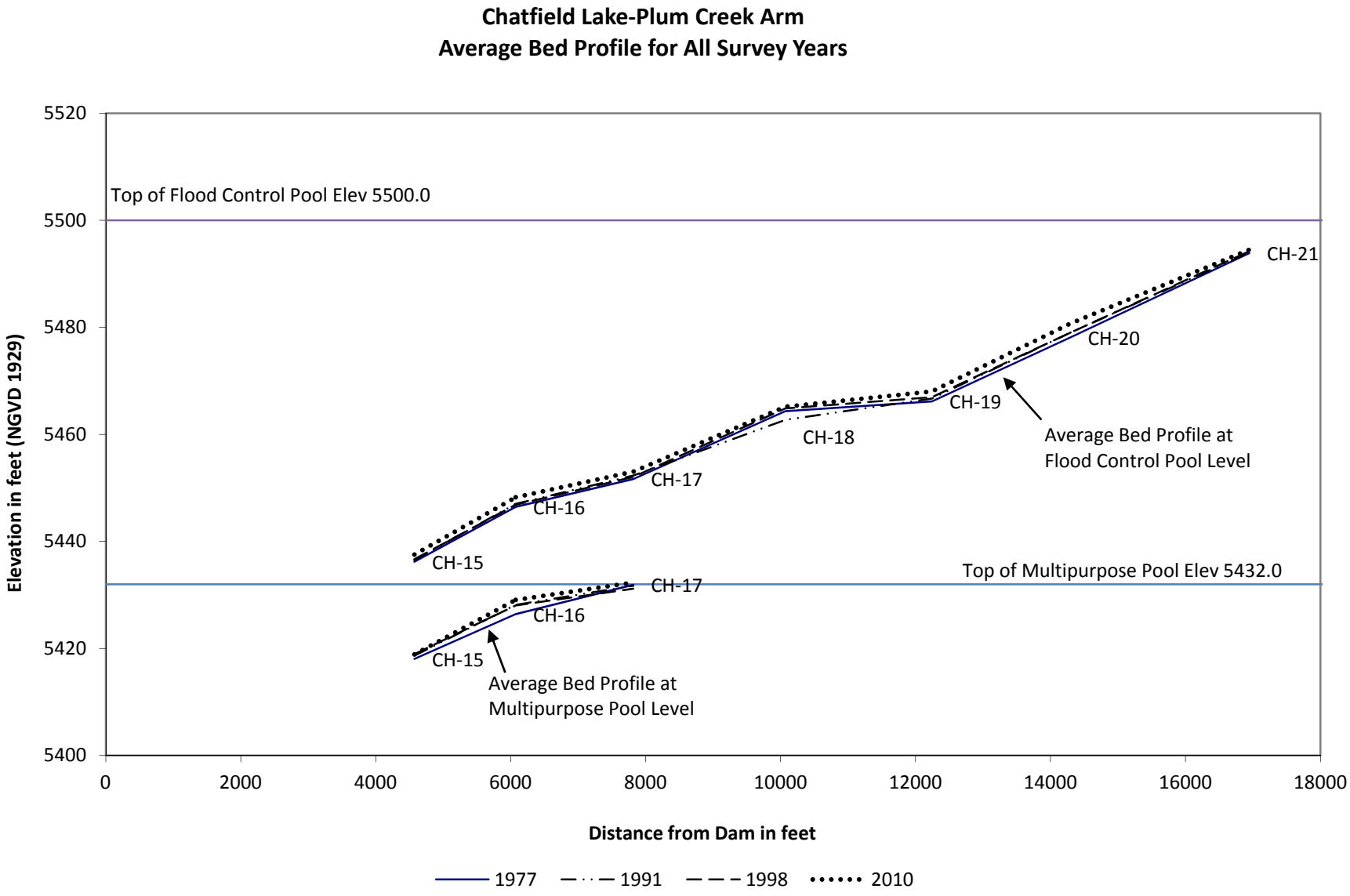


Figure 4-5. Plum Creek Arm of Chatfield Lake - Average Bed Profiles for the Flood Control Pool and Multipurpose Pool

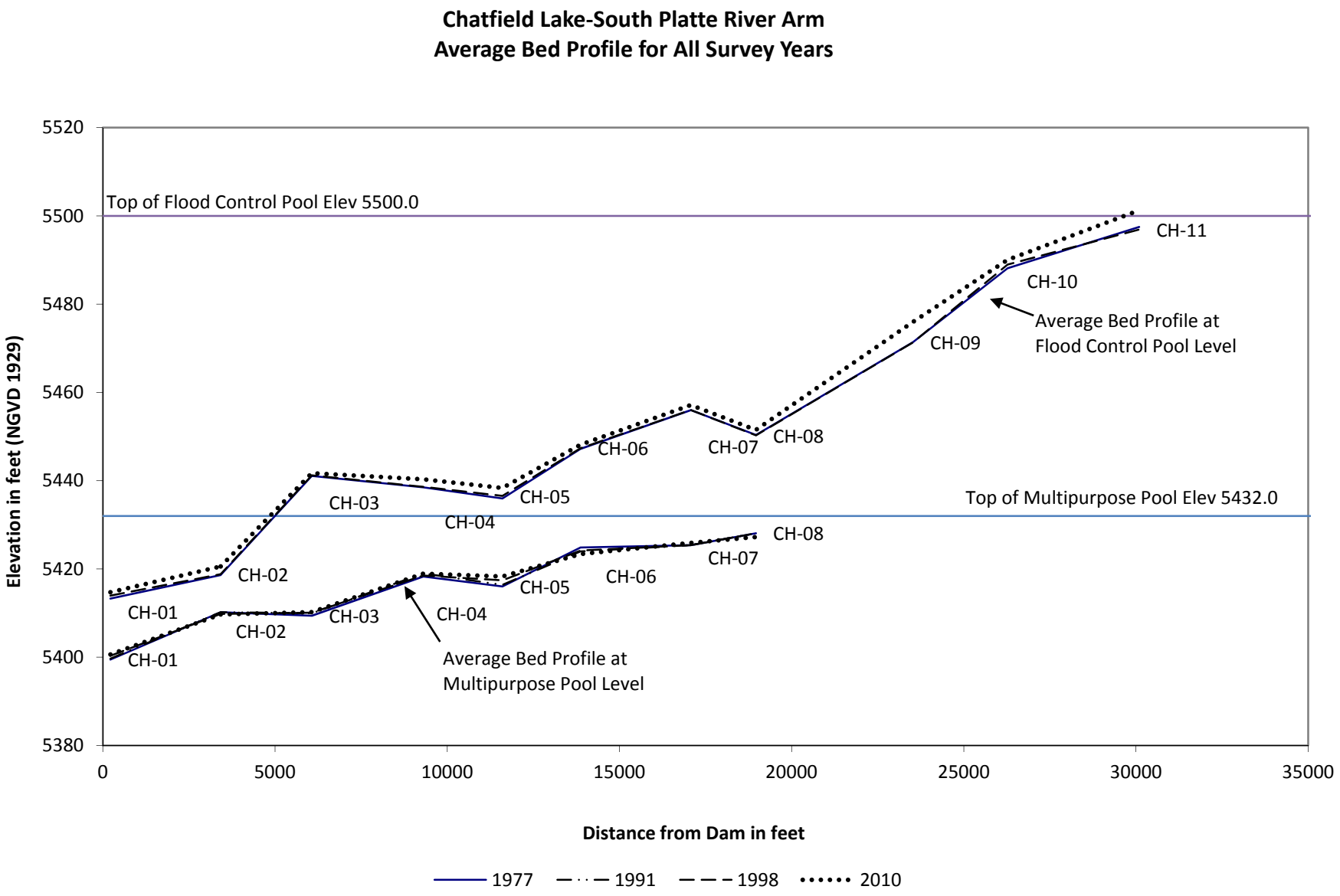


Figure 4-6. South Platte River Arm of Chatfield Lake - Average Bed Profiles for the Flood Control Pool and Multipurpose Pool

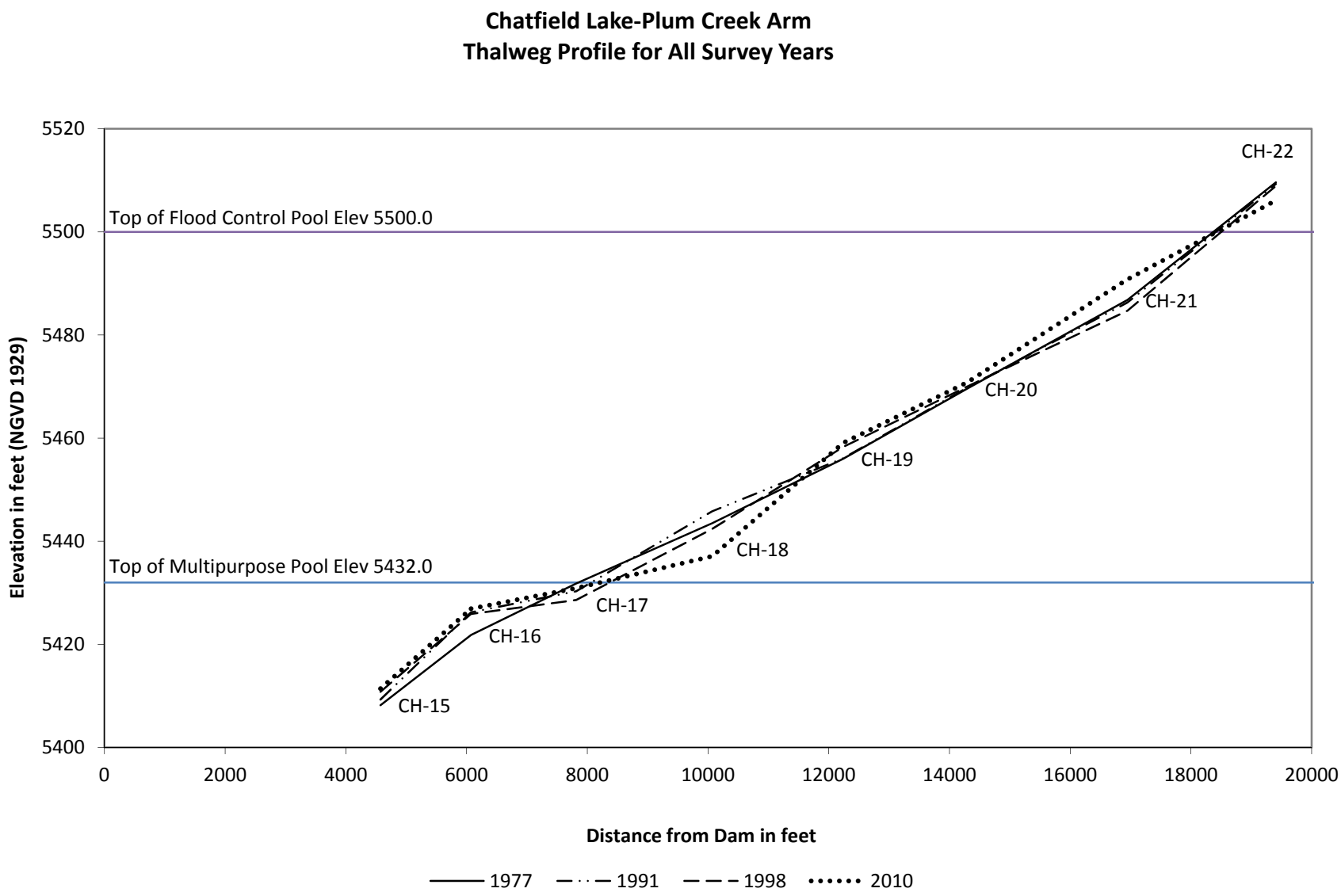


Figure 4-7. Plum Creek Arm of Chatfield Lake – Thalweg Profiles

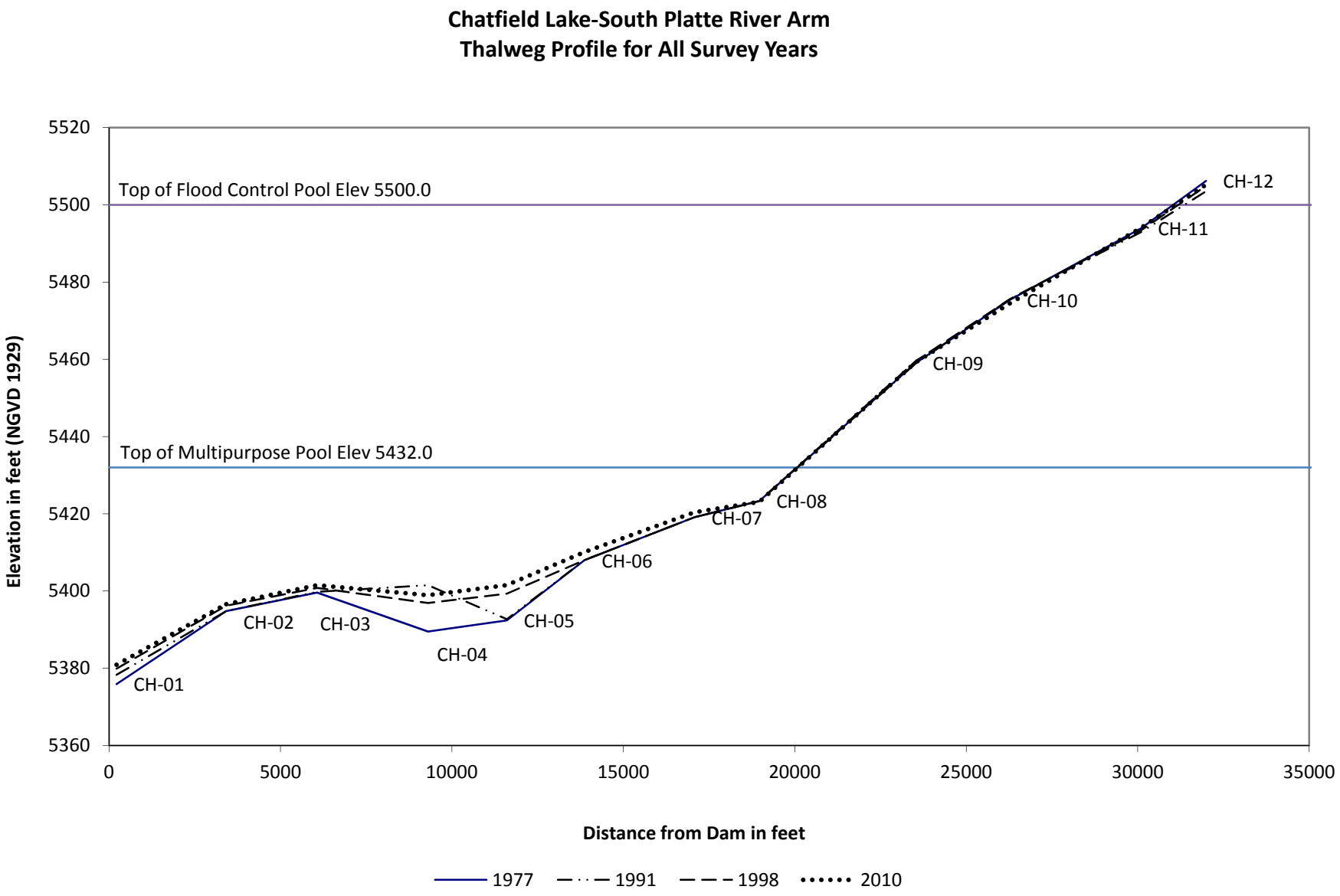


Figure 4-8. South Platte River Arm of Chatfield Lake - Thalweg Profiles

Chatfield Lake Capacity Change 1977-2010

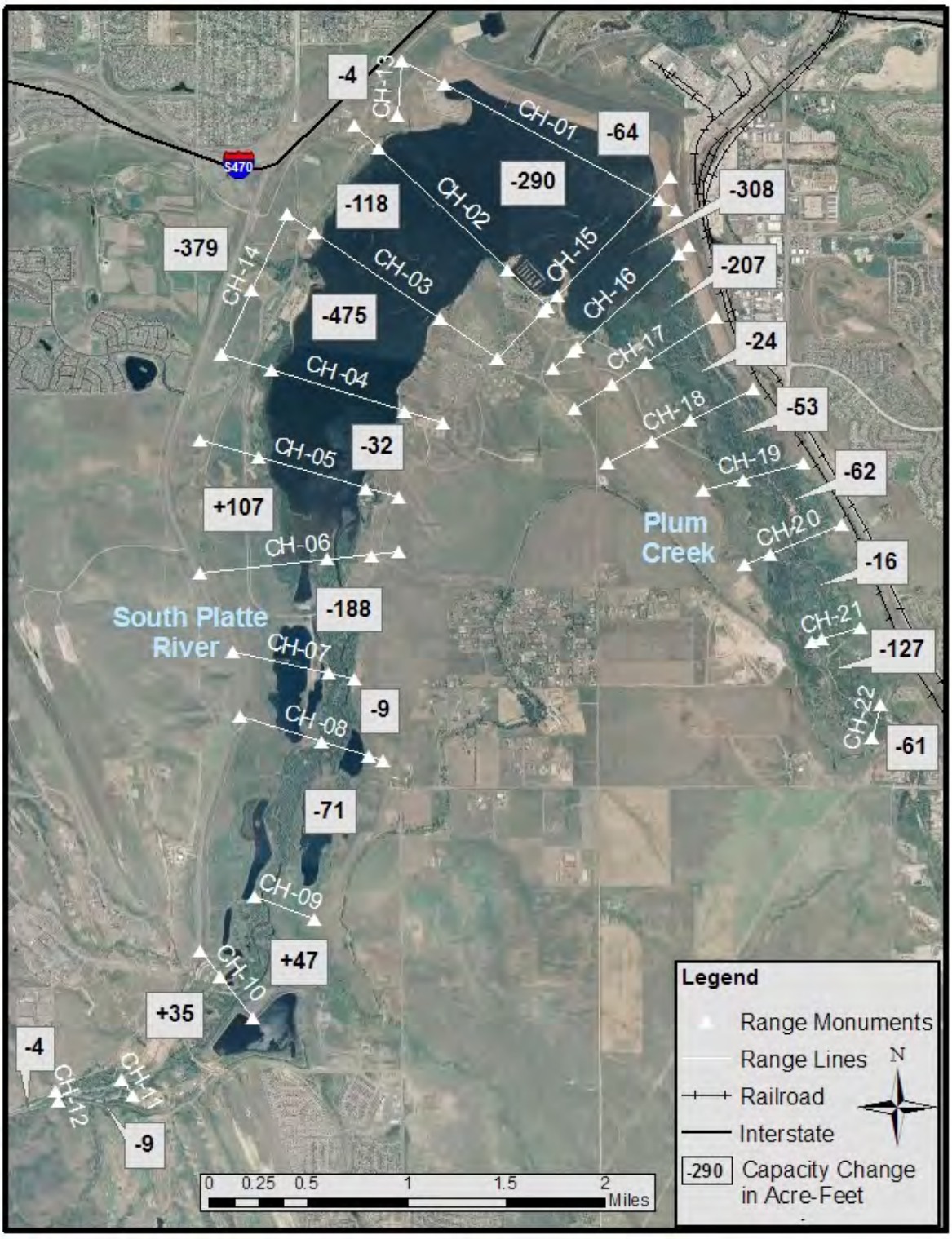
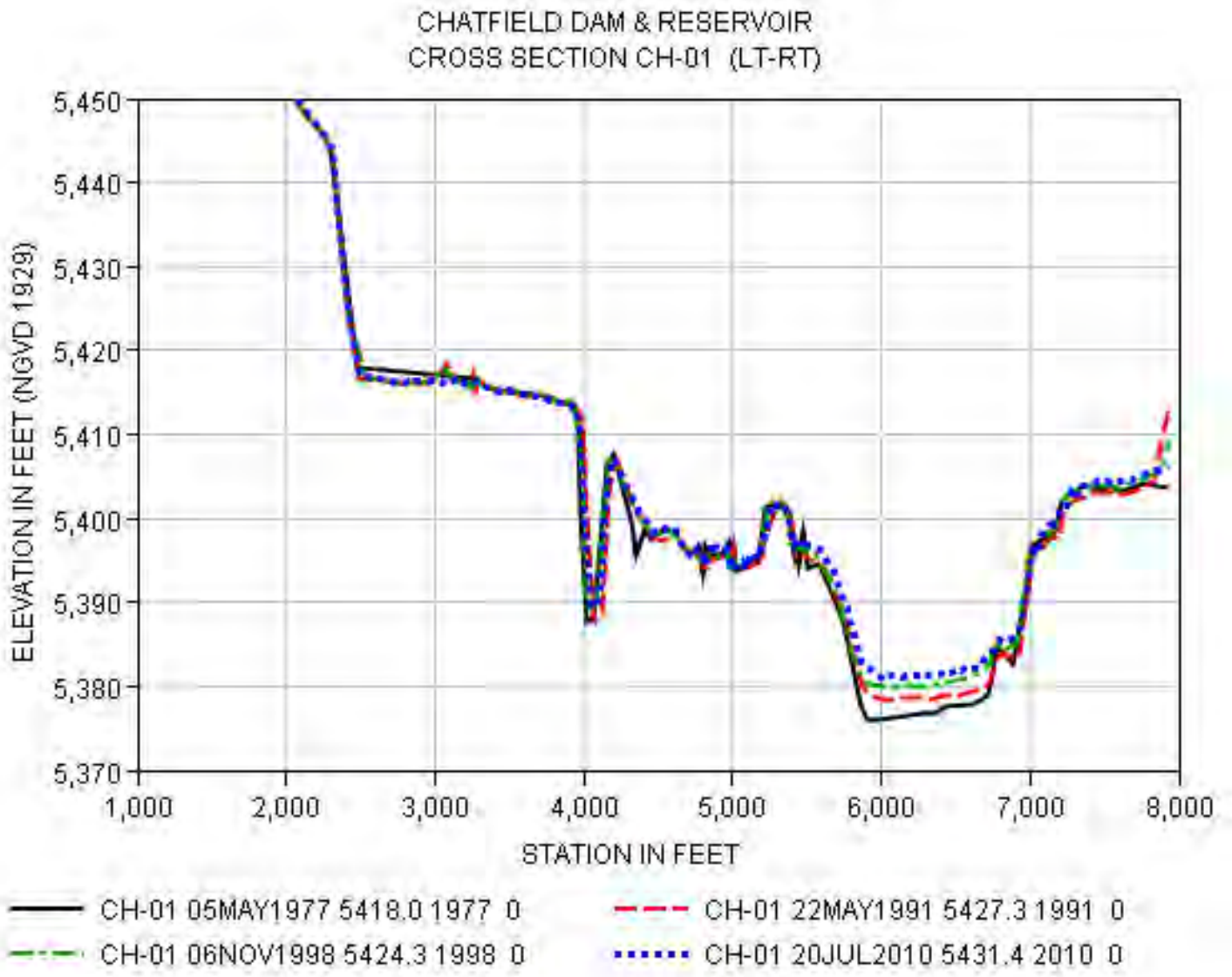
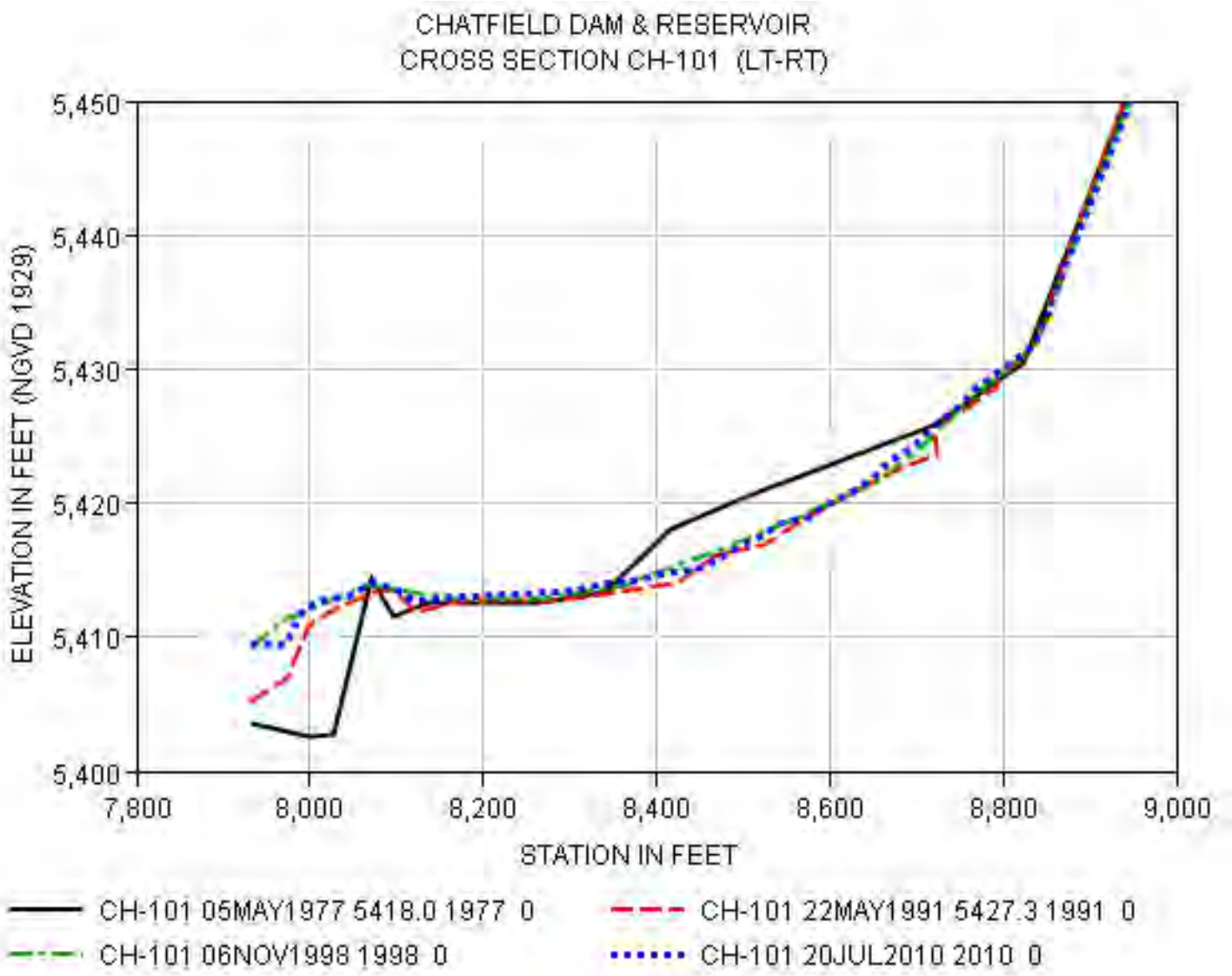


Figure 4-9. Change in Capacity by Segment of Chatfield Lake



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-10. Sediment Range Line CH-01 Cross Section

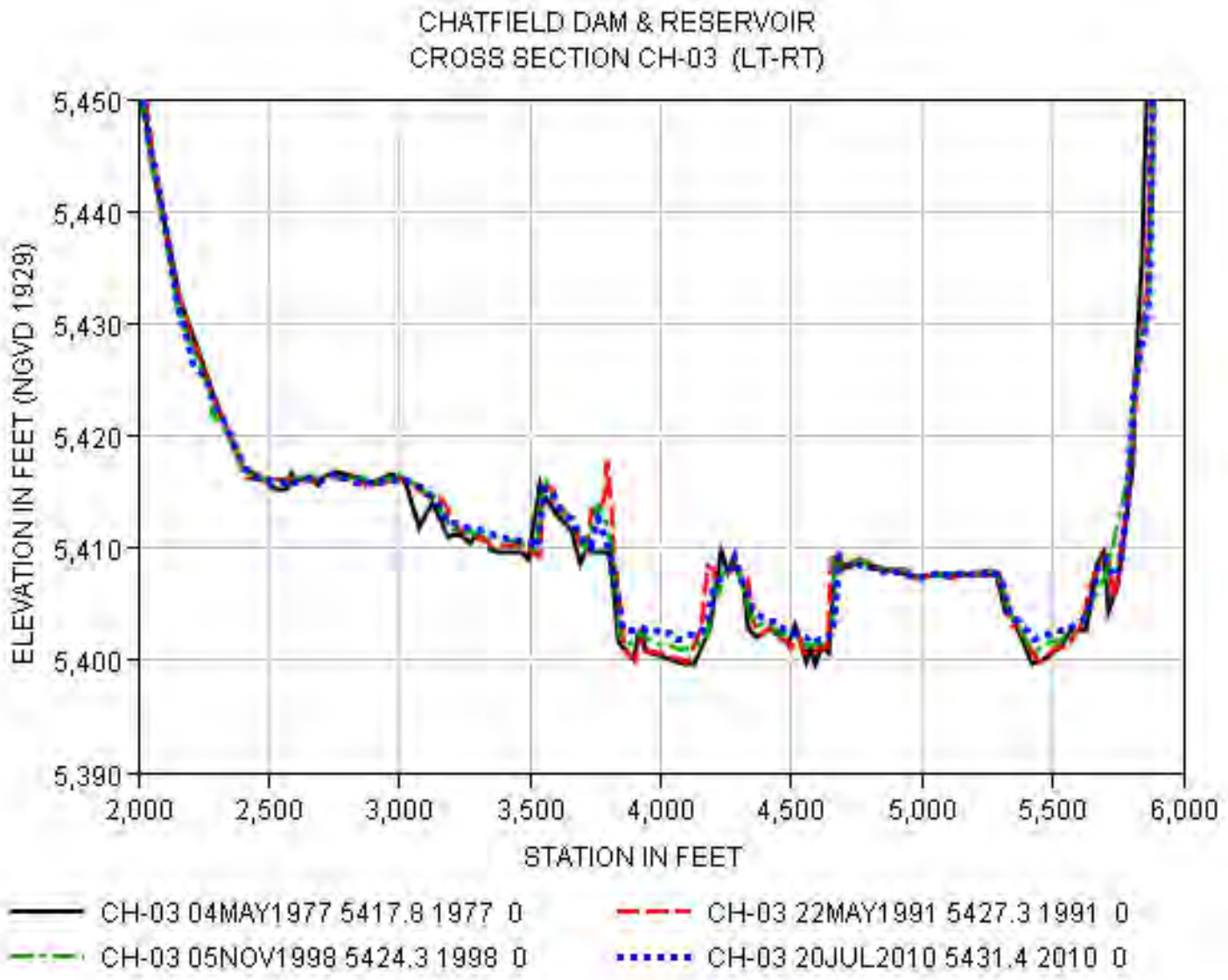


Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-11. Cross Section CH-101, Part of Sediment Range Line CH-01 for Segment Calculations

Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-12. Sediment Range Line CH-02 Cross Section

