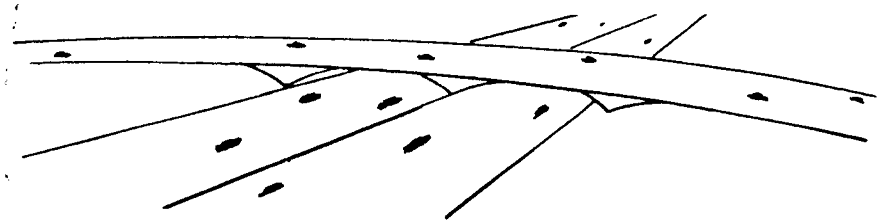
Frc- Publication #23



DEPARTMENTAL RESEARCH

Report Number: SS 3.0

INVESTIGATION OF PAVEMENT FAILURES

ON I.H. 10

IN DISTRICT 13

TEXAS HIGHWAY DEPARTMENT

INVESTIGATION OF PAVEMENT FAILURES

ON IH10 IN DISTRICT 13

By

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and

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Report Number SS 3.0

Conducted by
The Research Section of
The Highway Design Division
Texas Highway Department
April 1966

Report On

INVESTIGATION OF PAVEMENT FAILURES ON I 10 IN DISTRICT 13

I. INTRODUCTION

In the summer of 1963 the Columbus "bypass" portion of I 10 was paved with continuously reinforced concrete pavement. To this date the pavement is less than three years old and is showing distress in many areas. Maintenance personnel first spotted the severely cracked and spalled areas. Research section personnel were contacted and made a visual inspection of the pavement areas and chose eleven of the distressed areas as sections to conduct an investigation to determine what was causing the distress.

II. METHODS OF INVESTIGATION

The eleven areas chosen for study were investigated by three methods. Successively they were first the Swiss Hammer which is a nondestructive test of concrete strength. The concrete was tested with the Swiss Hammer up to 20 feet to either side of the failure area. The tests were run one foot apart through the worst area. The results of many tests at each point should then provide a profile of the relative strength of the concrete. Secondly, deflection was measured by the Lane Wells Dynaflect. The Dynaflect measures the deflection basin shape with five sensors, the number one sensor being under the load and the other four spaced even distances in t of the load as shown in Figure 2.1. Deflections were measured r feet from the outside edge and also four feet right of the main e center line. Measurements were made the same in both directions y from the failure areas. Measurements were taken over a distance 00 feet, the failure area being at the midpoint. All measurements e taken ten feet apart except for ten feet on both sides of the lurearea where measurements were made one foot apart. The third hod of investigation was based on the analysis of the first two hods and this was the core drilling operation. The results of h of these three investigations on each of the eleven sections presented sequentially by section number in the next chapter.

III. PRESENTATION OF RESULTS

The results from each of the three methods of investigation ll be presented together and compared by section.

ection I (768 + 00 EBL)

The general pavement condition is portrayed in Figures 3.1a and 3.1b. Section I was the section on which the Swiss Hammer test procedure was developed, consequently the plot of hammer test value to the left of the failure area is different from that to the right of the failure area. This is clearly shown in Figure 3.1c. The data from the Swiss Hammer is relative but it does indicate that there is some question as to the strength of the concrete in the center of Section I.

Figure 2.1

Lane Wells Dynaflect in operation

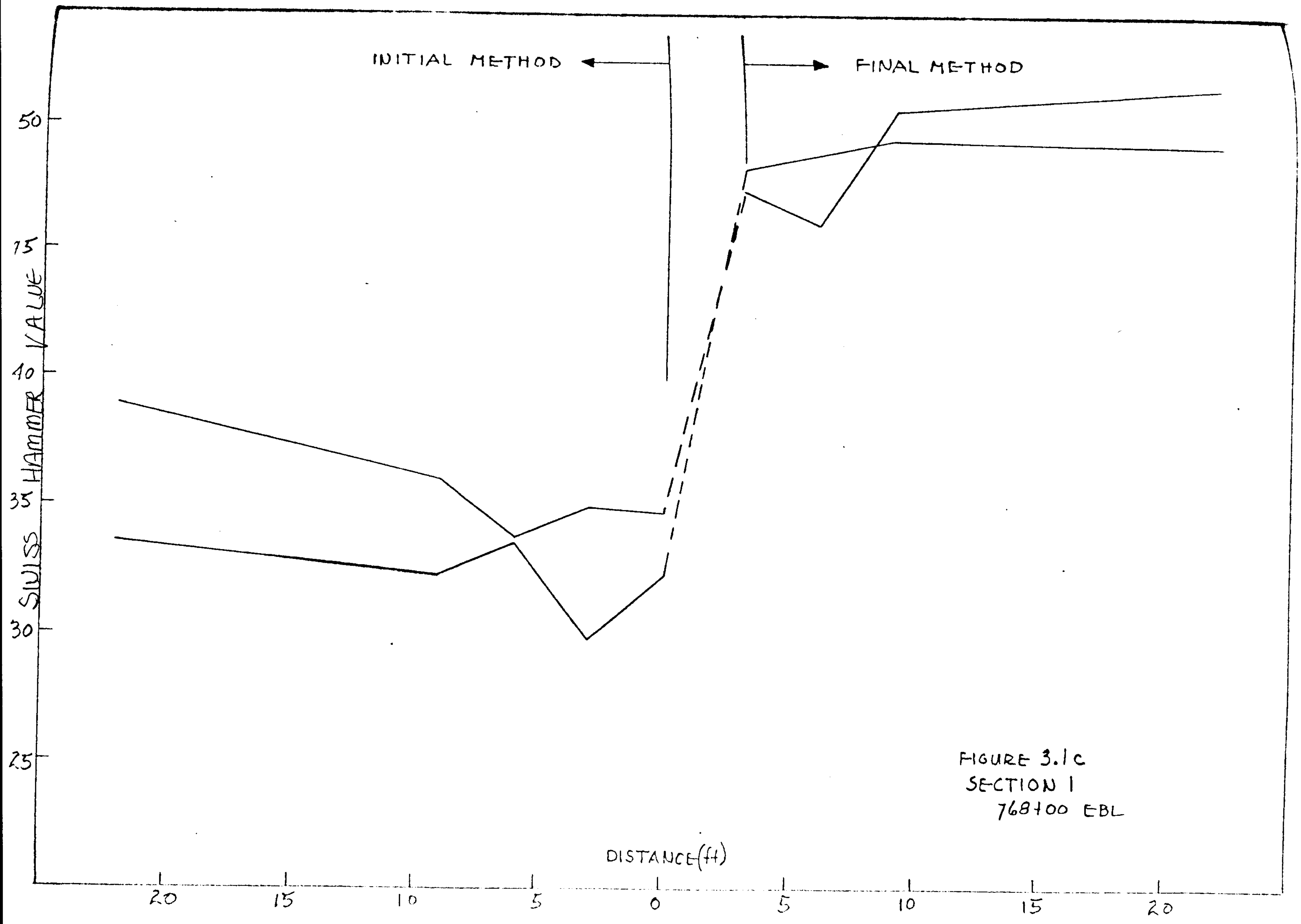


FIGURE 3.1c
SECTION 1
768+00 EBL

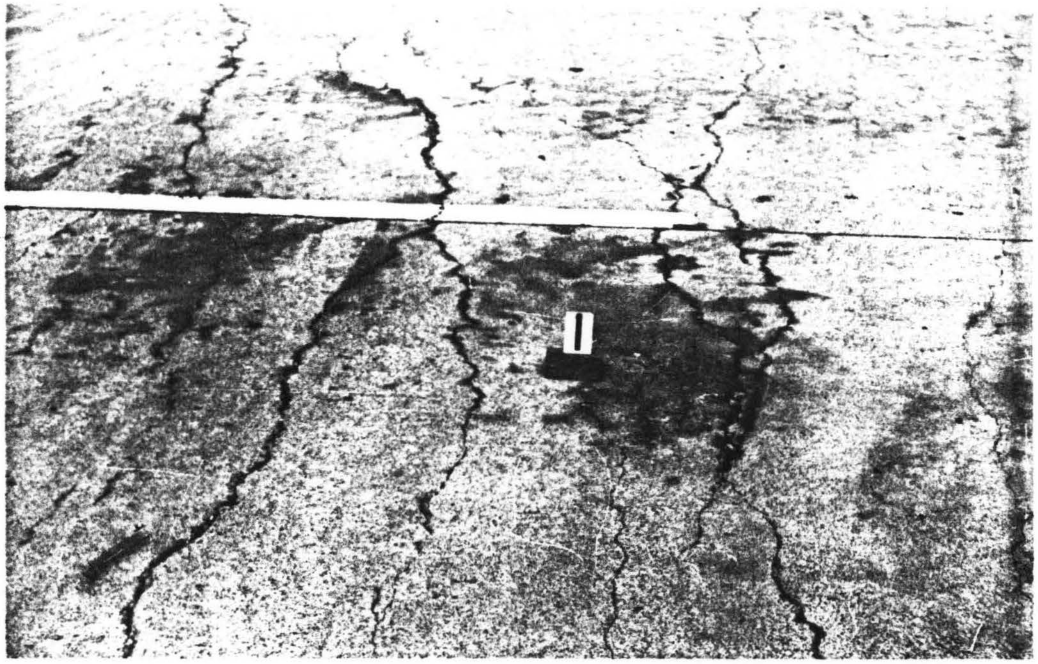


Figure 3.1a

Close-up view of crack pattern in Section 1

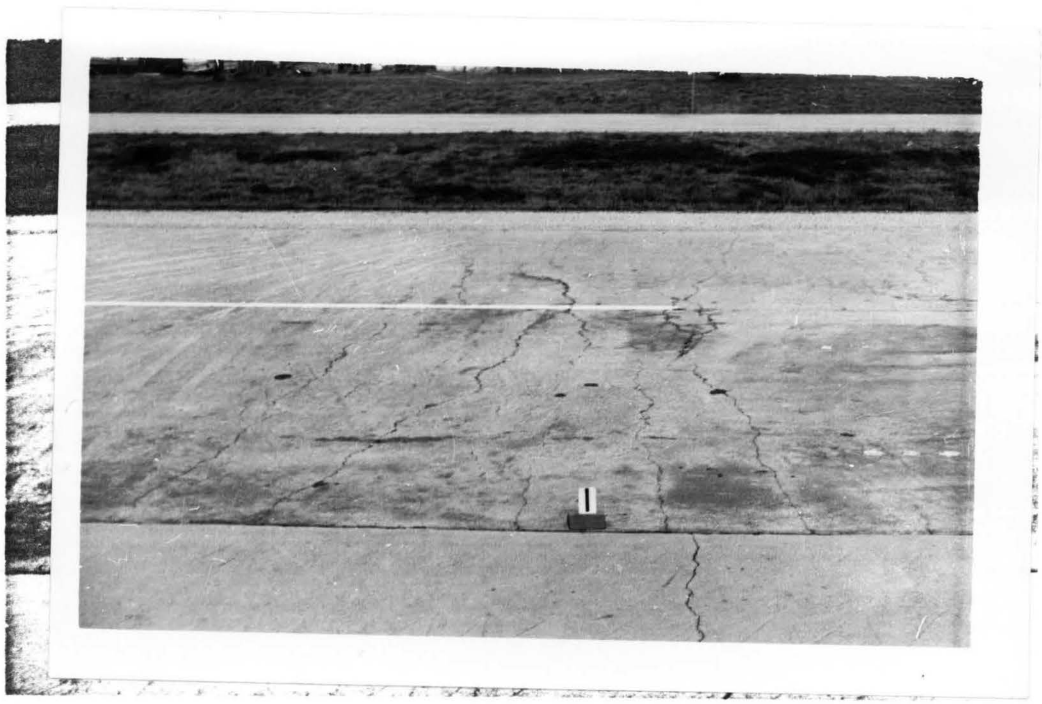


Figure 3.1b

General view of Section 1

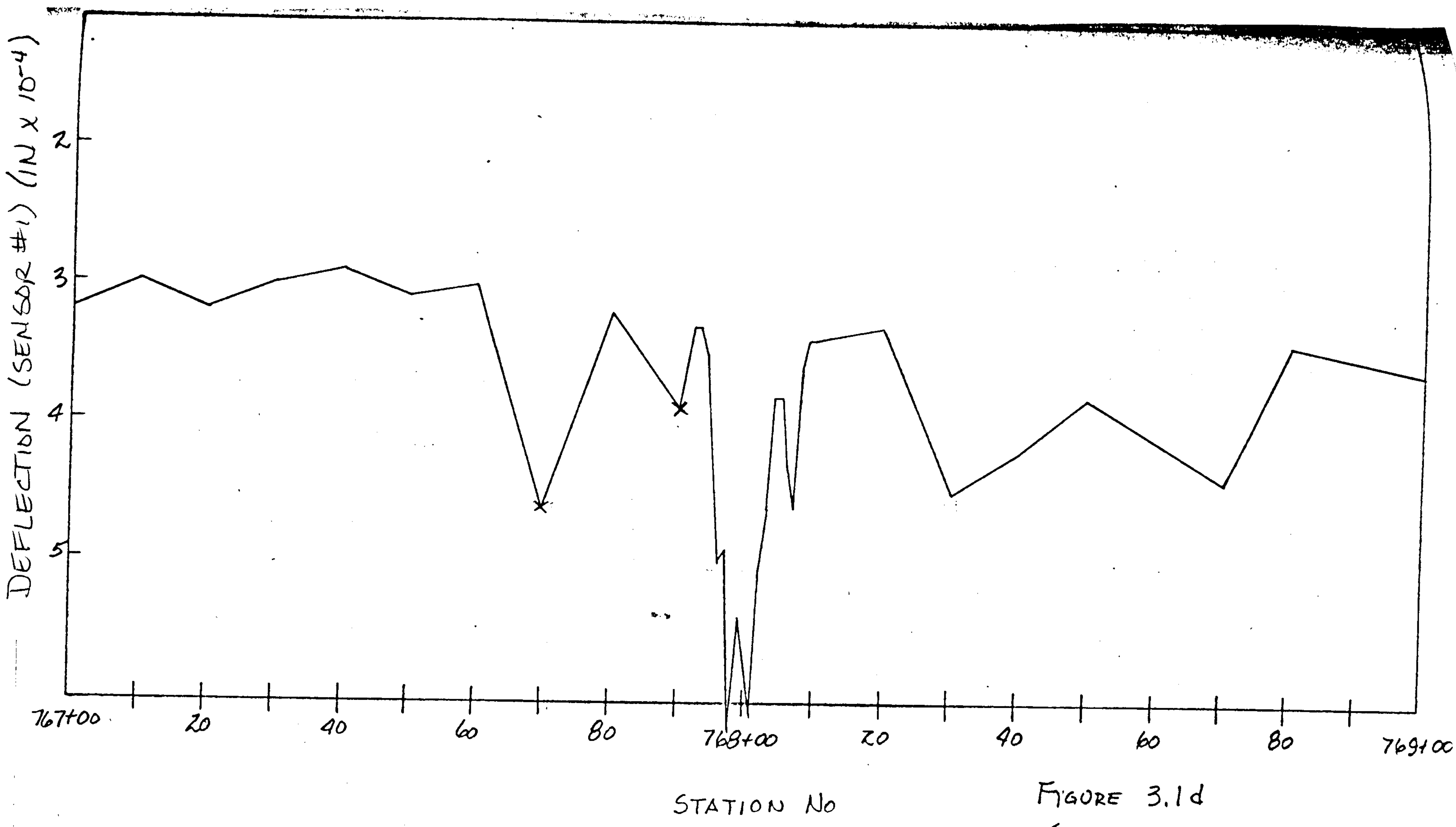


FIGURE 3.1d
SECTION 1
STA 768+00 EBL
4' Rt. OF ℄

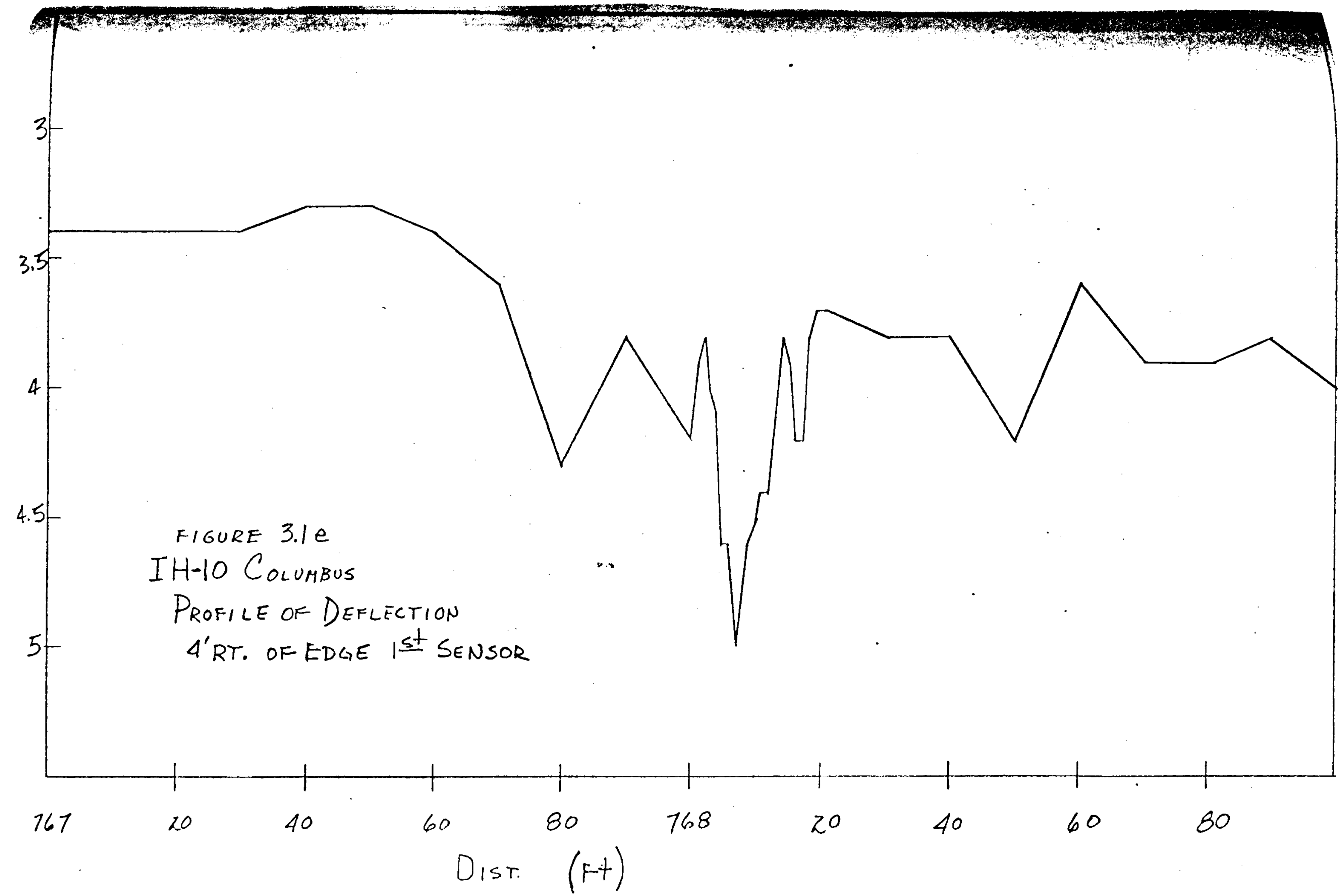


FIGURE 3.1e
IH-10 COLUMBUS
PROFILE OF DEFLECTION
4'RT. OF EDGE 1st SENSOR

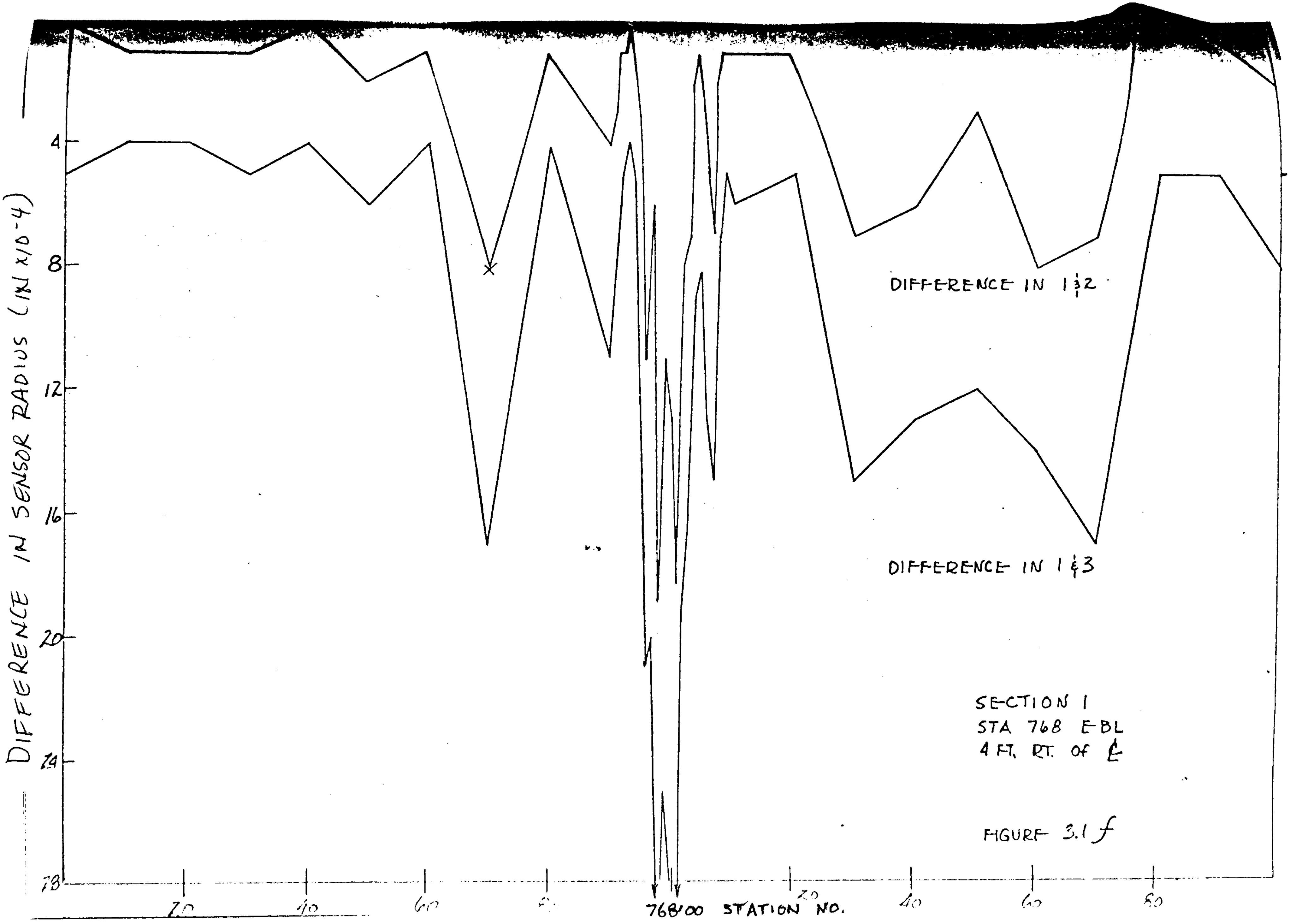
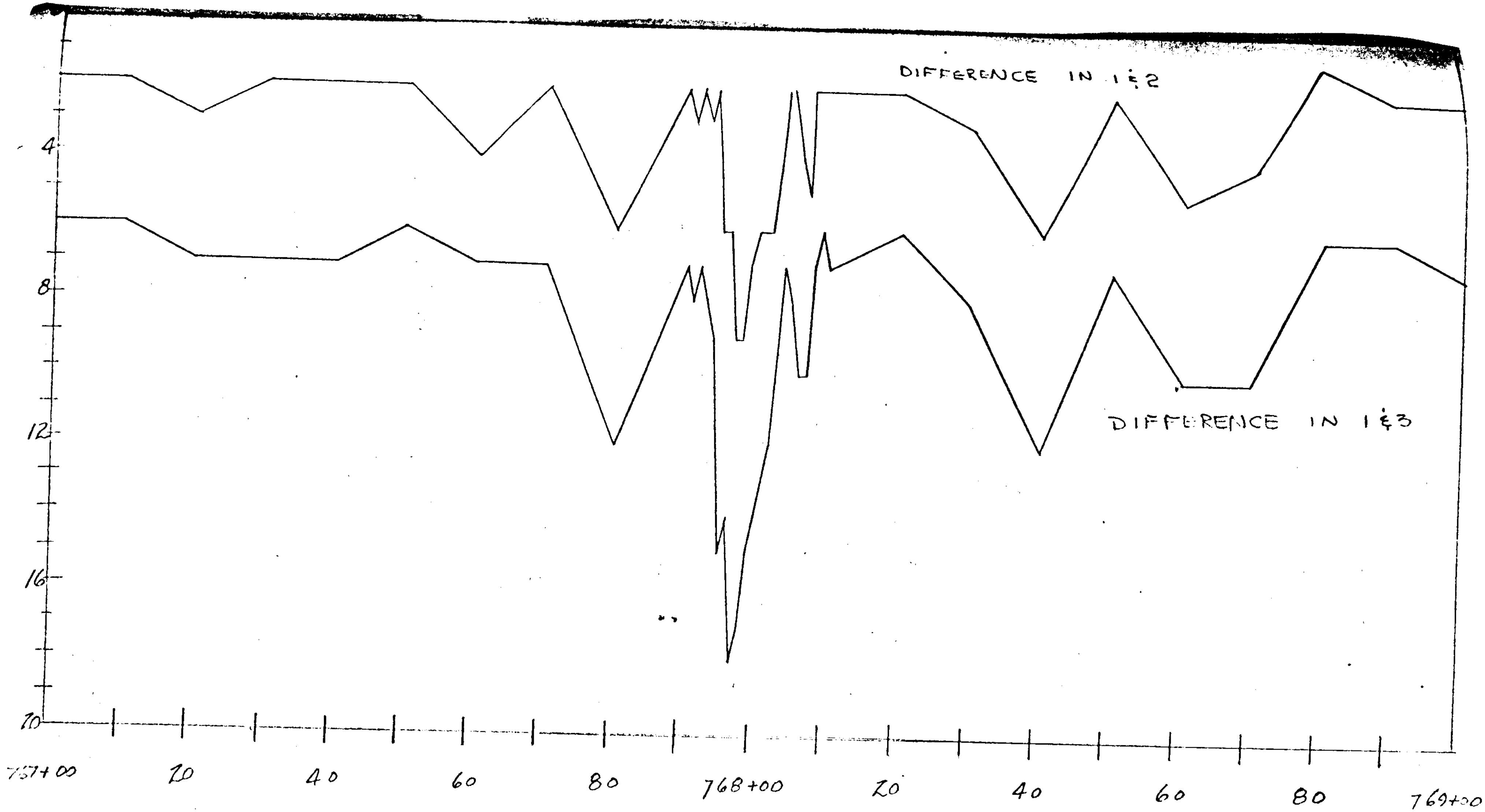

DIFFERENCE IN SENSOR RADIUS (IN x10-4)
4
8
12
16
20
24
28
20
40
60
768+00 STATION NO.
20
40
60
80
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 1
STA 768 EBL
4 FT. RT. OF ℄

FIGURE 3.1 f



STATION NO
Figure 3.1g
SECTION 1
STA. 768+00 WBL
4 FT FROM RT. EDGE.

DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3

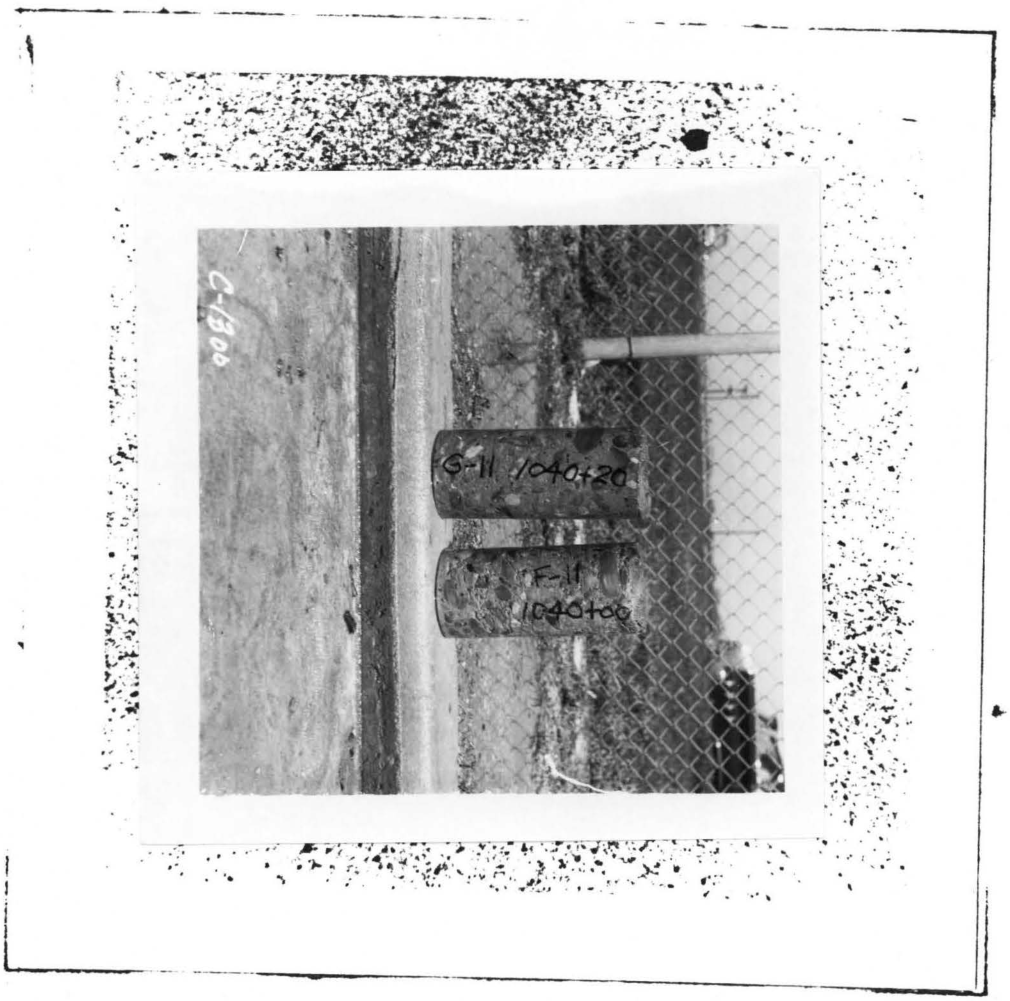


Figure 3.1h

Good and bad cores taken from Section 1

Figure 3.2a

General view of failure in Section 2

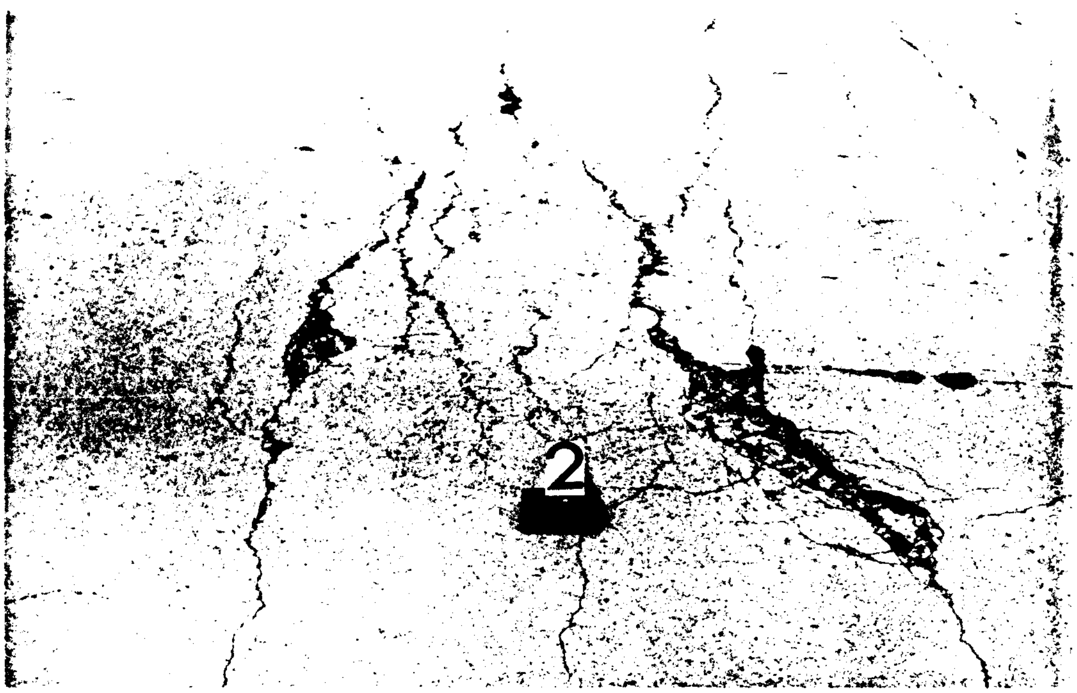


Figure 3.2b

Close-up view of failure in Section 2

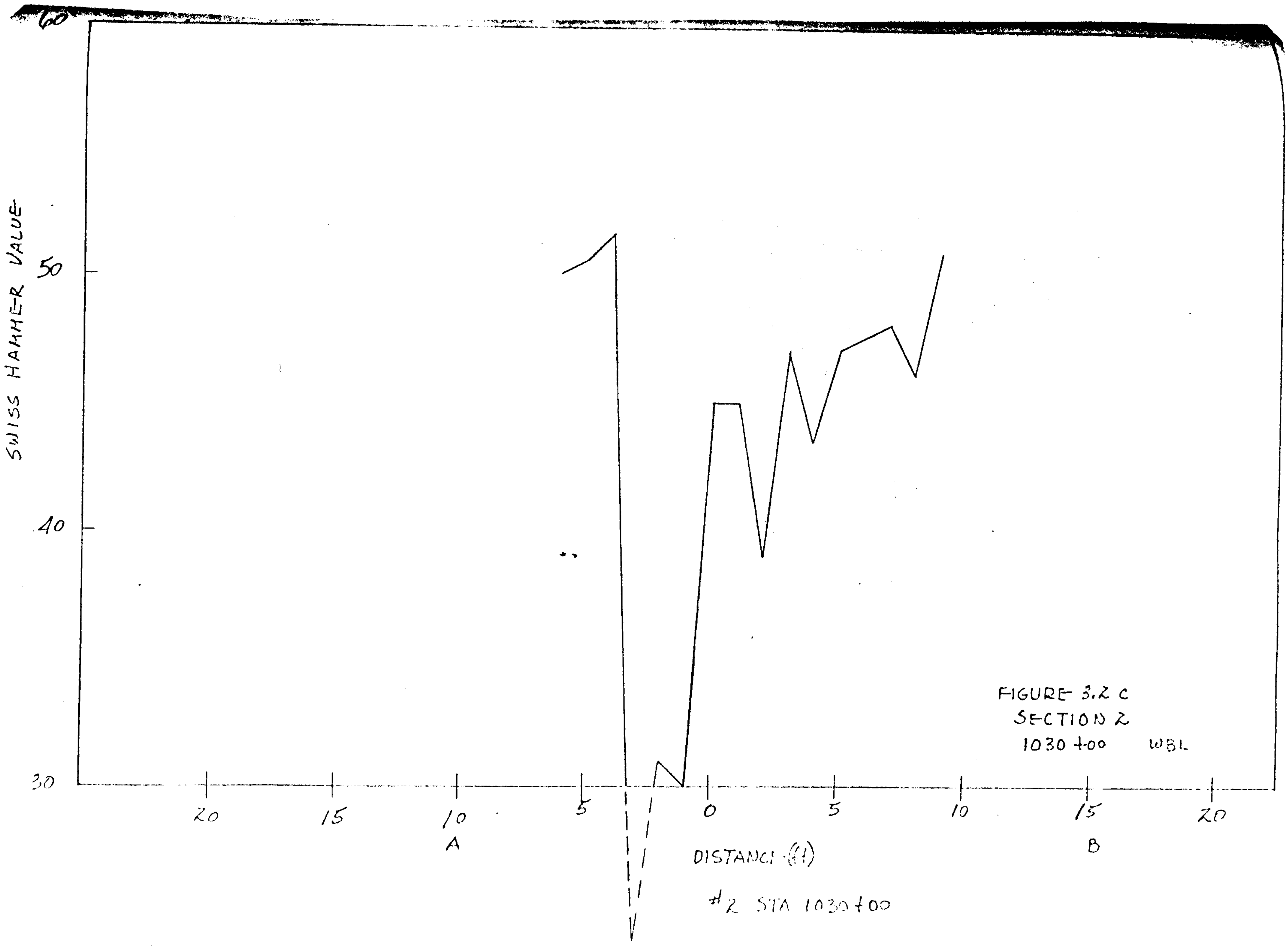

SWISS HAMMER VALUE
60
50
40
30
20
15
10
A
5
0
5
10
15
B
20
DISTANCE (ft)
#2 STA 1030+00
FIGURE 3.2 C
SECTION 2
1030+00
WBL

Figure 3.1d and 3.1e show the deflection profile at four feet right of center line and four feet from the edge respectively. It is rather evident from a deflection standpoint that there is an area of weakness at station 768 + 00. Another method of presenting the deflection data is by plotting the difference in deflection by sensor #1 and #2 and sensor #1 and #3 as a profile instead of deflection. Figures 3.1f and 3.1g show this difference in deflection as a profile over 200 feet. This difference in deflection is really a measure of the radius of curvature. Note in the two figures that the pavement at station 768 is having a large difference in deflection or in other words, a short radius of curvature.

The third method of investigation was the core drilling operation. The first two investigations were used to decide where to drill the core. A core was taken in an area which was thought to be very good concrete and the core showed that the concrete was very good. The core drilled in the failure area was not as smooth and sound in appearance as was the good core. These two cores are shown in Figure 3.1h. The core labeled G-1 is the good one and F-1 is the core from the failure area.

Section 2 (1040 + 00 WBL)

Figures 3.2a and 3.2b show the general surface condition of the pavement at Section 2. Section 2 was in the worst condition of any of the pavement sections studied.

The Swiss Hammer study on this section showed that the concrete was very weak through the failure area. Figure 3.2c is a profile of the Swiss Hammer value through the failure area. The profile shows a definite sign of poor concrete.

The deflection study also revealed the weak or poor concrete at station 1030. The deflection profile shown in Figure 3.2d portrays the failure area along a line four feet from the pavement edge. Figure 3.2e is a deflection profile four feet right of center line. Deflection alone on this section would not be a measure of the condition of the pavement.

The difference in deflection or the radius of curvature profile in Figure 3.2f definitely indicates that there is some questionable concrete at station 1030.

The Swiss Hammer, deflection, and difference in deflection investigations were used to determine where cores should be drilled. Two cores were drilled in the failure area and one in an area of good concrete. While drilling the two cores in the failure area each core broke into pieces. The salvageable parts of these two cores are shown in Figure 3.2g. The batch quantities in the concrete at this section are definitely in question.

Section 3 (973 + 50 WBL)

Figures 3.3a and 3.3b portray the general condition of the pavement at station 973 + 50. The cracking is quite severe.

The Swiss Hammer investigation on this section revealed that there is definitely some low strength concrete in the failure area. Figure 3.3c shows a profile of the Swiss Hammer value through the failure area.

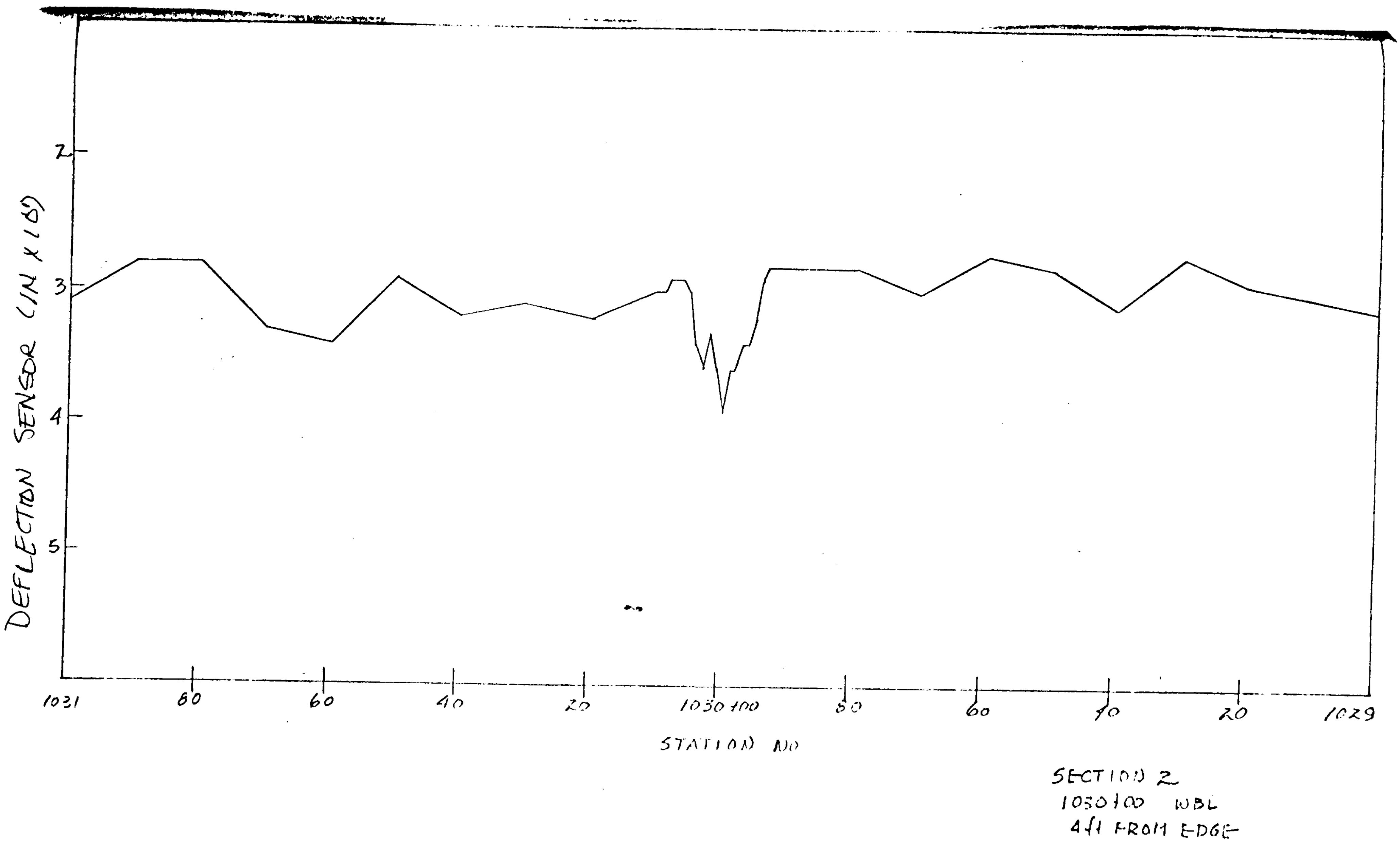

DEFLECTION SENSOR (IN X 10³)
2
3
4
5
1031
80
60
40
20
1030+00
80
60
40
20
1029
STATION NO
SECTION 2
1030+00 WBL
4 ft FROM EDGE

FIGURE 3.2 d

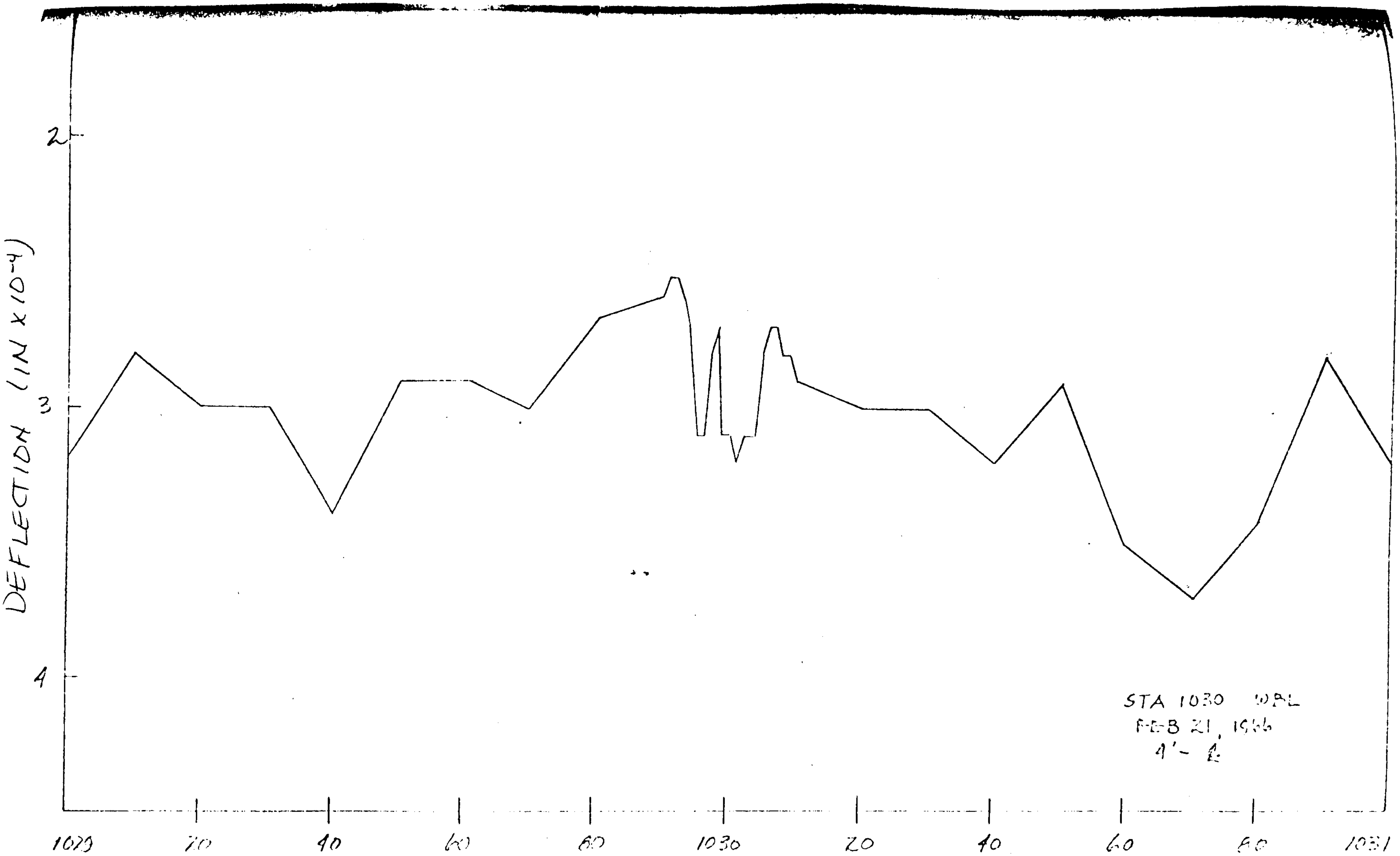

DEFLECTION (IN x 10-4)
2
3
4
STA 1030 WBL
FEB 21, 1966
4' - ℄
1029
20
40
60
80
1030
20
40
60
80
1031
STATION NO.

FIGURE 3.20

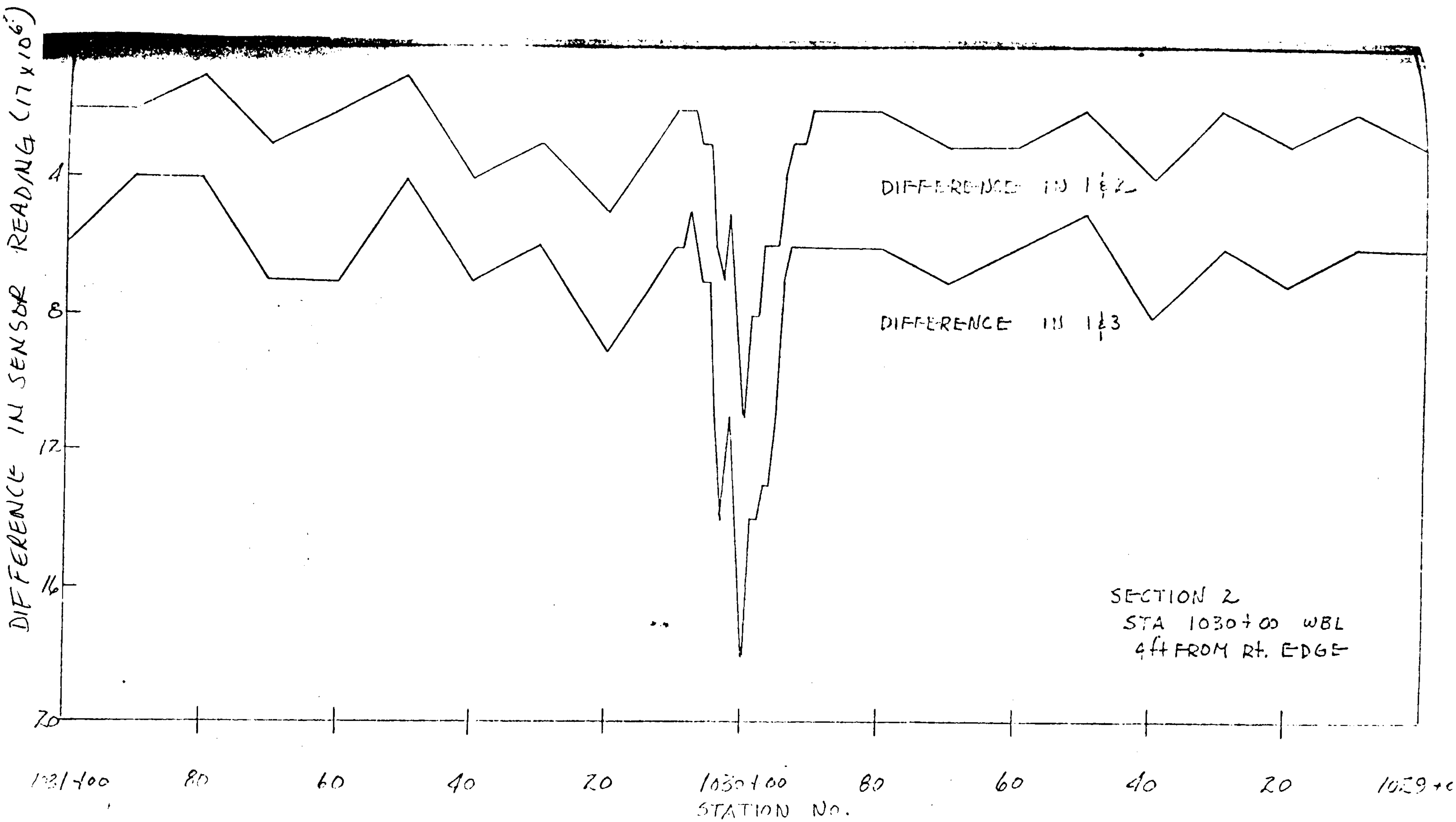

DIFFERENCE IN SENSOR READING (17 x 10⁻⁶)
4
8
12
16
20
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 2
STA 1030+00 WBL
4 ft FROM Rt. EDGE
1031+00
80
60
40
20
1030+00
80
60
40
20
1029+00
STATION No.

FIGURE 3.2 f

Figure 3.2g

Broken cores taken from failure Section 2

Figure 3.3a

Close-up view of crack pattern on Section 3

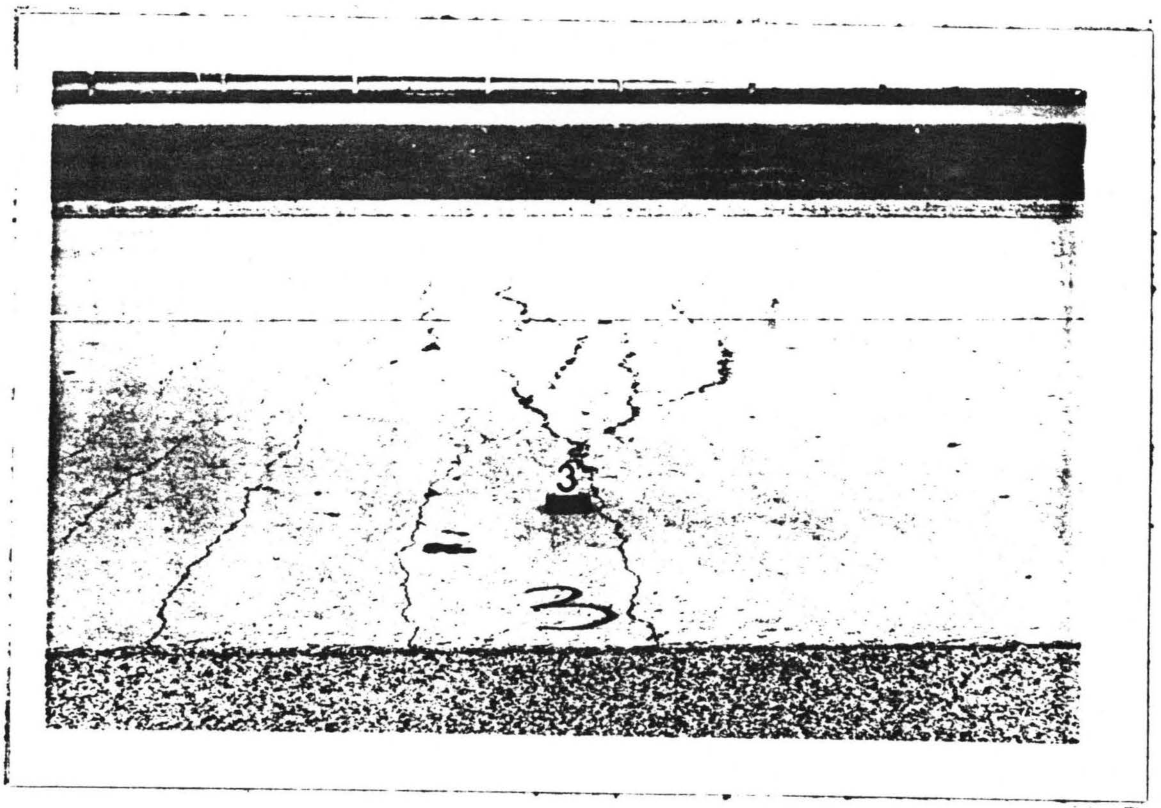
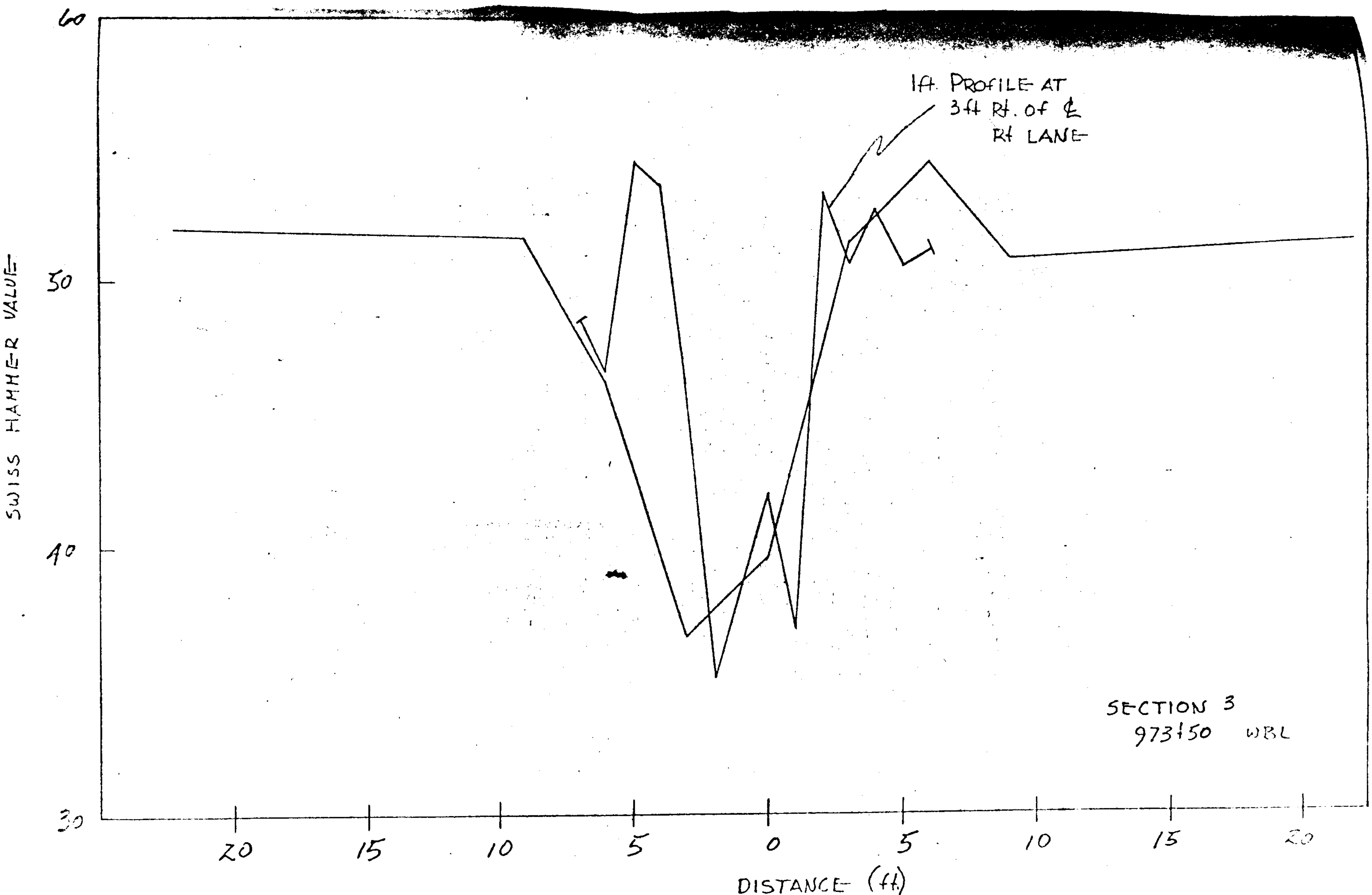


Figure 3.3b

General view of Section 3



60
50
40
30
SWISS HAMMER VALUE
1ft. PROFILE AT
3ft Rt. of ℄
Rt LANE
20
15
10
5
0
5
10
15
20
DISTANCE (ft)
A
B
SECTION 3
973+50 WBL

FIGURE 3.3C

Deflection in the failure was not very significant as can be seen in Figures 3.3d and 3.3e. The variations down the roadway were just as great as were the deflections in the failure area.

