UNIVERSITY OF NEVADA-RENO

Nevada Bureau of Mines and Geology
University of Nevada-Reno
Reno, Nevada 89557-0088
(702) 784-6691

1987

NBMG OPEN FILE REPORT 87-7

RESULTS OF LEVELING ACROSS FAULT SCARPS IN THE LAS VEGAS VALLEY, NEVADA APRIL, 1978 - APRIL, 1987

Nick C. Varnum

This information should be considered preliminary. It has not been edited or checked for completeness or accuracy.

ABSTRACT

Land subsidence due to ground-water withdrawal exceeding ground-water recharge has been well documented in the Las Vegas Valley. The presence of several major fault escarpments within or near subsidence basins prompted concern about the potential hazard for surface faulting and fissuring.

Nine level lines were established across fault scarps in 1978-1980, producing 8-10 year records as of the summer of 1987. The level lines were designed to determine the existence, if any, of narrow zones of severe differential movement occurring along or near existing fault scarps resulting from ground-water withdrawal-induced land subsidence.

Seven of the level lines demonstrated differential movement, while two lines showed no conclusive evidence for movement. The maximum displacement recorded was 1.26 ft across a distance of about 2000 ft. The maximum differential movement between adjacent bench marks (200-250 ft apart) was 0.40 ft.

The sense of movement observed in lines exhibiting differential movements demonstrate that differential movement is controlled by the location of local subsidence basins, regardless of the pre-existing movements of the faults. Plots of elevation changes show that some of the lines are composed of a series of blocks, and that some of the differential movements may be the result of vertical movements between individual fault-bounded blocks or the response of inhomogeneities of surface sediments to movements of structural blocks at depth. Overall, vertical movements are accommodated by extension and warping over large areas rather than rupturing (faulting) of near-surface sediments.

TABLE OF CONTENTS

INTRODUCTION.....1

METHODS.....4

RESULTS.....6
Level Line 1.....6
Level Line 2.....8
Level Line 3.....10
Level Line 4.....10
Level Line 5.....10
Level Line 6.....14
Level Line 7.....14
Level Line 8.....14
Level Line 10.....21

SUMMARY.....21

REFERENCES CITED.....24

TABLES

1. City Street Intersections Near the Ends of Level Lines...4

2. Benchmarks and elevations used as fixed elevations.....5

3. Annual elevation changes at selected stations for lines demonstrating differential movements (excluding line 5)..6

FIGURES

1. Water use in the Las Vegas Valley, 1956-1985.....1

2. Land subsidence between 1963 and 1980 due to artesian head decline, locations of fault scarps, and locations of level lines in the Las Vegas Valley.....3

3. Las Vegas Level Line #1.....7

4. Las Vegas Level Line #2.....9

5. Las Vegas Level Line #3.....11

6. Las Vegas Level Line #4.....12

7. Las Vegas Level Line #5.....13

8. Las Vegas Level Line #6.....15

9. Las Vegas Level Line #7.....16

10. Las Vegas Level Line #8A.....17

11. Las Vegas Level Line #8B.....18

12. Las Vegas Level Line #8C.....19

13. Las Vegas Level Line #8D.....20

14. Las Vegas Level Line #10.....22

APPENDICES

A. Listing of leveling data.

The author would like to thank John Bell of the Nevada Bureau of Mines and Geology and Terry Katzer of the Las Vegas Valley Water District for reviews of the manuscript and helpful suggestions. The report also benefited from the assistance of Malcom Wilson of the Nevada Department of Transportation.

INTRODUCTION

Land subsidence in the Las Vegas Valley has been studied for more than 45 years by many public and private interests. A comprehensive summary of all studies prior to 1981 by Bell (1981a) shows that subsidence in the Las Vegas Valley is primarily due to ground-water withdrawal exceeding ground-water recharge. The primary mechanism for subsidence is the irreversible decrease in volume, or consolidation, of fine grained sediments upon reduction of artesian head. The reduced volume of these sediments is reflected at the surface by land subsidence. The hydrologic and geologic characteristics of the Las Vegas Valley are ideally suited to produce large amounts of subsidence. These characteristics are summarized by Bell (1981a).

Ground-water development in the Las Vegas Valley began in the first two decades of this century. Based on calculated recharge rates of 25,000-35,000 acre-feet per year (Maxey and Jameson, 1948; Malmberg, 1961, 1965; Domenico and Maxey, 1964), significant overdrafts of the system began in the mid-1940's. Records of ground-water discharge (pumpage) from the Las Vegas Valley and imported water from Henderson and Lake Mead between 1956 and 1985 are plotted in figure 1. As the figure shows, ground-water pumpage increased annually until 1968 when 81,000 acre-feet were pumped. Since 1968, pumpage has decreased slightly due to imported water from Henderson and Lake Mead.

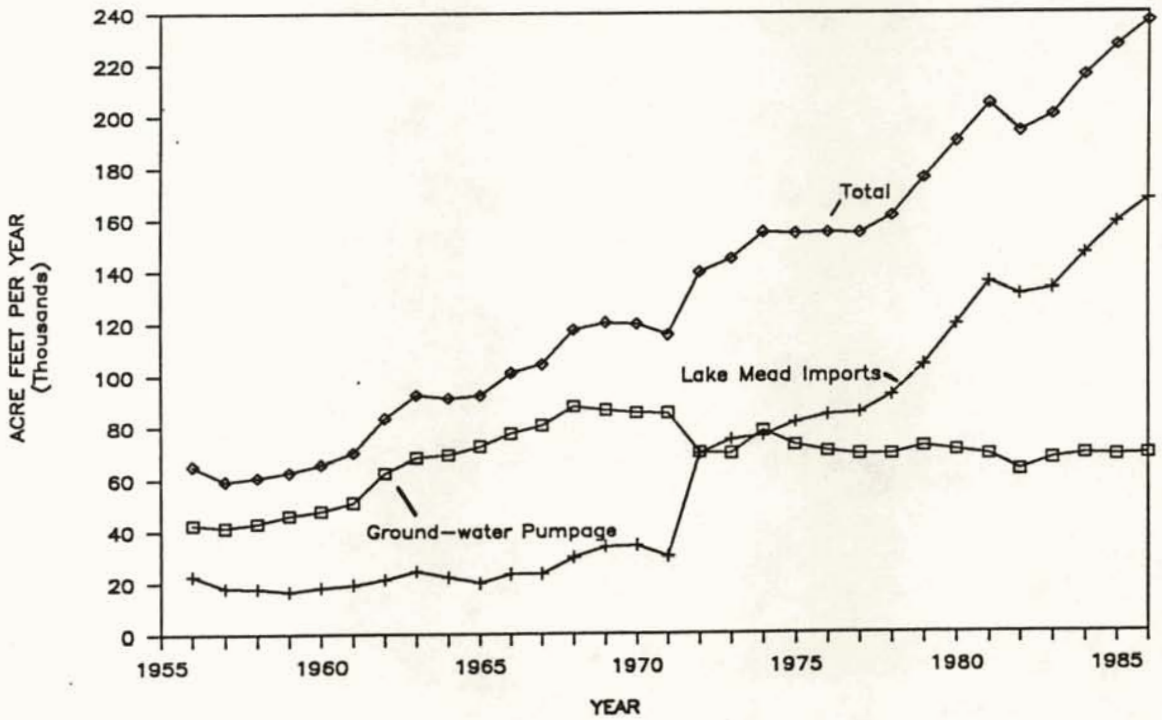

Figure 1. Water usage in Las Vegas Valley, 1956-1985. (from: Coache, 1986)

In 1935, the Hoover Dam Level Network was established and included two first-order level lines within the Las Vegas Valley. One line extends northwest-southeast along U.S. Highway 95; the other extends northeast-southwest along the Union Pacific rail line. The lines are 20-25 mi long with downtown Las Vegas near the intersection of the two. The lines were releveled at first- or second-order accuracy in 1941, 1950, 1963, 1972 and 1980. Contours of land subsidence based on these lines show that by 1980 the total area affected by subsidence was 400 mi^2 (Bell, 1981a). Figure 2 is a map of the Las Vegas Valley and shows land subsidence due to artesian head decline for the period 1963 to 1980. The contours of subsidence in figure 2 generally agree with trends reported by earlier workers (Bell, 1981a; Harrill, 1976; Mindling, 1971), but should be regarded as approximations. Since 1980, the locations of local subsidence basins may have shifted depending on the location and activity of pumping centers.

Several major fault escarpments cross the Las Vegas Valley (fig. 2). The escarpments have been described by Bell (1981a) as being as much as 30 ft high, 1-10 mi in length, and considerably modified by erosion. Evidence reviewed and presented by Bell suggests that the escarpments are due to faulting resulting from a combination of tectonic activity and natural compaction.

In 1965, John A. Blume and Associates established level lines designed to span major fault scarps within the Las Vegas city limits. Two of the lines had 0.13 to 0.22 ft of differential movements by 1968. Their study, together with visual observations of subsidence features, suggested that existing fault scarps posed a potential hazard for surface faulting and fissuring.

A comparision of published subsidence maps and fault locations led Holzer (1978) to conclude that differential subsidence over narrow zones could be precursory to surface faulting. Recognition of the potential for surface faulting in Las Vegas Valley was based on a similair setting in south-central Arizona where modern scarp offset related to ground-water withdrawal ranged from 1-2 ft.

In April 1978, level lines 1-8 (vertical control only) were established across selected faults and subsidence features in the Las Vegas Valley. Level line 10 was added in 1980. Level line 9 was never activated. The lines were selected by the Nevada Bureau of Mines and Geology and Nevada Department of Transportation. The level lines were designed to determine the existence, if any, of narrow zones of severe differential movement occurring along or near existing fault scarps and which may be due to ground-water withdrawal-induced land subsidence. The names of city street intersections closest to the ends of the level lines are listed in table 2. Locations of the lines are also shown in figure 2.

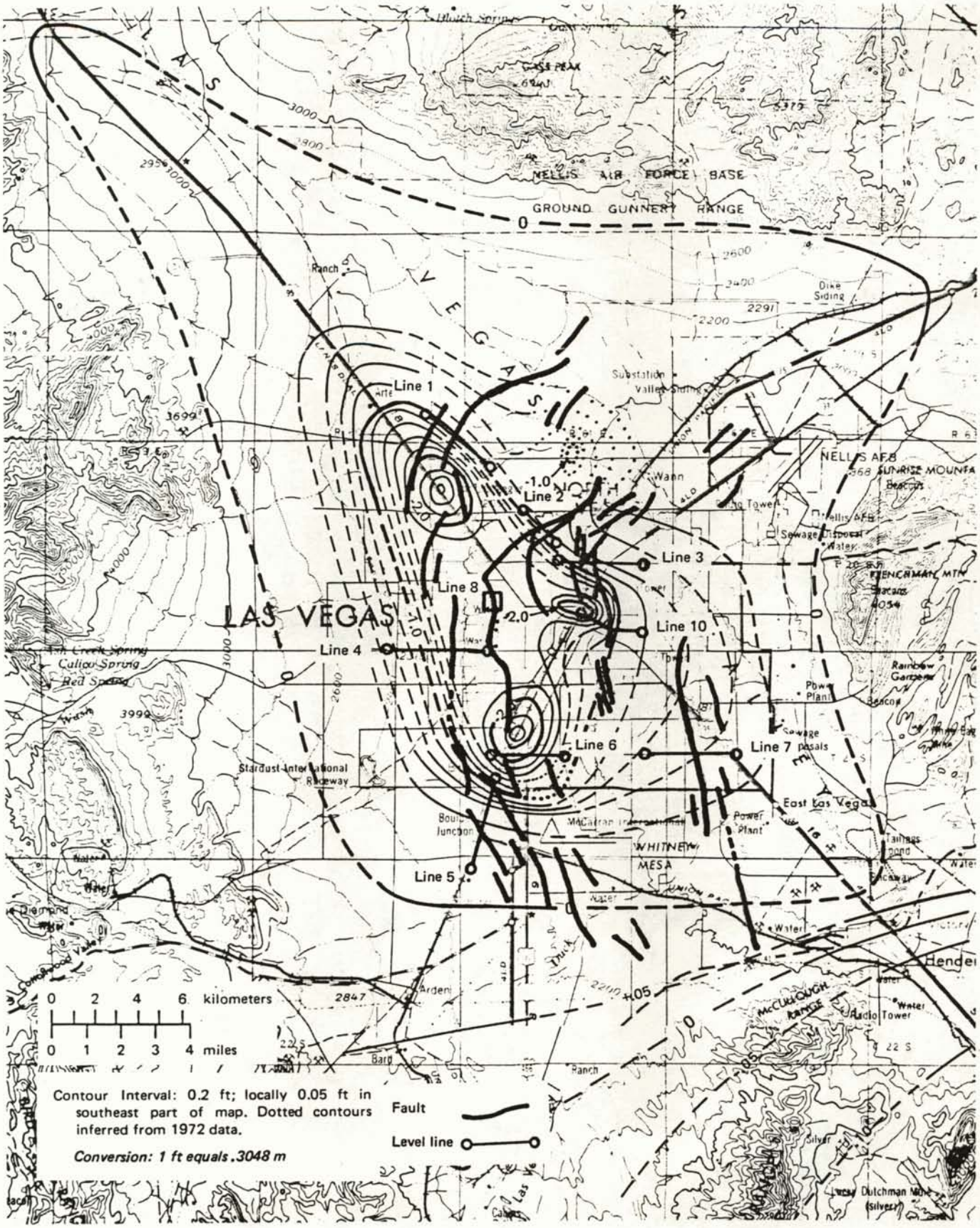

Figure 2. Land subsidence between 1963 and 1980 due to artesian-head decline, location of fault scarps, and location of level lines in Las Vegas Valley (modified from Bell, 1981).

Table 2. City Street Intersections Near the Ends of Level Lines.

Level Line Number	Level Line End	Street Intersection
1	NW	Jones Blvd, Anns Rd.
	SE	Craig Rd., Allen Rd.
2	NW	Cheyenne Rd., Colman Ave.
	SE	Cartier Ave., Highland Dr.
3	W	Lake Mead Blvd, Concord St.
	E	Lake Mead Blvd, Carroll St.
4	W	Charelston Ln., Arville Rd.
	E	Charelston Ln., Rainbow Blvd
5	N	Tropicana Ave., Union Pacific RR
	S	Sunset Rd., Union Pacific RR
6	W	Flamingo Rd., Valley View Blvd
	E	Flamingo Rd., Paradise Rd.
7	W	Flamingo Rd., Pearl Ave.
	E	Flamingo Rd., Nellis Blvd
8A	N	West Washigton Ave., Twin Lakes Dr.
	S	West Nugget Ave., Twin Lakes Dr.
8B	E	West Nugget Ave., Twin Lakes Dr.
	W	West Nugget Ave., Valley View Blvd
8C	S	West Nugget Ave., Valley View blvd
	N	West Washigton Ave., Valley View Blvd
8D	W	West Washigton Ave., Valley View Blvd
	E	West Washigton Ave., Twin Lakes Dr.
10	W	Stewart St., Third St.
	E	Stewart St., Eastern Ave.

