HEART BUTTE RESERVOIR
1992 SEDIMENTATION SURVEY

U.S. Department of the Interior
Bureau of Reclamation

7-2090 (4-81)
Bureau of Reclamation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE	5. REPORT DATE
Heart Butte Reservoir 1992 Sedimentation Survey	July 1994
	6. PERFORMING ORGANIZATION CODE D-5753
7. AUTHOR(S) Joe Lyons	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bureau of Reclamation Technical Service Center Denver CO 80225	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO.
	13. TYPE OF REPORT AND PERIOD COVERED DIBR
12. SPONSORING AGENCY NAME AND ADDRESS Same	14. SPONSORING AGENCY CODE D-5753

15. SUPPLEMENTARY NOTES

Microfiche and hard copy available at the Technical Service Center, Denver, Colorado

16. ABSTRACT

The Bureau of Reclamation surveyed Heart Butte Reservoir in 1992 to monitor changes in Heart Butte Reservoir after 42.9 years of reservoir sediment accumulation. The capacity of the reservoir from the 1992 survey is estimated to be 67,146 acre-feet with a surface area of 3,290 acres at elevation 2064.5 feet. Since the reservoir's initial filling in October 1949, it is estimated that 8,898 acre-feet of sediment have been trapped in Heart Butte Reservoir. The average annual rate of sediment accumulation for the spillway crest elevation is about 207.4 acre-feet.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS-- reservoir area and capacity/ sedimentation/ reservoir surveys/ sonar/ sediment distribution/ contour area/ reservoir area/ sedimentation survey/

b. IDENTIFIERS-- Heart Butte Reservoir/ Lake Tschida/ Dakota Area Office/

c. COSATI Field/Group 13/B ***COWRR:*** 1302.66 ***SRIM:***

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (THIS REPORT) *UNCLASSIFIED*	21. NO. OF PAGES 53
	20. SECURITY CLASS (THIS PAGE) *UNCLASSIFIED*	22. PRICE

HEART BUTTE RESERVOIR

1992 SEDIMENTATION SURVEY

by

Joe Lyons

Sedimentation and River Hydraulics Section
Water Resources
Technical Service Center
Reclamation Service Center
Denver, Colorado

July 1994

ACKNOWLEDGMENTS

The Bureau of Reclamation prepared and published this report under the supervision of Wayne Graham, Acting Head, Sedimentation Section, Earth Sciences Division. Joe Lyons of the Denver Office conducted the hydrographic survey. Personnel from the Dakota Area Office of the Great Plains Region assisted during the hydrographic survey and performed the required land survey for the hydrographic and aerial data collection. Joe Lyons completed the data processing needed to generate the area-capacity tables.

U.S. Department of the Interior
Mission Statement

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

CONTENTS

Page

Introduction 1
Summary and conclusions 1
Description of the basin 2
Surveys 2
  Survey history 2
  Survey methods and equipment 2
Reservoir sediment distribution 3
  Longitudinal distribution 3
  Lateral distribution 3
  Depth distribution 3
Sediment analyses 3
  Sediment accumulation 3
  Reservoir sedimentation summary 4
Reservoir area and capacity 4
References 5

TABLES

Table

1 Reservoir sediment data summary (page 1 of 2) 6
1 Reservoir sediment data summary (page 2 of 2) 7
2 Sediment volume computations, Heart Butte Reservoir 8

FIGURES

Figure

1 Heart Butte Reservoir location map 9
2 Heart Butte Dam, plan 10
3 Heart Butte Dam, sections 11
4 Heart Butte Reservoir range lines (map 1 of 3) 13
4 Heart Butte Reservoir range lines (map 2 of 3) 15
4 Heart Butte Reservoir range lines (map 3 of 3) 17
5 Heart Butte Reservoir, thalweg profiles 19
6 Heart Butte Reservoir, North Dakota, ground profile for section 1 20
7 Heart Butte Reservoir, North Dakota, ground profile for section 2 21
8 Heart Butte Reservoir, North Dakota, ground profile for section 2N 22
9 Heart Butte Reservoir, North Dakota, ground profile for section 3 23
10 Heart Butte Reservoir, North Dakota, ground profile for section 3SW 24
11 Heart Butte Reservoir, North Dakota, ground profile for section 3S 25
12 Heart Butte Reservoir, North Dakota, ground profile for section 4 26
13 Heart Butte Reservoir, North Dakota, ground profile for section 4N 27
14 Heart Butte Reservoir, North Dakota, ground profile for section A 28
15 Heart Butte Reservoir, North Dakota, ground profile for section B 29
16 Heart Butte Reservoir, North Dakota, ground profile for section 5 30
17 Heart Butte Reservoir, North Dakota, ground profile for section 5NW 31
18 Heart Butte Reservoir, North Dakota, ground profile for section 6 32
19 Heart Butte Reservoir, North Dakota, ground profile for section 6N 33
20 Heart Butte Reservoir, North Dakota, ground profile for section 6S 34
21 Heart Butte Reservoir, North Dakota, ground profile for section 7 35
22 Heart Butte Reservoir, North Dakota, ground profile for section 7S 36
23 Heart Butte Reservoir, North Dakota, ground profile for section 8 37

CONTENTS — CONTINUED

FIGURES — CONTINUED

Figure		Page
24	Heart Butte Reservoir, North Dakota, ground profile for section 9	38
25	Heart Butte Reservoir, North Dakota, ground profile for section C	39
26	Heart Butte Reservoir, North Dakota, ground profile for section 10	40
27	Heart Butte Reservoir, North Dakota, ground profile for section 11	41
28	Heart Butte Reservoir, North Dakota, ground profile for section 12	42
29	Heart Butte Reservoir, North Dakota, ground profile for section 13	43
30	Heart Butte Reservoir, North Dakota, ground profile for section 13NW	44
31	Heart Butte Reservoir, North Dakota, ground profile for section 14	45
32	Heart Butte Reservoir, North Dakota, ground profile for section 14NW	46
33	Heart Butte Reservoir, North Dakota, ground profile for section 15	47
34	Heart Butte Reservoir, North Dakota, ground profile for section 16	48
35	Heart Butte Reservoir, North Dakota, ground profile for section 17	49
36	Heart Butte Reservoir, North Dakota, ground profile for section 18	50
37	Heart Butte Reservoir, North Dakota, ground profile for section 19	51
38	Heart Butte Reservoir, North Dakota, ground profile for section 20	52
39	Area and capacity curves - Heart Butte Reservoir	53

INTRODUCTION

Heart Butte Dam, the central feature of Reclamation's Heart Butte Unit in North Dakota, was completed in December 1949. Operation and maintenance of the dam is done by the Bureau of Reclamation. Located on the Heart River in Grant County, 18 miles south of Glen Ullin, North Dakota (fig. 1), the reservoir (known as Lake Tschida or Heart Butte Reservoir) provides flood control, recreational, and fish and wildlife benefits, in addition to supplying water for downstream irrigators.

The earthfill dam contains about 1,140,000 cubic yards of material with a structural height of 142 feet and a crest length of 1,850 feet.* The morning-glory type spillway leads to a 14-foot tube with a capacity of 5,700 cubic feet per second. The outlet works consists of a gated tube with a capacity of 700 cubic feet per second. The original general plans and sections of the dam, spillway, and outlet works are shown on figures 2 and 3.

At the time of closure, October 4, 1949, the reservoir surface area at the spillway crest elevation, 2,064.5 feet, is estimated to have been 3,423 acres with an active capacity of 76,044 acre-feet. These estimates were developed using Reclamation's ACAP85 (1985) program. Total capacity at elevation 2118.2 feet (top of surcharge, maximum water surface elevation) was estimated to be 433,000 acre-feet at the time of construction. No reservoir space allocation for sediment was made during project planning for Heart Butte reservoir. The reservoir is about 12.9 miles long with an average width of 0.4 miles at spillway elevation.

The drainage area at Heart Butte Dam is about 1,710 square miles; about 400 square miles of the Heart River watershed upstream from Heart Butte reservoir is controlled by E.A. Patterson reservoir near Dickinson, North Dakota. The basin averages 20 miles in width over an 86-mile length upstream from Heart Butte reservoir.

SUMMARY AND CONCLUSIONS

This report presents the results of an investigation to monitor changes in Lake Tschida (Heart Butte Reservoir) after 42.9 years of reservoir sediment accumulation. Also, field survey techniques and equipment used in the study are described.

The primary purpose of the 1992 survey was to gather data to compute the capacity of Lake Tschida and evaluate the sediment deposition and distribution in the reservoir. Concerns about the fishery within Lake Tschida and local water quality were also factors in the request for a survey of reservoir sedimentation. Standard land surveying techniques were used to relocate the reservoir sedimentation ranges established in 1949. Much of the reservoir and tributary ranges were surveyed in this way during the summer and fall of 1992 and the spring of 1993. Some data were gathered within the reservoir limits by drilling through ice cover and probing the channel bottom during winter of 1992-93.

* The definition of terms such as "structural height," "hydraulic height," etc., may be found in manuals such as Reclamation's *Design of Small Dams* and *Guide for Preparation of Standing Operating Procedures for Dams and Reservoirs*, or ASCE's *Nomenclature for Hydraulics*.

On August 25, 1992, a hydrographic survey of range lines 1 through 5 was conducted using boat-mounted sonic depth recording equipment and a land-based EDM (electronic distance measuring) device. This system produced a continuous record of reservoir depth as the boat was steered across a range line. Horizontal distance from the boat to an established point on the range line was periodically measured and recorded on the continuous depth trace of the range line. A reservoir water surface elevation read on the gauge at the dam for August 25, 1992, was used in converting sonic depth measurements to true bottom elevations and to delineate cross section profiles.

The capacity of the reservoir from the 1992 survey is estimated to be 67,146 acre-feet with a surface area of 3,290 acres at elevation 2,064.5 feet. Area - capacity information for Heart Butte Reservoir which reflect the sediment deposition found in 1992 are published separately (Reclamation, 1994).

DESCRIPTION OF THE BASIN

The Heart River basin extends westward from its confluence with the Missouri River near Bismarck, North Dakota (approximate elevation 1,600 feet) to a maximum elevation of about 3,000 feet in western North Dakota. Much of the basin is devoted to agriculture, including small grains, row crops, and pasture for livestock operations. Average annual precipitation is about 16 inches; mean annual runoff was about 86,450 acre-feet from 1950 to 1992. Temperatures range from -37 to 107 °F with a mean temperature of 43 °F.

SURVEYS

Survey History

The original sediment ranges were located and surveyed by Reclamation during 1948 and 1949. The original contour surface areas were obtained from a contour map of the reservoir area developed by Reclamation in 1949. The scale for this map is 1:24,000 (1 in = 2,000 ft) and the contour interval is 10 feet. A layout of the reservoir sediment range system is shown on figure 4.

Survey Methods and Equipment

The preliminary field work for the 1992 survey consisted of locating and flagging the existing sediment range end markers and relocating those which had been lost or destroyed. Standard land surveying procedures were used to profile the portion of each range line from the range monuments to water's edge.

The hydrographic survey was completed on August 25, 1992, using sonic depth recording equipment to sound the underwater portion of 5 range lines. Low water conditions limited the accessibility of reservoir range lines upstream from range line 5 at the time of survey; these upstream ranges were completed by drilling holes in the ice cover during the winter of 1992-93 and probing the reservoir bottom.

For the hydrographic survey, procedures described by Blanton (1982) were followed. The hydrographic survey was performed using Reclamation's small boat bathymetric survey system. The small boat system consisted of a sonic depth recorder and reflector prism mounted on the boat. The distances from a known point, usually one of the end range

markers, to the small boat were determined as it proceeded along the range line by an EDM instrument set up on shore aimed at the mounted reflector target. Range distances were communicated by radio, from the shore to the boat at preselected intervals and marked on the sonar charts as the boat proceeded across the reservoir. The boat was held on course as closely as possible by radio communication from the EDM operator to the survey boat.

RESERVOIR SEDIMENT DISTRIBUTION

Longitudinal Distribution

The distribution of sediment throughout the length of the reservoir is illustrated in part by plots of the thalweg profiles representing the original and 1992 resurveyed profiles of the main channel (fig. 5). Thalweg elevations representing original reservoir conditions are taken from the original range survey notes. Thalweg elevations for the 1992 profiles were derived from the sonar charts and from field notes of the ground survey.

This comparative plot of thalweg profiles illustrates the placement of sediment deposits in the reservoir pool. The delta deposits are associated with a range of elevations approximated by the top of conservation pool elevation (2064.5 ft).

Lateral Distribution

Ground profiles for 33 of the original sediment ranges were remeasured in this study and are shown on figures 6 through 38. Tributary portions of the range lines are shown separate from the main channel portions in these plots. The 1992 range profile data are superimposed on these plots to indicate the changes which have occurred and to represent in general the lateral distribution of sediment within the reservoir. Most of the sediment deposition is located within the historic river channel, although deltaic deposits are apparent in the vicinity of range 6 at an elevation range approximated by the spillway elevation.

Depth Distribution

The computation of sediment distribution by elevation is given in section 43 of the Reservoir Sediment Data Summary (table 1). About 61 percent of the deposited sediment is found within the elevation range 2034.5 to 2064.5 feet. An additional 14 percent of the total sediment deposition is found within a range of 0 to 20 feet above the spillway crest (2064.5 feet to 2084.5 feet). The remaining 25 percent of the deposited sediment is located below elevation 2034.5 feet.

SEDIMENT ANALYSES

Sediment Accumulation

Sediment has accumulated in Lake Tschida to a total volume of 8,898 acre-feet at the spillway elevation (2064.5 feet). At the flood control elevation of 2118.2 feet, the estimate of total sediment deposition is about 10,353 acre-feet. The average annual accumulation rate for the spillway crest elevation is about 207.4 acre-feet per year (241.3 acre-feet per year for the flood control elevation). Over the contributing basin area, this rate equates to 0.16 acre-feet per square mile per year (0.18 acre-feet per square mile per year for the sediment deposited up to the flood control elevation) for the same period. The results of the sediment

volume computations are shown in table 2. Column (2) in the table gives the original measured contour areas. The original capacity values were recomputed using the ACAP85 procedure and the original measured surface areas. Thus, the capacities in column (3) differ somewhat from those found in the original estimates for Heart Butte Reservoir. The discrepancy was caused by computational procedure differences between the least squares curve fitting technique used for producing the recomputed capacities and the volume estimating procedure used in the original area - capacity table.

Reservoir Sedimentation Summary

A summary of the reservoir sediment data for the 1992 survey is shown in table 1. The data include a tabulation of incremental sediment inflow volume and sediment accumulation computed for the storage period between 1949 and 1992. Also included are data describing the drainage basin, inflow records, reservoir operation, and reservoir storage.

RESERVOIR AREA AND CAPACITY

The 1992 reservoir surface areas were computed by the Width Adjustment Method described by Blanton (1982). Briefly, the method entails computing the revised contour areas between any two ranges by applying an adjustment factor to each of the original segmental contour areas between adjacent ranges. The adjustment factor is determined as the ratio of the new average width to the original average width for both the upstream and downstream ranges at a specified contour. Computations were facilitated by subdividing the reservoir into segments using the sedimentation range lines to delineate the limit of each segmental boundary. Segmental contour areas for each elevation were determined by digitizing the segmental contours on the original topography. For any given contour elevation, the original segmental area was multiplied by the adjustment factor to obtain the 1992 surface area for that elevation. The total surface area at a given contour elevation was computed as the summation of all segmental areas at that elevation. These computations were obtained by means of Reclamation's RESSED computer program.

The 1992 surface areas were used as control parameters for computing the reservoir capacities by means of Reclamation' ACAP85 (1985) program. The resulting surface area and storage capacity versus elevation relationships are shown graphically on figure 39. The results include computations of surface area for 0.01- to 1.0-foot elevation increments by linear interpolation between measured contour areas. The respective capacities and capacity equations are then obtained by integration of the area equations. The initial capacity equation is tested over successive intervals to check whether it fits within an allowable error margin. This one equation is used over the whole range that fits within this error term. At the next interval beyond, a new capacity equation (integrated from the basic area equation over that interval) begins testing the fit until it too exceeds the error term. The capacity curve thus becomes a series of curves, each fitting a certain region of data. The final area equations are obtained by differentiation of the capacity equations. Capacity equations are of the form:

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

where:

y = capacity,
x = elevation above a reference base,
a = intercept, and
a_2 and a_3 = coefficients

Results of the 1992 area and capacity computations are listed in columns (4) and (5) of table 2. Listed in columns (2) and (3) of this table are the original area and capacity values. Capacity values have been revised by using the same curve fitting technique as was used for the 1992 area and capacity computation. Area and capacity tables have been published separately for the 0.01-, 0.10-, and 1-foot elevation increments (Reclamation, 1994. Both the original and 1992 area and capacity curves are plotted on figure 39. At the top of active conservation elevation, 2064.5 feet, the 1992 capacity is 67,146 acre-feet and the surface area is 3,290 acres.

REFERENCES

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

Blanton, J.O. III, *Procedures for Monitoring Reservoir Sedimentation: Technical Guideline for Bureau of Reclamation*, Reclamation Service Center, Denver, CO, October 1982.

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

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

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

Bureau of Reclamation, Heart Butte Reservoir Area and Capacity Tables, Reclamation Service Center, Denver, CO, July 1994.

RESERVOIR SEDIMENT
DATA SUMMARY

Heart Butte (Lake Tschida)
NAME OF RESERVOIR

39 -
DATA SHEET NO.

DAM

1. OWNER Bureau of Reclamation	2. STREAM Heart River	3. STATE North Dakota
4. SEC 13 T 136 S R 89 W	5. NEAREST PO Glen Ullin, ND	6. COUNTY Grant
7. LAT 46° 36′ LONG 101° 49′	8. TOP OF DAM 2,124.0	9. SPILLWAY CREST 2,064.5 [1]

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, Ac	13. ORIGINAL CAPACITY, AF	14. GROSS STORAGE ACRE FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL	2,118.2[2]	10,985	356,346[3]	433,000	
b. MULTIPLE USE					10/4/49
c. POWER					
d. WATER SUPPLY					16. DATE NORMAL OPERATION BEGAN
e. IRRIGATION					
f. CONSERVATION	2,064.5	3,423	69,905[3]	76,654	
g. INACTIVE	2,030.0	814	6,749[3]	6,749	10/4/49

17. LENGTH OF RESERVOIR 12.9 MILES — AVG. WIDTH OF RESERVOIR 0.4 MILES

BASIN

18. TOTAL DRAINAGE AREA 1,710 SQ. MI.	22. MEAN ANNUAL PRECIPITATION 16.2 IN.[4]
19. NET SEDIMENT CONTRIBUTING AREA 1,310 SQ. MI.	23. MEAN ANNUAL RUNOFF 1.1 IN.
20. LENGTH 86.0 MI. AV. WIDTH 20.0 MI.	24. MEAN ANNUAL RUNOFF 99,000 AC.-FT.[4]
21. MAX. ELEV. 3,000 FT. MIN. ELEV. 2,000 FT.	25. ANNUAL TEMP. MEAN 43 °F RANGE -37 to 107 °F[4]

SURVEY DATA

26. DATE OF SURVEY	27. PER. YRS.	28. ACCL. YRS.	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVAL	31. SURFACE AREA, AC.	32. CAPACITY ACRE-FEET	33. C/I RATIO AF/AF
10/4/49	0		Contour(D)	10 ft.	3,423[5]	76,044[5]	0.77
8/25/92	42.9	42.9	Range(D)	20	3,290	67,146	0.68

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIP.	35. PERIOD WATER INFLOW, ACRE FEET			36. WATER INFLOW TO DATE, AF	
		a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	a. MEAN ANN.	b. TOTAL
8/25/92	16.1[6]	86,450[7]	306,870[7]	3,717,300[7]	86,450[7]	3,717,300[7]

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SEDIMENT DEPOSITS TO DATE, AF		
	a. TOTAL	b. AV. ANN.	c. /MI.^{2}-YR.	a. TOTAL	b. AV. ANNUAL	c. /MI.^{2}-YR.
8/25/92	8,898	207.4	0.16	8,898	207.4	0.16
				10,353[8]	241.3[8]	0.18[8]

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT^3)	40. SED. DEP. TONS/MI.^{2}-YR.		41. STORAGE LOSS, PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.
8/25/92	N/A			0.27	11.6		
				0.06[8]	2.4[8]		

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

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW AND ABOVE CREST ELEVATION								
	-60 to -50	-50 to -40	-40 to -30	-30 to -20	-20 to -10	-10 to 0	0 to 10	10 to 20	
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION								
8/25/92	2	6	17	23	23	15	9	5	

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-105	105-110	110-115	115-120	120-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														
	N/A														

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1950	2,081.67	2,015.10	167,800[9]	1972	2,079.75	2,059.56	251,810[10]
1951	2,074.62	2,058.98	92,080[9]	1973	2,069.20	2,057.93	90,359[10]
1952	2,086.23	2,059.23	141,800[9]	1974	2,064.25	2,056.87	25,496[10]
1953	2,066.45	2,059.80	25,990[9]	1975	2,073.80	2,056.39	175,042[10]
1954	2,071.95	2,057.99	76,990[9]	1976	2,065.77	2,058.10	39,466[10]
1955	2,064.99	2,058.56	29,660[10]	1977	2,068.00	2,057.40	75,637[10]
1956	2,065.05	2,056.71	33,788[10]	1978	2,083.77	2,061.40	245,489[10]
1957	2,067.25	2,056.04	52,982[10]	1979	2,069.30	2,060.63	143,948[10]
1958	2,066.20	2,058.50	37,330[10]	1980	2,064.12	2,060.11	18,879[10]
1959	2,069.30	2,055.80	68,533[10]	1981	2,061.69	2,058.86	18,076[10]
1960	2,066.26	2,056.00	51,766[10]	1982	2,073.70	2,061.41	306,872[10]
1961	2,061.00	2,053.50	1,962[10]	1983	2,067.80	2,061.78	125,797[10]
1962	2,062.60	2,052.50	26,697[10]	1984	2,068.33	2,058.98	78,950[10]
1963	2,066.00	2,058.60	37,120[10]	1985	2,064.48	2,058.91	20,207[10]
1964	2,069.16	2,058.51	51,138[10]	1986	2,073.19	2,058.90	146,623[10]
1965	2,067.95	2,060.43	94,180[10]	1987	2,069.76	2,059.84	111,463[10]
1966	2,069.18	2,059.12	111,596[10]	1988	2,062.05	2,055.07	7,120[10]
1967	2,068.93	2,058.76	155,152[10]	1989	2,061.68	2,055.02	15,903[10]
1968	2,062.18	2,058.18	19,256[10]	1990	2,056.58	2,051.70	6,838[10]
1969	2,072.86	2,058.25	169,450[10]	1991	2,055.12	2,049.23	4,009[10]
1970	2,082.70	2,058.54	198,831[10]	1992	2,051.95	2,049.00	6,514[10]
1971	2,068.72	2,058.34	158,697[10]				