The difference in deflection, radius of curvature profile more definitely outlined the failure area as is clearly shown in Figure 3.3f. The above studies were used locate places to drill cores. The core drilling showed that the concrete was not as design intended it to be. The core taken in the failure area broke while drilling. The core was very rough and showed that the batch quantities may not have been right or the cement may not have been real good. The broken core is shown in Figure 3.3g with a good core from the same general area; note the difference in texture.

Section 4 (813 + 00 WBL)

Section 4 is not considered a bad area but there is more cracking than is normally expected. The general pavement condition is shown in Figures 3.4a and 3.4b.

The Swiss Hammer study showed that this section was not weak in strength. Figure 3.4c is the Swiss Hammer Profile.

The deflection study showed that the variations in the severely cracked area were no greater than the point to point variations along the roadway. Deflection profiles four feet right of center line and four feet from the right edge both show that the cracked concrete is not deflecting more than the concrete which is in good condition. Figures 3.4d and 3.4e show these deflection profiles.

The difference in deflection or radius of curvature profile

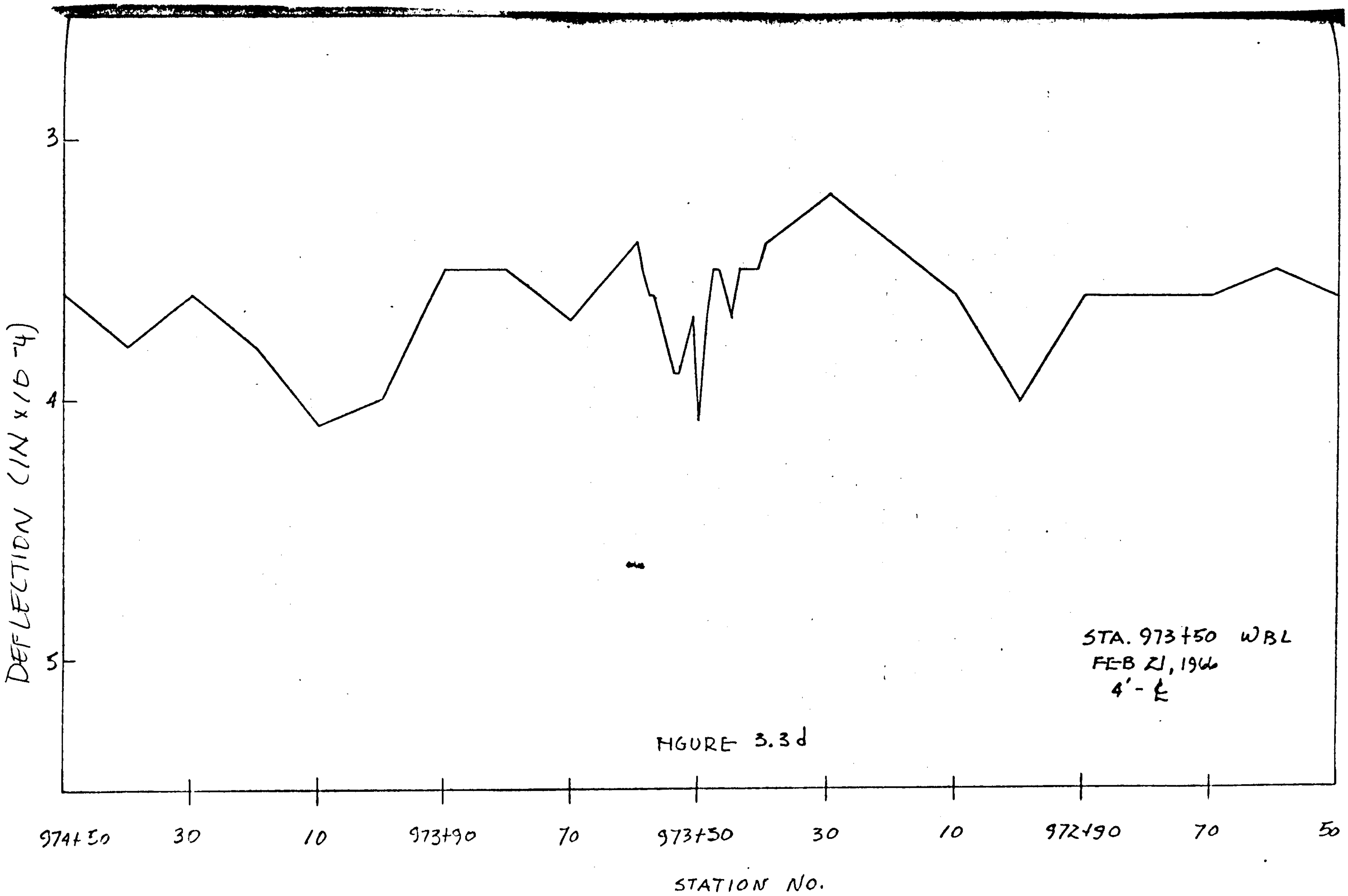

DEFLECTION (IN x 10^-4)
3
4
5
STA. 973+50 WBL
FEB 21, 1966
4' - ℄
974+50
30
10
973+90
70
973+50
30
10
972+90
70
50
STATION NO.

FIGURE 3.3d

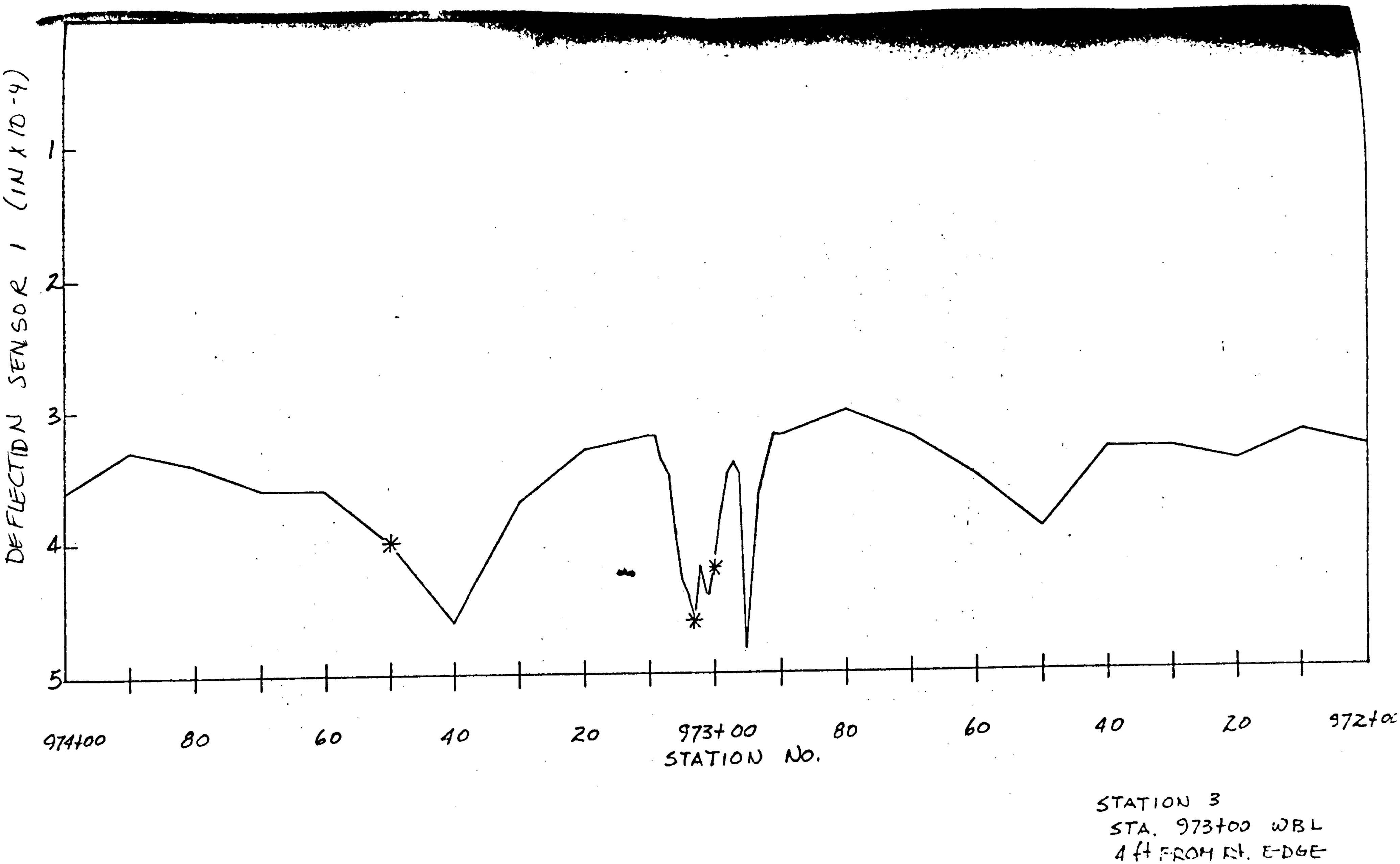

DEFLECTION SENSOR 1 (IN x 10-4)
1
2
3
4
5
974+00
80
60
40
20
973+00
80
60
40
20
972+00
STATION No.
STATION 3
STA. 973+00 WBL
4 ft FROM Rt. EDGE

FIGURE 3.3e

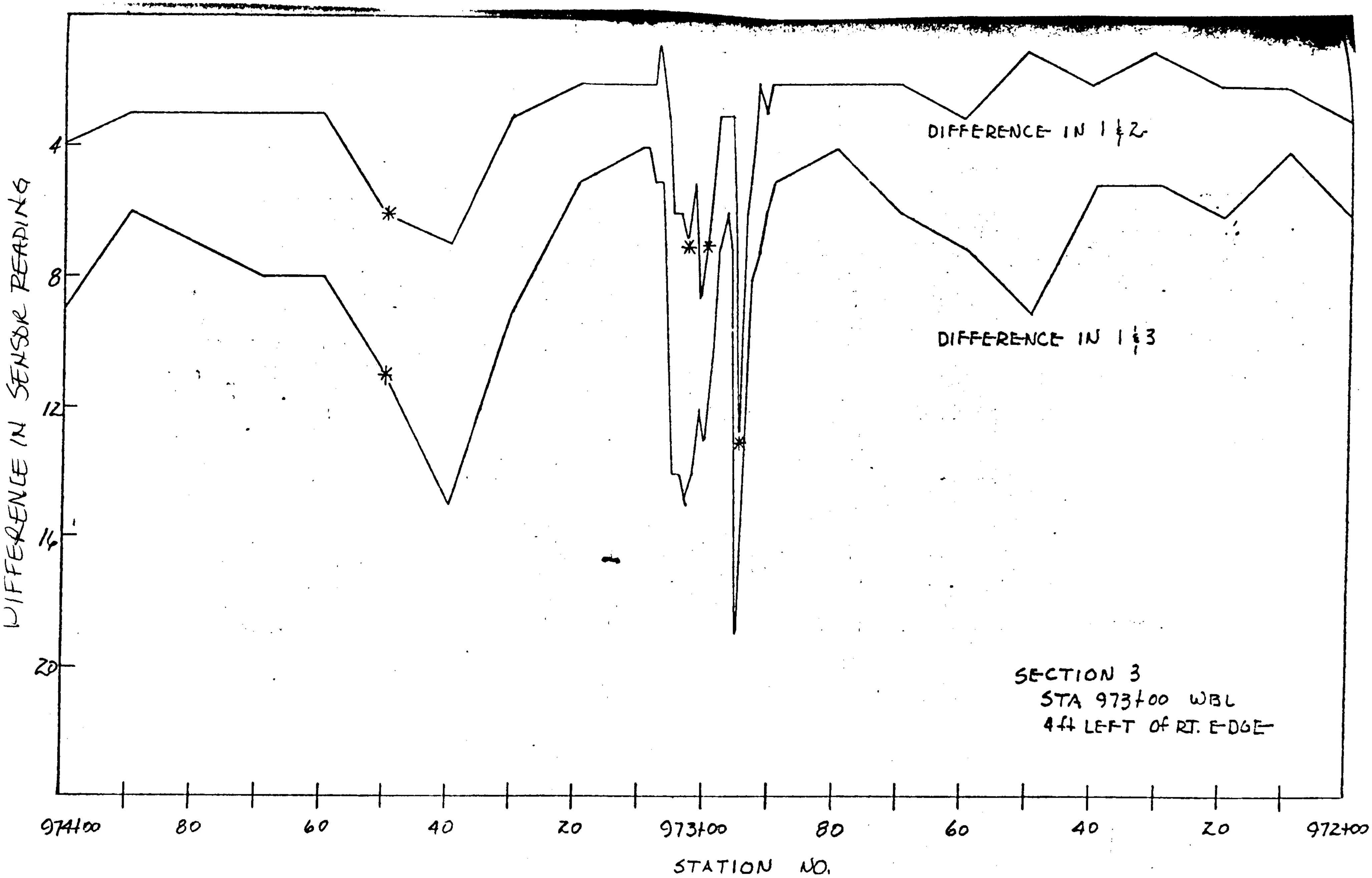

DIFFERENCE IN SENSOR READING
4
8
12
16
20
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 3
STA 973+00 WBL
4 ft LEFT OF RT. EDGE
974+00
80
60
40
20
973+00
80
60
40
20
972+00
STATION NO.

FIGURE 3.3 f

Figure 3.3g

Comparison of good and bad cores from Section 3

Figure 3.4a

General view of Section 4

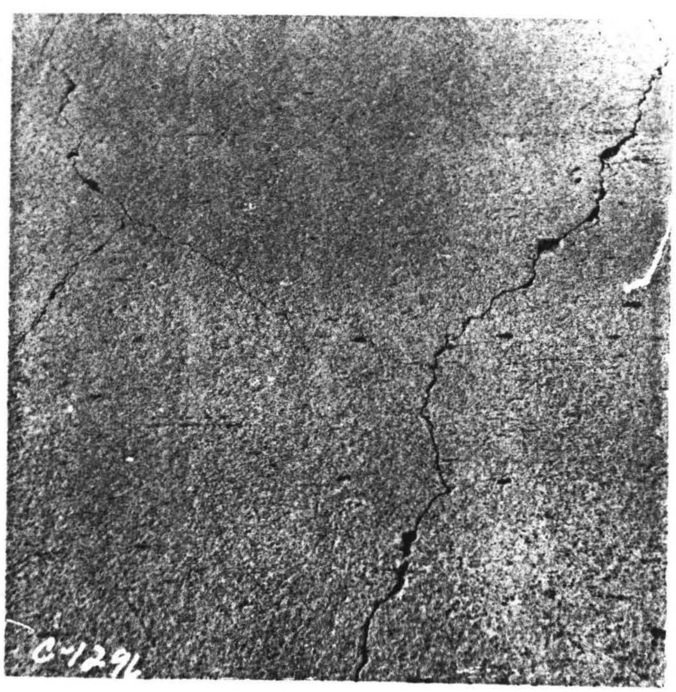


Figure 3.4b

Close-up view of cracking on Section 4

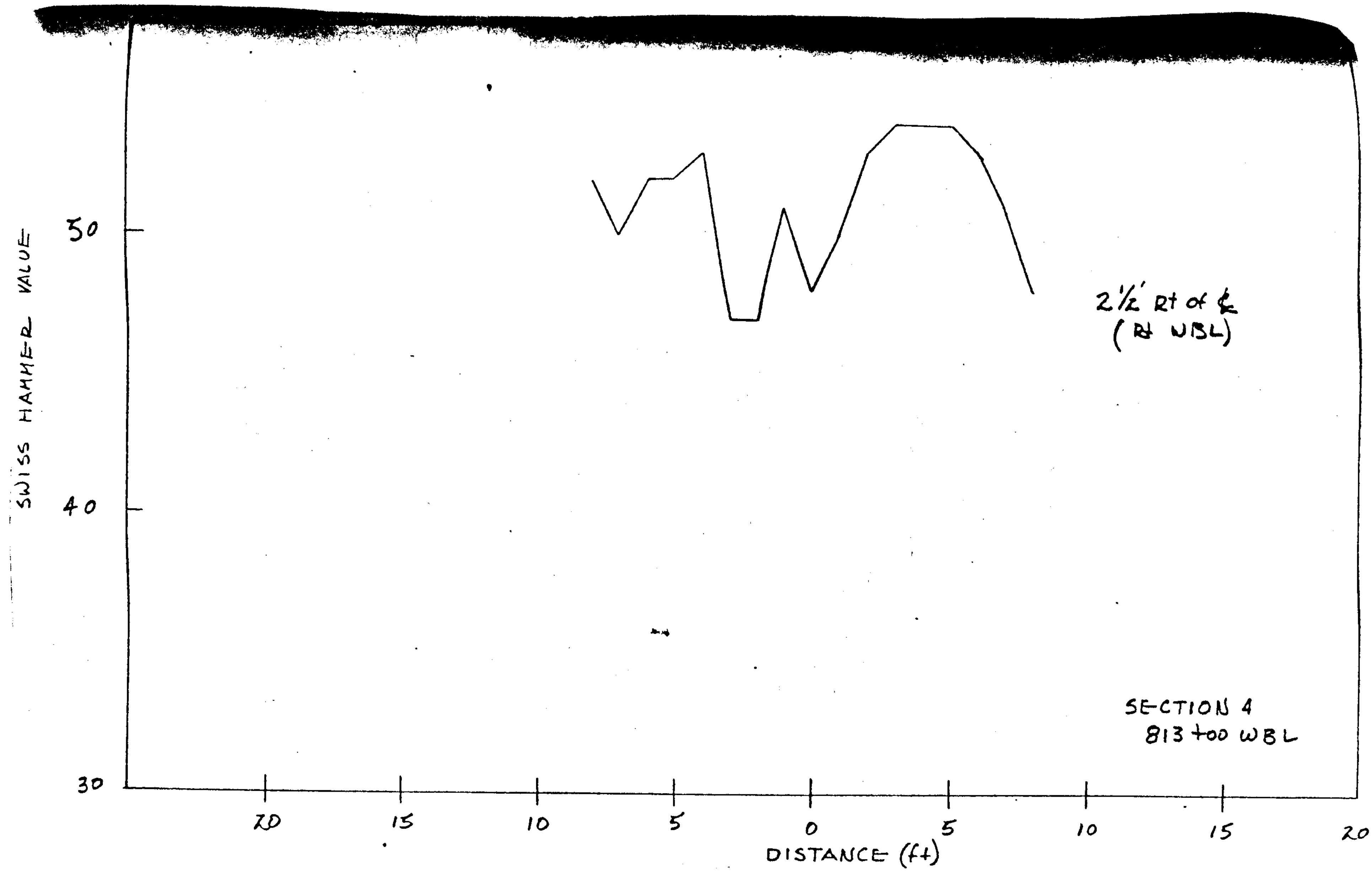

50
40
30
SWISS HAMMER VALUE
2 1/2' Rt of ℄
(Rt WBL)
SECTION 4
813+00 WBL
20
15
10
5
0
5
10
15
20
DISTANCE (ft)
A
B

FIGURE 3.4c

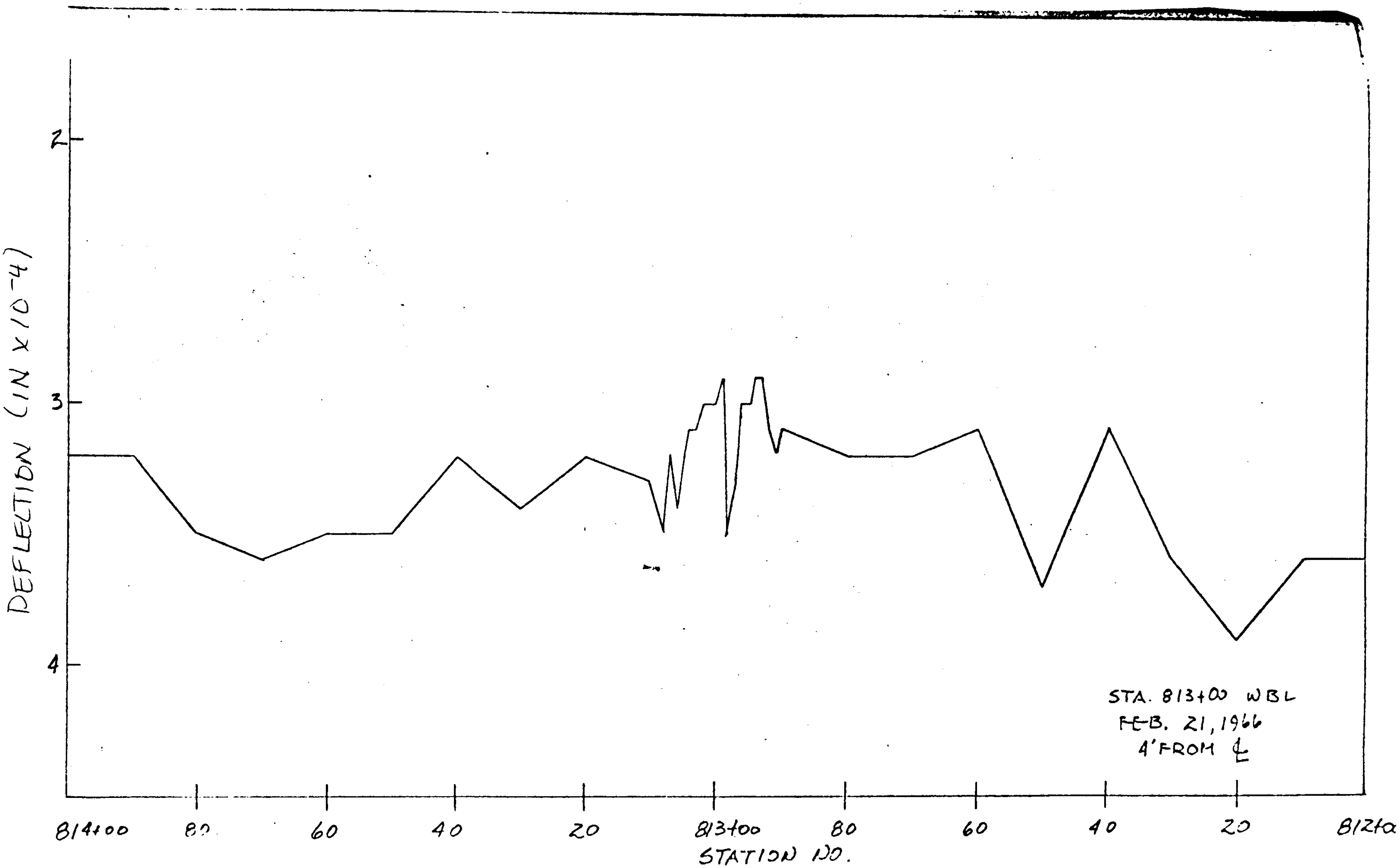
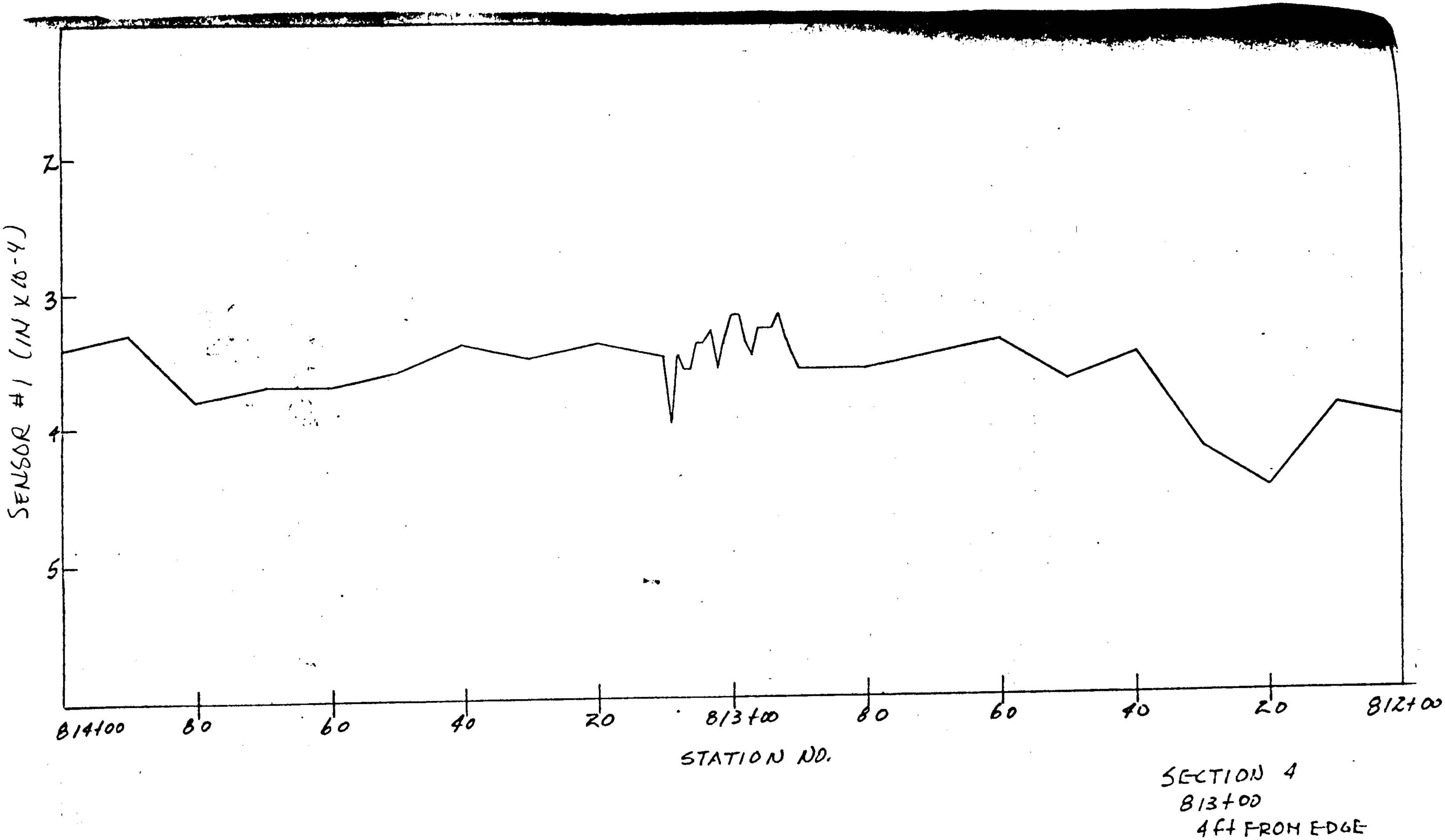

2
3
4
DEFLECTION (IN x 10^-4)
814+00
80
60
40
20
813+00
80
60
40
20
812+00
STATION NO.
STA. 813+00 WBL
FEB. 21, 1966
4' FROM ℄

FIGURE 3.4 d



SENSOR #1 (IN X 10-4)
2
3
4
5
814+00
80
60
40
20
813+00
80
60
40
20
812+00
STATION NO.
SECTION 4
813+00
4 ft FROM EDGE

FIGURE 3.4 e

gives a more clear indication of the presence of the narrow crack spacings. Figure 3.4f shows the radius of curvature profile.