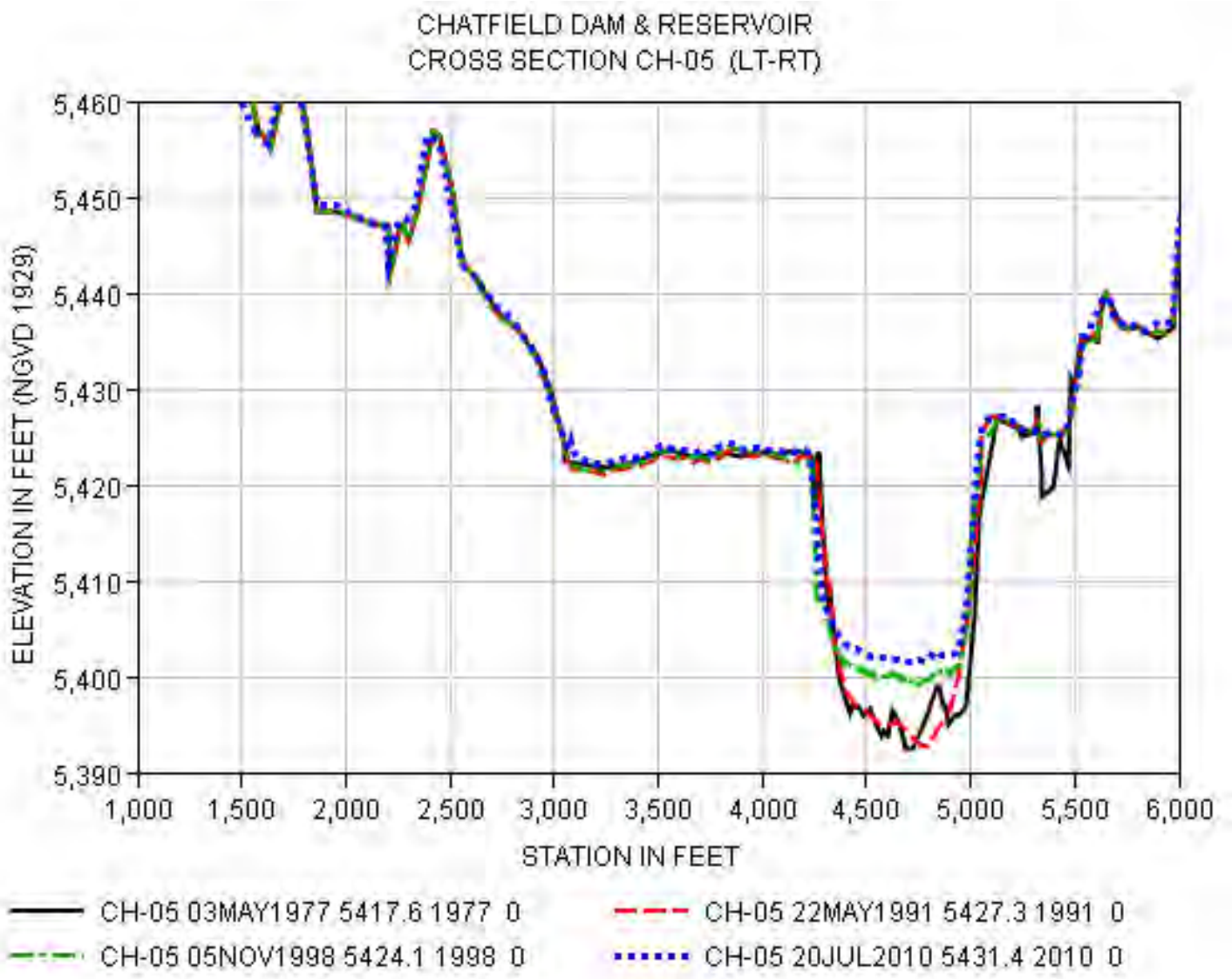


Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-13. Sediment Range Line CH-03 Cross Section

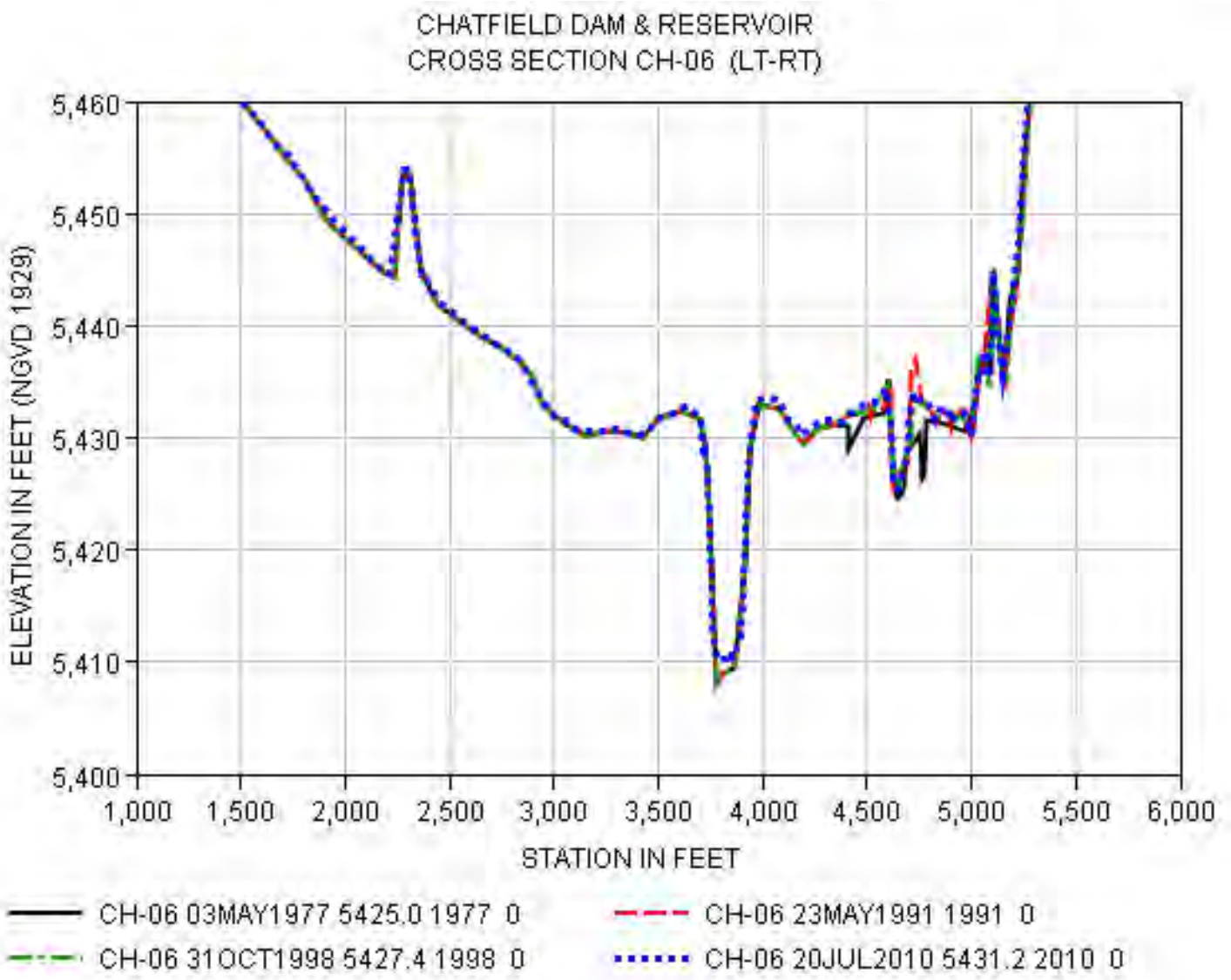
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-14. Sediment Range Line CH-04 Cross Section



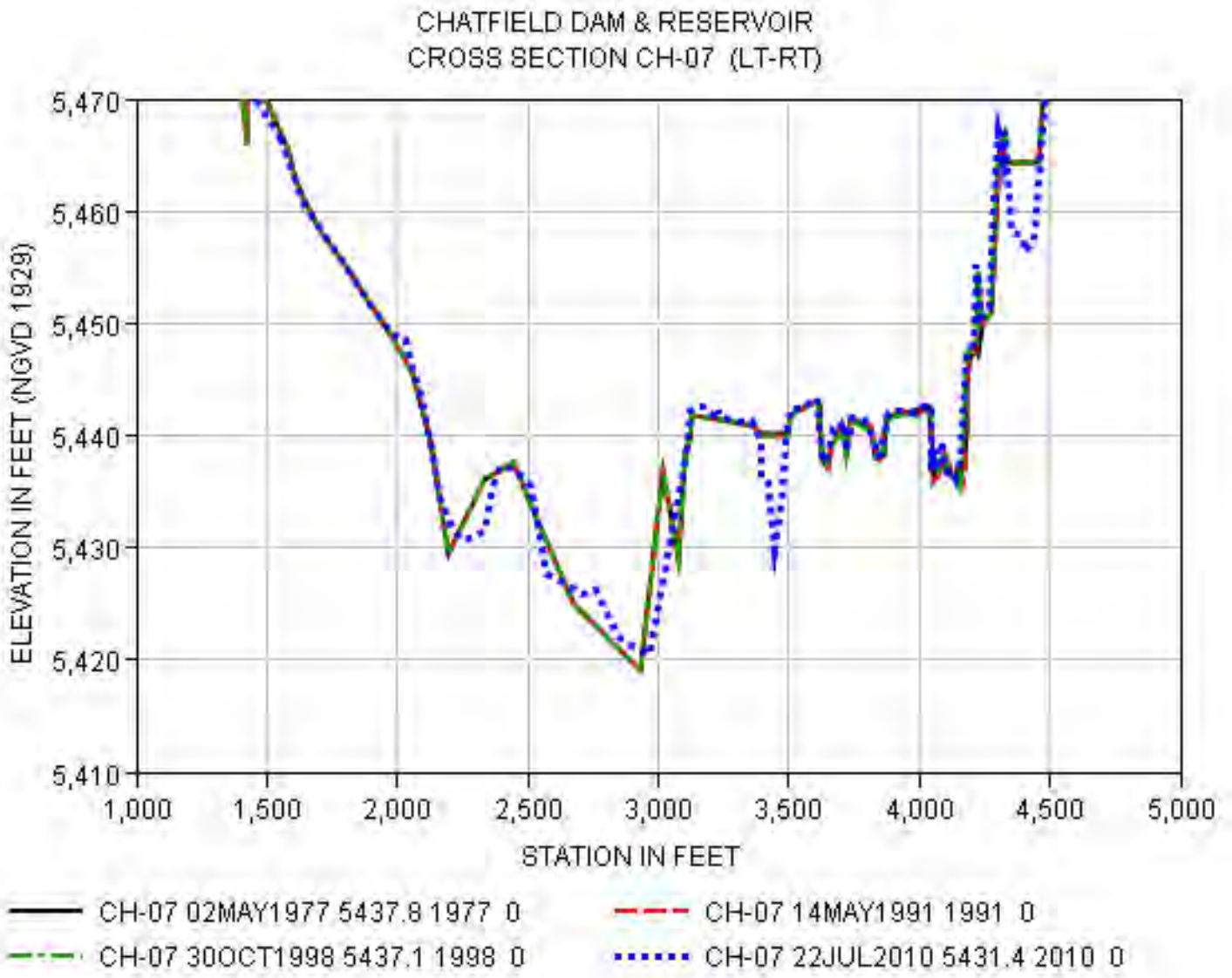
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-15. Sediment Range Line CH-05 Cross Section



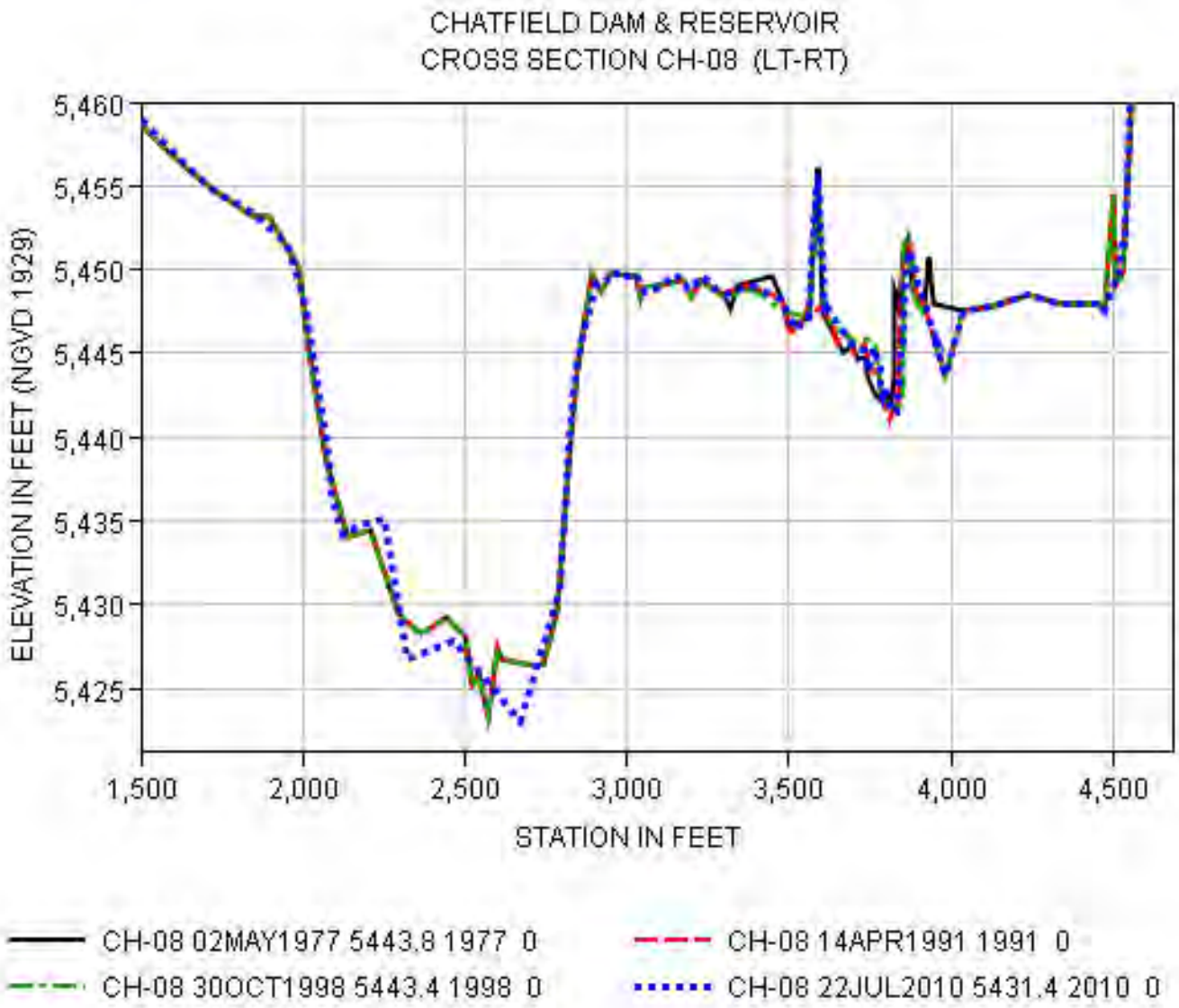
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-16. Sediment Range Line CH-06 Cross Section



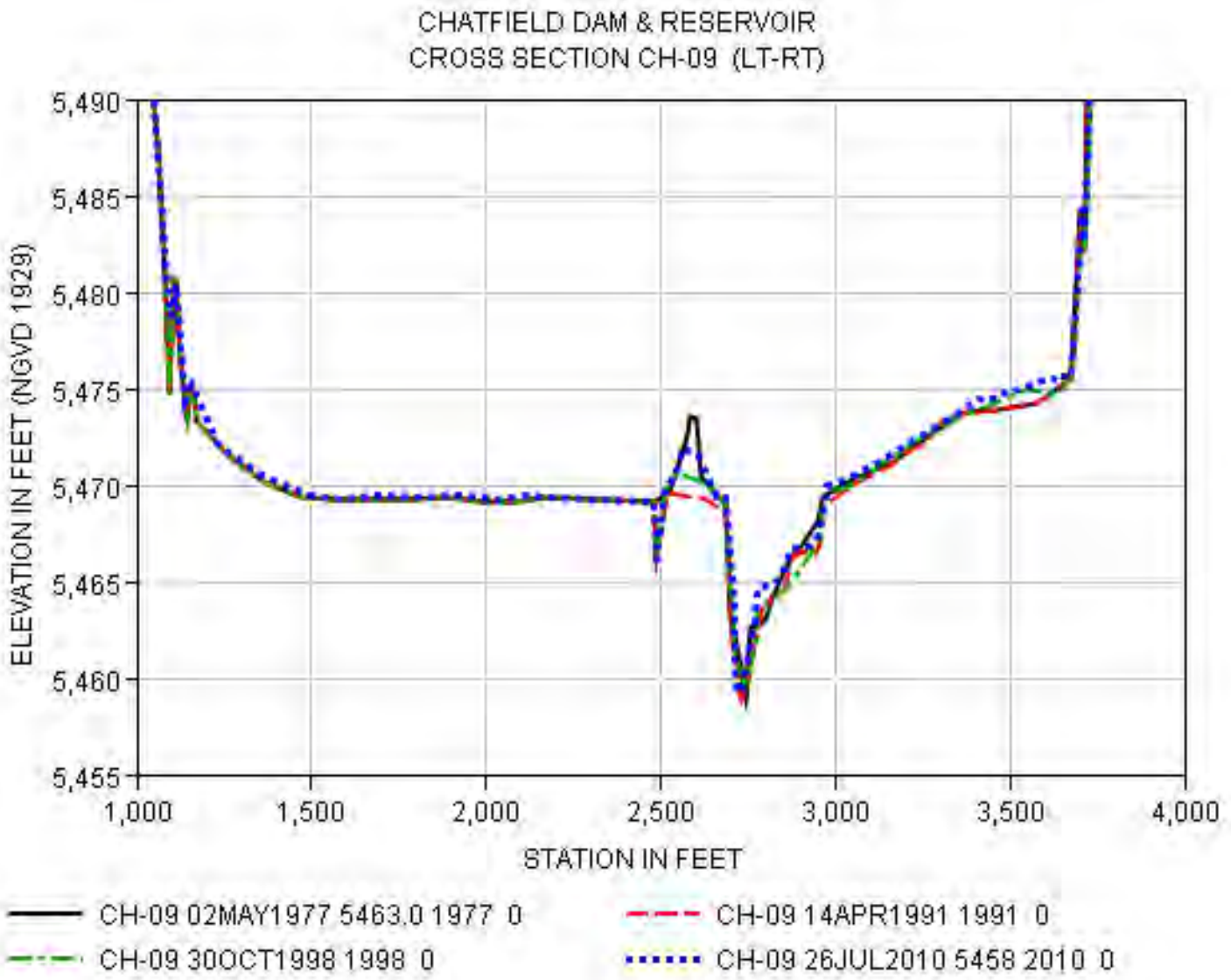
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-17. Sediment Range Line CH-07 Cross Section



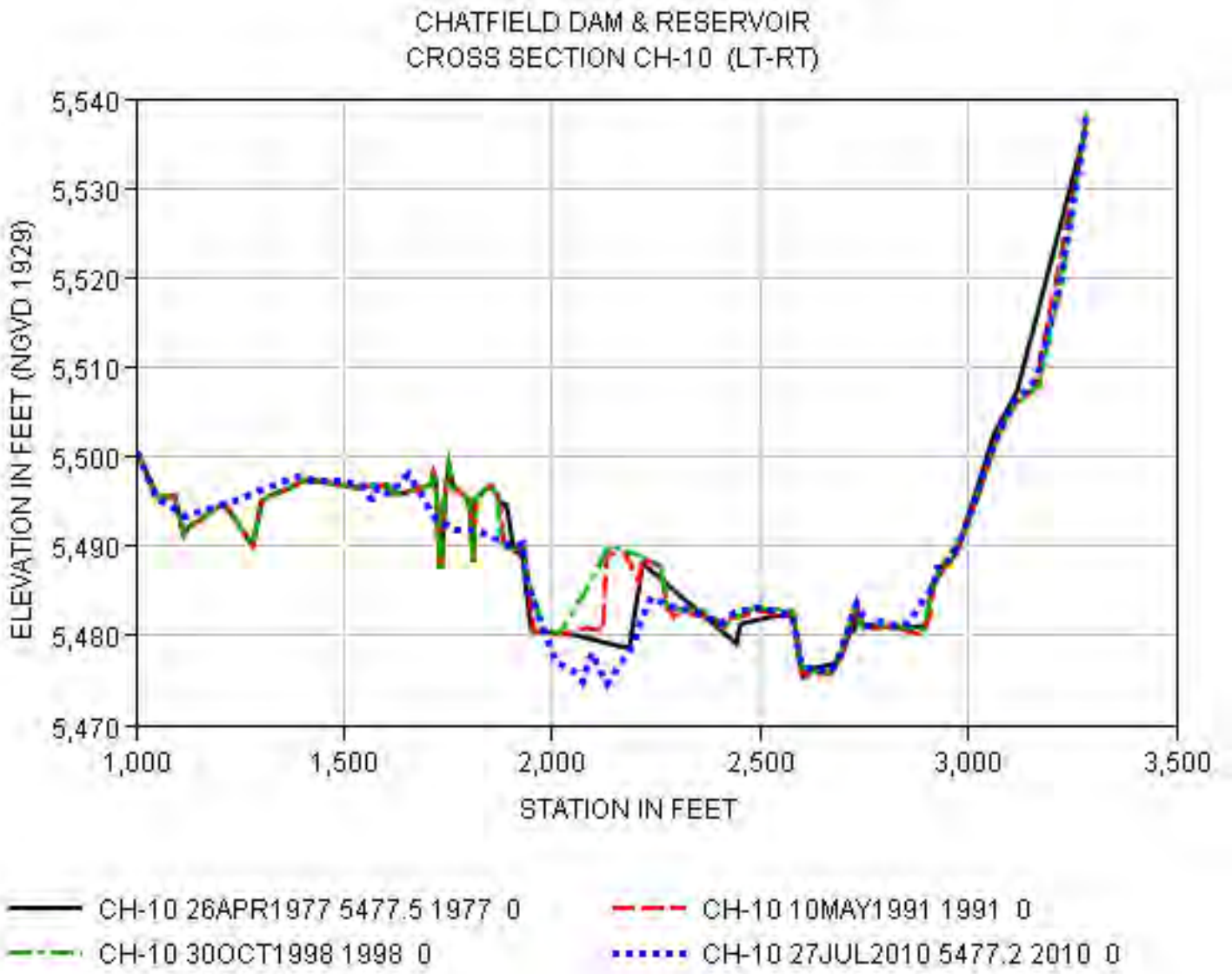
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-18. Sediment Range Line CH-08 Cross Section



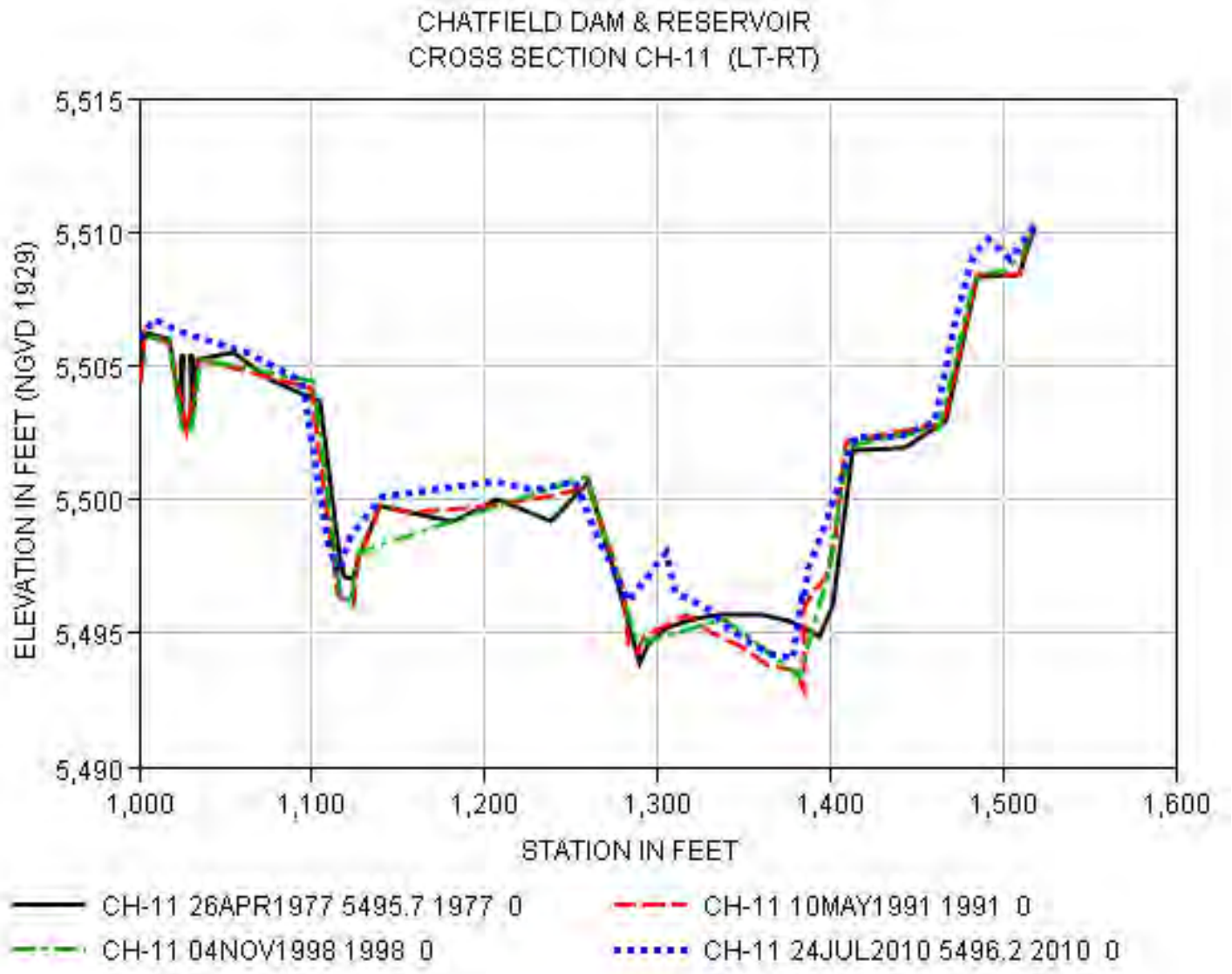
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-19. Sediment Range Line CH-09 Cross Section



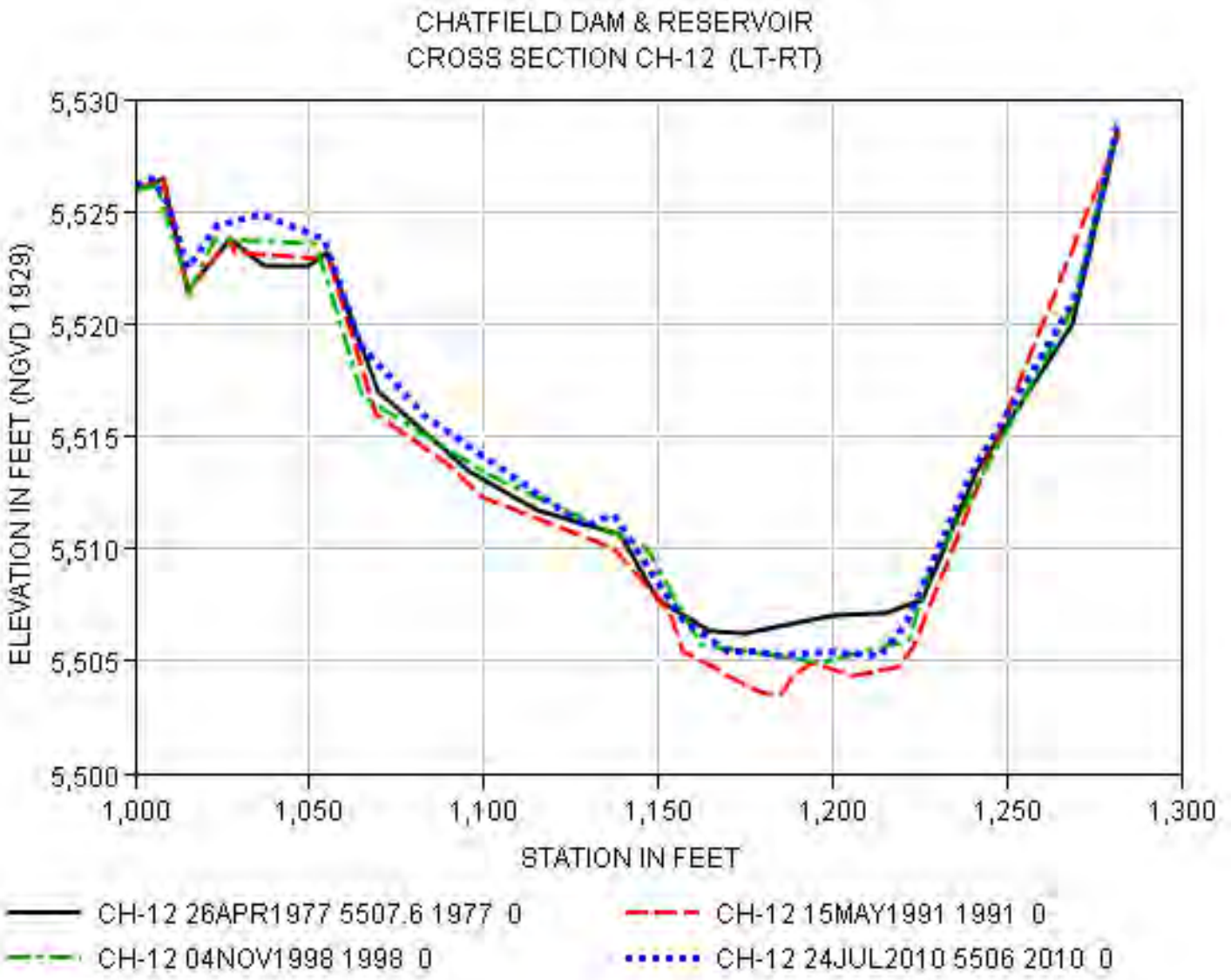
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-20. Sediment Range Line CH-10 Cross Section