The nine level lines described here have been releveled annually --most recently in April, 1987--by the Nevada Department of Transportation thereby providing a ten-year record for lines 2-8, and an 8-year record for lines 1 and 10 (line 1 was discontinued after 1985 due to construction).

The purpose of this report is to provide tabular and graphical summaries of the ten-year record, and to interpret the data.

METHODS

Each of the level lines is approximately 1-2 1/2 mi in length and consist of a series of benchmarks spaced at 200-300 ft intervals. All of the lines are more or less straight lines with the exception of line 8 which is a four-sided circuit. The level

lines contain only relative elevations; they are not tied to absolute elevations. The values reported in Appendix B are different than the data originally obtained from the Nevada Department of Transportation in that the values were adjusted so as to not exceed a value of 1,000.000. This was done primarily for compatibility with the computer software used for compilation and graphics. For this report, Malcom Wilson of the Nevada Department of Transportation chose a fixed benchmark for each line (having the same elevation for the period of record) with the rest of the line adjusted accordingly. An example demonstrating both of these adjustments is as follows. Benchmark 29 was chosen as the fixed elevation for line 1 with an elevation of 2,209.685 ft. The elevations for this benchmark were reported originally as 2,209.685 ft in 1978 and 2,209.669 ft in 1979. The 1979 line was adjusted by subtracting 2,000.016 ft from each station. The benchmarks and fixed elevations used for each of the lines are listed in table 2.

Table 2. Benchmarks and Elevations Used as Fixed Elevations.

Line	Benchmark	Elevation (ft)
1	29	2,209.685
2	22	2,186.991
3	G368	1,845.265
4	49	2,370.719
5	R366	2,301.931
6	29	2,073.729
7	CLN066	1,706.191
8	13	1,000.000
10	Z314	1,850.540

All lines were leveled to at least second-order accuracy. The maximum closed-loop (closure) error using this technique is 0.035 multiplied by the square root of the closure distance in miles. For example, on line 1 the total length of the closed loop is about 4.5 mi. Maximum allowable error = $0.035 \sqrt{4.5} = 0.07$ ft. This closure error is distributed to individual stations (benchmarks) based on distance along the line. Therefore, all stations are adjusted by some fraction of the total error.

Profiles and cumulative elevation changes for the level lines are plotted in figures 3 to 14. Lines 1, 2, 3, 7, and 8 use 1978 as the base year and odd-numbered years are plotted. Lines 4 and 5 use 1982 and 1981, respectively, as base years due to numerous benchmark resets in those years. Line 10 uses 1980 as the base year. In all the lines, once a benchmark is reset following the base year, it is no longer used and appears as a gap in the elevation change plot. To provide a comparison of the relative magnitude of changes in the lines, the results are plotted at approximately the same scales.

RESULTS

Level Line 1

Line 1 crosses the Eglington fault scarp near the center of the line. The original sense of movement of the fault is down to the southeast. A 2,000-ft-wide graben-like depression has now developed along, and parallel to, the Eglington scarp; it attained a maximum depth of 1.26 ft between 1978 and 1985 (fig. 3). The annual elevation changes of the lowest point in this feature are listed in table 3 and indicate a possible slight decrease in the rate of differential movement since 1980. The maximum differential movement between two adjacent bench marks (located 250 ft apart) is 0.39 ft during the period of record and is located near the base of the Eglington fault scarp.

Table 3. Annual Elevation Changes at Selected Stations* for Lines Demonstrating Differential Movements (excluding line 5).

ELEVATION CHANGE (FT)

YEAR	LINE 1 STA 21	LINE 2 STA 16	LINE 3 STA 1	LINE 6 STA 15	LINE 8 STA 8	LINE 10 STA BMK16
1979-78	-0.20	0.03	-0.15	0.02	-0.06	--
1980-79	-0.24	0.03	-0.09	0.04	-0.04	--
1981-80	-0.02	0.03	-0.08	0.01	-0.02	-0.09
1982-81	-0.14	0.02	-0.08	0.01	-0.01	-0.08
1983-82	-0.20	0.02	-0.11	0.02	-0.02	-0.11
1984-83	-0.16	0.02	-0.06	0.02	-0.02	-0.09
1985-84	-0.15	0.03	-0.08	0.02	-0.02	-0.10
1986-85	--	0.00	-0.08	0.04	0.01	-0.05
1987-86	--	0.03	-0.10	-0.01	-0.00	-0.12
TOTAL	-1.26	0.21	-0.83	0.17	-0.18	-0.64
MEAN	-0.18	0.02	-0.09	0.02	-0.02	-0.09

*Stations are selected on the basis of having no resets during the period of record and of having the greatest amount of elevation change in the line.

The plot of elevation change for line 1 also shows another smaller graben-like feature that developed near the northwest end of the line. The line does not appear to completely cross this feature but at least 0.23 ft of subsidence occurred relative to the northeast end of the line. The profile of the line shows a small 1000-1500 ft wide pre-existing scarp at the location of the graben near the northern limit of a mapped fault (fig. 2). These observations suggest the presence of a second fault crossing the line with the original sense of fault movement also down to the southeast. The subsidence movement observed during the monitoring period is also down to the southeast. The differential subsidence movements recorded along the primary Eglington fault scarp, however, are down to the northwest--

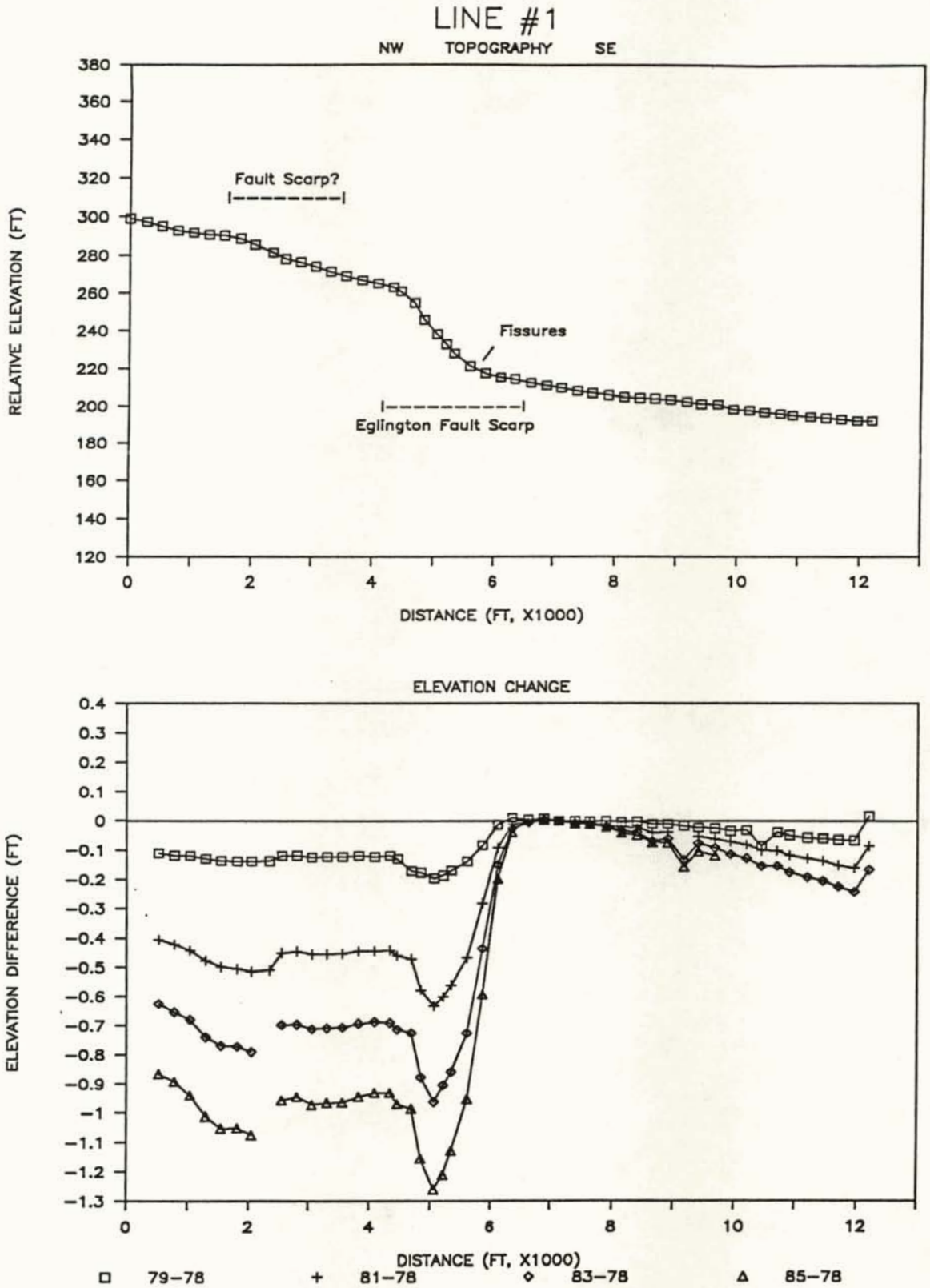

Figure 3. Las Vegas Level Line #1, Topography and Elevation Change.

opposite the original sense fault of movement.

Overall, elevation changes on this line suggest that subsidence is occurring as differential movements of individual fault-bounded blocks with the block between the faults subsiding at a slightly faster rate. The center of a local subsidence basin is located 1-2 mi southwest of the line near the North Las Vegas Airport (fig. 2). Thus, the observed movements in the line may be due to more dewatering of the blocks northwest of the Eglington fault scarp; the middle block may possibly be experiencing a slightly faster rate of dewatering due to ground-water barriers imposed by the faults. Although this interpretation is somewhat speculative, it does appear that the local subsidence basin is exerting considerable control on the differential movements in this line.

Finally, the vertical movements in line 1 are distributed over relatively wide zones (1,000-2,000 ft wide) and are not manifested by vertical offsets of near-surface sediments. This, together with apparent graben formation, suggest that vertical movement here is accommodated by extension and warping rather than faulting. Fissures observed at the base of the Eglington fault scarp (Bell, 1981a) appear to be the expression of lateral separation of the blocks, at least near the surface, as the blocks subside.

Level Line 2

Line 2 crosses two fault scarps (fig. 2) showing pre-existing movements down to the southeast. Several relatively narrow zones of differential movement occur over the length of the line. The maximum differential subsidence movement between two adjacent stations (located 250 ft apart) for the period of record is 0.40 ft and occurs at the base of the northwest scarp. The average annual elevation change for the station (number 16, table 3) showing the greatest amount of differential movement (near the base of the northwest scarp) is 0.02 ft. It does not, however, show a clear trend in the rate of differential movement.

The differential movements on this line suggest a more complicated mechanism than can be explained by the presence of just two faults. There is also no apparent relation between the observed sense of movements and the pre-existing movements of the faults. The line lies parallel to the edge of the main valley-wide subsidence basin and is between three smaller local subsidence basins located within two miles of the line. Two of the smaller basins are located northwest and north of the line and one is located southeast of the line (fig. 2). These local basins should create an extensional stress field at the site of the line if they have not shifted significantly since 1980. The observed movements may be the expression of either differential settling of several structural blocks or the response of inhomogeneities of surface sediments to movements of structural

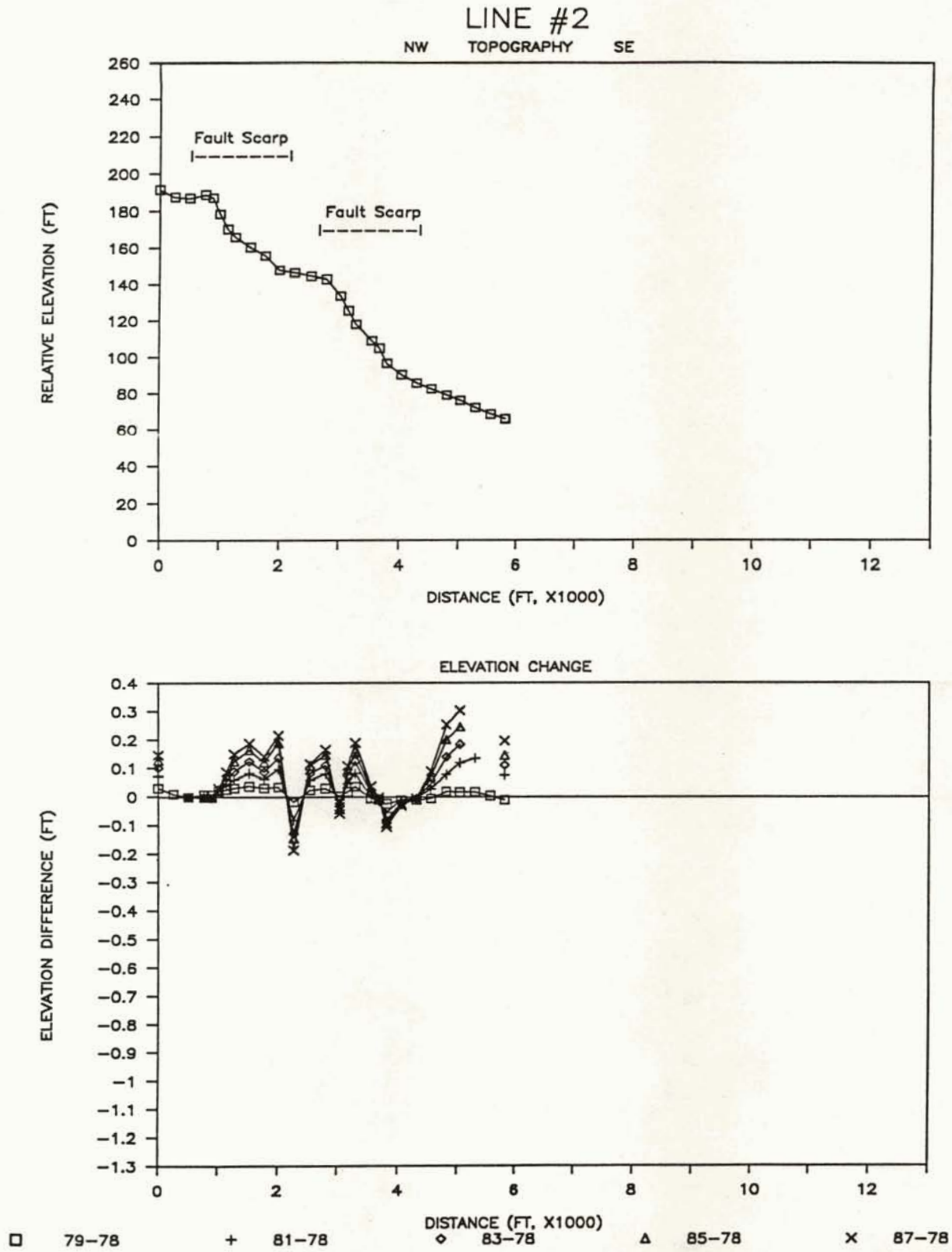

Figure 4. Las Vegas Level Line #2, Topography and Elevation Change.

blocks. In either case, the distribution of differential movements across the entire line demonstrates that stresses are being relieved over a broad region, thereby reducing the possibility of significant surface rupture at a particular location.