A core was drilled in the severely cracked area but its appearance gave no clues as to what may have caused the cracking.

Section 5 (761 + 50 WBL)

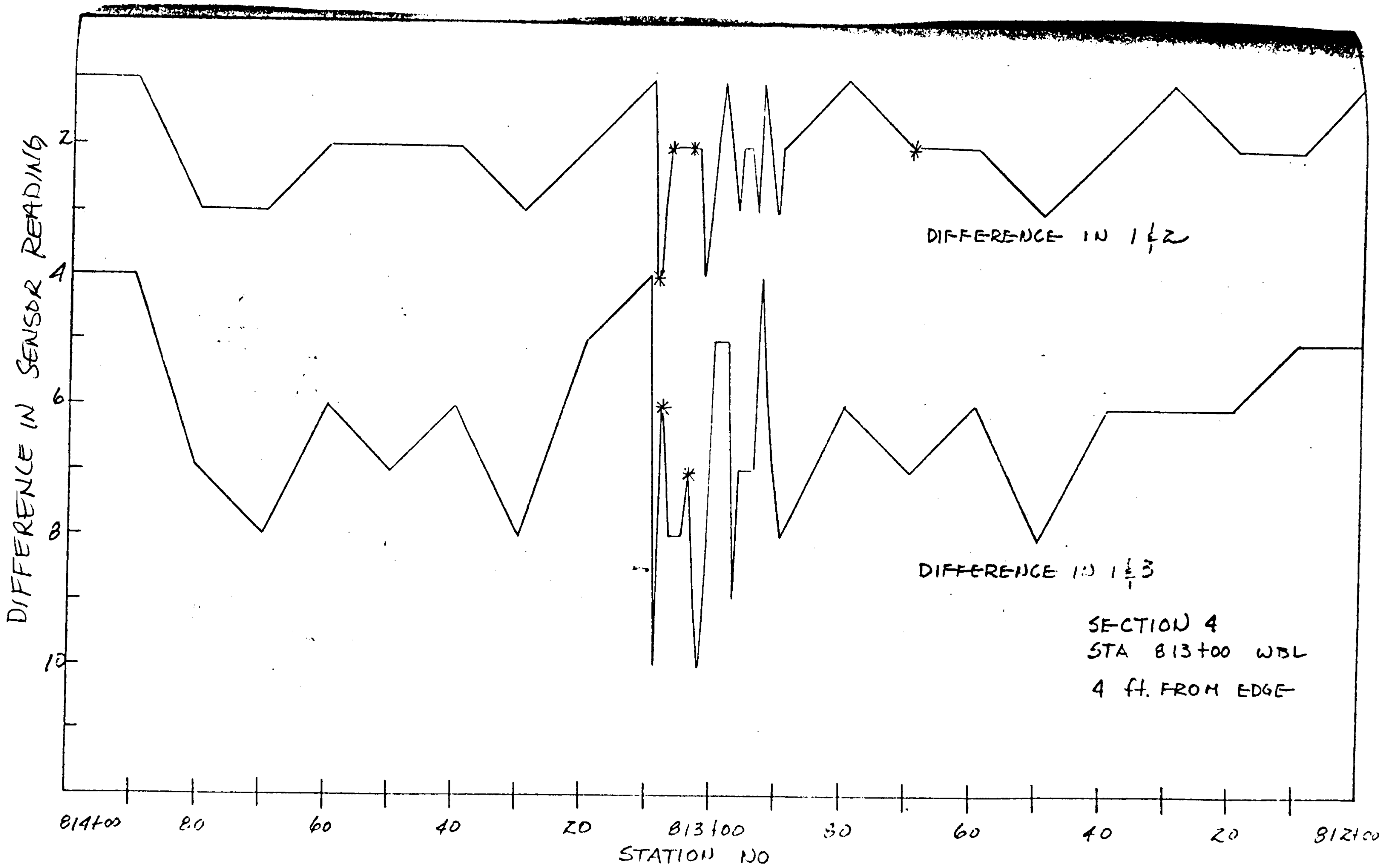
Section 5 is another section which is not in poor condition other than the severe cracking as shown in Figures 3.5 a and 3.5b.

The Swiss Hammer investigation showed that there was an area of slightly weaker concrete in the center of the section. This is shown on the profile of the Swiss Hammer value shown in Figure 3.5c. The deflection was no greater in the failure area than the point to point variation. Figures 3.5d and 3.5e show deflection profiles. The difference in deflection in the failure area was not as great as some of the point to point variations. Figure 3.5f shows the large variations along the roadway. The core drilled in the failure area did not show any significant differences from the core taken from the good area.

Section 6 (809 + 00 WBL)

Section 6 was not considered bad but it may develop into a more dramatic failure as loads get heavier and time goes on. Figure 3.6a shows a general view of the area of pavement which is severely cracked.

The Swiss Hammer study showed that there was no weak concrete in the cracked area. Figure 3.6b is profile of the Swiss Hammer value which shows no weakness in the failure area. Deflection did



DIFFERENCE IN SENSOR READING
2
4
6
8
10
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 4
STA 813+00 WBL
4 ft. FROM EDGE
814+00
80
60
40
20
813+00
80
60
40
20
812+00
STATION NO

FIGURE 3.4f

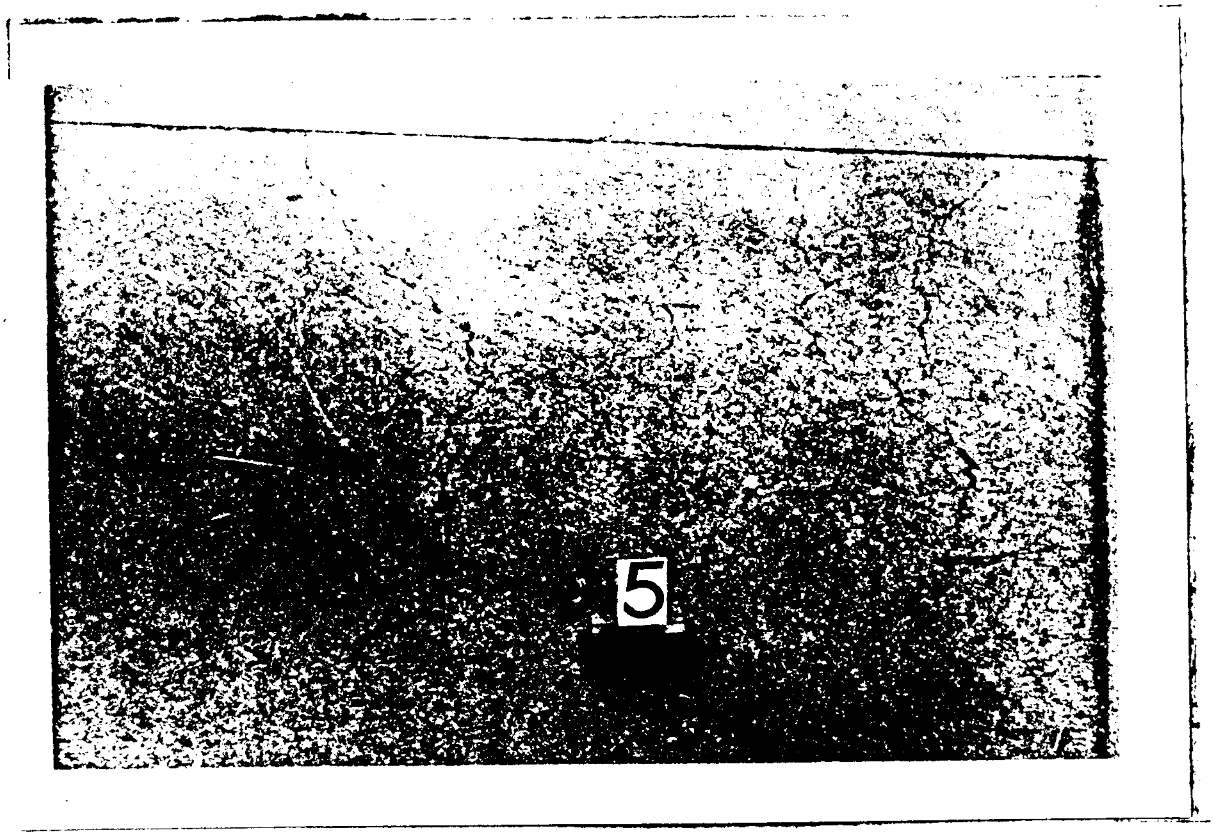


Figure 3.5a

Close-up view of cracking on Section 5

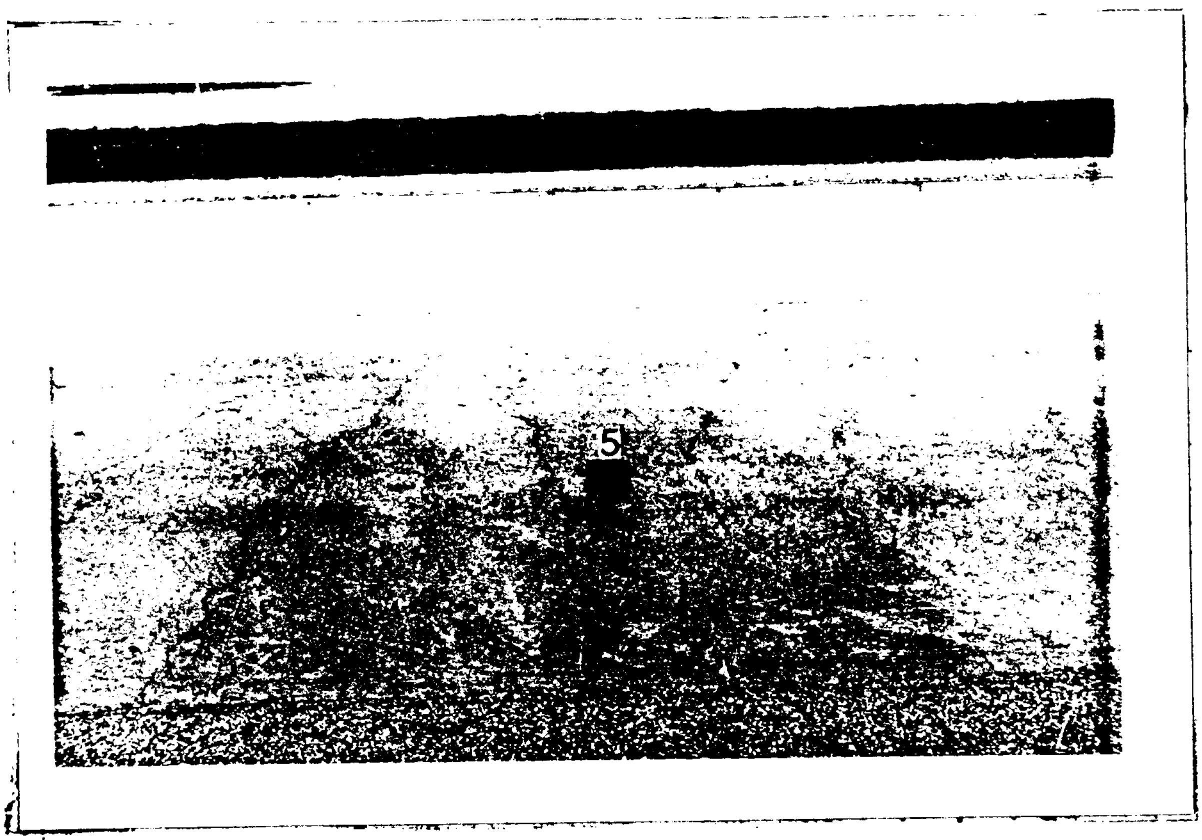
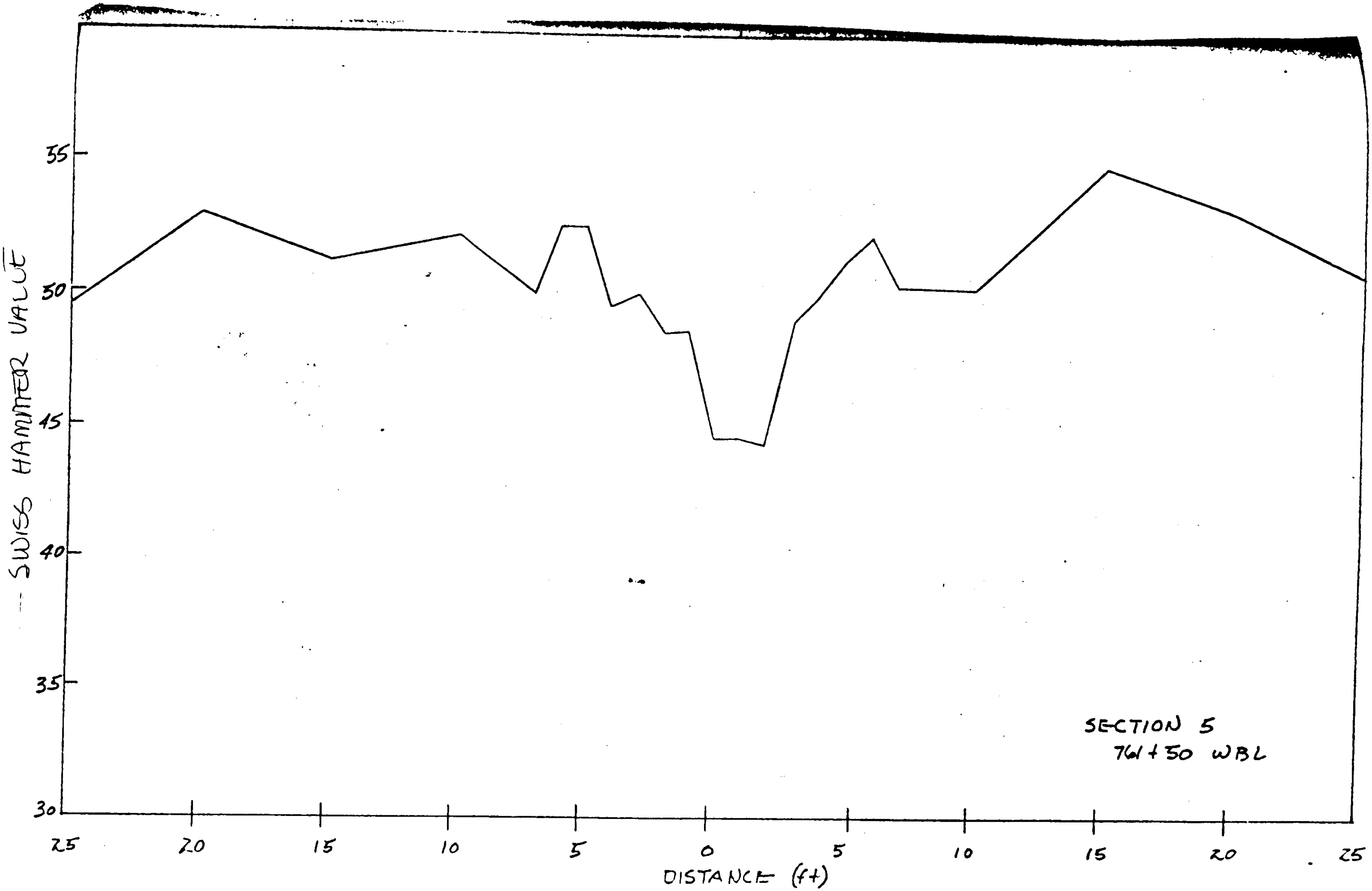


Figure 3.5b

General view of pavement at Section 5



SWISS HAMMER VALUE
35
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20
25
DISTANCE (ft)
SECTION 5
761+50 WBL

FIGURE 3.5c

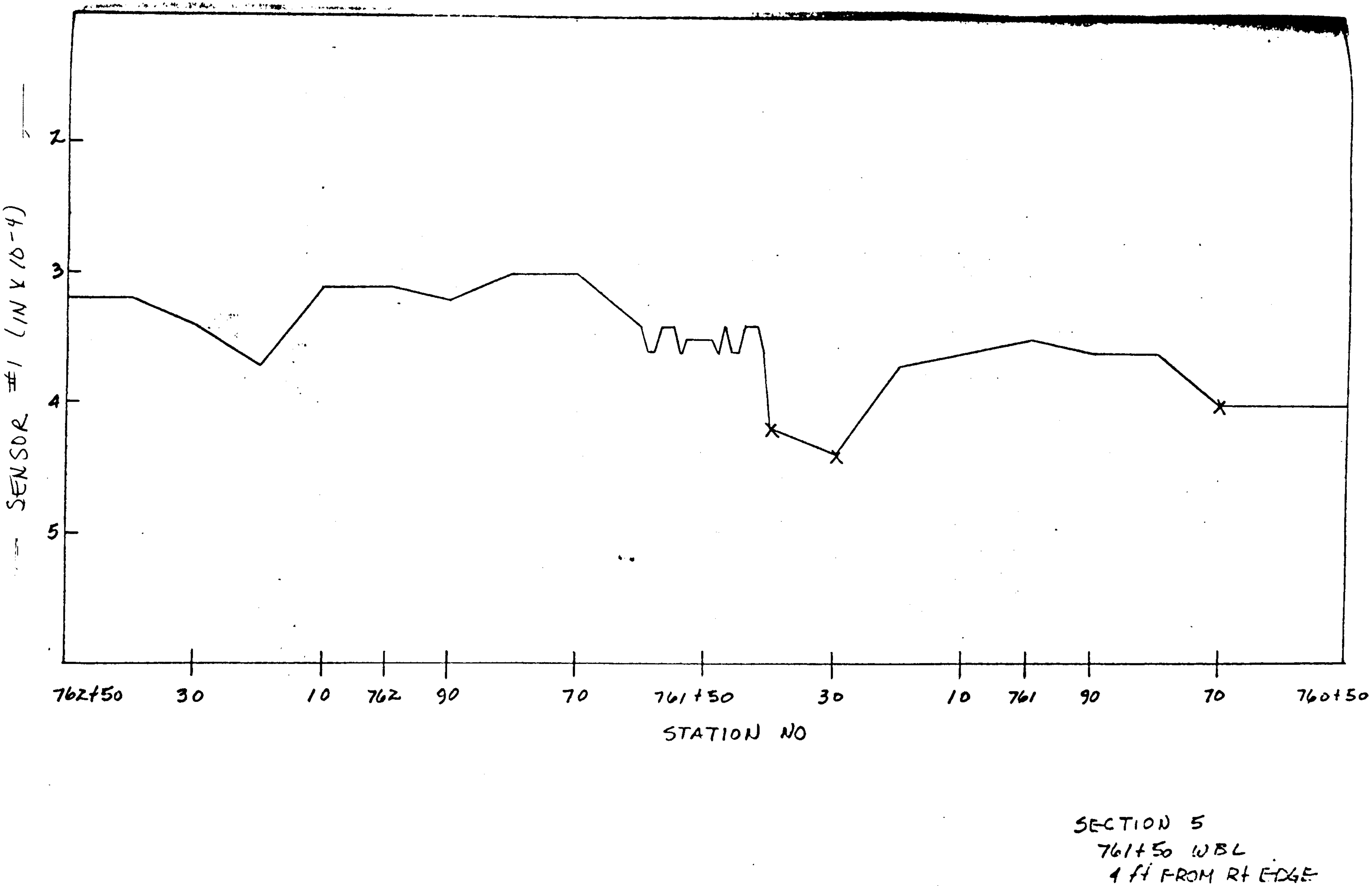
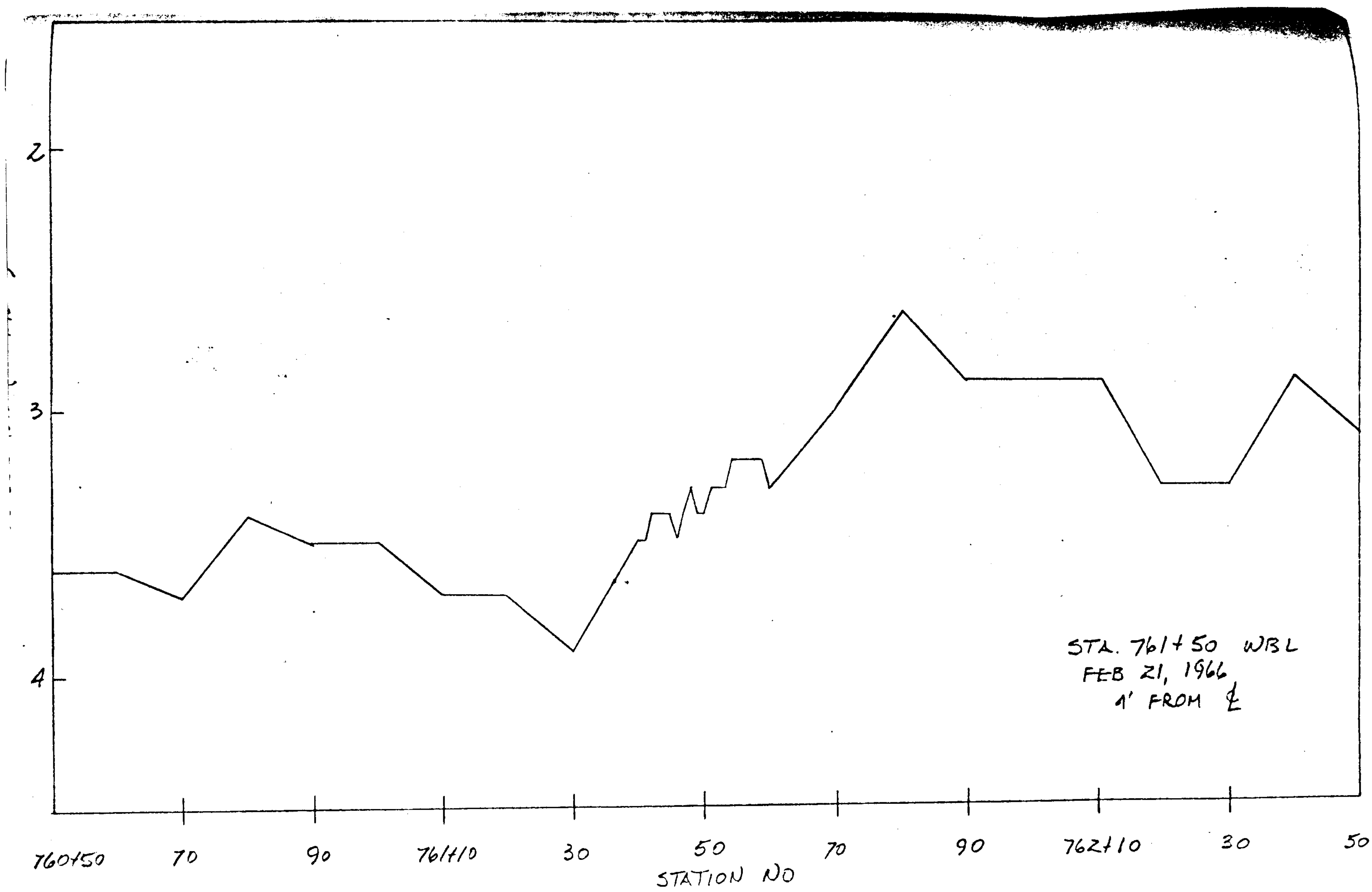

SENSOR #1 (IN x 10-4)
2
3
4
5
762+50
30
10
762
90
70
761+50
30
10
761
90
70
760+50
STATION NO
SECTION 5
761+50 WBL
4 ft FROM Rt EDGE

FIGURE 3.5 d



2
3
4
760+50
70
90
761+10
30
50
70
90
762+10
30
50
STATION NO
STA. 761+50 WBL
FEB 21, 1966
1' FROM ℄

FIGURE 3.5e

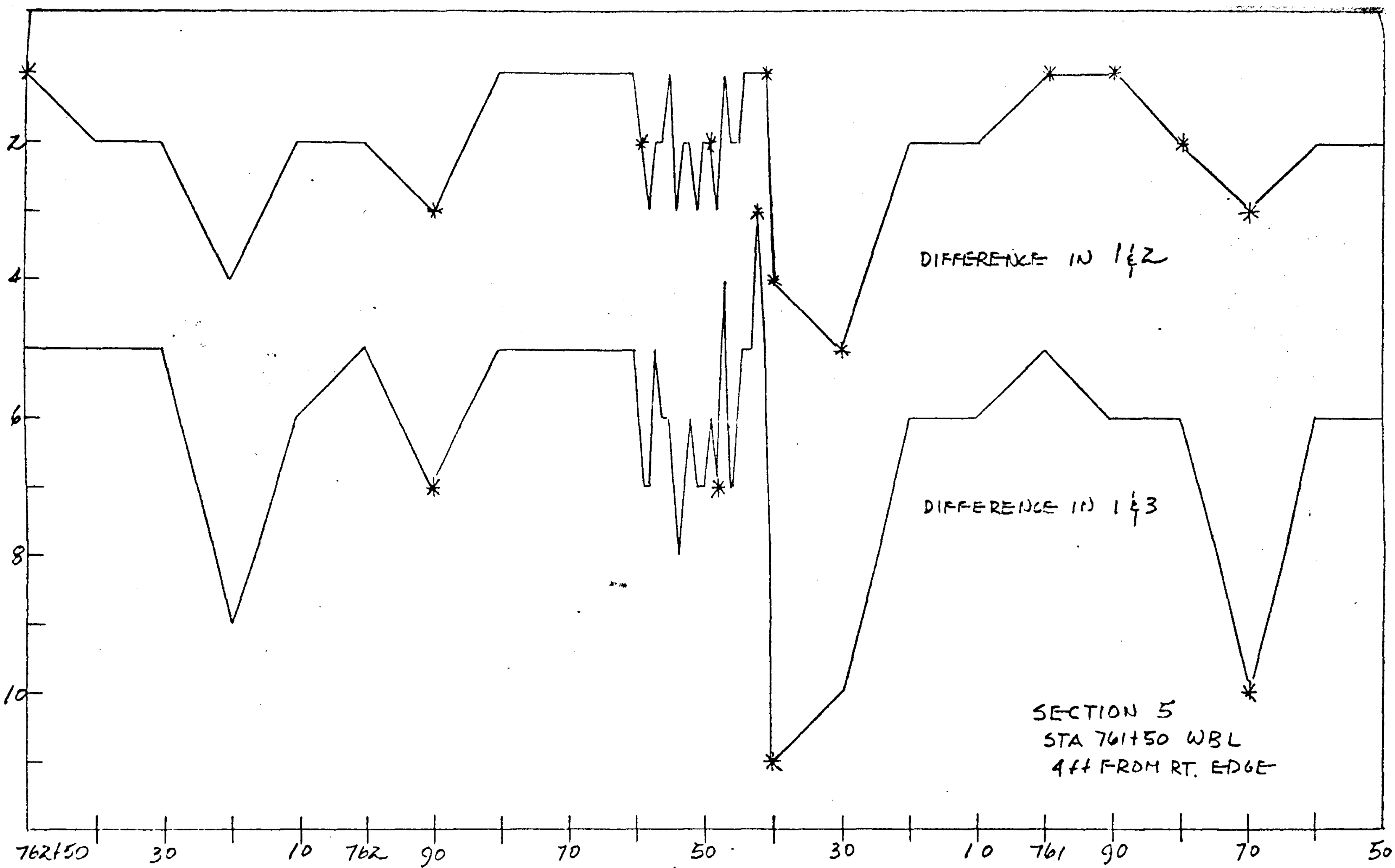

DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 5
STA 761+50 WBL
4 ft FROM RT. EDGE
2
4
6
8
10
762+50
30
10
762
90
70
50
30
10
761
90
70
50
STATION NO.