46. ELEVATION - AREA - CAPACITY DATA FOR 1949 AND 1992[5]

ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.
1949 (Min. elev. 2,003.8')						1992 (Min. elev. 2,009.4')					
2,010	44	132	2,070	3,856	96,062	2,010	44	22	2,070	3,774	86,594
2,020	242	1,562	2,080	5,018	140,432	2,020	181	1,149	2,080	4,968	130,300
2,030	814	6,842	2,090	6,059	195,817	2,030	634	5,225	2,090	6,051	185,395
2,040	1,382	17,822	2,100	7,566	263,942	2,040	1,133	14,059	2,100	7,577	253,535
2,050	2,136	35,412	2,110	9,348	348,512	2,050	1,890	29,173	2,110	9,348	338,159
2,060	3,069	61,437	2,120	11,344	451,972	2,060	2,910	53,175	2,120	11,344	441,619
2,064.5	3,423	76,044				2,064.5	3,299	67,146			

47. REMARKS AND REFERENCES

[1] Top of active conservation.
[2] Top of surcharge, maximum water surface elevation.
[3] Original storage allocations.
[4] *Project Data Book*, USBR.
[5] Original area and capacity values recomputed by current methods (ACAP85) for comparison with 1992 values to compute sediment deposition.
[6] Computed from Dickinson ND Experiment Station weather station (1949 - 1992).
[7] Estimated, see notes 9 and 10 for details of inflow data.
[8] Total sediment deposits including measured deposition above crest elevation of 2064.5 feet to elevation 2118.2 feet.
[9] Inflow for USGS gauge 06345500, Heart River near Richardton, ND (D.A. = 1,240 square miles).
[10] Computed inflow from changes in reservoir contents.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE 2/94

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

	1949 ORIG.	1949 ORIG.	1992 COMP.	1992 COMP.	COMP.SED.	PERC. OF
ELEV.,FT	AREA (AC.)	CAPA. (AF.)	AREA (AC.)	CAPA. (AF.)	VOL. (AF)	COMP. SED.
2120	11344	451972	11344	441619	10353	100
2115	10346	397747	10346	387394	10353	100
2110	9348	348512	9348	338159	10353	100
2105	8458	303999	8462	293633	10366	100
2100	7566	263942	7577	253535	10407	101
2095	6812	227996	6814	217558	10438	101
2090	6059	195817	6051	185395	10422	101
2085	5538	166823	5509	156493	10330	100
2080	5018	140432	4968	130300	10132	98
2075	4437	116794	4371	106955	9839	95
2070	3856	96062	3774	86594	9468	91
2064.5	3423	76044	3299	67146	8898	86
2060	3069	61437	2910	53175	8262	80
2055	2602	47258	2400	39899	7359	71
2050	2136	35412	1890	29173	6239	60
2045	1759	25674	1511	20670	5004	48
2040	1382	17822	1133	14059	3763	36
2035	1098	11622	883	9019	2603	25
2030	814	6842	634	5225	1617	16
2025	528	3487	408	2622	865	8
2020	242	1562	181	1149	413	4
2015	143	599	113	414	185	2
2010	44	132	44	22	110	1
2005	7	4	0	0	4	0
2004	0	0	0	0	0	0

Table 2. - Sediment volume computations, Heart Butte Reservoir.

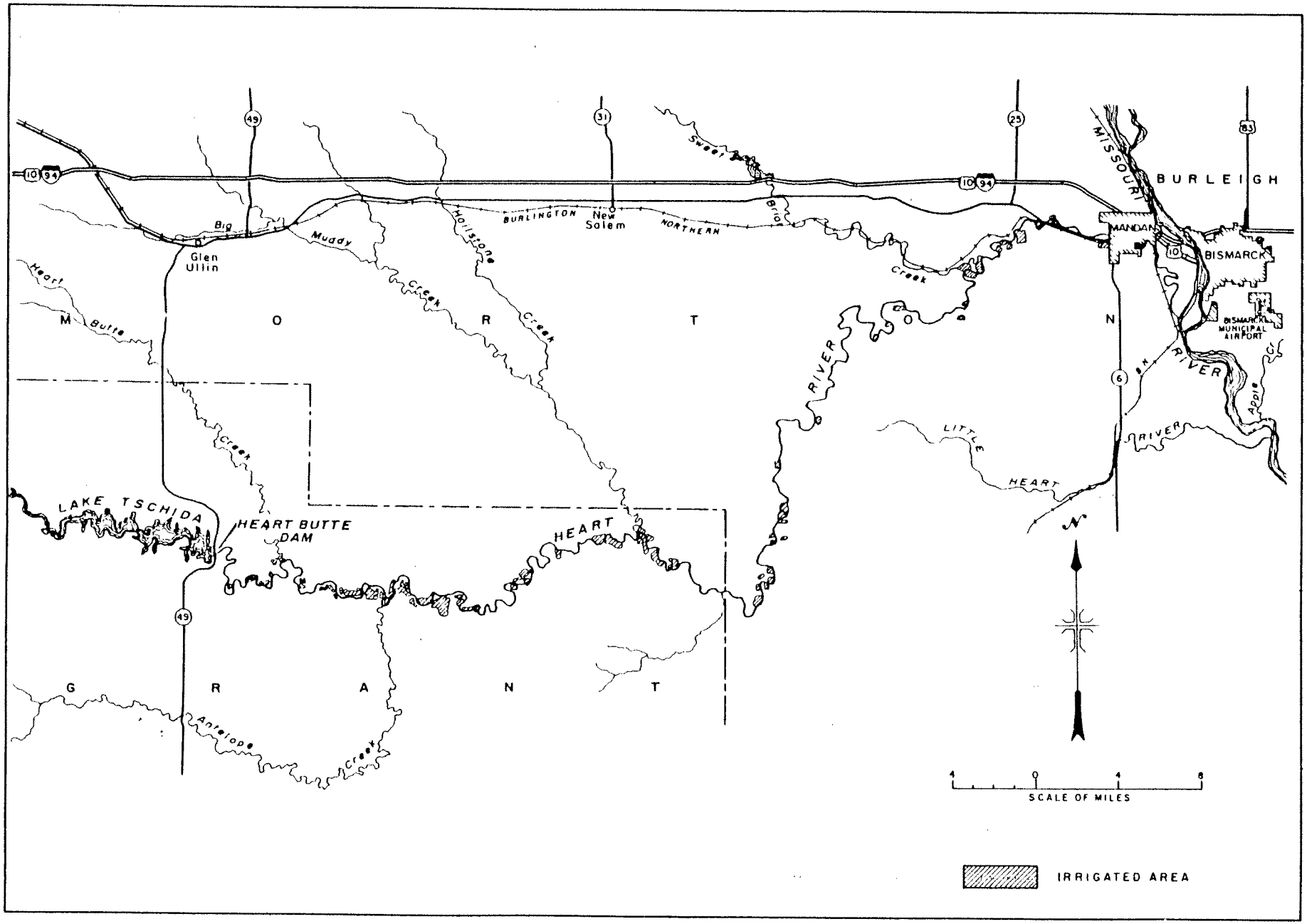

Figure 1. - Heart Butte Reservoir location map.

Space intentionally left blank due to security concerns

Space intentionally left blank due to security concerns

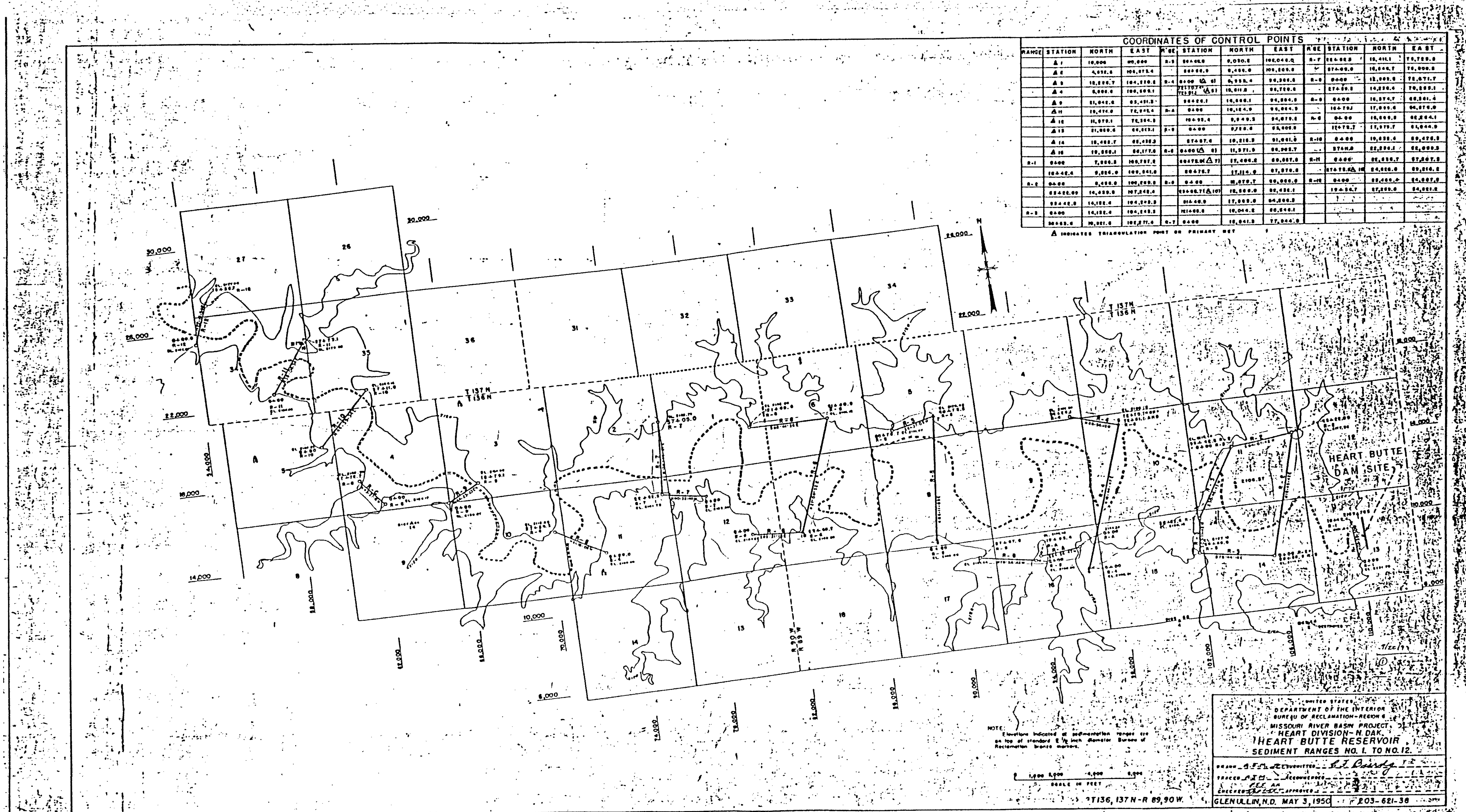

Figure 4. - Heart Butte Reservoir range lines (map 1 of 3)

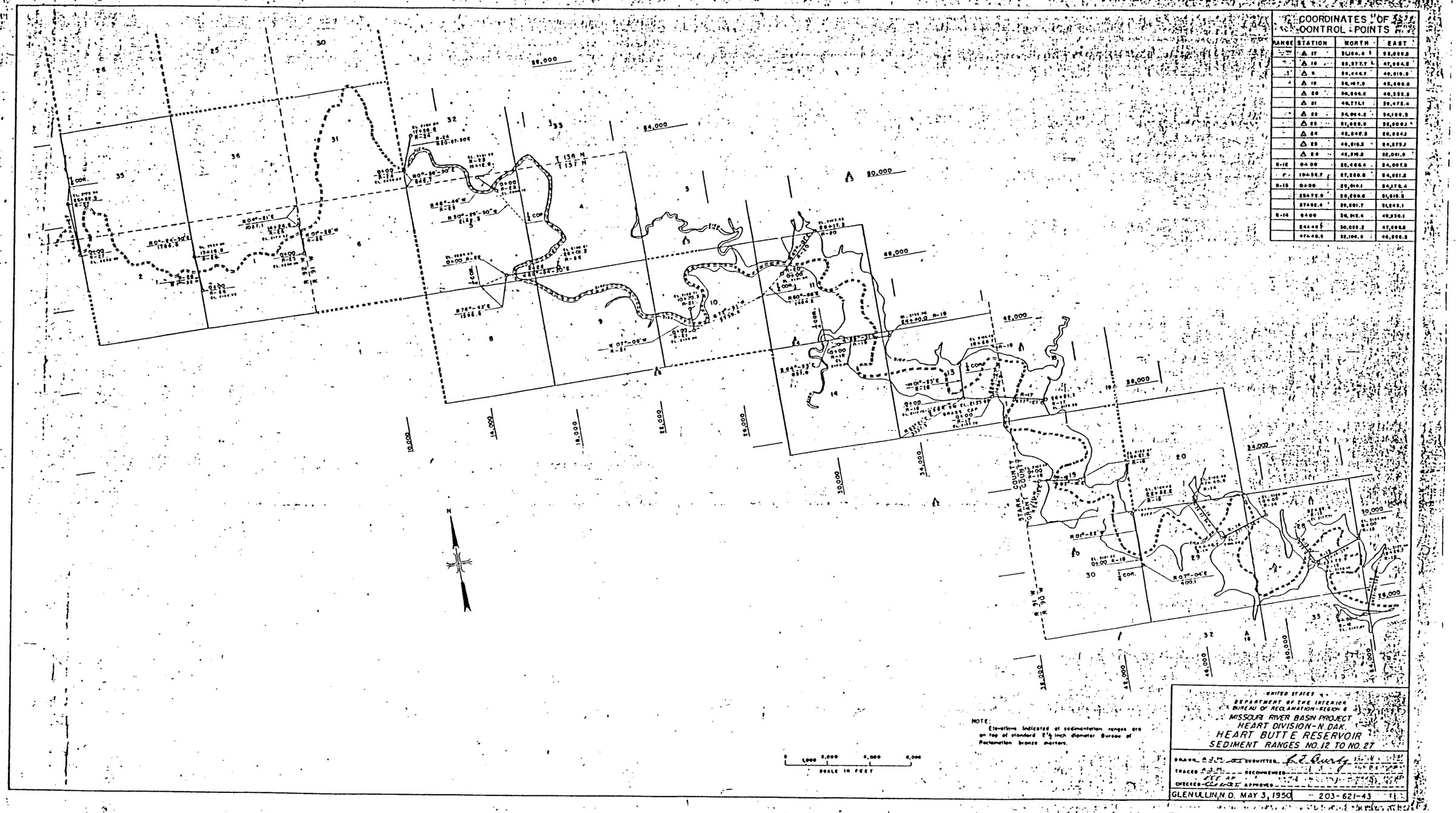

Figure 4. - Heart Butte Reservoir range lines (map 2 of 3).

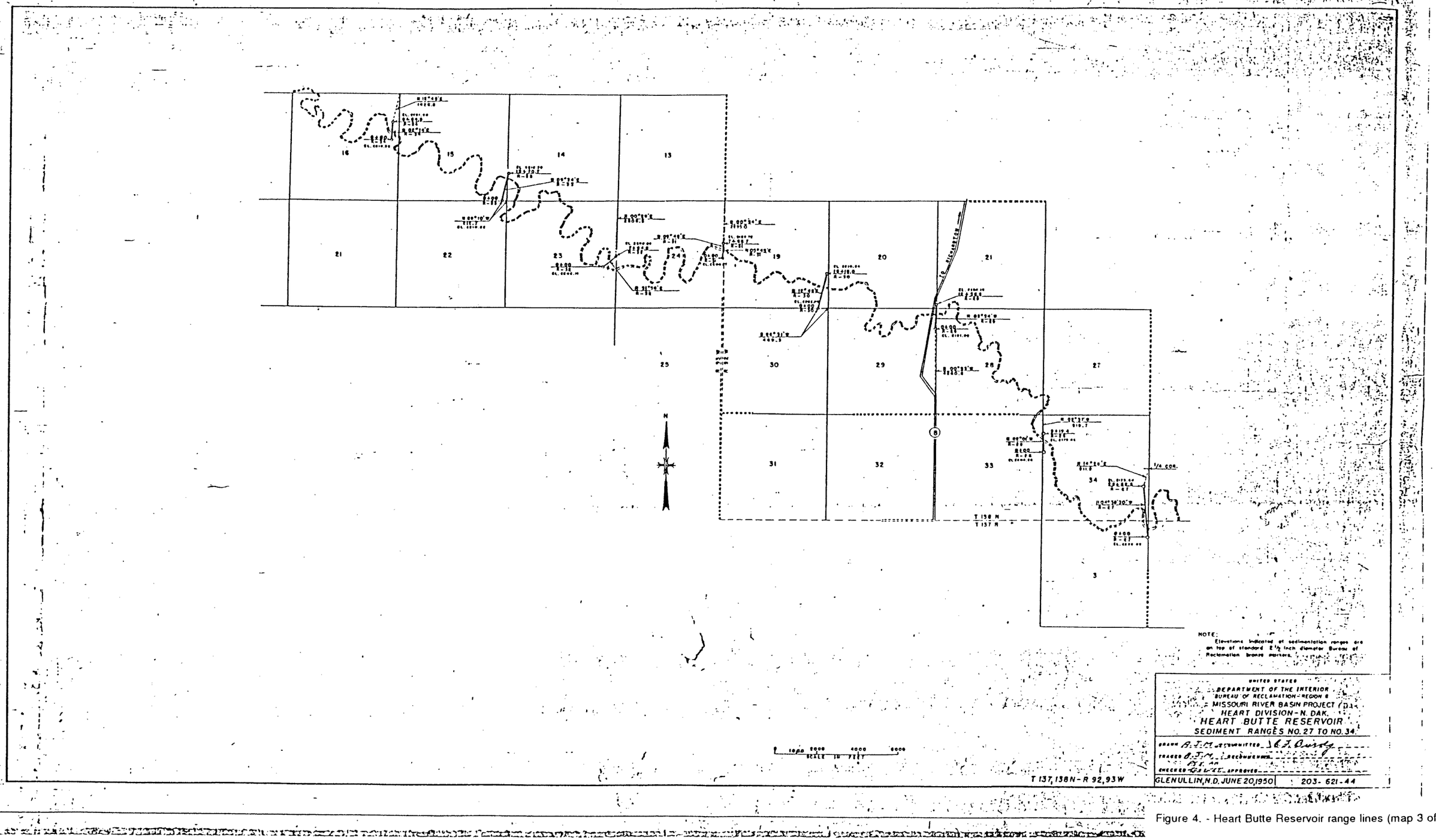

Figure 4. - Heart Butte Reservoir range lines (map 3 of 3).

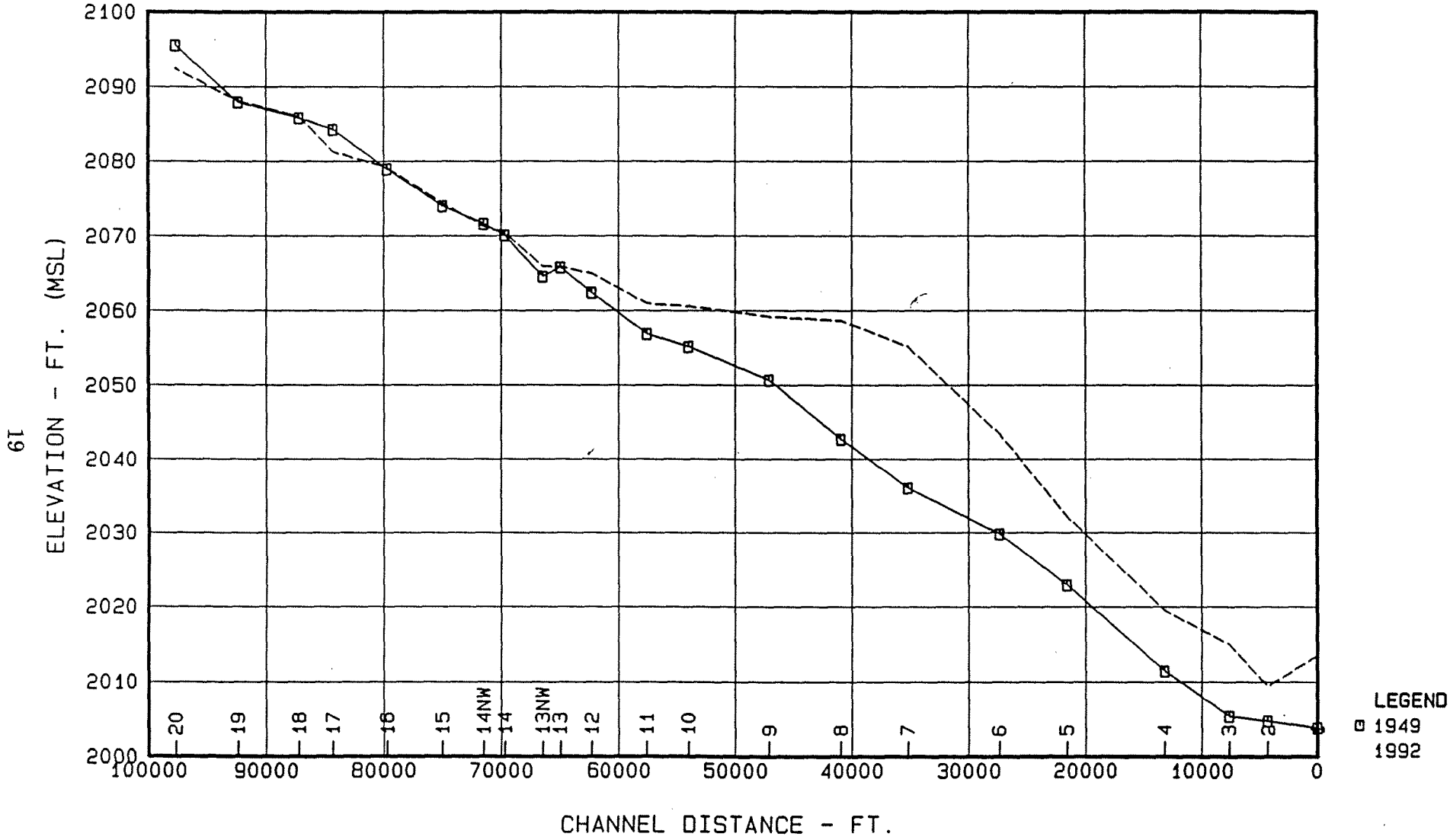

Figure 5. - Heart Butte Reservoir, thalweg profiles.