Level line 3

Line 3 crosses a series of faults having an original sense of movement down to the east. The eastern half of the line shows only minor elevation changes that are within the error allowed for second-order accuracy (0.073 ft per year). The western portion of the line is subsiding relative to the east side with a 0.83 ft maximum elevation drop since 1978. The zone of differential movement is about 5,000 ft wide and extends westward from the base of the prominent scarp shown in the profile. A 1,500 ft wide graben-like feature is apparent near the center of the subsiding area and may reflect the presence of multiple faults along the scarp. Since 1978, the maximum differential movement between adjacent benchmarks (250 ft apart) is about 0.10 ft located near the middle of the scarp. The annual elevation change at station 1 ranged from -0.06 to -0.15 ft (table 3).

The ten year record clearly indicates that movement is down to the west--opposite to the original sense of movement--and is apparently controlled by the main subsidence bowl lying to the west of the line.

Level Line 4

Line 4 crosses a single fault scarp with the original sense of movement down to the east. The plot of cumulative elevation change uses 1982 as the base year. This line shows no conclusive evidence of any differential movement. Elevation changes from 1983 to 1985 show increasing deflections down to the east, while 1986 and 1987 show a reversal in trend (up to the east). The second-order accuracy for this line allows an annual error of 0.076 ft and most of the apparent deflections are within this range.

Level Line 5

Line 5 appears to cross at least two fault scarps, one near the center of the line and one at the north end of the line, with the original sense of movement down to the north on both. Differential movement for the southern two-thirds of the line is well within the limits of second-order accuracy (0.05 ft per year). A 4,000-5,000-ft-wide zone of differential movement is discernible at the northeast end of line where a maximum elevation change of at least 0.20 ft has occurred since 1981. Definition of this zone is complicated by benchmark resets since 1981, and because the line does not appear to completely cross the zone. The trend of the differential movement is in the same sense as the pre-existing fault displacements, and is into the main basin-wide subsidence basin.

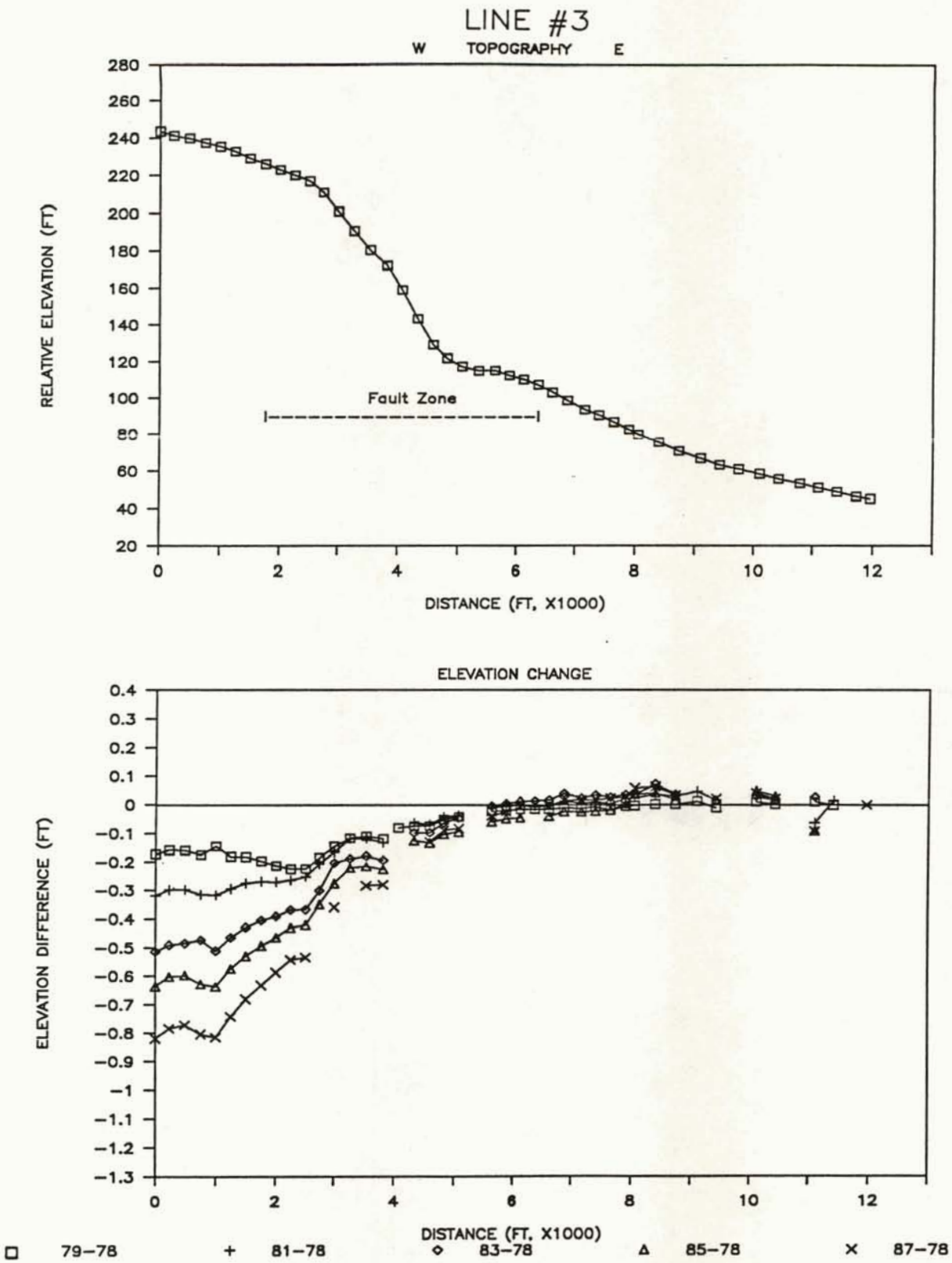

Figure 5. Las Vegas Level Line #3, Topography and Elevation Change.

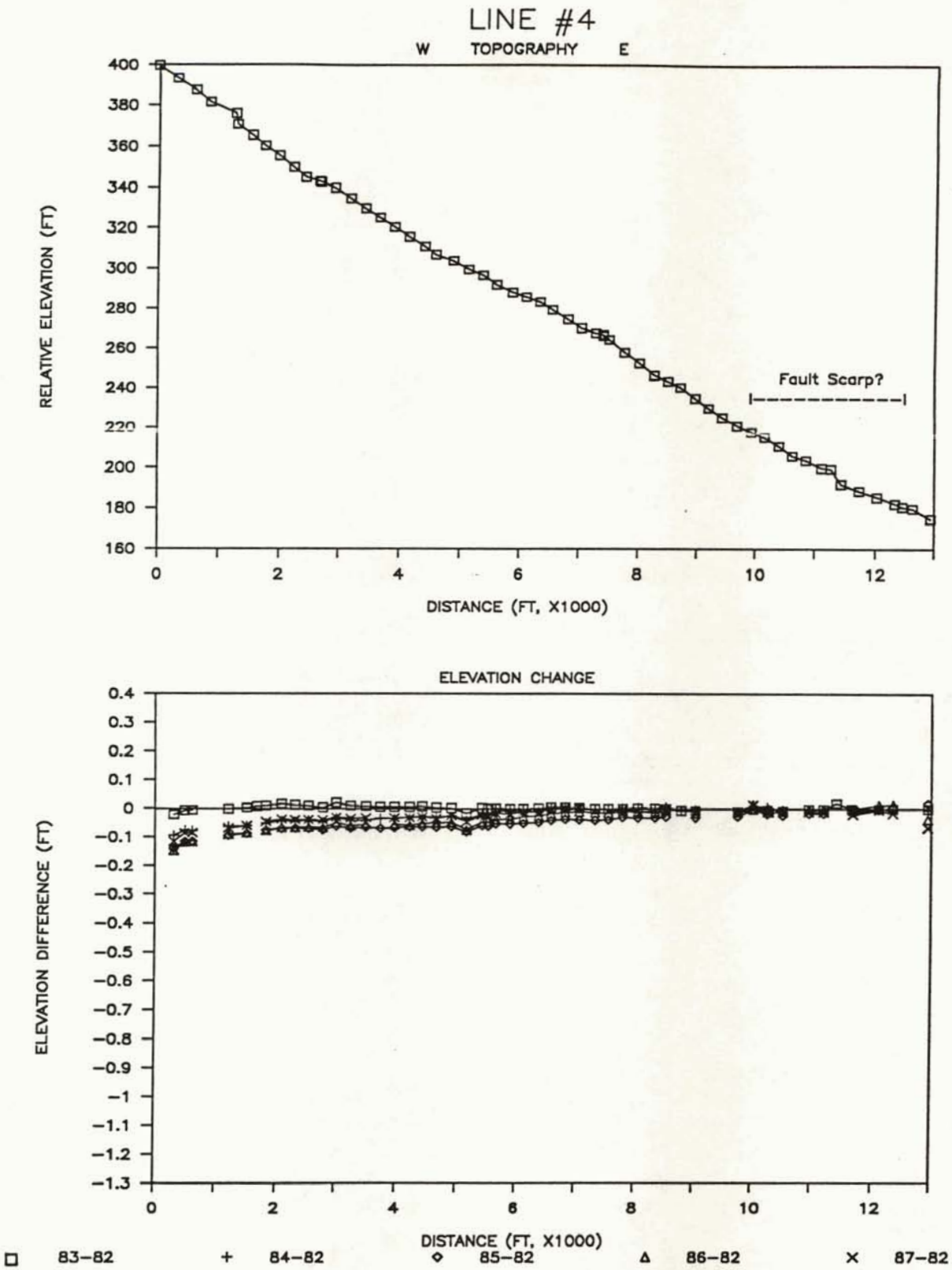

Figure 6. Las Vegas Level Line #4, Topography and Elevation Change.

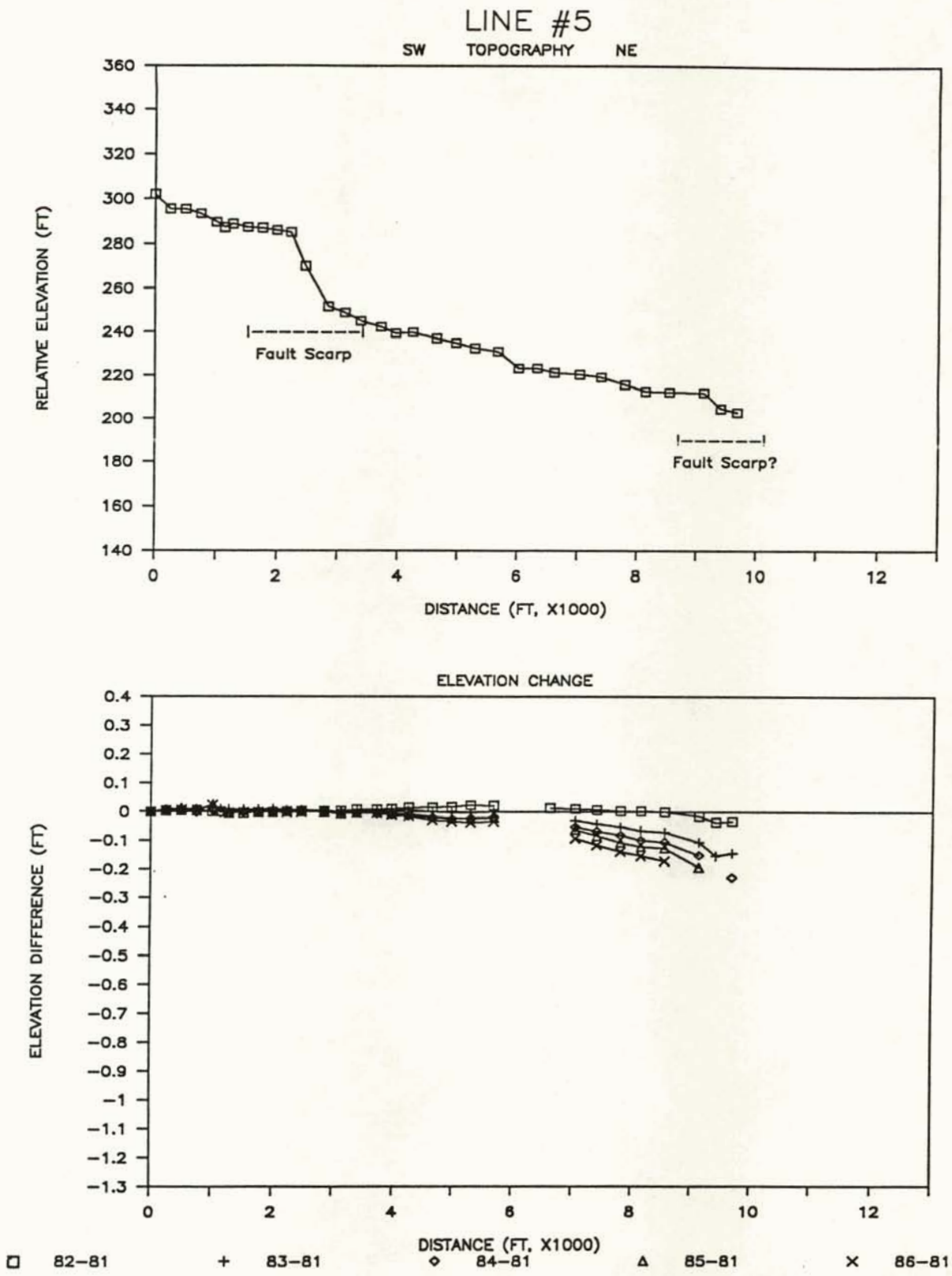

Figure 7. Las Vegas Level Line #5, Topography and Elevation Change.