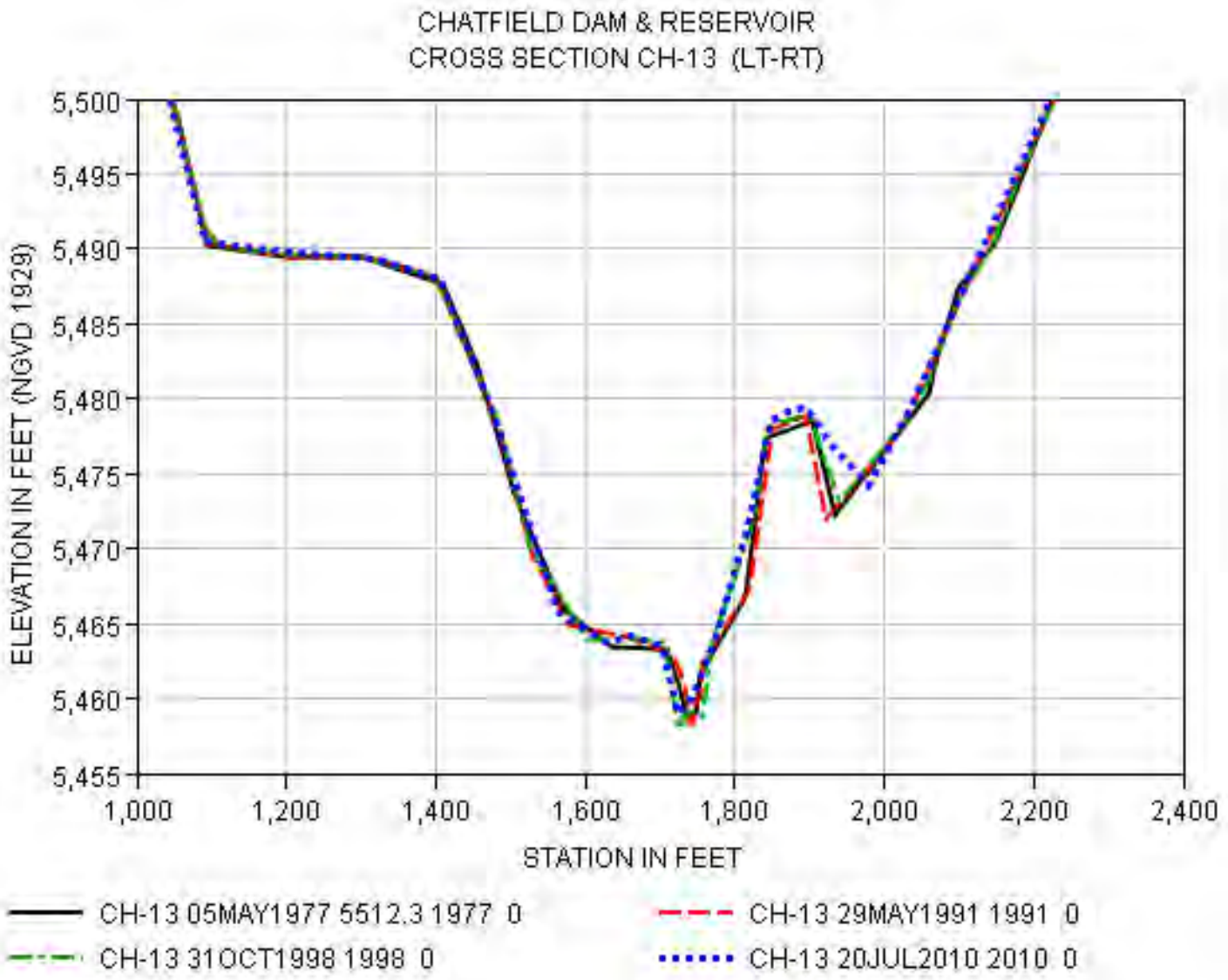
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-21. Sediment Range Line CH-11 Cross Section



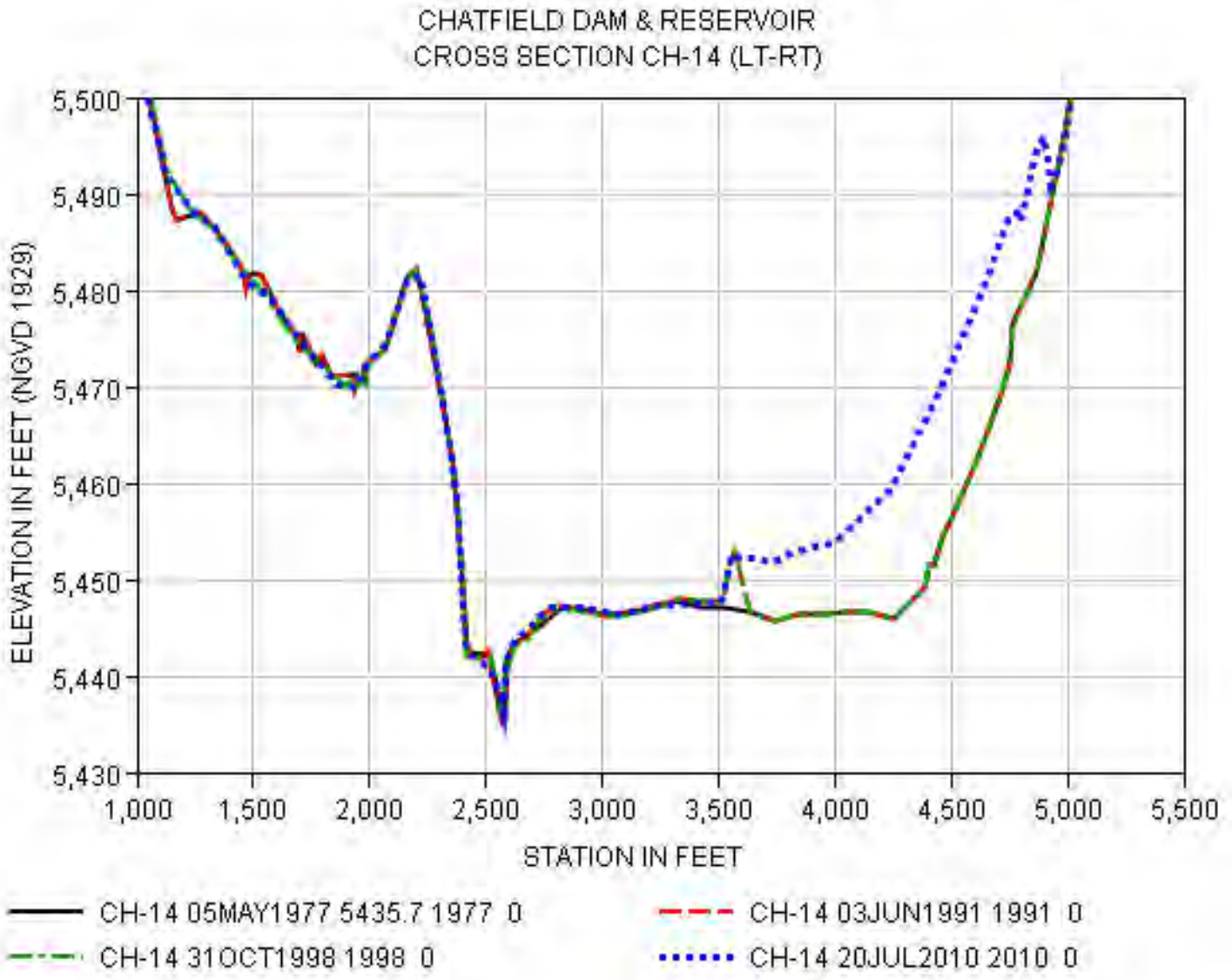
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-22. Sediment Range Line CH-12 Cross Section



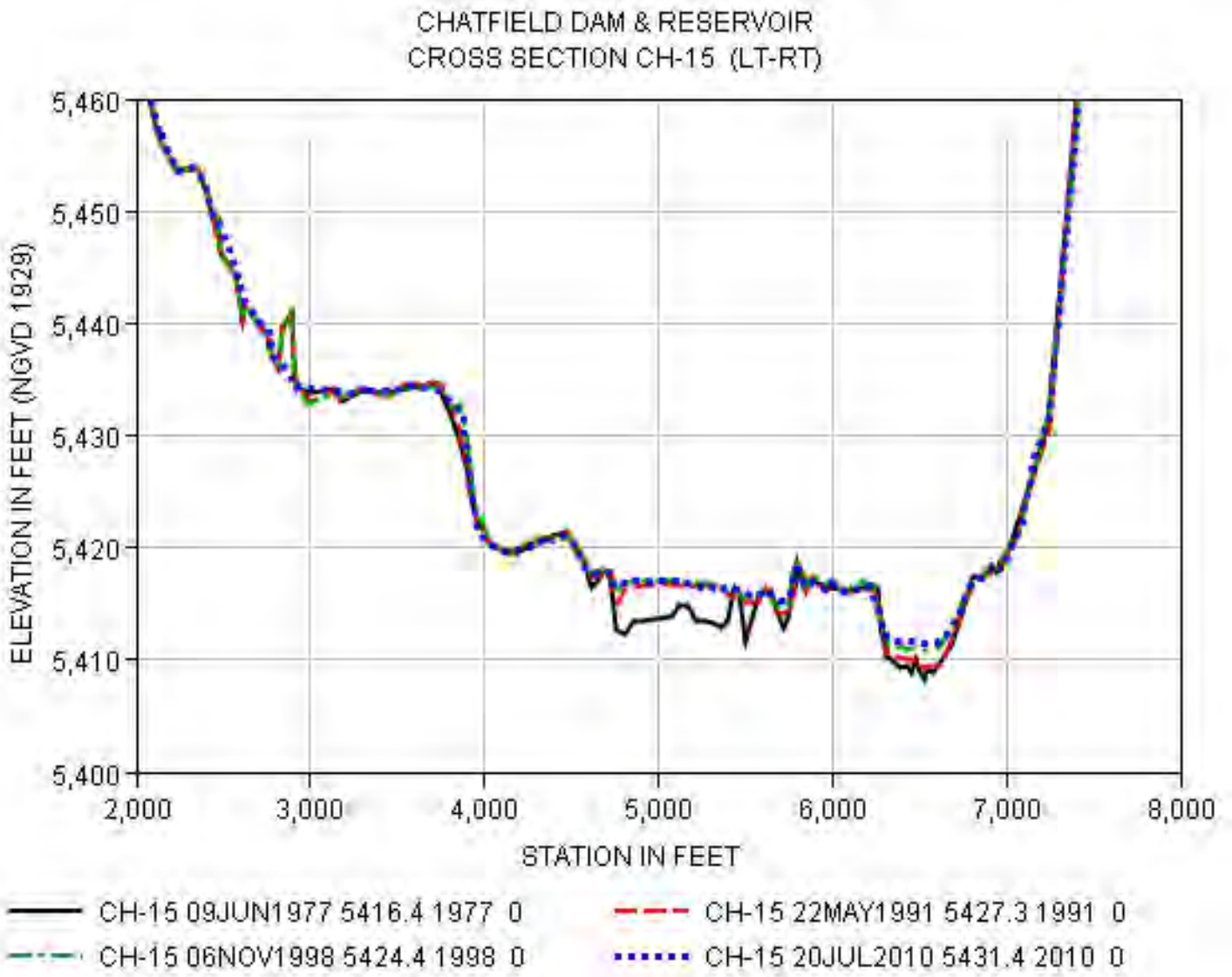
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-23. Sediment Range Line CH-13 Cross Section



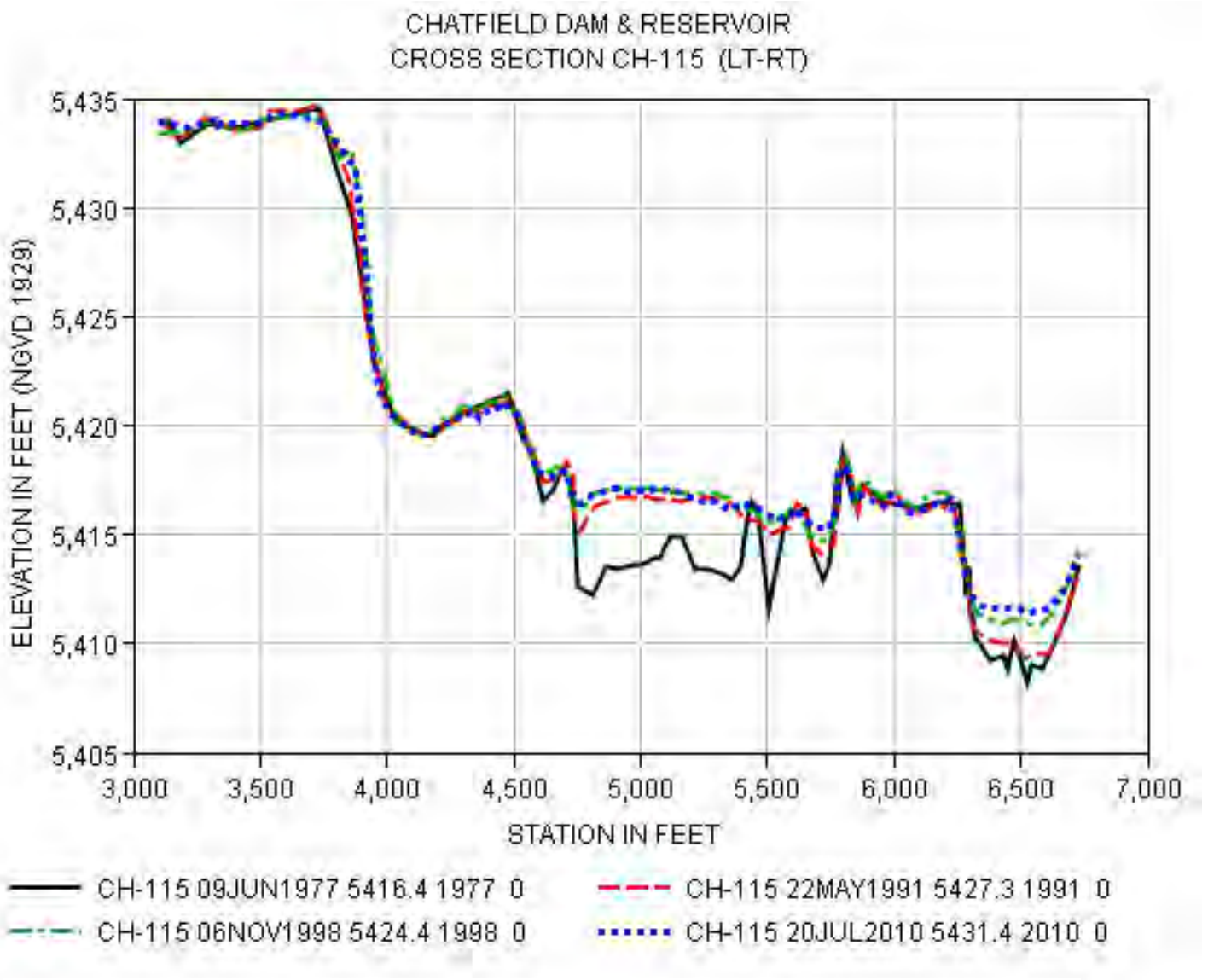
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-24. Sediment Range Line CH-14 Cross Section



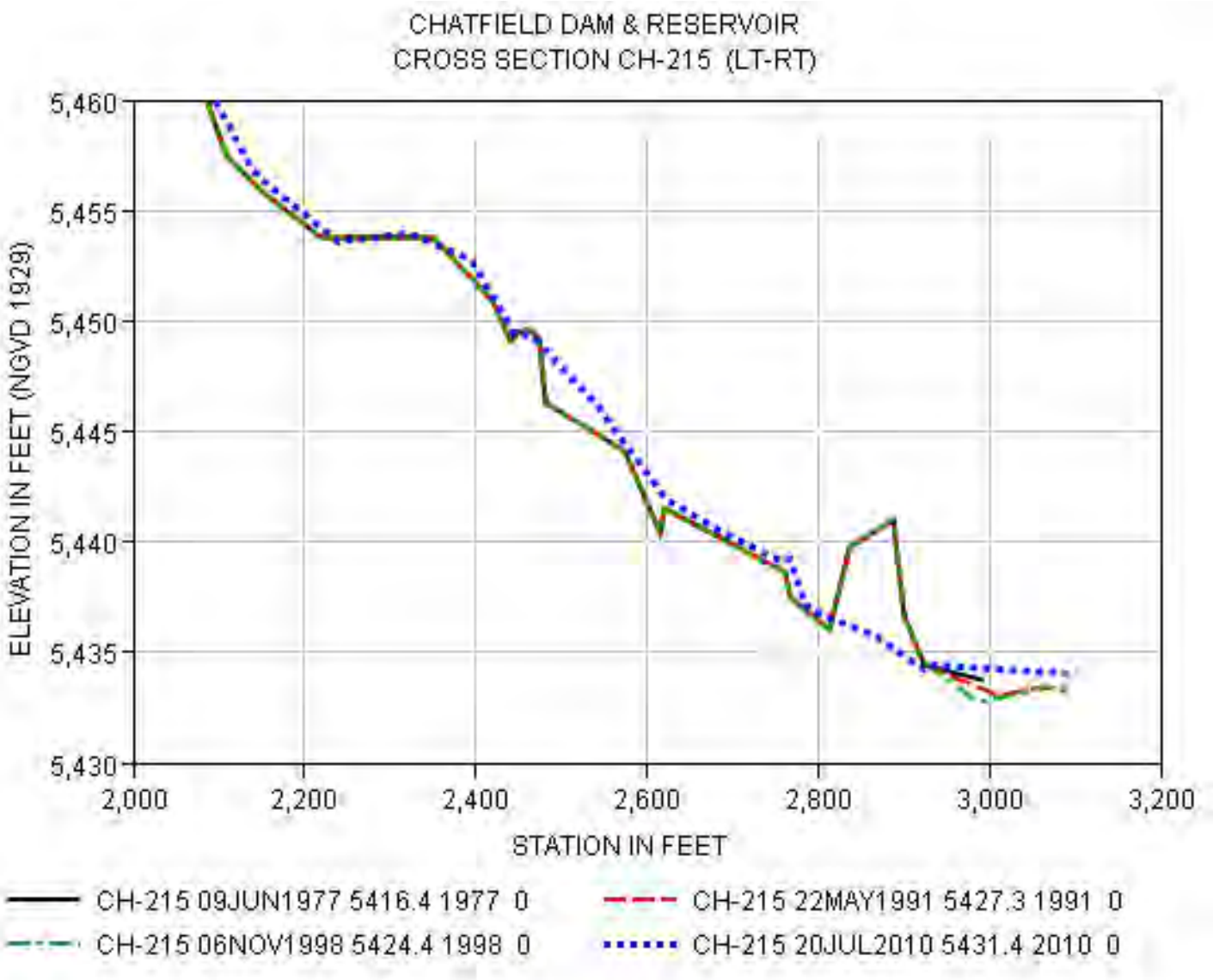
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-25. Sediment Range Line CH-15 Cross Section



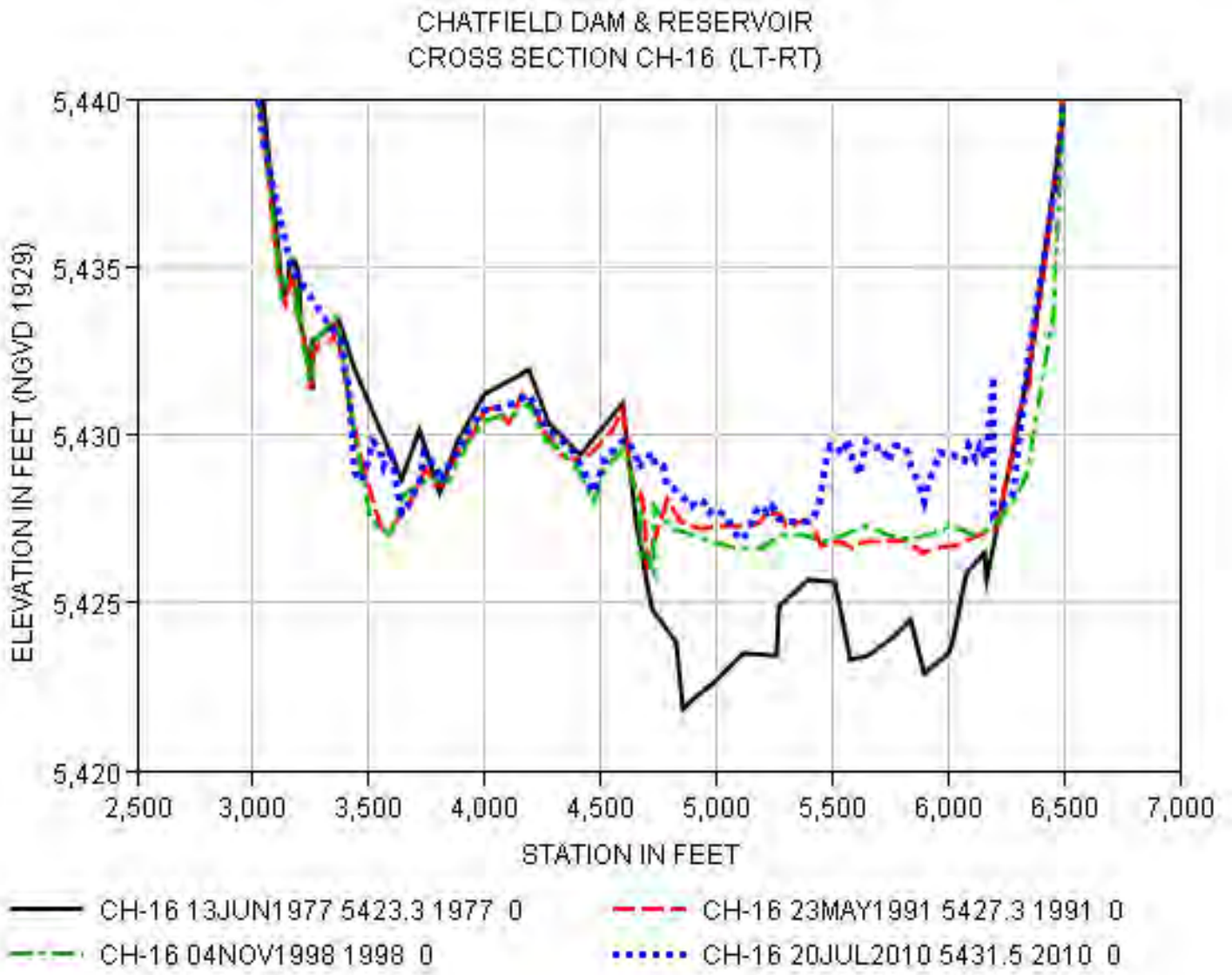
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-26. Cross Section CH-115, Part of Sediment Range Line CH-15 for Segment Calculations



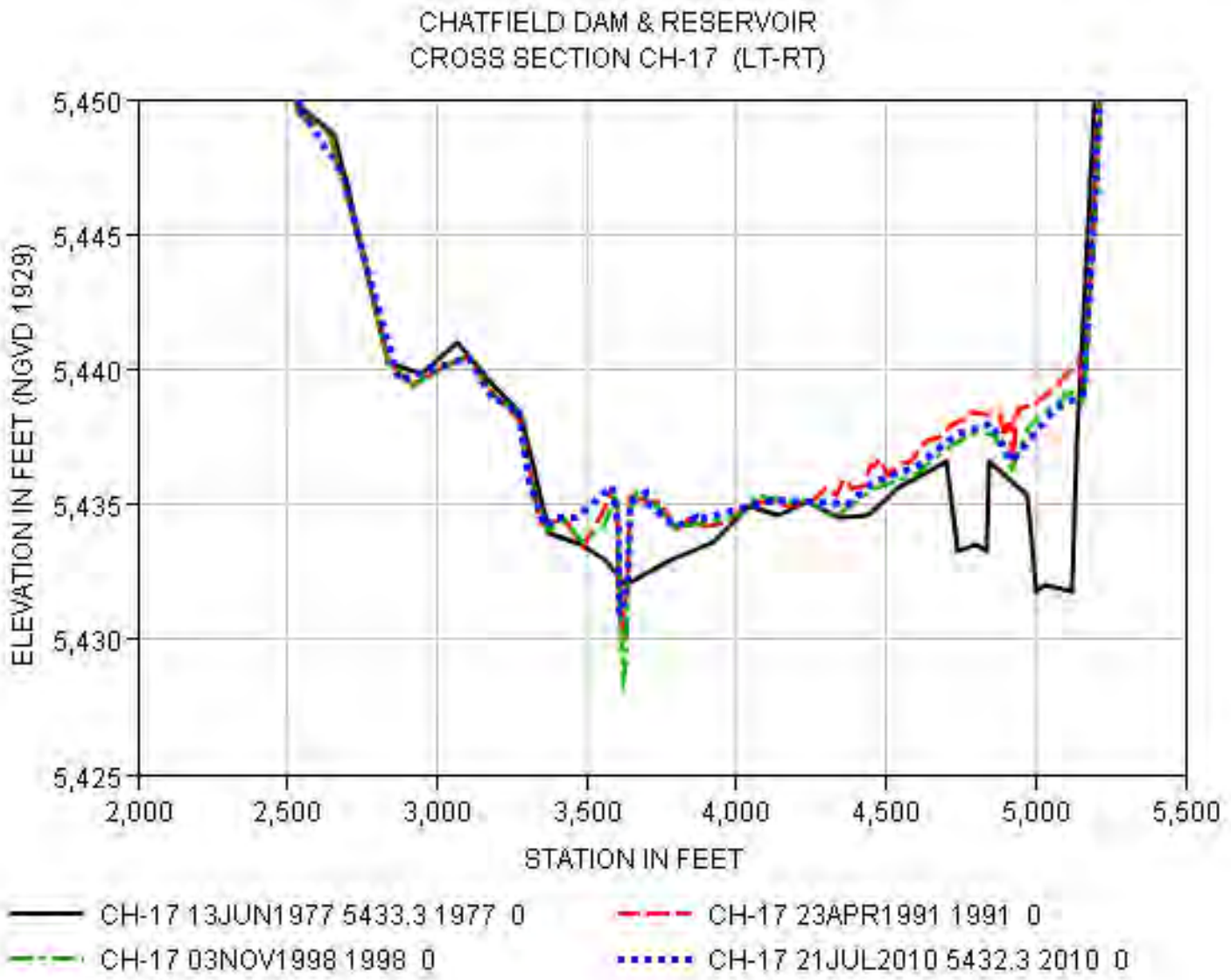
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-27. Cross Section CH-215, Part of Sediment Range Line CH-15 for Segment Calculations



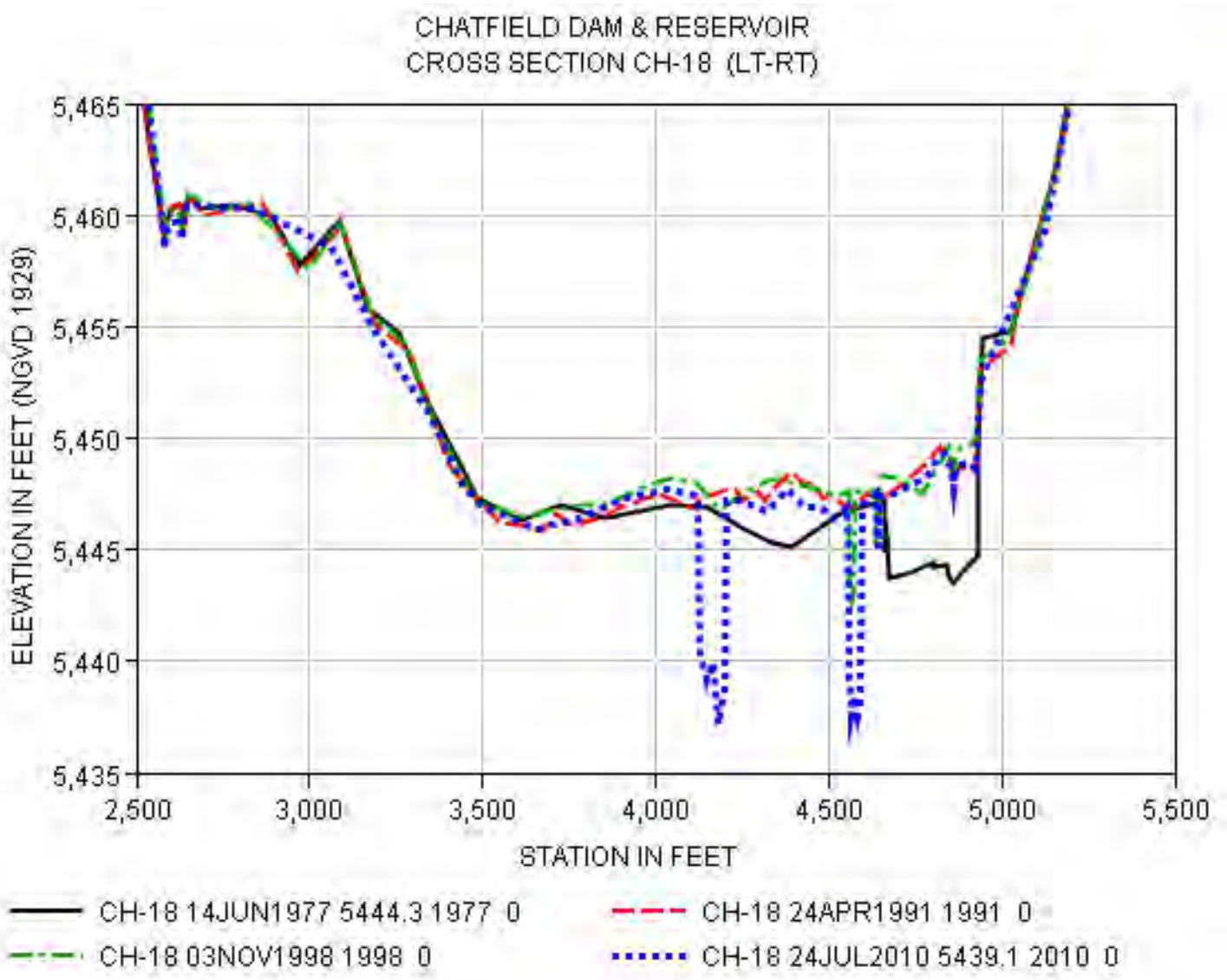
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-28. Sediment Range Line CH-16 Cross Section