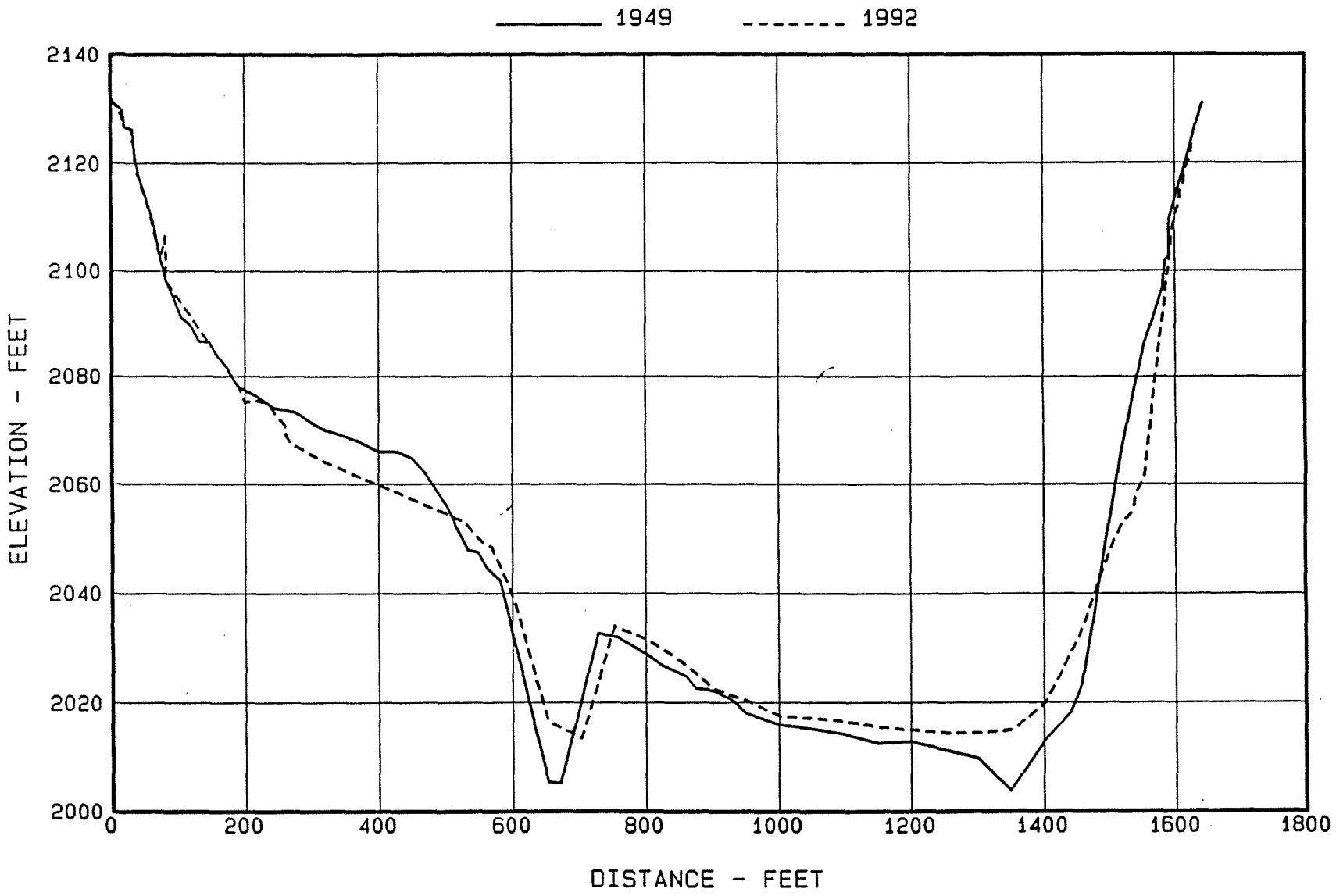

Figure 6. - Heart Butte Reservoir, North Dakota, ground profile for section 1.

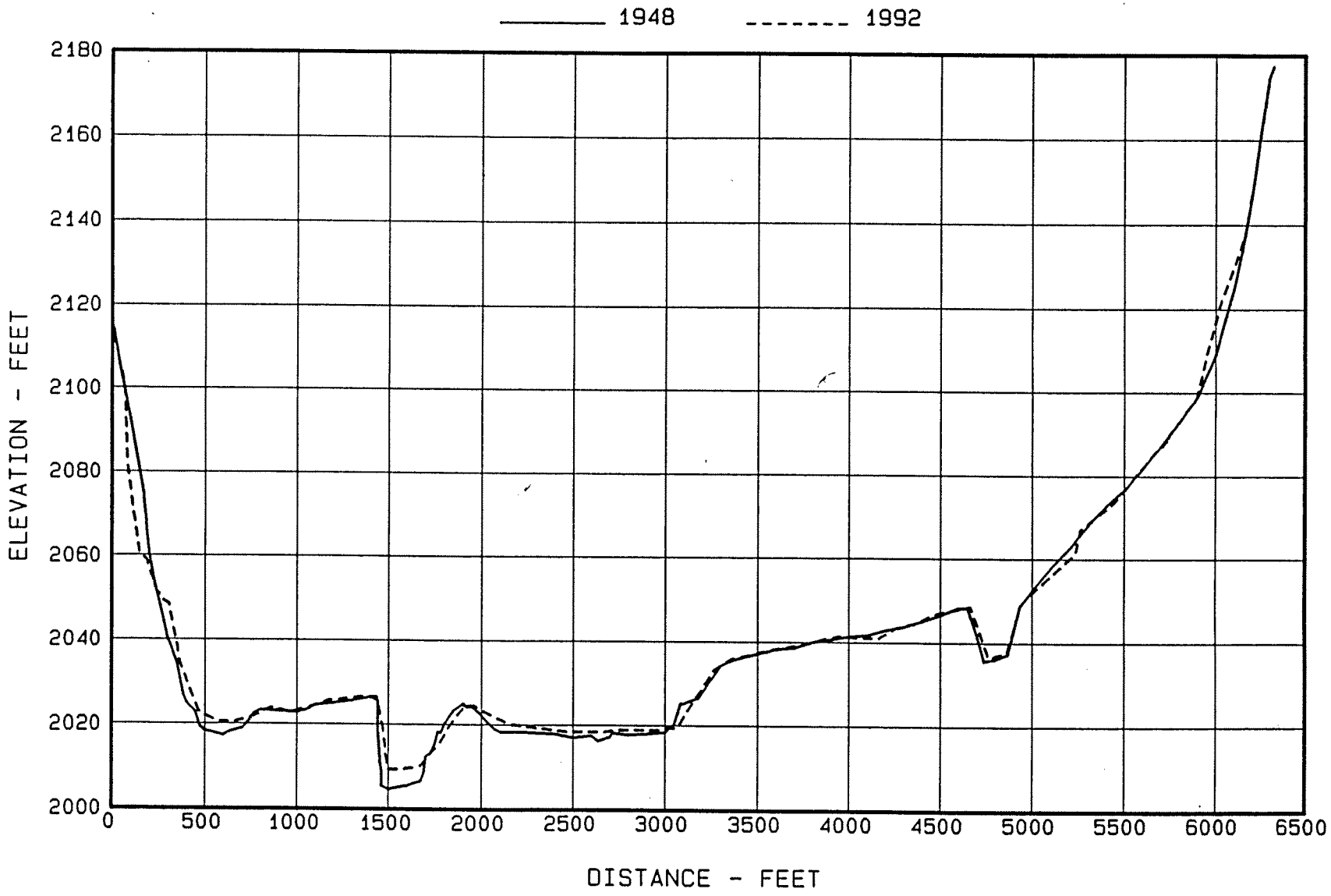

Figure 7. - Heart Butte Reservoir, North Dakota, ground profile for section 2.

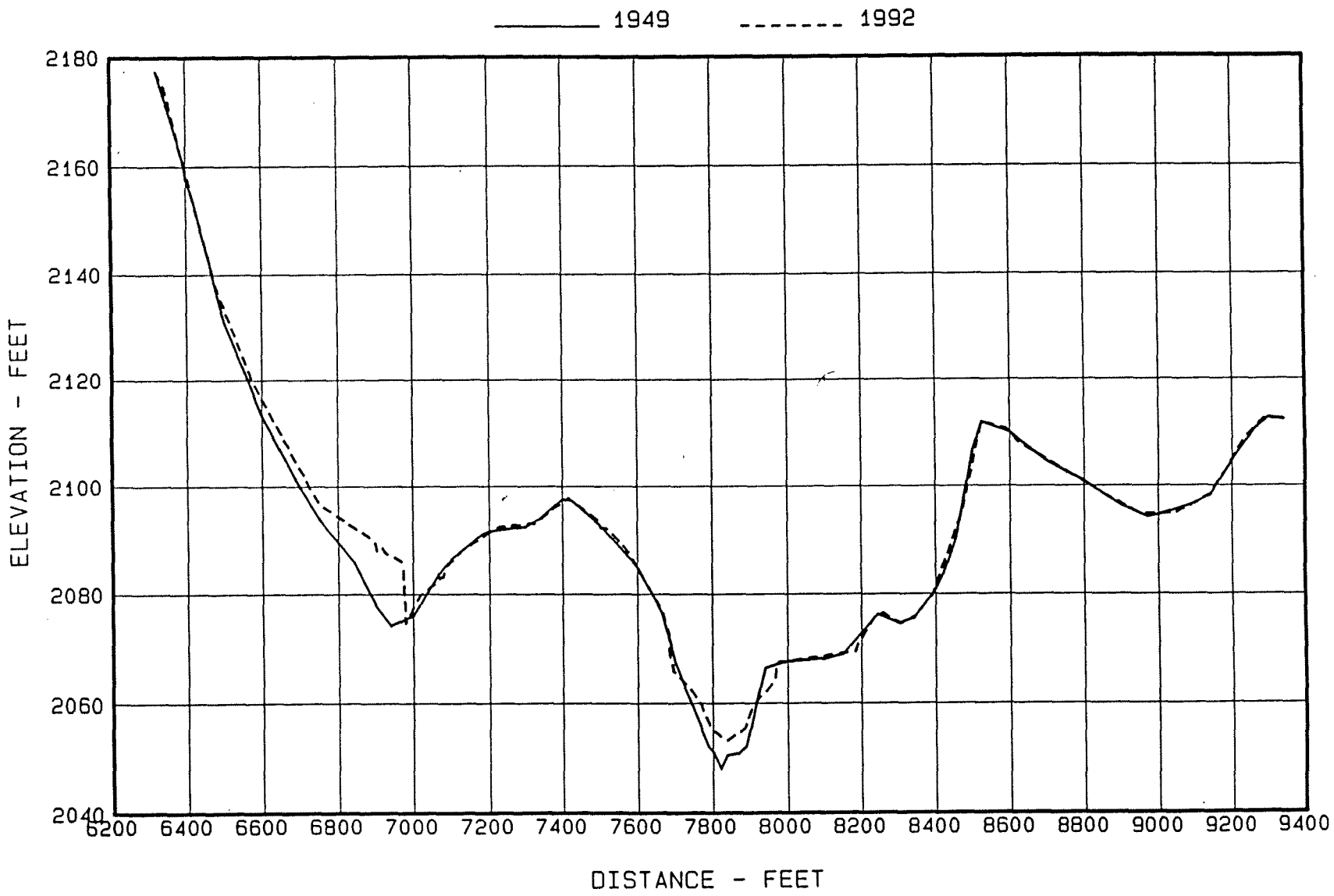

Figure 8. - Heart Butte Reservoir, North Dakota, ground profile for section 2N.

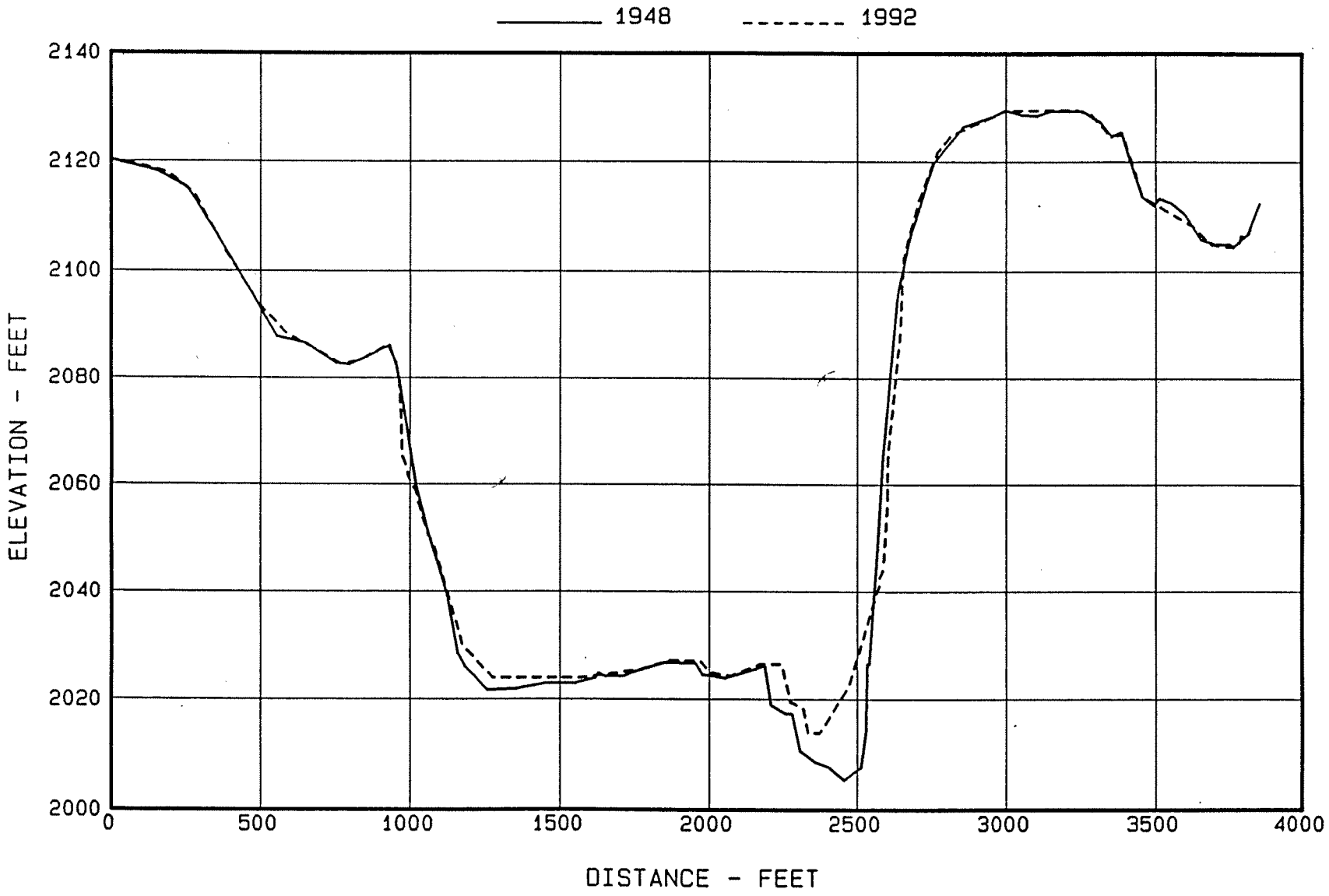

Figure 9. - Heart Butte Reservoir, North Dakota, ground profile for section 3.

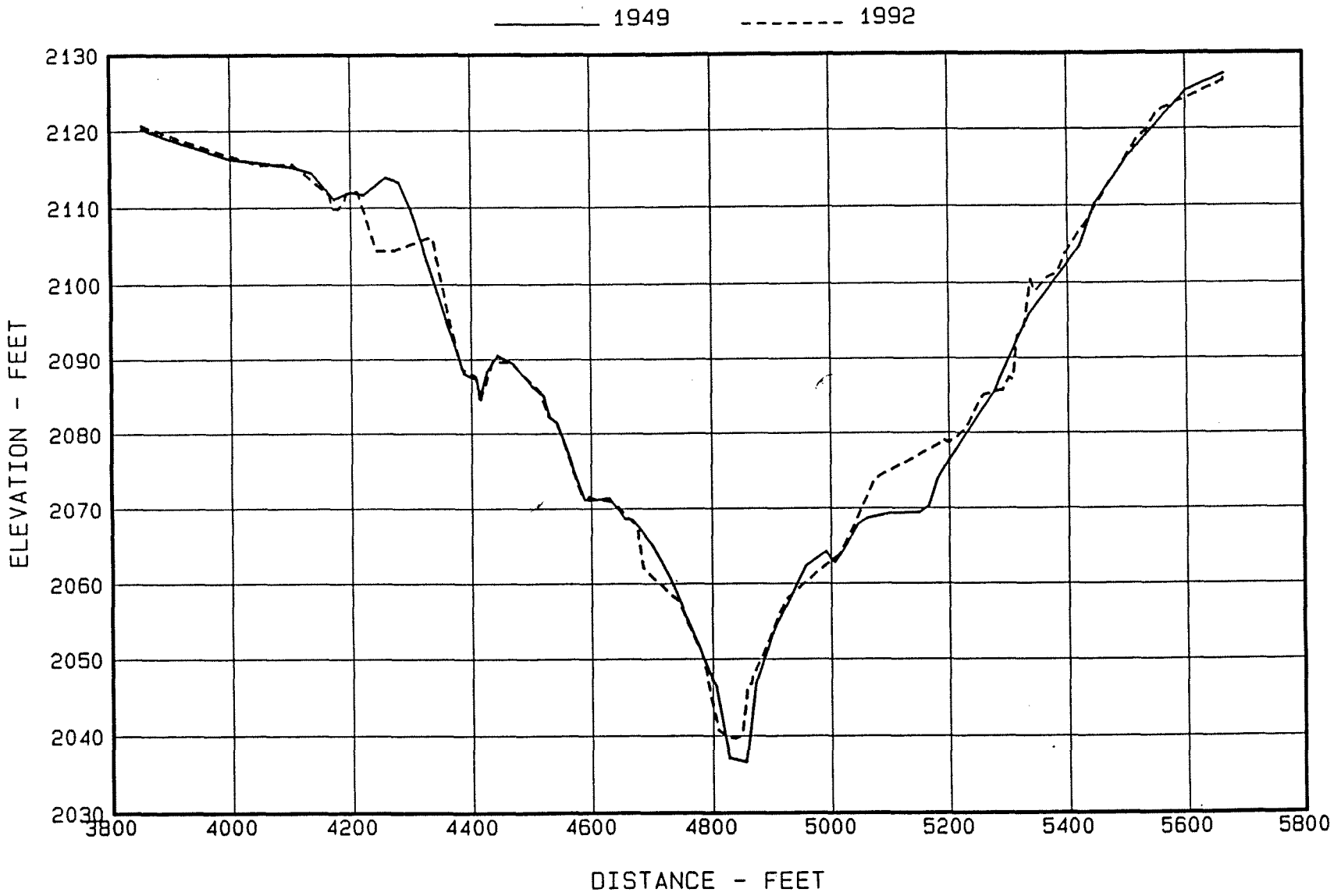

Figure 10. - Heart Butte Reservoir, North Dakota, ground profile for section 3SW.

