1984 PES ANNUAL REPORT

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

1984 PES ANNUAL REPORT

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projected 18-k ESAL for 10-mile sections of IH 10, IH 20, IH 35, and IH 45. These profiles identify both local and regional trends in pavement and traffic condition which are useful in assessing highway-level needs.

The Interstate pavement condition profiles suggest that, in urban areas, ride quality decreases despite a similar decrease in surface distress. High traffic volumes usually overshadow the reduction in surface distress, resulting in a much lower pavement score. This trend was confirmed by a study of pavement condition (i.e. ride quality, UVU, and pavement score) versus traffic (ADT and 18-k ESAL). In this study, ride quality was highest on sections with ADT of 2,001 to 25,000 (or 20-year projected 18-k ESAL of 2,001,000 to 25,000,000 repetitions). UVU peak values and pavement score minimum values occur with ADT volumes in excess of 25,000. Much of this trend can be attributed to the increased use of concrete in high-traffic areas since concrete does normally produce a lower ride quality, even with less surface distress. Increased maintenance and rehabilitation activity on these high-priority highways is also a factor.

The pavement condition profiles identify regional trends which can only be obtained from a survey of all sections. A total survey is also the most reliable method available for selecting rehabilitation projects. Comparison of mandatory and total evaluations for District 11 indicates some of the risk involved in extrapolating District needs from a partial sample. Although the PES mandatory section survey is adequate for network-level assessments of relative District needs, reliable project-level analysis requires a continuous record of pavement condition.

This report also discusses current efforts aimed at eliminating current PES limitations and thus improving the utility and reliability of PES data. These efforts are:

1. Video Equipment -- For use in collecting visual evaluation data in urban areas. Ultimate objective is to collect, analyze, and transmit visual and ride data for all pavement sections automatically.

2. Structural Adequacy -- Develop a structural adequacy index which considers the effects of sub-surface condition on remaining service life.

3. Maintenance and Rehabilitation Project Selection -- Develop a method which will select projects for maintenance or rehabilitation based upon current and projected performance, District costs, and District work practices.

4. New JCP Survey -- Develop a quicker and simpler survey procedure for JCP sections to be used during 1985 PES survey.

EXECUTIVE SUMMARY

District personnel evaluated 16,214 mainlane sections and 2,458 frontage road sections during the 1984 PES survey. The survey included all Interstate system mileage, half of the US and SH system mileage, and 20 percent of the FM system mileage. Rigid pavement sections (1,004 mainlane sections of continuously reinforced concrete and 460 mainlane sections of jointed concrete) were included in the survey for the first time. The 1984 PES survey covered 27,498 centerline miles, or approximately 39 percent of the total state-maintained centerline mileage. Data collection began in September, 1984, and was completed in April, 1985.

Analysis of the mainlane sections indicates a 3 percent statewide increase in average ride quality. Flexible pavements have the highest average ride quality, followed by CRC sections, and then JCP sections. Surface distress (as measured by unadjusted visual utility, or "UVU") has increased by about five percent, as has the relative priority (as measured by pavement score). Surface distress is highest on JCP sections and lowest on CRC sections, while pavement score is highest on flexible sections and lowest on JCP sections. Traffic load (as measured by ADT and 18-k ESAL) increased 66 percent from 1983 to 1984, primarily due to the inclusion of high-traffic concrete sections in the survey.

Three flexible pavement distresses -- rutting, longitudinal cracking, and transverse cracking -- were more common during the 1984 survey. Rutting "problems" are restricted to the eastern half of the state (i.e. the 16 Districts on or east of IH 35), while longitudinal and transverse cracking "problems" are most often observed around the perimeter of the state. Patching and block cracking were evaluated for the first time during the 1984 survey, with patching being the more prevalent distress type. Two distress types -- alligator cracking and failures -- have actually been reduced from 1983 levels.

Of the rigid pavement distress types, punchouts and asphalt patches are unusually high on CRC sections. Slabs with longitudinal cracks, corner breaks and punchouts, and asphalt patches are unusually common on JCP sections.

Frequency distributions for ride quality, UVU, and pavement score indicate that sections tend to be grouped towards the higher levels, especially for flexible and CRC sections. JCP sections, however, are more uniformly distributed across all levels of condition. In fact, pavement scores for JCP sections tend to be grouped towards the lower levels.

Inclusion of rigid pavement sections enabled a special analysis of the Interstate system which documents the overall high-quality of the system. The major cross-state routes (IH 10, IH 20, IH 35, and IH 45) display high ride quality and UVU values. High traffic volumes, though, reduce the average pavement score and suggest the need for localized maintenance. Continuous pavement condition profiles depict the average ride quality, UVU, pavement score, 2-way ADT, and 20-year

Executive Summary continues on page ii in the physical copy.

CHAPTER 1

INTRODUCTION

Outlines the objectives of this report and provides a brief overview of the Pavement Evaluation System.

OBJECTIVES

This report summarizes the results of the 1984 PES pavement condition survey which began in September, 1984. It was prepared to meet the following objectives:

1. Describe the condition of the entire state-maintained highway system. (Chapters 2, 4, 5, and 6)

2. Describe the general condition of highways in each District. (Chapter 2)

3. Provide a basis for comparing the condition of highways in one District with those in other Districts, or with the statewide average. (Chapter 3)

4. Examine the condition of pavements in high-volume (ADT) and high-truck traffic (18-k ESAL) areas. (Chapter 7)

5. Describe the condition of each Interstate highway in Texas. (Chapter 6)

6. Illustrate the use of continuous pavement condition profiles to identify condition and traffic trends along the highway. (Chapters 6 and 9)

7. Compare the results of a partial survey (mandatory sections only) with the results of a total survey (all mileage). (Chapter 8)

8. Identify current limitations and future improvements to PES. (Chapter 10)

OVERVIEW OF PES

The Pavement Evaluation System (PES) was established in September, 1982, as a first step in the development of a statewide Pavement Management System (PMS). PES was intended to provide District, Division, and Administration personnel with quantifiable measures of pavement condition to be used in assessing relative maintenance and rehabilitation needs.

1984 PES SURVEY

The 1984 PES survey began on September 1, 1984, and was completed on April 15, 1985. Specially-trained District raters evaluated and stored data on 18,672 sections covering nearly 40 percent of the state-maintained centerline mileage. Tables 1.1 and 1.2 summarize the amount of centerline mileage rated by District and by highway system, respectively.

PES rated sections were selected at random prior to the start of the survey, according to the following criteria:

* IH System -- All sections.
* US System -- 15 percent of sections rated in 1983 PLUS all sections not rated in 1983.
* SH System -- 15 percent of sections rated in 1983 PLUS all sections not rated in 1983.
* FM System -- 15 percent of sections rated in 1983 PLUS 20 percent of all other sections.
* PR System -- Evaluated at District's discretion.

PES contains many descriptors of pavement condition. This report is primarily concerned with three of these descriptors: ride quality, unadjusted visual utility, and pavement score.

Ride Quality (or PSI) measures the overall roughness of the pavement surface using the Mays Ride Meter. PSI readings are recorded at 0.2-mile increments during the PES survey. Ride quality values range from 0.1 (extremely rough) to 5.0 (very smooth).

Unadjusted Visual Utility (or UVU) measures only the amount of distress on the pavement surface. As a result, UVU provides a basic measure of relative surface condition. UVU values range from 1 (maximum distress) to 100 (no distress).

Pavement Score (or PS) is a composite index which describes the relative priority of one pavement section as compared to all others. Pavement score adjusts the UVU values to account for the effects of environment (county freeze-thaw cycles and rainfall), traffic (ADT and 18-k ESAL repetitions), ride quality (PSI), and functional class (relative importance of the section to the overall highway network). In its present form, however, pavement score is not a perfectly reliable means of prioritizing projects since several important factors are not yet considered. Pavement score values range from 1 (most urgent need) to 100 (no need).

Of these three descriptors, pavement score is the most frequently cited measure of pavement condition. In its present form, however, pavement score is not a perfectly reliatble means of prioritizing projects, since several important factors are not yet considered in the PS formula. These factors include structural adequacy of pavement layers, historical trends in pavement condition (which may identify "good" sections which will rapidly deteriorate within a year or two), and current and prior maintenance expenditures. Development of these parameters will remedy current deficiencies and make pavement score a more reliable measure of relative pavement condition and project priority.

Table 1.1 -- Centerline Mileage Rated in Each District During 1984 PES Survey.

District	Centerline Miles Rated	Centerline Miles Total	Percent of Mileage Rated
1	970.6	2883.9	33.7
2	1096.5	2686.7	40.8
3	975.3	2611.9	37.3
4	1296.3	3598.3	36.0
5	1500.7	4814.4	31.2
6	1270.8	2656.7	47.8
7	1518.1	3599.2	42.2
8	1196.1	3243.0	36.9
9	963.7	2944.8	32.7
10	1232.7	3547.7	34.7
11	2712.5	2756.9	98.4
12	848.5	2096.5	40.5
13	1287.6	3366.0	38.3
14	965.0	2943.4	32.8
15	1764.3	4388.2	40.2
16	303.0	2493.9	12.1
17	981.9	2870.5	34.2
18	1241.4	2847.1	43.6
19	912.8	2532.9	36.0
20	738.9	1948.3	37.9
21	1039.7	2685.0	38.7
23	905.9	2560.1	35.4
24	854.7	1685.6	50.7
25	921.3	2416.7	38.1
TOTAL	27,498.3	70,177.7	39.2

Table 1.2 -- Centerline Mileage Rated in Each System During 1984 PES Survey.

System	Centerline Miles Rated	Centerline Miles Total	Percent of Mileage Rated
IH	2911.7	3093.0	94.1
US	7356.4	12,333.8	59.6
SH	8587.1	14,491.0	59.3
FM	8514.6	40,007.3	21.3
PR	128.5	252.6	50.9
TOTAL	27,498.3	70,177.7	39.2

DESCRIPTION OF PAVEMENT CONDITION USING UVU AND PAVEMENT SCORE

As mentioned before, both UVU and pavement score values range from 1 to 100. In general, these values describe pavement sections which fall into three distinct groups.

Group 1: UVU (or PS) Range = 70-100

These pavements exhibit little or no surface distress and usually have good ride quality (PSI > 3.0). Pavement sections in this group need minor, if any, maintenance to preserve their excellent condition. Figures 1.1 and 1.2 show typical Group 1 pavement sections.

Group 2: UVU (or PS) Range = 35-70

Pavements in this group are in the most critical phase of condition. Routine maintenance is usually sufficient to restore these sections to excellent quality. However, neglect will lead to further deterioration. Rehabilitation or maintenance usually costs five to ten times as much when the pavement has failed. As a result, money should be spent on restoring these Group 2 sections (using routine maintenance) and then using any remaining funds to rehabilitate failed sections.

Figures 1.3-1.5 show examples of Group 2 pavement sections.

Group 3: UVU (or PS) Range = 1-35

Pavements in this group have failed -- that is, they do not provide for the safe, comfortable, and efficient transportation of people and goods. These Group 3 sections require labor- and capital-intensive work such as heavy maintenance, rehabilitation or reconstruction to restore their initial condition. Further deterioration in condition is more difficult to determine in Group 3 because of the already poor surface conditions.

It is difficult to justify concentrating most pavement expenditures on these failed sections. However, safety and public service considerations dictate that these roads cannot simply be abandoned. Instead, Group 3 sections should be rehabilitated using funds left over after maintenance of Groups 1 and 2. Such a practice will eventually result in an overall improvement in pavement condition as Group 2 sections are brought up to Group 1 and the number of Group 3 sections gradually declines.

Figures 1.6-1.7 show examples of "failed" Group 3 pavements.