FIGURE 3.5 f

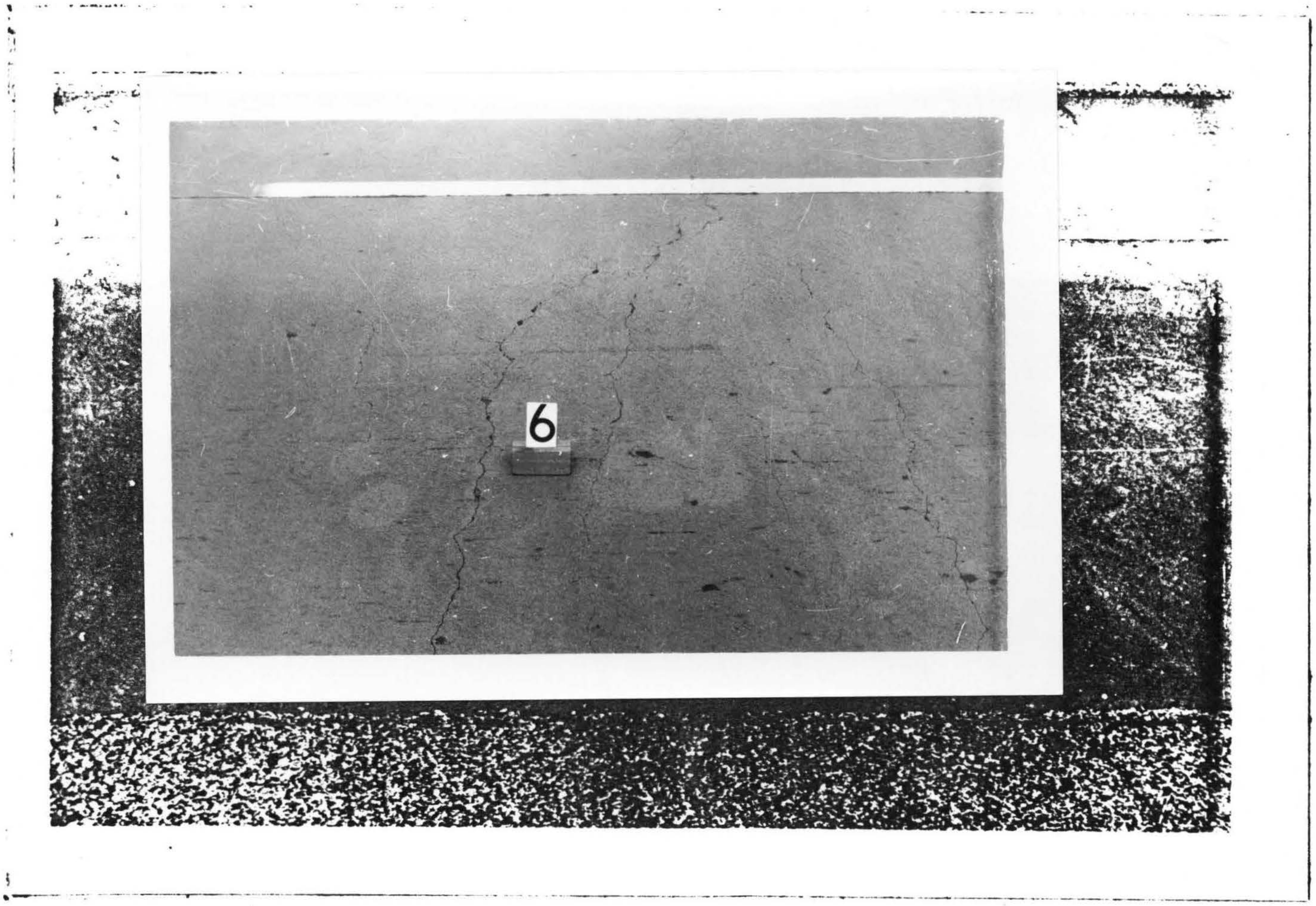


Figure 3.6a

General view of pavement condition at Section 6

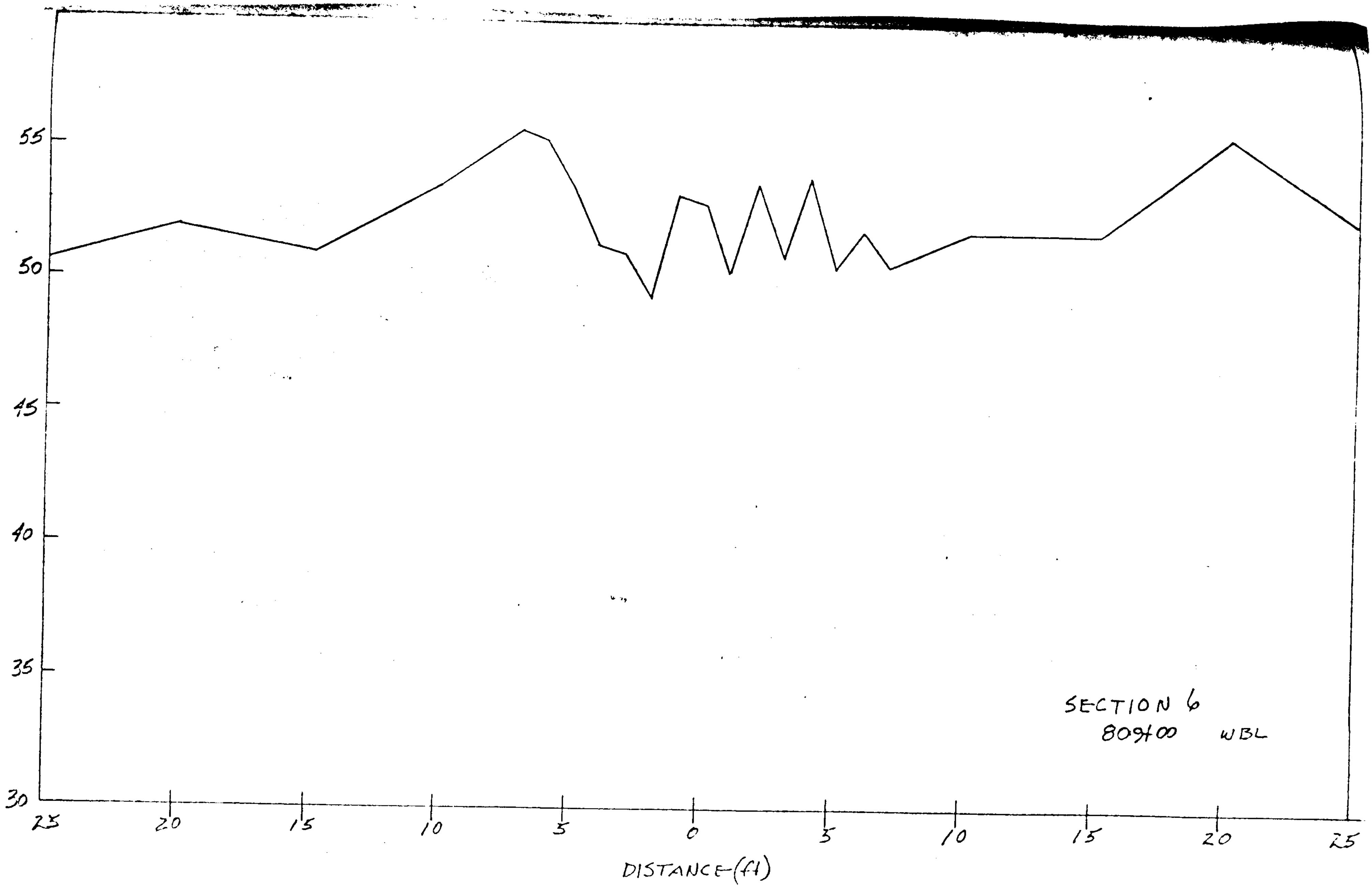

55
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20
25
DISTANCE-(ft)
SECTION 6
809+00 WBL

FIGURE 3.6b

show the failure area either as can be seen in the deflection profiles in Figures 3.6c and 3.6d. The difference in deflection profile in Figure 3.6e shows that there is an area in which the concrete is performing slightly different than away from the cracked area. The core drilling operation did not show the presence of any weak concrete either. The large differences in deflection were probably caused by the close crack spacing.

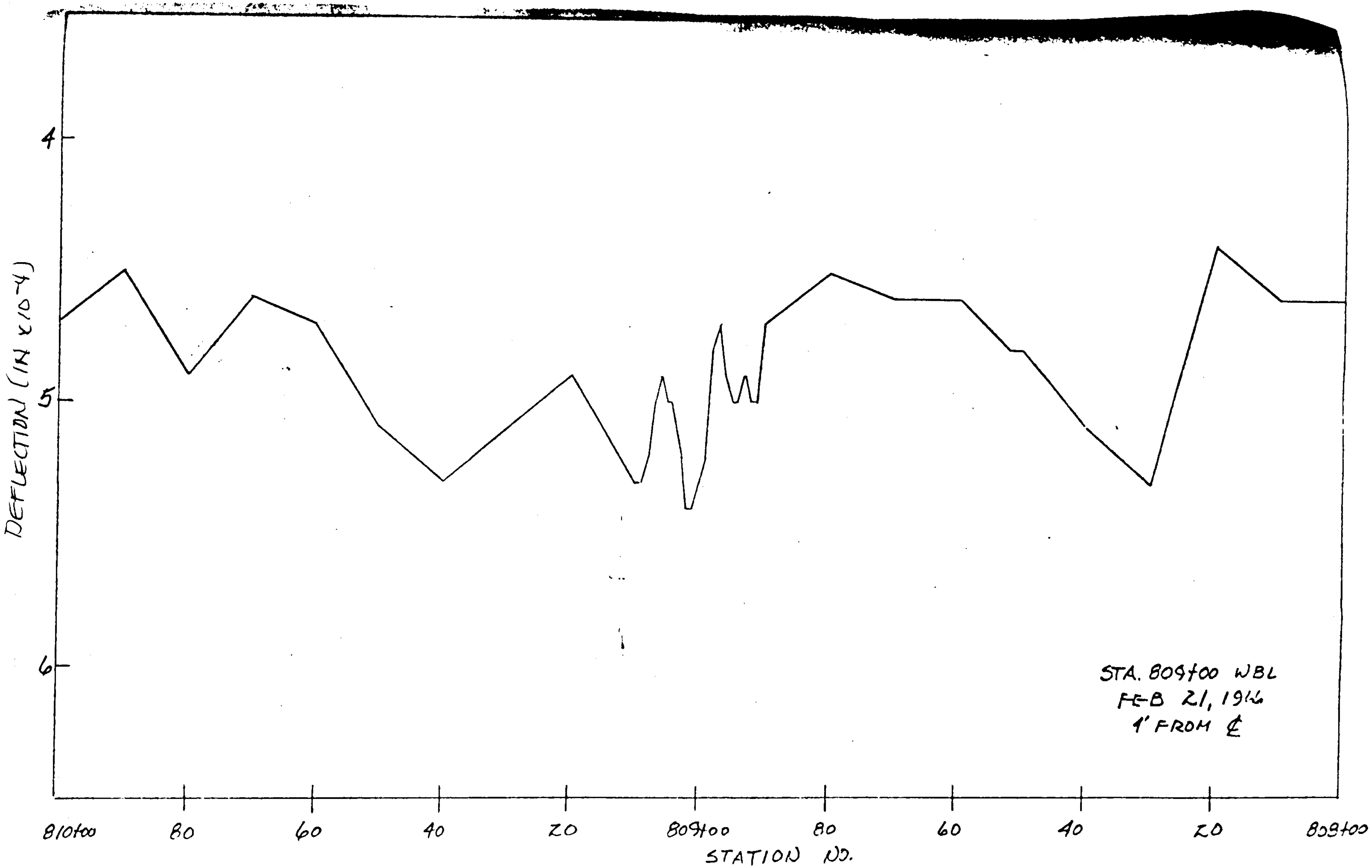
Section 7 (823 + 00 EBL)

The general surface condition of Section 7 is shown in Figures 3.7a and 3.7b. The failure area consists of excessive cracking in various directions.

The Swiss Hammer study showed that the severely cracked concrete was not particularly weaker than the good concrete. The variations in the failure area were similar to the point to point variations along the road as is portrayed in Figure 3.7c. Deflections varied through the same range in the failure area as they did down the roadway as is shown in Figure 3.7d. The difference in deflection or radius of curvature variations showed to be slightly greater in the cracked area than along the roadway as is shown in Figure 3.7e. The core drilled from this area also showed the concrete to be in good shape.

Section 8 (953 + 50 EBL)

In appearance Section 8 might be classified quite bad due to severe spalling and cracking. Figure 3.8a shows a general view of



DEFLECTION (IN x10^-4)
4
5
6
STA. 809+00 WBL
FEB 21, 1966
1' FROM ℄
810+00
80
60
40
20
809+00
80
60
40
20
808+00
STATION NO.

FIGURE 3.6C

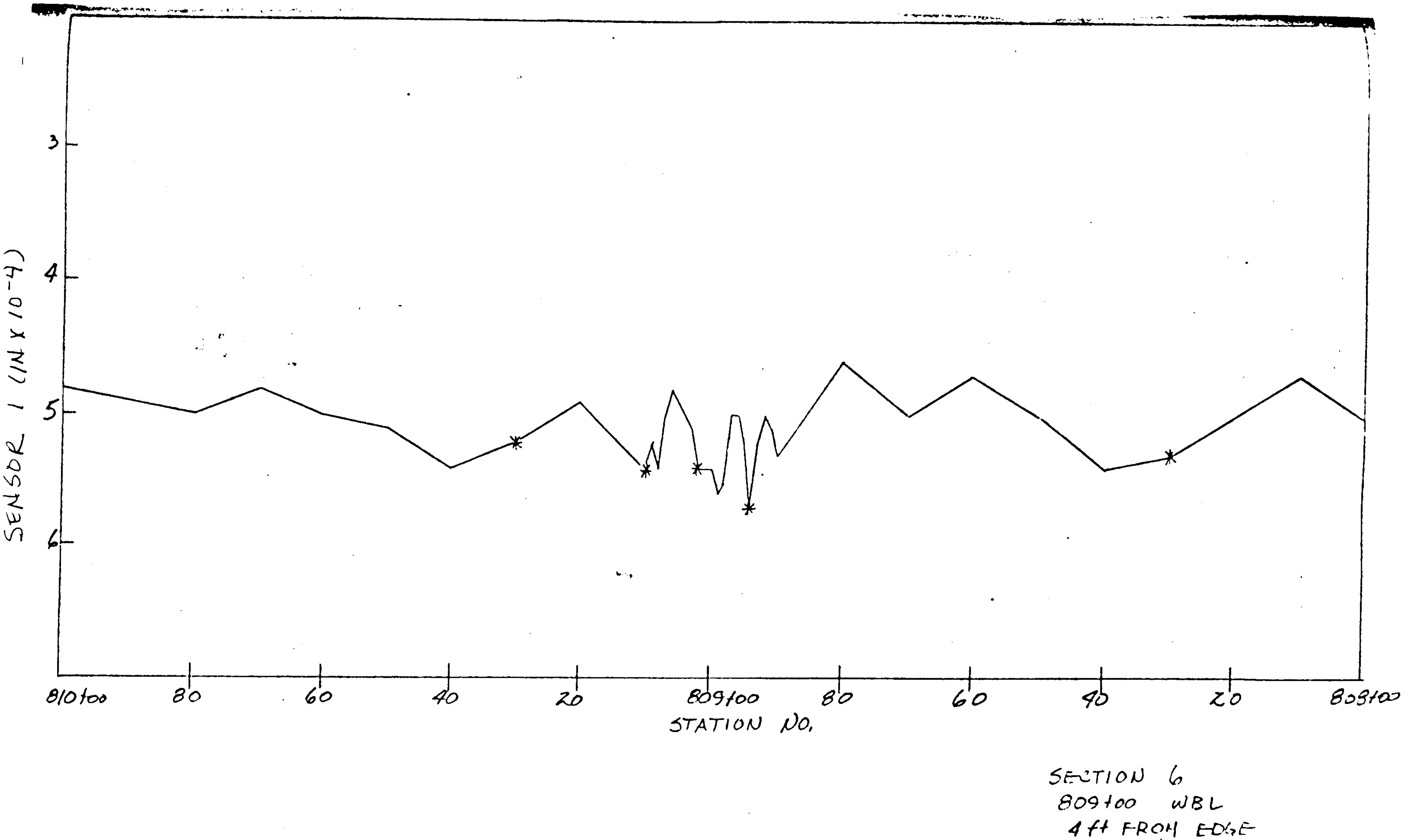
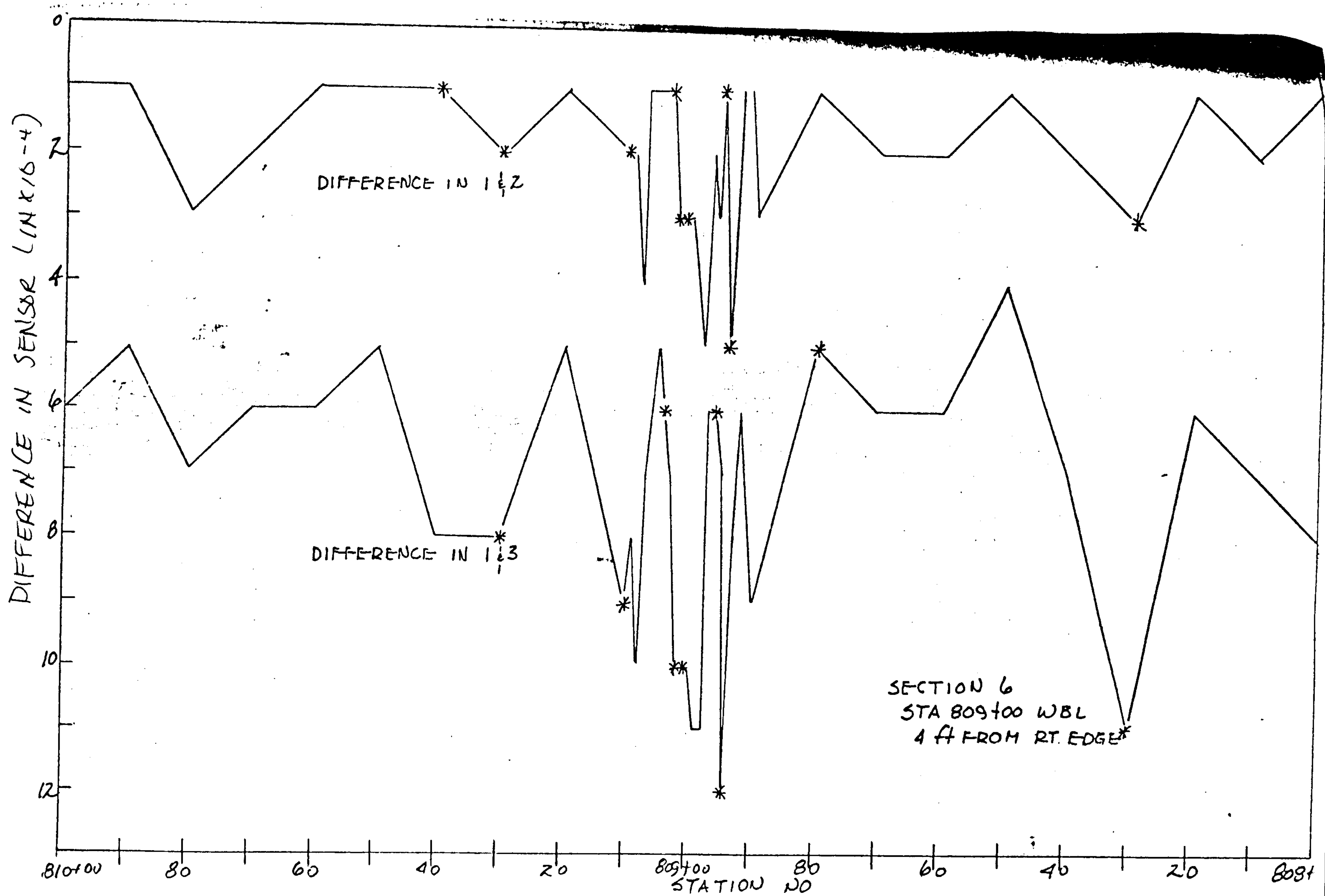

SENSOR 1 (IN x 10^-4)
3
4
5
6
810+00
80
60
40
20
809+00
80
60
40
20
808+00
STATION NO.
SECTION 6
809+00 WBL
4 ft FROM EDGE

FIGURE 3.6d



DIFFERENCE IN SENSOR (IN x10-4)
0
2
4
6
8
10
12
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 6
STA 809+00 WBL
4 ft FROM RT. EDGE
810+00
80
60
40
20
809+00
80
60
40
20
808+
STATION NO

FIGURE 3.6e

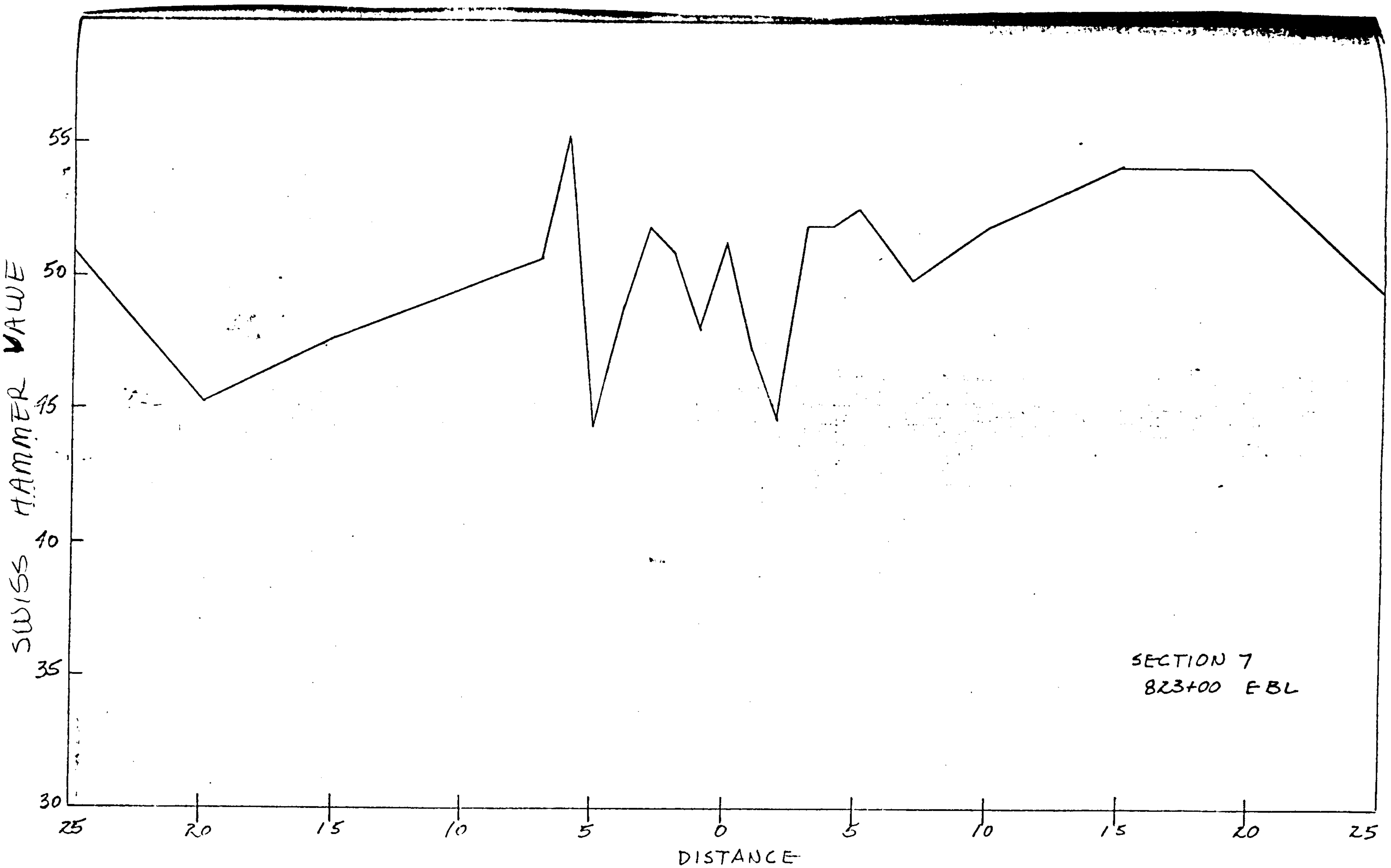

SWISS HAMMER VALUE
55
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20
25
DISTANCE
SECTION 7
823+00 EBL