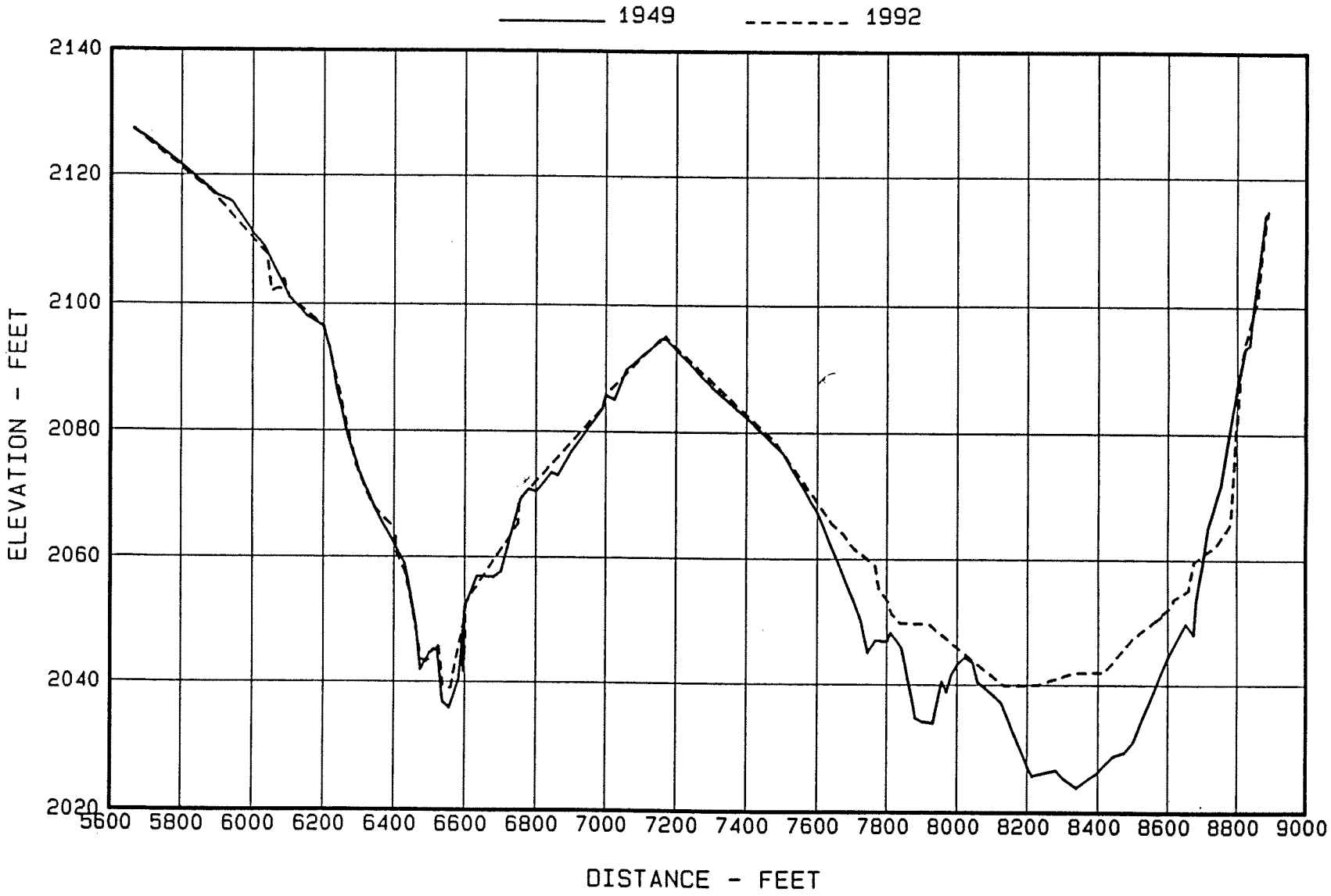

Figure 11. - Heart Butte Reservoir, North Dakota, ground profile for section 3S.

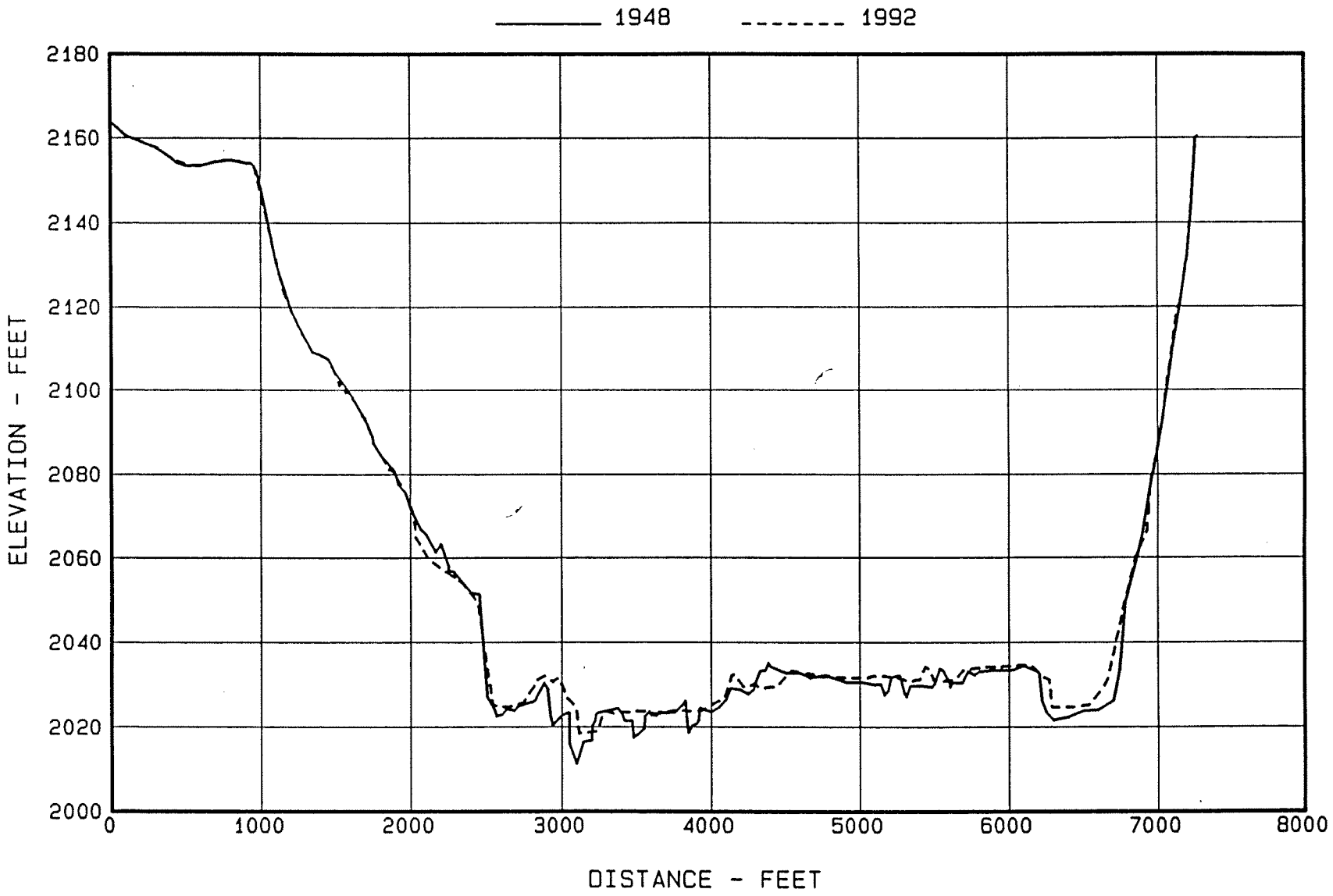

Figure 12. - Heart Butte Reservoir, North Dakota, ground profile for section 4.

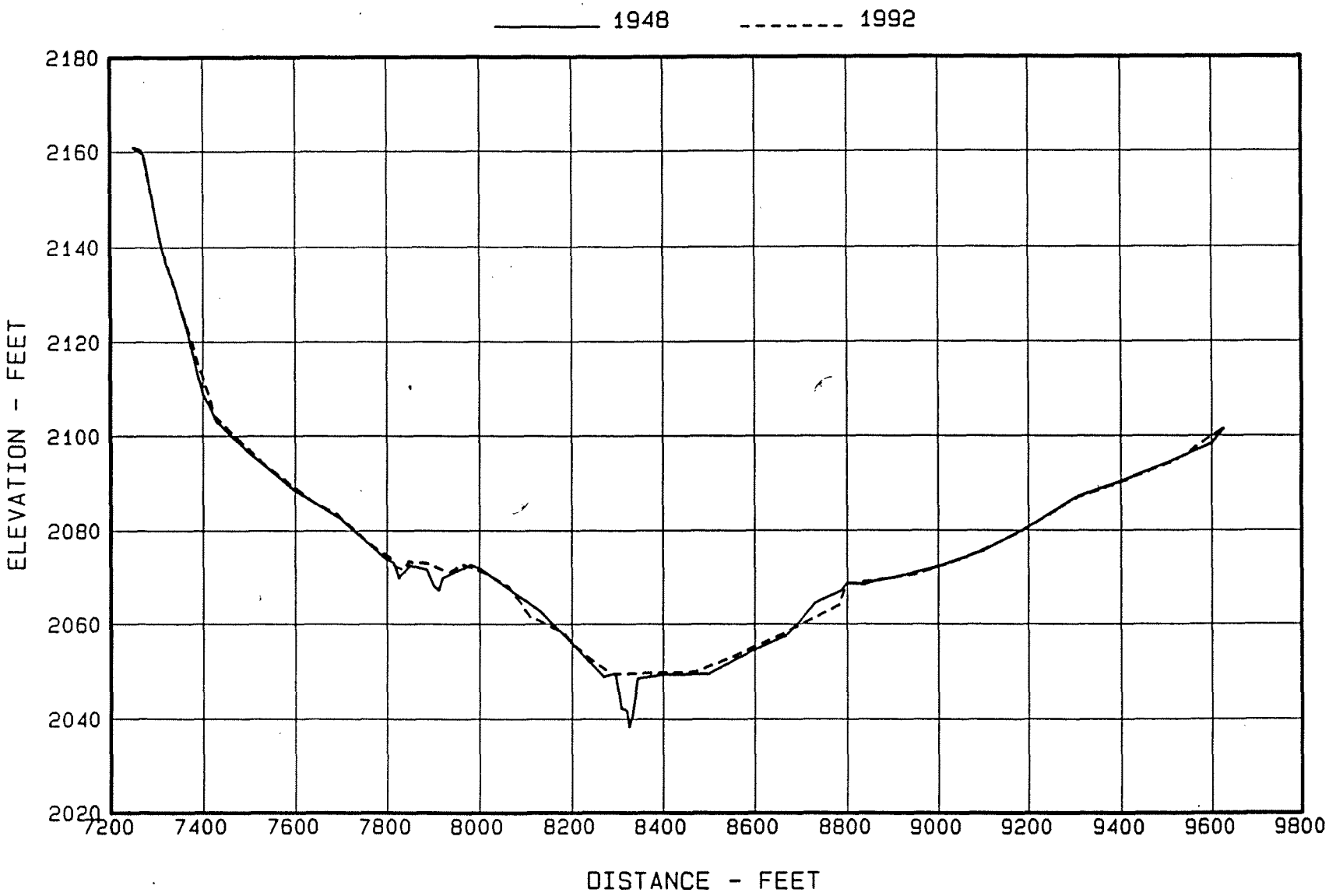

Figure 13. - Heart Butte Reservoir, North Dakota, ground profile for section 4N.

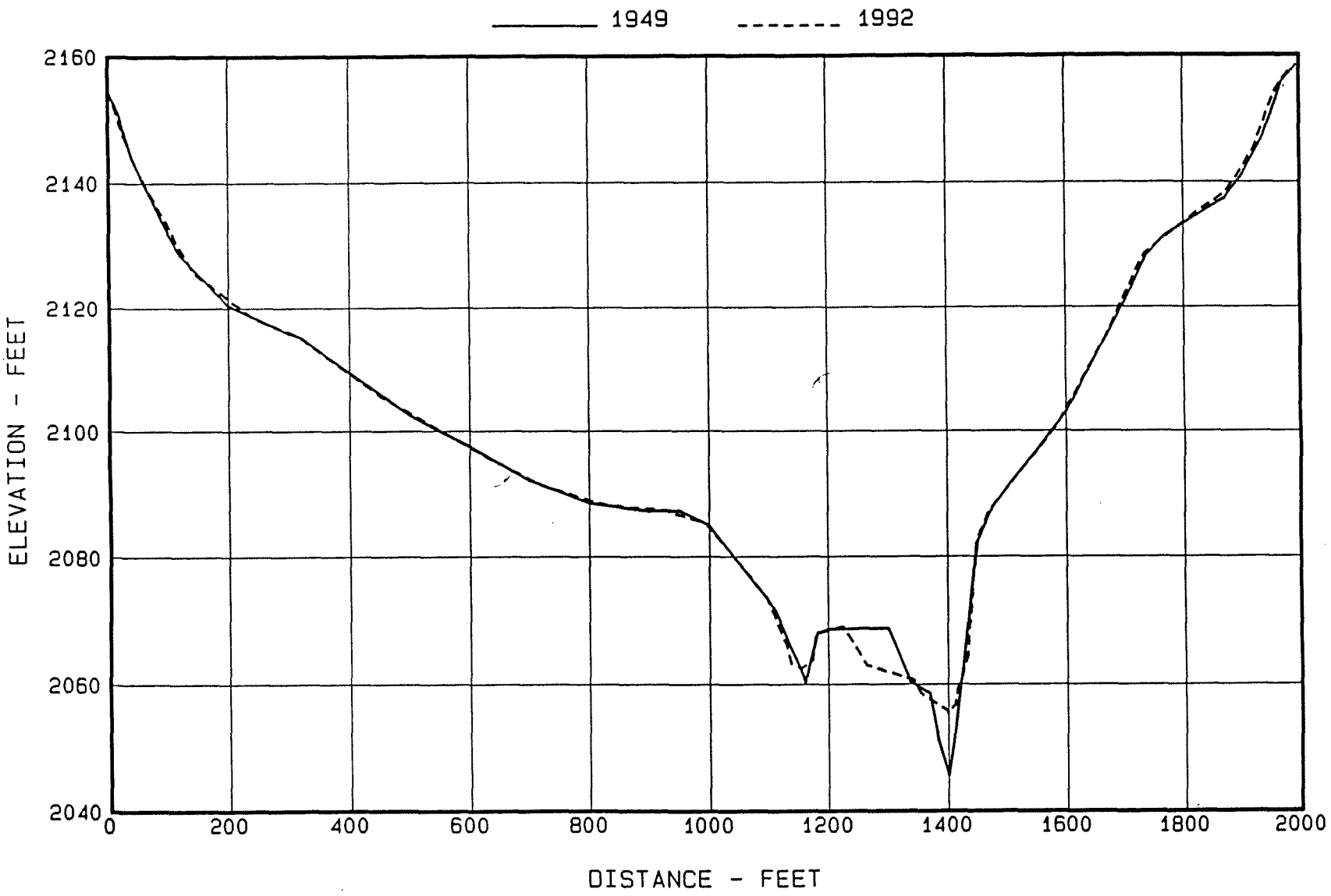

Figure 14. - Heart Butte Reservoir, North Dakota, ground profile for section A.

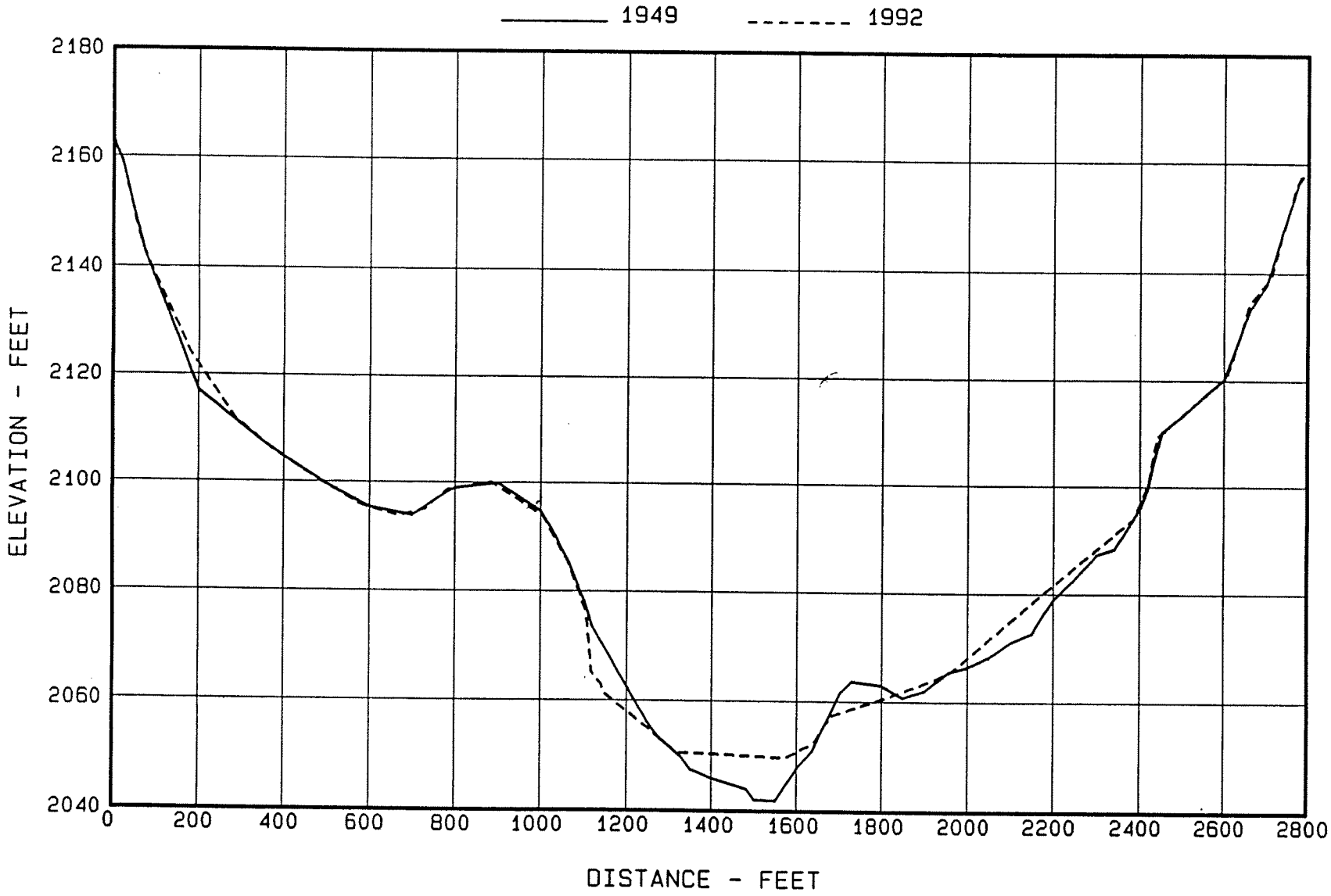

Figure 15. - Heart Butte Reservoir, North Dakota, ground profile for section B.

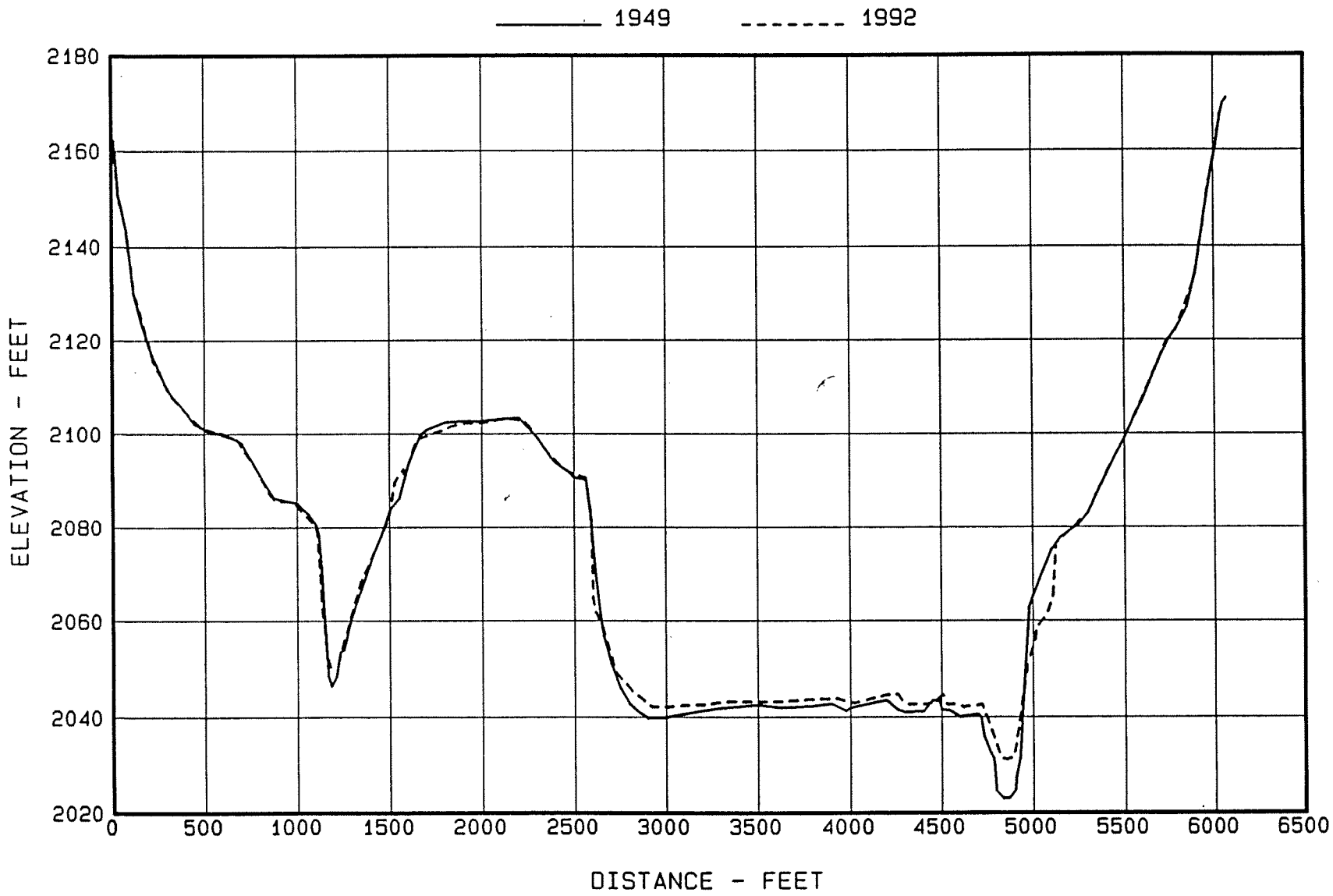

Figure 16. - Heart Butte Reservoir, North Dakota, ground profile for section 5.