Level Line 6

Line 6 crosses the northern end of two fault scarps having an original sense of movement down to the east. Three zones of differential movements can be seen in elevation changes since 1978. The western third of the line is poorly defined due to benchmark resets, but there appears to be a negative elevation change of at least 0.22 ft over a distance of about 2000 ft. The middle portion of this line demonstrates up to 0.18 ft of positive elevation change. No conclusive evidence for differential movement exists within the eastern third of the line. The maximum annual elevation change (station 15, table 3) ranged from -0.01 to 0.04 ft.

The plot of elevation changes suggests that the line is composed of three fault-bounded blocks, the boundaries of which lie at approximately the location of the mapped faults. The observed sense of movement between the western and middle blocks is opposite the original sense of movement while the movement between the middle and eastern blocks is similar to that of the original fault displacement. The observed movements in this line are likely to be affected by the local subsidence basin located immediately to the north, but more information on aquifer characteristics and fault geometries are needed to determine any relationships.

Level Line 7

Line 7 crosses a scarp with pre-existing movement down to the east. This line shows no clear evidence of differential movements during the period of record. The range in elevation changes are within the annual error allowed for second-order accuracy (0.068 ft).

Level Line 8

Line 8 consists of a square circuit with 2 north-south and 2 east-west lines lying directly north of the Las Vegas Valley Water District main well field. Each of the four lines are plotted separately in figures 10 to 13. One scarp, trending north-south, crosses the circuit. One of the east-west lines (8B) shows the eastern 900 ft of the line dropping relative to the western side. The maximum elevation change, located at the eastern end of the line, is about -0.19 ft since 1978 with annual elevation changes ranging from 0.00 to -0.06 ft (table 3). The other east-west line (8D) shows occasional slight reversals in the direction of elevation change, but there appears to be a similar trend in magnitude and sense of movement to that of 8B. Movement is similar to the pre-existing fault movement with the eastern sides moving down into the main subsidence basin.

Line 8A shows a maximum cumulative displacement of 0.21 ft since 1978. Most elevation changes appear to be consistent, and the values do not suggest closure error. No explanation is evident for the trend seen in this line.

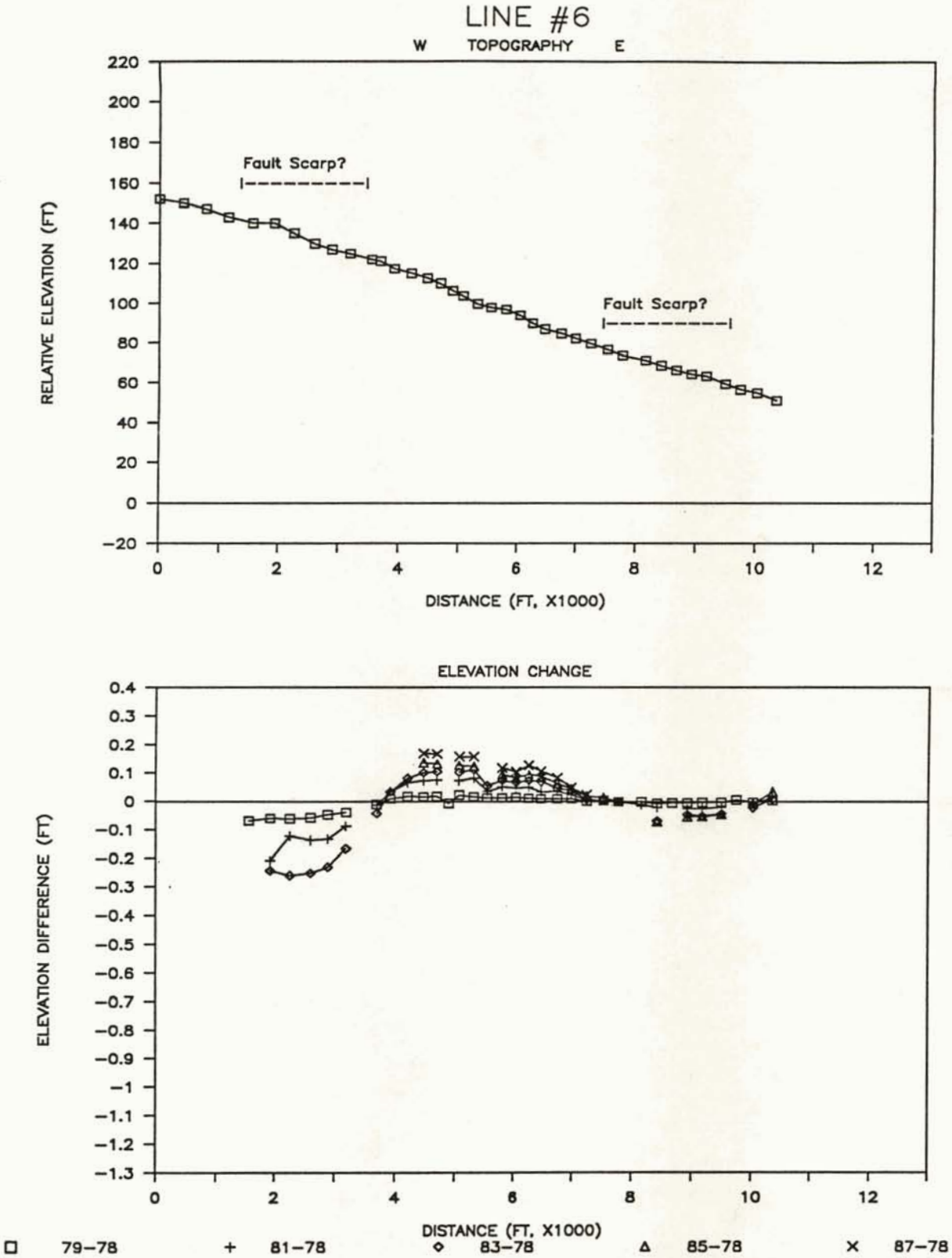

Figure 8. Las Vegas Level Line #6, Topography and Elevation Change.

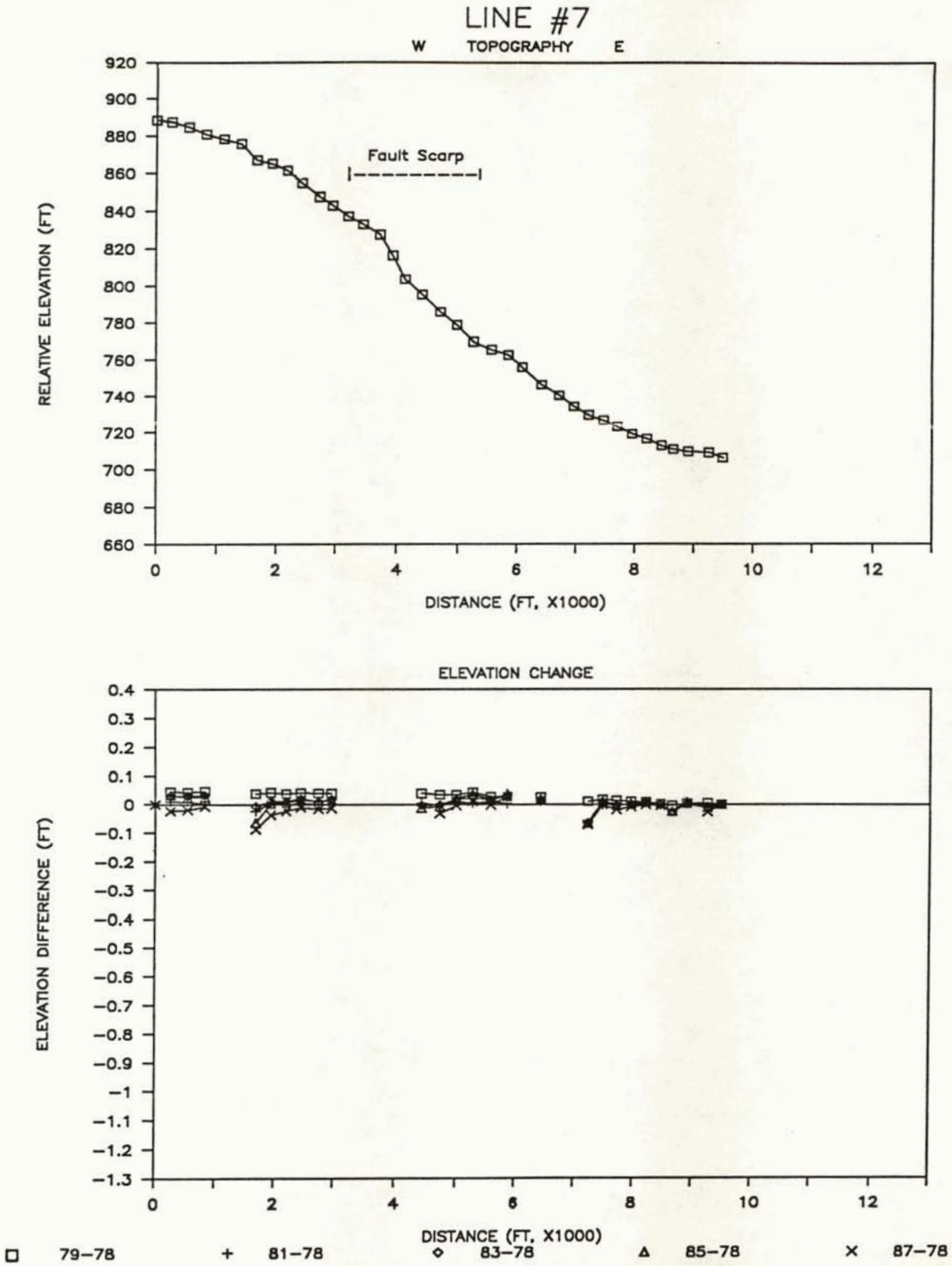

Figure 9. Las Vegas Level Line #7, Topography and Elevation Change.

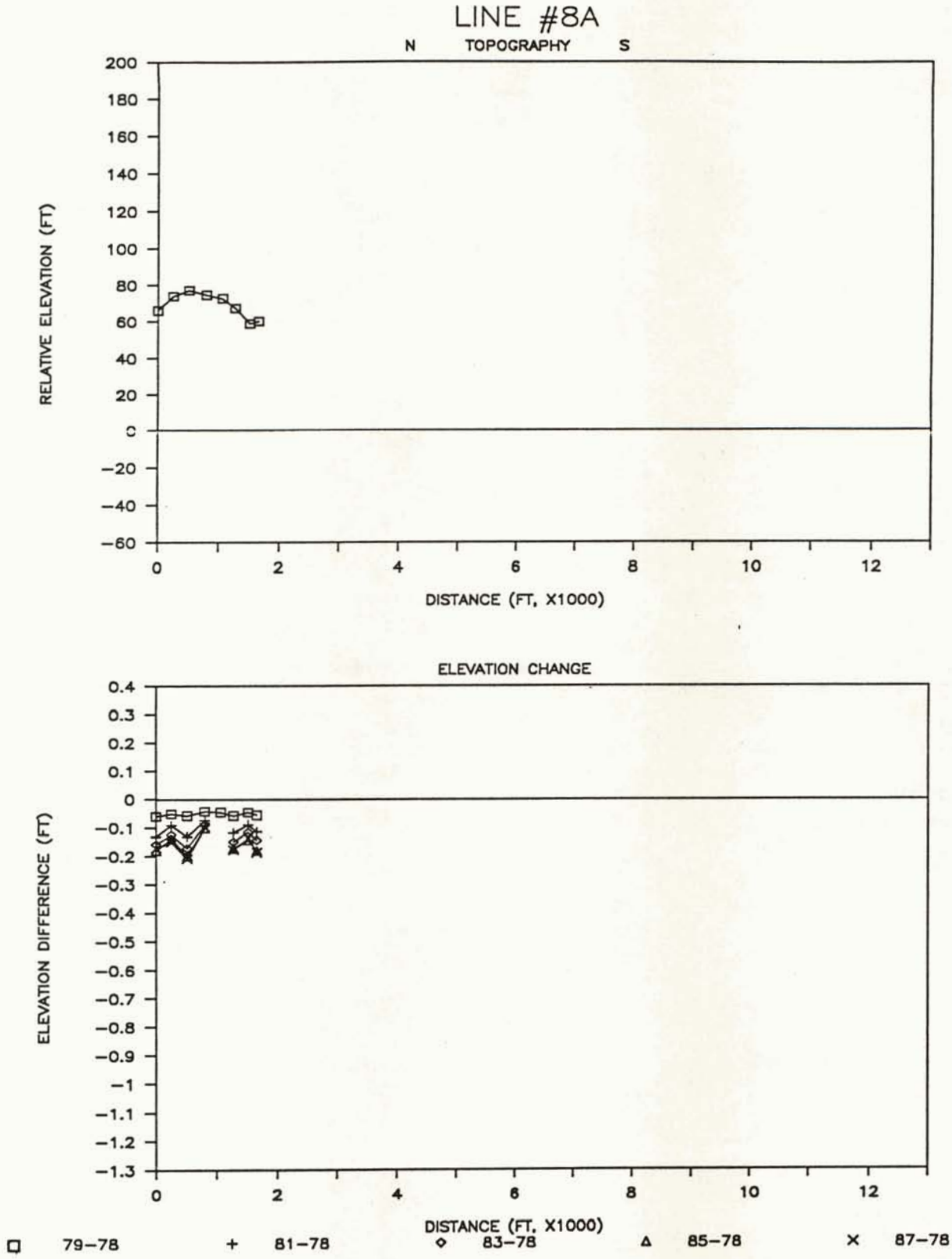

Figure 10. Las Vegas Level Line #8A, Topography and Elevation Change.