FIGURE 3.7c

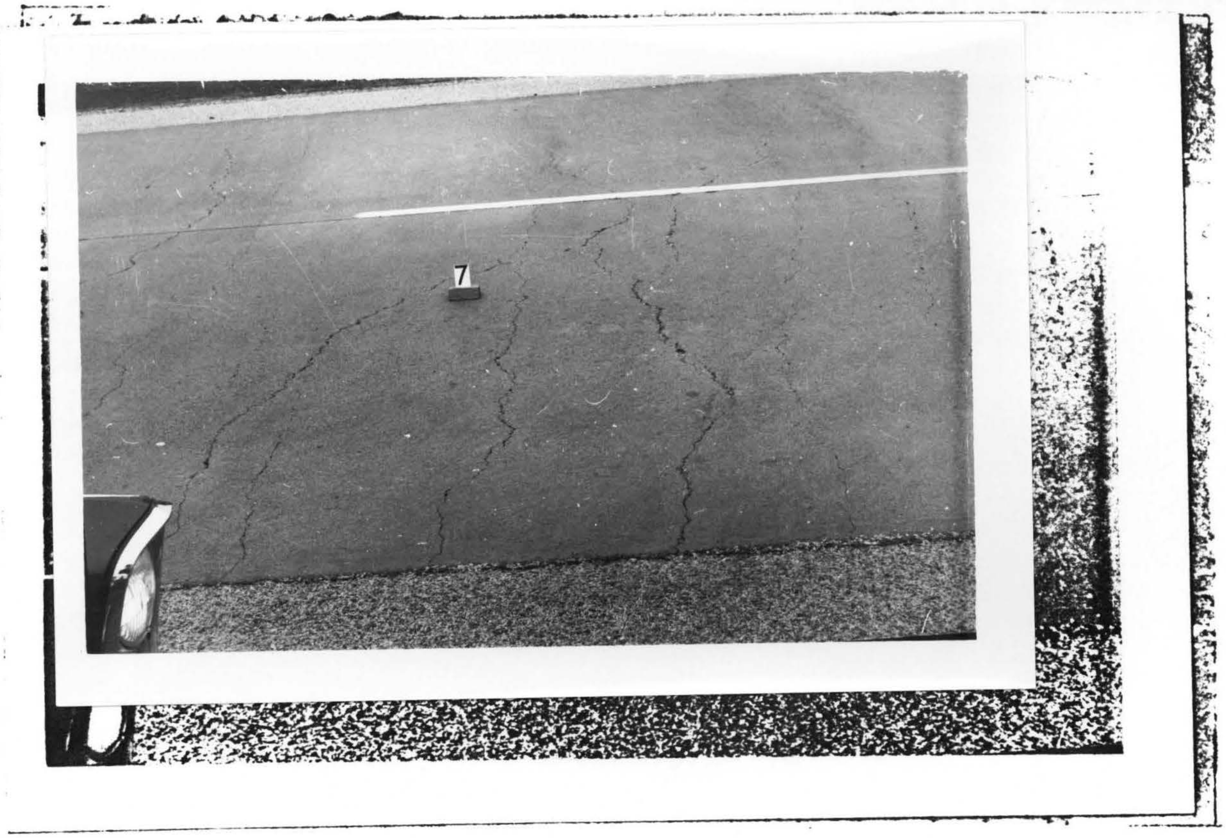


Figure 3.7a

General view of pavement at Section 7

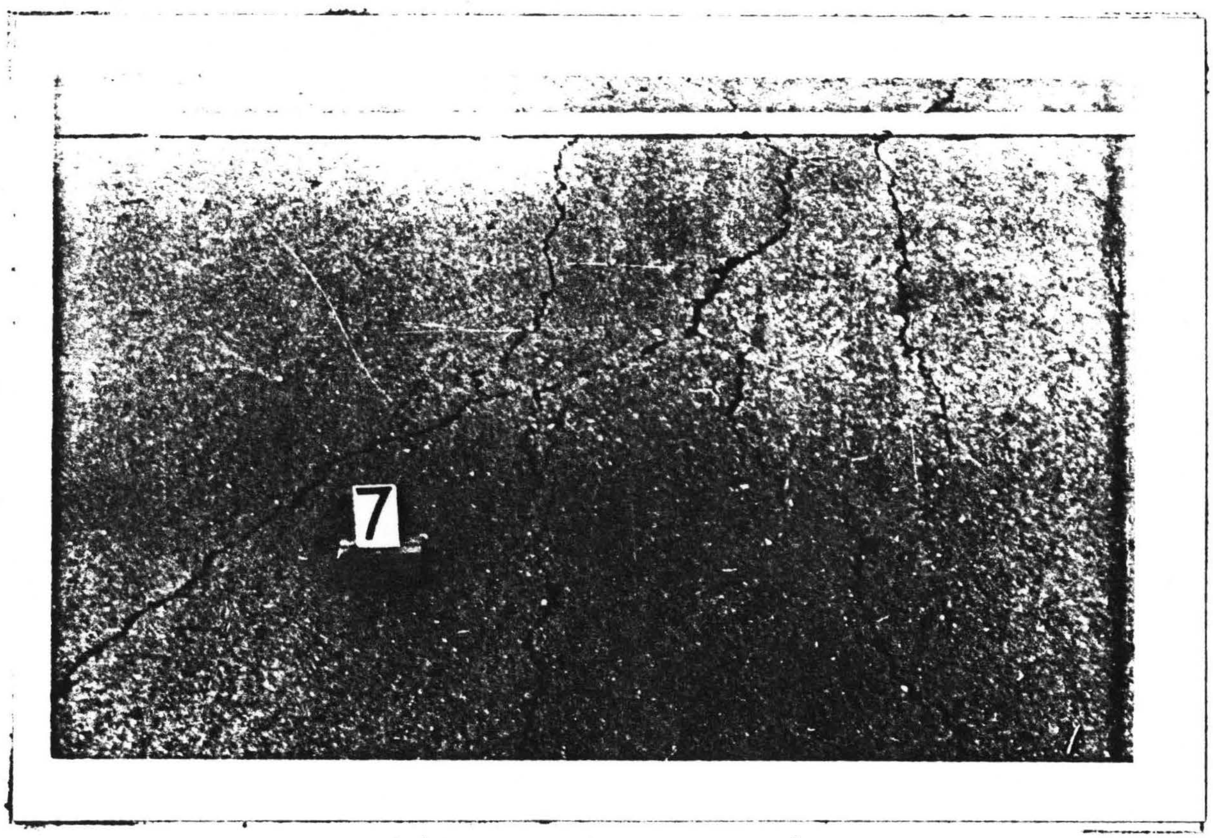
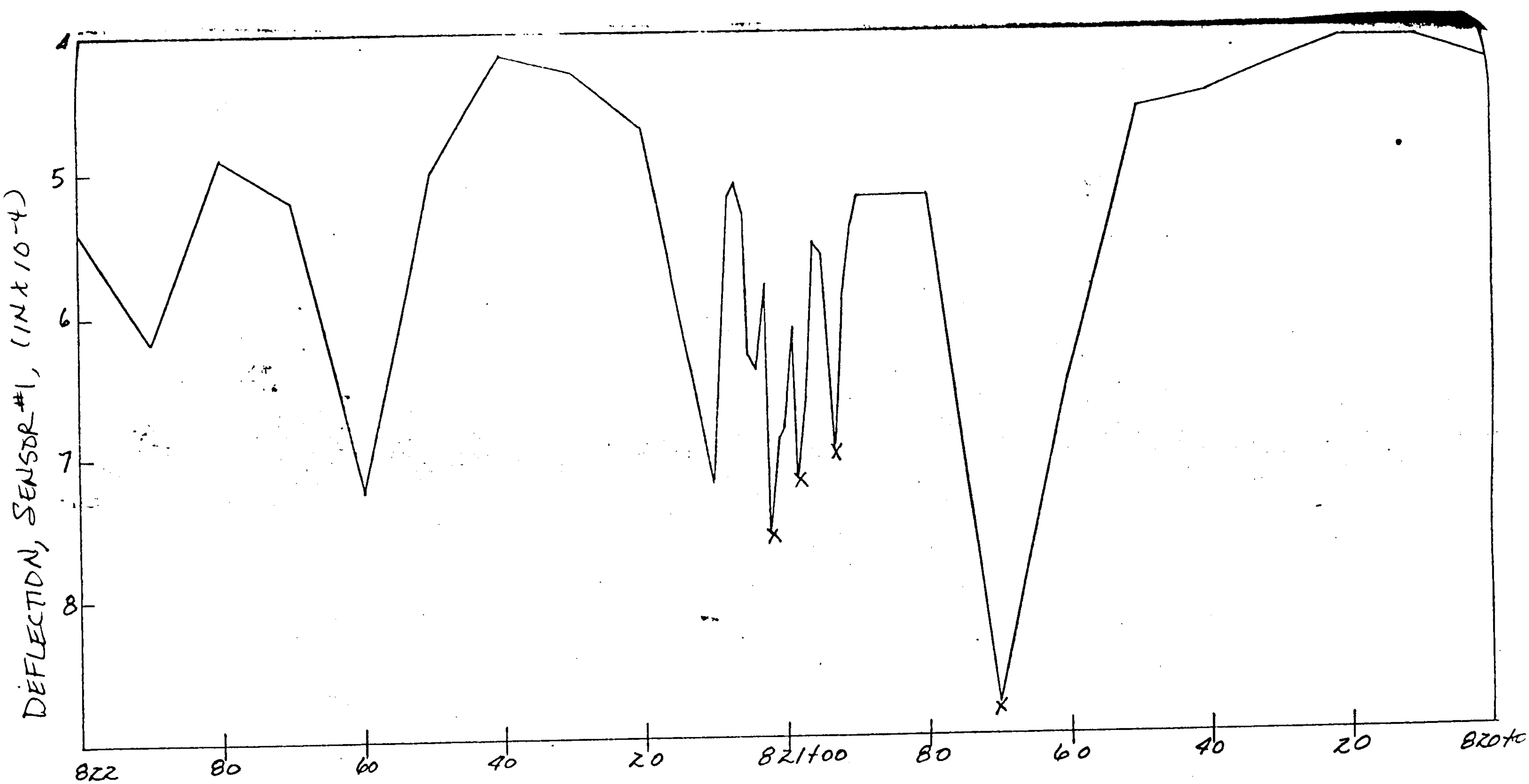


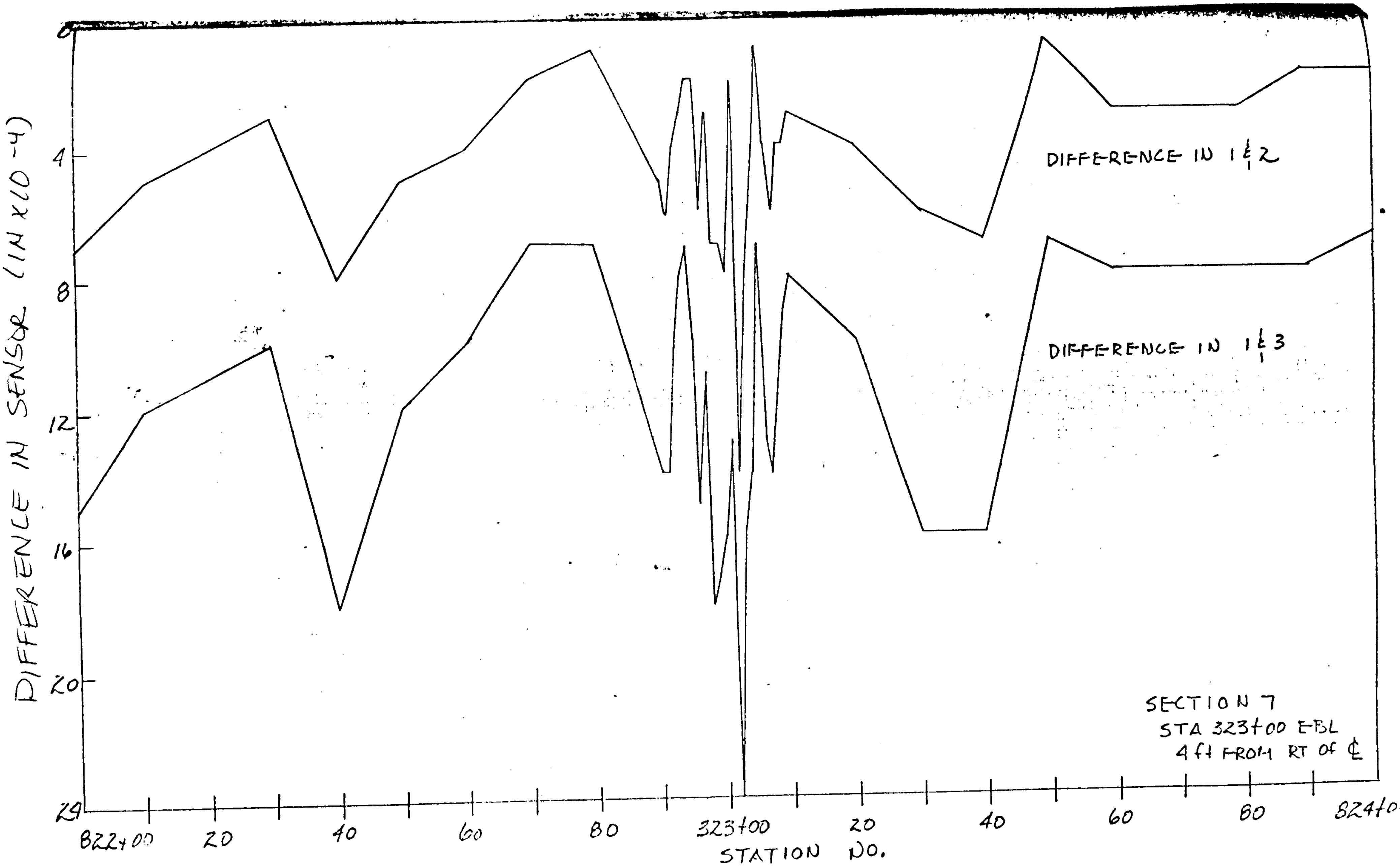
Figure 3.7b

Close-up view of cracking at Section 7



SECTION · 7
823+00 EBL
4 ft. FROM Rt EDGE

FIGURE 3.7 d



DIFFERENCE IN SENSOR (IN X10 -4)
0
4
8
12
16
20
24
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 7
STA 323+00 EBL
4 ft FROM RT OF ℄
822+00
20
40
60
80
323+00
20
40
60
80
824+00
STATION NO.

FIGURE 3.7e

s severely cracked section. Figure 3.8b reveals some of the ex-ssive spalling which has occurred.

The Swiss Hammer study definitely showed that the concrete s weak in the area of severe cracking. Figure 3.8c is a profile the Swiss Hammer value through the section. Deflection and fference in deflection profiles are shown in Figures 3.8d and 8e respectively. The variations in the failure area are not pecially larger than they are in the good areas. Coring opera-ons at Section 8 did show the concrete to be weak. The core om the failure area looked as if the batch quantities might have en in error or the quality of the cement may not have been real ood.

ection 9 (957 + 00 WBL)

Section 9 was initially classed as intermediately bad. Cracking s more than normal and spalling is taking place. Figures 3.9a and 3.9b show the cracks and the spalling.

The Swiss Hammer study indicated the presence of some weak concrete as is shown on the profile of Figure 3.9c. Deflections and differences in deflection were no greater in the failure area than other points along the slab as is shown in Figures 3.9d, 3.9e, and 3.9f. The core drilled in Section 9 did not look bad but it was not quite as smooth as the good core.

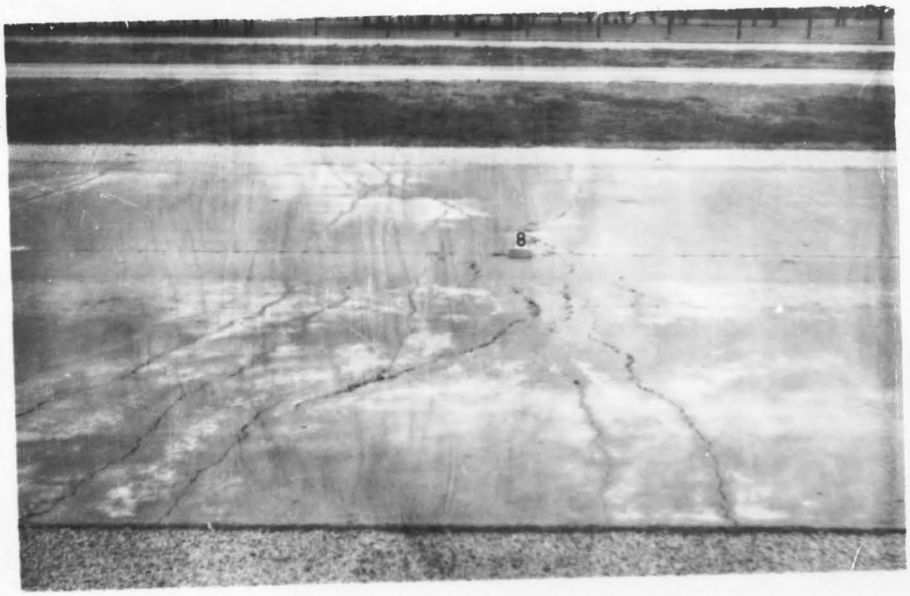


Figure 3.8a

General view of Section 8

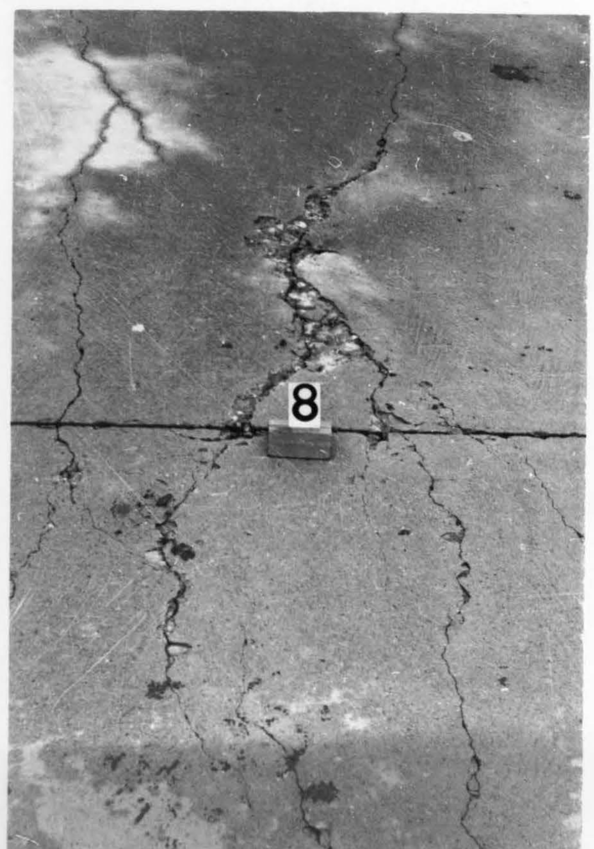
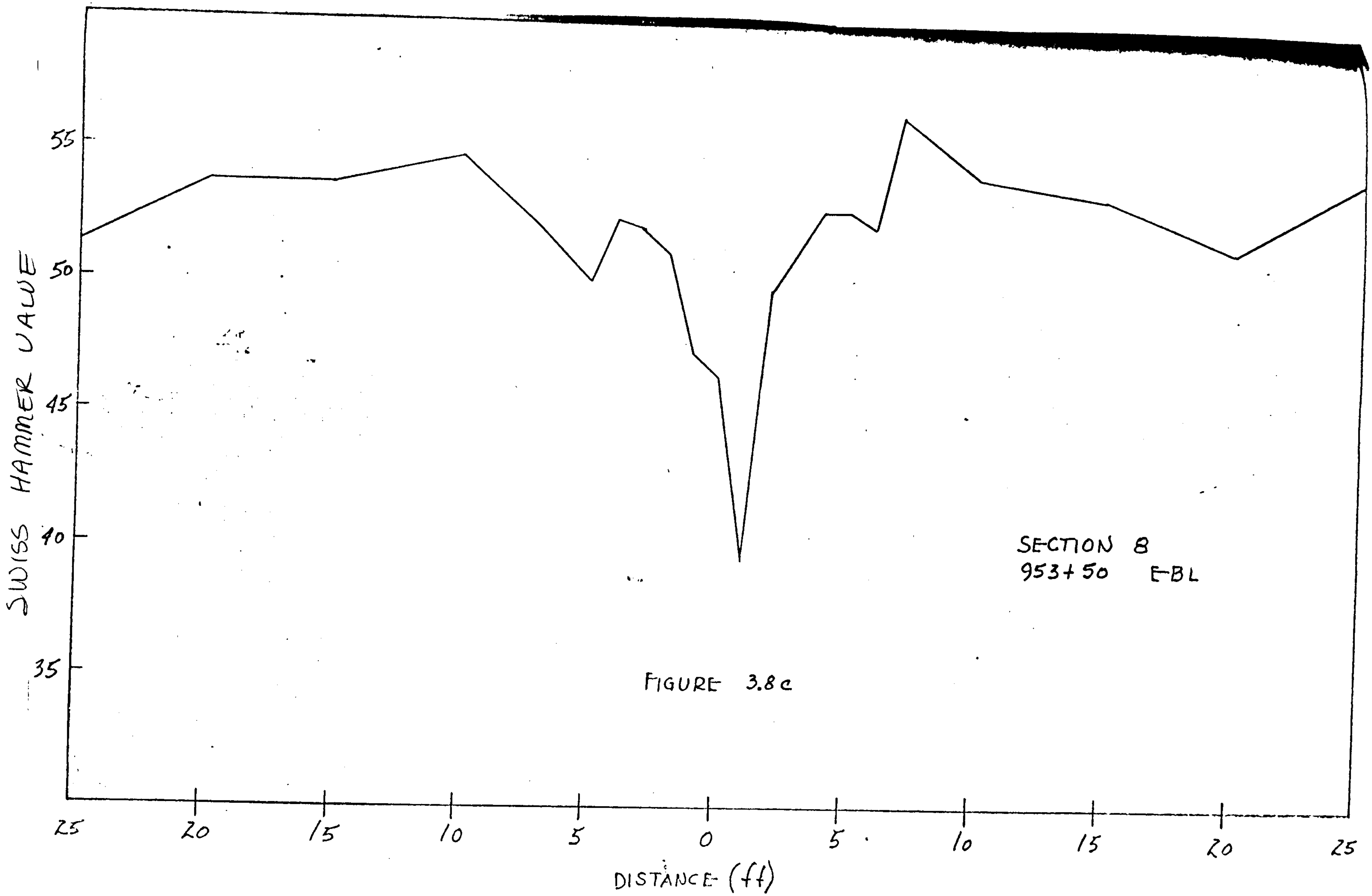


Figure 3.8b

Close-up of failure

at Section 8



SWISS HAMMER VALUE
55
50
45
40
35
SECTION 8
953+50 E-BL
25 20 15 10 5 0 5 10 15 20 25
DISTANCE (ft)

FIGURE 3.8c

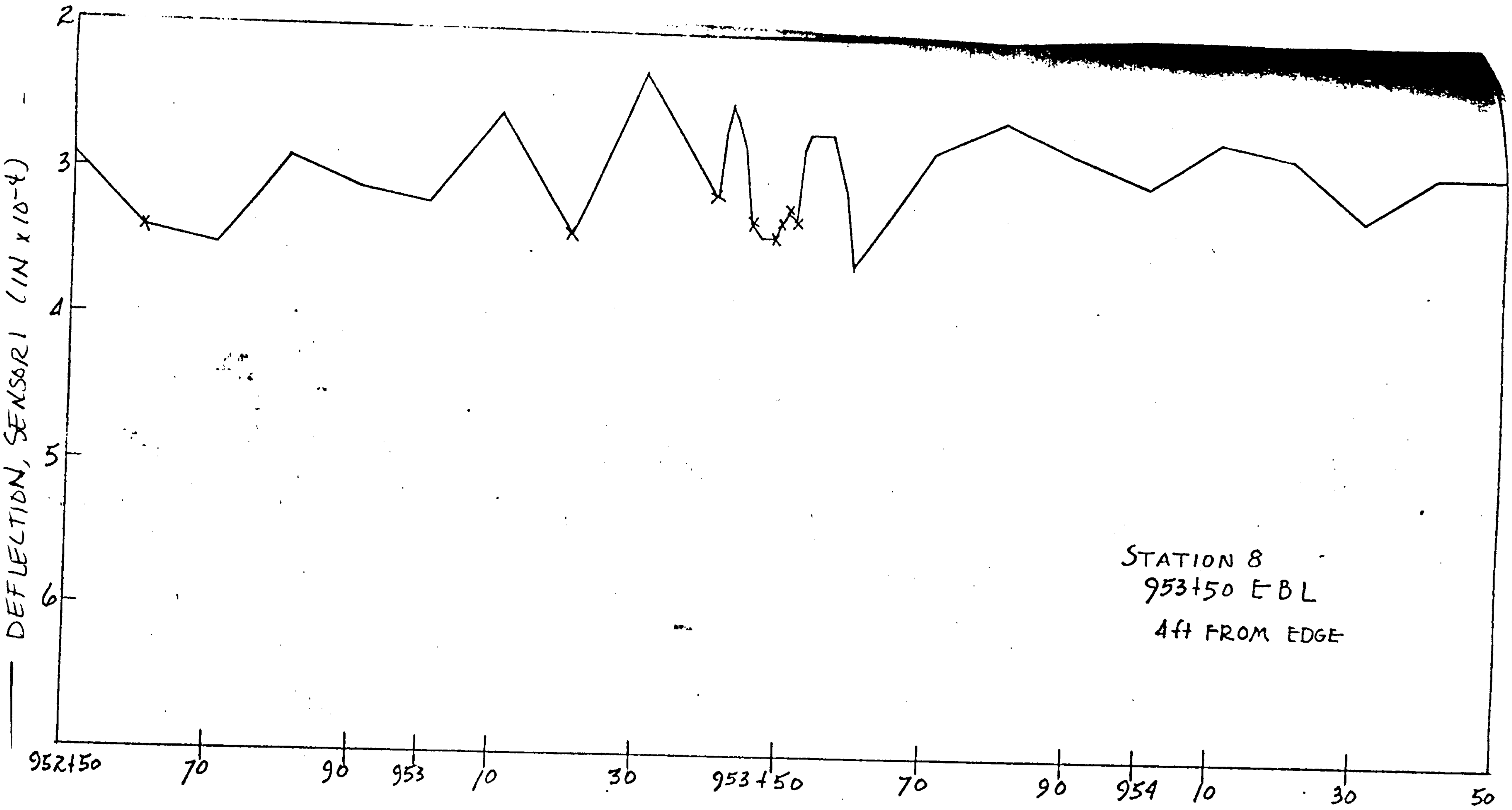

DEFLECTION, SENSOR1 (IN x 10^-4)
2
3
4
5
6
952+50
70
90
953
10
30
953+50
70
90
954
10
30
50
STATION 8
953+50 EBL
4ft FROM EDGE