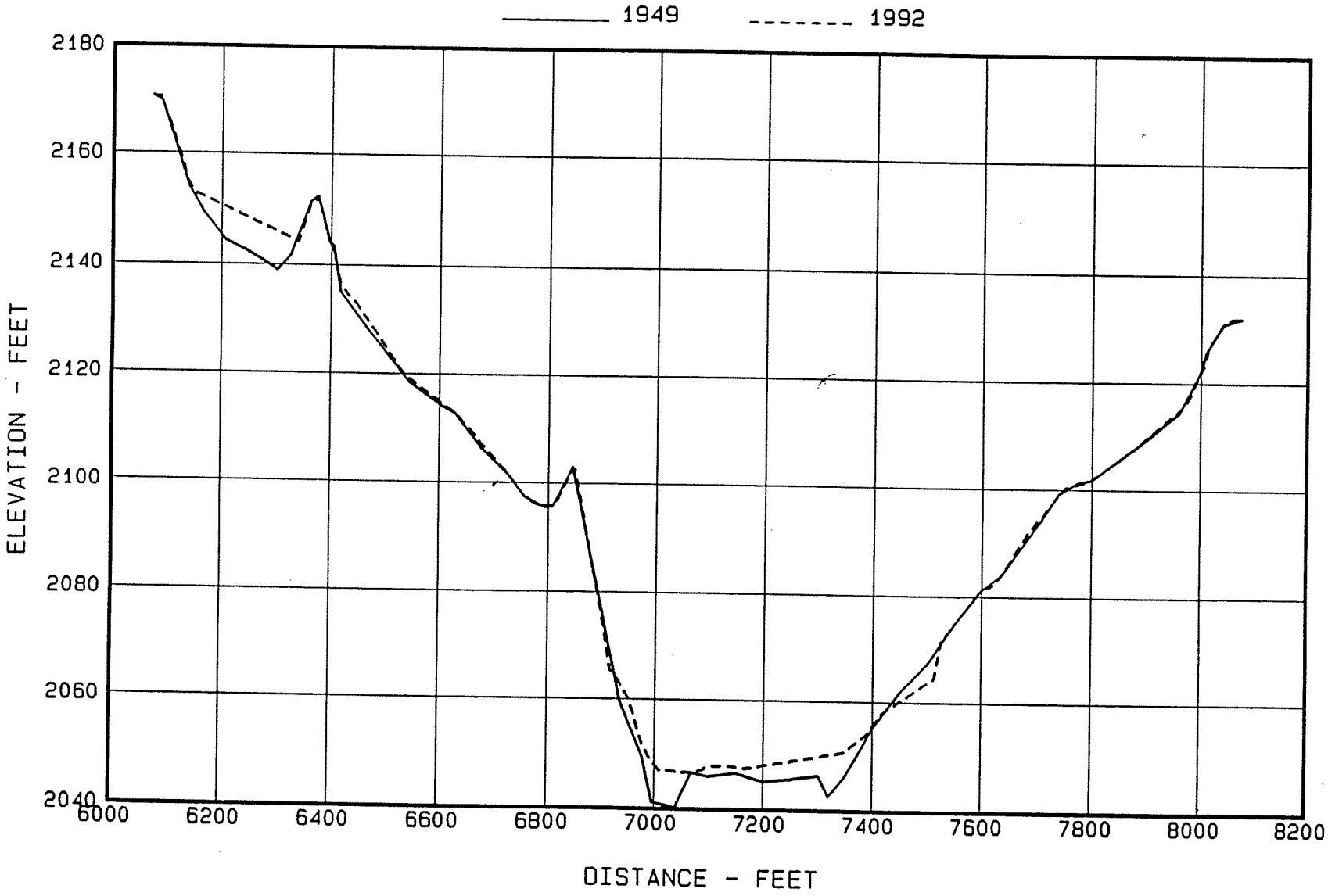

Figure 17. - Heart Butte Reservoir, North Dakota, ground profile for section 5NW.

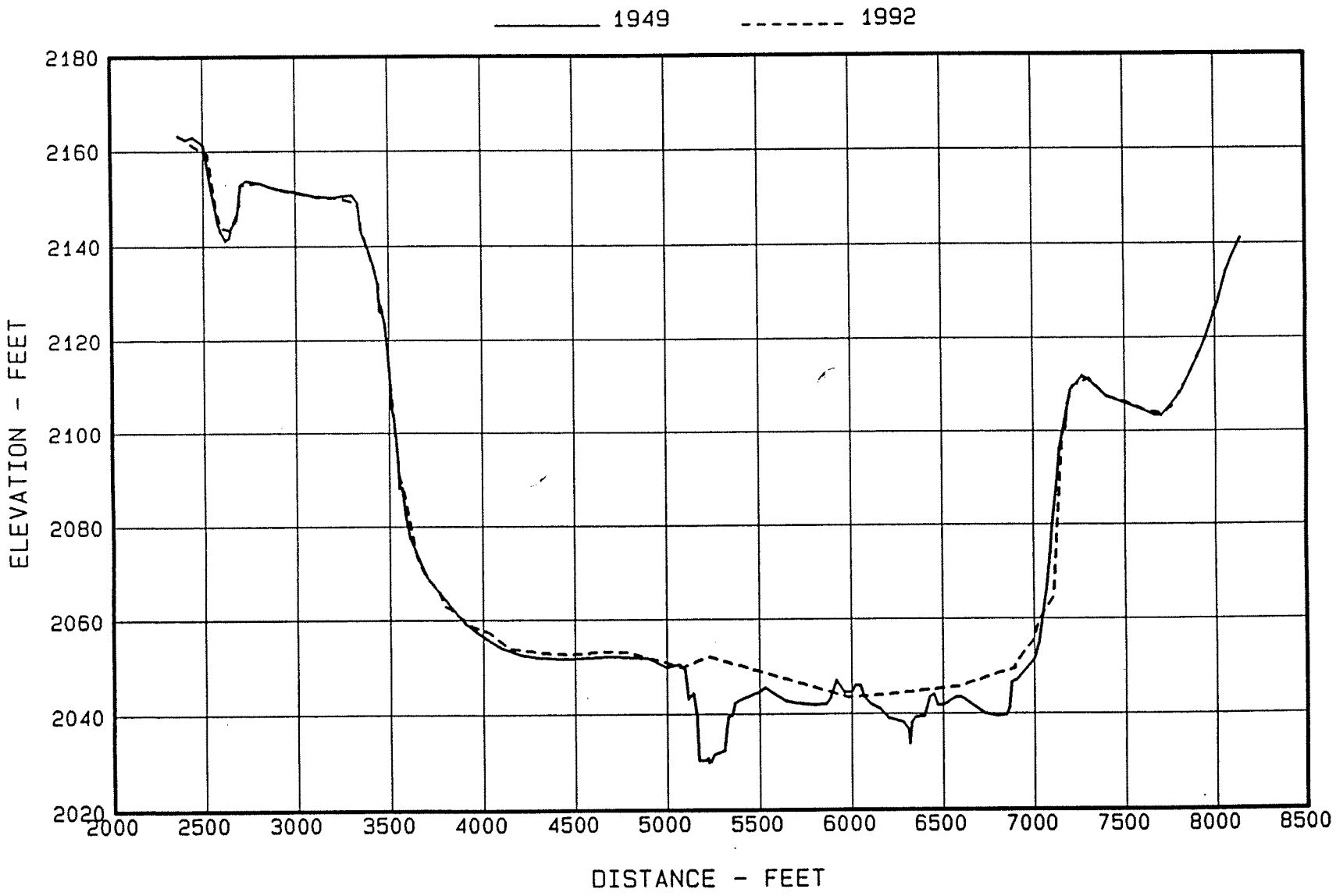

Figure 18. - Heart Butte Reservoir, North Dakota, ground profile for section 6.

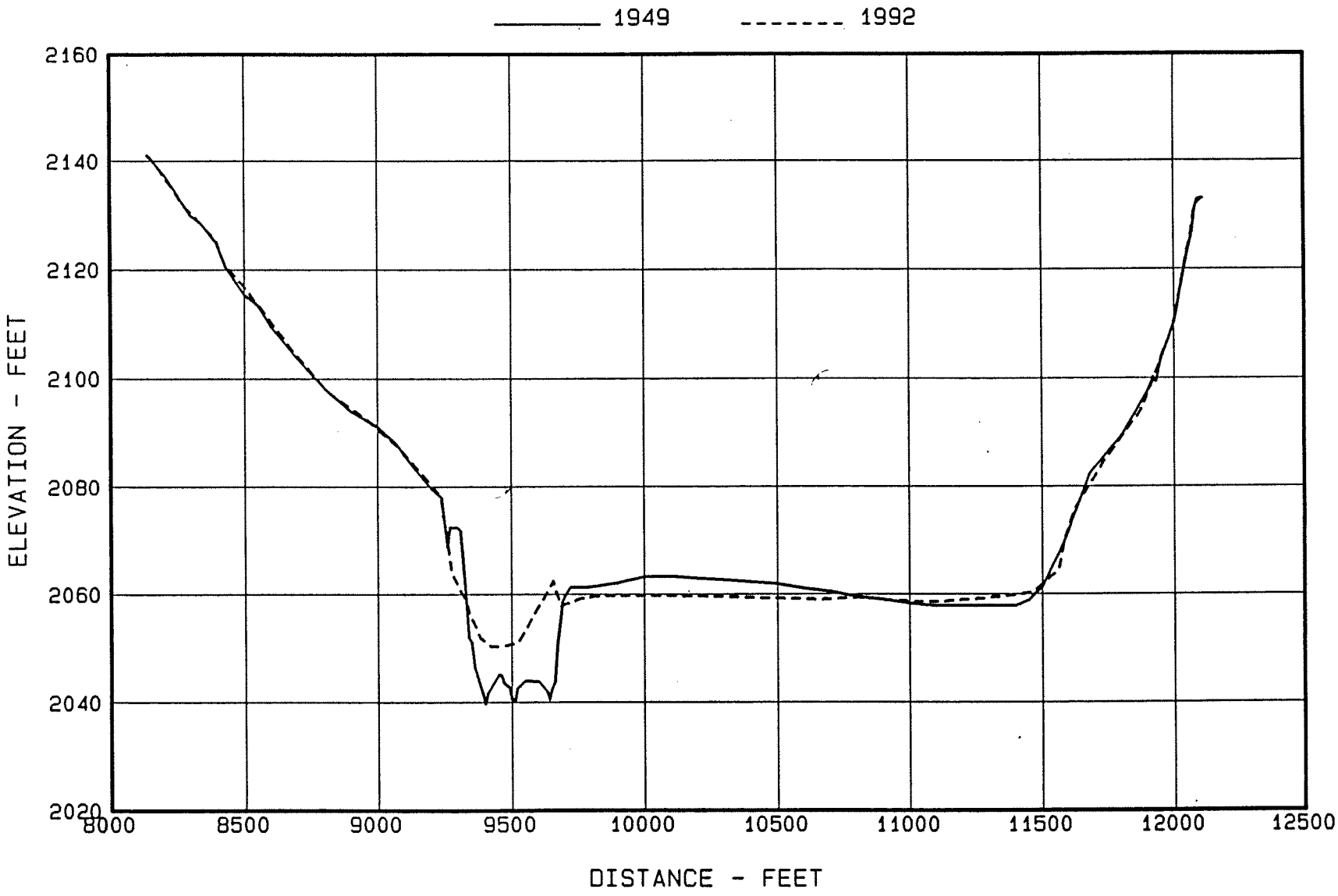

Figure 19. - Heart Butte Reservoir, North Dakota, ground profile for section 6N.

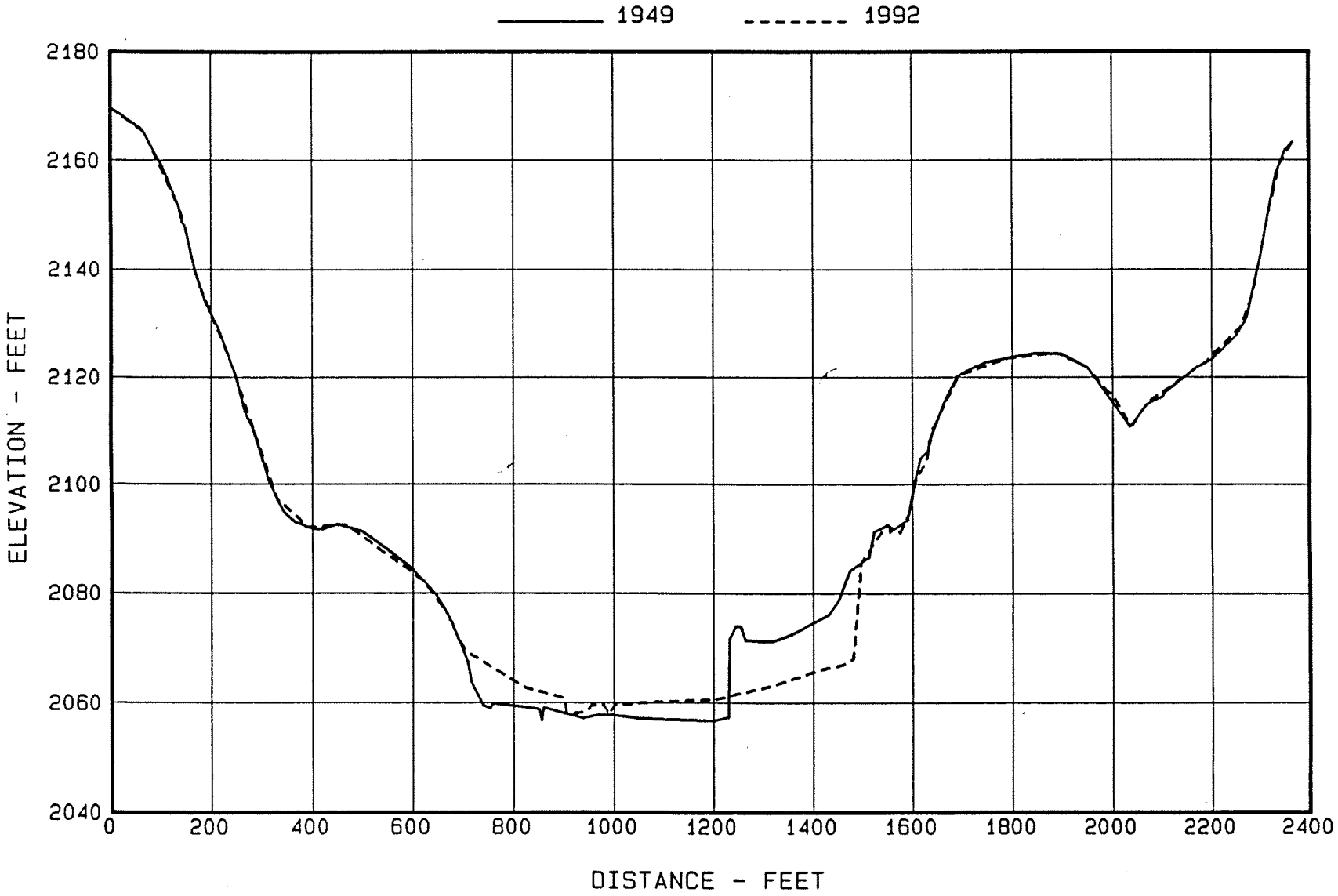

Figure 20. - Heart Butte Reservoir, North Dakota, ground profile for section 6S.

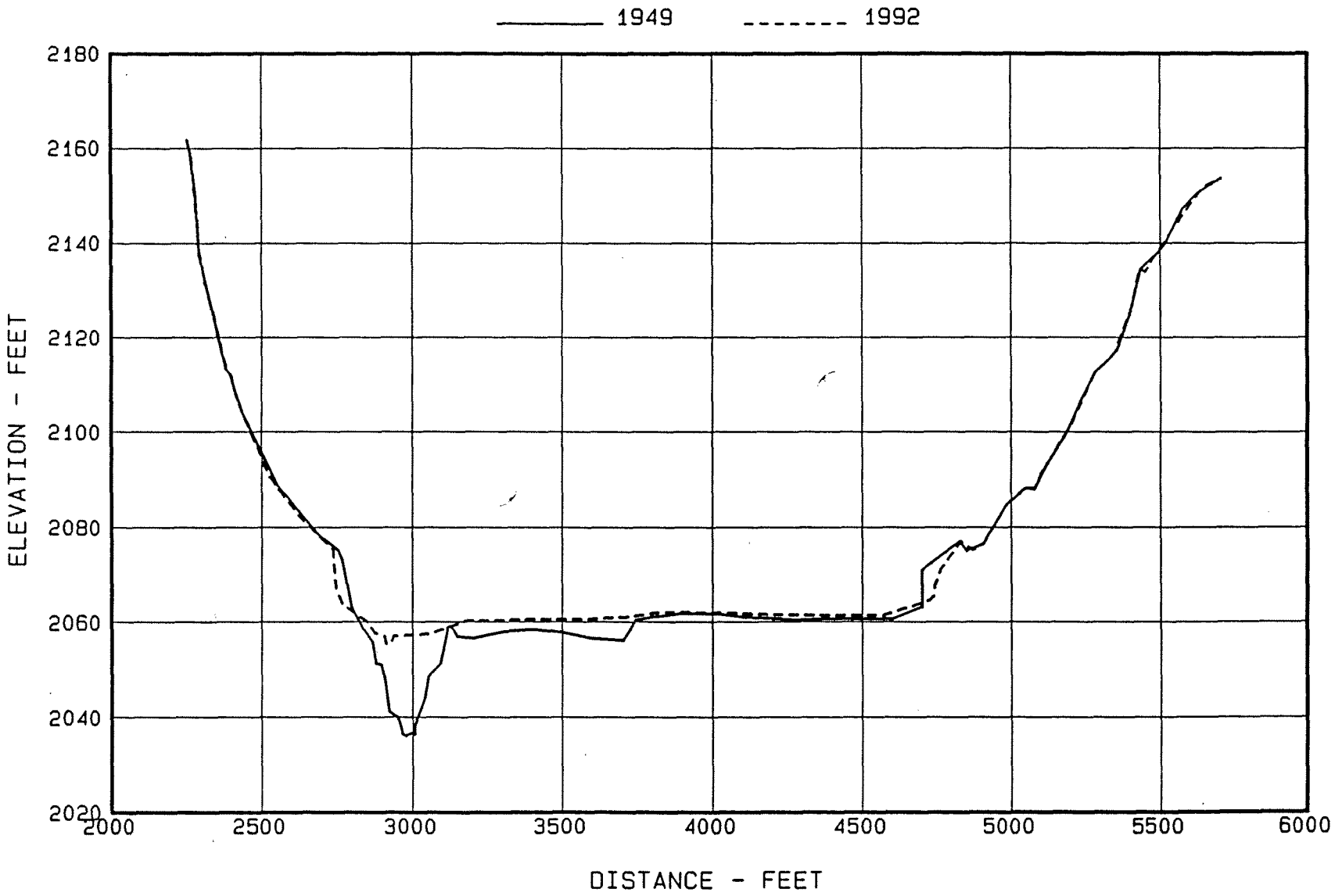

Figure 21. - Heart Butte Reservoir, North Dakota, ground profile for section 7.

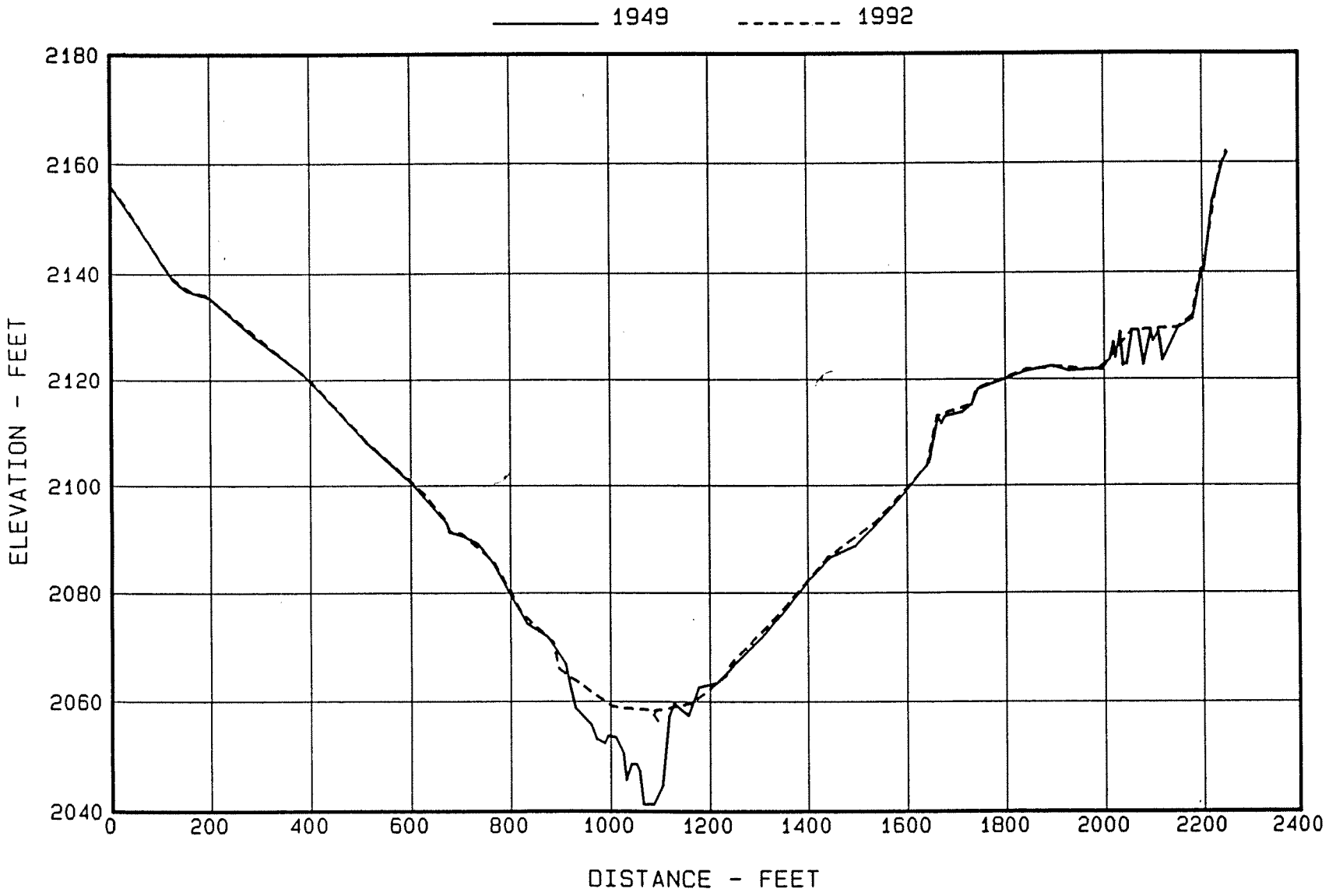

Figure 22. - Heart Butte Reservoir, North Dakota, ground profile for section 7S.