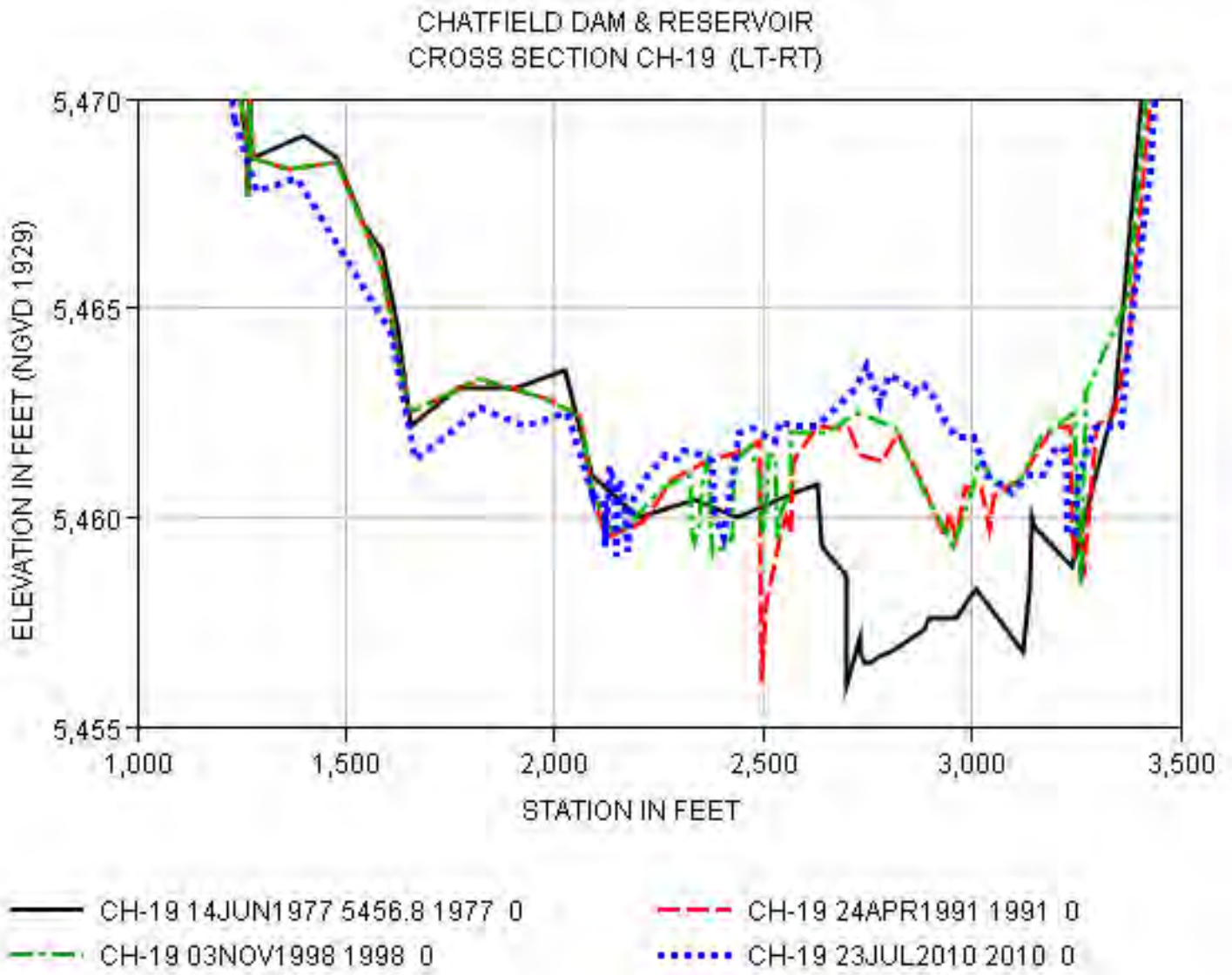
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-29. Sediment Range Line CH-17 Cross Section



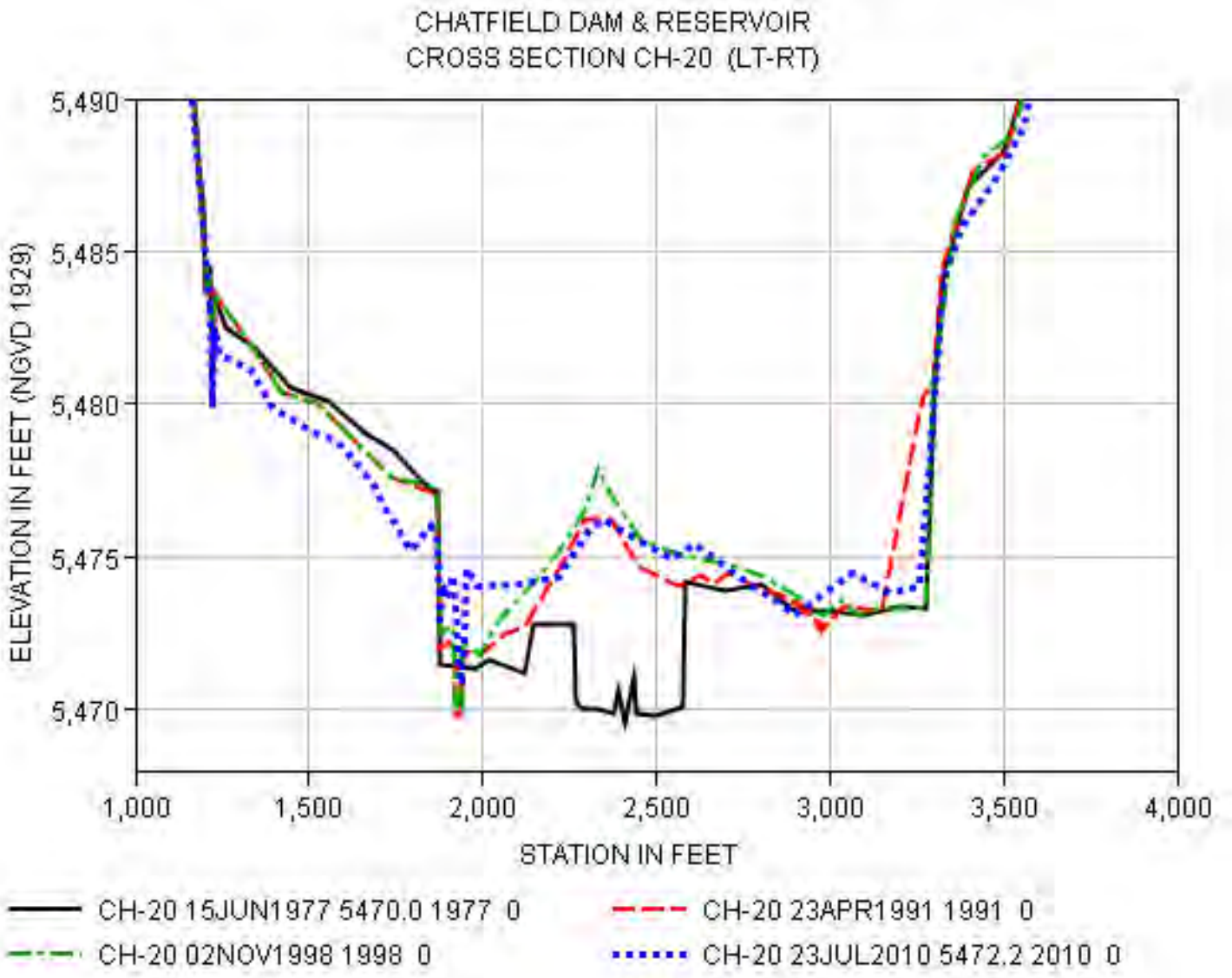
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-30. Sediment Range Line CH-18 Cross Section



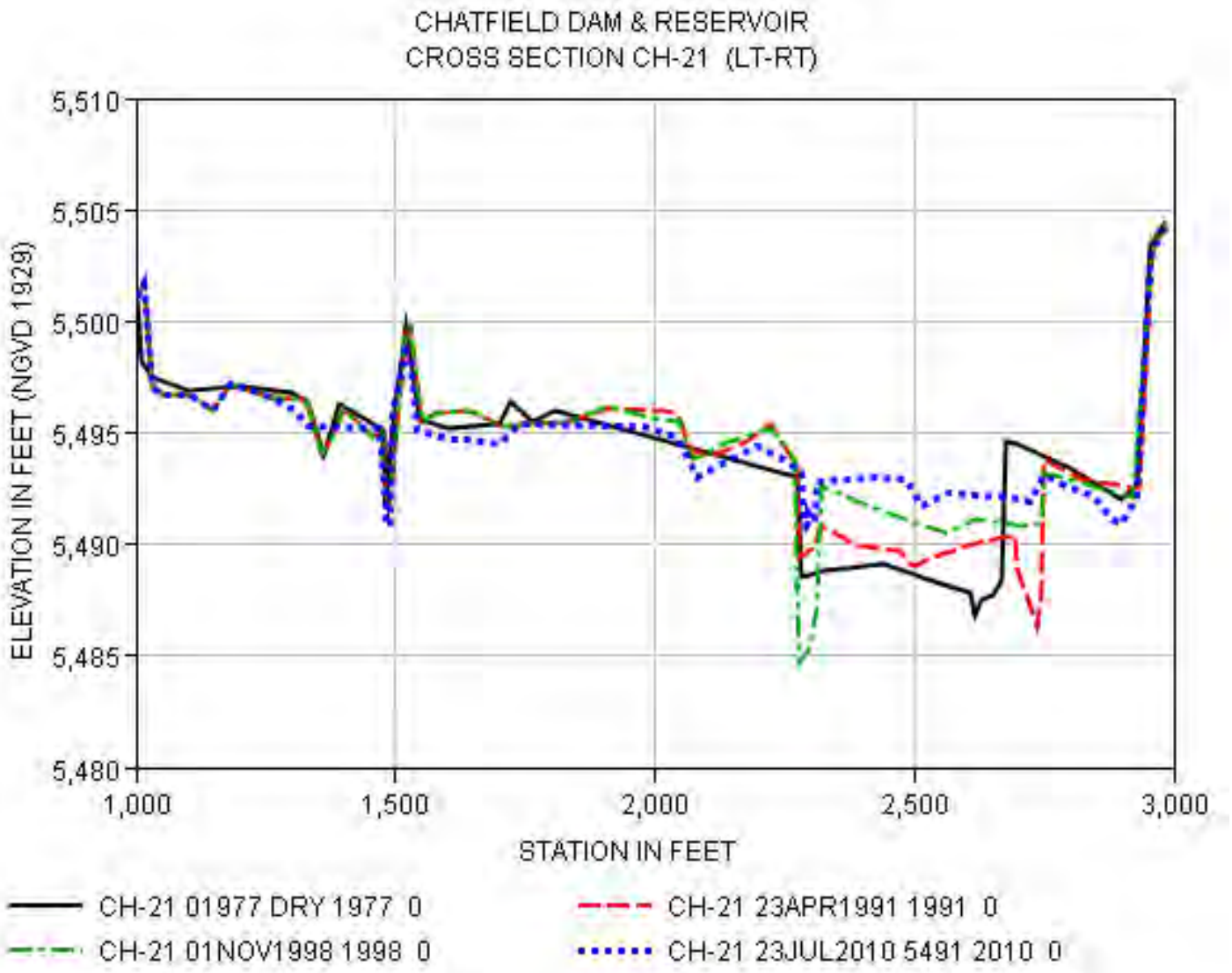
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-31. Sediment Range Line CH-19 Cross Section



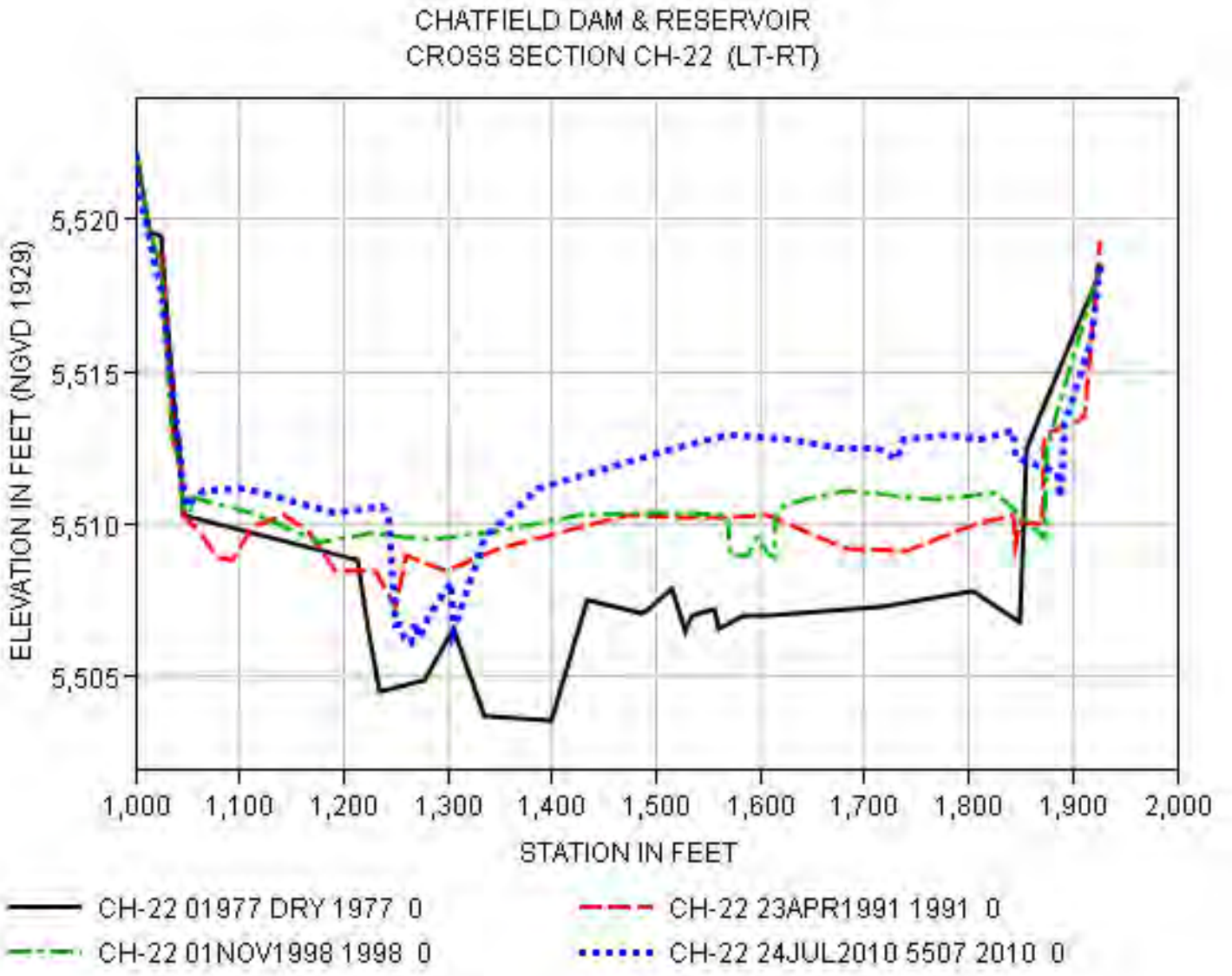
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-32. Sediment Range Line CH-20 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-33. Sediment Range Line CH-21 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 4-34. Sediment Range Line CH-22 Cross Section

5 Cherry Creek Lake

5.1 Background

Cherry Creek Lake is located in Arapahoe County approximately 10 miles southeast of Denver, Colorado. A map of Cherry Creek Lake, including its sediment range lines, is shown in Figure 5-1. Cherry Creek Dam is a rolled earth dam 14,300 feet long and 141 feet high containing 13,000,000 cubic yards of fill material. Cherry Creek Lake was closed in October 1948. The lake is 1.5 miles long with five miles of shoreline at the multipurpose pool elevation of 5550.0 feet and covers approximately 850 acres. The original estimated long term average annual depletion rate for the lake was 151 acre-feet.

The extents of the sediment range lines for the original overbank survey, completed in 1950, extended beyond the project boundary in some places which have since been developed. These outer edges of the range lines have not been surveyed again in subsequent survey trips and the 1950 data was used to extend the lines for the area-capacity programs to reach comparable elevations. *Due to the data repetition, the data are not reflective of all changes above the multipurpose pool, elevation 5550.0, and are not reported in the tables and figures of this section. However, they are included in the area-capacity tables in Appendix D.* Surveys of range lines CC-09 through CC-13 extend above the flood control pool, elevation 5598.0, and several are also above the surcharge pool, elevation 5598.0, accurately capturing changes since 1950. Surveys of range lines CC-01 through CC-08, where the bulk of the storage capacity is located, only extend to an elevation within the flood control pool, but do not represent it entirely.

5.2 LiDAR Comparison Study

A detailed Cherry Creek basin survey was performed using LiDAR mapping, which extended to a higher elevation and covered a larger area than the range line surveys. The LiDAR data was provided to the Sedimentation and Channel Stabilization Section for comparison to the range line surveys. This data provided an opportunity to compare the traditional methods of data collection and area and capacity calculations to alternative methods using more modern technologies. The study is included in Appendix G and produces similar results using both methods.

5.3 Surface Area

Figure 5-2 is a plot of elevation versus surface area for all survey years. Table 5-1 shows the reservoir surface area by elevation. The surface area at the top of the Cherry Creek multipurpose pool (5550.0 feet) decreased by 46 acres between 1950 and 2009. Shoreline erosion increases the surface area while delta growth decreases the surface area of the lake. The decrease in this case is likely due to delta growth at the multipurpose level.

Table 5-1. Reservoir Surface Area by Elevation for Cherry Creek Lake

		Surface Area (acres)					
Storage Pool	**Top of Pool Elevation**	**1950**	**1961**	**1965**	**1974**	**1988**	**2009**
Flood Control	5598.0	2,640	*	*	*	*	*
Multipurpose	5550.0	886	872	856	851	847	840

*Survey data did not reach this elevation.

5.4 Capacity Changes

Plate 5-3 is a plot of the elevation versus reservoir capacity curve for all survey years. Table 5-2 presents the reservoir capacity by storage pool and Table 5-3 presents the rate of change by elevation. Due to the survey data limitations previously described, a qualitative assessment was made of the change in capacity of the reservoir. Gross storage (elevation 5504.0 – 5645.0 feet) decreased an estimated two percent between 1950 and 2009. The flood control pool (elevation 5550.0 – 5598.0 feet) storage also decreased an estimated two percent. Storage in the multipurpose pool (elevation 5504.0 – 5550.0 feet) decreased approximately 2,600 acre-feet (17%) between 1950 and 2009 using the composite data from 2006, 2007 and 2009. There is not a designated inactive pool for Cherry Creek Lake.

The storage depletion rate up to the multipurpose pool between survey years 1950 and 2009 is 44.0 acre-feet per year. The original projected depletion rate for the gross storage was 151 acre-feet per year. The original projected depletion rate was made with limited data at the time the dam was constructed. Lower than predicted deposition is most likely attributable to the data limitations for the original prediction and lower sediment inflow rates during the late 1970's and early 1980's.

Table 5-2. Cherry Creek Lake - Reservoir Storage Capacity by Storage Pool

Storage Pool	Reservoir Capacity (ac-ft)					
	1950	1961	1965	1974	1988	2009[2]
Surcharge 5645.0[1] - 5598.0	152,525	*	*	*	*	*
Flood Control 5598.0 - 5550.0	80,638	*	*	*	*	*
Multipurpose 5550.0 - 5504.0	15,155	14,585	13,941	13,220	12,805	12,558
Gross Storage 5645.0[1] - 5504.0	**248,318**	*	*	*	*	*

Storage Pool	Change in Reservoir Capacity (ac-ft)						Depletion Rate (ac-ft/yr)	Percent Lost per Year
	1950-1961	1961-1965	1965-1974	1974-1988	1988-2009[2]	1950-2009	1950-2009	1950-2009
Surcharge 5645.0[1] - 5598.0	*	*	*	*	*	*	*	*
Flood Control 5598.0 - 5550.0	*	*	*	*	*	*	*	*
Multipurpose 5550.0 - 5504.0	-570	-644	-721	-415	-247	-2,597	-44.0	-0.29%
Gross Storage 5645.0[1] - 5504.0	*	*	*	*	*	*	*	*

Note: Cherry Creek elevations are reported in local project vertical datum.

*Survey data did not reach this elevation.

[1]The Hydrological Improvement Assessment for Cherry Creek Reservoir updated the maximum pool elevation to 6545.0 which would overtop the dam. Capacity data only calculated to elevation 5640.0.

[2]The 2009 survey is a composite of data collected in 2006, 2007 and 2009.

Table 5-3. Cherry Creek Lake -Cumulative Reservoir Capacity Changes

Top of Pool	1950	1961			1965			1974		
	Capacity (ac-ft)	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original
Surcharge 5645.0[1]	248,318	*	*	*	*	*	*	*	*	*
Flood Control 5598.0	95,793	*	*	*	*	*	*	*	*	*
Multipurpose 5550.0	15,155	14,585	-51.8	96.2%	13,941	-80.9	92.0%	13,220	-80.6	87.2%

Top of Pool	1950	1988			2009[2]		
	Capacity (ac-ft)	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original	Capacity (ac-ft)	Rate (ac-ft/yr)	Percent of Original
Surcharge 5645.0[1]	248,318	*	*	*	*	*	*
Flood Control 5598.0	95,793	*	*	*	*	*	*
Multipurpose 5550.0	15,155	12,805	-61.8	84.5%	12,558	-44.0	82.9%

Note: All elevations are reported in local project vertical datum.

*Survey data did not reach this elevation.

[1]The Hydrological Improvement Assessment for Cherry Creek Reservoir updated the maximum pool elevation to 6545.0 which would overtop the dam. Capacity data only calculated to elevation 5640.0.

[2]The 2009 survey is a composite of data collected in 2006, 2007 and 2009.

5.5 Profile Plots

Figure 5-4 compares the average bed elevation of each survey year for both the flood control and multipurpose pool levels. Figures 5-5 compares the thalweg profile of the reservoir for each survey year. The deposition is greatest nearest to the dam showing over 19 feet of build up between 1950 and 2009.

5.6 Sediment Volume

Figure 5-6 represents the change in reservoir capacity below the multipurpose pool, elevation 5550.0, by segment from sedimentation and erosion between 1950 and 2009. The volume of sediment that deposited in the multipurpose pool between surveys is represented by the reservoir capacity depletion as shown in Table 5-4.

Table 5-4. Total Sediment Change and Capacity Depletion in Cherry Creek Lake Multipurpose Pool, below Elevation 5550.0

Survey Period	Total Sediment Aggradation or Capacity Depletion (ac-ft)	Rate of Change (ac-ft/yr)
1950-1961	570	51.8
1961-1965	644	161.0
1965-1974	721	80.1
1974-1988	415	29.6
1988-2009[1]	247	11.8
1950-2009[1]	**2,597**	**44.0**

[1]The 2009 survey is a composite of data collected in 2006, 2007, and 2009

5.7 Area-Capacity Tables

Area and capacity tables computed at 1.0-foot increments are located in Appendix D. The capacity tables computed at 0.01-foot increments are available from the USACE Omaha District Sedimentation and Channel Stabilization Section.

5.8 Cross Section Data

Cross sectional plots are shown in Figures 5-7 through 5-19. The plots do not show the entire surveyed cross section, only the lower portion where sedimentation is occurring is plotted to magnify the changes. Plots of the full cross sections are available from the USACE Omaha District Sedimentation and Channel Stabilization Section.

5.9 Engineering Form 1787 – Reservoir Sediment Data Summary

Engineering Form 1787, "Reservoir Sedimentation Data Summary" is presented in Appendix E. The purpose of this form is to provide a means for the uniform documentation of pertinent Cherry Creek Lake sedimentation data.

Figure 5-1. Cherry Creek Lake with Sediment Range Line Locations

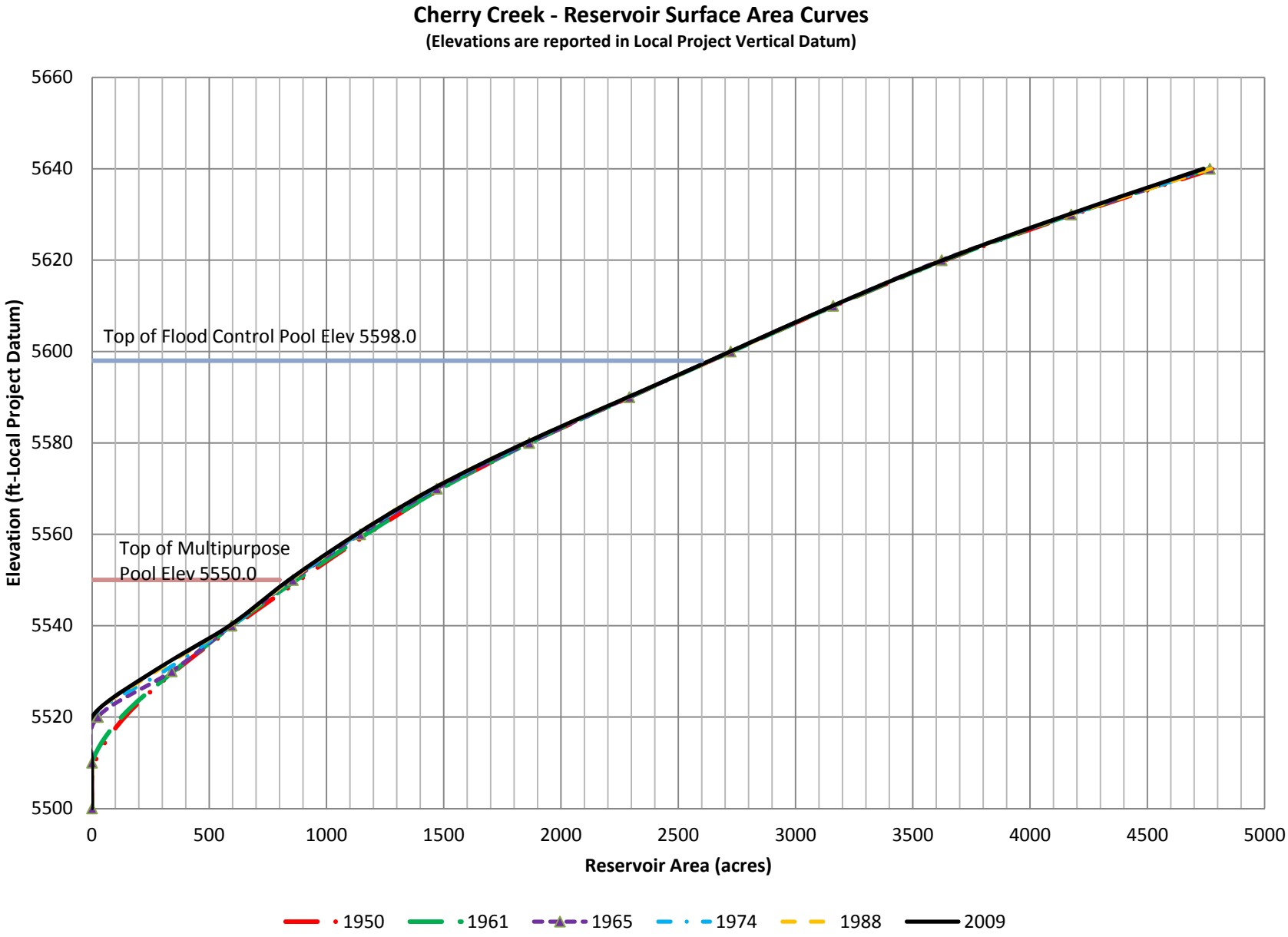


Figure 5-2. Cherry Creek Lake – Reservoir Surface Area Curves

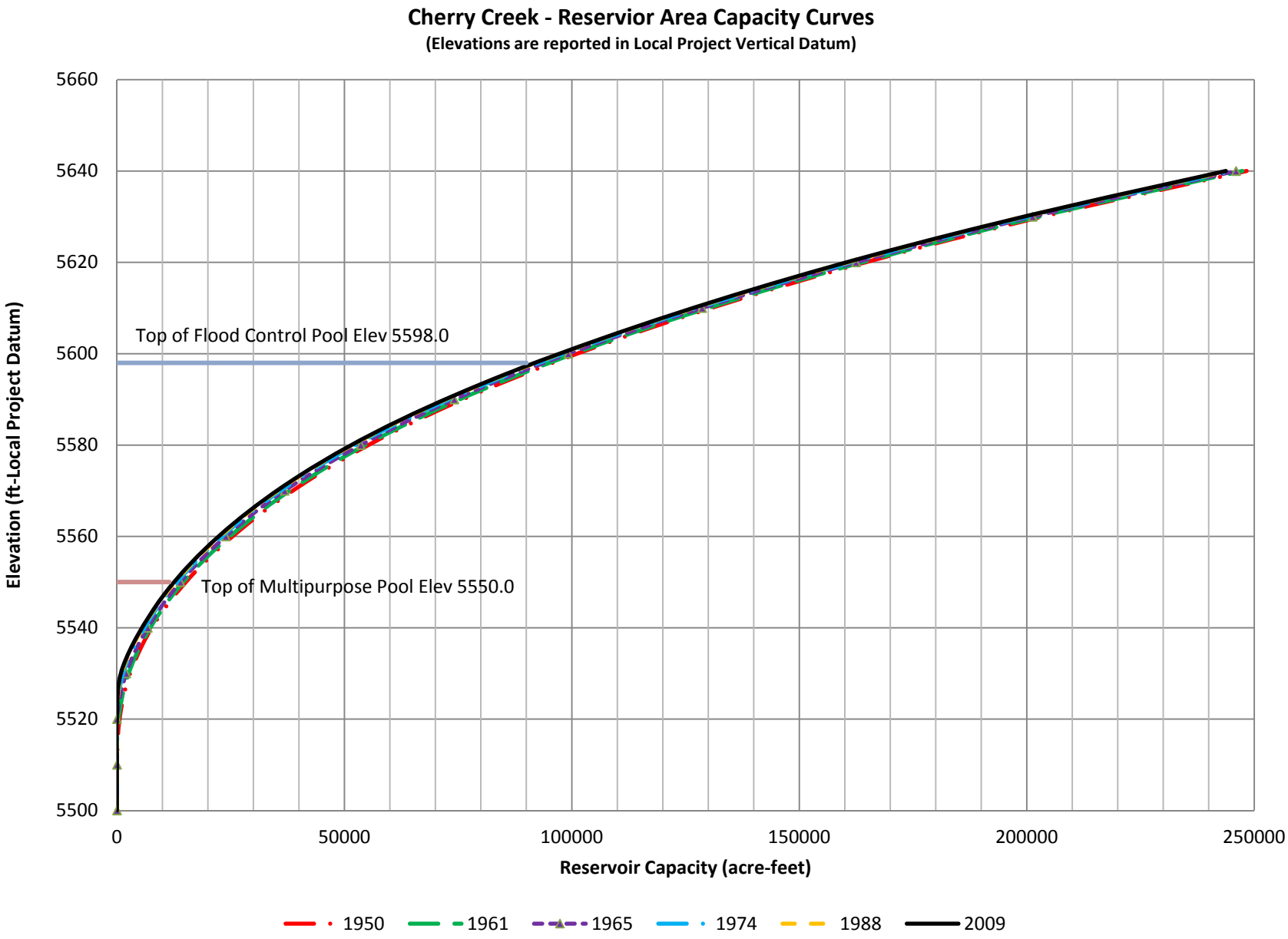


Figure 5-3. Cherry Creek Lake – Reservoir Area Capacity Curves

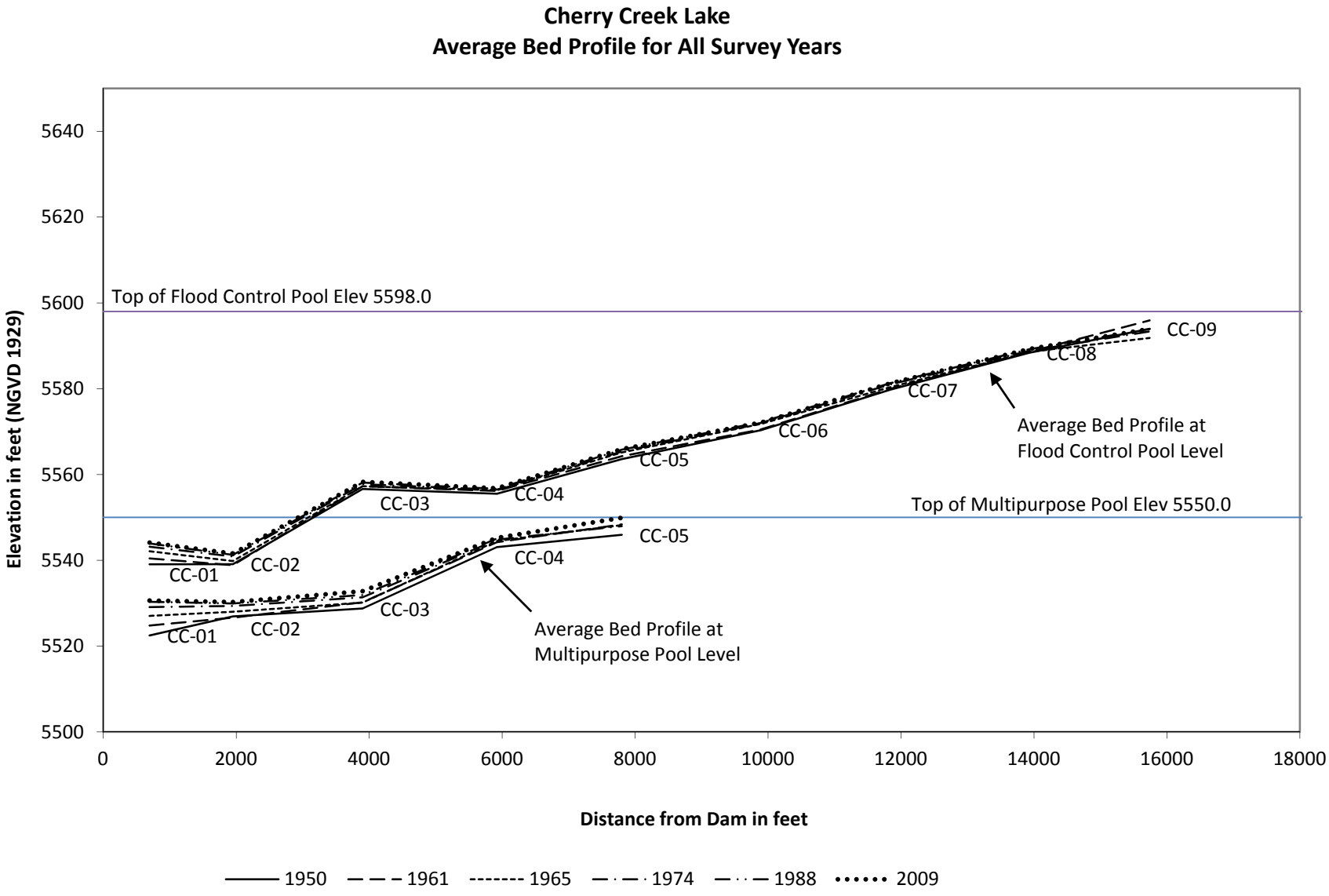


Figure 5-4. Cherry Creek Lake - Average Bed Profiles for the Flood Control Pool and Multipurpose Pool