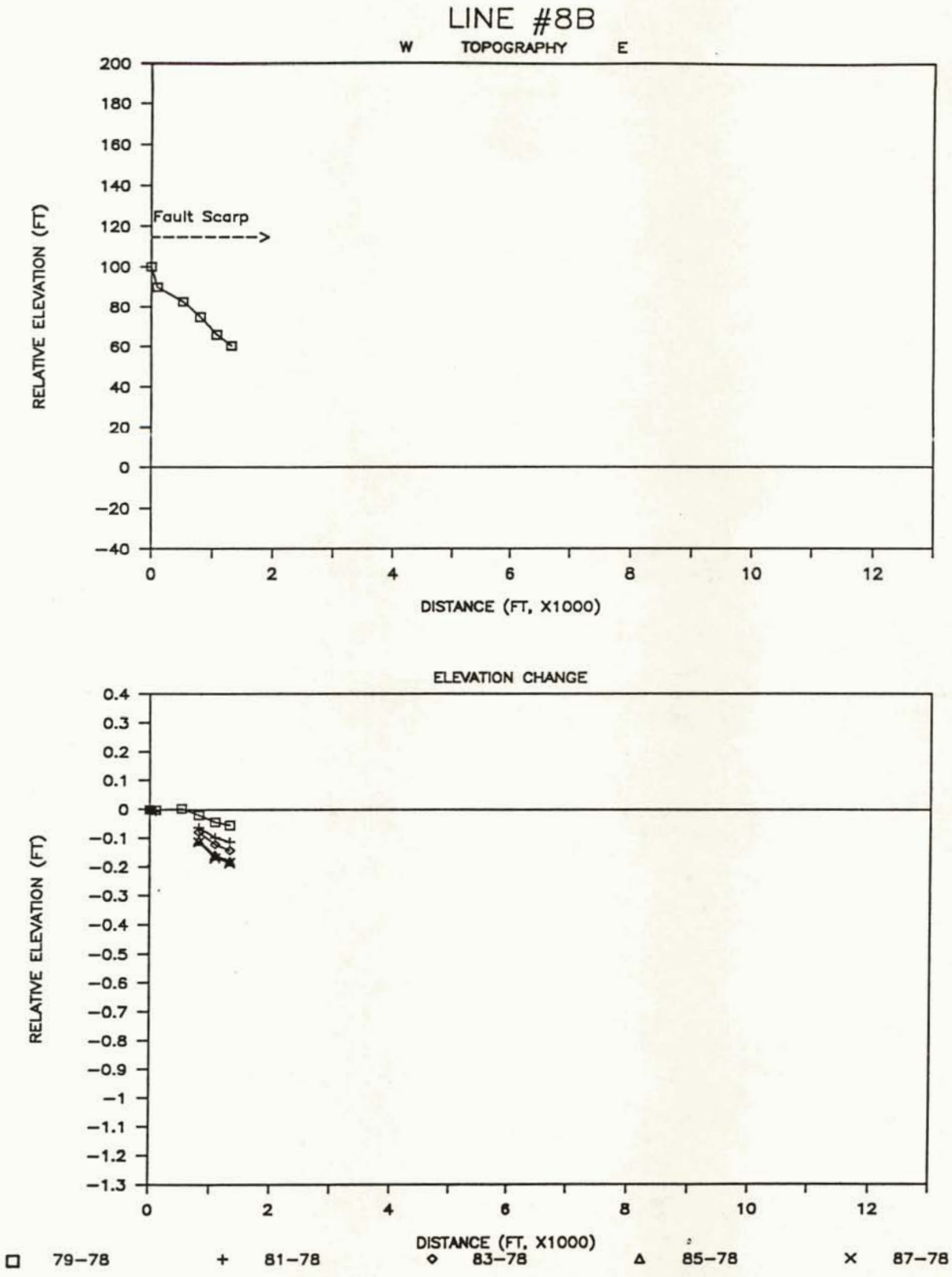

Figure 11. Las Vegas Level Line #8B, Topography and Elevation Change.

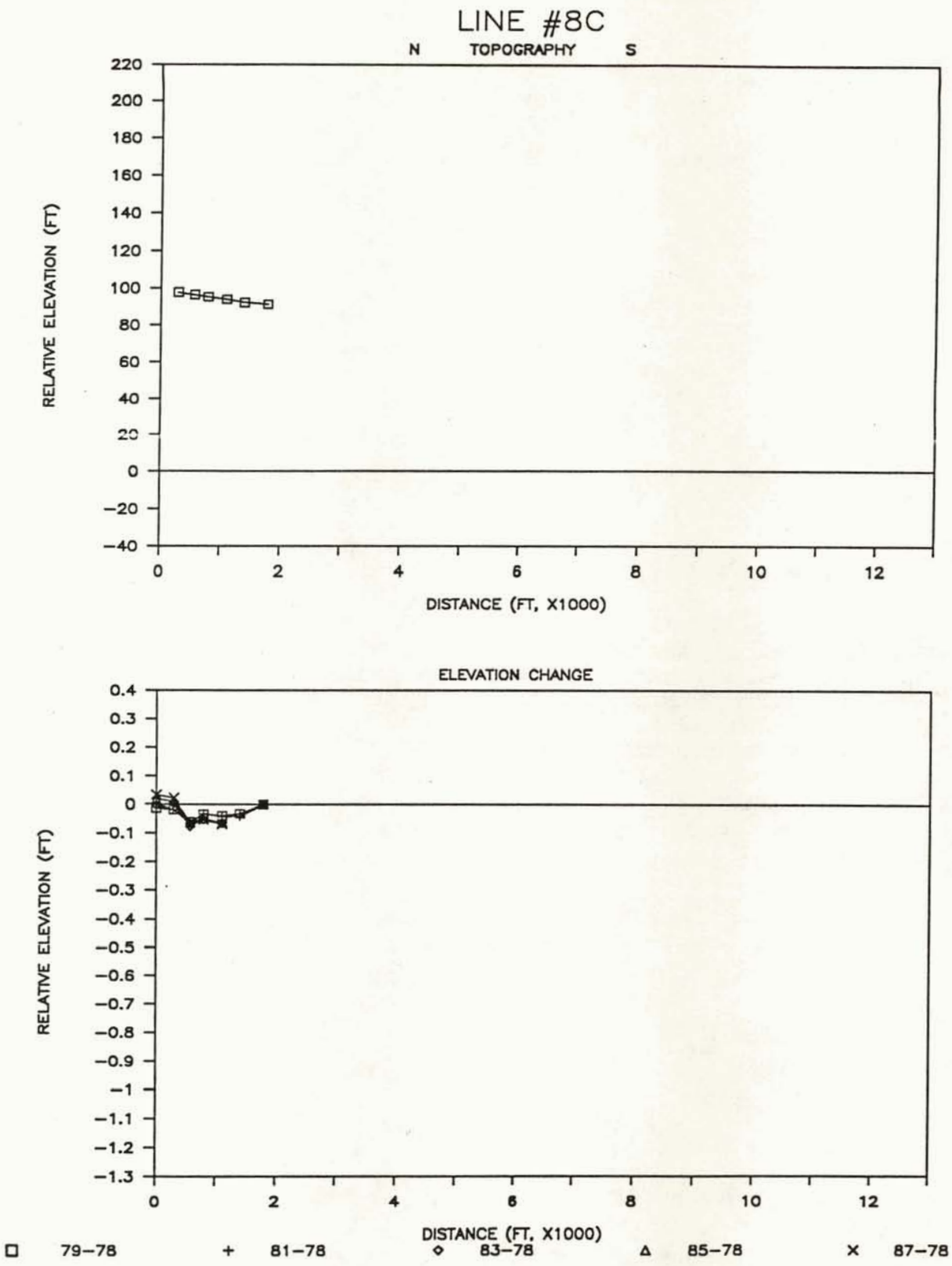

Figure 12. Las Vegas Level Line #8C, Topography and Elevation Change.

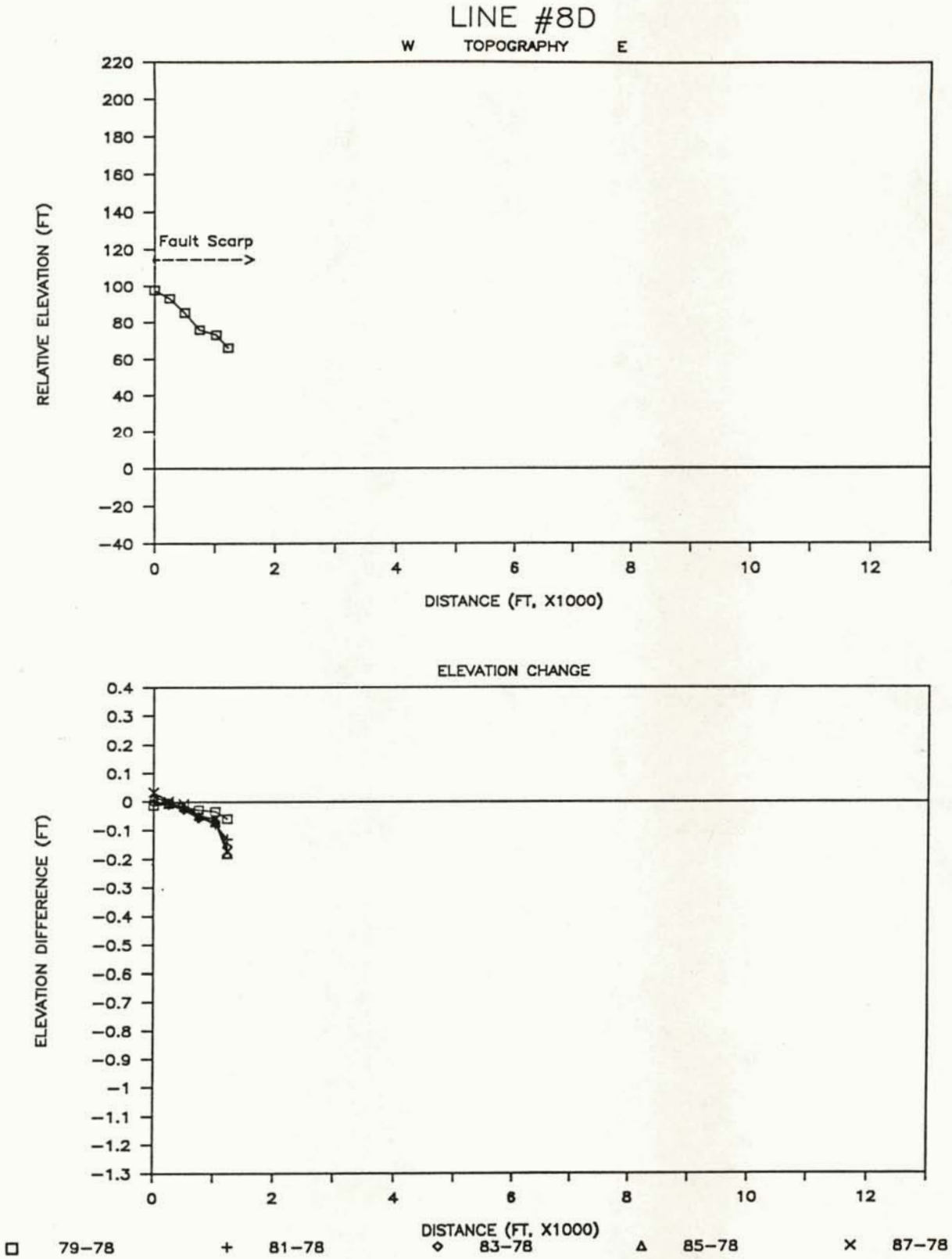

Figure 13. Las Vegas Level Line #8D, Topography and Elevation Change.

The third and fifth stations of level line 8C appear to have been reset after 1978. If this is the case, there is little evidence for differential movement on this line.

Level Line 10

Line 10 crosses a fault scarp with pre-existing movement down to the east. The elevation changes indicate that a 6500 ft portion of the line is dropping to the west, and that a 1500 ft wide graben-like feature has formed near the base of the scarp. The maximum elevation change for the period of record is nearly -0.65 ft at the west end of the line. The annual elevation change at this station (BMK169) ranged from -0.05 to -0.12 ft. The maximum differential movement between adjacent stations (200 ft apart) is 0.17 ft for the period of record and is located near the base of the scarp. The differential movement is opposite to the original sense of movement; the western end of the line is subsiding down to the east and into a local subsidence basin.

SUMMARY

Nine level lines designed to monitor differential movement across fault scarps were established in 1978-1980. The eight to ten year record shows seven of the lines (lines 1, 2, 3, 5, 6, 8, and 10) have demonstrated differential movement, while two (lines 4 and 7) show no conclusive evidence for movement. Lines 1 and 3 display the greatest amount of displacement during the period of record with maximum displacements of -1.26 and -0.82 ft respectively. Differential movement occurred over relatively wide zones ranging from a minimum of 900 ft (line 8) to 8000 ft (line 6). The maximum differential movement between adjacent stations (200-250 ft apart) for the period of record was 0.40 ft on line 2 and 0.39 ft on line 1.

The maximum mean annual elevation change for lines demonstrating differential movements ranged from 0.18 ft on line 1 to 0.02 ft on lines 2 and 8. No consistent trends were observed in annual elevation changes, and there is no apparent correlation with total ground-water pumpage, although the relationship between movement and localized pumpage hasn't been analyzed.

The sense of movement observed in lines exhibiting differential movement demonstrates that differential movement is controlled by local subsidence basins, regardless of the pre-existing movement of faults. Those portions of the faults closest to a basin are subsiding most rapidly. Plots of elevation change show that at least some of the lines are composed of a series of fault-bounded blocks, and that some differential movements are the result of differential settlement between individual blocks. Overall, vertical movements are accommodated by extension and warping rather than rupturing (faulting) of near-surface sediments.