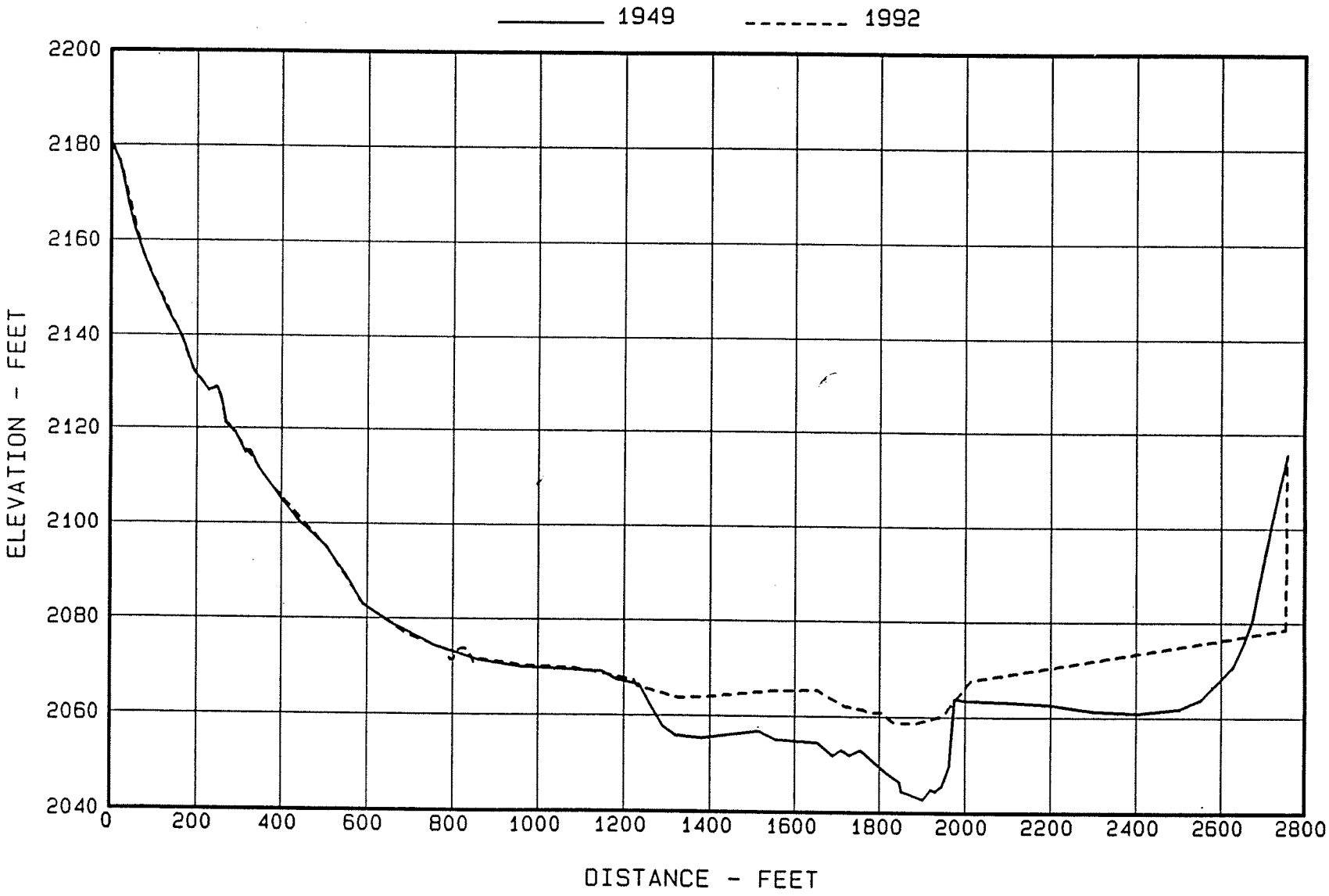

Figure 23. - Heart Butte Reservoir, North Dakota, ground profile for section 8.

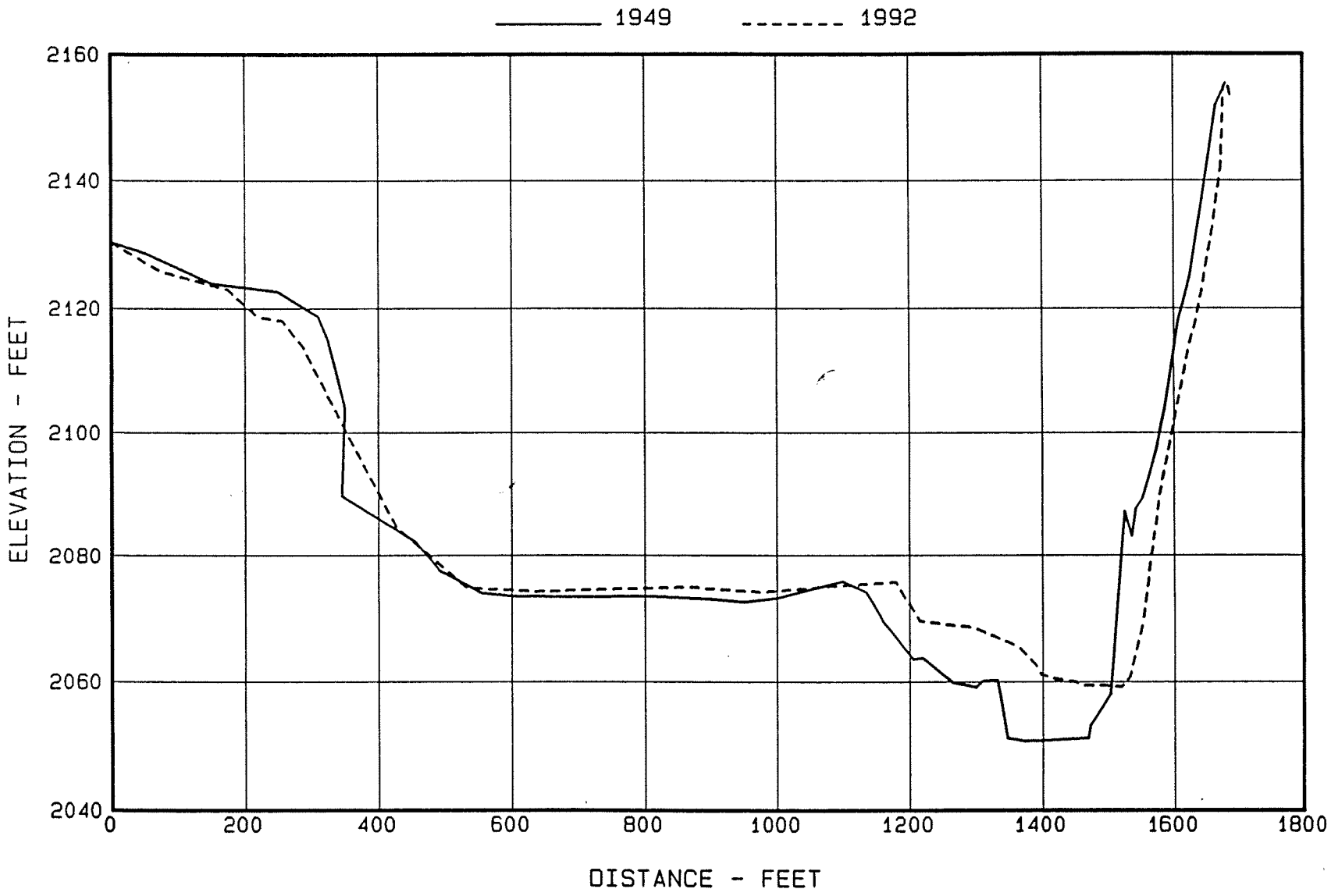

Figure 24. - Heart Butte Reservoir, North Dakota, ground profile for section 9.

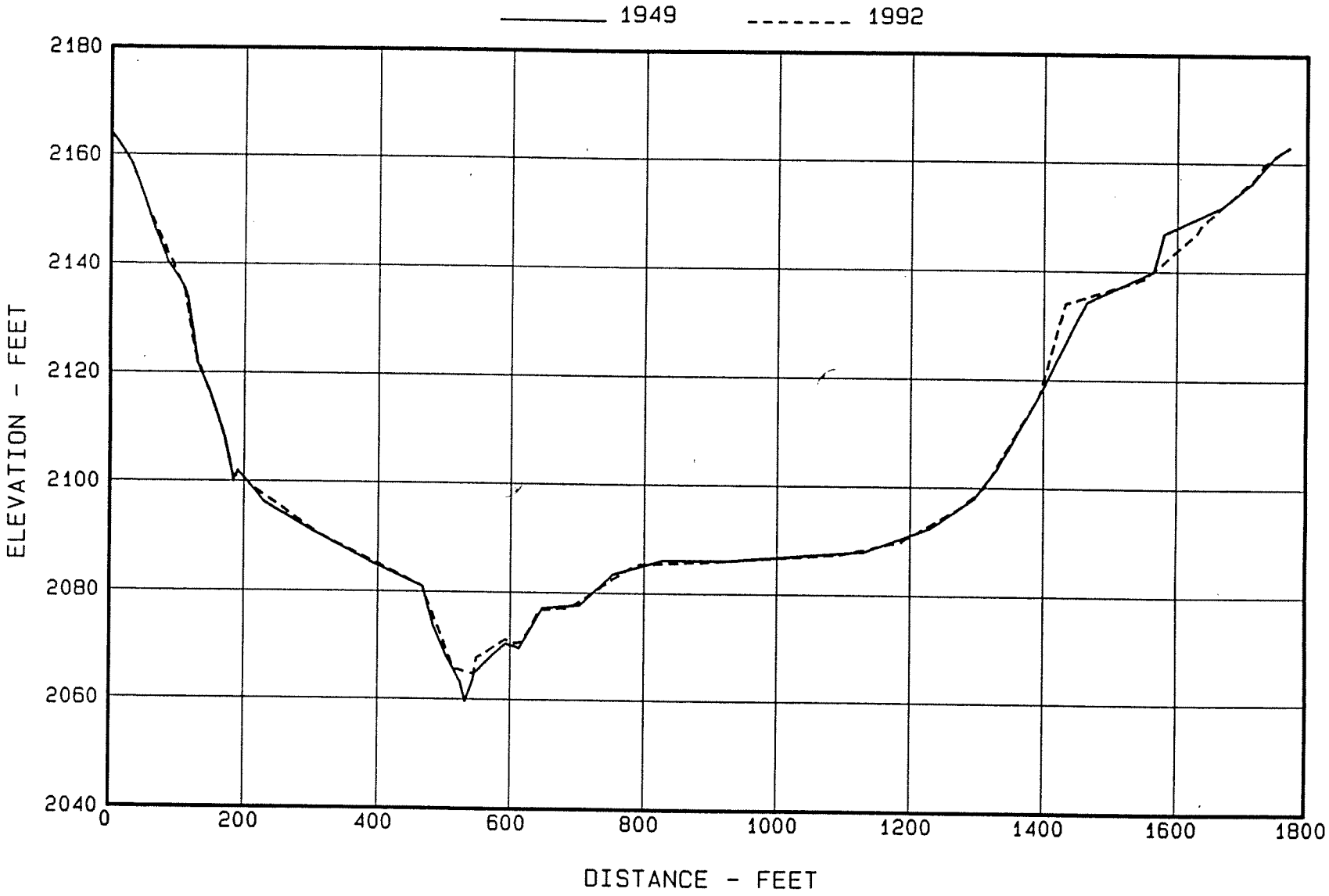

Figure 25. - Heart Butte Reservoir, North Dakota, ground profile for section C.

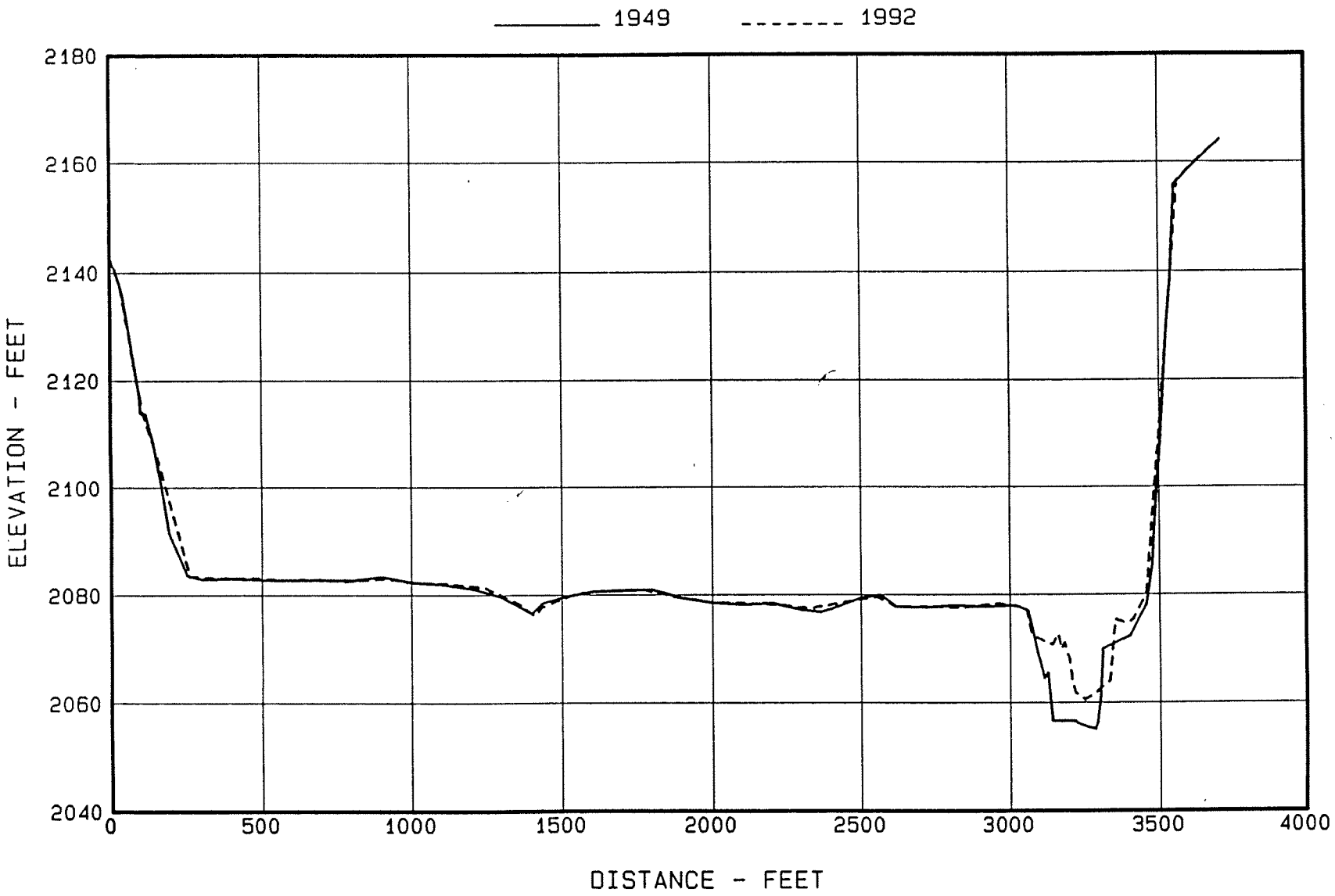

Figure 26. - Heart Butte Reservoir, North Dakota, ground profile for section 10.

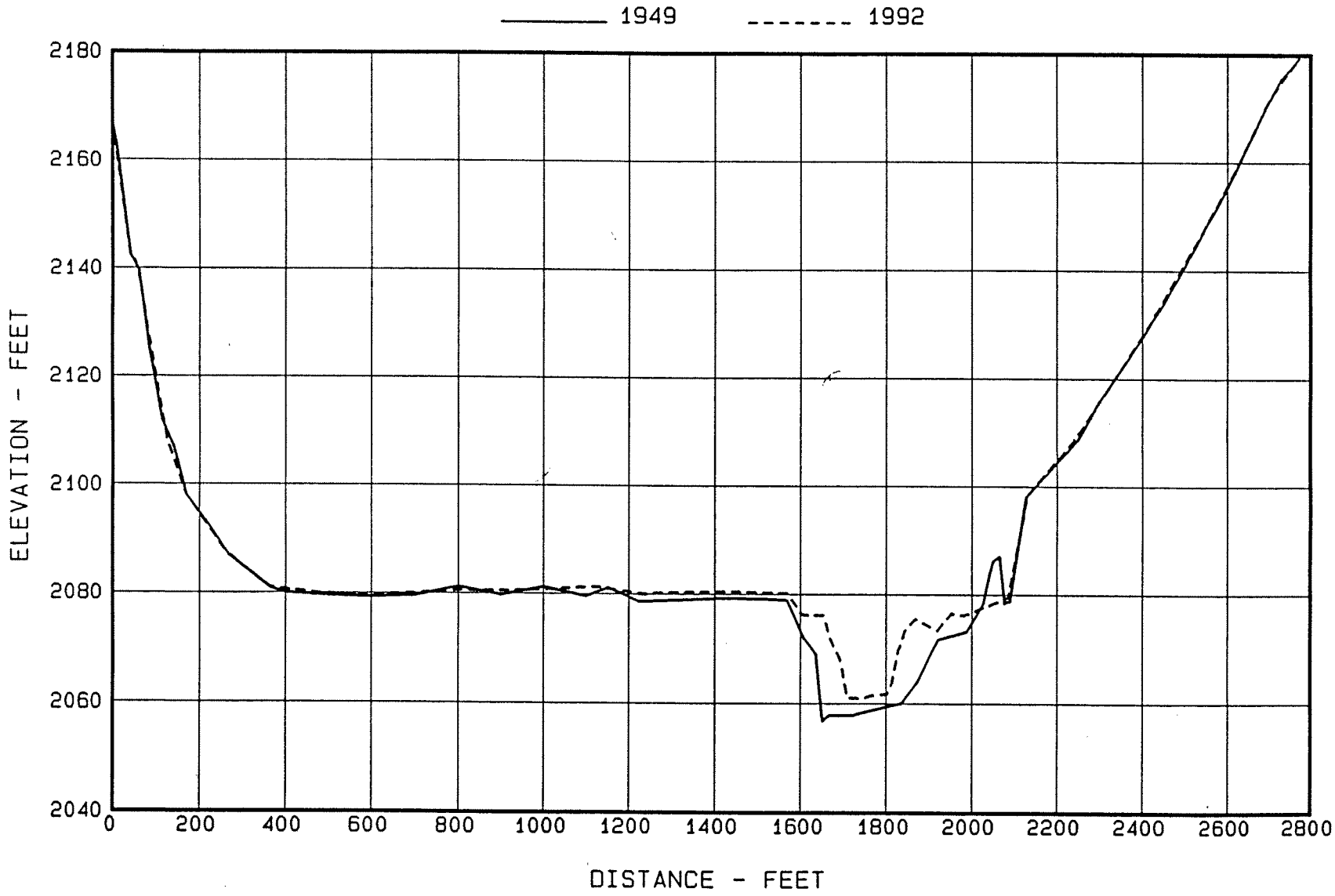

Figure 27. - Heart Butte Reservoir, North Dakota, ground profile for section 11.

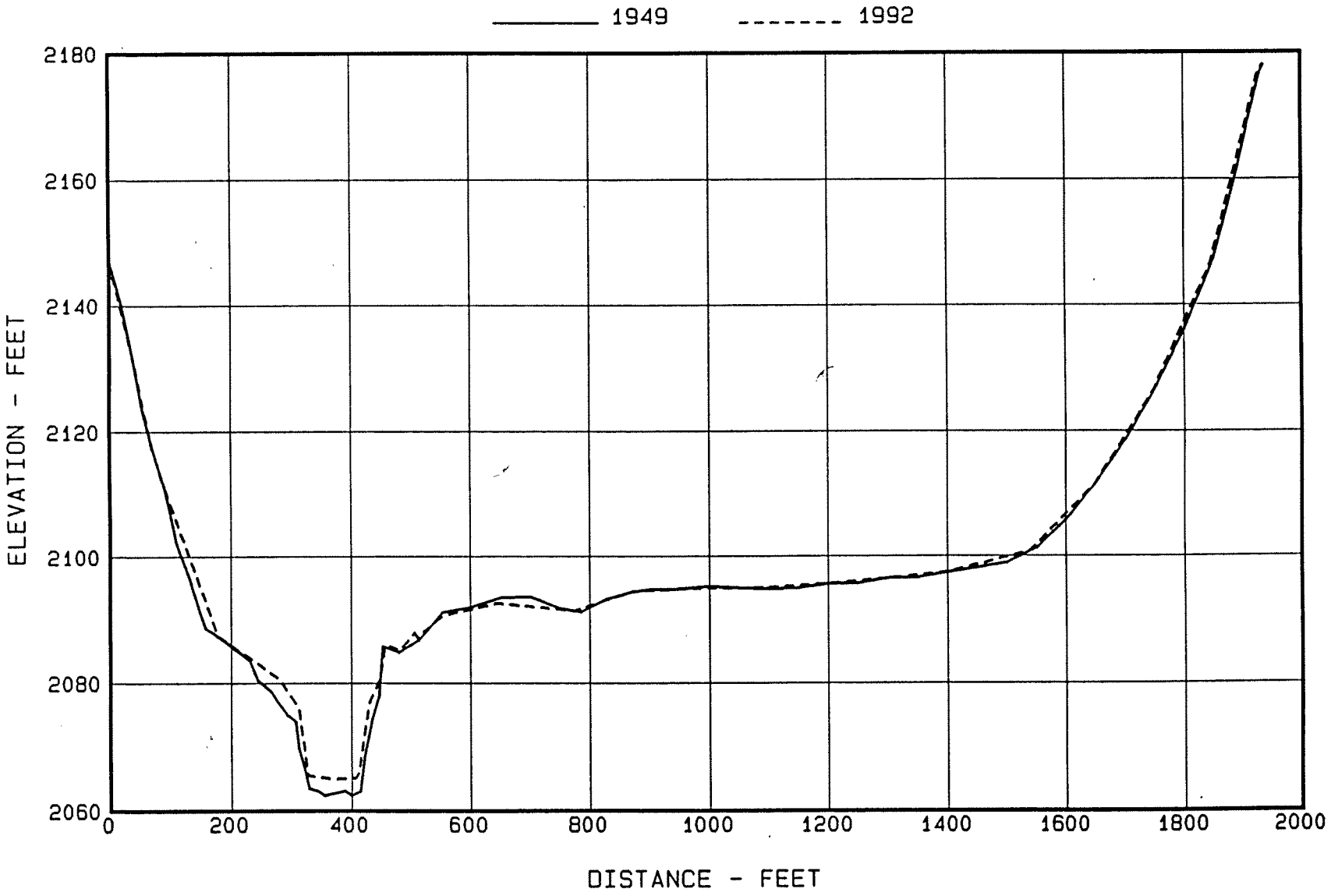

Figure 28. - Heart Butte Reservoir, North Dakota, ground profile for section 12.