This section was included to provide general illustrations of the meaning of various pavement scores. In reality, there is very little difference between two sections having PS values of 35 and 36 (or even

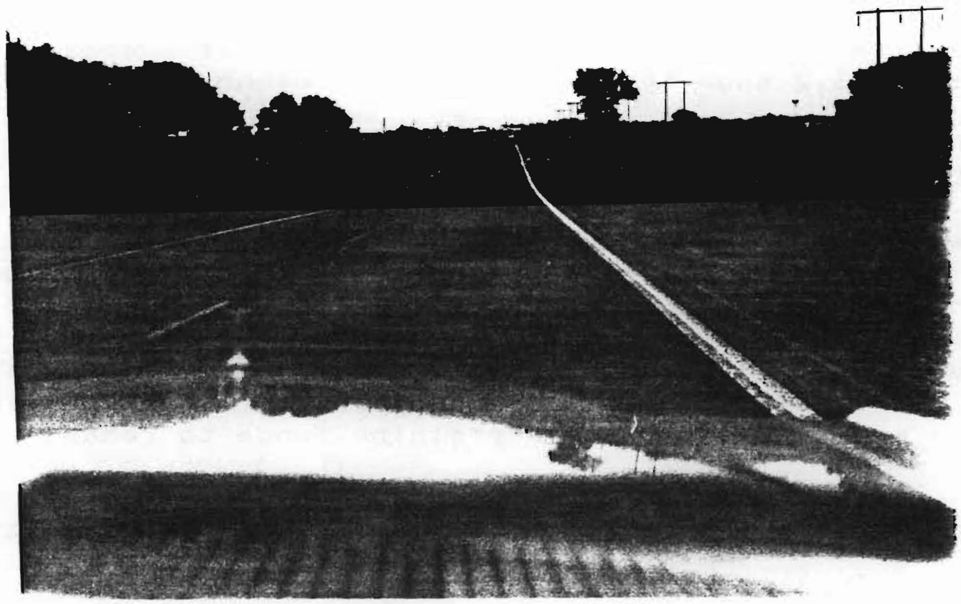


Figure 1.1 - Group 1 Pavement Section

Ride Quality: PSI = 4.0
Distresses: Minor transverse cracking
UVU = 98
Pavement Score: PS = 98

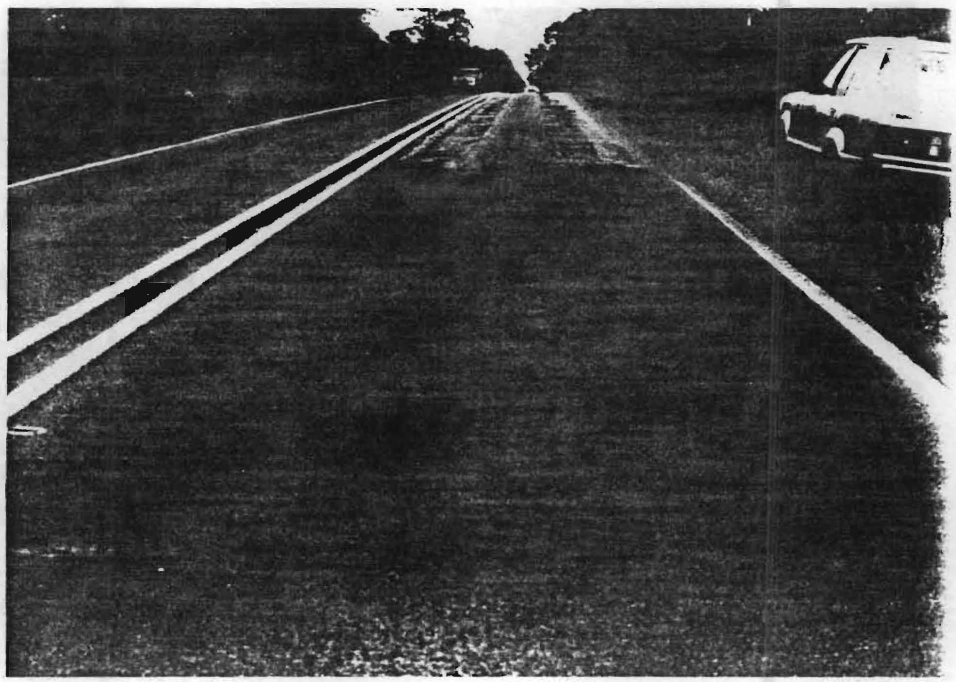


Figure 1.2 - Group 1 Pavement Section

Ride Quality: PSI = 2.8
Distresses: Minor patching
Minor transverse cracking
UVU = 92
Pavement Score: PS = 88

Figure 1.3 - Group 2 Pavement Section

Ride Quality: PSI = 3.3
Distresses: Minor rutting
Minor patching
Minor longitudinal cracking
Moderate transverse cracking
UVU = 66
Pavement Score: PS = 55

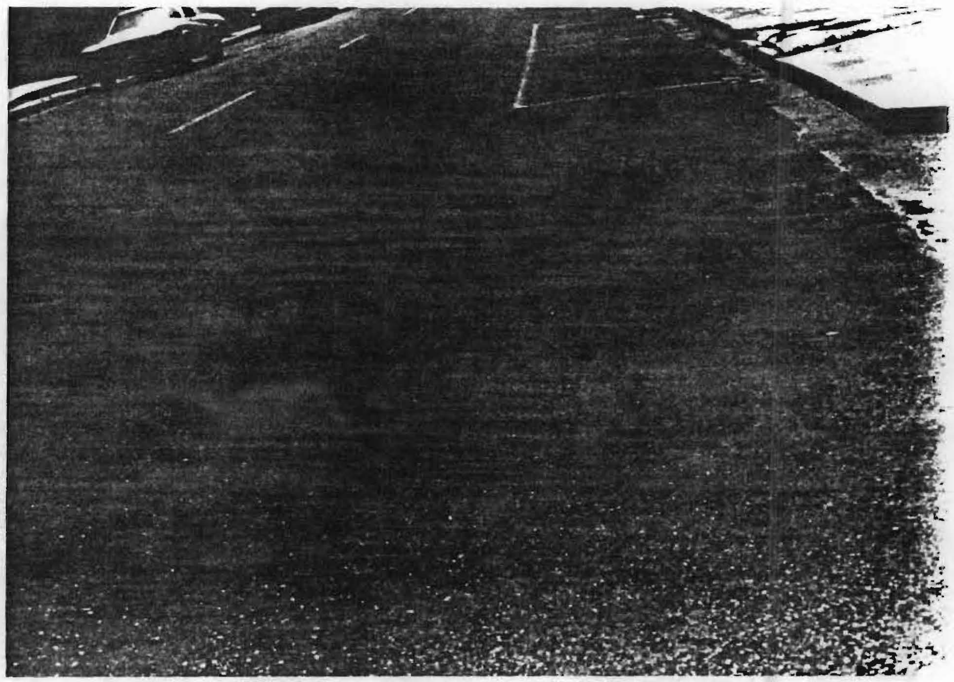


Figure 1.4 - Group 2 Pavement Section

Ride Quality: PSI = 2.2
Distresses: Minor rutting
Minor block cracking
Minor longitudinal cracking
Moderate transverse cracking
UVU = 76
Pavement Score: PS = 44

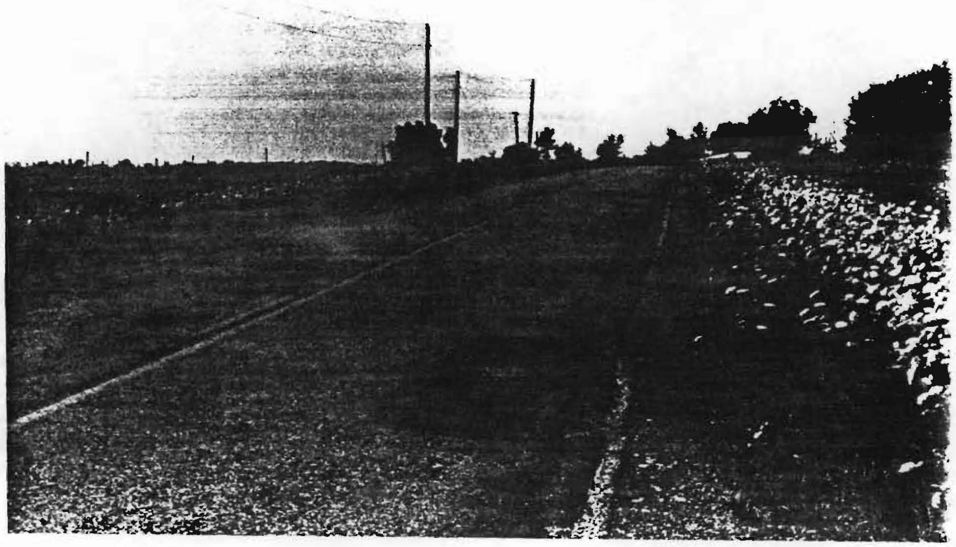


Figure 1.5 - Group 2 Pavement Section

Ride Quality: PSI = 2.1
Distresses: Minor rutting
Minor patching
Minor failures
Moderate alligator cracking
UVU = 49
Pavement Score: PS = 42

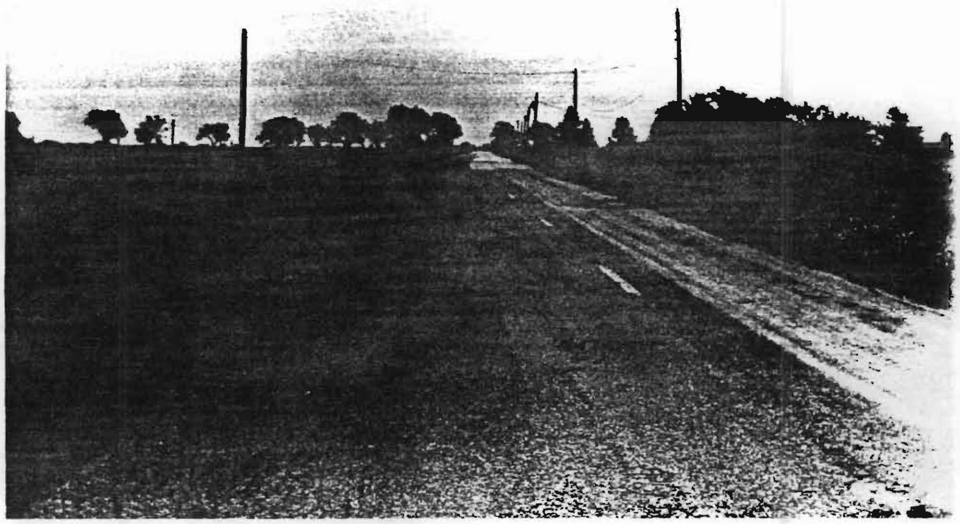


Figure 1.6 - Group 3 Pavement Section

Ride Quality: PSI = 2.6
Distresses: Severe rutting
Moderate patching
Minor failures
Moderate alligator cracking
Minor longitudinal cracking
UVU = 31
Pavement Score: PS = 26

Figure 1.7 - Group 3 Pavement Section

Ride Quality: PSI = 2.6
Distresses: Severe rutting
Moderate patching
Minor failures
Moderate alligator cracking
Minor longitudinal cracking
UVU = 31
Pavement Score: PS = 26

35 and 40). Differences in pavement scores (and UVU values) become noticeable only at 10 or more (for example, between 30 and 40). Another inherent limitation of Figures 1.1-1.7 occurs because the pictures attempt to provide "discrete" views of a "continuous" phenomenon. Pavement score and UVU values describe the entire pavement section (which may be several miles in length), and cannot be easily condensed into the smaller range of the camera. Despite these limitations, Figures 1.1-1.7 do provide views of various levels of pavement condition which should prove useful to persons conducting future field studies.

DISCUSSION OF ANALYSIS PROCEDURES USED IN THIS REPORT

Each of the following eight chapters in this report contains a different analysis of the 1984 PES data. Although each analysis is unique, they share several common characteristics.