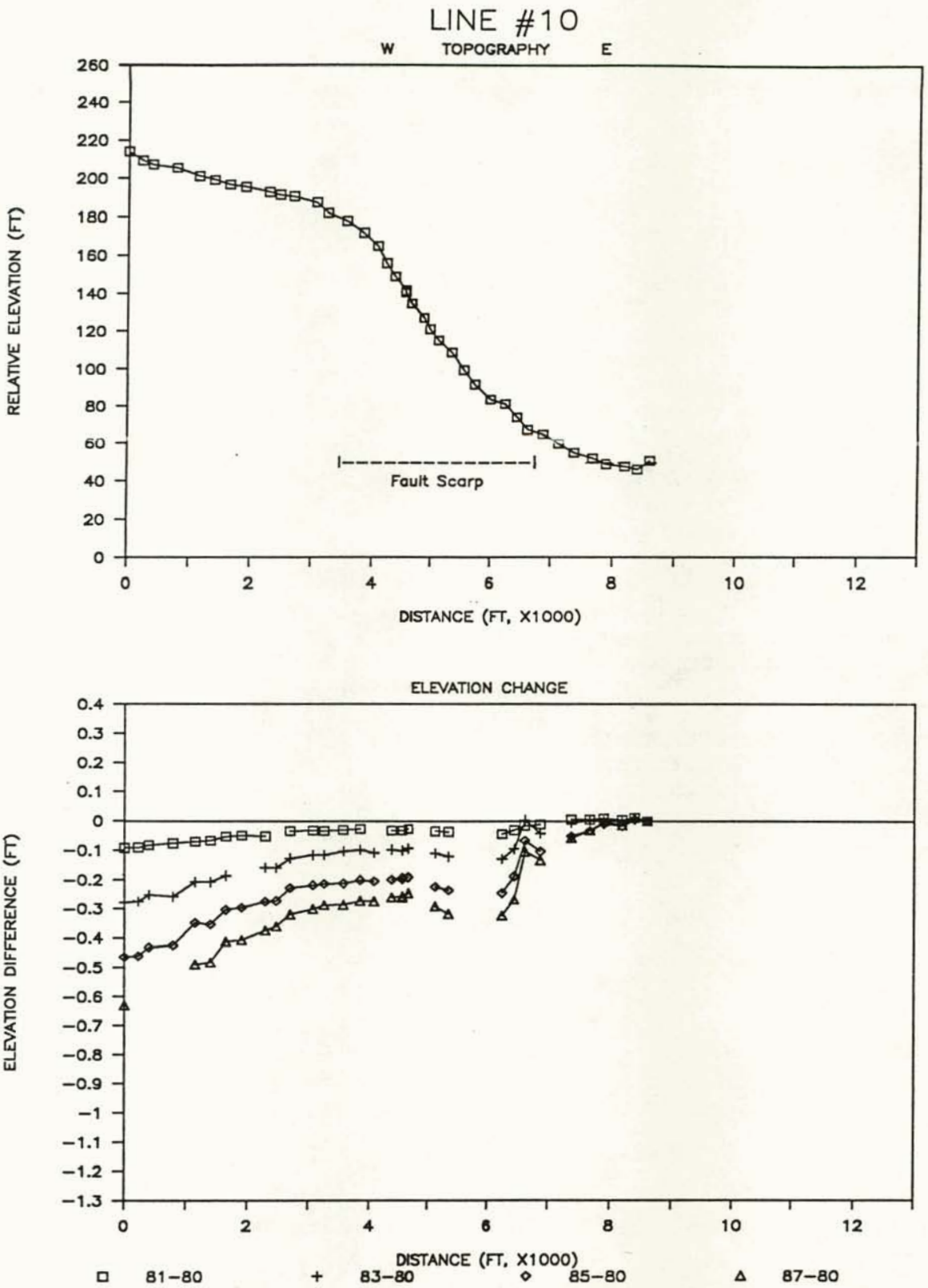

Figure 14. Las Vegas Level Line #10, Topography and Elevation Change.

The results of eight to ten years of annual benchmark releveling show that differential movement has been generally consistent on a year-to-year basis. Although some interpretations differ slightly from previous reports (Bell 1980, 1981a, 1981b, 1982), current trends are essentially the same as those in the earlier reports. This suggests that rate, distribution, and direction of differential movement due to ground-water withdrawal can be identified by annual leveling. At the present level of pumpage, several years of data appear sufficient to adequately monitor local zones of differential movement.

REFERENCES CITED

Bell, John W. (1980) Results of leveling across fault scarps in Las Vegas Valley, April, 1978-June, 1980: Nevada Bureau of Mines and Geology Open-file Report 80-7, 15 p.

------ (1981a) Subsidence in Las Vegas Valley: Nevada Bureau of Mines and Geology Bulletin 95, 84 p.

------ (1981b) Results of leveling across fault scarps in Las Vegas Valley, April, 1978-June, 1981: Nevada Bureau of Mines and Geology Open-file Report 81-5, 7 p.

------ (1982) Results of leveling across fault scarps in Las Vegas Valley, April, 1978-March, 1982: Nevada Bureau of Mines and Geology Open-file Report 82-10, 7 p.

Coache, R. (1986) Las Vegas artesian basin, ground-water pumpage inventory: Nevada Division of Water Resources.

Domenico, P. A., and Maxey, G. B. (1964) An evaluation of the cause and effect of land subsidence in Las Vegas Valley with special reference to the Owens Avenue area: University of Nevada Desert Research Institute report to Nevada Highwy Department.

Harrill, J. R. (1976) Water-level changes associated with ground-water development in Las Vegas Valley, Nevada, 1971-75: Fourth Progress Report--Summary of Data, Nevada Department of Conservation and Natural Resources, Water Resources Information Series Report 22, 46 p.

Holzer, T. L. (1978) Documentation of potential for surface faulting related to ground-water withdrawal in Las Vegas Valley, Nevada: U.S. Geological Survey Open-file Report 78-79, 18 p.

Malmberg, G. T. (1961) A summary of the hydrology of the Las Vegas Valley ground-water basin, Nevada, with special reference to the available supply: Nevada Department of Conservation and Natural Resources, Water Resources Information Series Report 5, 10 p.

------ (1965) Available water supply of the Las Vegas ground-water basin, Nevada: U.S. Geological Survey Water-Supply Paper 1780, 116 p.

Maxey, G. B., and Jameson, C. H. (1948) Geology and water resources of the Las Vegas, Pahrump, and Indian Springs Valley, Clark and Nye Counties, Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Bulletin 5, 128 p.

Mindling, A. L. (1971) A summary of data related to land subsidence in Las Vegas Valley: University of Nevada Desert Research Institute Publication, 55 p.

APPENDIX A. LISTING OF LEVELING DATA

LEGEND

R--Monument reset

M--Missing data

D--Monument destroyed

?--Questionable data value; usually due to unreported resets in original data

LAS VEGAS LEVEL LINE #1

STATION	1983	1984	1985	1986
1	299.128	298.998	298.884	DISCONTINUED
2	296.690	296.574	296.455	
3	294.426	294.308	294.187	
4	292.171	292.050	291.933	
5	291.043	290.830	290.701	
6	289.931	289.770	289.640	
7	289.366	289.220	289.083	
8	287.767	287.622	287.488	
9	284.900	284.586	284.448	
10	R280.639	R280.486	280.358	
11	277.707	277.405	277.280	
12	276.010	275.811	275.700	
13	273.439	273.300	273.179	
14	270.558	270.691	270.573	
15	268.830	268.266	268.149	
16	266.080	265.941	265.829	
17	264.431	264.290	264.188	
18	262.680	262.377	262.274	
A18	260.261	260.117	260.005	
19	254.289	254.145	254.028	
20	245.075	244.928	244.796	
21	237.137	236.981	236.839	
A21	232.045	231.804	231.664	
22	227.181	227.045	226.912	
23	220.632	220.513	220.404	
24	217.147	217.070	216.991	
25	215.212	215.187	215.164	
26	214.395	214.391	214.383	
27	212.466	212.467	?212.571	
28	210.977	210.975	210.975	
29	209.685	209.685	209.685	
30	208.289	208.290	208.287	
31	206.858	206.860	206.859	
32	205.845	205.843	205.843	
33	204.702	204.700	204.696	
34	204.275	204.274	204.265	
35	203.915	203.915	203.911	
36	203.220	203.209	203.205	
37	202.124	202.113	202.100	
38	200.943	200.928	200.915	
39	200.794	200.778	200.766	
40	198.182	198.164	R198.182	
41	197.544	197.528	R197.510	
42	196.473	196.449	R196.112	
43	195.728	195.703	R195.577	
44	194.917	194.896	R196.578	
45	194.104	194.037	R197.588	
46	193.423	193.385	R197.312	
47	192.700	192.653	R196.752	
48	191.987	191.940	R195.415	
B-369	192.019	191.973	?194.507	

LAS VEGAS LEVEL LINE #1

STATION	1978	1979	1980	1981	1982
1	D299.176	R299.640	298.913	299.348	299.258
2	D297.326	R297.200	297.040	296.913	296.820
3	295.052	294.941	294.779	294.647	294.549
4	292.825	292.706	292.537	292.404	292.304
5	291.640	291.520	291.339	291.198	291.091
6	290.652	290.523	290.328	290.175	290.059
7	290.135	289.998	289.798	289.637	289.517
8	288.539	288.400	288.199	288.035	287.917
9	285.523	285.384	285.175	285.009	284.890
10	281.520	281.382	281.178	281.011	280.897
11	278.237	278.117	277.936	277.787	277.682
12	276.645	276.526	276.347	276.200	276.092
13	274.150	274.026	273.846	273.695	273.583
14	271.538	271.416	271.236	271.083	270.974
15	269.113	268.990	268.813	268.660	268.553
16	266.773	266.653	266.480	266.329	266.222
17	265.118	264.996	264.820	264.675	264.568
18	263.204	263.084	262.911	262.763	262.659
A18	260.974	260.844	260.665	260.514	260.409
19	255.014	254.842	254.696	254.543	254.438
20	245.952	245.775	245.557	245.375	245.252
21	238.100	237.904	237.668	237.468	237.332
A21	232.874	232.688	232.460	232.273	232.146
22	228.040	227.870	227.657	227.480	227.354
23	221.356	221.217	221.038	220.889	220.782
24	217.582	217.500	217.385	217.301	217.236
25	215.362	215.348	215.293	215.270	215.246
26	214.422	214.431	214.407	214.408	214.402
27	212.474	212.478	212.464	212.468	212.467
28	210.973	210.980	210.966	210.976	210.978
29	209.685	209.685	209.685	209.685	209.685
30	208.297	208.297	208.286	208.289	208.292
31	206.872	206.870	206.857	206.863	206.865
32	205.864	205.864	205.852	205.848	205.851
33	204.737	204.732	204.709	204.715	204.713
34	204.314	204.312	204.284	204.291	204.289
35	203.984	203.972	203.941	203.944	203.939
36	203.280	203.269	203.236	203.242	203.238
37	202.257	202.240	202.214	R202.151	202.142
38	201.019	200.996	200.963	200.965	200.962
39	200.886	200.860	200.826	200.825	200.815
40	198.296	198.261	198.233	198.225	198.210
41	197.671	197.638	197.602	197.591	197.576
42	196.627	196.543	196.544	196.527	196.509
43	195.882	195.844	195.798	195.780	195.766
44	195.093	195.044	194.996	194.975	194.958
45	194.297	194.240	194.195	194.169	194.150
46	193.628	193.568	193.521	193.491	193.472
47	192.924	192.860	192.807	192.772	192.755
48	192.228	192.162	192.100	192.066	192.047
B-369	192.186	192.202	192.140	192.101	192.078

LAS VEGAS LEVEL LINE #2

STATION	1978	1979	1980	1981	1982
1	66.030	66.019	66.076	66.105	66.122
2	68.569	68.573	68.641	?68.970	R 68.382
3	72.103	72.120	72.193	72.237	R 71.592
4	76.067	76.083	76.147	76.184	76.218
5	79.071	79.090	79.147	R79.148	79.175
6	82.497	82.491	82.518	82.524	82.538
7	85.760	85.749	85.759	85.756	85.763
8	90.401	90.389	90.390	90.389	90.396
9	96.633	96.609	96.595	96.577	96.572
A9	104.816	104.806	104.802	104.799	104.804
10	108.904	108.898	108.904	108.904	108.915
11	118.021	118.057	118.084	118.102	118.128
A11	125.608	125.626	125.645	125.655	125.674
12	133.813	133.816	133.806	133.792	133.793
13	143.030	143.059	143.085	143.109	143.131
14	144.772	144.796	144.813	144.830	144.849
15	146.510	146.492	146.459	146.428	146.414
16	147.984	148.018	148.053	148.079	148.100
17	155.808	155.838	155.858	155.870	155.883
18	160.598	160.635	160.661	160.680	160.702
19	166.044	166.074	166.091	166.104	166.119
A19	170.498	170.524	170.533	170.539	170.547
20	178.619	178.639	178.644	178.639	178.632
A20	187.129	187.137	187.137	187.127	187.126
21	188.909	188.916	188.916	188.913	188.910
22	186.991	186.991	186.991	186.991	186.991
23	187.611	187.620	187.621	?187.439	187.449
24	D191.510	R191.540	191.565	191.583	191.596

LAS VEGAS LEVEL LINE #2

STATION	1983	1984	1985	1986	1987
1	66.140	66.186	66.174	66.190	66.226
2	68.093	68.465	68.465	68.416	68.520
3	71.643	71.372	R71.751	71.776	71.818
4	76.250	76.311	76.312	76.327	76.370
5	79.210	79.264	79.271	79.280	79.324
6	82.543	82.580	82.567	82.557	82.586
7	85.752	85.774	85.750	85.736	85.756
8	90.381	90.402	90.375	90.356	90.370
9	96.551	96.564	96.538	96.519	96.527
A9	104.802	104.823	104.809	104.799	104.816
10	108.916	108.933	108.927	108.922	108.942
11	118.145	118.170	118.178	118.178	118.210
A11	125.680	125.699	125.700	125.689	125.716
12	133.781	133.784	133.770	133.742	133.754
13	143.139	143.162	143.176	143.175	143.195
14	144.854	144.876	144.881	144.865	144.886
15	146.381	146.381	146.364	146.323	146.323
16	148.120	148.141	148.173	148.169	148.199
17	155.894	155.907	155.928	155.923	155.948
18	160.721	160.734	160.762	160.759	160.785
19	166.132	166.144	166.168	166.168	166.193
A19	170.551	170.554	170.571	170.569	170.585
20	178.639	178.633	178.645	178.643	178.650
A20	187.125	187.123	187.127	187.127	187.133
21	188.908	188.906	188.907	188.913	188.912
22	186.991	186.991	186.991	186.991	186.991
23	187.453	187.457	R185.898	185.900	185.906
24	191.611	191.623	191.637	191.645	191.656

LAS VEGAS LEVEL LINE #3

STATION	1978	1979	1980	1981	1982
1	243.475	243.302	243.242	243.158	243.073
2	241.246	241.087	?240.025	240.948	240.866
3	239.997	239.837	239.779	239.700	239.622
4	237.618	237.443	237.386	237.304	237.226
5	235.565	235.420	235.325	235.249	235.165
CLVD4	232.967	232.785	232.745	232.673	232.603
7	229.265	229.082	229.051	228.990	228.927
8	226.240	226.043	226.019	225.971	225.914
9	223.244	223.030	223.012	222.974	222.922
10	220.212	219.987	219.979	219.948	219.900
11	217.128	216.904	216.898	216.876	216.824
12	211.271	211.086	211.085	211.064	211.026
13	201.065	200.919	200.914	200.898	200.876
14	190.785	190.667	190.674	190.666	190.637
15	180.520	180.409	180.409	180.401	180.374
16	172.476	172.356	172.345	172.343	172.314
A16	M	M	M	M	172.323
17	159.088	159.008	R163.103	163.108	163.072
18	143.280	143.206	143.205	143.217	143.192
19	129.275	129.201	129.198	129.207	129.186
20	121.789	121.737	121.731	121.747	121.733
21	117.257	117.215	117.206	117.221	117.216
22	D115.630	R115.579	115.566	115.586	115.584
23	115.052	115.029	115.019	115.040	115.046
24	112.428	112.408	112.397	112.423	112.431
25	110.120	110.104	110.090	110.117	110.126
26	107.140	107.124	107.102	107.132	107.147
28	102.920	102.904	102.886	102.916	102.932
29	98.602	98.591	98.577	98.615	98.626
30	93.461	93.447	93.439	93.466	93.478
31	90.348	90.340	90.329	90.357	90.369
32	86.670	86.651	86.644	86.674	86.684
33	82.483	82.477	82.479	82.506	82.509
34	79.879	79.876	79.881	79.903	79.907
35	75.512	75.514	75.525	75.547	R 75.572
36	70.854	70.855	70.867	70.884	70.882
37	66.873	66.885	66.907	66.920	D 66.910
38	63.208	63.196	63.210	63.225	63.218
39	D 60.902	R 60.886	60.902	60.922	60.914
40	58.526	58.535	58.544	58.558	58.553
41	55.822	55.823	55.831	55.844	55.834
42	D 53.429	R 53.591	53.611	53.624	53.615
43	51.063	51.073	51.084	51.000	51.090
44	48.912	48.911	48.915	48.927	48.916
45	46.437	46.446	46.461	46.488	46.428
G368	45.265	45.265	45.265	45.265	45.265