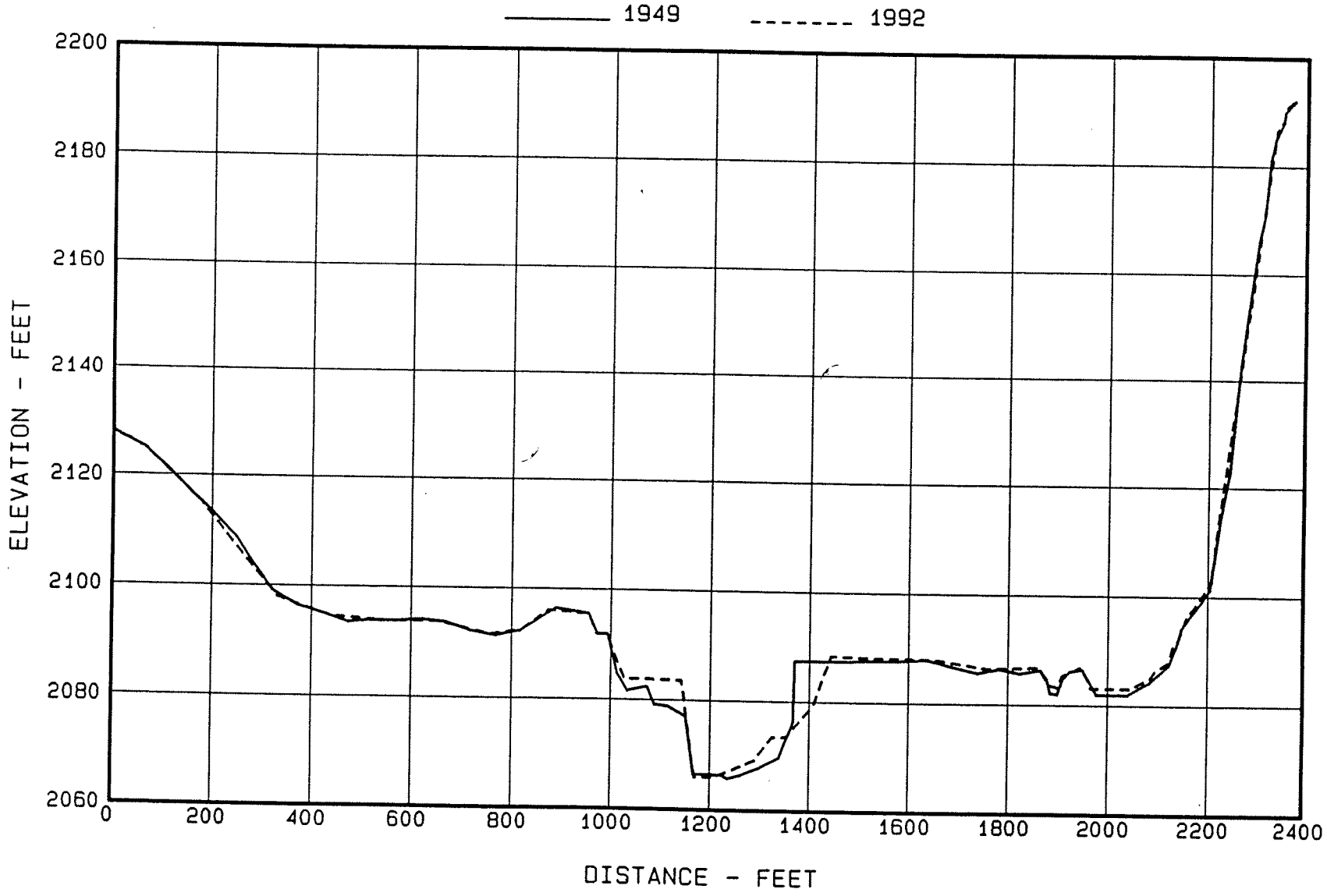

Figure 29. - Heart Butte Reservoir, North Dakota, ground profile for section 13.

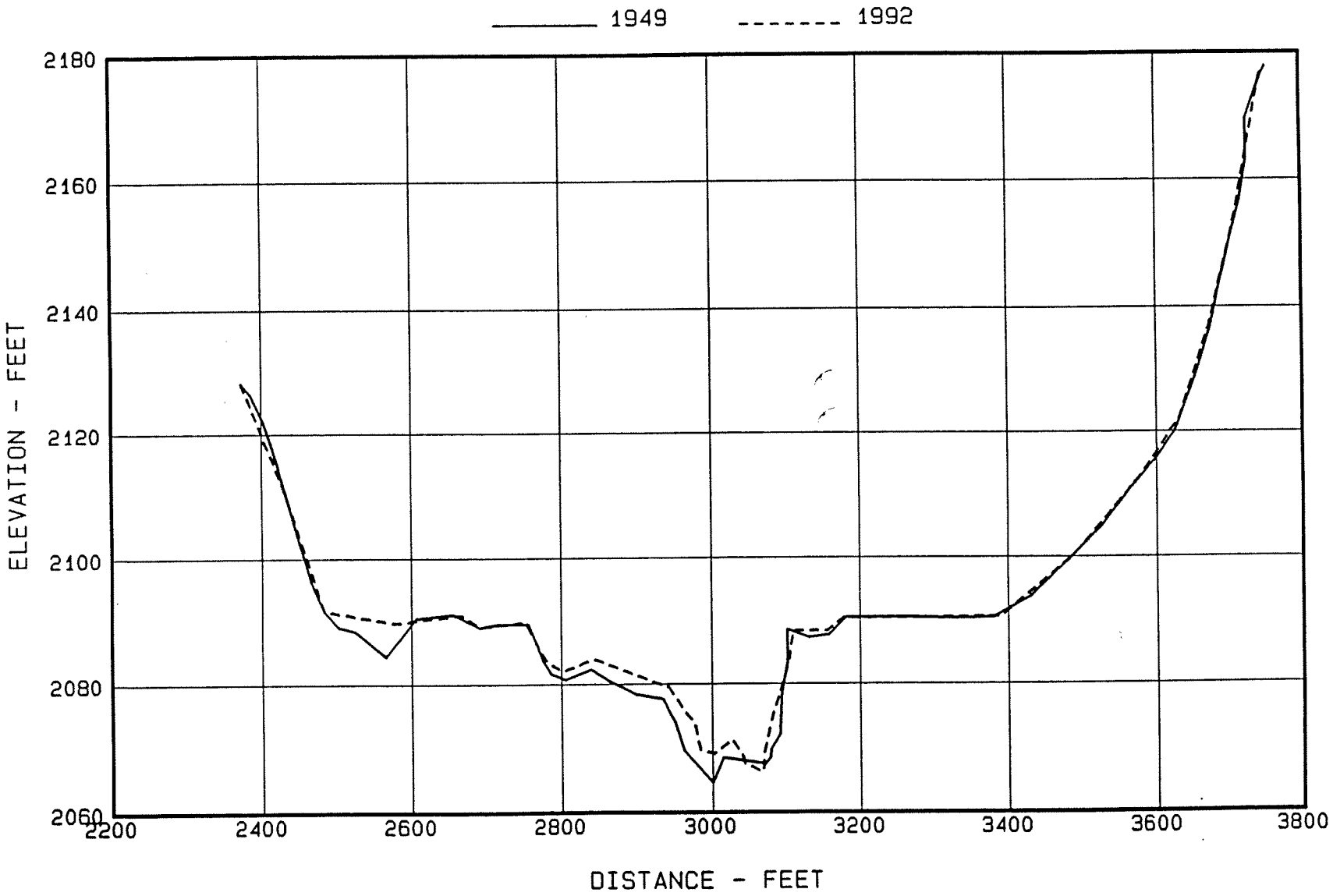

Figure 30. - Heart Butte Reservoir, North Dakota, ground profile for section 13NW.

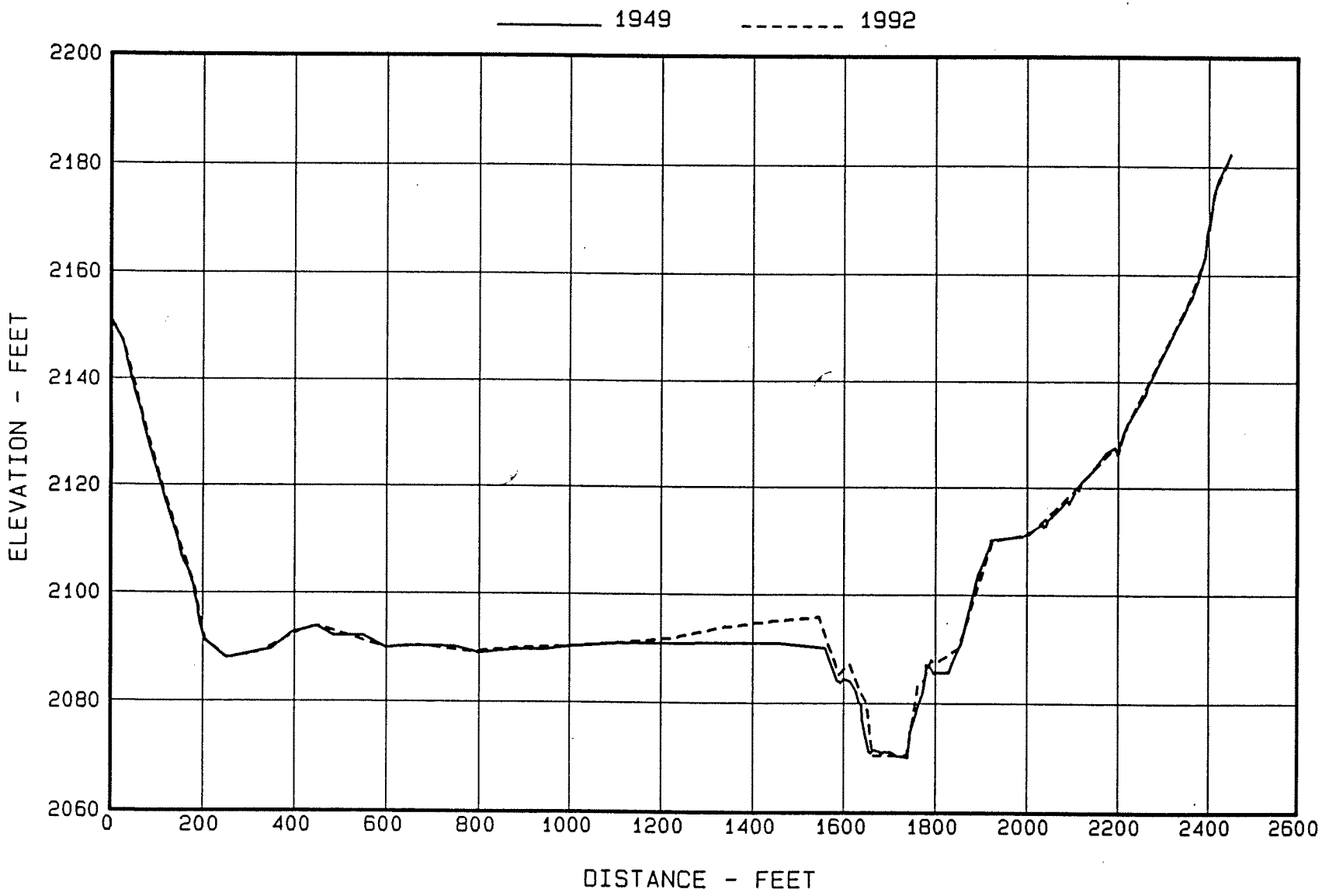

Figure 31. - Heart Butte Reservoir, North Dakota, ground profile for section 14.

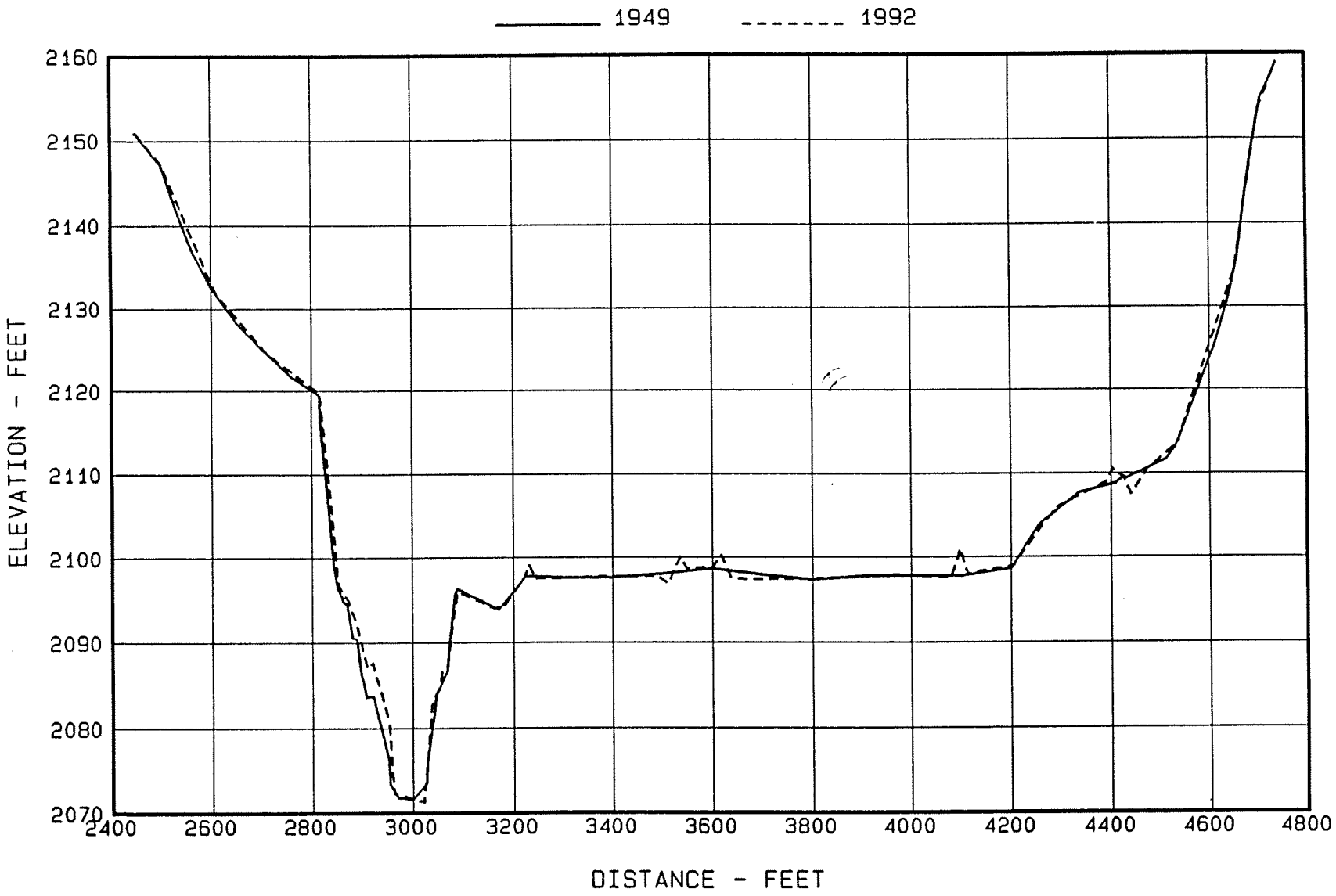

Figure 32. - Heart Butte Reservoir, North Dakota, ground profile for section 14NW.

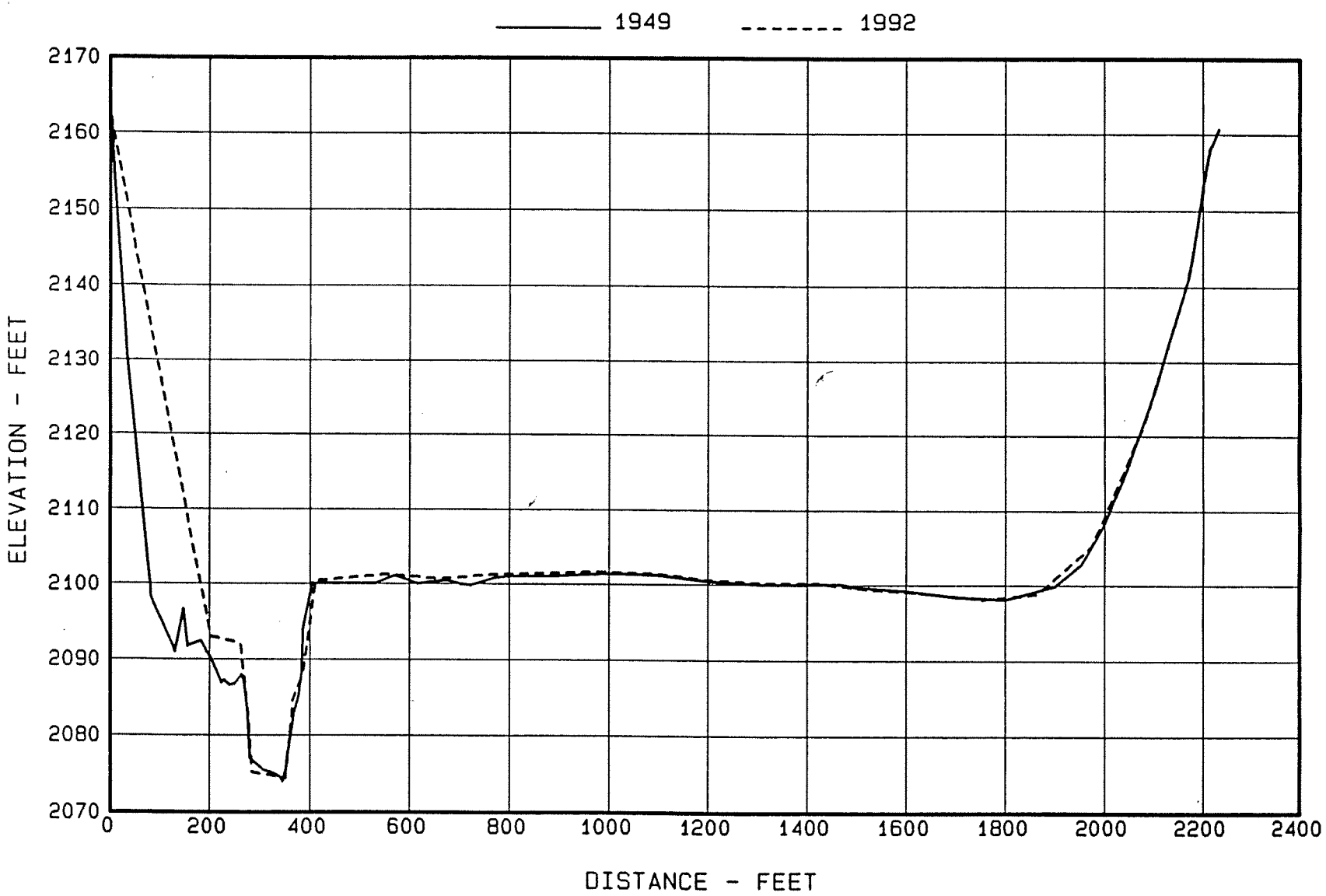

Figure 33. - Heart Butte Reservoir, North Dakota, ground profile for section 15.