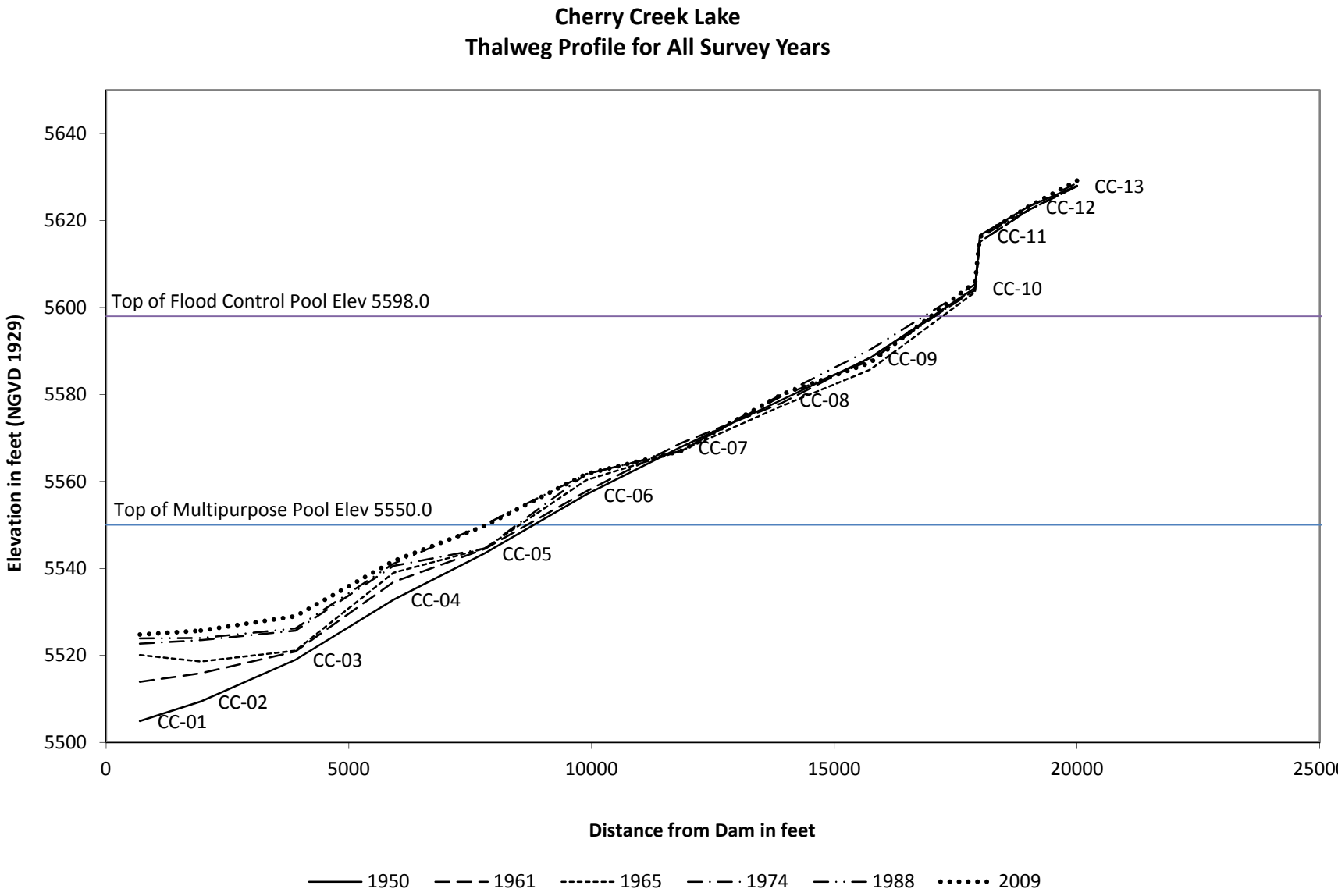
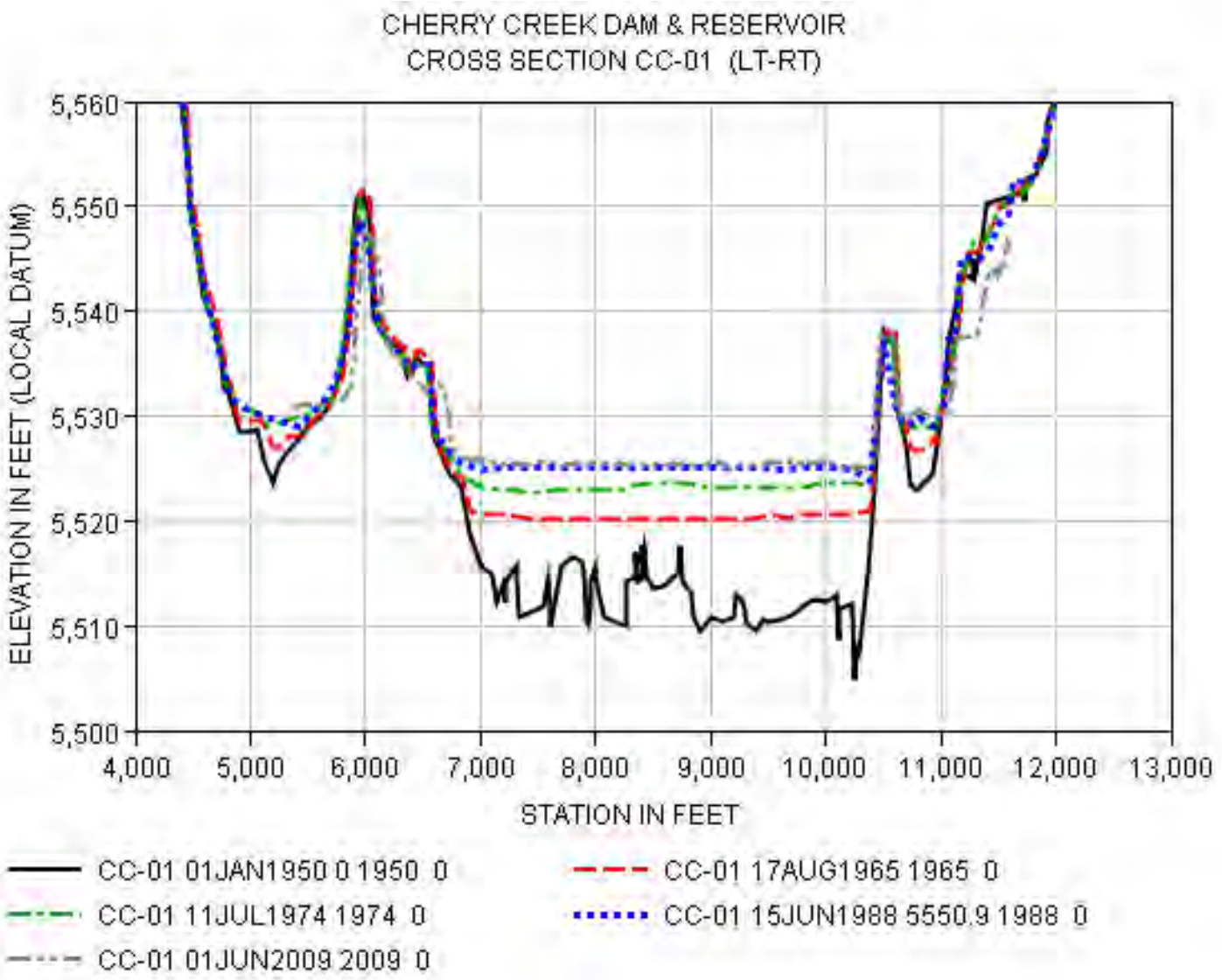


Figure 5-5. Cherry Creek Lake - Thalweg Profiles

Figure 5-6. Change in Multipurpose Pool Capacity by Segment of Cherry Creek Lake

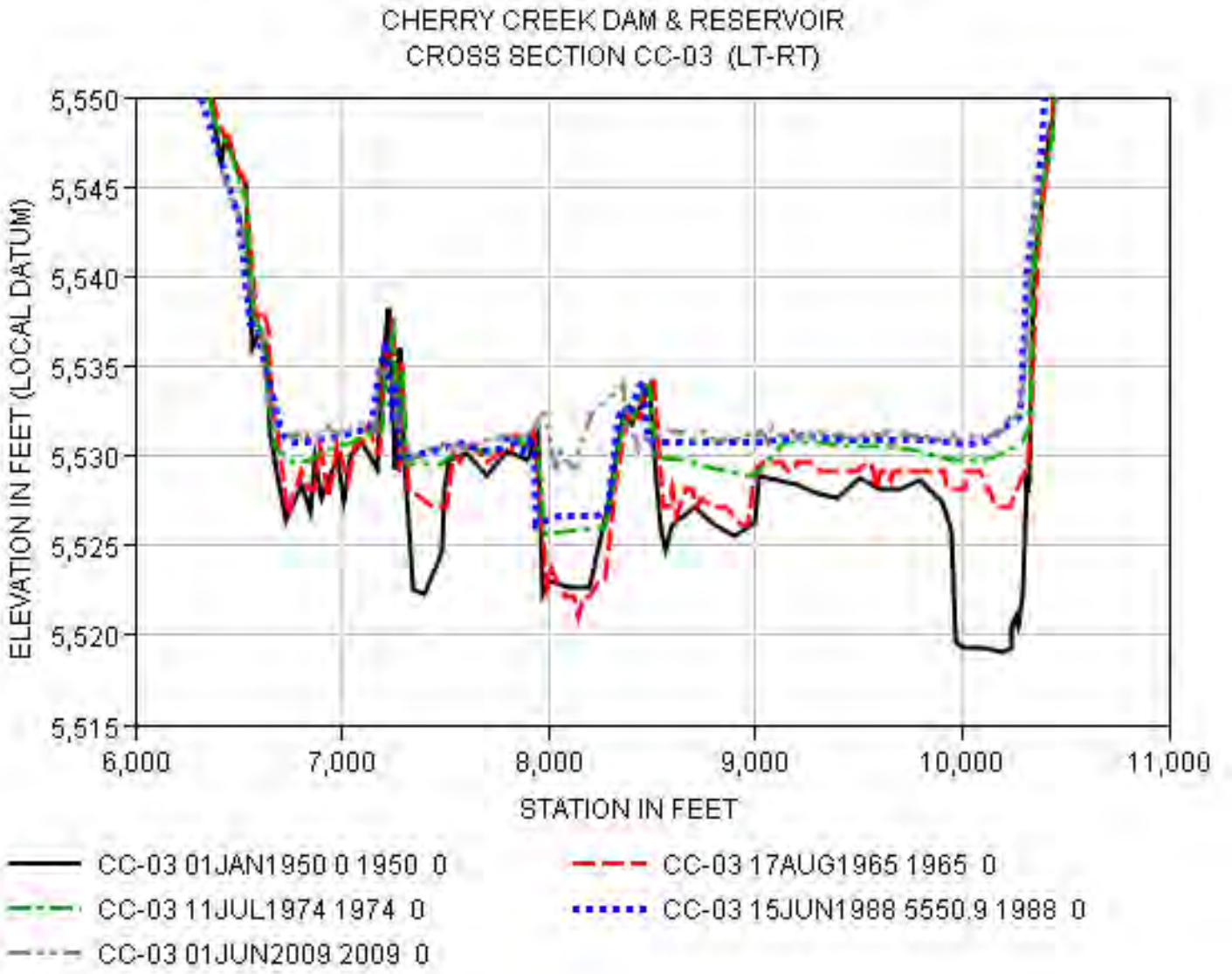


Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-7. Sediment Range Line CC-01 Cross Section

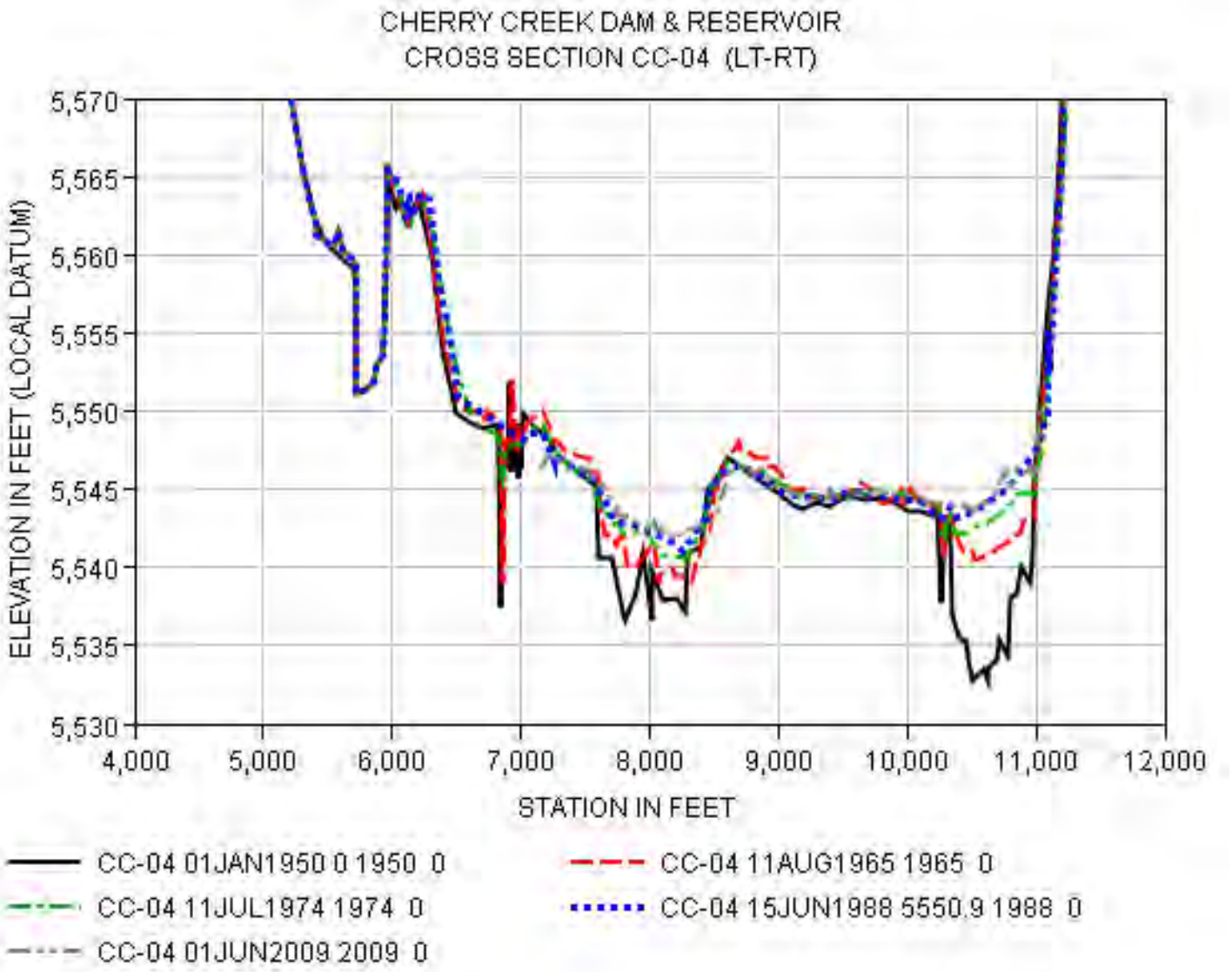
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-8. Sediment Range Line CC-02 Cross Section



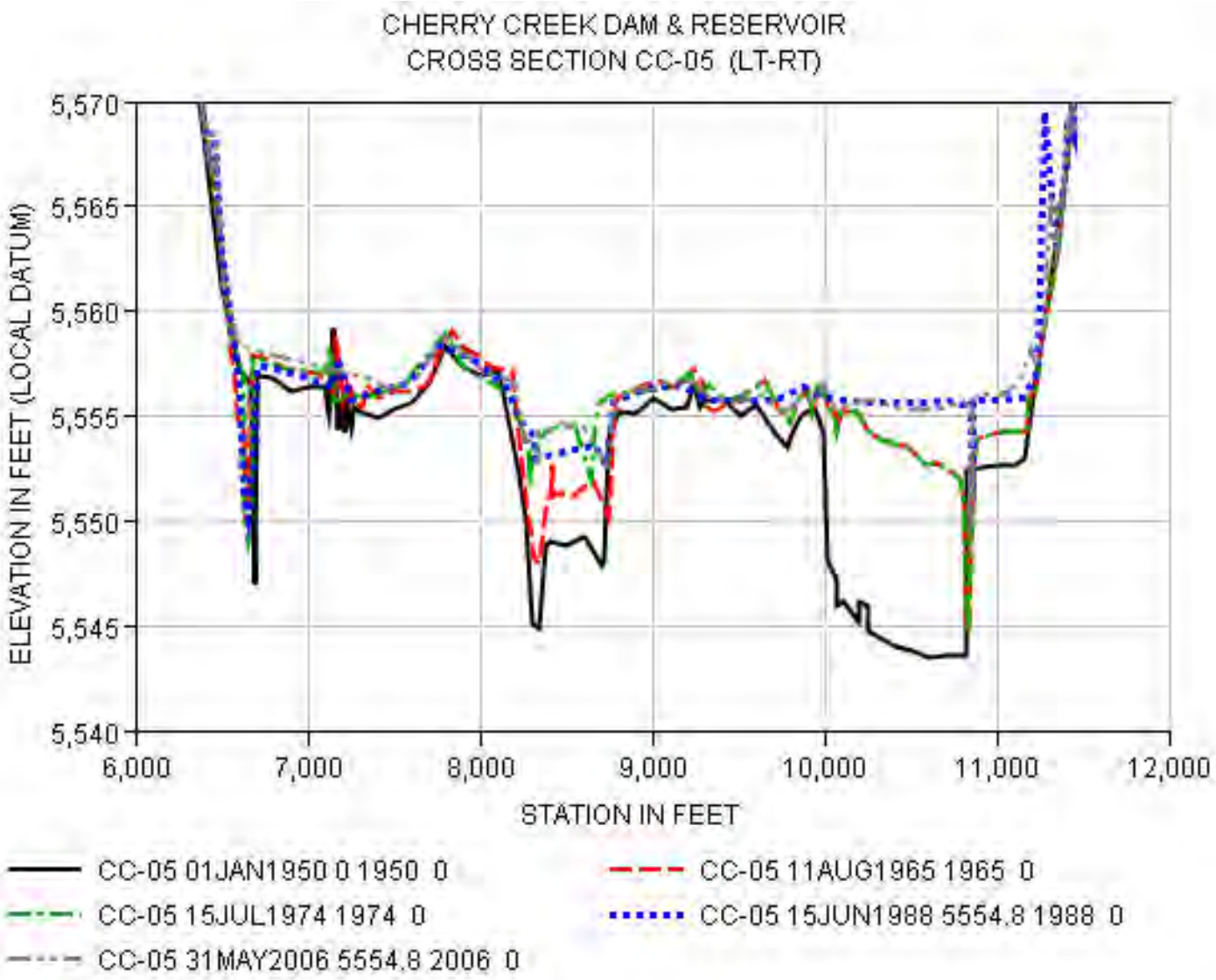
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-9. Sediment Range Line CC-03 Cross Section



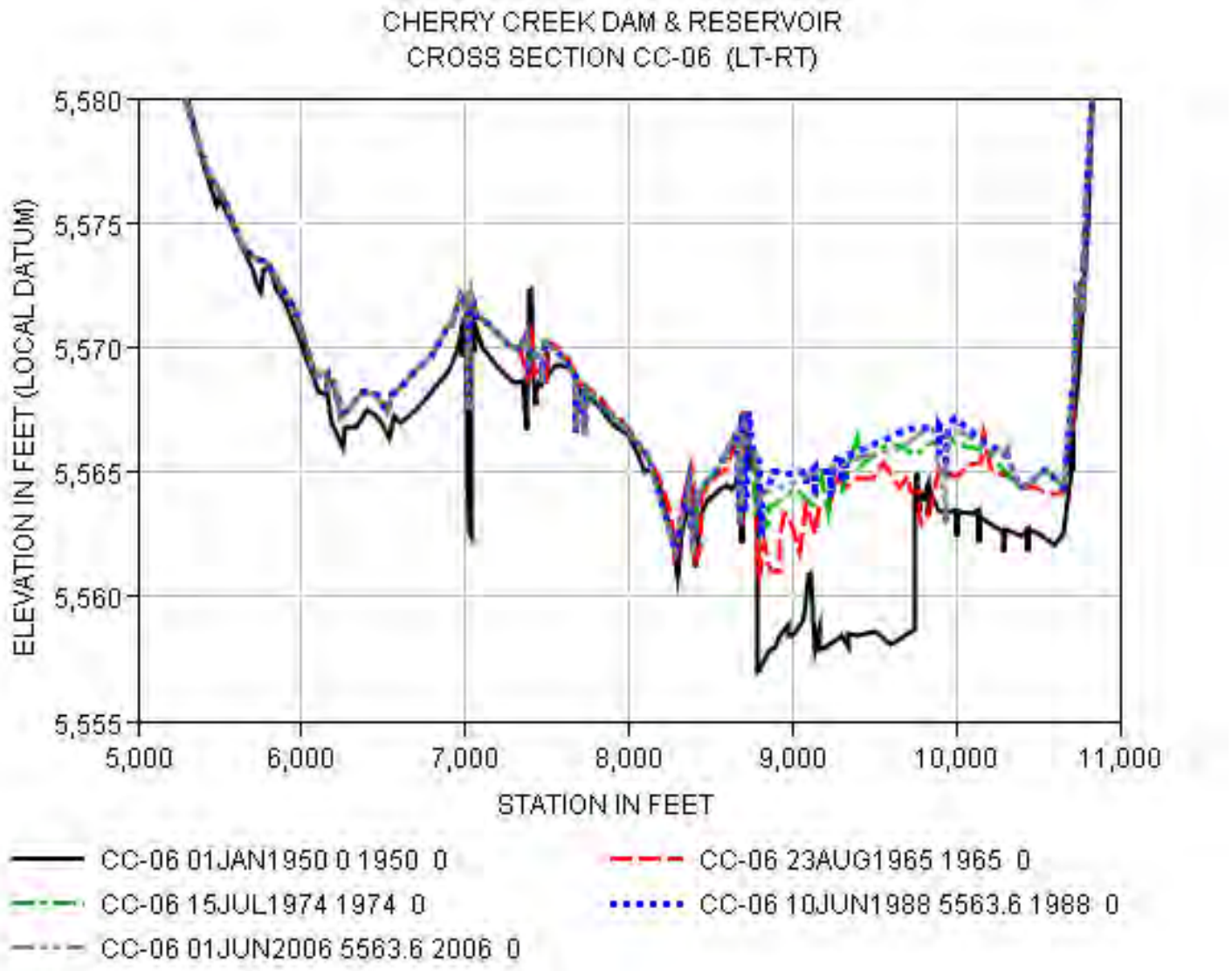
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-10. Sediment Range Line CC-04 Cross Section



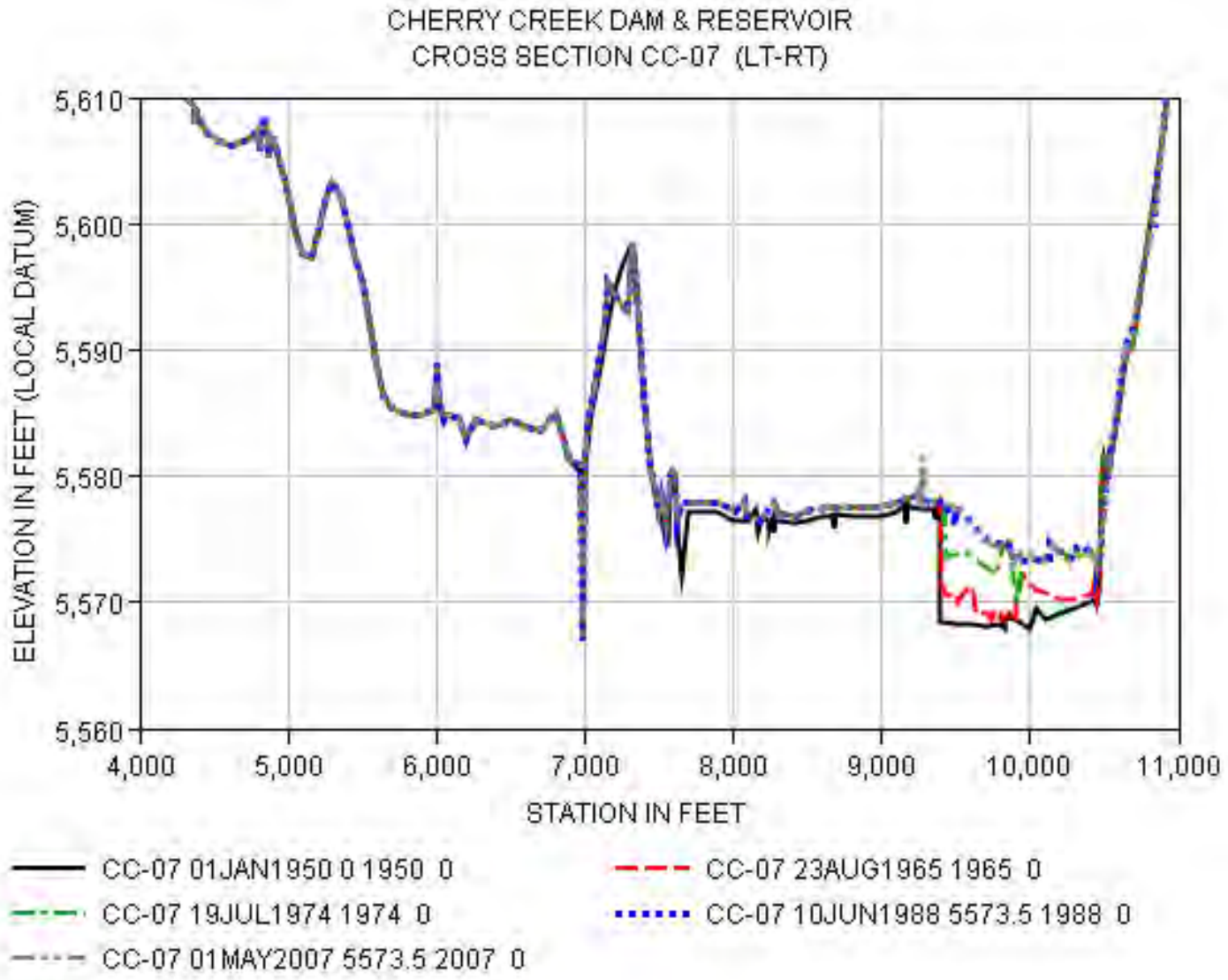
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-11. Sediment Range Line CC-05 Cross Section