1. Source of Data -- A modified version of the 1984 PES Master tape provided all PES data used in this report. This modified version contains basic roadway and evaluation data for each rated lane on a separate record.

2. SAS Programs -- Approximately 30 Statistical Analysis System (SAS) computer programs were written to analyze the PES data. SAS version 82.4 currently resides on the SDHPT mainframe computer system.

3. Sections Analyzed -- Only mainlane sections with PSI and pavement score values greater than zero were analyzed. This restriction insured that each section had been rated and properly stored on the 1984 PES Master tape. Frontage roads were not considered for the following reasons: many sections are discontinuous, especially in urban areas; maintenance is not performed at the same level as on mainlanes, thus producing misleading condition values; mainlane sections are more heavily-travelled and generally form the basis of the public's estimation of the highway system.

4. Pavement Type Groups -- Each analysis divided rated mainlane sections into the following groups, based on PES pavement type value:

   * Jointed Concrete Pavement (JCP) -- Types 2 and 3.

   * Continuously Reinforced Concrete (CRC) -- Type 1.

   * Flexible Pavement (ACP) -- Types 4-10.

CHAPTER 2

CONDITION OF STATE-MAINTAINED HIGHWAYS

Contains average pavement condition values (ride quality, unadjusted visual utility, pavement score, ADT, and 18-k ESAL) for the entire state, each District, each highway prefix (IH, US, SH, FM, and PR), and each highway type (flexible, continuous concrete, and jointed concrete). 1983 values are also provided for comparison.

District PES raters evaluated 16,214 pavement sections during the 1984 survey, as compared to the 15,792 sections rated during the 1983 survey. The 1984 survey included 14,750 flexible sections, 1004 continuously-reinforced concrete (CRC) sections, and 460 jointed concrete pavement (JCP) sections. The 1983 survey covered only flexible pavements.

Tables 2.1 and 2.2 contain statewide average pavement condition values for 1984 and 1983, respectively. The statewide averages indicate a general decline in condition of 5 to 10 percent from 1983 and a substantial increase (65 percent) in ADT and projected 18-k ESAL. This historical perspective, however, is affected by the inclusion of rigid pavement sections in the 1984 survey. Rigid pavements tend to be found in urban areas, which accounts for the dramatic rise in ADT and 18-k ESAL. Rigid pavements are also often rougher and more highly-distressed than flexible pavements, as will be shown later in this chapter. The effect of the new rigid pavement sections is most evident in Districts 2, 12, and 18, since these are predominantly urban Districts. Tables 2.3 and 2.4 contain average condition values, by District, for 1984 and 1983, respectively.

Comparison of statewide averages for rigid and flexible pavement sections clearly defines the impact of the additional rigid pavement sections. Table 2.5 indicates several key points:

* Ride Quality -- Even with less distress (as measured by UVU), rigid pavements are typically rougher than flexible pavements.

* Distress -- Many CRC pavements are relatively new, especially when compared to JCP sections. This accounts for the substantially lower UVU and PS values associated with JCP.

* Traffic -- Average traffic values are 5 times higher for rigid pavements, which is indicative of the use of concrete in urban areas.

Table 2.1

1984 PES -- AVERAGE CONDITIONS ON TEXAS HIGHWAYS All Rated Mainlane Sections						N = 16,214 Sections
Prefix	PSI	UVU	PS	ADT	18-k	N
IH	3.76	90.74	81.05	25999	20734	2726
US	3.52	83.07	74.67	7535	6670	4497
SH	3.36	81.53	73.44	5819	4729	4645
FM	2.91	77.58	72.93	893	555	4276
PR	2.41	78.97	63.16	2493	1587	70
Mean	3.35	82.45	74.88	8374	6844	16214

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from 20-year projected values.

Table 2.2

1983 PES -- AVERAGE CONDITIONS ON TEXAS HIGHWAYS All Rated Mainlane Sections						N = 15,792 Sections
Prefix	PSI	UVU	PS	ADT	18-k	N
IH	3.94	92.31	87.98	17691	15772	1604
US	3.54	85.16	79.07	5955	5126	3675
SH	3.30	85.70	79.70	4101	3409	3718
FM	2.93	85.21	78.10	2118	1236	6727
PR	2.36	88.06	69.63	1021	742	68
Mean	3.26	86.05	79.67	5055	4127	15792

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from 20-year projected values.

Table 2.3

1984 PES -- AVERAGE CONDITIONS ON TEXAS HIGHWAYS All Rated Mainlane Sections N = 16,214 Sections						
District	PSI	UVU	PS	ADT	18-k	N
1	2.94	76.37	67.06	5229	7525	555
2	2.97	84.27	66.80	15636	14393	712
3	2.81	76.65	61.20	4523	6183	566
4	3.74	72.52	67.63	3989	4671	755
5	3.80	75.94	72.09	2957	2674	903
6	3.45	90.19	86.62	3943	5008	819
7	3.49	84.06	81.30	1854	2336	865
8	3.34	83.95	79.68	4568	5671	725
9	3.74	84.80	79.86	7299	6787	546
10	3.34	81.37	75.61	5467	5921	680
11	2.84	81.46	74.12	2653	2638	1441
12	3.64	88.40	77.40	45582	19756	588
13	3.29	80.32	70.53	5207	7477	739
14	3.84	89.16	86.75	11456	7238	525
15	3.72	89.59	86.04	10596	7211	1117
16	3.14	77.57	70.74	8905	5848	152
17	3.23	86.71	82.55	5961	7584	559
18	2.99	82.80	58.86	26805	16809	871
19	3.37	83.78	76.84	5813	6762	526
20	3.38	82.79	70.53	10762	9574	442
21	3.29	76.23	69.39	5633	3627	603
23	3.37	84.41	81.30	2454	2818	483
24	3.23	85.50	77.43	7386	7379	523
25	3.58	75.53	71.39	2008	2635	519
Mean	3.35	82.45	74.88	8374	6844	16214

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from
20-year projected values.

Table 2.4

1983 PES -- AVERAGE CONDITIONS ON TEXAS HIGHWAYS
All Rated Mainlane Sections N = 15,792 Sections

District	PSI	UVU	PS	ADT	18-k	N
1	2.87	88.49	79.26	3332	3611	554
2	3.64	91.46	87.87	6799	4076	611
3	3.43	84.67	80.43	2576	2833	482
4	3.57	84.23	80.27	3312	4236	807
5	3.55	75.12	70.51	2930	2192	859
6	3.51	85.77	81.89	3355	4203	665
7	3.58	92.48	90.24	2072	2841	825
8	3.36	88.61	83.32	4428	5825	704
9	3.94	93.12	91.17	5472	4295	491
10	3.28	84.53	78.98	4054	2796	724
11	2.41	83.63	69.36	2445	2476	1457
12	3.41	90.86	85.37	10719	5227	618
13	3.08	86.77	80.15	2978	3715	660
14	3.53	93.35	90.38	8519	5812	666
15	3.43	86.33	82.05	9037	5817	1157
16	2.99	83.51	74.52	5958	4673	516
17	3.06	79.13	71.21	3299	3561	564
18	2.99	77.48	64.85	11752	7231	618
19	3.07	87.96	81.04	4149	3507	623
20	3.14	85.95	79.38	5864	5559	533
21	3.27	86.67	79.87	5877	3375	744
23	3.41	88.91	85.40	2535	2933	463
24	3.13	86.08	76.61	6594	6304	449
25	4.25	100.00	100.00	7600	10347	2
Mean	3.26	86.05	79.67	5055	4127	15792

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from
20-year projected values.

Table 2.5

1984 PES -- AVERAGE CONDITIONS ON TEXAS HIGHWAYS All Rated Mainlane Sections N = 16,214 Sections						
Pavement	PSI	UVU	PS	ADT	18-k	N
ACP	3.38	81.86	76.50	5945	4967	14750
CRC	3.24	91.30	66.21	33902	27240	1004
JCP	2.76	82.07	41.97	30568	22484	460
Mean	3.35	82.45	74.88	8374	6844	16214

Note: ACP = Pavement Types 4-10
JCP = Pavement Types 2-3
CRC = Pavement Type 1
ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from 20-year projected values.

CHAPTER 3

STATEWIDE PAVEMENT CONDITION MAPS

Maps identify areas (and Districts) associated with each distress type, as well as those areas (and Districts) especially characterized by rough or poor-condition roads. Maps are provided for ACP, CRC, and JCP sections.

Many factors influence pavement performance. However, three factors are considered to be of major importance: pavement structure (which would include design and construction), traffic, and environment. Although all three factors vary widely across the state, it can be assumed that pavement structure is the most constant of the three (especially when sections are divided into large groups by surface type). Such an assumption is useful when describing the condition of pavement sections in different parts of the state.

PES presently addresses pavement condition at the network level (for example, by District). At this network level, localized variations in pavement structure are overshadowed by broader changes in traffic and environment. This chapter contains pavement condition maps which are useful in assessing the effects of regional traffic and environmental characteristics on pavement condition and performance.

This chapter examines ACP, CRC, and JCP sections. The result is three sets of pavement condition maps covering the following subjects:

* Distress in excess of state average.
* Severe distress in excess of state average.
* Rough roads in excess of state average.
* Poor-condition roads in excess of state average.

ANALYSIS PROCEDURE

Statewide averages and distress frequency distributions provided the figures used to develop each pavement condition map. For example, in Table 3.1, a frequency distribution of rutting values indicated that 66.70 percent of all flexible pavement sections had no rutting (i.e. a PES rutting value of "000"). Excessive rutting was then defined as 10 percent below the state average (66.70 - 10% = 60.00). Another category of even more excessive rutting was defined as 15 percent below the state average (66.70 - 15% = 56.70). Once again, these figures indicate the total percent of sections having <u>no distress</u>.

Frequency distributions also provided values for each District. In District 1, for example, only 57.50 percent of all flexible sections had no rutting (this also means that 42.50 percent of all flexible sections had rutting). Since 57.50 is less than the 10% level of 60.00, District 1 is marked with light crosshatching in Figure 3.1.

Distress distributions for rigid pavements were computed on the basis of number per mile. For example, in Table 3.5, a statewide frequency distribution computed the mean number of spalled cracks to be 11.01 per mile. Adding 10% and 15% to this value resulted in the two limiting values of 12.11 and 12.66, respectively. A frequency distribution for District 13, for example, computed a mean of 16.74 spalled cracks per mile. Since 16.74 is greater than the 15% level of 12.66, District 13 is marked with dense crosshatching in Figure 3.25.

An arbitrary dispensation was made for Districts with five or fewer sections in a group. For example, in Table 3.8, Districts 10 and 11 fall below the 15% level (24.84) for spalled cracks. As a result, both Districts should be marked with dense crosshatching in Figure 3.37. However, the two JCP sections rated in District 10 were not considered to be a sufficient sample size. Thus District 10 is not crosshatched while District 11, with only four more sections, is marked with dense crosshatching in Figure 3.37.

ACP SECTIONS

Maps for ACP sections are organized as follows:

* Distress in excess of state average.

  All ACP -- Figures 3.1-3.7, pages 43-49.

* Severe distress in excess of state average.

  All ACP -- Figures 3.8-3.14, pages 51-57.

* Rough roads in excess of state average.

  All ACP -- Figures 3.15-3.19, pages 59-63.

* Poor-condition roads in excess of state average.

  All ACP -- Figures 3.20-3.24, pages 65-69.

Distress in Excess of State Average

The most prevalent flexible pavement distresses are patching, rutting, longitudinal cracking, and transverse cracking. Patching (9 Districts) indicates a pavement's prior susceptibility to other distress types (usually potholes or failures). Although scheduling and performance of maintenance patching varies from one District to another, PES survey data indicated that patching is definitely a statewide problem, especially on surface-treated pavements. The only major region of the state not affected by excessive patching was the five Districts bordering the Rio Grande.