LAS VEGAS LEVEL LINE #3

STATION	1983	1984	1985	1986	1987
1	242.961	242.900	242.839	242.755	242.655
2	240.756	240.693	240.643	240.557	240.462
3	239.513	239.451	239.399	239.320	239.225
4	237.144	237.052	236.989	236.908	236.814
5	235.054	234.989	234.928	234.848	234.750
6	232.502	232.442	232.393	232.316	232.225
7	228.836	228.779	228.735	228.671	228.584
8	225.835	225.874	225.746	225.682	225.607
9	222.853	222.804	222.780	222.726	222.656
10	219.843	219.798	219.781	219.731	219.668
11	216.760	216.713	216.708	216.662	216.594
12	210.971	210.932	210.922	210.879	210.518
13	200.862	200.789	200.790	200.759	200.706
14	190.596	190.562	190.564	?190.713	190.666
15	180.340	180.301	180.305	180.274	180.237
16	172.282	172.240	172.250	172.217	172.196
A16	172.292	172.251	172.257	?172.220	172.199
17	163.054	163.014	163.035	163.009	163.000
18	143.181	143.133	143.154	?143.130	143.151
19	129.177	129.126	129.141	129.125	129.146
20	121.725	121.674	121.686	121.689	121.699
21	117.209	117.151	117.161	117.167	117.174
22	115.518	115.502	115.518	115.531	115.520
23	115.047	114.979	114.993	115.020	115.014
24	112.433	112.366	112.379	112.414	112.404
25	110.132	110.059	110.075	110.115	110.111
26	107.153	107.075	?107.094	?107.135	107.127
28	102.936	102.854	102.879	102.920	102.915
29	98.642	98.552	98.578	98.619	98.617
30	93.485	93.420	93.436	93.473	93.478
31	90.382	90.305	90.325	90.363	90.365
32	86.697	86.627	86.650	86.682	86.693
33	82.519	82.467	82.486	82.505	82.511
34	79.914	R 79.890	79.915	79.935	79.938
35	75.583	75.541	75.554	75.572	75.575
36	70.892	70.863	70.870	70.887	70.888
37	R 66.934	66.921	66.924	66.940	66.940
38	63.221	63.221	63.225	63.238	63.230
39	60.919	R 60.926	60.932	60.937	60.928
40	58.555	58.563	58.575	58.576	58.567
41	55.835	55.846	55.853	55.852	55.843
42	53.616	53.869	R 53.905	53.901	53.898
43	51.091	R 50.973	50.972	50.977	50.970
44	48.919	R 49.438	49.432	49.432	49.417
45	R 46.890	46.893	? 46.901	? 47.544	46.417
G368	45.265	45.265	45.265	45.265	45.265

LAS VEGAS LEVEL LINE #4

STATION	1978	1979	1980	1981	1982
1	174.676	174.611	174.558	174.541	R175.089
2	179.820	179.766	R179.416	179.401	179.363
CLV23	180.694	180.639	180.588	180.581	180.542
3	182.073	182.019	181.979	181.973	181.933
4	185.365	185.314	185.274	185.273	R186.008
5	188.399	188.361	188.324	188.322	188.292
6	191.731	191.701	191.662	191.666	191.639
CLN046	198.973	198.950	198.914	198.922	198.897
7	199.318	199.288	199.262	199.266	199.237
8	203.088	203.058	203.007	203.371	203.343
9	205.428	205.397	205.379	R205.720	205.696
10	210.324	210.302	210.280	R210.766	210.739
11	214.845	214.820	214.802	R215.193	215.170
12	217.422	217.399	217.382	R217.837	R217.923
13	220.571	220.545	220.529	220.531	220.510
14	224.731	224.710	224.690	R224.652	224.627
15	229.374	229.350	229.330	R229.767	229.749
16	234.616	234.594	234.569	R234.963	234.948
17	240.112	240.091	240.065	R239.999	239.981
18	243.050	243.030	243.007	243.015	242.995
19	246.146	246.127	246.101	246.109	246.091
20	252.363	252.341	252.318	252.325	252.314
21	257.800	257.782	257.753	257.763	257.769
22	264.261	264.247	264.219	264.229	264.220
K367	266.147	266.130	266.107	266.116	266.110
CLN045	266.655	266.640	266.616	266.624	266.618
24	267.493	267.482	267.459	267.467	267.463
25	270.059	270.044	270.015	270.023	270.017
26	274.449	274.436	274.418	274.425	274.420
27	279.321	279.308	279.290	279.297	279.292
28	283.254	283.242	283.126	283.233	283.230
29	285.688	285.677	285.665	R286.118	286.112
30	288.028	288.046	R287.690	287.683	287.667
31	291.832	291.821	291.801	291.808	291.800
32	296.649	296.643	296.637	296.641	296.635
33	299.547	299.540	R298.533	298.532	298.527
34	303.932	303.929	R302.233	302.236	302.229
35	306.925	306.922	306.914	306.916	306.913
36	311.023	311.019	R311.007	311.008	311.004
37	315.797	315.793	315.791	315.789	315.790
38	320.401	320.397	320.392	320.393	320.397
39	325.041	325.037	325.034	325.041	R325.237
40	329.655	329.652	329.650	329.539	R329.975
41	334.643	334.640	334.638	334.637	334.643
42	339.684	339.683	R339.673	R340.088	340.103
43	342.680	342.682	R342.392	R342.721	342.733
M367	343.120	343.120	343.120	343.119	343.125
44	344.952	344.952	R344.917	R345.185	345.189
45	349.846	349.843	349.841	349.830	R350.121
46	355.557	355.556	355.555	355.554	355.557
47	360.379	360.380	360.378	360.369	360.371

LAS VEGAS LEVEL LINE #4

STATION	1978	1979	1980	1981	1982
48	356.399	365.400	365.401	M	365.490
49	370.719	370.719	370.719	370.719	370.719
50	376.029	376.026	376.027	R376.208	376.203
51	381.567	381.568	381.570	381.563	381.561
52	387.502	387.503	387.512	387.511	387.505
53	393.144	393.145	393.151	393.276	R393.477
54	399.656	399.653	399.660	399.655	399.648

LAS VEGAS LEVEL LINE #4

STATION	1983	1984	1985	1986	1987
1	175.068	R175.043	174.999	174.990	175.025
2	179.342	179.267	179.222	179.216	179.246
CLV23	180.535	180.465	180.426	180.422	180.456
3	181.927	181.855	181.817	181.816	181.847
4	185.954	185.890	185.853	185.851	185.884
5	188.291	188.228	188.197	188.201	188.223
6	191.642	191.580	191.552	191.553	191.580
CLN046	198.904	D			
7	199.247	199.186	199.161	199.160	R199.191
8	203.360	203.301	203.273	203.277	203.306
9	205.708	205.652	205.628	205.629	205.658
10	210.748	210.699	210.669	210.675	210.701
11	215.174	215.123	215.095	215.104	215.130
12	217.944	217.893	217.862	217.873	217.893
13	220.519	220.468	220.441	220.450	220.476
14	224.635	224.586	224.562	224.572	224.594
15	229.755	229.714	229.680	229.526	229.712
16	234.954	234.914	234.881	234.892	234.916
17	239.987	239.950	239.918	239.923	239.948
18	243.002	242.968	242.932	242.944	242.966
19	246.095	246.061	246.026	246.041	246.057
20	252.316	252.289	252.251	252.266	252.290
21	257.754	257.730	257.689	257.694	257.723
22	264.222	264.203	264.160	264.173	264.197
K367	266.111	266.094	266.049	266.065	266.085
CLN045	266.618	266.603	266.558	266.573	266.592
24	267.464	267.456	267.410	267.426	267.447
25	270.016	270.009	269.963	269.981	270.000
26	274.420	274.413	274.369	274.391	274.408
27	279.293	279.283	279.244	279.267	279.281
28	283.235	283.231	283.189	283.213	283.229
29	286.117	286.109	286.076	286.099	286.114
30	287.669	287.666	287.629	287.656	287.670
31	291.799	291.796	291.760	291.786	R291.973
32	296.634	296.635	296.597	296.620	296.625
33	298.527	298.528	298.497	298.518	298.524
34	302.230	302.232	302.196	302.217	302.220
35	306.914	306.914	306.880	306.900	306.905
36	311.003	311.010	310.975	310.997	310.997
37	315.783	315.783	315.757	316.033	315.719
38	320.389	320.393	320.366	320.382	320.381
39	325.228	325.228	325.209	325.224	325.224
40	329.964	329.967	329.945	329.963	329.961
41	334.632	334.633	334.616	334.631	334.633
42	340.101	340.113	340.101	340.117	340.116
43	342.729	342.739	342.715	342.732	342.723
M367	343.114	343.125	D		
44	345.180	345.183	345.166	345.184	345.178
45	350.116	350.116	350.103	350.117	350.113
46	355.555	355.553	355.541	355.555	355.545
47	360.369	360.368	360.356	R360.369	360.360

LAS VEGAS LEVEL LINE #4

STATION	1983	1984	1985	1986	1987
48	365.509	365.403	M	365.657	365.389
49	370.719	370.719	370.719	370.719	370.719
50	376.197	376.194	376.191	376.203	376.184
51	381.561	381.560	381.561	381.573	381.557
52	387.505	387.503	387.507	387.519	387.490
53	393.474	393.473	393.478	393.489	393.459
54	399.648	399.644	399.666	R399.612	399.582

LAS VEGAS LEVEL LINE #5

STATION	1978	1979	1980	1981	1982
R366	301.931	301.931	301.931	301.931	301.931
1	295.529	295.528	295.526	R298.680	298.684
2	295.323	295.322	295.318	295.318	295.323
3	293.357	293.356	293.354	293.352	293.358
4	289.522	289.523	289.522	290.280	290.281
5	287.192	287.190	287.190	R287.159	287.160
A3	288.750	288.746	288.749	288.748	288.743
6	287.311	287.312	287.309	287.241	287.236
7	286.927	286.928	286.924	286.928	286.926
8	285.923	285.925	285.918	285.921	285.920
9	285.107	285.106	285.099	285.102	285.103
15	269.999	269.992	269.979	R284.710	284.713
16	251.426	251.453	251.428	R283.761	283.764
17	248.644	248.638	248.617	R278.388	278.390
18	244.865	244.853	244.832	R275.485	275.492
19	242.117	242.103	242.082	R260.002	260.009
20	239.283	239.267	239.243	R254.985	254.995
21	239.603	239.594	239.602	R250.116	250.130
22	236.811	236.795	236.764	R246.186	246.201
23	234.693	234.679	234.648	R243.112	243.128
24	232.285	232.263	232.229	R240.291	240.313
25	230.845	230.825	230.790	R240.801	240.822
26	223.173	223.142	223.105	R236.084	R237.363
27	223.173	223.142	223.105	R234.865	234.880
28	221.193	221.156	221.117	R232.498	232.510
29	220.363	220.320	220.276	R225.600	225.609
30	219.069	219.024	218.975	R221.886	221.892
31	215.607	215.560	215.512	R219.770	219.772
32	212.473	212.421	212.370	R217.056	217.058
33	212.084	212.030	211.975	211.946	R211.945
34	211.836	211.761	211.695	211.655	211.640
35	204.466	204.379	204.235	R207.227	207.191
36	202.822	202.735	202.652	R201.409	201.375

LAS VEGAS LEVEL LINE #5

STATION	1983	1984	1985	1986	1987
R366	301.931	301.931	301.931	301.931	301.931
1	298.685	298.685	298.688	298.685	298.687
2	295.325	295.325	295.330	295.325	295.325
3	293.361	293.351	293.358	293.356	293.354
4	290.297	290.285	290.306	290.304	290.301
5	287.169	287.156	R289.723	289.717	289.719
A3	288.755	288.743	288.748	288.745	288.744
6	287.249	287.239	287.246	287.241	287.235
7	286.936	286.928	286.931	286.928	286.930
8	285.931	285.925	285.927	285.919	285.927
9	285.108	285.104	285.103	285.098	285.105
15	284.716	284.714	284.711	284.709	284.714
16	283.765	283.763	283.759	283.761	283.765
17	278.382	278.386	278.380	278.383	278.388
18	275.490	275.481	275.481	275.482	275.489
19	260.005	259.995	260.001	259.996	260.007
20	254.989	254.974	254.977	254.972	254.982
21	250.122	250.102	250.108	250.101	250.114
22	246.186	246.166	246.171	246.156	246.166
23	243.108	243.087	243.090	243.077	243.088
24	240.287	240.270	240.267	240.253	240.266
25	240.800	240.784	240.780	240.766	240.774
26	237.337	235.350	235.313	237.300	237.305
27	R235.477	235.487	235.453	235.432	235.447
28	R233.768	233.781	233.628	233.603	233.615
29	225.569	225.546	225.537	225.506	225.518
30	221.843	221.818	221.801	221.768	221.780
31	219.716	219.688	219.661	219.629	219.635
32	216.990	216.956	216.933	216.901	216.907
33	211.873	211.840	211.818	211.773	R207.826
34	211.548	211.502	211.461	210.380	210.386
35	207.072	R206.803	206.747	206.679	206.670
36	201.264	201.180	R202.295	202.221	202.211