Figure 3.8d

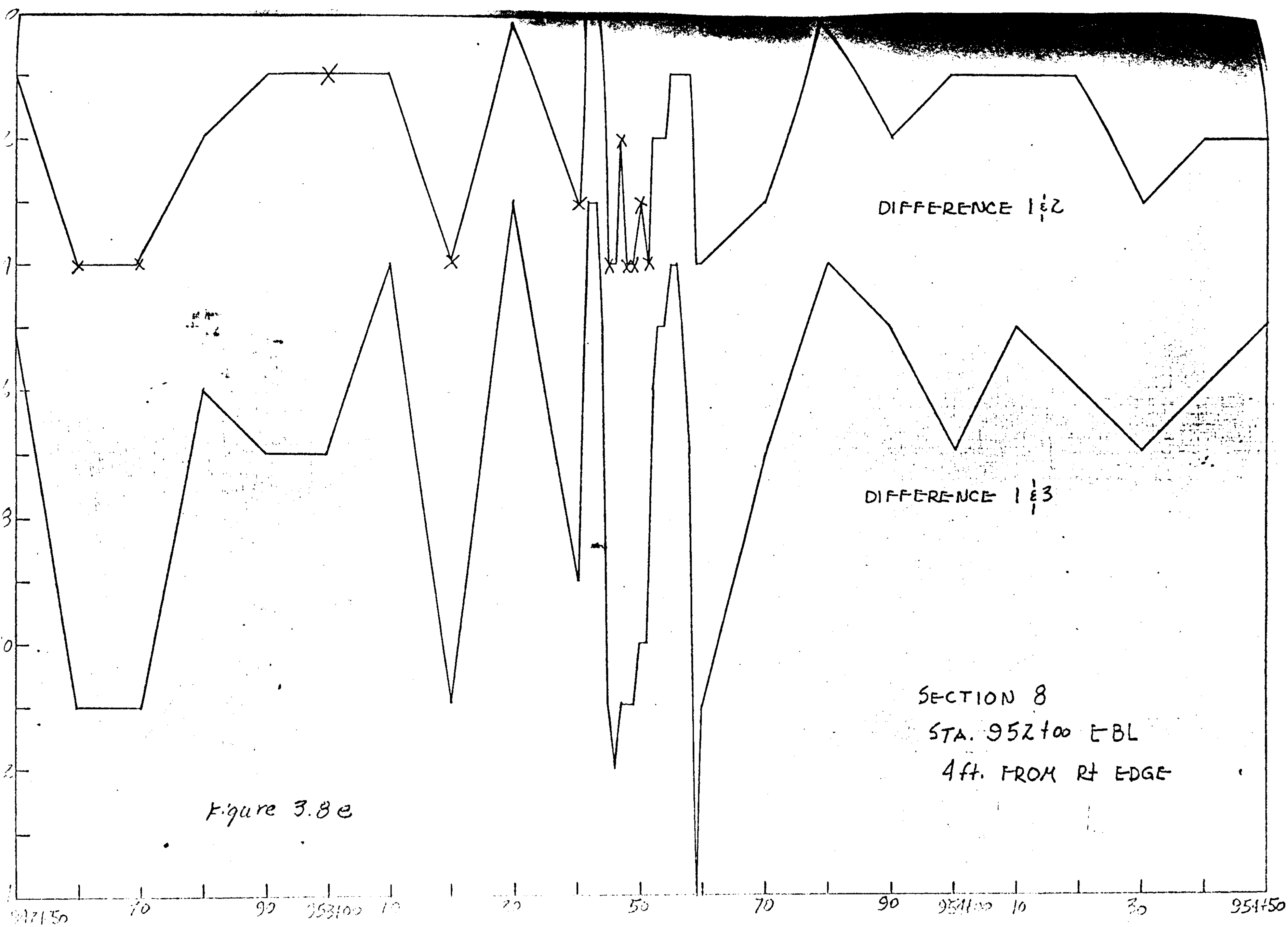

DIFFERENCE 1 & 2
DIFFERENCE 1 & 3
SECTION 8
STA. 952+00 EBL
4 ft. FROM Rt EDGE
951+50

Figure 3.8e

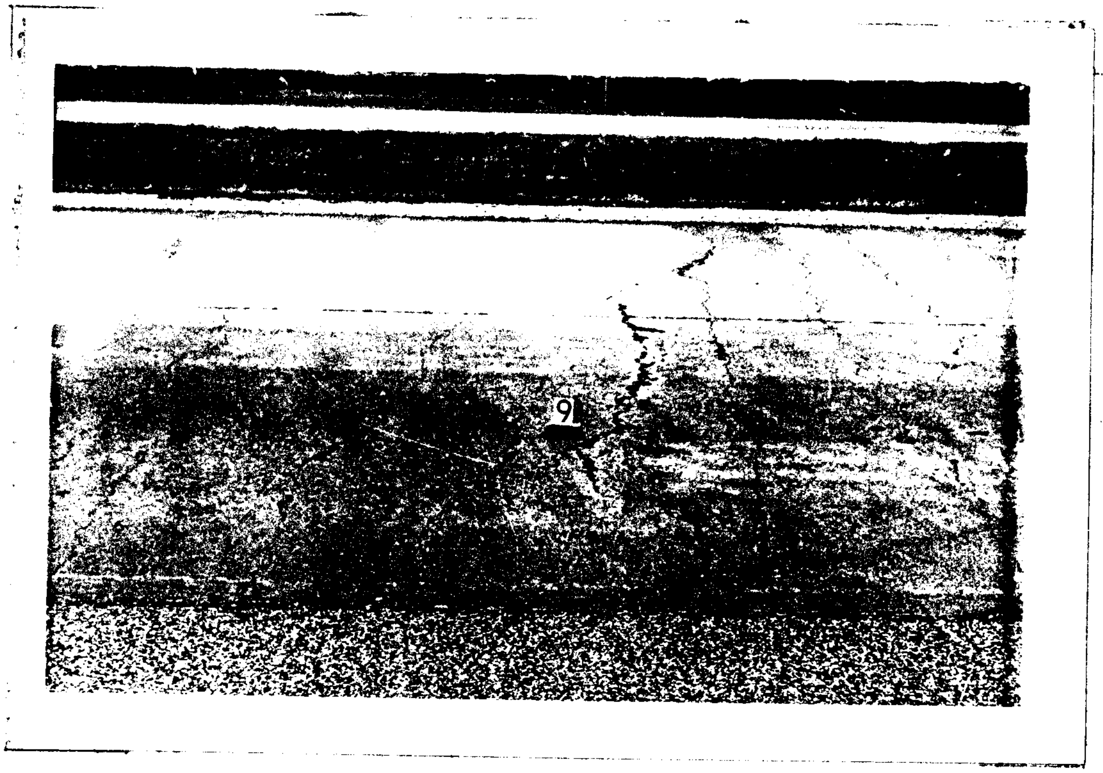


Figure 3.9a

General view of Section 9

Figure 3.9b

Close-up view of cracking on Section 9

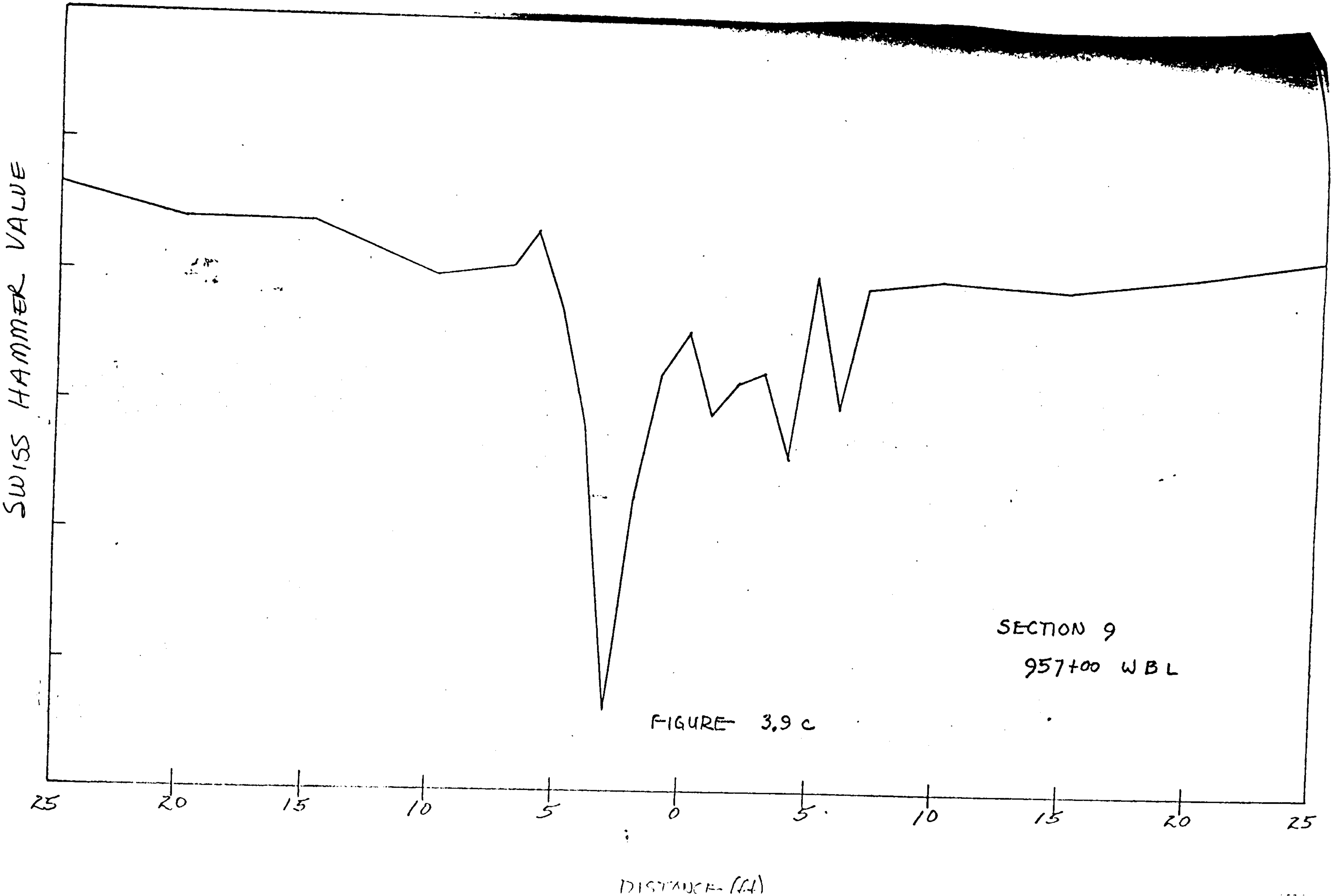
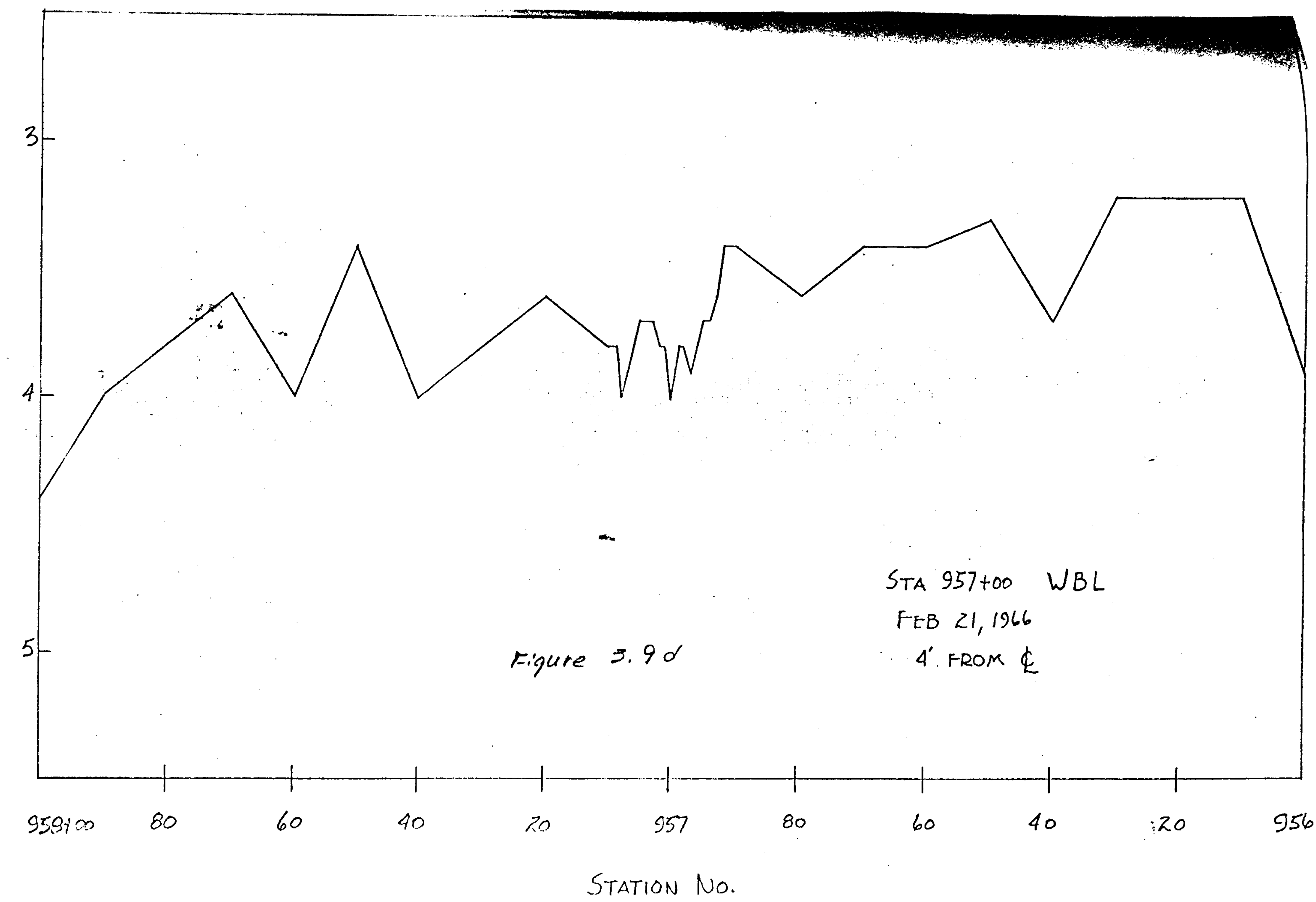
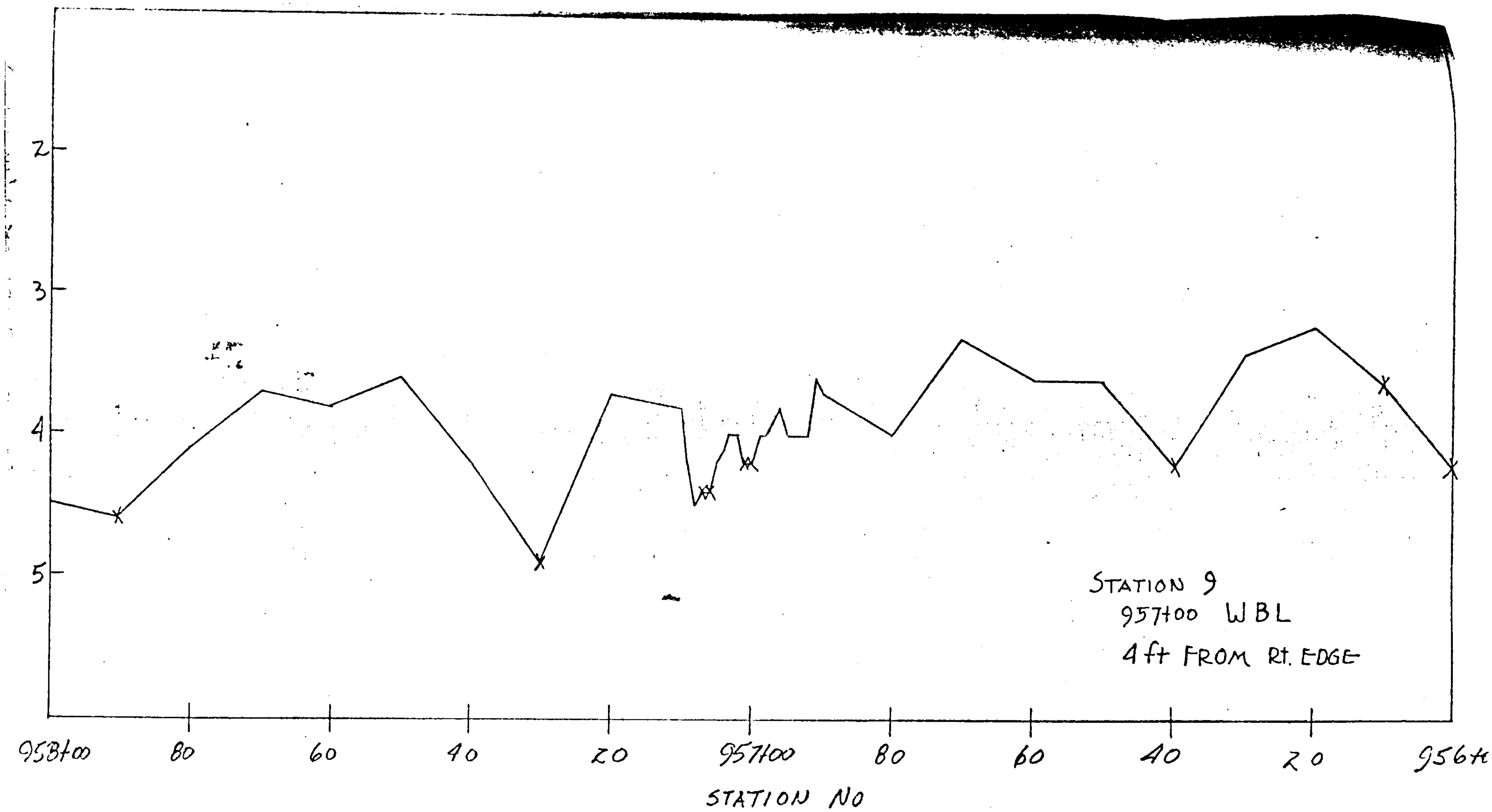

SWISS HAMMER VALUE
25
20
15
10
5
0
5
10
15
20
25
DISTANCE (ft)
SECTION 9
957+00 WBL

FIGURE 3.9 c



3
4
5
958+00
80
60
40
20
957
80
60
40
20
956
STATION NO.
STA 957+00 WBL
FEB 21, 1966
4' FROM ℄

Figure 3.9d



2
3
4
5
958+00
80
60
40
20
957+00
80
60
40
20
956+
STATION No
STATION 9
957+00 WBL
4 ft FROM Rt. EDGE

FIGURE 3.9e

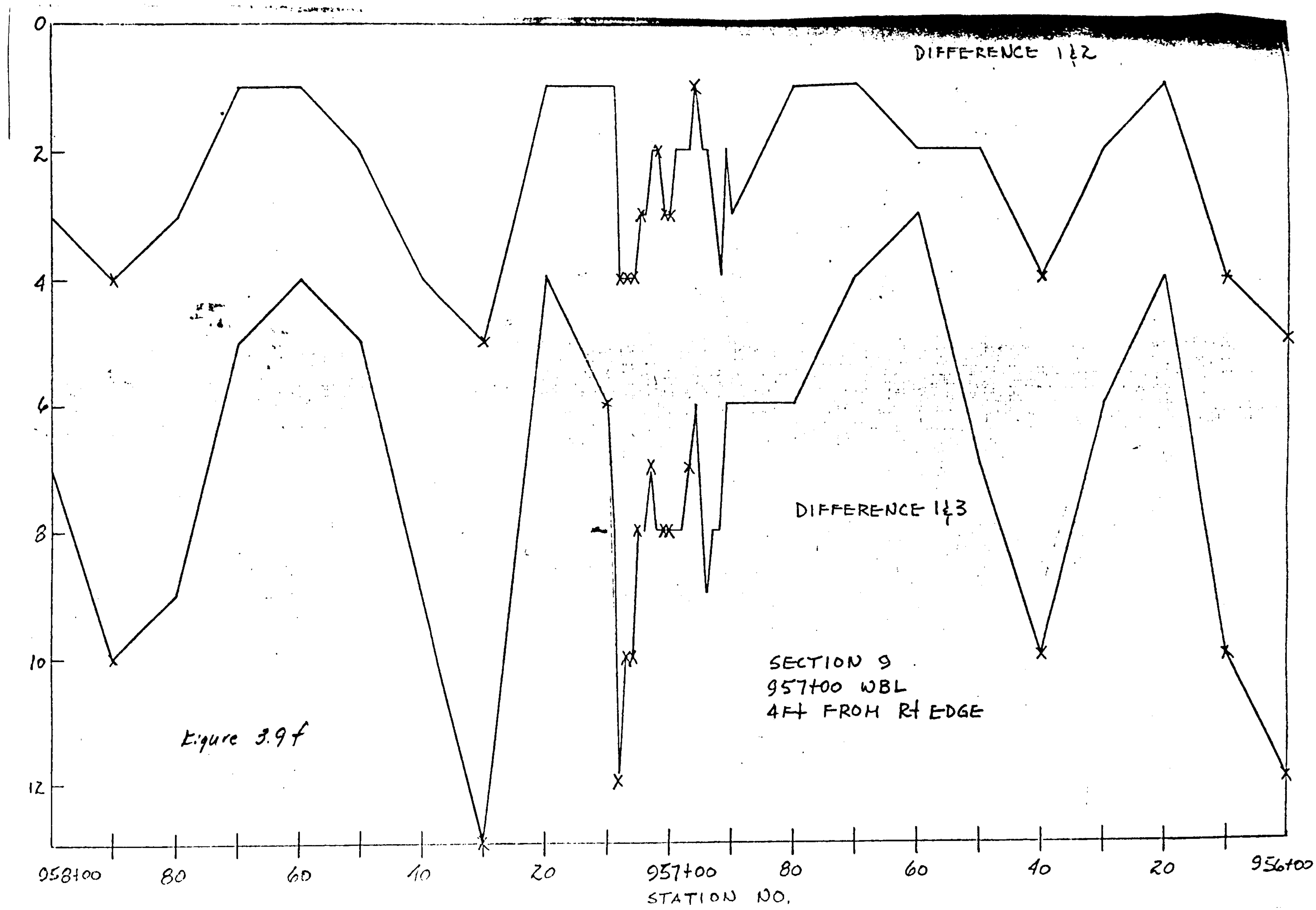

DIFFERENCE 1&2
DIFFERENCE 1&3
SECTION 9
957+00 WBL
4Ft FROM Rt EDGE
0
2
4
6
8
10
12
958+00
80
60
40
20
957+00
80
60
40
20
956+00
STATION NO.

Figure 3.9f

Section 10 (971 + 00 EBL)

The general pavement condition at failure section 10 is shown in Figures 3.10a and 3.10b. The concrete is cracked quite severely.

The Swiss Hammer profile in Figure 3.10c shows that there was some concrete with low strength. Both deflection and difference in deflection show the failure area in Figures 3.10d and 3.10e respectively. The core drilled in the failure area had a rough texture indicating that the intended design was probably not attained. Figure 3.10f shows the core from the failure area and the one from a good section.

Section 11 (1040 + 00 WBL)

A general view of failure area 11 is shown in Figure 3.11a. A closer view in Figure 3.11b shows the longitudinal cracking very clearly. This section was initially classified as intermediately bad.

The Swiss Hammer Value Profile in Figure 3.11c shows that the concrete which is severely cracked was weaker than the good concrete.

Deflection and difference in deflection did not show the the failure area very distinctly because of the large point to point variations which were as large as those in the failure area as shown in Figures 3.11d and 3.11e respectively.

The core drilling operations revealed that the concrete was questionable and not as design had intended. Figure 3.11f compares a core from a good section to the failure section. The bad core