Rutting (8 Districts) is associated with heavy trucks, poor soils, or excess moisture. These characteristics are representative of the 16-District group on or east of IH 35. Of that group, eight Districts had excessive rutting. Not one of the eight Districts west of IH 35 had excessive rutting.

Longitudinal cracking (7 Districts) occurs both in North Texas and in South Texas along the Gulf coast. Central, East, and West Texas are less affected. Five of the seven Districts with longitudinal cracking problems also have transverse cracking problems.

Transverse cracking (7 Districts) is distributed around the perimeter of the state and is less noticeable in Central and East Texas. Temperature extremes are primarily responsible for the transverse cracking observed in North Texas and the Panhandle.

Alligator cracking (6 Districts) and failures (3 Districts) are not confined to any one region. The important consideration is that these distress types require immediate repair, otherwise they will rapidly deteriorate into major rehabilitation problems. Even minor levels of either distress type pose a definite threat to the overall condition of a pavement section.

Block cracking (3 Districts) was primarily observed in the Panhandle, where extreme ranges in temperature cause excessive expansion and contraction of new surface layers.

Tables 3.1-3.4 contain figures used in developing the pavement condition maps for all ACP sections, hot-mix sections, composite sections, and surface-treated sections, respectively.

Severe Distress in Excess of State Average

The term "severe" was reserved for only the highest PES distress values. Table 3.2 contains the definition used for "severe." These maps (Figures 3.8-3.14) identify areas in need of serious attention. At times the maps depict conditions to be worse than they really are because the statewide mean values used for comparison are so low. District personnel should consult both the maps and the tables to obtain a more reliable perspective on the extent of each distress type.

Detailed analysis of each distress type will not be given here, since the previous section should have provided an indication of how each map may be read. However, trends for severe distress do resemble those already described for excessive distress.

Rough Roads in Excess of State Average

Figures 3.15-3.19 and Table 3.3 depict statewide trends in pavement roughness. Analysis of these maps, however, will be conducted in a slightly different manner.

Figure 3.15 identifies four Districts with an average flexible PSI of at least ten percent below the statewide average. This map raises several questions:

1. Is the roughness restricted to any one type of highway (i.e. highway prefix)?

2. Are these the only Districts having problems with ride quality on flexible pavements?

Analysis of the highway prefix maps for all flexible pavements (Figures 3.16-3.19) identifies the relative ride quality problems associated with each highway prefix: Interstate highways (3 of 3 -- District 11 has no IH mileage), US highways (2 of 4), State highways (4 of 4), and FM highways (2 of 4). Interstate highways fared so poorly because the ride quality standard, PSI = 2.5, was set at a high level. FM highways, however, appeared to be in good condition because the standard was set at PSI = 1.5. These PSI standards, though arbitrarily selected, are consistent with typical maintenance practice.

Ride quality problems are not the sole domain of just four Districts in Northeast Texas. Twelve of the twenty-four Districts have ride quality problems with flexible pavements. Other combinations, such as hot-mix roads, or hot-mix FM roads, may identify problems in other Districts.

<u>Poor Condition Roads in Excess of State Average</u>

The pavement score maps (Figures 3.20-3.24) and Table 3.4 indicate the relative priority of flexible pavements in each District as compared to the statewide average. As with the PSI maps previously, these pavement score maps use arbitrarily-selected limiting values for each highway prefix. These maps and tables are the most complicated to analyze since pavement score not only considers surface distress and ride quality, but also traffic, truck loads, environment, and functional class.

Figure 3.20 identifies three Districts as having low flexible pavement scores. Districts 3 and 18 have low scores on each highway prefix, whereas District 4 has low scores on all but the FM system (as shown in Figures 3.20-3.24).

At first, District 4 may seem to be in this list by mistake. However, the following analysis will identify reasons for its inclusion in Figure 3.20. District averages for PSI and UVU are contained in Table 2.3. This table indicates that District 4 ride quality is very high (PSI = 3.74 compared to 3.35 statewide). However, District pavement distress is also very high (UVU = 72.52 compared to 82.45 statewide). (Note: Use of Table 2.3 values is not recommended for a detailed study. A thorough analysis of pavement condition in District 4 would have used mean values taken for <u>ACP sections only.</u> A table was actually prepared with such values, but was not included in this report, in the interest of simplicity. The results, however, lead to the same conclusion.) Lending supporting evidence are Figures 3.1-3.7 and 3.8-3.14, which specifically identify the following distress types: patching (excessive and severe), failures (severe only), longitudinal cracking (excessive and severe), and transverse cracking (excessive and severe). The predominance of surface cracking distress types is reasonable for the extreme hot and cold temperatures experienced in that region of the state.

CRC SECTIONS

Maps for CRC sections are organized as follows:

* Distress in excess of state average.

  All CRC -- Figures 3.25-3.28, pages 71-74.

* Severe distress in excess of state average.

  All CRC -- No maps drawn.

* Rough roads in excess of state average.

  All CRC -- Figures 3.29-3.32, pages 75-78.

* Poor-condition roads in excess of state average.

  All CRC -- Figures 3.33-3.36, pages 79-82.

Analysis of the rigid pavement condition maps (CRC and JCP) will be nowhere near as involved as that for the flexible pavement maps. In addition, the greater strength of the rigid surface makes it less susceptible to traffic and environmental effects. As a result, the rigid pavement condition maps are offered more as information for the Districts than as problem solving tools.

Of the four CRC pavement types, only punchouts can truly be associated with traffic and environment, although spalled cracks can be develop more rapidly when hot weather induces shrinkage cracking. The other two distress types -- concrete patches and asphalt patches -- primarily depend upon each District's maintenance practices. Figures 3.25-3.28 depict regional trends for each distress type. Of particular interest are the trends for punchouts, and their repair. Four Districts have significant problems with punchouts, as shown in Figure 3.27. District 1 apparently patches their punchouts with asphalt, while District 13 uses concrete. Districts 10 and 20, however, appear to use both materials interchangeably. Regardless of the repair method, punchouts are most commonly observed in the high-rainfall areas of East Texas, which suggests that the punchouts are preceded by water-induced pumping of fine base material.

The ride quality maps (Figures 3.29-3.32) are affected by the relative absence of CRC in urban areas. Most rigid pavements in the urban areas were built using JCP. Dallas, Fort Worth, and Waco do have CRC Interstate sections, as indicated in Figure 3.30. As a rule however, CRC (and JCP) sections were "few and far between."

The pavement score maps (Figures 3.33-3.36) emphasize the impact of surface distress on pavement score. Of the eight Districts identified in Figure 3.33 for low pavement score, only two were cited for low ride quality on Figure 3.29.

Maps for FM sections with low ride quality and FM sections with low pavement scores were deleted from this analysis because they contained no pertinent information.

JCP SECTIONS

Maps for JCP sections are organized as follows:

* Distress in excess of state average.

  All JCP -- Figures 3.37-3.42, pages 84-89.

* Severe distress in excess of state average.

  All JCP -- No maps drawn.

* Rough roads in excess of state average.

  All JCP -- Figures 3.43-3.46, pages 90-93.

* Poor-condition roads in excess of state average.

  All JCP -- Figures 3.47-3.50, pages 94-97.

The JCP sections comprise probably the most unique of the three pavement surfaces. Few extended stretches of JCP may be found outside of the major urban areas. As shown in Table 3.8, only ten Districts had more than the minimum of 5 sections required for consideration in the pavement condition maps. Each of these ten Districts showed up in at least one of the 14 JCP pavement condition maps (Figures 3.37-3.50).

JCP sections are more likely to be affected by traffic loads and environment than CRC sections, especially if joint-to-joint connections have failed. High-rainfall and swelling clays in East Texas are evidenced by the prevalence of joint spalling (Figure 3.37), slabs with longitudinal cracks (Figure 3.38), and corner breaks and punchouts (Figure 3.40). These distress types suggest the loss of subsurface support, which may be caused by pumping of fine base material. Extensive patching of corner breaks and punchouts is also evidenced by Figures 3.41 (asphalt patches) and 3.42 (concrete patches).

The ride quality (Figures 3.43-3.46) and pavement score (Figures 3.47-3.50) maps illustrate the same general trends. With regards to pavement score, distress and ride quality appear to have had the same relative impact. This is due to the nature of jointed concrete, in which the presence of any identifiable distress (except perhaps for transverse cracks) will drastically reduce ride quality.

Two maps were deleted from the analysis of JCP sections. They were: FM sections with low ride quality and FM sections with low pavement score.

A FEW REMARKS CONCERNING CHAPTER 3

This is by far the most involved chapter in this report. The analysis procedure resulted in a total of 54 pavement condition maps -- 4 of which were deleted. Additional maps for hot-mix, composite, and surface-treated sections are also available to any District which may be interested in a more detailed study of the flexible pavement system. Although such a procedure may seem excessive, it was considered more acceptable than withholding information from those who may have need for it. District personnel are encouraged to study these maps, in the hope that they may identify pavement condition trends of special use to them in their present and future pavement work.

NOTES

Table 3.1

1984 PES -- ALL FLEXIBLE PAVEMENTS N = 14,750 Sections

Percent of Sections With No Distress

Dist.	Rut	Block	Patch	Fail	Allig	Long	Trans	Sect.
1	57.50	85.60	59.60	88.10	69.20	56.10	65.30	478
2	47.90	88.30	48.30	98.40	75.40	48.90	63.80	495
3	50.20	81.40	54.50	83.30	80.80	31.40	38.50	468
4	65.10	95.10	53.10	98.70	81.10	40.30	39.80	708
5	84.30	80.70	63.30	96.50	48.90	44.50	49.90	867
6	85.80	94.20	90.90	99.80	84.20	72.50	73.70	816
7	62.70	85.50	79.10	98.00	82.30	61.30	80.30	865
8	84.60	91.10	78.40	98.50	75.50	57.00	63.10	723
9	56.00	96.00	58.30	98.90	92.80	65.80	84.20	530
10	78.20	86.80	69.00	94.80	62.90	90.40	83.10	657
11	44.30	92.50	57.50	87.70	72.60	73.10	76.60	1435
12	90.20	82.60	83.10	97.80	72.20	40.70	40.20	356
13	52.00	91.60	62.40	82.10	56.80	53.50	62.30	604
14	83.60	98.50	60.20	100.00	97.70	62.90	93.50	525
15	81.90	98.70	82.70	99.50	84.60	66.80	86.00	1098
16	60.50	94.10	42.80	76.30	57.20	65.80	86.80	152
17	71.10	93.00	71.50	88.10	77.00	70.40	82.40	540
18	66.00	93.40	76.80	92.00	72.10	59.20	56.90	573
19	38.40	91.40	71.00	97.90	60.70	65.00	76.20	466
20	67.90	86.70	83.40	88.30	72.30	75.80	67.40	368
21	39.60	98.20	66.90	100.00	84.60	67.70	71.10	599
23	74.50	94.80	68.30	98.10	84.30	63.10	81.00	483
24	77.20	84.60	75.00	96.50	88.70	64.80	61.50	460
25	79.50	71.90	60.10	99.80	53.50	25.00	30.00	484
MEAN	66.70	90.40	68.30	94.70	75.00	60.40	68.30	14750
	60.00	81.40	61.50	85.20	67.50	54.40	61.50	
	56.70	76.80	58.10	80.50	63.80	51.30	58.10	