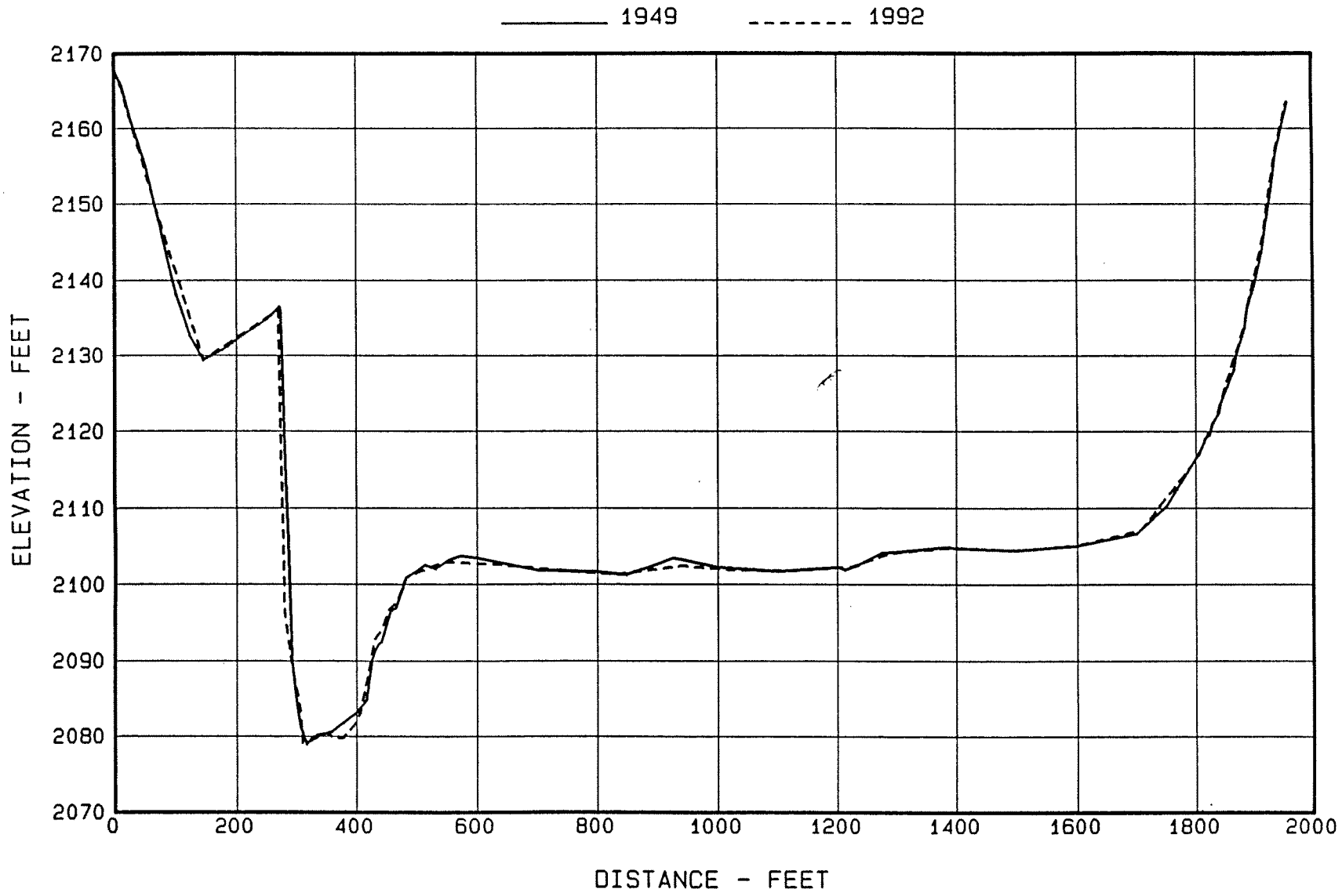

Figure 34. - Heart Butte Reservoir, North Dakota, ground profile for section 16.

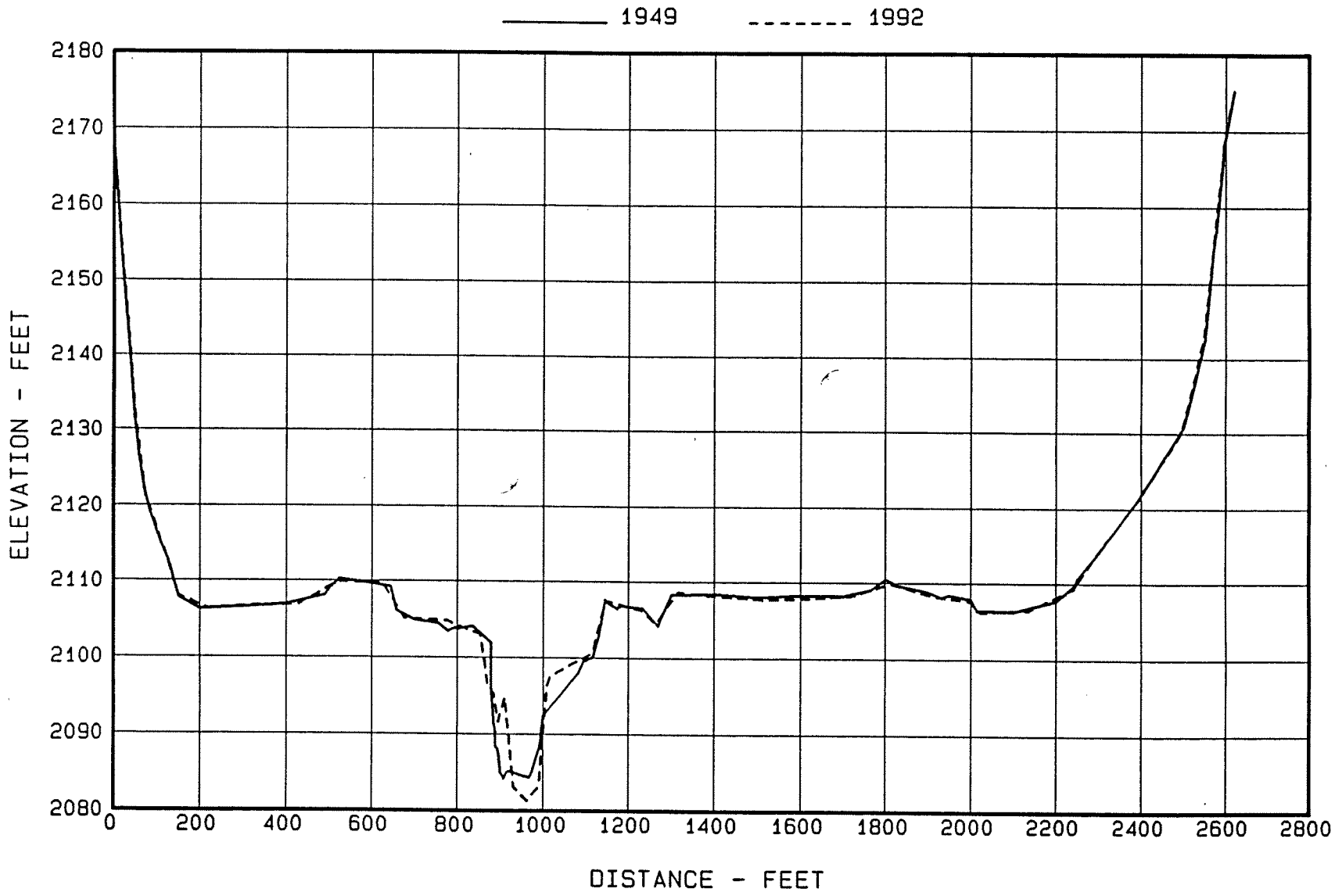

Figure 35. - Heart Butte Reservoir, North Dakota, ground profile for section 17.

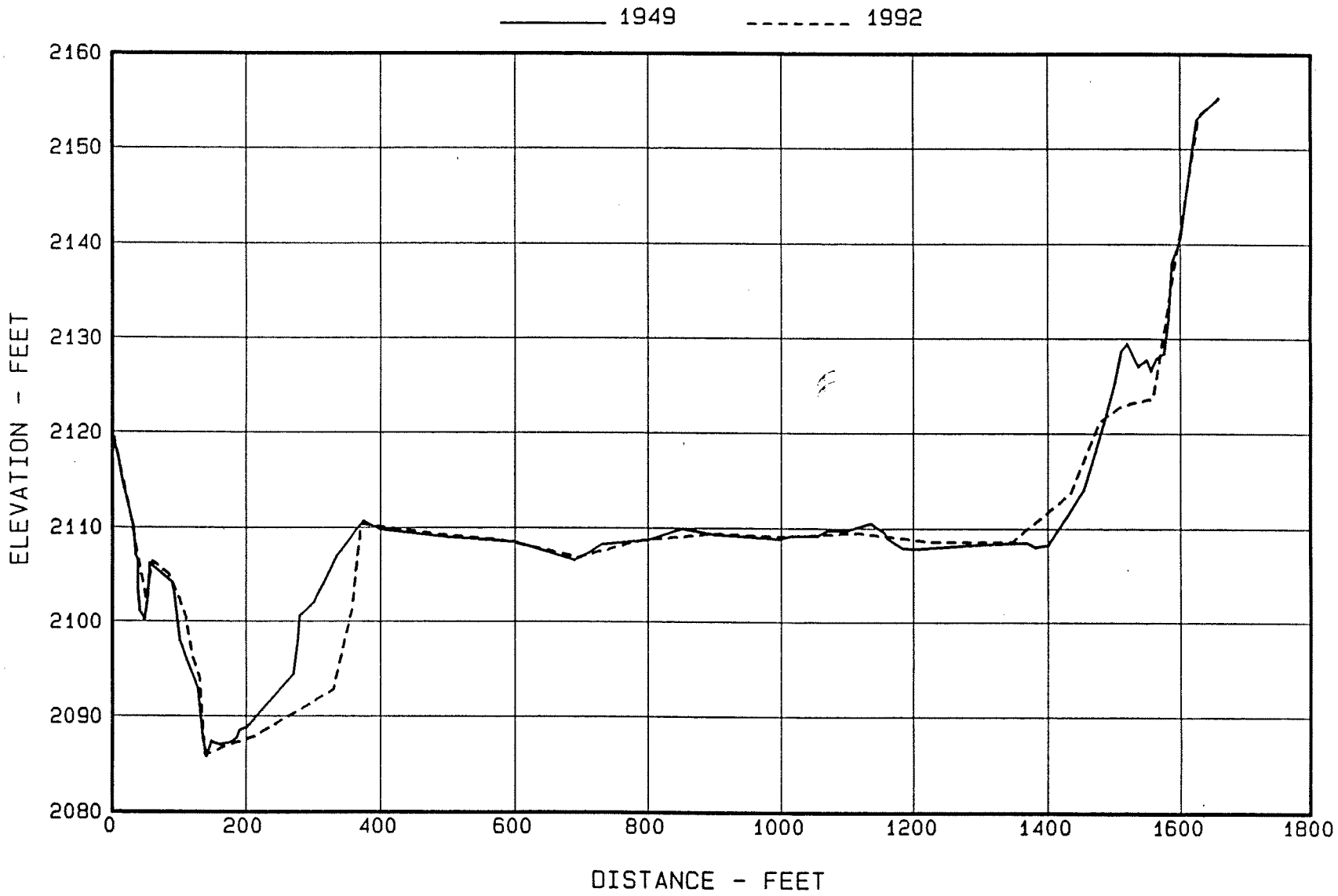

Figure 36. - Heart Butte Reservoir, North Dakota, ground profile for section 18.

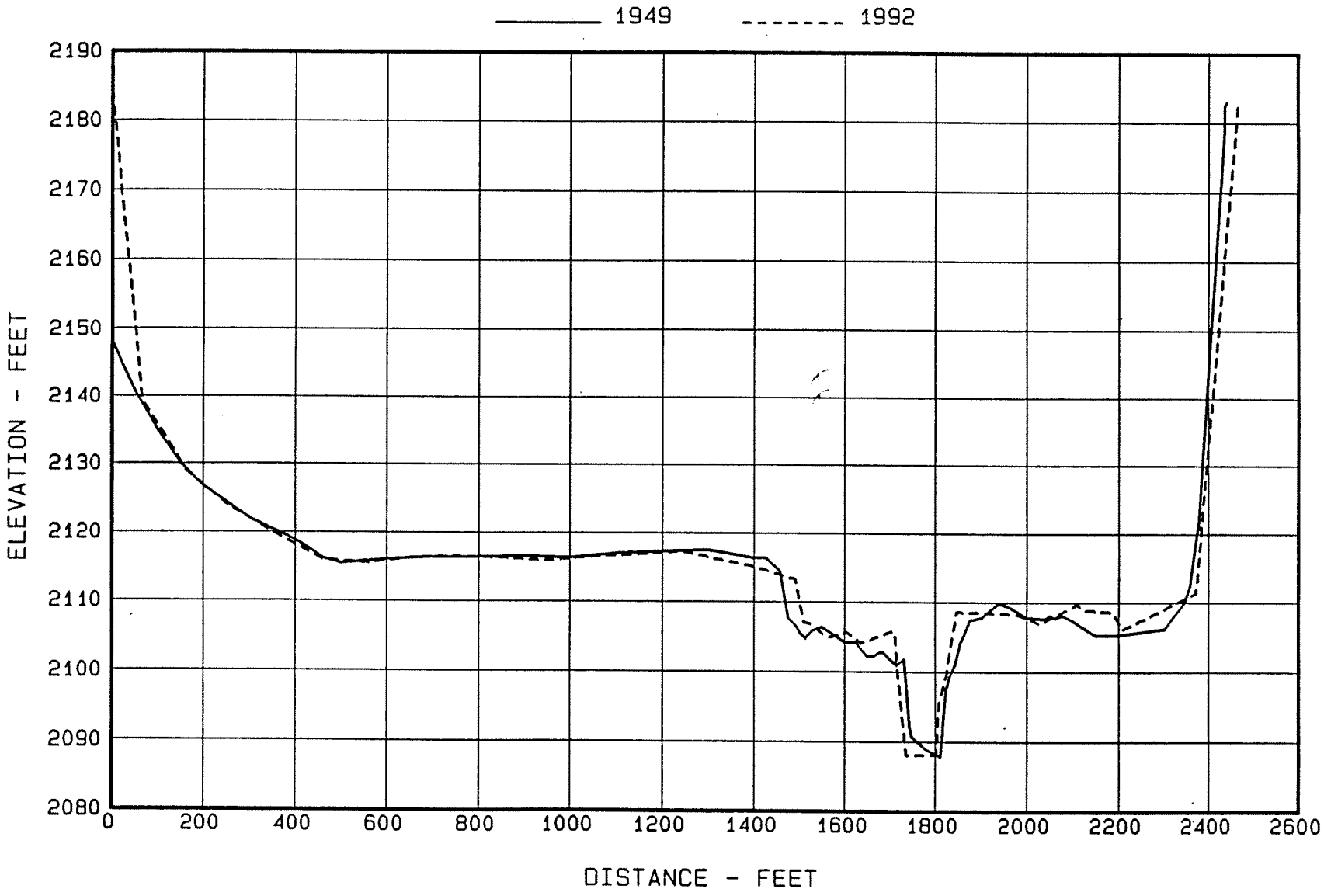

Figure 37. - Heart Butte Reservoir, North Dakota, ground profile for section 19.

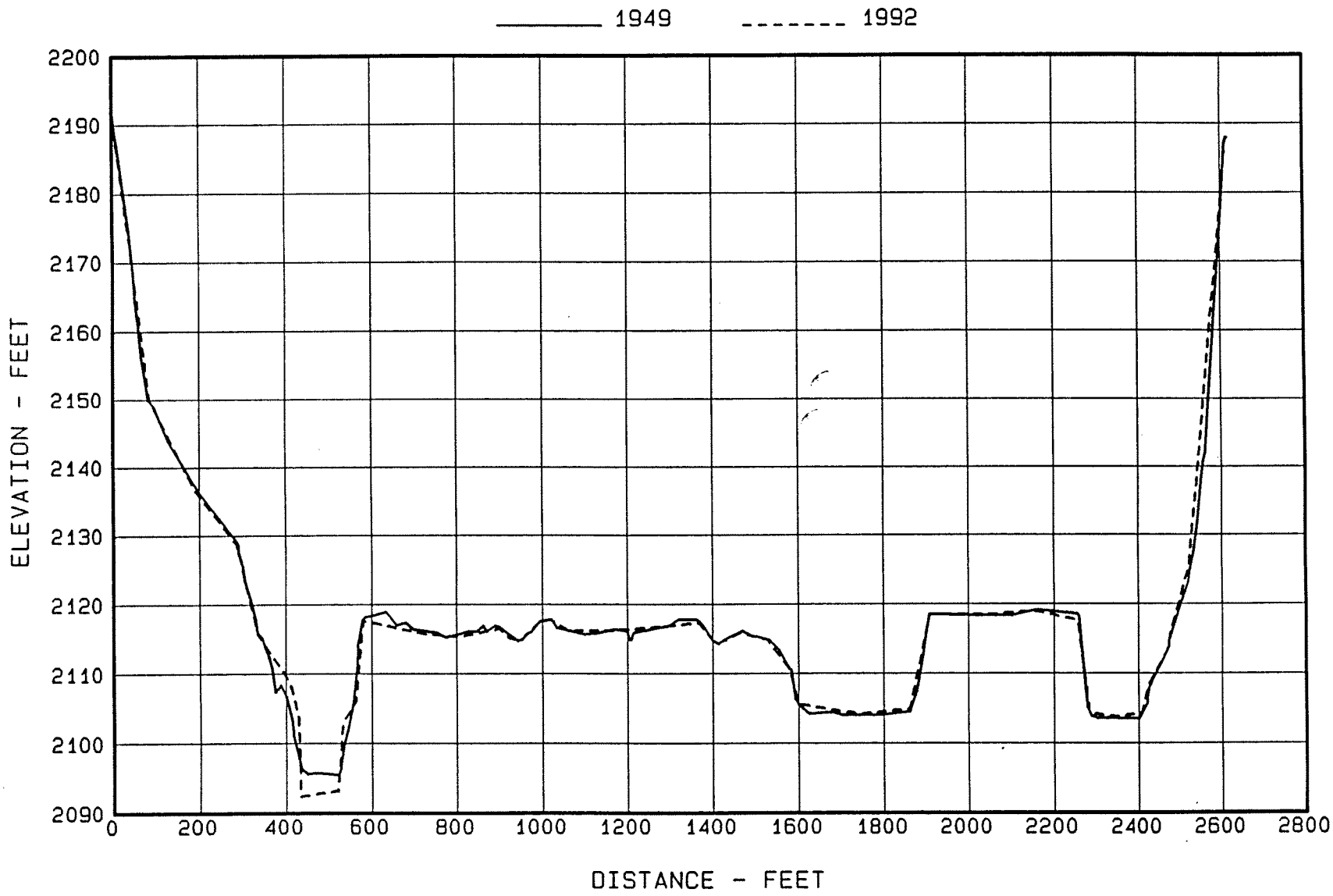

Figure 38. - Heart Butte Reservoir, North Dakota, ground profile for section 20.

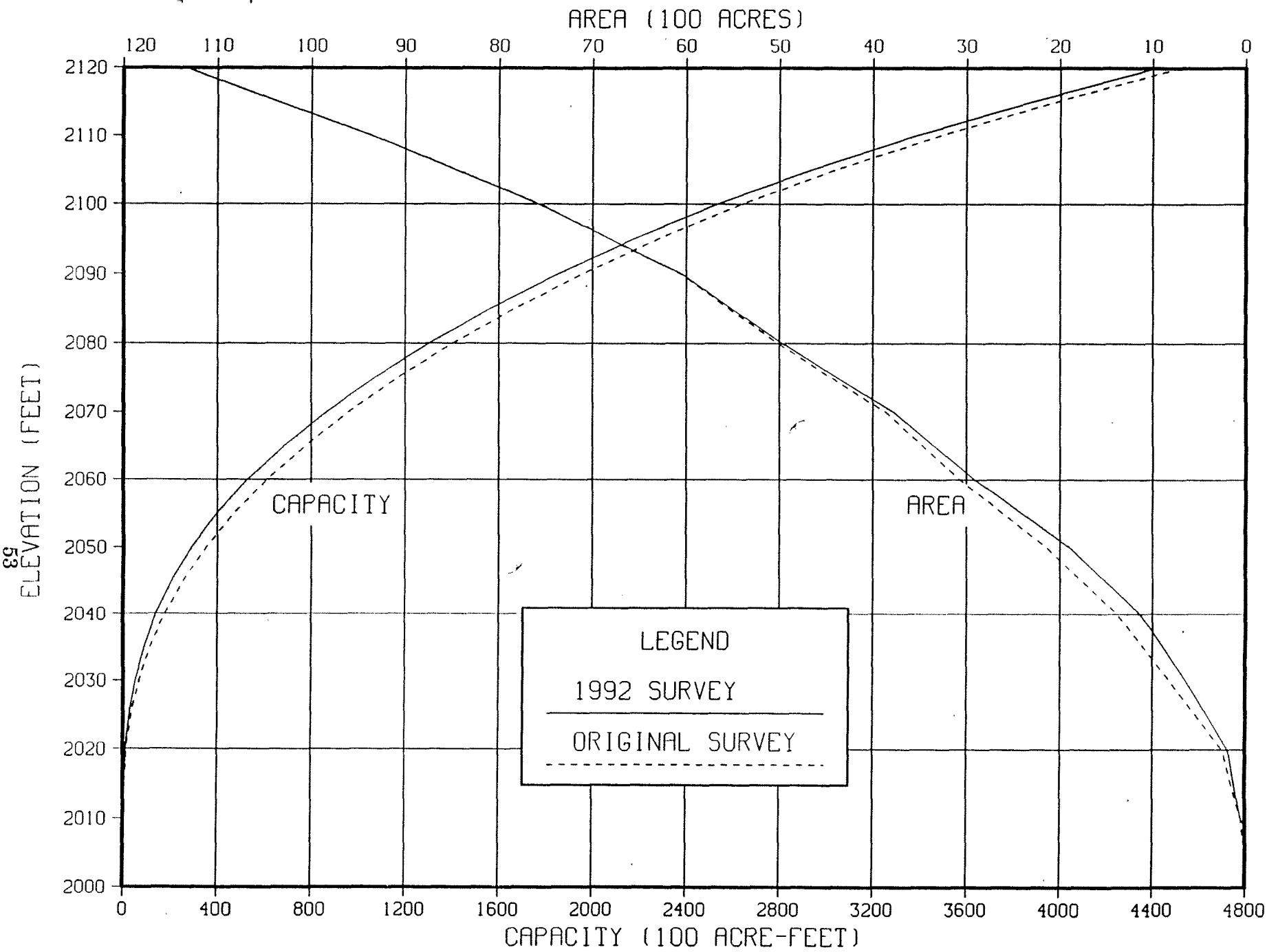

Figure 39. - Area-capacity curves, Heart Butte Reservoir, North Dakota, ground profile for section 19.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American Public.