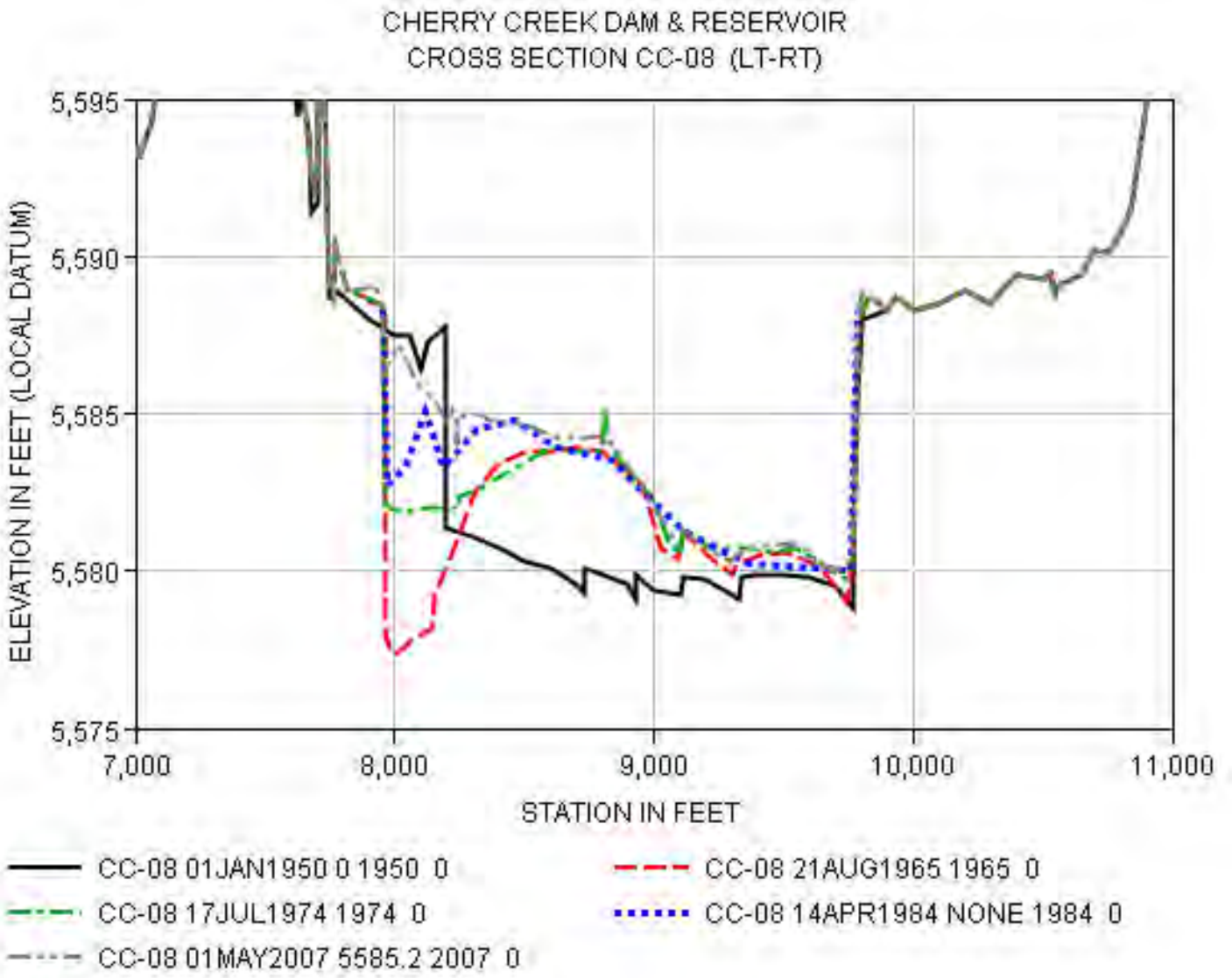
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-12. Sediment Range Line CC-06 Cross Section



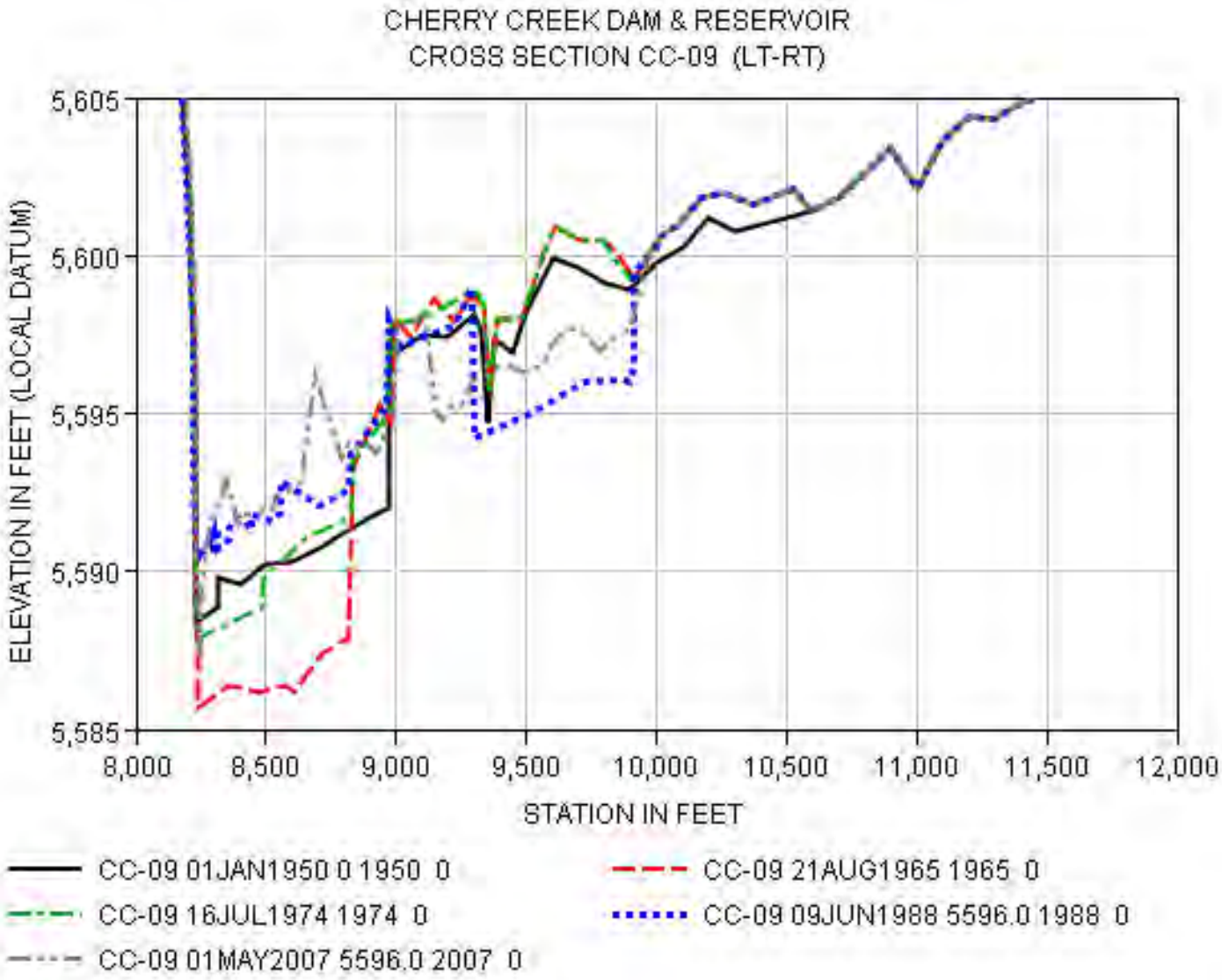
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-13. Sediment Range Line CC-07 Cross Section



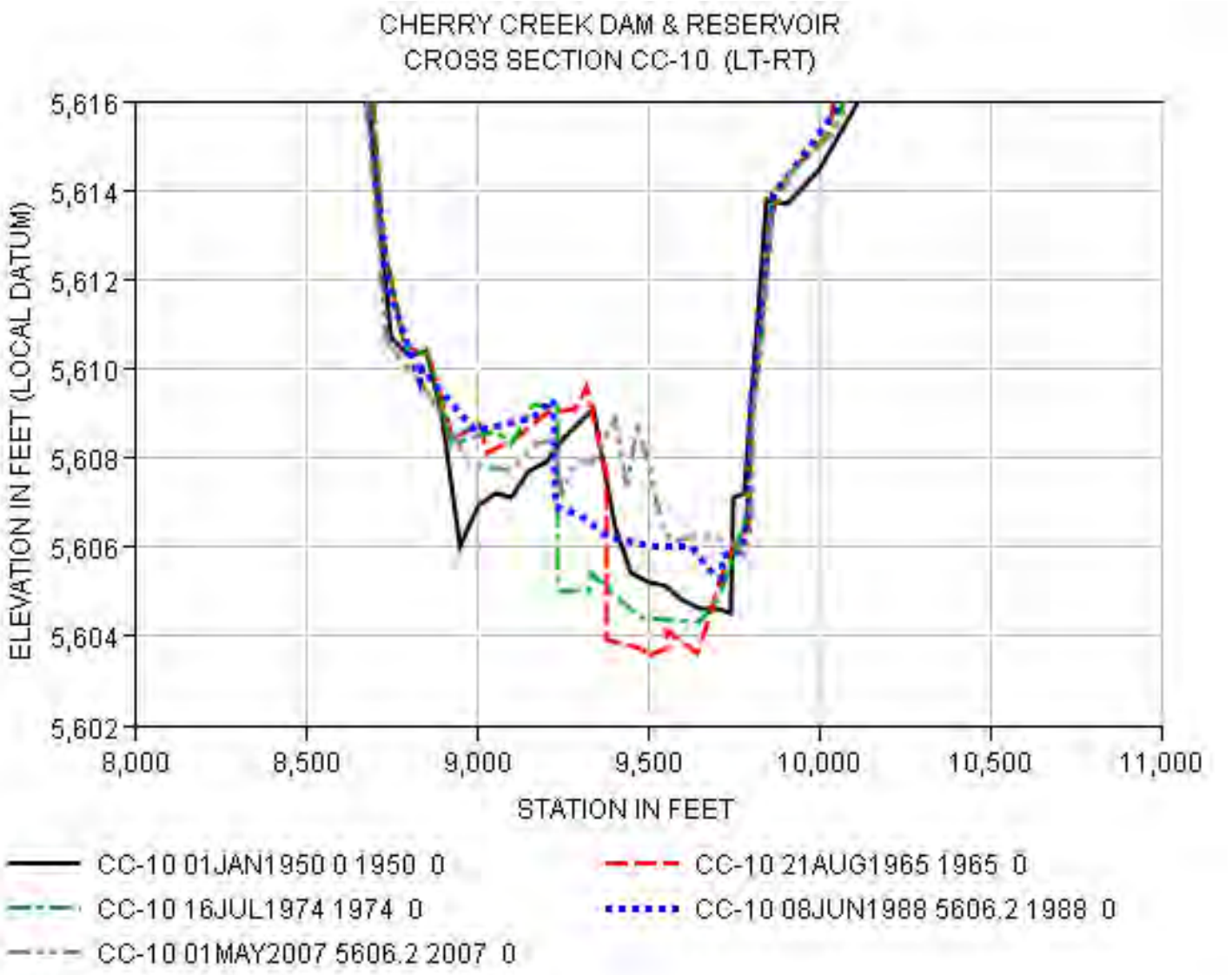
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-14. Sediment Range Line CC-08 Cross Section



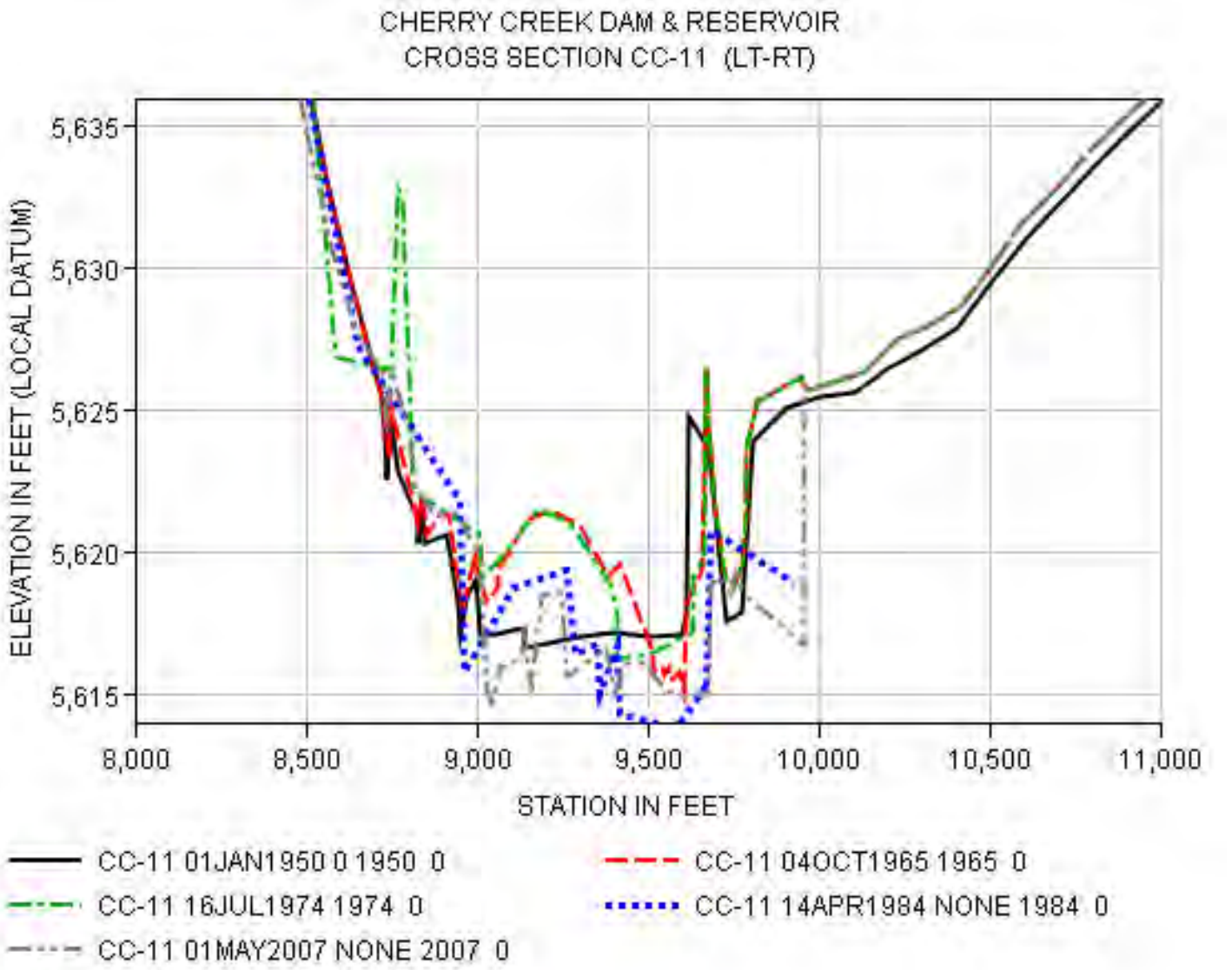
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-15. Sediment Range Line CC-09 Cross Section



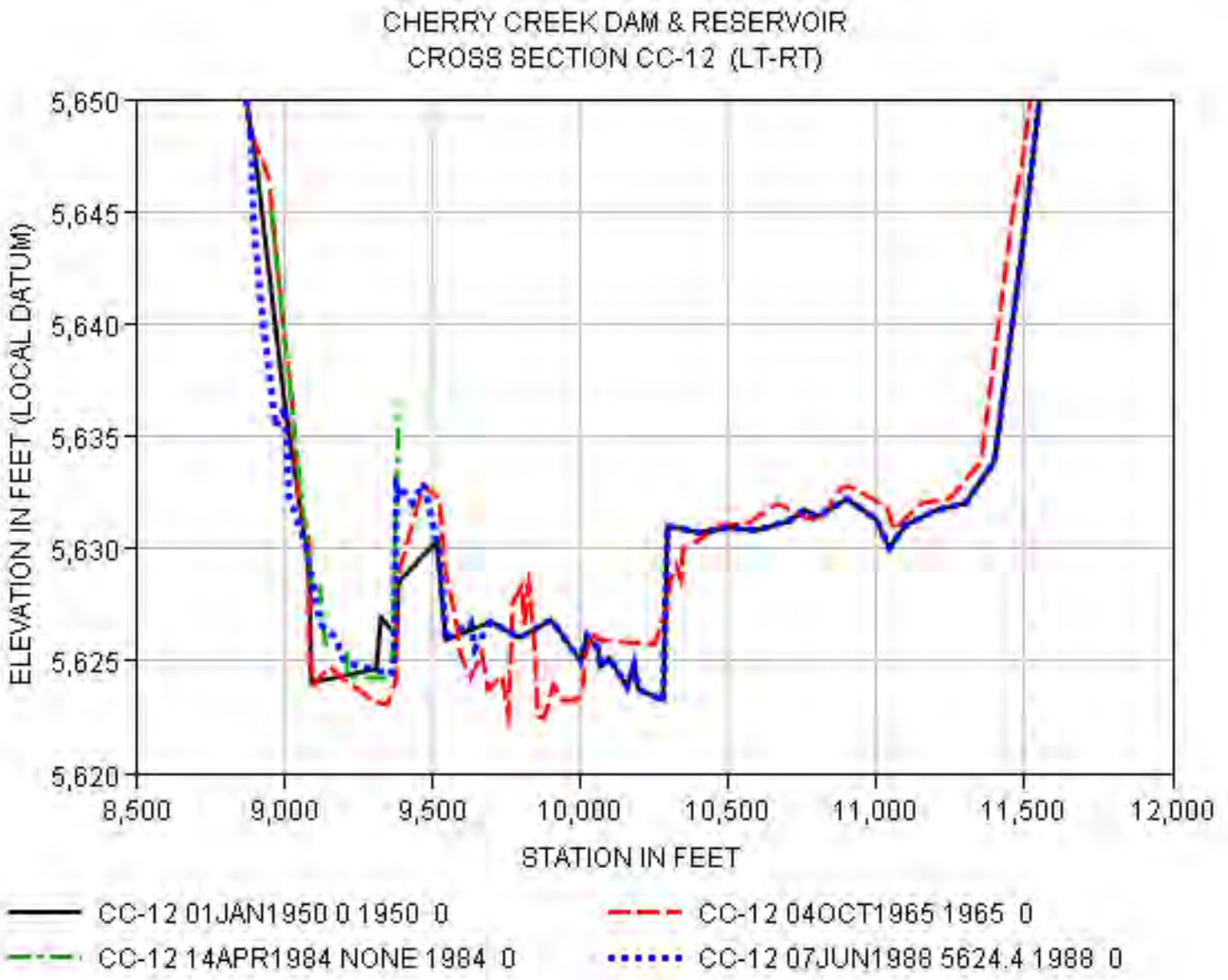
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-16. Sediment Range Line CC-10 Cross Section



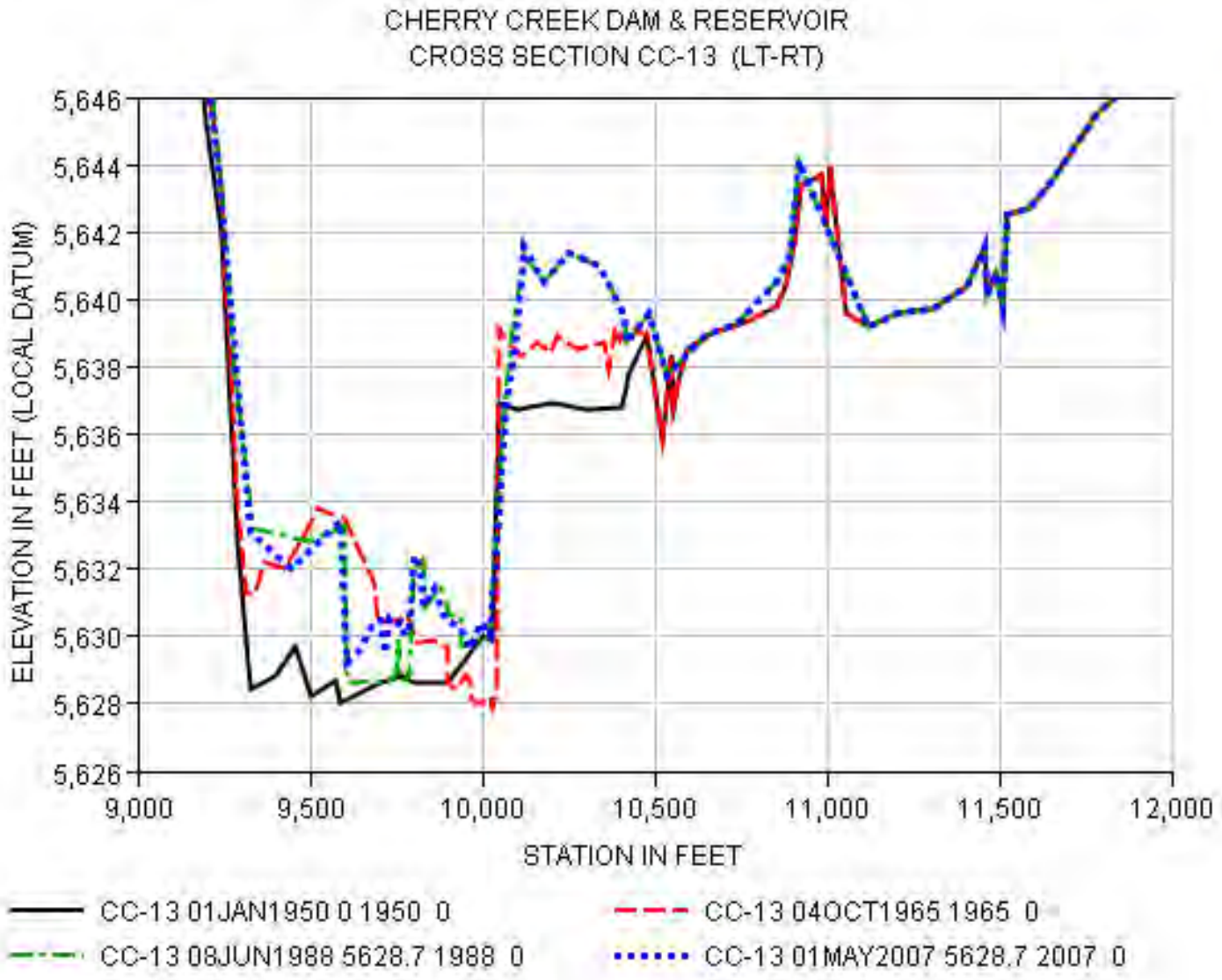
Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-17. Sediment Range Line CC-11 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-18. Sediment Range Line CC-12 Cross Section



Note: Not representative of entire cross section, only area of significant change is shown.

Figure 5-19. Sediment Range Line CC-13 Cross Section

Appendix A
Omaha District Reservoir Area-Capacity Analysis

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

Area-Capacity Computation Procedure

The constant factor method is the USACE Omaha District procedure for determining reservoir capacity by elevation which is an offshoot of the traditional "average-end-area" method, adjusted to include factors that take into account the non-uniformity of reservoir contours. For this procedure, portions of the reservoir bounded by one or more sediment range lines and the dam crest contour are considered as segments for determining storage capacity. Those portions of a segment situated between consecutive contours are referred to as sub-segments. The four steps required in developing the constant factor method are as follows:

$$L = \frac{V_o}{\frac{1}{2}(A'_o + A''_o)} \qquad \textit{Equation 1}$$

$$V_f = \frac{(A'_f + A''_f)\,L}{2} \qquad \textit{Equation 2}$$

$$V_f = \frac{V_o}{(A'_o + A''_o)}(A'_f + A''_f) \qquad \textit{Equation 3}$$

$$Let\ f = \frac{V_o}{(A'_o + A''_o)}$$

$$V_f = f(A'_f + A''_f) \qquad \textit{Equation 4}$$

where:

L = The effective length of the sub-segment

V_o = Original volume of the sub-segment

V_f = Future volume of the sub-segment (difference between V_o and sediment volume)

A_o'= Original area of downstream sub-segment section

A_o" = Original area of upstream sub-segment section or sections

A_f' and A_f'' = Respective future sub-segment section areas

f = Constant factor (ratio) for sub-segment

The first equation above is based upon the effective length of an incremental volume, namely, the distance by which the mean end area is multiplied to obtain the original volume. Equation 2 shows it is possible to estimate the subsequent volume having the same effective length as the original volume. In Equation 3, the effective length cancels out and the constant factor (also referred to as "ratio") obtained is simply a ratio of the original volume to the sum of the original end areas. Substituting the factor f for this ratio, Equation 4 becomes the simplified formula for computing volumes. Once determined for a unit, this factor is assumed constant and is applied for all future sedimentation surveys.

The capacity computations were originally part of a four part software package written in FORTRAN that was developed by the USACE Omaha District in 1992. The software package includes SATOVOL, SACHELM, VOLRATIO, and SAREACAP. The output from each program serves as an input file to the program that follows. The program AreaCapacity, developed by WEST Consultants, Inc. in August 2000, for the USACE Omaha District, is a Windows® based graphical user interface integrating the four original programs.

The first program, SATOVOL, uses the surface areas at given contour elevations for each segment of the reservoir to compute original segment volumes at incremental elevations (V_o in the above equations). These volumes are combined with original cross section end areas (A_o' and A_o" above), computed by SACHELM, to calculate sub-segment ratios (the constant factor f in Equation 3 and 4) using VOLRATIO. This surface area-to-volume-to-ratio procedure needs to be run only for the original capacity computations of each reservoir since the computed ratios are assumed to remain constant for all subsequent resurveys. The remaining program in the series, SAREACAP, combines reservoir sub-segment and segment volumes to compute total reservoir volume by elevation, the area and capacity tables. For resurveys the reservoir storage-elevation relationship is updated (to account for sediment deposition) by multiplying the new segment end areas by the original constant factor (Equation 4).

Appendix B
Bear Creek Area-Capacity Tables

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

Bear Creek Lake Area-Capacity Tables

The following tables are the Bear Creek Lake surface area and area-capacity tables for each survey year (1980, 1987, 1997, and 2009) in one-foot increments. The capacity tables for the one-hundredth foot increments are available from the U.S. Army Corps of Engineers Omaha District Sedimentation and Channel Stabilization Section. The effective date listed on each table is the date the area-capacity computations were performed for the survey data. The elevations are reported in NGVD29.

The original sediment range line survey collected overbank data to the farthest permanent sediment monument. However, overbank data for some subsequent surveys were only collected to the sediment monument nearest the water's edge. These shortened surveys used the previous overbank data in calculating reservoir area-capacity curves to equivalent elevations. The flood control and surcharge pools are affected most by this procedure. Sediment changes between survey periods where range line overbanks were copied from previous surveys will not accurately reflect sediment aggradation or degradation. The 1980 and 2009 surveys for Bear Creek Lake covered the entire extents of the range lines accurately representing the reservoir conditions.

Bear Creek Project - Effective 11 July 2000
Area in Acres
(1980 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	1	1
5520	2	3	5	6	8	10	12	14	16	19
5530	22	25	28	31	34	38	41	44	47	51
5540	54	58	61	65	68	70	74	77	80	82
5550	85	87	89	92	95	99	102	105	109	112
5560	116	119	123	127	131	134	138	142	146	151
5570	156	161	165	170	177	183	188	194	200	208
5580	215	221	228	236	245	256	265	274	282	290
5590	297	304	312	319	327	334	342	349	357	366
5600	374	382	390	399	409	419	430	439	449	458
5610	466	474	482	492	503	514	525	536	548	560
5620	574	589	602	613	622	630	638	647	656	663
5630	670	678	686	694	703	712	721	730	739	749
5640	759	768	778	787	798	809	819	829	840	850
5650	861	871	882	892	903	913	923	934	944	955
5660	965	976	987	997	1007	1017	1027	1037	1047	1058
5670	1068	1078	1089	1099	1111	1122	1133	1143	1155	1168
5680	1180	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 11 JUL 2000
Area-Capacity in Acre-Feet
(1980 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	1	1	3
5520	4	7	11	17	24	33	44	57	72	89
5530	110	134	161	191	224	260	300	342	388	437
5540	490	546	606	669	736	805	877	953	1032	1113
5550	1197	1283	1371	1461	1555	1652	1753	1857	1964	2075
5560	2189	2307	2428	2553	2682	2815	2951	3091	3236	3384
5570	3538	3697	3860	4027	4201	4381	4567	4758	4955	5159
5580	5371	5590	5814	6047	6287	6538	6799	7069	7348	7634
5590	7928	8229	8537	8853	9176	9507	9845	10191	10544	10906
5600	11276	11654	12041	12435	12840	13254	13679	14114	14558	15012
5610	15474	15944	16422	16909	17407	17916	18436	18967	19509	20063
5620	20630	21212	21809	22417	23035	23661	24295	24937	25589	26249
5630	26916	27590	28272	28962	29660	30368	31085	31811	32546	33290
5640	34044	34808	35581	36364	37156	37960	38774	39598	40433	41278
5650	42134	43000	43877	44764	45662	46570	47488	48417	49356	50306
5660	51266	52237	53219	54212	55214	56227	57249	58281	59323	60376
5670	61439	62512	63596	64690	65795	66912	68040	69178	70327	71489
5680	72663	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 11 July 2000
Area in Acres
(1987 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	0
5520	1	2	4	6	8	10	11	13	16	20
5530	24	28	32	35	37	40	42	45	47	51
5540	54	57	60	63	66	70	74	77	80	83
5550	85	88	90	93	96	99	101	104	107	111
5560	115	118	121	125	129	134	138	142	146	151
5570	156	160	164	170	176	182	188	194	200	207
5580	214	221	229	236	245	256	265	274	282	290
5590	297	304	311	319	327	333	341	348	356	364
5600	373	381	389	398	408	418	429	438	448	457
5610	466	474	483	493	503	514	525	535	547	559
5620	573	588	601	612	620	628	637	646	655	663
5630	670	677	685	694	703	712	720	729	739	748
5640	758	768	777	787	798	808	819	829	839	850
5650	861	871	882	892	902	913	923	934	944	954
5660	965	976	987	997	1007	1017	1026	1036	1047	1057
5670	1068	1078	1089	1099	1110	1121	1132	1143	1154	1167
5680	1180	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 11 July 2000
Area-Capacity in Acre-Feet
(1987 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	0
5520	0	2	5	11	18	27	38	50	65	83
5530	105	131	161	195	231	270	311	355	401	450
5540	503	559	617	679	744	812	884	960	1038	1120
5550	1204	1291	1380	1472	1567	1665	1765	1868	1974	2083
5560	2196	2313	2432	2556	2683	2815	2951	3091	3235	3383
5570	3537	3695	3857	4024	4197	4376	4561	4752	4949	5153
5580	5364	5582	5807	6040	6280	6531	6792	7062	7341	7627
5590	7921	8222	8530	8845	9169	9499	9836	10181	10533	10893
5600	11262	11639	12024	12417	12820	13233	13657	14091	14534	14987
5610	15449	15919	16397	16885	17383	17892	18412	18942	19483	20036
5620	20602	21183	21778	22385	23002	23626	24258	24900	25551	26210
5630	26877	27551	28232	28922	29620	30328	31044	31769	32503	33247
5640	34000	34763	35536	36318	37111	37914	38728	39552	40387	41231
5650	42087	42953	43830	44717	45614	46522	47440	48369	49308	50257
5660	51217	52188	53170	54162	55164	56176	57198	58229	59271	60323
5670	61386	62459	63543	64637	65742	66858	67985	69123	70271	71432
5680	72606	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 12 July 2000
Area in Acres
(1997 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	0
5520	0	1	2	4	6	9	12	14	17	18
5530	20	21	23	25	29	34	37	40	44	48
5540	51	55	58	61	65	69	72	76	79	82
5550	84	87	89	92	95	98	100	103	106	109
5560	113	116	119	123	127	132	136	141	146	150
5570	155	160	165	170	176	183	189	195	202	209
5580	215	222	229	237	246	256	265	274	282	290
5590	296	304	311	319	326	333	340	348	355	364
5600	373	381	389	398	408	419	429	439	449	457
5610	466	474	484	494	504	515	526	537	548	561
5620	575	589	602	613	621	628	637	646	654	661
5630	668	675	683	691	701	710	719	728	737	747
5640	757	767	776	786	796	807	817	827	837	848
5650	859	870	880	891	901	912	922	932	942	952
5660	961	971	981	991	1002	1012	1023	1033	1044	1055
5670	1065	1076	1087	1097	1109	1120	1131	1142	1153	1166
5680	1179	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 12 July 2000
Area-Capacity in Acre-Feet
(1997 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	0
5520	0	0	2	5	10	18	29	42	58	76
5530	95	116	138	162	189	221	257	296	338	384
5540	434	487	544	604	667	734	805	879	957	1038
5550	1121	1207	1295	1386	1479	1576	1675	1777	1882	1990
5560	2101	2216	2333	2454	2579	2709	2844	2982	3126	3274
5570	3427	3585	3747	3915	4088	4268	4454	4646	4844	5050
5580	5262	5481	5706	5939	6180	6431	6692	6962	7240	7527
5590	7820	8120	8428	8743	9066	9396	9733	10077	10429	10788
5600	11157	11534	11919	12312	12715	13129	13553	13987	14432	14885
5610	15347	15817	16296	16785	17284	17794	18315	18847	19389	19944
5620	20512	21095	21691	22299	22917	23542	24174	24816	25466	26124
5630	26789	27461	28140	28827	29523	30229	30944	31668	32400	33143
5640	33895	34657	35429	36210	37001	37803	38615	39437	40269	41112
5650	41966	42831	43706	44592	45488	46395	47312	48239	49177	50124
5660	51081	52047	53023	54009	55006	56013	57031	58059	59098	60148
5670	61208	62279	63361	64453	65556	66671	67797	68933	70081	71240
5680	72413	0	0	0	0	0	0	0	0	0