Table 3.2

1984 PES -- ALL FLEXIBLE PAVEMENTS Percent of Sections With Severe Distress								N = 14,750 Sections
Dist.	Rut	Block	Patch	Fail	Allig	Long	Trans	Sect.
1	6.90	1.46	0.00	0.00	1.46	2.09	1.46	478
2	8.48	0.20	0.81	0.00	0.00	0.20	0.40	495
3	7.27	1.71	4.70	0.21	0.43	2.35	5.77	468
4	0.71	0.42	6.50	0.14	0.14	2.97	18.36	708
5	0.92	0.46	3.81	0.00	4.73	0.12	0.12	867
6	0.86	0.49	0.74	0.12	1.23	0.00	1.72	816
7	3.70	1.16	0.81	0.12	1.97	1.50	1.73	865
8	1.38	1.80	0.55	0.14	1.11	1.94	1.94	723
9	5.47	0.19	3.77	0.00	0.19	0.19	0.00	530
10	4.11	1.52	0.15	0.30	3.04	0.00	0.00	657
11	3.42	0.07	1.12	0.21	0.35	0.28	0.98	1435
12	0.00	0.56	0.00	0.00	0.84	0.00	0.28	356
13	0.50	0.00	0.33	0.17	1.66	0.00	0.50	604
14	0.38	0.00	4.95	0.00	0.00	1.52	0.38	525
15	0.91	0.00	0.27	0.00	2.55	1.55	0.18	1098
16	15.13	0.00	0.00	1.97	0.00	0.00	0.00	152
17	2.78	0.74	0.56	0.19	0.37	0.56	0.19	540
18	8.38	0.35	1.92	0.00	1.05	2.97	10.47	573
19	1.50	0.00	0.00	0.00	0.64	0.00	0.64	466
20	2.17	1.36	0.54	0.00	4.35	0.00	2.45	368
21	22.37	0.17	1.00	0.00	0.67	1.34	4.17	599
23	0.41	0.00	1.24	0.00	0.62	0.62	0.21	483
24	0.22	8.04	0.22	0.22	0.65	0.00	5.44	460
25	1.86	2.69	2.07	0.00	2.48	0.00	0.21	484
MEAN	3.65	0.85	1.55	0.11	1.37	0.90	2.42	14750
	4.02	0.94	1.71	0.12	1.51	0.99	2.66	
	4.20	0.98	1.78	0.13	1.58	1.04	2.78	

Definition of "Severe:" Rutting -- 200, 020, or 002 rating
Others -- 001 rating

Table 3.3

1984 PES -- ALL FLEXIBLE PAVEMENTS Percent of Sections Having Rough Surfaces						N = 14,750 Sections
Dist.	Avg. PSI	IH	US	SH	FM	Sect.
1	2.97	2.50	1.08	4.27	6.15	478
2	2.98	2.78	1.23	6.79	0.00	495
3	2.83	16.67	6.40	4.17	0.69	468
4	3.74	0.00	0.00	0.00	0.00	708
5	3.80	-----	0.57	0.00	1.63	867
6	3.46	0.00	1.61	2.68	0.93	816
7	3.49	0.00	0.88	4.66	2.78	865
8	3.35	9.49	0.46	2.52	0.53	723
9	3.76	0.00	0.00	0.00	0.00	530
10	3.34	0.00	0.56	1.27	0.54	657
11	2.84	-----	0.00	3.48	2.73	1435
12	3.79	0.00	0.00	0.00	0.00	356
13	3.37	0.00	1.16	2.55	6.90	604
14	3.84	0.00	0.00	0.00	0.00	525
15	3.73	0.81	0.00	1.78	1.84	1098
16	3.14	0.00	0.00	0.00	0.00	152
17	3.22	0.00	0.00	0.67	1.24	540
18	3.06	6.79	2.75	7.19	4.44	573
19	3.38	0.00	0.73	1.42	0.00	466
20	3.51	5.36	0.00	1.53	0.00	368
21	3.30	0.00	0.49	2.74	4.69	599
23	3.37	0.00	0.00	0.93	0.69	483
24	3.20	0.87	6.00	22.06	15.25	460
25	3.53	0.00	0.52	1.32	0.00	484
MEAN	3.38	1.83	1.00	2.88	2.06	14750
	3.04	2.01	1.10	3.17	2.27	
	2.87	2.10	1.15	3.31	2.37	

Definition of "Rough:"

IH -- PSI of 2.5 or below
US -- PSI of 2.0 or below
SH -- PSI of 2.0 or below
FM -- PSI of 1.5 or below

Table 3.4

1984 PES -- ALL FLEXIBLE PAVEMENTS Percent of Sections Having Low Pavement Scores						N = 14,750 Sections
Dist.	Avg. PS	IH	US	SH	FM	Sect.
1	73.79	2.50	8.60	14.02	18.99	478
2	71.27	2.78	20.25	14.82	3.18	495
3	63.36	66.67	18.02	28.47	17.12	468
4	66.32	40.00	22.98	17.36	7.45	708
5	70.97	-----	14.97	14.63	12.05	867
6	86.73	4.71	10.22	3.57	4.63	816
7	81.30	4.70	9.62	8.29	9.44	865
8	79.90	27.22	5.53	11.95	5.32	723
9	80.94	14.77	1.19	2.16	2.94	530
10	76.44	0.00	12.02	10.97	12.37	657
11	74.38	-----	10.98	8.99	7.71	1435
12	81.55	3.39	4.55	8.67	2.50	356
13	73.92	0.00	5.78	9.79	14.37	604
14	86.75	0.00	4.44	4.65	3.73	525
15	86.65	2.43	3.15	6.41	8.26	1098
16	70.74	5.88	20.00	12.20	21.15	152
17	82.36	0.00	6.15	6.67	10.56	540
18	64.35	27.78	28.44	32.24	18.52	573
19	77.79	0.00	10.87	7.09	0.76	466
20	76.71	10.71	15.73	15.27	5.56	368
21	69.81	7.90	11.17	13.24	10.94	599
23	81.30	21.05	9.09	11.11	6.90	483
24	76.54	13.04	12.00	17.65	5.09	460
25	69.67	0.00	15.63	9.21	9.42	484
MEAN	76.50	9.55	11.72	11.61	9.10	14750
	68.85	10.51	12.89	12.77	10.01	
	65.03	10.98	13.48	13.35	10.47	

Definition of "Low:"

IH -- PS of 50 or below
US -- PS of 40 or below
SH -- PS of 40 or below
FM -- PS of 35 or below

NOTES

Table 3.5

1984 PES -- ALL CRCP SECTIONS Mean Number of Distress Occurrences Per Mile				N = 1,004 Sections	
Dist.	Spalls	PC Patches	Punchouts	AC Patches	Sect.
1	9.99	0.11	4.17	7.71	34
2	3.67	0.94	0.58	0.56	204
3	6.58	0.68	0.83	0.59	67
4	8.67	1.18	0.52	0.31	46
5	1.29	0.14	0.00	0.00	36
6	0.00	0.00	0.00	0.00	2
7	------	------	------	------	0
8	------	------	------	------	0
9	15.80	6.64	0.33	0.00	8
10	14.23	3.68	2.25	2.28	21
11	------	------	------	------	0
12	4.98	1.72	0.16	0.16	114
13	16.74	3.21	1.12	0.08	116
14	------	------	------	------	0
15	20.02	0.15	0.00	0.34	19
16	------	------	------	------	0
17	23.99	1.12	0.53	0.24	19
18	7.25	1.99	0.15	0.25	150
19	4.69	1.81	0.44	0.59	48
20	108.31	2.30	4.84	0.84	23
21	------	------	------	------	0
23	------	------	------	------	0
24	21.62	0.18	0.36	0.42	63
25	4.10	0.58	0.28	0.54	34
MEAN	11.01	1.49	0.73	0.64	1004
	12.11	1.64	0.80	0.70	
	12.66	1.71	0.84	0.74	

Table 3.6

1984 PES -- ALL CRCP SECTIONS Percent of Sections Having Rough Surfaces						N = 1,004 Sections
Dist.	Avg. PSI	IH	US	SH	FM	Sect.
1	3.04	6.25	0.00	------	------	34
2	3.00	14.29	0.00	4.88	------	204
3	2.83	------	1.49	------	------	67
4	3.71	0.00	0.00	------	------	46
5	3.79	0.00	------	------	------	36
6	3.30	------	0.00	------	------	2
7	-----	------	------	------	------	0
8	-----	------	------	------	------	0
9	3.28	12.50	------	------	------	8
10	3.45	4.76	------	------	------	21
11	-----	------	------	------	------	0
12	3.43	0.00	0.00	0.00	------	114
13	2.99	0.00	0.00	0.00	------	116
14	-----	------	------	------	------	0
15	3.60	0.00	0.00	------	------	19
16	-----	------	------	------	------	0
17	3.51	0.00	0.00	------	------	19
18	3.07	14.68	0.00	0.00	------	150
19	3.58	0.00	0.00	------	------	48
20	2.82	------	0.00	0.00	------	23
21	-----	------	------	------	------	0
23	-----	------	------	------	------	0
24	3.44	0.00	0.00	------	------	63
25	4.29	0.00	------	------	------	34
MEAN	3.24	5.69	0.39	1.75	------	1004
	2.92	6.26	0.43	1.93	0.00	
	2.75	6.54	0.45	2.01	0.00	

Definition of "Rough:"

IH -- PSI of 2.5 or below
US -- PSI of 2.0 or below
SH -- PSI of 2.0 or below
FM -- PSI of 1.5 or below

Table 3.7

1984 PES -- ALL CRCP SECTIONS Percent of Sections Having Low Pavement Scores						N = 1,004 Sections
Dist.	Avg. PS	IH	US	SH	FM	Sect.
1	23.29	81.25	88.89	------	------	34
2	59.56	35.29	18.18	46.34	------	204
3	57.94	------	31.34	------	------	67
4	87.39	7.50	0.00	------	------	46
5	99.00	0.00	------	------	------	36
6	83.00	------	0.00	------	------	2
7	------	------	------	------	------	0
8	------	------	------	------	------	0
9	49.63	62.50	------	------	------	8
10	53.90	42.86	------	------	------	21
11	------	------	------	------	------	0
12	82.87	6.15	26.32	6.67	------	114
13	60.72	23.08	19.15	35.29	------	116
14	------	------	------	------	------	0
15	51.16	46.67	100.00	------	------	19
16	------	------	------	------	------	0
17	88.00	6.67	0.00	------	------	19
18	51.67	51.38	20.00	56.25	------	150
19	84.10	10.87	0.00	------	------	48
20	37.09	------	69.23	20.00	------	23
21	------	------	------	------	------	0
23	------	------	------	------	------	0
24	83.94	8.77	33.33	------	------	63
25	97.38	0.00	------	------	------	34
MEAN	66.21	25.59	30.74	33.33	------	1004
	59.59	28.15	33.81	36.66	0.00	
	56.28	29.43	35.35	38.33	0.00	

Definition of "Low:"
IH -- PS of 50 or below
US -- PS of 40 or below
SH -- PS of 40 or below
FM -- PS of 35 or below

NOTES

Table 3.8

1984 PES -- ALL JCP SECTIONS N = 460 Sections

Mean Number of Distress Occurrences Per Mile

Dist.	Spalls	Long. Cracks	Trans. Cracks	CB & Punch.	AC Patch	PC Patch	Sect.
1	50.55	10.56	11.36	11.36	10.85	0.05	43
2	43.30	18.54	8.66	6.35	12.30	1.62	13
3	12.36	6.68	3.69	4.63	4.43	0.26	31
4	0.00	0.00	0.00	2.78	0.00	0.00	1
5	----	----	----	----	----	----	0
6	2.35	0.00	0.59	0.00	0.00	0.00	1
7	----	----	----	----	----	----	0
8	11.25	19.54	107.13	80.67	9.92	0.00	2
9	17.09	13.55	18.06	2.96	0.16	0.15	8
10	43.40	4.62	104.14	7.95	5.78	1.15	2
11	34.56	24.00	84.58	10.58	1.39	0.39	6
12	8.65	3.34	31.76	2.09	4.56	3.40	118
13	16.03	1.83	122.03	4.15	0.75	20.51	19
14	----	----	----	----	----	----	0
15	----	----	----	----	----	----	0
16	----	----	----	----	----	----	0
17	----	----	----	----	----	----	0
18	13.20	3.50	8.15	1.28	1.45	0.75	148
19	171.68	4.92	279.07	8.35	4.22	4.61	12
20	16.78	3.17	16.29	4.08	0.69	1.89	51
21	30.07	13.60	154.67	11.49	6.86	0.13	4
23	----	----	----	----	----	----	0
24	----	----	----	----	----	----	0
25	44.14	1.72	102.41	3.45	5.52	0.00	1
MEAN	21.60	5.27	30.36	4.03	3.68	2.37	460
	23.76	5.80	33.40	4.43	4.05	2.61	
	24.84	6.06	34.91	4.63	4.23	2.73	