LAS VEGAS LEVEL LINE #6

STATION	1978	1979	1980	1981	1982
1	150.514	?150.265	150.212	150.149	R150.788
2	144.318	144.101	144.094	144.057	143.921
3	D140.418	R140.330	R141.171	141.104	141.011
4	D141.409	R138.298	138.274	138.233	138.156
N366	143.683	143.614	143.607	R143.538	143.494
6	121.899	121.839	121.831	121.691	121.718
7	120.649	120.588	120.572	120.526	120.461
8	148.016	147.959	147.937	147.878	147.835
9	115.808	115.761	115.734	115.675	115.639
10	121.901	121.862	121.850	121.813	121.787
11	D120.007	R126.979	126.987	126.952	126.938
12	119.971	119.961	119.980	119.957	119.957
13	117.200	117.209	117.237	117.236	117.239
14	114.954	114.972	115.009	115.021	115.027
15	112.484	112.501	112.544	112.557	112.566
16	109.964	109.982	110.023	110.039	110.047
17	106.368	106.361	R106.476	106.460	106.497
18	103.748	103.771	103.804	103.821	103.828
19	99.556	99.573	99.614	99.637	99.643
20	97.812	97.825	97.845	97.848	97.853
21	96.717	96.730	96.761	96.769	96.773
22	93.964	93.979	94.006	94.012	94.014
23	89.815	89.826	89.857	89.865	89.871
24	86.769	86.778	86.797	86.803	86.817
25	84.639	84.649	84.664	84.674	84.677
26	82.207	82.216	82.230	82.231	82.227
27	79.689	79.690	79.691	79.695	79.697
28	76.669	76.673	76.671	76.672	76.677
29	73.729	73.729	73.729	73.729	73.729
30	71.317	71.316	71.307	71.306	71.308
31	68.586	68.579	68.566	68.565	68.559
32	66.268	66.263	66.243	R 66.127	66.159
33	64.313	64.309	64.282	64.287	64.285
34	63.279	63.276	63.251	63.255	63.249
35	59.385	59.383	59.358	59.366	59.362
36	56.573	56.579	R 56.432	56.415	56.442
37	54.832	54.830	54.810	54.824	54.827
38	51.111	51.115	51.110	51.125	51.133

LAS VEGAS LEVEL LINE #6

STATION	1983	1984	1985	1986	1987
1	150.452 D				
2	143.818 D				
3	140.920 D				
4	138.086 D				
0.366	143.435 D				
6	121.655 D				
7	120.389 D				
8	147.764 D				
9	115.578 D				
10	121.734 D				
11	126.887	126.870 D			
12	119.929	119.924 D			
13	117.234	117.245 D			
14	115.035	115.052 D			
15	112.584	112.600	112.620	112.660	112.653
16	110.068	110.080	110.096	110.136	110.131
17	106.515	106.517	106.534	106.567	106.559
18	103.850	103.852	103.875	103.916	103.905
19	99.668	99.670	99.680	99.722	99.713
20	97.867	97.870 R	97.505	97.498	97.537
21	96.790	96.796	96.810	96.840	96.834
22	94.030	94.032	94.047	94.075	94.069
23	89.887	89.896	89.910	89.941	89.941
24	86.838	86.836	86.857	86.877	86.875
25	84.686	84.691	84.702	84.722	84.722
26	82.246	82.234	82.252	82.276	82.255
27	79.696	79.697	79.709	79.716	79.714
28	76.673	76.675	76.683	76.684 R	76.759
29	73.729	73.729	73.729	73.729	73.729
30	R 72.857	72.858	72.850 R	72.162 R	72.914
31	68.517	68.516	68.514 R	70.620 R	71.588
32	R 65.994	66.006	65.999 R	69.189 R	69.388
33	64.266	64.265	64.259 R	66.762 R	67.378
34	63.228	63.232	63.226 R	63.046 R	65.023
35	59.343 M		59.340 R	62.050 R	62.071
36	56.424 M		56.424 R	61.278 R	60.019
37	54.810 M		54.823 R	59.342 R	58.528
38	51.118 M		51.145 R	55.622 R	55.624

LAS VEGAS LEVEL LINE #7

STATION	1978	1979	1980	1981	1982
1	D888.391	R888.413	888.395	888.380	888.404
2	887.503	887.548	887.532	887.512	887.533
3	884.885	884.928	884.908	884.892	884.911
4	881.095	881.142	881.115	881.099	881.122
5	879.104	879.148	R878.698	878.680	878.704
6	D876.225	R873.102	873.082	873.063	873.082
7	867.277	867.315	867.272	867.254	867.278
8	865.320	865.362	865.340	865.325	865.335
9	861.773	861.811	861.793	861.772	861.786
10	854.943	854.984	854.963	854.948	854.960
11	847.883	847.923	847.899	847.884	847.895
12	843.278	843.318	843.292	843.279	843.292
13	D837.503	R837.483	837.462	837.453	837.465
14	D833.324	R833.106	833.085	833.080	833.088
15	D827.996	R826.404	826.380	826.370	826.384
16	D816.599	R816.997	816.975	816.971	816.980
17	D803.899	R804.983	804.959	?804.851	804.959
18	795.599	795.638	795.611	795.604	R795.587
19	786.002	786.036	786.004	786.000	R785.999
20	778.948	778.982	778.958	778.957	778.960
21	769.913	769.956	769.936	R769.918	769.923
22	765.606	765.634	765.612	765.616	765.619
23	762.688	762.716	762.694	762.692	762.712
24	D756.039	R756.047	R756.025	R756.018	R756.040
25	746.295	746.320	746.294	746.305	746.306
26	D740.270	R740.125	740.118	740.111	740.116
27	D734.434	R734.455	734.440	734.438	734.440
28	729.595	729.605	729.588	R729.588	R729.531
29	726.572	726.589	726.575	726.571	726.575
30	723.048	723.061	723.049	723.045	723.046
31	719.065	719.074	719.065	719.064	719.068
32	716.359	716.366	716.364	716.364	716.368
33	712.667	712.668	712.659	R712.666	712.667
34	710.743	710.738	R710.722	710.723	710.715
35	709.547	709.550	709.549	709.551	709.550
36	709.021	709.026	709.017	709.013	709.009
36.006	706.191	706.191	706.191	706.191	706.191

LAS VEGAS LEVEL LINE #7

STATION	1983	1984	1985	1986	1987
1	888.400	888.373	888.391	888.396	888.347
2	887.532	887.503	R887.535	887.528	887.48
3	884.914	884.894	884.910	884.910	884.866
4	881.127	881.101	881.122	881.122	881.087
5	878.698	878.681	878.691	878.693	878.663
6	873.078	873.056	873.066	873.063	873.035
7	867.271	R867.208	867.213	867.180	867.189
8	865.332	865.309	865.323	865.311	865.284
9	861.784	861.768	861.780	861.770	861.75
10	854.963	854.942	854.958	854.948	854.932
11	847.893	847.877	847.896	847.879	847.867
12	843.296	843.279	843.292	843.279	843.264
13	837.472	837.458	837.446	837.453	837.447
14	833.087	833.077	833.089	833.071	833.062
15	826.384	826.368	826.377	R827.458	827.443
16	816.986	816.964	816.969	R816.094	816.085
17	804.965	R803.457	803.468	R802.476	802.458
18	795.597	795.576	795.586	R795.622	795.617
19	786.001	785.978	785.995	785.981	785.97
20	778.967	778.950	778.969	778.952	778.944
21	769.936	769.919	769.948	769.941	769.922
22	765.622	765.606	765.623	765.614	765.605
23	762.719	762.702	762.726	762.722	762.716
24	756.050	R756.025	756.058	756.049	756.043
25	746.309	746.300	746.314	746.312	746.308
26	740.125	740.096	740.110	740.117	R740.074
27	734.445	734.436	734.438	734.437	734.43
28	729.530	729.518	729.528	729.526	729.523
29	726.581	726.571	726.579	726.581	726.57
30	723.045	723.032	723.043	723.035	723.029
31	719.066	719.060	719.067	719.069	719.056
32	716.367	716.362	716.368	716.365	716.357
33	712.665	712.666	M	712.665	712.662
34	710.716	710.715	710.718	710.682	R710.726
35	709.548	709.550	709.554	709.547	709.532
36	709.007	709.011	709.009	708.999	708.994
CLN066	706.191	706.196	706.191	706.191	706.191

LAS VEGAS LEVEL LINE #8

STATION	1978	1979	1980	1981	1982
A					
1	66.240	66.181	66.137	66.109	66.096
2	73.971	73.920	73.887	73.879	73.868
3	77.265	77.208	77.163	77.134	77.115
4	74.631	74.589	74.568	74.557	74.551
5	72.739	72.694	R 72.652	72.642	72.644
6	67.341	67.284	67.247	67.223	67.211
7	58.752	58.706	58.677	58.663	58.663
8	60.281	60.225	60.188	60.167	60.154
B					
8	60.281	60.225	60.188	60.167	60.154
9	65.892	65.848	65.813	65.793	65.783
10	74.746	74.726	74.695	74.683	74.678
11	82.453	82.456	R 82.442	82.423	82.432
12	89.824	89.822	89.812	89.817	89.817
13	100.000	100.000	100.000	100.000	100.000
C					
13	100.000	100.000	100.000	100.000	100.000
14	91.321	91.288	91.281	91.281	R 91.262
15	92.352	92.313	92.305	92.310	92.291
16	94.017	93.982	93.975	93.984	93.966
17	95.477	95.417	95.407	95.412	95.400
18	96.508	M	96.490	96.500	96.491
19	97.848	97.835	97.828	97.848	97.840
D					
19	97.848	97.835	97.828	97.848	97.840
20	93.183	93.176	93.173	93.176	93.170
21	85.323	85.308	85.302	85.299	85.301
22	75.986	75.957	75.936	75.936	75.935
23	73.213	73.179	73.144	73.133	R 73.156
1	66.240	66.181	66.137	66.109	66.096

LAS VEGAS LEVEL LINE #8

STATION	1983	1984	1985	1986	1987
A					
1	66.082	66.083	66.060	66.039	66.068
2	73.847	73.841	73.832	73.824	73.821
3	77.094	77.079	77.065	77.061	77.057
4	74.541	74.537	74.529	74.531	74.533
5	R 72.607	72.602	72.590	72.592	72.592
6	67.192	67.170	67.168	67.166	67.164
7	R 58.635	58.620	58.608	58.605	58.616
8	60.138	60.120	60.100	60.093	60.095
B					
8	60.138	60.120	60.100	60.093	60.095
9	65.770	65.748	65.731	65.725	65.722
10	74.667	74.650	74.636	74.631	74.632
11	R 82.419	82.405	82.396	82.393	82.395
12	M	M	M	M	M
13	100.000	100.000	100.000	100.000	100.000
C					
13	100.000	100.000	100.000	100.000	100.000
14	91.246	91.258	91.259	91.246	91.253
15	92.288	92.292	92.287	92.276	92.282
16	93.965	93.970	93.966	93.953	93.963
17	95.400	95.412	95.412	95.406	95.415
18	96.497	96.512	96.513	96.518	96.531
19	97.846	97.866	97.866	97.872	97.881
D					
19	97.846	97.866	97.866	97.872	97.881
20	93.173	93.190	93.181	93.178	93.186
21	85.294	85.308	85.305	85.305	85.316
22	75.929	75.935	75.936	75.919	75.938
23	73.145	73.144	73.141	73.124	73.154
1	66.082	66.083	66.060	66.039	66.068

LAS VEGAS LEVEL LINE #10

STATION	1980	1981	1982	1983	1984
0.169	214.123	214.031	213.955	213.845	213.756
2	209.472	209.381	209.310	209.198	209.109
3	207.301	207.219	207.150	207.049	206.962
4	205.552	205.475	205.395	205.294	205.209
5	201.170	201.099	R201.052	200.963	R200.896
6	199.223	199.156	199.100	199.016	198.936
7	196.736	196.683	196.632	196.550	196.479
8	195.593	195.543	195.489	R195.415	195.352
9	192.947	192.895	192.848	192.787	192.725
10	191.450	R191.379	191.346	191.290	191.230
11	190.756	190.722	190.679	190.629	190.570
12	187.553	187.521	187.484	187.436	187.377
13	182.035	182.001	181.963	181.919	181.864
14	177.891	177.861	177.823	177.788	177.724
15	171.745	171.718	171.680	171.646	171.585
16	164.923	R164.871	164.843	164.814	164.757
17	156.041	R156.633	156.619	156.565	156.503
18	149.012	148.980	148.947	148.914	148.853
19	141.615	141.582	141.550	141.514	141.452
20	140.698	140.666	140.635	140.598	140.528
21	134.844	134.817	134.787	134.750	134.686
22	127.076	R127.008	126.154	126.950	127.158
23	121.083	R121.388	121.358	121.320	121.259
24	115.113	115.078	115.043	115.002	114.937
25	108.684	108.648	108.603	108.563	108.494
26	99.544	R 99.504	R 99.430	99.381	99.313
27	91.678	R 91.633	R 91.572	91.539	91.474
28	83.543	R 83.502	R 83.629	83.411	83.341
29	81.144	81.100	81.060	81.015	80.948
30	73.919	73.888	73.855	73.823	73.763
31	67.215	R 67.200	R 67.233	67.219	67.166
32	64.710	64.698	64.679	64.668	64.621
33	59.562	R 59.524	59.515	59.509	59.477
34	54.713	54.719	54.703	54.707	54.670
35	51.871	51.877	51.866	51.872	51.838
36	48.792	48.801	48.794	48.800	48.777
37	47.400	47.405	47.395	47.398	47.382
38	46.050	46.061	46.059	46.063	46.047
Z314	50.540	50.540	50.540	50.540	50.540

LAS VEGAS LEVEL LINE #10

STATION	1985	1986	1987
0.169	213.658	213.611	213.493
2	209.011	208.950	206.714
3	206.869	206.824	204.983
4	205.127	205.082 M	
5	200.822	200.785	200.681
6	198.870	198.841	198.741
7	196.433	196.415	196.323
8	195.298	195.281	195.186
9	192.673	192.662	192.572
10	191.178	191.179	191.090
11	190.529	190.529	190.437
12	187.335	187.347	187.253
13	181.822	181.834	181.748
14	177.679	177.693	177.605
15	171.544	171.559	171.473
16	164.718	164.738	164.650
17	156.465	156.447	156.400
18	148.812	148.796	148.751
19	141.422	141.404	141.359
20	140.498	140.478	140.435
21	134.653	134.634	134.598
22	126.843	126.821	126.788
23	121.216	121.193	121.156
24	114.889	114.861	114.822
25	108.448	108.414	108.367
26	99.259	99.220	99.173
27	91.419	91.384	91.339
28	83.286	83.257	83.220
29	80.898	80.862	80.821
30	73.731	73.705	73.651
31	67.148	67.139	67.111
32	64.606	64.593	64.576
33	59.478	59.466	59.452
34	54.662	54.660	54.656
35	51.838	51.836	51.839
36	48.782	48.782	48.790
37	47.383	47.382	47.386
38	46.054	46.052	46.059
Z314	50.540	50.540	50.540