Bear Creek Project - Effective 12 March 2010
Area in Acres
(2009 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	1	3	6	8	11	14	16	18
5530	21	23	25	27	30	33	36	40	43	46
5540	50	53	56	60	63	66	69	72	75	77
5550	80	81	84	87	91	95	100	103	107	111
5560	114	117	120	124	129	133	137	141	146	150
5570	155	160	164	169	175	181	187	193	199	206
5580	213	219	226	234	244	254	264	273	282	290
5590	297	304	312	319	326	332	338	345	353	361
5600	371	380	389	397	404	411	417	424	433	445
5610	457	469	480	491	502	512	522	533	545	557
5620	571	585	598	609	617	625	633	641	650	658
5630	666	674	682	690	698	707	715	723	732	742
5640	753	762	772	782	792	802	812	822	832	843
5650	853	864	875	886	896	907	918	929	939	949
5660	959	968	978	988	998	1008	1018	1028	1038	1048
5670	1058	1068	1078	1088	1099	1110	1119	1130	1141	1154
5680	1167									

Bear Creek Project - Effective 12 March 2010
Area-Capacity in Acre-Feet
(2009 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	2	7	14	24	37	53	70
5530	90	112	136	162	191	223	258	296	338	382
5540	430	482	537	595	657	721	789	859	933	1009
5550	1088	1169	1251	1337	1426	1519	1617	1719	1824	1933
5560	2046	2162	2281	2403	2530	2661	2796	2935	3079	3227
5570	3380	3538	3700	3867	4039	4218	4402	4592	4788	4990
5580	5200	5417	5639	5869	6108	6357	6617	6886	7164	7451
5590	7744	8045	8353	8669	8992	9322	9657	9999	10348	10705
5600	11071	11447	11832	12225	12626	13034	13448	13868	14296	14735
5610	15186	15649	16124	16609	17106	17613	18131	18658	19198	19749
5620	20313	20892	21484	22088	22702	23323	23952	24589	25235	25890
5630	26552	27222	27900	28586	29280	29983	30694	31413	32141	32878
5640	33626	34384	35151	35928	36716	37513	38320	39137	39964	40802
5650	41650	42509	43379	44260	45151	46053	46966	47890	48824	49769
5660	50723	51687	52660	53644	54637	55641	56654	57678	58711	59754
5670	60808	61871	62945	64028	65122	66227	67342	68466	69602	70749
5680	71910									

Appendix C
Chatfield Area-Capacity Tables

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

Chatfield Lake Area-Capacity Tables

The following tables are the Chatfield Lake surface area and area-capacity tables for each survey year (1977, 1991, 1998, and 2010) in one-foot increments. The capacity tables for the one-hundredth foot increments are available from the U.S. Army Corps of Engineers Omaha District Sedimentation and Channel Stabilization Section. The effective date listed on each table is the date the area-capacity computations were performed for the survey data. The elevations are reported in NGVD29.

The original sediment range line survey collected overbank data to the farthest permanent sediment monument. However, overbank data for some subsequent surveys were only collected to the sediment monument nearest the water's edge. These shortened surveys used the previous overbank data in calculating reservoir area-capacity curves to equivalent elevations. The flood control and surcharge pools are affected most by this procedure. Sediment changes between survey periods where range line overbanks were copied from previous surveys will not accurately reflect sediment aggradation or degradation. The 1977 and 2010 surveys for Chatfield Lake covered the entire extents of the range lines accurately representing the reservoir conditions.

Chatfield Lake - Effective 24 July 2000
Area in Acres
(1977 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	0
5380	1	2	3	5	9	12	13	16	23	35
5390	45	50	59	79	110	146	180	209	237	266
5400	293	318	346	377	412	448	484	518	551	584
5410	616	648	680	712	742	772	800	830	864	900
5420	937	972	1007	1047	1092	1139	1185	1229	1272	1315
5430	1358	1401	1444	1488	1533	1579	1624	1669	1715	1763
5440	1812	1861	1909	1957	2004	2050	2097	2144	2191	2238
5450	2285	2330	2377	2425	2476	2529	2582	2633	2679	2721
5460	2760	2801	2844	2886	2929	2970	3011	3053	3098	3147
5470	3198	3248	3296	3344	3392	3441	3489	3538	3585	3631
5480	3676	3720	3766	3814	3863	3911	3956	4003	4057	4118
5490	4181	4242	4301	4361	4421	4482	4543	4604	4662	4719
5500	4774	4830	4886	4944	5002	5061	5119	5177	5235	5293
5510	5351	5411	5469	5525	5579	5632	5687	5741	5795	5849
5520	5901	5954	6007	6062	6118	6175	6231	6287	6343	6399
5530	6455									

Chatfield Lake - Effective 24 July 2000

Area-Capacity in Acre-Feet

(1977 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	1
5380	1	3	6	10	17	29	42	56	75	103
5390	145	194	246	312	405	533	698	893	1116	1368
5400	1648	1954	2285	2646	3040	3470	3937	4439	4974	5542
5410	6142	6774	7438	8135	8862	9620	10406	11220	12067	12948
5420	13868	14823	15812	16838	17906	19022	20185	21392	22643	23937
5430	25274	26654	28076	29542	31052	32609	34211	35857	37549	39288
5440	41076	42913	44799	46732	48713	50740	52814	54934	57102	59316
5450	61578	63886	66239	68640	71090	73592	76148	78757	81415	84116
5460	86857	89637	92460	95325	98233	101183	104174	107205	110280	113402
5470	116575	119799	123071	126392	129760	133177	136642	140156	143718	147326
5480	150980	154678	158421	162211	166049	169937	173871	177849	181878	185964
5490	190114	194327	198599	202930	207321	211773	216286	220860	225494	230185
5500	234932	239734	244592	249507	254480	259512	264602	269750	274957	280221
5510	285543	290924	296365	301863	307416	313022	318681	324396	330164	335987
5520	341862	347790	353770	359805	365894	372041	378244	384503	390818	397189
5530	403616									

Chatfield Lake - Effective 07 Aug 2000
Area in Acres
(1991 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	0
5380	1	2	3	6	10	12	13	16	23	35
5390	45	49	57	78	110	149	185	215	244	271
5400	296	321	348	377	408	441	474	505	535	563
5410	588	613	640	672	710	751	790	827	863	898
5420	932	964	999	1037	1079	1121	1160	1200	1244	1292
5430	1342	1391	1438	1484	1529	1573	1616	1661	1709	1759
5440	1812	1866	1917	1964	2007	2048	2089	2132	2179	2229
5450	2281	2332	2382	2430	2478	2526	2576	2625	2670	2713
5460	2755	2797	2841	2885	2930	2975	3019	3064	3109	3155
5470	3200	3244	3290	3337	3387	3439	3490	3540	3587	3633
5480	3677	3721	3766	3814	3862	3909	3953	4000	4054	4117
5490	4183	4247	4308	4369	4428	4487	4547	4607	4665	4722
5500	4778	4835	4892	4948	5003	5057	5109	5163	5222	5284
5510	5350	5416	5478	5536	5589	5641	5694	5748	5802	5854
5520	5905	5957	6009	6063	6119	6176	6232	6288	6343	6399
5530	6454									

Chatfield Project - Effective 07 Aug 2000
Area-Capacity in Acre-Feet
(1991 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	0
5380	0	2	4	8	16	28	41	55	74	102
5390	144	192	242	307	398	528	697	898	1128	1386
5400	1670	1978	2312	2674	3066	3490	3948	4438	4959	5508
5410	6085	6685	7311	7966	8656	9387	10159	10968	11813	12694
5420	13610	14558	15539	16557	17614	18715	19856	21036	22257	23525
5430	24842	26209	27624	29086	30593	32145	33739	35377	37061	38795
5440	40580	42420	44312	46254	48241	50269	52337	54447	56602	58805
5450	61060	63367	65725	68131	70586	73088	75639	78240	80889	83581
5460	86316	89092	91911	94774	97681	100634	103631	106673	109760	112892
5470	116070	119293	122559	125873	129234	132647	136112	139628	143192	146803
5480	150458	154157	157900	161690	165528	169415	173346	177321	181346	185430
5490	189580	193797	198075	202414	206813	211270	215787	220365	225002	229696
5500	234446	239252	244116	249037	254012	259043	264126	269261	274453	279705
5510	285021	290405	295853	301361	306925	312540	318207	323928	329704	335532
5520	341412	347343	353326	359362	365452	371600	377804	384064	390380	396751
5530	403178									

Chatfield Lake - Effective 07 Aug 2000
Surface Area in Acres
(1998 Survey)

ELEV	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	0
5380	0	1	2	5	9	12	13	15	22	34
5390	44	49	58	77	104	135	164	189	217	246
5400	275	302	331	362	398	437	476	511	542	567
5410	588	609	634	665	703	742	779	814	852	890
5420	929	966	1004	1044	1087	1131	1173	1215	1258	1302
5430	1344	1386	1429	1474	1523	1572	1620	1668	1717	1766
5440	1818	1870	1920	1967	2009	2049	2089	2132	2179	2229
5450	2282	2333	2383	2432	2480	2527	2577	2625	2670	2713
5460	2754	2795	2837	2881	2926	2971	3016	3061	3107	3152
5470	3197	3241	3287	3335	3385	3439	3492	3543	3590	3635
5480	3677	3720	3765	3811	3859	3906	3949	3995	4049	4112
5490	4179	4243	4304	4365	4425	4486	4547	4608	4667	4723
5500	4779	4837	4895	4950	5004	5056	5106	5160	5218	5280
5510	5346	5412	5474	5532	5586	5639	5693	5748	5802	5855
5520	5907	5959	6013	6067	6123	6180	6236	6292	6348	6403
5530	6458									

Chatfield Lake - Effective 07 Aug 2000
Area-Capacity in Acre-Feet
(1998 Survey)

ELEV	0	1	2	3	4	5	6	7	8	9
5370	0	0	0	0	0	0	0	0	0	0
5380	0	0	2	5	12	23	36	49	67	94
5390	135	182	234	299	388	508	659	836	1038	1270
5400	1531	1820	2136	2482	2861	3278	3735	4230	4758	5314
5410	5893	6491	7112	7760	8443	9166	9928	10724	11557	12428
5420	13338	14286	15270	16294	17359	18468	19621	20815	22052	23332
5430	24656	26021	27428	28879	30377	31925	33522	35166	36859	38600
5440	40392	42236	44132	46077	48066	50096	52165	54275	56430	58633
5450	60889	63197	65556	67964	70421	72924	75476	78079	80727	83420
5460	86154	88928	91744	94603	97507	100456	103450	106489	109573	112703
5470	115878	119098	122361	125672	129031	132443	135909	139428	142995	146609
5480	150266	153964	157706	161494	165329	169213	173141	177111	181131	185210
5490	189356	193568	197842	202177	206572	211027	215544	220122	224760	229456
5500	234207	239015	243882	248805	253783	258814	263895	269027	274215	279463
5510	284776	290156	295600	301105	306665	312278	317944	323665	329440	335269
5520	341151	347084	353070	359110	365204	371356	377564	383828	390148	396524
5530	402955									

Chatfield Lake - Effective 21 January 2011
Surface Area in Acres
(2010 Survey)

ELEV	0	1	2	3	4	5	6	7	8	9
5380	0	0	1	3	7	10	12	15	22	33
5390	43	49	57	75	100	128	153	176	203	233
5400	264	292	321	354	392	434	477	515	546	570
5410	589	608	632	664	702	744	785	822	858	892
5420	925	958	992	1029	1068	1108	1144	1182	1225	1272
5430	1320	1366	1412	1460	1511	1563	1615	1665	1716	1765
5440	1817	1870	1921	1965	2003	2036	2068	2106	2150	2201
5450	2254	2305	2354	2404	2456	2509	2564	2616	2663	2705
5460	2744	2785	2828	2871	2914	2957	3000	3044	3087	3131
5470	3174	3215	3258	3307	3361	3420	3477	3531	3581	3626
5480	3669	3712	3757	3805	3853	3900	3945	3993	4046	4108
5490	4172	4234	4294	4355	4418	4482	4548	4611	4670	4727
5500	4782	4839	4896	4952	5006	5058	5110	5164	5221	5279
5510	5339	5399	5457	5515	5572	5630	5688	5745	5801	5853
5520	5904	5956	6008	6063	6119	6175	6231	6287	6343	6398
5530	6453									

Chatfield Lake - Effective 21 January 2011
Area-Capacity in Acre-Feet
(2010 Survey)

ELEV	0	1	2	3	4	5	6	7	8	9
5380	0	0	0	1	6	16	27	40	57	84
5390	123	170	221	285	371	486	628	792	981	1198
5400	1448	1727	2033	2370	2742	3154	3610	4108	4640	5200
5410	5781	6379	6997	7644	8325	9048	9814	10618	11458	12334
5420	13243	14184	15159	16169	17217	18306	19433	20595	21798	23046
5430	24343	25687	27076	28511	29997	31534	33124	34764	36455	38196
5440	39986	41830	43727	45672	47658	49679	51730	53816	55942	58116
5450	60344	62625	64954	67333	69763	72245	74782	77374	80015	82701
5460	85426	88190	90997	93846	96739	99675	102654	105676	108742	111851
5470	115005	118200	121436	124717	128050	131440	134890	138395	141953	145557
5480	149205	152895	156629	160410	164239	168117	172040	176008	180026	184101
5490	188242	192446	196710	201034	205420	209870	214385	218966	223607	228307
5500	233061	237871	242739	247664	252643	257676	262760	267897	273089	278339
5510	283648	289018	294447	299933	305477	311078	316737	322454	328228	334056
5520	339935	345865	351847	357882	363973	370120	376324	382583	388898	395269
5530	401695									

Appendix D
Cherry Creek Area-Capacity Tables

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

Cherry Creek Lake Area-Capacity Tables

The following tables are the Cherry Creek Lake surface area and area-capacity tables for each survey year (1950, 1961, 1965, 1974, 1988, and 2009) in one-foot increments. The capacity tables for the one-hundredth foot increments are available from the U.S. Army Corps of Engineers Omaha District Sedimentation and Channel Stabilization Section. The effective date listed on each table is the date the area-capacity computations were performed for the survey data. The elevations are reported in the local project datum.

The original sediment range line survey collected overbank data to the farthest permanent sediment monument. However, overbank data for some subsequent surveys were only collected to the sediment monument nearest the water's edge. These shortened surveys used the previous overbank data in calculating reservoir area-capacity curves to equivalent elevations. The flood control and surcharge pools are affected most by this procedure. Sediment changes between survey periods where range line overbanks were copied from previous surveys will not accurately reflect sediment aggradation or degradation. The 1950 survey for the Cherry Creek Lake is the only survey to cover the entire extents of the range lines accurately representing the reservoir conditions.

Cherry Creek Project - Effective 26 July 2000
Area in Acres
(1950 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5500	0	0	0	0	0	1	2	3	4	4
5510	12	20	21	26	34	44	58	75	95	118
5520	140	156	169	185	203	222	245	269	296	325
5530	353	379	402	426	452	477	503	529	557	584
5540	611	638	664	690	717	744	771	800	828	857
5550	886	914	941	969	998	1027	1055	1085	1115	1145
5560	1174	1201	1228	1256	1286	1316	1349	1383	1418	1455
5570	1490	1521	1551	1583	1618	1654	1693	1734	1777	1822
5580	1868	1909	1949	1990	2032	2074	2116	2159	2203	2248
5590	2293	2336	2380	2423	2467	2510	2553	2597	2640	2684
5600	2727	2770	2813	2856	2899	2943	2987	3032	3077	3123
5610	3167	3209	3251	3294	3339	3386	3434	3483	3535	3588
5620	3639	3685	3730	3778	3828	3881	3937	3996	4058	4122
5630	4187	4248	4307	4367	4426	4485	4545	4604	4663	4723
5640	4783									

Cherry Creek Project - Effective 26 July 2000
Area-Capacity in Acre-Feet
(1950 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5500	0	0	0	0	0	0	2	5	9	13
5510	18	38	58	81	110	149	199	265	349	455
5520	586	736	898	1074	1268	1480	1713	1970	2252	2562
5530	2902	3269	3660	4074	4513	4978	5468	5984	6527	7098
5540	7696	8321	8972	9649	10352	11083	11840	12626	13440	14283
5550	15155	16056	16984	17939	18923	19936	20977	22047	23147	24277
5560	25437	26625	27839	29081	30352	31653	32985	34351	35752	37188
5570	38662	40169	41704	43271	44871	46507	48180	49893	51649	53448
5580	55294	57184	59113	61083	63094	65147	67242	69380	71561	73787
5590	76058	78373	80731	83133	85578	88067	90599	93174	95793	98455
5600	101161	103910	106701	109536	112413	115335	118300	121310	124365	127465
5610	130611	133800	137029	140302	143618	146981	150391	153849	157358	160920
5620	164535	168198	171905	175658	179461	183315	187223	191190	195216	199306
5630	203461	207680	211958	216295	220692	225148	229663	234238	238872	243565
5640	248318									

Cherry Creek Project - Effective 26 July 2000
Area in Acres
(1961 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	-8	25	42	60	81	104
5520	126	143	158	176	195	216	239	264	291	320
5530	349	375	401	426	451	476	501	526	551	575
5540	599	621	643	666	691	718	746	775	806	839
5550	872	903	932	962	992	1022	1051	1081	1111	1141
5560	1169	1196	1224	1252	1282	1314	1346	1380	1416	1452
5570	1488	1519	1549	1582	1617	1654	1692	1733	1776	1821
5580	1866	1907	1947	1987	2029	2071	2114	2157	2201	2246
5590	2291	2335	2379	2423	2466	2510	2553	2597	2641	2684
5600	2728	2771	2814	2858	2901	2945	2989	3033	3078	3122
5610	3165	3206	3246	3289	3333	3380	3428	3477	3529	3583
5620	3634	3681	3727	3775	3826	3879	3934	3992	4052	4115
5630	4178	4238	4297	4355	4413	4472	4530	4588	4647	4705
5640	4762									

Cherry Creek Project - Effective 26 July 2000
Area-Capacity in Acre-Feet
(1961 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	-33	-16	16	67	137	229
5520	345	481	631	798	983	1189	1416	1667	1944	2249
5530	2584	2947	3335	3749	4188	4652	5141	5655	6194	6757
5540	7345	7955	8587	9241	9920	10624	11356	12116	12907	13729
5550	14585	15473	16391	17338	18315	19323	20359	21426	22522	23648
5560	24804	25987	27197	28435	29702	31000	32330	33693	35091	36525
5570	37996	39501	41035	42600	44199	45834	47507	49219	50973	52772
5580	54616	56504	58431	60398	62406	64456	66548	68684	70863	73087
5590	75356	77670	80027	82428	84873	87361	89893	92468	95087	97750
5600	100456	103206	105998	108835	111714	114638	117605	120616	123672	126772
5610	129916	133102	136328	139595	142906	146262	149666	153118	156621	160177
5620	163787	167446	171150	174900	178700	182552	186458	190421	194442	198526
5630	202673	206882	211150	215476	219860	224303	228804	233363	237981	242657
5640	247391									

Cherry Creek Project - Effective 09 Aug 2000
Area in Acres
(1965 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	1
5520	25	68	107	144	179	211	241	269	294	317
5530	340	367	396	424	451	477	503	527	551	574
5540	595	617	640	663	687	713	739	767	797	827
5550	856	884	912	939	967	996	1025	1054	1084	1114
5560	1143	1169	1194	1222	1252	1284	1318	1353	1392	1432
5570	1470	1505	1538	1572	1609	1647	1687	1729	1773	1818
5580	1864	1907	1949	1991	2033	2075	2118	2161	2204	2247
5590	2291	2334	2376	2419	2462	2506	2549	2592	2636	2680
5600	2723	2767	2810	2853	2897	2941	2984	3028	3073	3117
5610	3160	3200	3241	3284	3328	3374	3422	3472	3524	3577
5620	3628	3675	3720	3768	3819	3872	3928	3986	4047	4111
5630	4175	4236	4295	4354	4412	4471	4530	4589	4648	4707
5640	4766									

Cherry Creek Project - Effective 09 Aug 2000
Area-Capacity in Acre-Feet
(1965 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5510	0	0	0	0	0	0	0	0	0	1
5520	3	51	139	266	428	624	851	1107	1390	1696
5530	2024	2377	2759	3170	3608	4072	4563	5078	5617	6180
5540	6765	7371	8000	8651	9326	10026	10752	11505	12287	13099
5550	13941	14812	15710	16636	17589	18571	19582	20622	21691	22790
5560	23920	25077	26258	27466	28703	29971	31272	32607	33979	35391
5570	36843	38332	39853	41408	42998	44626	46293	48001	49752	51547
5580	53389	55275	57203	59173	61185	63239	65335	67475	69658	71883
5590	74153	76466	78821	81219	83660	86144	88672	91243	93857	96515
5600	99217	101962	104751	107583	110458	113377	116340	119346	122397	125492
5610	128631	131812	135032	138295	141600	144951	148349	151796	155294	158844
5620	162448	166101	169799	173542	177335	181180	185080	189036	193052	197131
5630	201275	205482	209747	214072	218455	222897	227398	231958	236577	241255
5640	245992									

Cherry Creek Project - Effective 26 July 2000
Area in Acres
(1974 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	53	100	136	171	205	238	271
5530	306	345	385	421	455	486	513	538	559	578
5540	596	616	638	661	686	711	737	764	793	822
5550	851	879	905	932	960	988	1017	1046	1076	1107
5560	1136	1162	1188	1216	1246	1277	1311	1346	1384	1423
5570	1461	1494	1526	1561	1597	1635	1675	1717	1762	1808
5580	1854	1898	1940	1982	2025	2068	2112	2155	2199	2243
5590	2287	2331	2374	2417	2461	2505	2548	2592	2636	2680
5600	2724	2767	2811	2854	2898	2942	2986	3030	3074	3118
5610	3161	3201	3242	3284	3328	3374	3422	3472	3524	3577
5620	3628	3674	3719	3767	3817	3870	3927	3985	4046	4110
5630	4174	4236	4295	4354	4413	4472	4531	4590	4649	4708
5640	4768									

Cherry Creek Project - Effective 26 July 2000
Area-Capacity in Acre-Feet
(1974 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	24	106	224	378	566	788	1043
5530	1330	1655	2021	2425	2864	3336	3836	4363	4912	5482
5540	6069	6674	7301	7950	8624	9322	10046	10796	11575	12383
5550	13220	14086	14978	15896	16842	17816	18819	19850	20911	22003
5560	23125	24275	25449	26651	27881	29143	30436	31765	33129	34533
5570	35976	37455	38965	40508	42087	43702	45357	47053	48792	50577
5580	52409	54286	56206	58167	60171	62218	64308	66442	68619	70840
5590	73105	75414	77767	80162	82602	85085	87612	90182	92796	95454
5600	98156	100902	103691	106524	109400	112320	115285	118293	121345	124441
5610	127581	130763	133984	137247	140553	143904	147302	150749	154247	157797
5620	161401	165054	168750	172493	176285	180128	184026	187982	191997	196075
5630	200218	204424	208690	213014	217398	221841	226342	230903	235522	240201
5640	244939									

Cherry Creek Project - Effective 26 July 2000
Area in Acres
(1988 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	0	55	115	143	171	199	227
5530	273	328	371	410	446	479	508	533	555	573
5540	590	611	634	659	683	709	735	762	790	819
5550	847	873	899	926	953	981	1010	1038	1068	1099
5560	1127	1153	1178	1205	1235	1266	1300	1336	1374	1414
5570	1453	1487	1519	1554	1590	1629	1669	1711	1756	1802
5580	1847	1890	1932	1974	2016	2059	2104	2149	2194	2240
5590	2286	2333	2379	2424	2469	2513	2556	2599	2642	2684
5600	2726	2768	2810	2853	2896	2939	2983	3027	3072	3116
5610	3160	3201	3242	3285	3329	3375	3423	3472	3523	3576
5620	3627	3672	3717	3764	3814	3867	3923	3982	4044	4109
5630	4174	4235	4295	4354	4413	4473	4532	4592	4651	4710
5640	4770									

Cherry Creek Project - Effective 26 July 2000
Area-Capacity in Acre-Feet
(1988 Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	0	9	110	240	397	583	796
5530	1037	1342	1693	2084	2513	2977	3471	3993	4538	5103
5540	5684	6284	6906	7553	8224	8920	9642	10391	11167	11972
5550	12805	13666	14552	15465	16405	17372	18368	19392	20445	21529
5560	22643	23784	24949	26140	27360	28610	29893	31211	32566	33959
5570	35394	36865	38368	39904	41476	43085	44734	46424	48157	49936
5580	51761	53631	55542	57495	59490	61528	63609	65736	67907	70124
5590	72387	74697	77053	79455	81901	84393	86928	89506	92127	94791
5600	97496	100243	103032	105864	108739	111657	114618	117623	120673	123767
5610	126906	130087	133308	136571	139878	143230	146628	150076	153573	157123
5620	160726	164377	168071	171811	175600	179440	183335	187287	191300	195376
5630	199518	203724	207989	212314	216697	221141	225643	230206	234827	239508
5640	244248									

Cherry Creek Project - Effective 09 December 2010
Area in Acres
(2009* Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	0	0	61	120	152	184	216
5530	263	321	369	413	452	486	515	540	559	574
5540	587	605	627	649	673	698	725	752	780	810
5550	840	867	894	920	948	977	1006	1036	1066	1098
5560	1128	1155	1182	1211	1241	1273	1307	1342	1379	1418
5570	1455	1488	1519	1553	1589	1627	1667	1710	1754	1801
5580	1847	1890	1932	1974	2017	2060	2104	2149	2193	2239
5590	2285	2330	2375	2420	2464	2508	2552	2595	2638	2681
5600	2723	2765	2808	2851	2894	2938	2982	3026	3071	3116
5610	3159	3201	3242	3285	3330	3376	3424	3473	3524	3577
5620	3628	3674	3720	3767	3817	3870	3924	3981	4041	4102
5630	4164	4223	4281	4338	4395	4453	4510	4568	4625	4682
5640	4740	0	0	0	0	0	0	0	0	0

*2009 Survey is a composite of data collected in 2006, 2007, and 2009.

Cherry Creek Project - Effective 09 December 2010
Capacity in Acre-Feet
(2009* Survey)

Elevation	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	0	0	17	122	258	426	626
5530	858	1153	1500	1892	2326	2796	3298	3827	4378	4946
5540	5526	6121	6737	7375	8036	8721	9433	10171	10937	11732
5550	12558	13412	14293	15200	16134	17097	18089	19110	20161	21243
5560	22357	23499	24668	25864	27090	28347	29637	30961	32321	33719
5570	35157	36630	38133	39669	41240	42848	44495	46183	47915	49692
5580	51517	53387	55298	57252	59247	61286	63368	65495	67666	69882
5590	72144	74452	76804	79202	81645	84131	86661	89235	91852	94512
5600	97214	99958	102745	105575	108447	111364	114324	117328	120376	123470
5610	126608	129789	133010	136274	139581	142934	146334	149782	153281	156831
5620	160435	164087	167784	171527	175319	179162	183059	187011	191022	195093
5630	199227	203422	207674	211984	216350	220775	225256	229796	234392	239046
5640	243757	0	0	0	0	0	0	0	0	0

*2009 Survey is a composite of data collected in 2006, 2007, and 2009.

Appendix E
Engineering Forms 1787

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

RESERVOIR SEDIMENT DATA SUMMARY

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Bear Creek Lake

NAME OF RESERVOIR

DATA SHEET NO.