Table 3.9

1984 PES -- ALL JCP SECTIONS Percent of Sections Having Rough Surfaces						N = 460 Sections
Dist.	Avg. PSI	IH	US	SH	FM	Sect.
1	2.53	68.75	9.09	75.00	0.00	43
2	2.12	------	100.00	54.55	------	13
3	2.40	------	27.27	55.56	------	31
4	3.20	------	0.00	------	------	1
5	------	------	------	------	------	0
6	1.50	------	100.00	------	------	1
7	------	------	------	------	------	0
8	2.55	------	0.00	------	------	2
9	2.39	------	0.00	50.00	------	8
10	2.00	------	------	100.00	0.00	2
11	1.67	------	100.00	66.67	100.00	6
12	3.41	0.00	0.00	11.77	0.00	118
13	2.58	42.86	------	20.00	------	19
14	------	------	------	------	------	0
15	------	------	------	------	------	0
16	------	------	------	------	------	0
17	------	------	------	------	------	0
18	2.65	33.33	0.00	11.58	0.00	148
19	2.28	------	33.33	------	------	12
20	2.72	20.00	0.00	23.53	------	51
21	1.60	------	------	100.00	------	4
23	------	------	------	------	------	0
24	------	------	------	------	------	0
25	1.90	------	------	100.00	------	1
MEAN	2.76	23.20	12.41	23.40	10.00	460
	2.48	25.52	13.65	25.74	11.00	
	2.35	26.68	14.27	26.91	11.50	

Definition of "Rough:"

IH -- PSI of 2.5 or below
US -- PSI of 2.0 or below
SH -- PSI of 2.0 or below
FM -- PSI of 1.5 or below

Table 3.10

1984 PES -- ALL JCP SECTIONS Percent of Sections Having Low Pavement Scores						N = 460 Sections
Dist.	Avg. PS	IH	US	SH	FM	Sect.
1	26.88	93.75	54.55	75.00	100.00	43
2	10.23	------	100.00	90.91	------	13
3	35.61	------	59.09	77.78	------	31
4	88.00	------	0.00	------	------	1
5	------	------	------	------	------	0
6	6.00	------	100.00	------	------	1
7	------	------	------	------	------	0
8	1.00	------	100.00	------	------	2
9	38.63	------	50.00	75.00	------	8
10	31.00	------	------	100.00	0.00	2
11	11.00	------	100.00	66.67	100.00	6
12	59.59	50.94	7.41	26.47	25.00	118
13	22.79	100.00	------	40.00	------	19
14	------	------	------	------	------	0
15	------	------	------	------	------	0
16	------	------	------	------	------	0
17	------	------	------	------	------	0
18	44.89	59.26	47.83	49.47	66.67	148
19	11.08	------	100.00	------	------	12
20	40.98	86.67	47.37	58.82	------	51
21	6.75	------	------	100.00	------	4
23	------	------	------	------	------	0
24	------	------	------	------	------	0
25	20.00	------	------	100.00	------	1
MEAN	41.97	68.00	49.64	52.66	50.00	460
	37.77	74.80	54.60	57.93	55.00	
	35.67	78.20	57.09	60.56	57.50	

Definition of "Low:"
IH -- PS of 50 or below
US -- PS of 40 or below
SH -- PS of 40 or below
FM -- PS of 35 or below

NOTES

Districts with Excessive Rutting
1984 PES--All Flexible Pavements

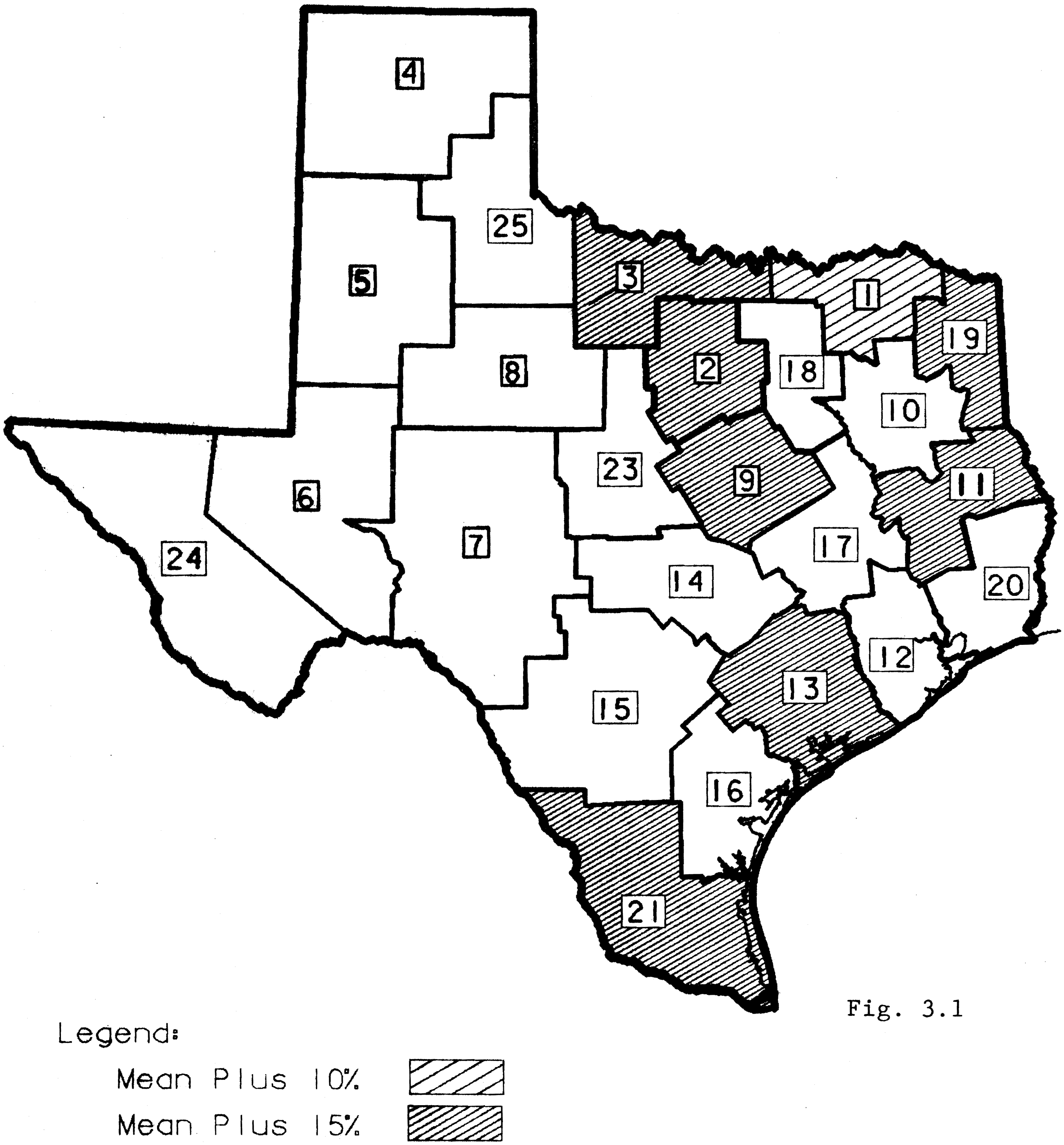


Fig. 3.1

Districts with Excesive Block Cracking
1984 PES--All Flexible Pavements

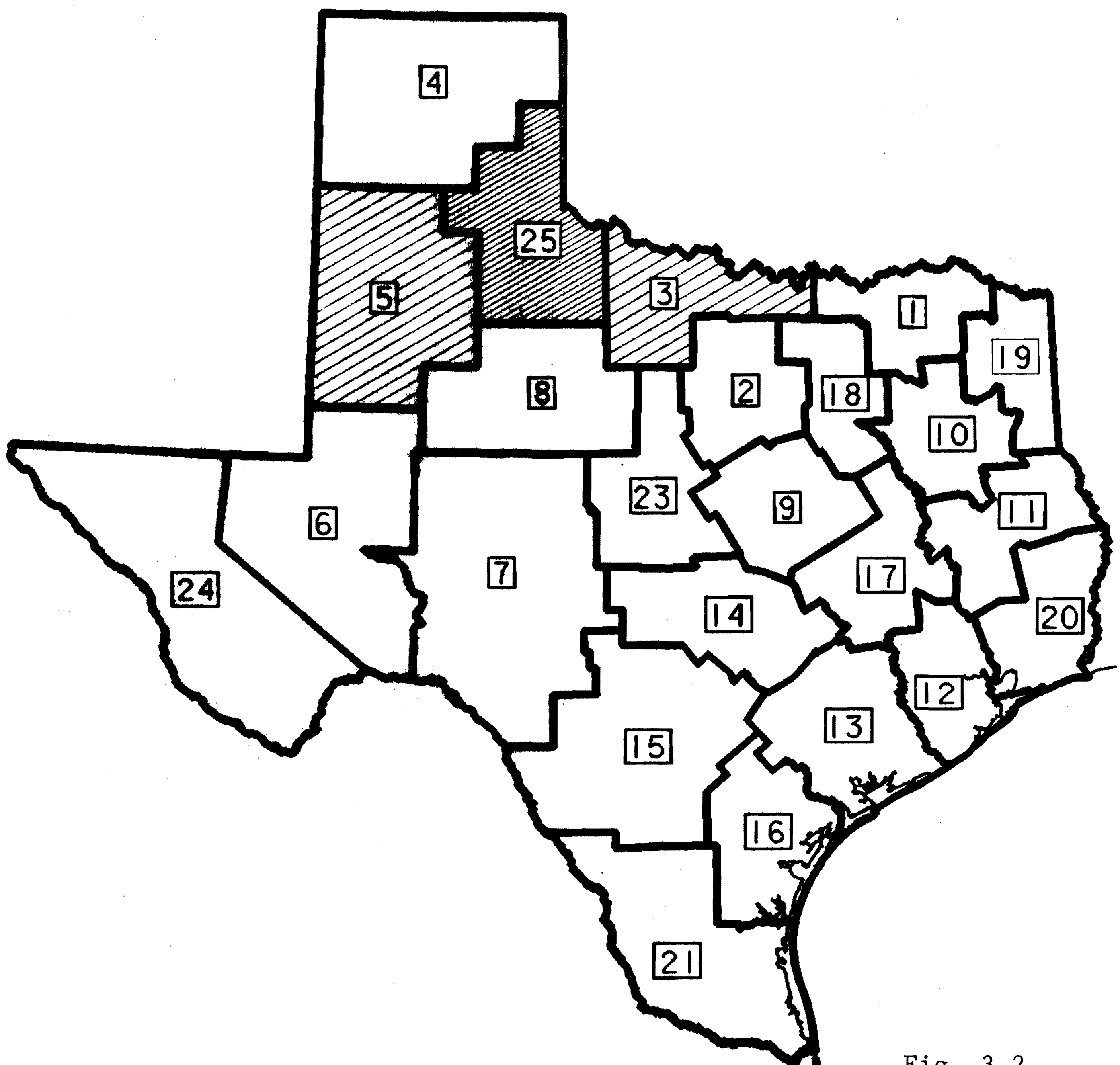
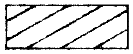


Fig. 3.2

Legend:

Mean Plus 10% 

Mean Plus 15% 

Districts with Excessive Patching
1984 PES--All Flexible Pavements

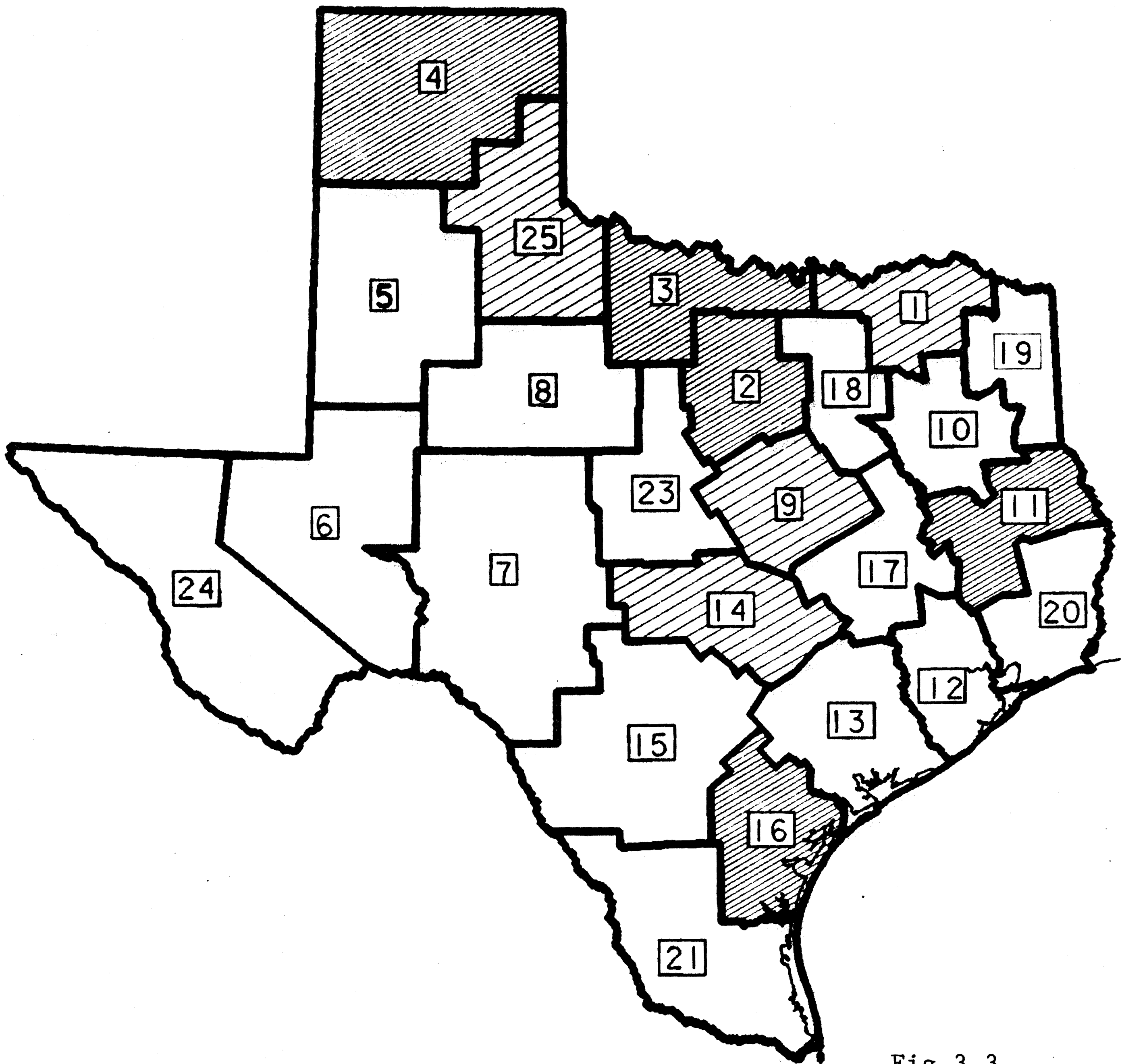


Fig 3.3

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive Failures

1984 PES--All Flexible Pavements

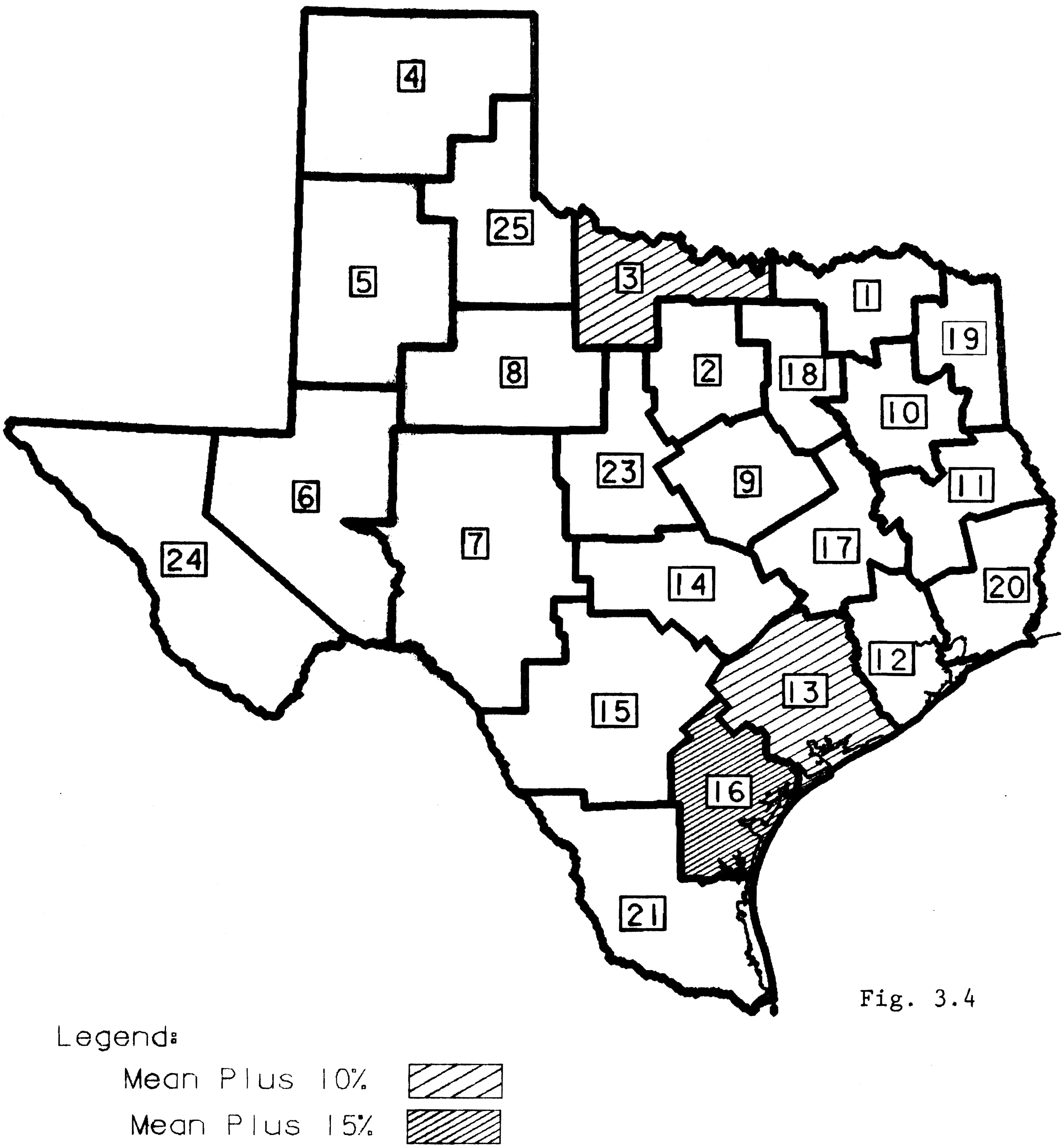


Fig. 3.4

Districts with Excessive Alligator Cracking
1984 PES--All Flexible Pavements

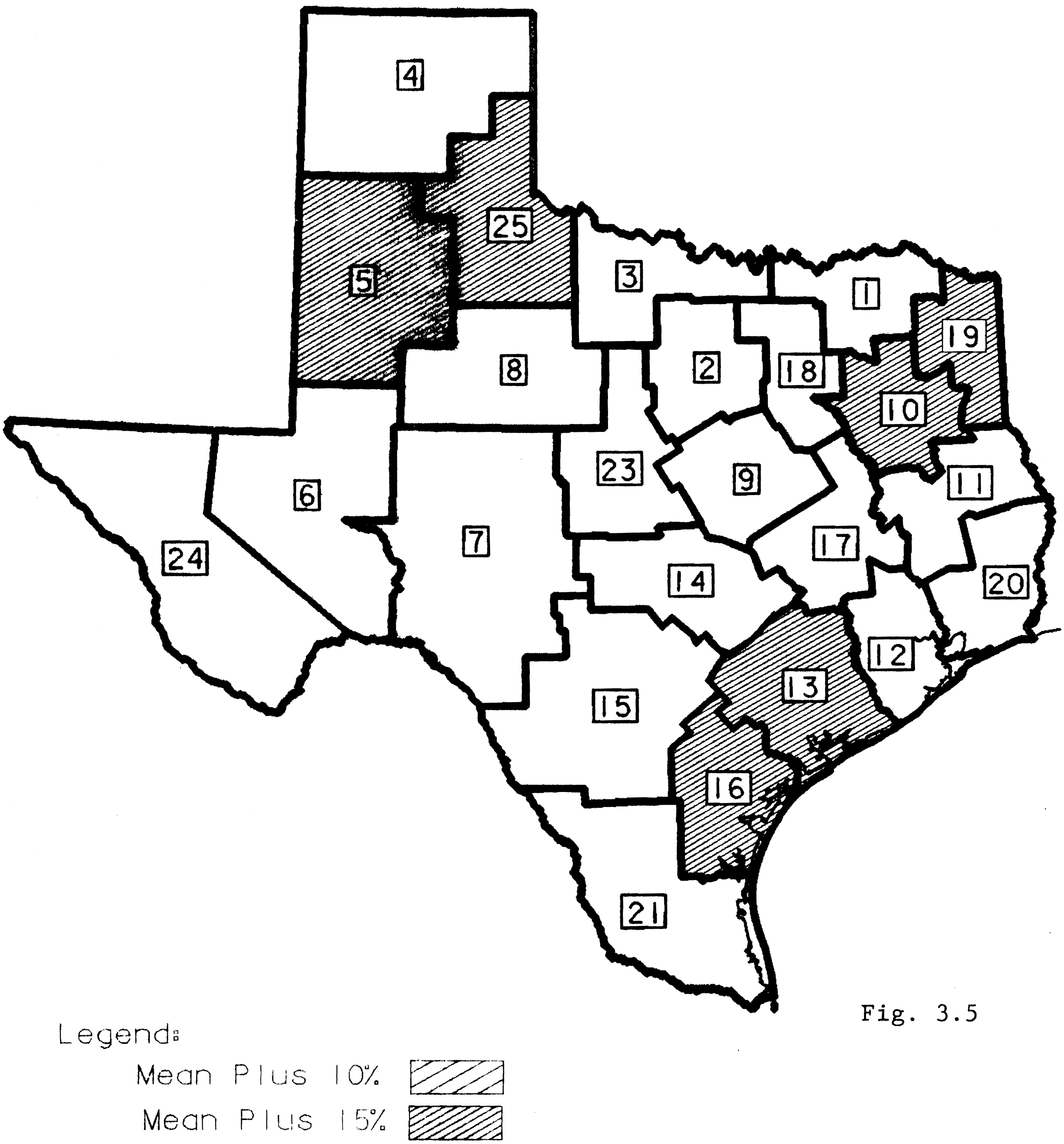


Fig. 3.5

Districts with Excesive Longitudinal Cracking