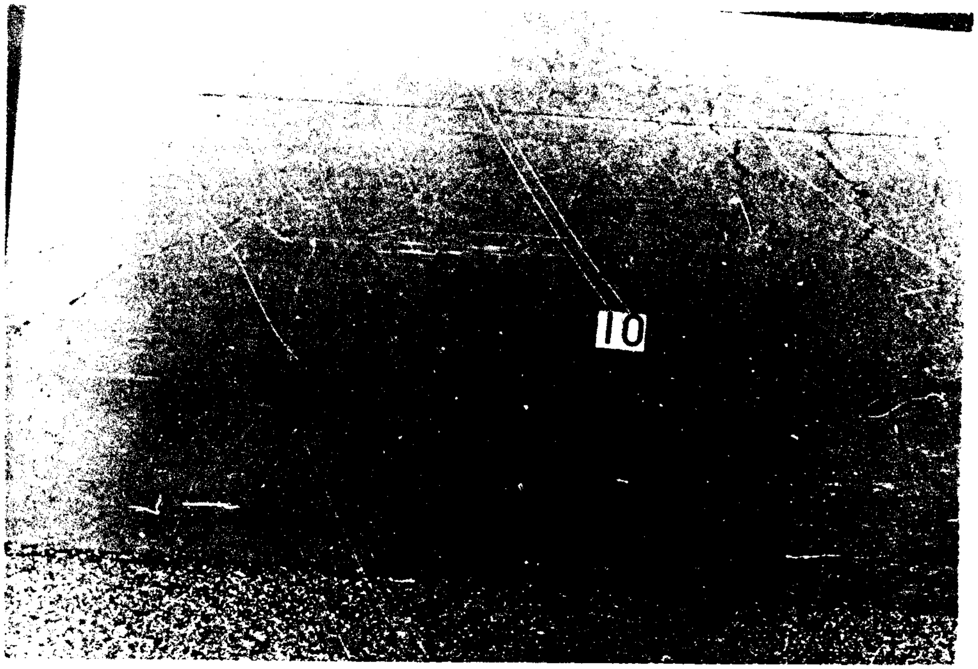


Figure 3.10a

General view of Section 10

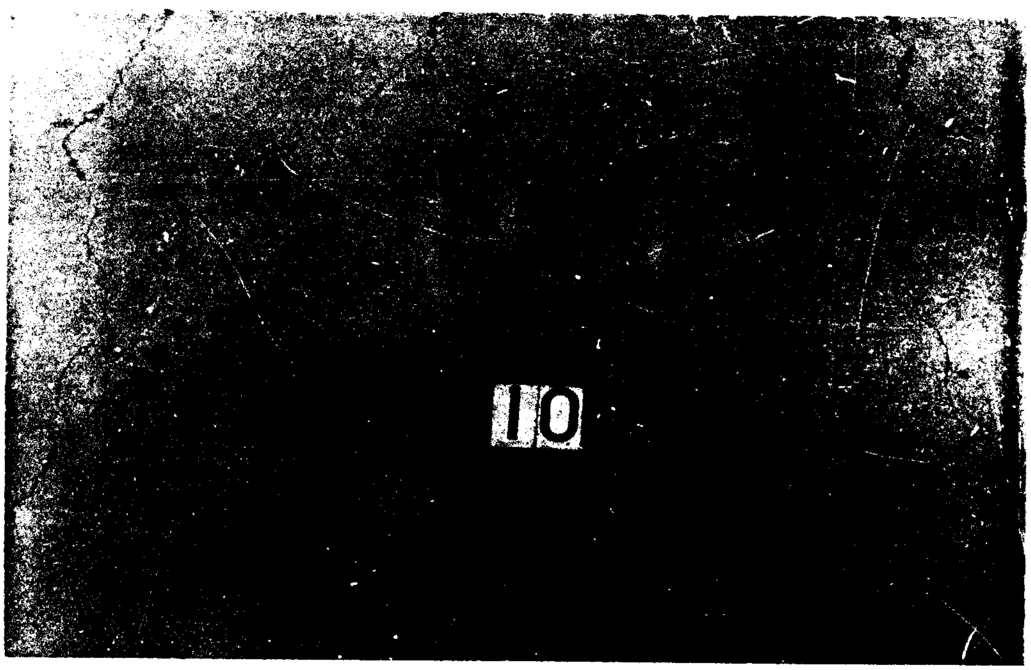


Figure 3.10b

Close-up view of cracking on Section 10

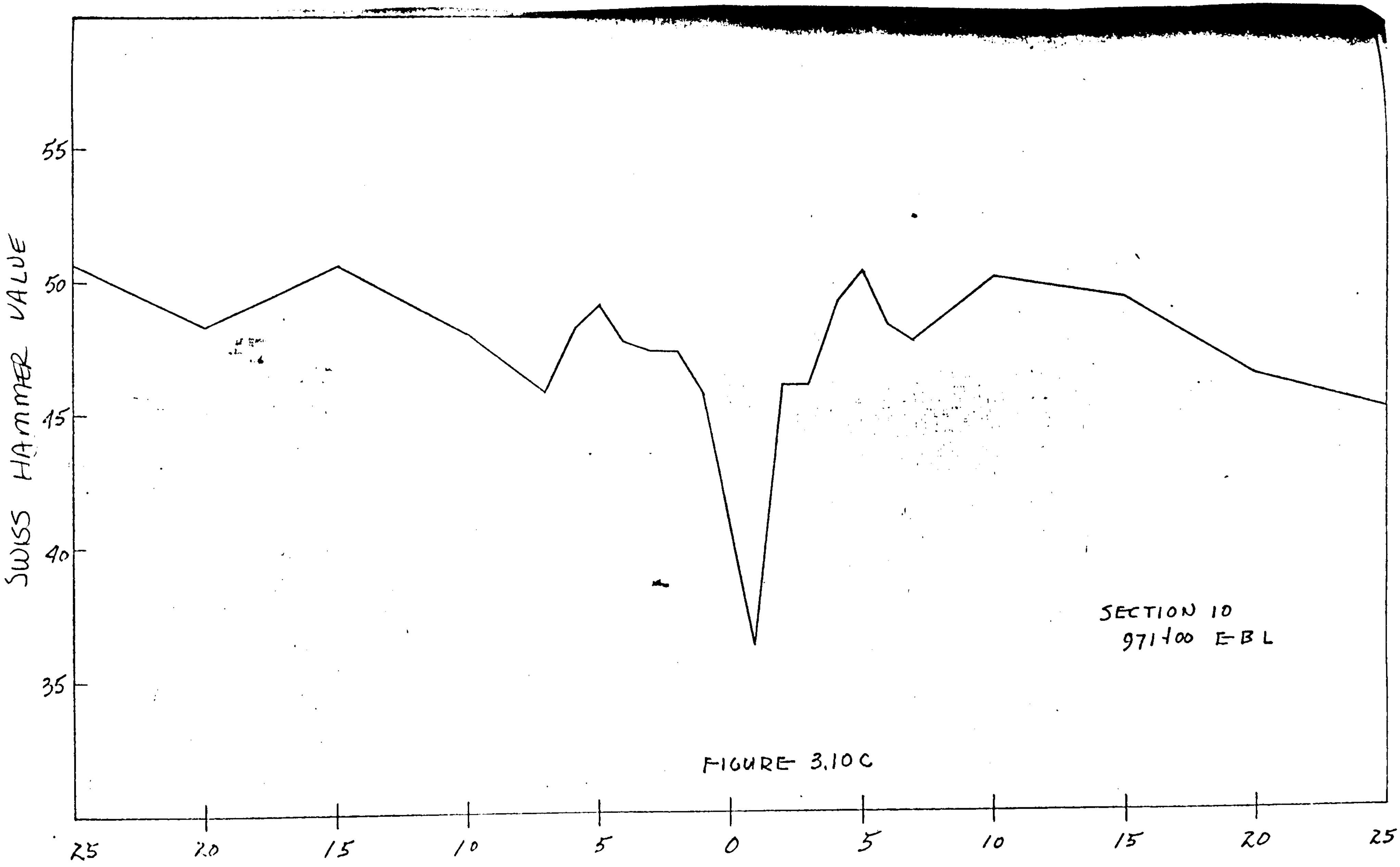

SWISS HAMMER VALUE
55
50
45
40
35
25
20
15
10
5
0
5
10
15
20
25
SECTION 10
971+00 E-B L

FIGURE 3.10C

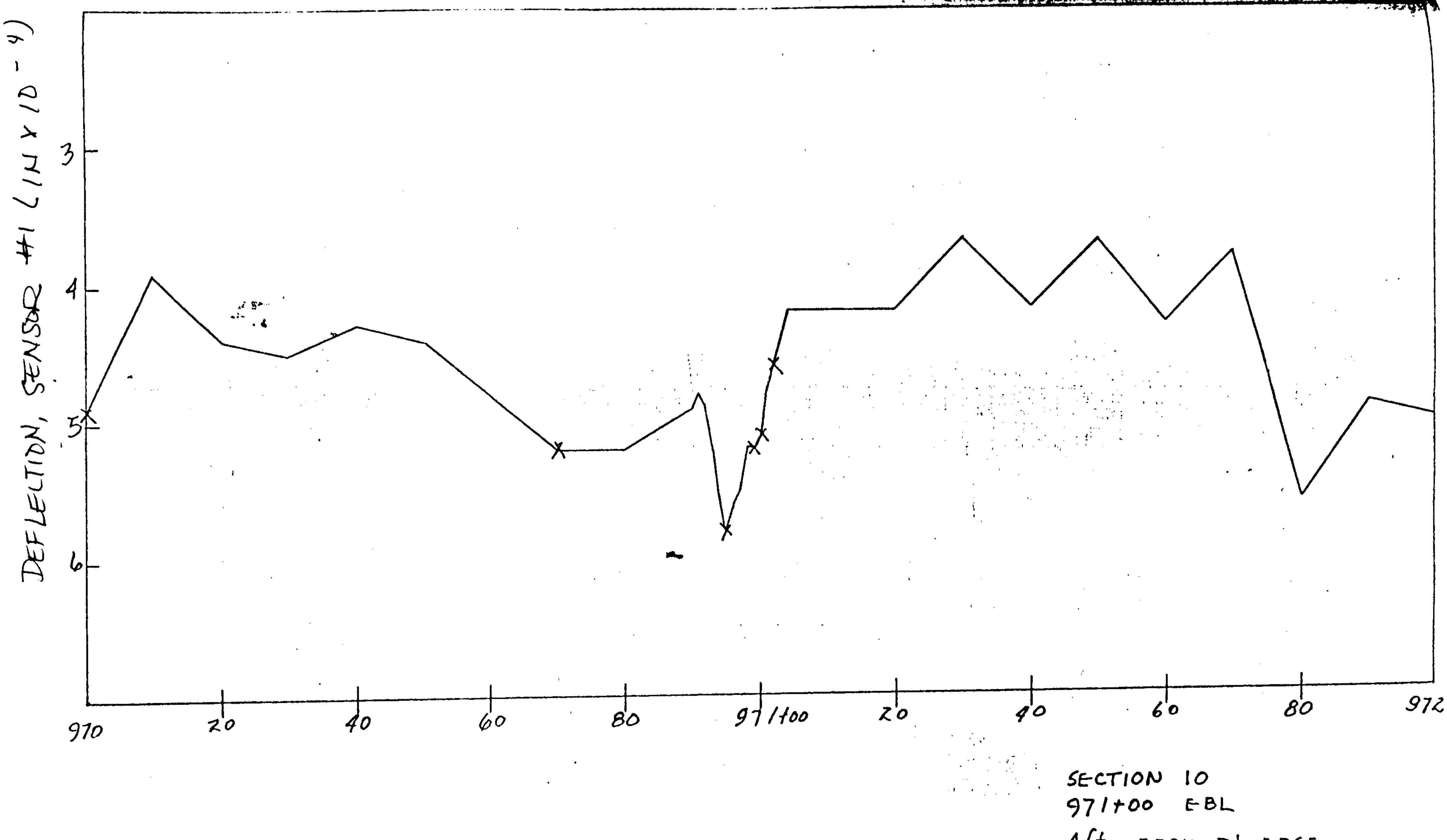
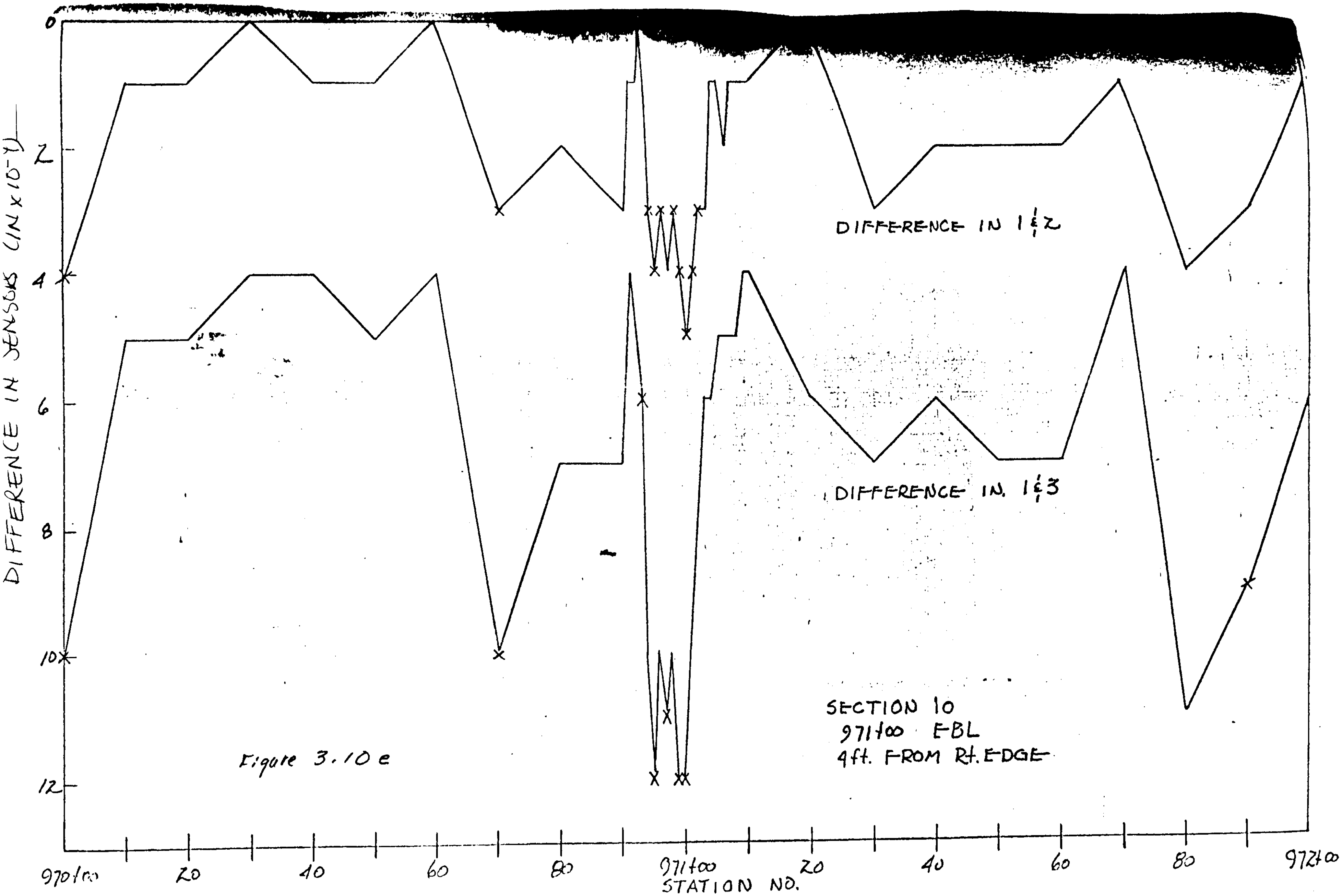

DEFLECTION, SENSOR #1 (IN x 10 - 4)
3
4
5
6
970
20
40
60
80
971+00
20
40
60
80
972+
SECTION 10
971+00 EBL
4ft FROM Rt EDGE

Figure 3.10d



DIFFERENCE IN SENSORS (IN x 10^-4)
0
2
4
6
8
10
12
970+00
20
40
60
80
971+00
20
40
60
80
972+00
STATION NO.
DIFFERENCE IN 1 & 2
DIFFERENCE IN 1 & 3
SECTION 10
971+00 EBL
4ft. FROM Rt. EDGE

Figure 3.10e

Figure 3.10f

Comparison of cores from good and bad areas on Section 10

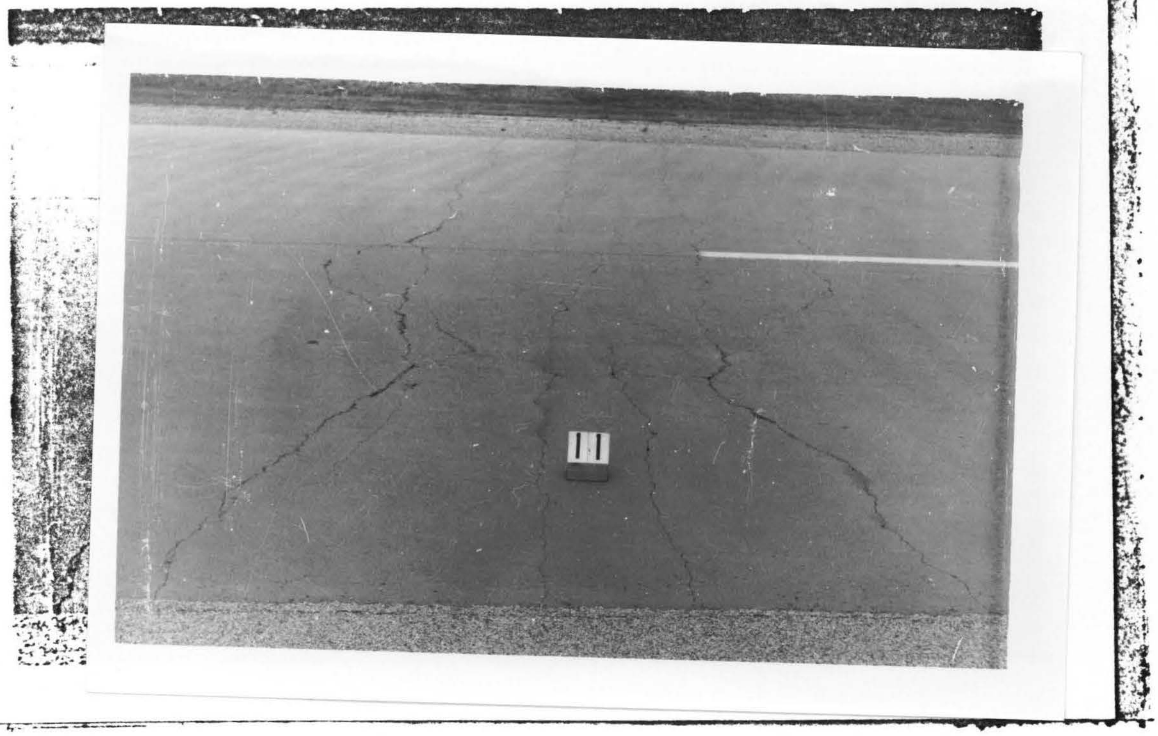


Figure 3.11a

General view of failure area on Section 11

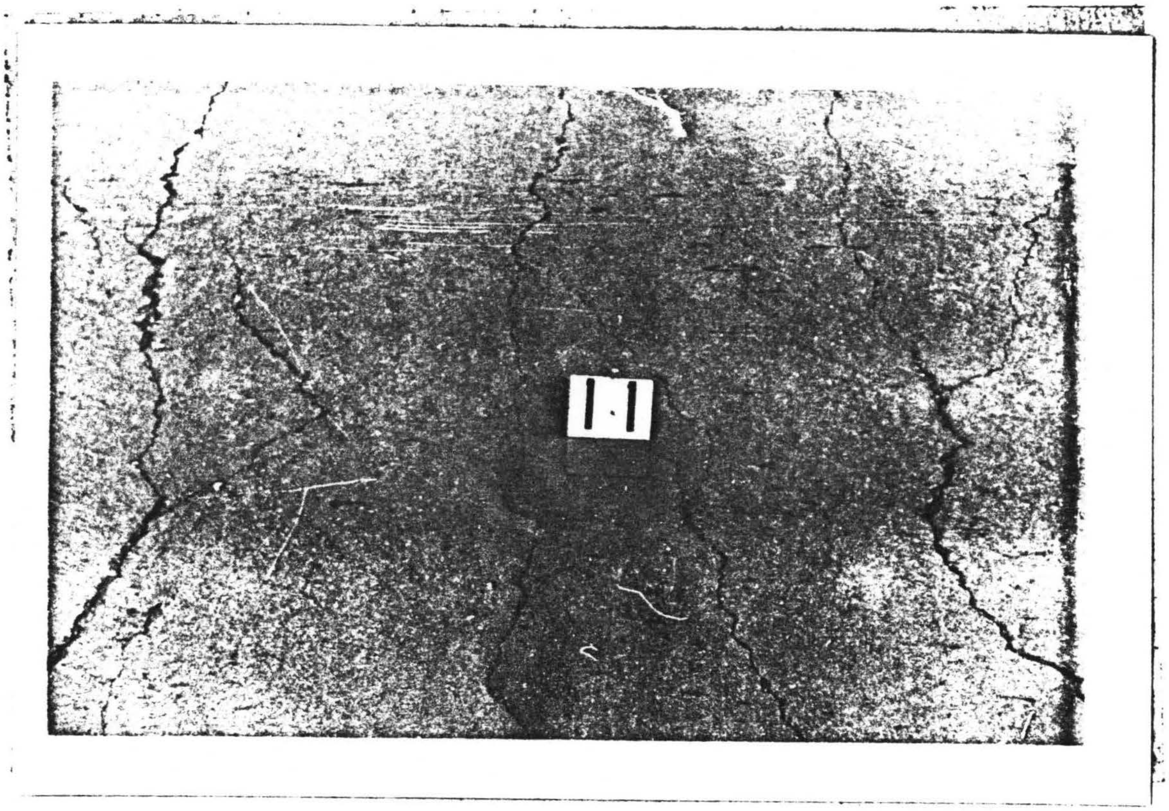
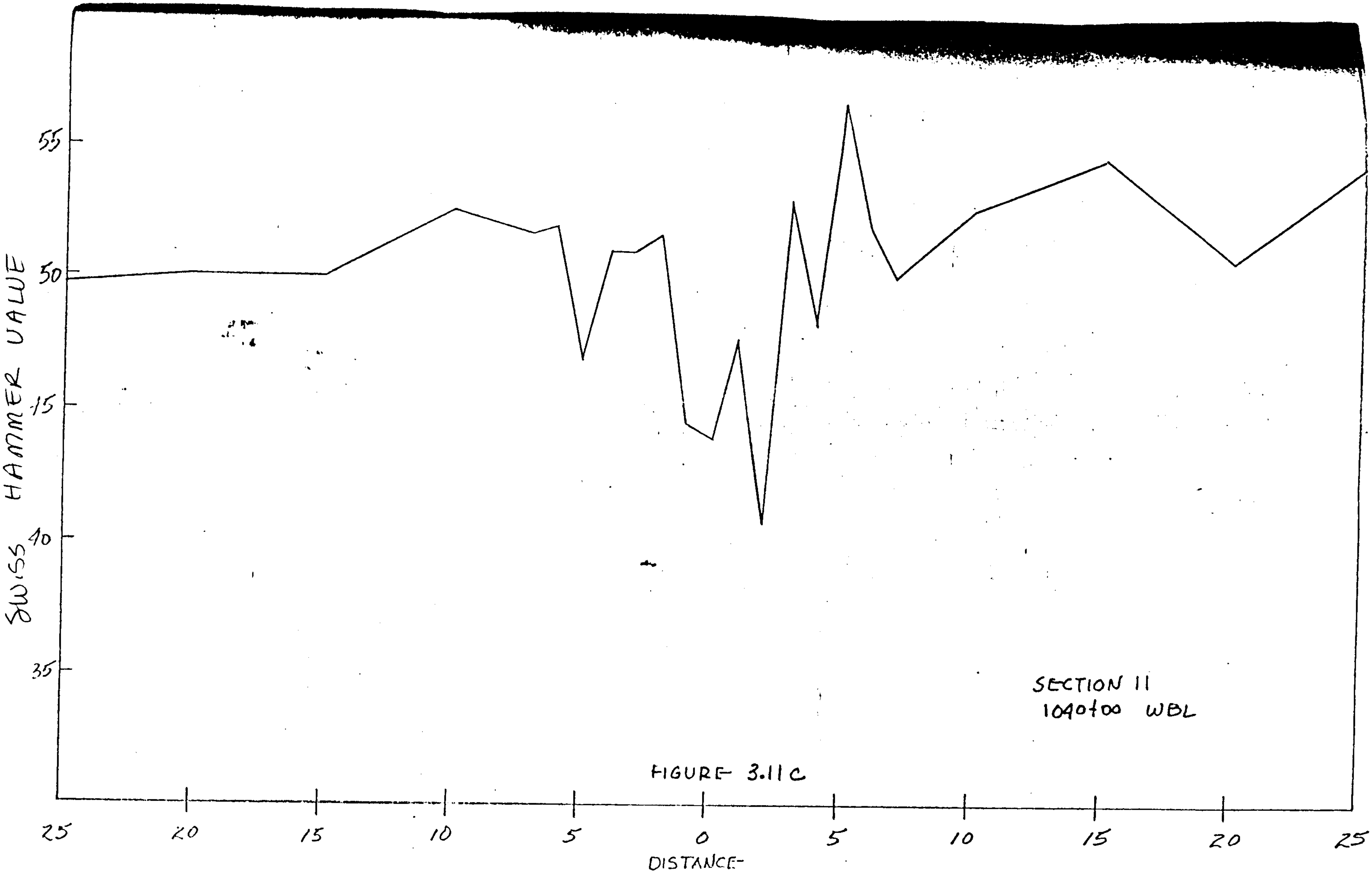


Figure 3.11b

Close-up view of severe cracking on Section 11



SWISS HAMMER VALUE
55
50
45
40
35
25
20
15
10
5
0
5
10
15
20
25
DISTANCE
SECTION 11
1040+00 WBL

FIGURE 3.11C

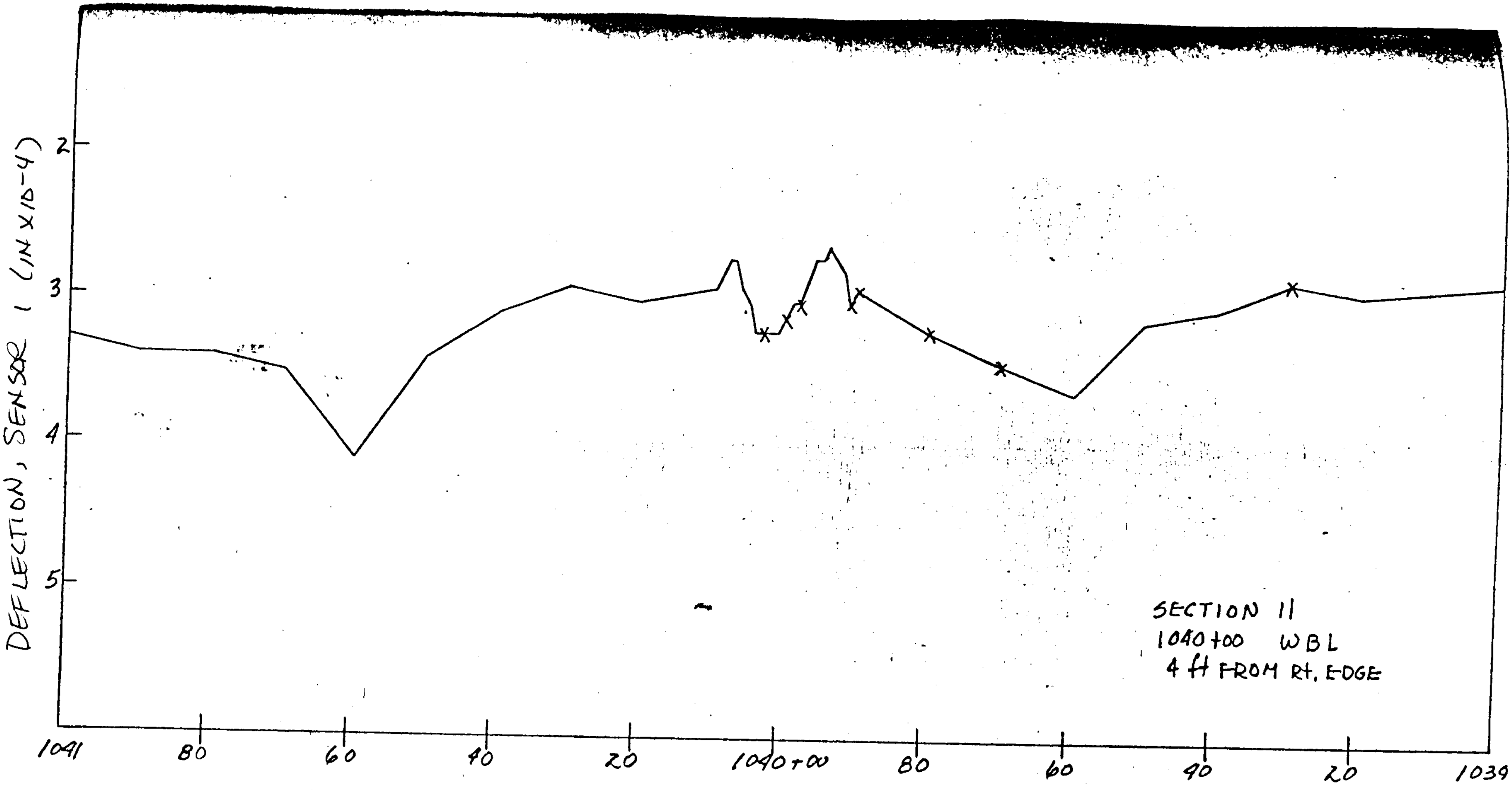

DEFLECTION, SENSOR 1 (IN X10-4)
2
3
4
5
1041
80
60
40
20
1040+00
80
60
40
20
1039
SECTION 11
1040+00 WBL
4 ft FROM Rt. EDGE

Figure 3.11 d

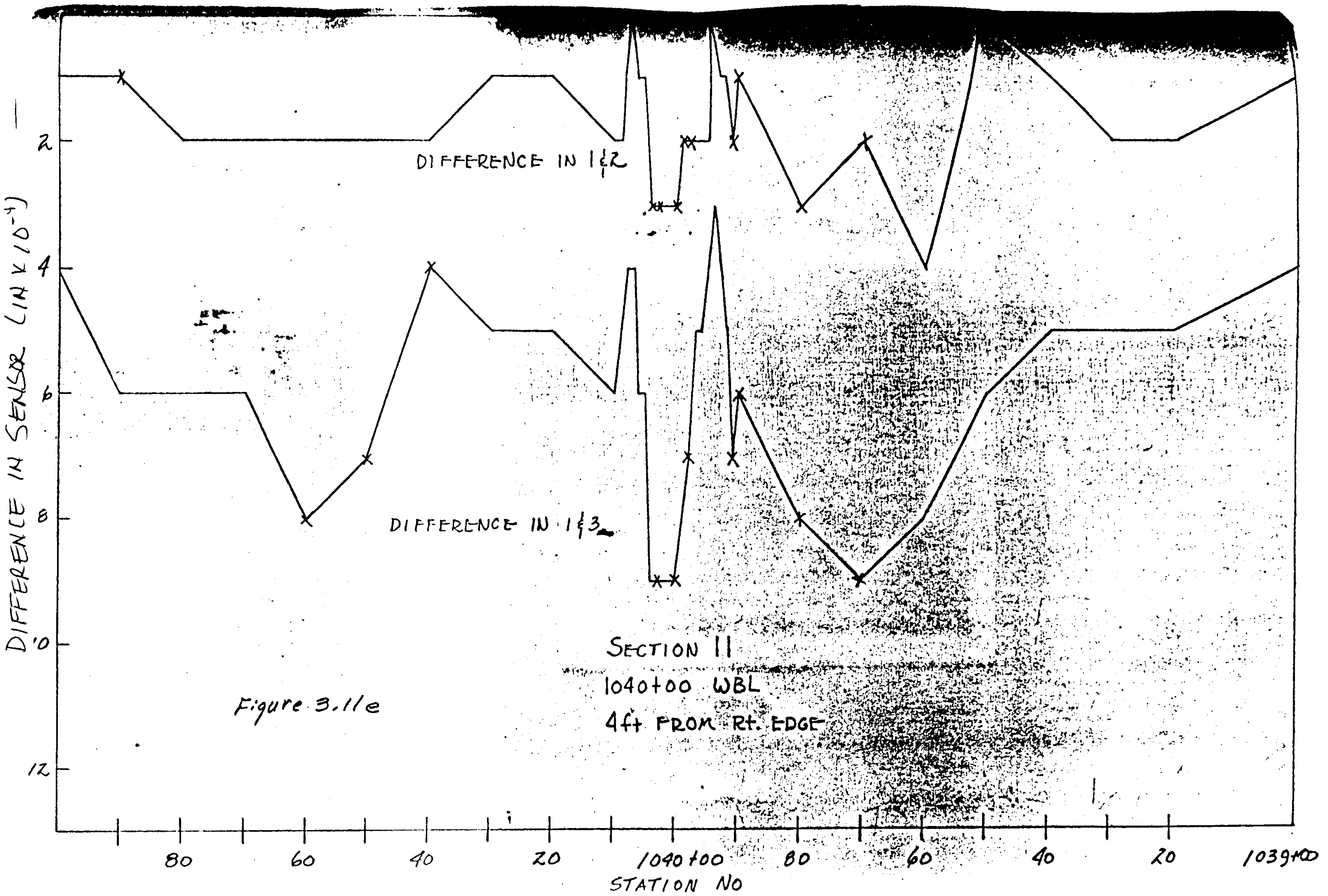

DIFFERENCE IN SENSOR (IN x 10^-4)
2
4
6
8
10
12
DIFFERENCE IN 1&2
DIFFERENCE IN 1&3
SECTION 11
1040+00 WBL
4ft FROM Rt. EDGE
80
60
40
20
1040+00
80
60
40
20
1039+00
STATION NO

Figure 3.11e

Figure 3.11f

Comparison of cores from good and failure areas in Section 11 is rough and the mortar has been washed out during the drilling operations. In this case again there may have been an error in batching somewhere along the line.

IV. SUMMARY AND CONCLUSIONS

On the Columbus bypass portion of IH 10 eleven irregular areas of the concrete pavement that exhibited the same general characteristics of excessive cracking and spalling in some cases were investigated to determine the possible cause or causes. The eleven pavement sections studied fell into various degrees of severity, ranging from several sections which are quite bad to those that are not critical and are only superficial problems. Two pieces of equipment were used to determine if a relative difference could be ascertained between the good and failure portions of the pavements. This equipment was the Lane Wells Dynaflect and a concrete impact hammer. As a follow up operation, all pavement sections were cored to ascertain the characteristics of the concrete.

The results of the investigation indicate that the problem or irregularities may be attributed to the concrete within the slab and no evidence could be found that deflections or support conditions were related to the failure. Basically, the failures or the problem areas may be attributed to poor or inferior concrete. Naturally, the first factor to attribute the inferior concrete to would be a breakdown in the batching operations. This breakdown may range from spilage during loading or unloading to oversanding. In line with problems experienced with bridges in other areas of the state it may be hypothesized that an adverse chemical reaction may have occurred between the air entraining admixture and the cement. Although the air content was well within specifications, observations of the pavement indicate that the air bubbles were rather large and not a wide dispersement of infinitesimal small bubbles as expected with air entrained concrete.

None of the equipment used in this analysis could be used as a construction inspection tool in its present form. The impact hammer is too slow and requires considerable detail in operation. The dynaflect has definite possibilities when using it as a radius of curvature meter, but a small computer would have to be added along with a recorder to provide an analog trace. It is recommended that this latter feature be thoroughly investigated if we obtain this equipment on another project.

Of the eleven areas investigated, repairs should be made in the near future on two of these. These being at stations 1030 + 00 WBL and 973 + 50 WBL. Although there are certain degrees of irregularity in the other sections they have not shown distress to a point where any concern should be expressed as to repairs.