DAM

1. OWNER Dept of Army; Corps of Engineers	2. STREAM Bear Creek	3. STATE Colorado
4. SEC. *32 TWP. 4S RANGE 69W	5. NEAREST P.O. Denver	6. COUNTY Jefferson
7. LAT. 39° 39' 00" LONG 105° 8' 30"	8. TOP OF DAM ELEVATION 5689.5	9. SPILLWAY CREST ELEV. 5667

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE, AREA ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE, ACRE-FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL	5635.5	717	28,762	30,726	
b. MULTIPLE USE	5558	109	1,892	1,964	July 1977
c. POWER					
d. WATER SUPPLY					16. DATE NORMAL OPER. BEGAN
e. IRRIGATION					
f. CONSERVATION					
g. INACTIVE	5528.0	16	72	72	May 1979

17. LENGTH OF RESERVOIR 0.7 MILES — AV. WIDTH OF RESERVOIR 1.6 MILES

WATERSHED

18. TOTAL DRAINAGE AREA 236 SQ. MI.		22. MEAN ANNUAL PRECIPITATION 18.71 (42years of record)***	INCHES
19. NET SEDIMENT CONTRIBUTING AREA 235 SQ. MI.		23. MEAN ANNUAL RUNOFF 3.0	INCHES
20. LENGTH 36 MILES	AV. WIDTH 6.5 MILES	24. MEAN ANNUAL RUNOFF 37,600	AC.-FEET
21. MAX ELEV. 14,264 FEET	MIN. ELEV. 5516 FEET	25. ANNUAL TEMP. MEAN 44.4	RANGE 27.2 - 60.7

SURVERY DATA

26. DATE OF SURVERY	27. PERIOD YEARS	28. ACCL YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR CONTOR INT.	31. SURFACE AREA, ACRES	32. CAPACITY, ACRE-FEET	33. C/I RATIO, AC.-FT. PER AC.-FT.
10/30/1980	0	0	Range	13	717	30,726	0.82
6/18/1987	6.64	6.64	Range	9	716	30,686	0.82
12/3/1997	10.47	17.10	Range	11	715	30,586	0.81
8/13/2009	11.70	28.81	Range	11	711	30,338	0.81

26. DATE OF SURVERY	34. PERIOD ANNUAL PERCIPITATION	35. PERIOD WATER INTERFLOW, ACRE-FEET			36. WATER INFL. TO DATE, AC.-FT.	
		a. MEAN ANNUAL	b. MAX. ANNUAL	c. PERIOD TOTAL	a. MEAN ANNUAL	b. TOTAL TO DATE
10/30/1980						
6/18/1987	19.39***	59,430	91,923	394,618	59,430	394,618
12/3/1997	19.53***	29,429	72,733	308,120	41,072	702,738
8/13/2009	18.31***	31,303	79,673	375,636	37,446	1,078,374

26. DATE OF SURVERY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SED. DEPOSITS TO DATE, ACRE-FEET		
	a. PERIOD TOTAL	b. AV. ANNUAL	c. PER SQ. MI.-YEAR	a. TOTAL TO DATE	b. AV. ANNUAL	c. PER SQ. MI.-YEAR
10/30/1980						
6/18/1987	52	7.84	0.0333	52	7.84	0.0333
12/3/1997	170	16.24	0.0691	222	12.98	0.0552
8/13/2009	381	35.56	0.1386	603	20.93	0.0891

26. DATE OF SURVERY	39. AV. DRY WGT., LBS PER CU. FT.	40. SED. DEP. TONS PER SQ. MI.-YR.		41. STORAGE LOSS PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANN.	b. TOT. TO DATE	a. PERIOD	b. TOT. TO DATE

ENG FORM 1787, NOV 1966 PREVIOUS EDITIONS ARE OBSOLETE (Proponent: CECW-EH-Y)

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, CREST ELEVATION										
	157-127	127-107	107-87	87-67	67-47	47-27	27-17	17-7	7-Crest	Crest-+3	+3-+13
	PERCENT OF TOTAL SEDIMENT LOCATED WITIN DEPTH DESIGNATION										
6/18/1987	-22.8	10.5	24.6	12.3	24.6	28.1	5.3	3.5	5.3	1.8	7
12/3/1997	22.4	12.8	8.4	4.0	-0.4	12.4	7.6	6.8	14.8	3.6	7.6
8/13/2009	8.0	11.0	3.7	4.5	14.9	13.4	8.8	7.8	8.0	3.7	16.2

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	-105	-110	-115	-120	-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														
6/18/1987	1.0	-20.0	0.8	31.0	34.4	32.2	7.8	4.3	4.2	4.2					
12/3/1997	3.0	19.6	19.9	8.0	9.8	12.2	5.1	4.1	8.6	9.8					
8/13/2009	27.6	29.7	17.6	9.0	5.7	5.5	1.2	0.6	1.4	1.6					

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.
1990	5559.81	5557.69	23,721	2000	5560.14	5549.17	28,035
1991	5560.39	5557.13	31,075	2001	5559.24	5557.07	14,612
1992	5559.70	5557.80	25,841	2002	5558.77	5555.89	7,841
1993	5559.70	5558.04	17,183	2003	5561.16	5554.65	21,275
1994	5559.57	5557.95	17,022	2004	5559.45	5558.08	19,393
1995	5587.17	5557.68	72,733	2005	5559.88	5556.76	40,001
1996	5559.30	5558.10	17,005	2006	5559.27	5555.16	8,850
1997	5560.86	5557.30	43,361	2007	5561.77	5555.10	56,060
1998	5567.21	5558.38	79,673	2008	5559.30	5556.16	17,282
1999	5565.46	5559.08	57,523	2009	5560.10	5558.10	25,091

46. ELEVATION-AREA-CAPACITY DATA

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
5520	0	0	5590	297	7744	5660	959	50723
5530	21	90	5600	371	11071	5670	1058	60808
5540	50	430	5610	457	15186	5680	1167	71910
5550	80	1088	5620	571	20313			
5560	114	2046	5630	666	26552			
5570	155	3380	5640	753	33626			
5580	213	5200	5650	853	41650			

47. REMARKS AND REFERENCES
*Item 4 - Part of the main dam and all of the South Dam are located in Sect 5, T5S, R69W
**Items 22 & 34 - NCDC Weather Station at Evergreen, CO

48. AGENCY MAKING SURVEY USACE-Omaha District, CENWO-ED-HF

49. AGENCY SUPPLYING DATA USACE-Omaha District, CENWO-ED-HF

50. DATE 7/26/2011

ENG FORM 1787, NOV 1966

RESERVOIR SEDIMENT DATA SUMMARY

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Chatfield Lake

NAME OF RESERVOIR

DATA SHEET NO.

DAM

1. OWNER Dept of Army; Corps of Eng	2. STREAM South Platte River	3. STATE Colorado
4. SEC. 1 TWP. 6S RANGE 69W	5. NEAREST P.O. Denver	6. COUNTY Jefferson Douglas Arapahoe
7. LAT. 39° 33' 30" LONG 105° 2' 30"	8. TOP OF DAM ELEVATION 5527.0	9. SPILLWAY CREST ELEV 5500.0

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE, AREA ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE, ACRE-FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL	5500.0	4774	206,856	234,932	
b. MULTIPLE USE	5432.0	1444	28,047	28,076	Aug 1973
c. POWER					
d. WATER SUPPLY					16. DATE NORMAL OPER. BEGAN
e. IRRIGATION					
f. CONSERVATION					
g. INACTIVE	5385.0	12	29	29	Jun 1979

17. LENGTH OF RESERVOIR 9.3* MILES — AV. WIDTH OF RESERVOIR 0.8 MILES

WATERSHED

18. TOTAL DRAINAGE AREA 3,018 SQ. MI.		22. MEAN ANNUAL PRECIPITATION 17.29 (48 years of record)** INCHES	
19. NET SEDIMENT CONTRIBUTING AREA 1261 SQ. MI.		23. MEAN ANNUAL RUNOFF 1.0 INCHES	
20. LENGTH 121 MILES	AV. WIDTH 25 MILES	24. MEAN ANNUAL RUNOFF 163,430*** AC.-FEET	
21. MAX ELEV. 14433 FEET	MIN. ELEV. 5380.0 FEET	25. ANNUAL TEMP. MEAN 47.5	RANGE 31.2 to 63.4

SURVERY DATA

26. DATE OF SURVERY	27. PERIOD YEARS	28. ACCL. YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR CONTOR INT.	31. SURFACE AREA, ACRES	32. CAPACITY, ACRE-FEET	33. C/I. RATIO, AC.-FT. PER AC.-FT.
5/3/1977	0	-	Range	22	4,774	234,932	1.44
5/22/1991	14.06	14.06	Range	22	4,778	234,446	1.43
11/6/1998	7.46	21.52	Range	22	4,779	234,207	1.43
7/20/2010	11.72	33.24	Range	22	4,782	233,061	1.43

26. DATE OF SURVERY	34. PERIOD ANNUAL PERCIPITATION	35. PERIOD WATER INTERFLOW, ACRE-FEET			36. WATER INFL. TO DATE, AC.-FT.	
		a. MEAN ANNUAL	b. MAX. ANNUAL	c. PERIOD TOTAL	a. MEAN ANNUAL	b. TOTAL TO DATE
5/3/1977						
5/22/1991	18.6	193,577	450,443	2,721,686	193,577	2,721,686
11/6/1998	17.3	132,766	334,210	990,437	172,496	3,712,123
7/20/2010	17.56	120,422	297,019	1,445,067	154,076	5,157,190

26. DATE OF SURVERY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SED. DEPOSITS TO DATE, ACRE-FEET		
	a. PERIOD TOTAL	b. AV. ANNUAL	c. PER SQ. MI.-YEAR	a. TOTAL TO DATE	b. AV. ANNUAL	c. PER SQ. MI.-YEAR
5/3/1977						
5/22/1991	486	34.57	0.0115	486	34.57	0.0115
11/6/1998	239	11.11	0.0106	725	33.69	0.0112
7/20/2010	1146	97.8	0.0324	1871	56.30	0.0187

26. DATE OF SURVERY	39. AV. DRY WGT., LBS PER CU. FT.	40. SED. DEP. TONS PER SQ. MI.-YR.		41. STORAGE LOSS PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANN.	b. TOT. TO DATE	a. PER OC.	b. TOT. TO DATE

ENG FORM 1787, NOV 1966 **PREVIOUS EDITIONS ARE OBSOLETE** (Proponent: CECW-EH-Y)

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, CREST ELEVATION										
	130-110	110-90	90-70	70-50	50-40	40-30	30-20	20-10	10-crest	crest-+10	+10-+30
	PERCENT OF TOTAL SEDIMENT LOCATED WITIN DEPTH DESIGNATION										
5/22/1991	0.2	12.8	85.6	19.6	5.3	-8.2****	3.9	2.7	-11.0****	8.2	-19.2****
11/6/1998	1.5	36.2	55.8	10.7	2.1	-0.9****	2.6	6.7	-5.0****	6.4	-16.0****
7/20/2010	1.1	17.6	29.7	15.8	10.3	7.2	10.7	5.0	-0.1****	1.2	1.4

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	-105	-110	-115	-120	-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														
7/20/2010	20.2	10.4	64.6	-5.4	2.4	1.2	4.7	1.5	0.2	0.2	****				

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV	INFLOW, AC.-FT.	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.
1991	5432.11	5434.33	75,347	2001	5432.70	5428.17	69,833
1992	5432.48	5426.79	77,553	2002	5432.09	5425.17	44,553
1993	5432.20	5426.67	71,405	2003	5433.42	5425.87	59,525
1994	5432.10	5426.34	76,775	2004	5430.18	5423.03	63,712
1995	5446.40	5427.62	334,210	2005	5432.12	5423.16	109,045
1996	5432.30	5423.60	82,585	2006	5432.60	5423.21	76,666
1997	5432.56	5426.86	118,284	2007	5434.06	5422.87	297,019
1998	5432.74	5425.67	177,010	2008	5432.51	5423.19	123,122
1999	5434.59	5423.59	227,171	2009	5433.90	5429.10	127,551
2000	5433.57	5427.48	119,839	2010	5433.60	5427.0	127,031

46. ELEVATION-AREA-CAPACITY DATA

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
5380	0	0	5432	1412	27076	5500	4782	233061
5385	10	16	5440	1817	39986	5510	5339	283648
5390	43	123	5450	2254	60344	5520	5904	339935
5400	264	1448	5460	2744	85426	5521.6	5959	349454
5410	589	5781	5470	3174	115005	5530	6453	401695
5420	925	13243	5480	3669	149205			
5430	1320	24343	5490	4172	188242			

47. REMARKS AND REFERENCES

* South Platte Arm is 5.7 miles and Plum Creek Arm is 3.6 miles

** NCDC Weather Station at Castle Rock, CO

*** 20 years of record 1977-1998

**** A negative value indicates degradation in the depth or reach designation.

48. AGENCY MAKING SURVEY USACE-Omaha District, CENWO-ED-HF

49. AGENCY SUPPLYING DATA USACE-Omaha District, CENWO-ED-HF

50. DATE 8/1/2011

ENG FORM 1787, NOV 1965

RESERVOIR SEDIMENT DATA SUMMARY

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Cherry Creek Lake

NAME OF RESERVOIR

DATA SHEET NO.

DAM

1. OWNER Dept of Army; Corps of Eng	2. STREAM Cherry Creek	3. STATE Colorado
4. SEC. 2 TWP. 5S RANGE 67W	5. NEAREST P.O. Denver	6. COUNTY Arapahoe
7. LAT. 39° 38' 30" LONG 104° 51' 30"	8. TOP OF DAM ELEVATION 5645.0	9. SPILLWAY CREST ELEV. 5610.6*

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE, AREA ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE, ACRE-FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL	5598.0	2,640	80,638	95,793	
b. MULTIPLE USE	5550.0	886	15,155	15,155	Oct 1948
c. POWER					
d. WATER SUPPLY					16. DATE NORMAL OPER. BEGAN
e. IRRIGATION					
f. CONSERVATION					
g. INACTIVE	**				Mar 1960

17. LENGTH OF RESERVOIR 3.2 MILES — AV. WIDTH OF RESERVOIR 1.3 MILES

WATERSHED

18. TOTAL DRAINAGE AREA 386 SQ. MI.		22. MEAN ANNUAL PRECIPITATION 16.86 (52 years of record)****	INCHES
19. NET SEDIMENT CONTRIBUTING AREA 380 SQ. MI.		23. MEAN ANNUAL RUNOFF 0.43	INCHES
20. LENGTH 44.2 MILES	AV. WIDTH 8.7 MILES	24. MEAN ANNUAL RUNOFF 8780	AC.-FEET
21. MAX ELEV. 7500 approx FEET	MIN. ELEV. 5504 FEET	25. ANNUAL TEMP. MEAN 49.8	RANGE 33.8 - 65.8

SURVERY DATA

26. DATE OF SURVERY	27. PERIOD YEARS	28. ACCL YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR CONTOR INT.	31. SURFACE AREA, ACRES	32. CAPACITY, ACRE-FEET	33. C/I RATIO, AC.-FT. PER AC.-FT.
4/1/1950*****	0	-	Range	13	2,640	95,793	10.91
5/24/1961	11.15	11.15	Range	10	2,641	95,087	10.83
8/17/1965	4.24	15.39	Range	13	2,636	93,857	10.69
7/11/1974	8.90	24.29	Range	11	2,636	92,796	10.57
6/15/1988	13.94	38.23	Range	12	2,642	92,127	10.49
6/1/2009*****	20.98	59.21	Range	13	2,638	91,852	10.46

26. DATE OF SURVERY	34. PERIOD ANNUAL PERCIPITATION	35. PERIOD WATER INTERFLOW, ACRE-FEET			36. WATER INFL. TO DATE, AC.-FT.	
		a. MEAN ANNUAL	b. MAX. ANNUAL	c. PERIOD TOTAL	a. MEAN ANNUAL	b. TOTAL TO DATE
4/1/1950*****						
5/24/1961	11.17					
8/17/1965	17.01	8599	24,578	36,459	8,599	36,459
7/11/1974	19.47	6501	24,387	57,859	7,178	94,318
6/15/1988	16.70	11,015	30,923	153,554	9,153	247,872
6/1/2009	16.23	14,290	28,428	314,385	11,400	562,257

26. DATE OF SURVERY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SED. DEPOSITS TO DATE, ACRE-FEET		
	a. PERIOD TOTAL	b. AV. ANNUAL	c. PER SQ. MI.-YEAR	a. TOTAL TO DATE	b. AV. ANNUAL	c. PER SQ. MI.-YEAR
4/1/1950*****						
5/24/1961	696	62.40	0.1617	696	62.40	0.1617
8/17/1965	1288	304.09	0.7878	1984	128.92	0.3340
7/11/1974	1050	117.92	0.3055	3034	124.89	0.3236
6/15/1988	675	48.42	0.1254	3709	97.01	0.2513
6/1/2009	298	14.21	0.0368	4007	67.68	0.1753

26. DATE OF SURVERY	39. AV. DRY WGT., LBS PER CU. FT.	40. SED. DEP. TONS PER SQ. MI.-YR.		41. STORAGE LOSS PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANN	b. TOT. TO DATE	a. PERIOD	b. TOT. TO DATE

ENG FORM 1787, NOV 1966 **PREVIOUS EDITIONS ARE OBSOLETE** (Proponent: CECW-EH-Y)

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, CREST ELEVATION										
	110.6-90.6	90.6-80.6	80.6-70.6	70.6-60.6	60.6-50.6	50.6-40.5	40.6-30.6	30.6-20.6	20.6-crest	c - −19.4	19.4+39.4
	PERCENT OF TOTAL SEDIMENT LOCATED WITIN DEPTH DESIGNATION										
5/24/1961	1.9	24.1	8.3	3.6	23.6	6.8	3.6	1.3	2.9	4.6	19.3
8/17/1965	0.8	24.3	12.7	2.3	12.2	13.0	13.0	3.7	1.7	6.1	10.3
7/11/1974	0.5	16.8	29.2	1.6	9.1	11.2	11.1	5.9	3.6	3.8	7.3
6/15/1988	0.4	14.0	31.4	3.6	8.3	10.9	11.6	6.5	3.2	3.5	6.4
6/1/2009	12.8	32.0	2.8	9.4	10.6	9.3	6.0	3.0	2.0	2.0	10.1

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	-105	-110	-115	-120	-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														
6/1/2009	26.8	30.6	10.5	9.6	3.3	-0.6	0.5	6.3	8.2	4.8	******				

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV	INFLOW, AC.-FT.	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.
1990	5551.75	5549.98	5,534	2000	5551.05	5549.84	21,024
1991	5551.39	5549.90	4,602	2001	5552.79	5548.89	19,482
1992	5551.48	5548.52	9,182	2002	5550.86	5549.97	8,420
1993	5550.65	5548.95	5,898	2003	5552.42	5548.84	14,253
1994	5550.90	5548.83	7,353	2004	5550.72	5549.58	9,610
1995	5551.00	5548.75	11,484	2005	5551.43	5549.22	20,404
1996	5550.90	5548.80	7,976	2006	5550.30	5548.02	12,193
1997	5550.81	5549.48	7,920	2007	5552.94	5548.20	28,428
1998	5552.16	5549.98	21,080	2008	5550.94	5548.70	19,526
1999	5553.23	5549.98	25,815	2009	5551.40	5548.50	27,126

46. ELEVATION-AREA-CAPACITY DATA

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
5520	0	0	5590	2285	72144			
5530	263	858	5598	2638	91852			
5540	587	5526	5600	2723	97214			
5550	840	12558	5610	3159	126608			
5560	1128	22357	5620	3628	160435			
5570	1455	35157	5630	4164	199227			
5580	1847	51517	5640	4740	243757			

47. REMARKS AND REFERENCES

*Spillway crest has been altered due to spillway side slope sloughing, elevation was originally 5598.0 matching the top of F.C. Pool. ** No conservation or inactive storage ***NCDC Weather Station at Cherry Creek Dam, CO **** 01 Apr is assumed date in 1950 ***** 2009 Survey is a composite of data collected in 2006, 2007, and 2009. The 1997 survey data is erroneous and not included. ****** A negative value indicates degradation in the depth or reach designation.

48. AGENCY MAKING SURVEY USACE-Omaha District, CENWO-ED-HF

49. AGENCY SUPPLYING DATA USACE-Omaha District, CENWO-ED-HF

50. DATE 8/1/2011

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Appendix F
MRD/MRR/MRB Sediment Memoranda

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

US Army Corps of Engineers ®
Omaha District

MRD/MRR/MRB Sediment Memoranda

No.	Title	Author	Date
1	Sedimentation in Kanapolis Reservoir	A. L. Hill & A. M. Gow	1955
2	1954 Aggradation Surveys in Garrison Reservoir	F. S. Witzigman & I. Sherperdson	1955
3	Degradation below Garrison Dam	F. S. Witzigman	1957
4	Observations of the Rate of Change in Sediment Concentration with Respect to Changing Hydraulic Conditions at the Head of a Reservoir	F. S. Witzigman	1955
5	Deposition in Fort Randall	R. H. Livesey	1955
6	Determination of Location and Rate of Growth of Delta Formations	L. C. Fowler	1957
7	Papillion Creek Site 11 - Sedimentation Studies and Area-Capacity Report	J. W. Garrison	1989
8	Sedimentation in Fort Peck Reservoir, 1937-1987	L. A. Timp	1989
9	Lake Francis Case Aggradation Study (Including the White River), 1953-1986	Stanley Consultants	1989
10	Cherry Creek Lake Sedimentation Studies & Area-Capacity Report	L. J. Morong	1988
11	Big Bend Project - Bad River Aggradation Assessment and Data Compilation	J. W. Garrison	1991
12	Sedimentation near the Confluence of the Missouri and Niobrara Rivers, 1954-1990	Resource Consultants and Engineers, Inc.	1992
13	Sedimentation in the Cheyenne River Arm - Lake Oahe, 1958-1991	Stanley Consultants	1993
14	Sedimentation in the Little Missouri River Arm of Lake Sakakawea	Resource Consultants and Engineers, Inc.	1993
15	Lake Oahe Aggradation Study, Volume I, 1958-1989	Resource Consultants and Engineers, Inc.	1993
15a	Lake Oahe Aggradation Study, Volume II, 1958-1989	Resource Consultants and Engineers, Inc.	1993
16	Garrison Project, North Dakota. Downstream Channel and Sediment Trends Study	J. W. Garrison	1993
16a	Garrison Project, North Dakota. Downstream Channel and Sediment Trends Study	J. W. Garrison	Updated 1999
17	Sedimentation Conditions at Pipestem Lake, North Dakota, 1973-1993	M. J. Brown	1993
18	Sedimentation Conditions at the Salt Creek Projects near Lincoln, Nebraska, 1963-1994	L. A. Timp	1995
19	Sedimentation Conditions at the Papio Creek Projects near Omaha, Nebraska, 1976-1994	L. A. Timp	1996

MRD/MRR/MRB Sediment Memoranda (Continued)

No.	Title	Author	Date
20	Sedimentation Impacts in the Cheyenne River Arm - Lake Oahe - Phase II, Projected to 2058	J. Tworek	1999
21	Phase I Study: Sedimentation at the Confluence of the Missouri and Musselshell Rivers, Fort Peck Lake, Montana, 1937 to 1998	P. Anderson	2000
22	Missouri River - Oahe Dam to Big Bend Dam Aggradation Assessment	WEST Consultants, Inc.	1999
23	Tri-Lakes Sedimentation Studies Area-Capacity Report	L. F. Schaper	2001
23a	Tri-Lakes Sedimentation Studies Area-Capacity Report	J. L. Gitt	Updated 2011
24	Missouri River - Gavins Point Project Degradation Trends Study	WEST Consultants, Inc.	2002

Appendix G
LiDAR and Area-Capacity Calculation Method Comparison Study

Tri-Lakes Sedimentation Studies Area-Capacity Report

Tri-Lakes Report for Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake near Denver, Colorado

M.R.B. Sediment Memorandum 23a

Revised: July 2011

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Omaha District

LiDAR Comparison Study

A detailed Cherry Creek basin survey was performed using LiDAR mapping, which extended to a higher elevation and covered a larger area than the range line surveys. The LiDAR data was provided to the Sedimentation and Channel Stabilization Section for comparison to the range line surveys. The LiDAR dataset was collected using vertical datum NGVD 1988, only for this comparison of data collection and analysis methods is the NGVD 1988 datum is used, the area and capacity information is otherwise reported in the Local Project Datum.

Data Processing

The LiDAR data was thinned using InRoads, Thin Surface command. The height tolerance was set at 0.5 feet, minimum distance was set at 10 feet and maximum distance was set at 150 feet. All breaklines were transferred from the original to the thinned tiles to maximize accuracy. These steps allowed the 21 tiles of original LiDAR data (each around 150 MB) to be combined to create one ground surface dtm file.

The elevation adjustment was applied to the 2009 bathymetric range line survey data to bring all data sources to the NAVD88 elevation. A constant shift of +1.76 feet was applied to the processed bathymetric data. Please see Section 2.4.2.3 regarding elevation adjustments for the Cherry Creek project.

Once processed, the LiDAR and the bathymetric data were combined to give a complete survey of Cherry Creek Lake in NAVD88. The final surface was reviewed to ensure triangles along the water's edge were not triangulating further into the water causing false slopes or elevations.

Alternative Volume and Area Calculations

Volumes and areas were calculated using Microstation/InRoads v8i by subtracting the topographic surface from a given water surface which is essentially 'cut' and 'fill' volumes and areas. Water surfaces were created using cross sections cut across the entire study area. There were 68 water surfaces developed, each at a 2-foot increment, beginning with 5520.0 (NAVD88) and going until 5650.0 (NAVD88). Water surfaces were taken up to 5 feet above the top of dam through the building of a "false wall" extending the dam vertically. Tables G-1 and G-2 display the Area and Volume for Cherry Creek Lake using the alternative (InRoads) method. All calculations were done using NAVD88 and the elevations in the chart reflect NAVD88.

The historic method of calculating volume and area uses average end area calculations within the software AreaCapacity as described in Section 2.6.1 and Appendix A. The difference between the historic and alternative InRoads method for the capacity calculations averaged around 4%. See Tables G-3 and G-4 to view the differences between the two calculation methods. The difference between the two methods increases with lower water surfaces. This could be attributed to a few variables including: the difference in software algorithms (which would be evident throughout the different water surface elevations), the difference in topographic data used, or an error in the bathymetric surveys (although no error is readily visible).

LiDAR Comparison Study Conclusions

The InRoads calculation method provides reasonable results and relies on more modern technology. At projects where LiDAR has been collected, it seems to be the fastest way to achieve area-capacity without having to send survey crews to monitor range lines. The only data that would be either dated or missing would be bathymetric data. If the LiDAR is flown at a low pool season, it would give an accurate measure of area-capacity above the water's edge.

In areas where LiDAR has not been collected, it may be more cost effective to send a survey crew up to survey the sediment range lines instead of flying LiDAR. Using the historic method of the average end area to calculate storage capacity curves would have to be done in those situations. However, if there are multiple studies ongoing at the project, LiDAR's capability to acquire ground elevations at a much denser rate may be more beneficial to a greater number of studies and perhaps then a more cost effective method.

Comparing the two methods of InRoads and Average End Area to calculate storage capacity, seems to give us higher capacity in the reservoir especially at lower lake levels. Any time both LiDAR and current storage capacity tables are available, additional comparison of the two methods would aid in a better understanding or further support or oppose the finding for Cherry Creek.

Table G-1. Area Capacity Calculated using the Alternative LiDAR-based InRoads Calculation Method

Cherry Creek Reservoir - LiDAR Based Alternative Calculation Method
Area Capacity in Acre-Feet
(2009-2010 Survey)

NAVD 88 Elevation	0	1	2	3	4	5	6	7	8	9
5520	0		0		1		34	220	405	688
5530	971	1320	1668	2071	2474	2920	3366	3863	4359	4902
5540	5445	6039	6632	7269	7905	8589	9273	10018	10763	11575
5550	12387	13242	14097	14992	15886	16841	17795	18812	19828	20909
5560	21989	23138	24287	25498	26709	27984	29259	30608	31956	33371
5570	34786	36264	37741	39283	40825	42436	44046	45736	47426	49196
5580	50966	52818	54670	56611	58551	60576	62600	64711	66822	69020
5590	71218	73501	75783	78147	80511	82962	85412	87951	90490	93114
5600	95738	98444	101149	103938	106727	109607	112486	115462	118437	121508
5610	124579	127741	130902	134147	137391	140721	144051	147473	150895	154415
5620	157935	161557	165179	168907	172635	176469	180302	184240	188177	192224
5630	196271	200429	204587	208861	213134	217537	221939	226471	231003	235662
5640	240321	245110	249899	254822	259744	264799	269853	275038	280222	285542
5650	290862									

*Blue numbers are estimated using the average of the bordering two values.

Table G-2. Surface Area Calculated using the Alternative LiDAR-based InRoads Calculation Method

Cherry Creek Reservoir - LiDAR Based Alternative Calculation Method Surface Area in Acres (2009-2010 Survey)										
NAVD 88 Elevation	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
5520	0	0	0	0	0	47	94	168	242	269
5530	296	317	338	378	418	446	473	500	527	549
5540	571	594	617	638	659	686	712	743	774	805
5550	836	855	873	898	923	954	984	1015	1045	1078
5560	1111	1146	1180	1209	1237	1274	1311	1346	1381	1413
5570	1445	1477	1509	1542	1575	1611	1647	1689	1731	1771
5580	1811	1855	1898	1940	1982	2025	2068	2112	2155	2199
5590	2242	2284	2325	2367	2408	2453	2497	2541	2584	2625
5600	2666	2706	2746	2790	2833	2881	2929	2975	3021	3069
5610	3116	3159	3201	3242	3282	3323	3364	3410	3455	3509
5620	3562	3611	3660	3719	3777	3827	3877	3931	3984	4040
5630	4096	4151	4206	4269	4332	4395	4457	4521	4585	4649
5640	4713	4785	4856	4924	4992	5059	5125	5195	5265	5338
5650	5411	2706								

*Blue numbers are estimated using the average of the bordering two values.

Table G-3. Comparison of the Capacity Calculation Methods

Capacity Comparison (Acre-feet)					
Local Elevation	**NAVD 88 Elevation**	**InRoads Calculation**	**End Area Calculation**	**Difference**	**Percent Difference**
5528.24	5530	971	474	497	51.18%
5538.24	5540	5445	4514	931	17.10%
5548.24	5550	12387	11128	1259	10.16%
5558.24	5560	21989	20421	1568	7.13%
5568.24	5570	34786	32657	2129	6.12%
5578.24	5580	50966	48341	2625	5.15%
5588.24	5590	71218	68198	3020	4.24%
5598.24	5600	95738	92490	3248	3.39%
5608.24	5610	124579	121119	3460	2.78%
5618.24	5620	157935	154133	3802	2.41%
5628.24	5630	196271	191999	4272	2.18%
5638.24	5640	240321	235509	4812	2.00%

Table G-4. Comparison of the Surface Area Calculation Methods

Surface Area Calculation Comparison (Acres)					
Local Elevation	**NAVD 88 Elevation**	**InRoads Calculation**	**End Area Calculation**	**Difference**	**Percent Difference**
5528.24	5530	296	184	112	37.84%
5538.24	5540	571	559	12	2.10%
5548.24	5550	836	780	56	6.70%
5558.24	5560	1111	1066	45	4.05%
5568.24	5570	1445	1379	66	4.57%
5578.24	5580	1811	1754	57	3.15%
5588.24	5590	2242	2193	49	2.19%
5598.24	5600	2666	2638	28	1.05%
5608.24	5610	3116	3071	45	1.44%
5618.24	5620	3562	3524	38	1.07%
5628.24	5630	4096	4041	55	1.34%
5638.24	5640	4713	4625	88	1.87%
5648.24	5650	5411			