1984 PES--All Flexible Pavements

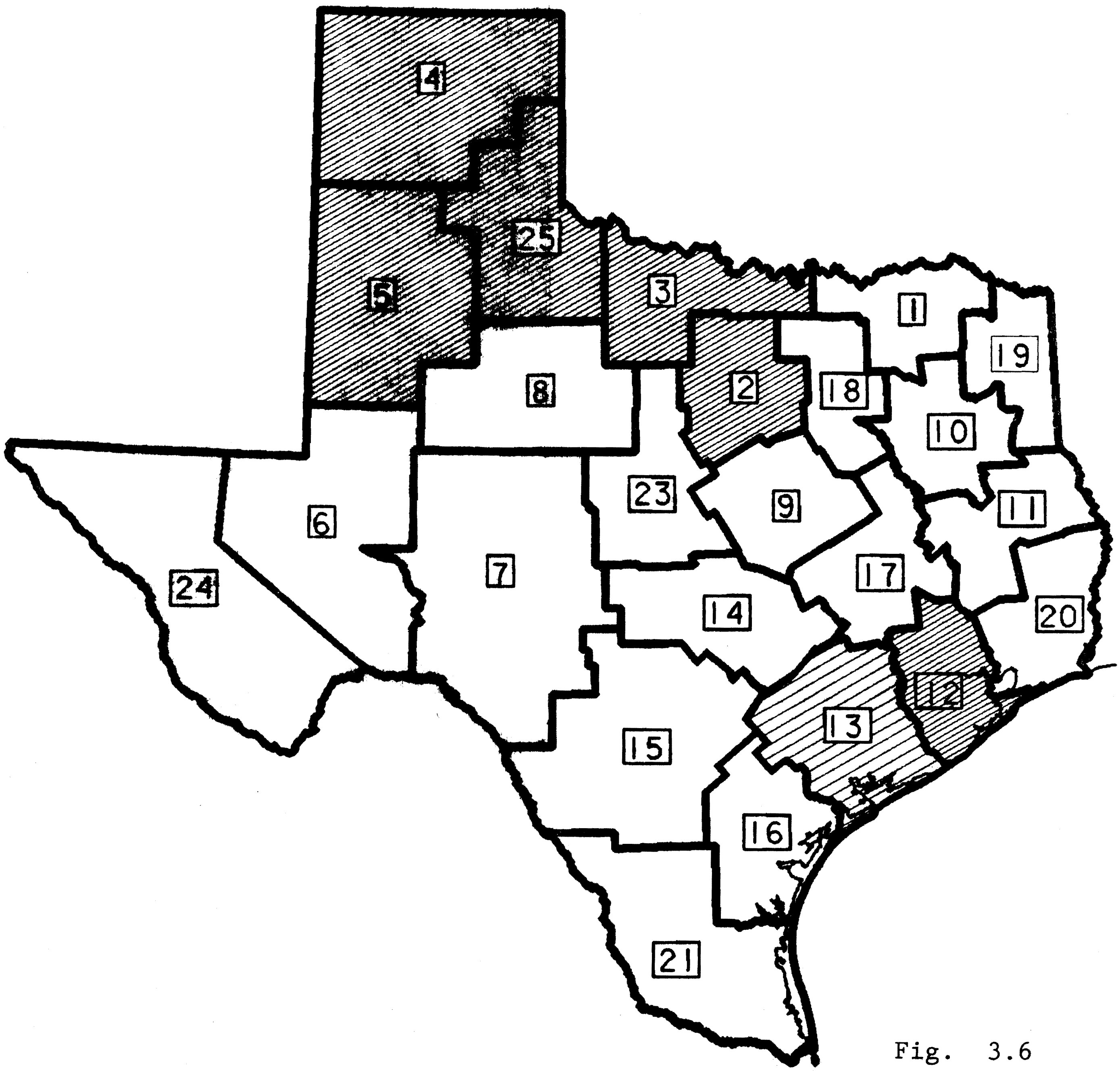


Fig. 3.6

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excesive Transverse Cracks
1984 PES--All Flexible Pavements

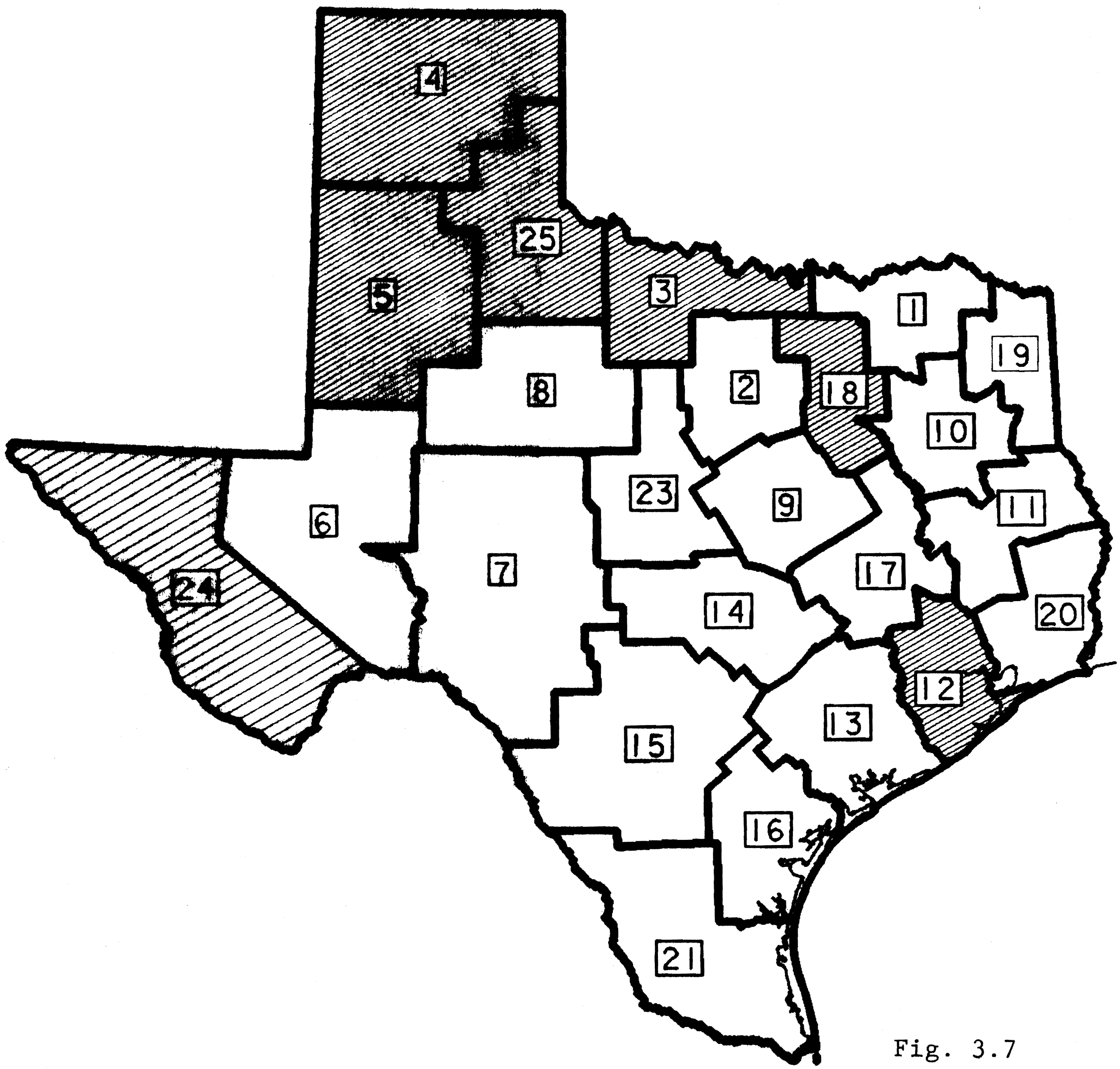


Fig. 3.7

Legend:

Mean Plus 10% 

Mean Plus 15% 

NOTES

Districts with Severe Rutting
1984 PES--All Flexible Pavements

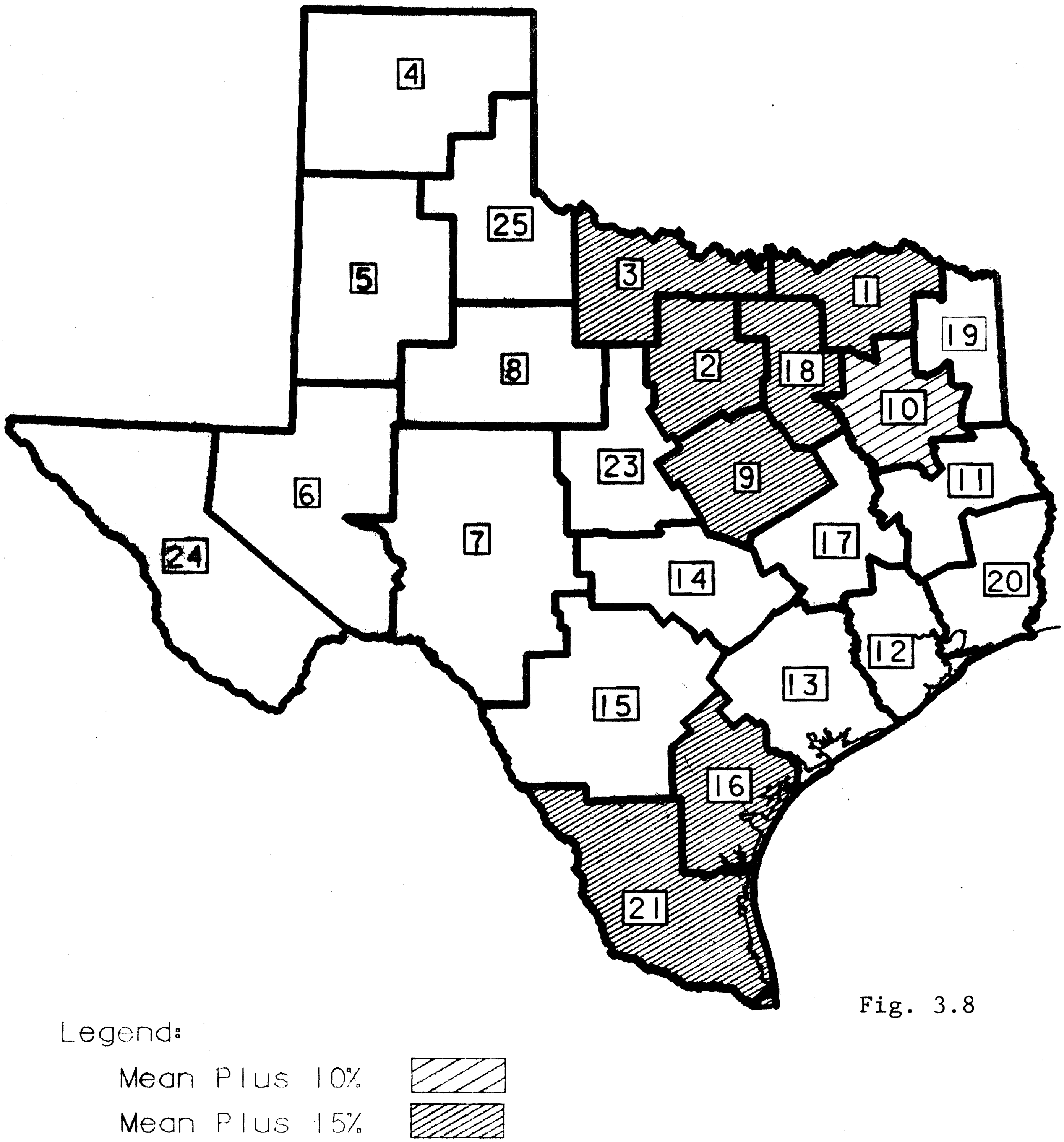


Fig. 3.8

Districts with Severe Block Cracking

1984 PES--All Flexible Pavements

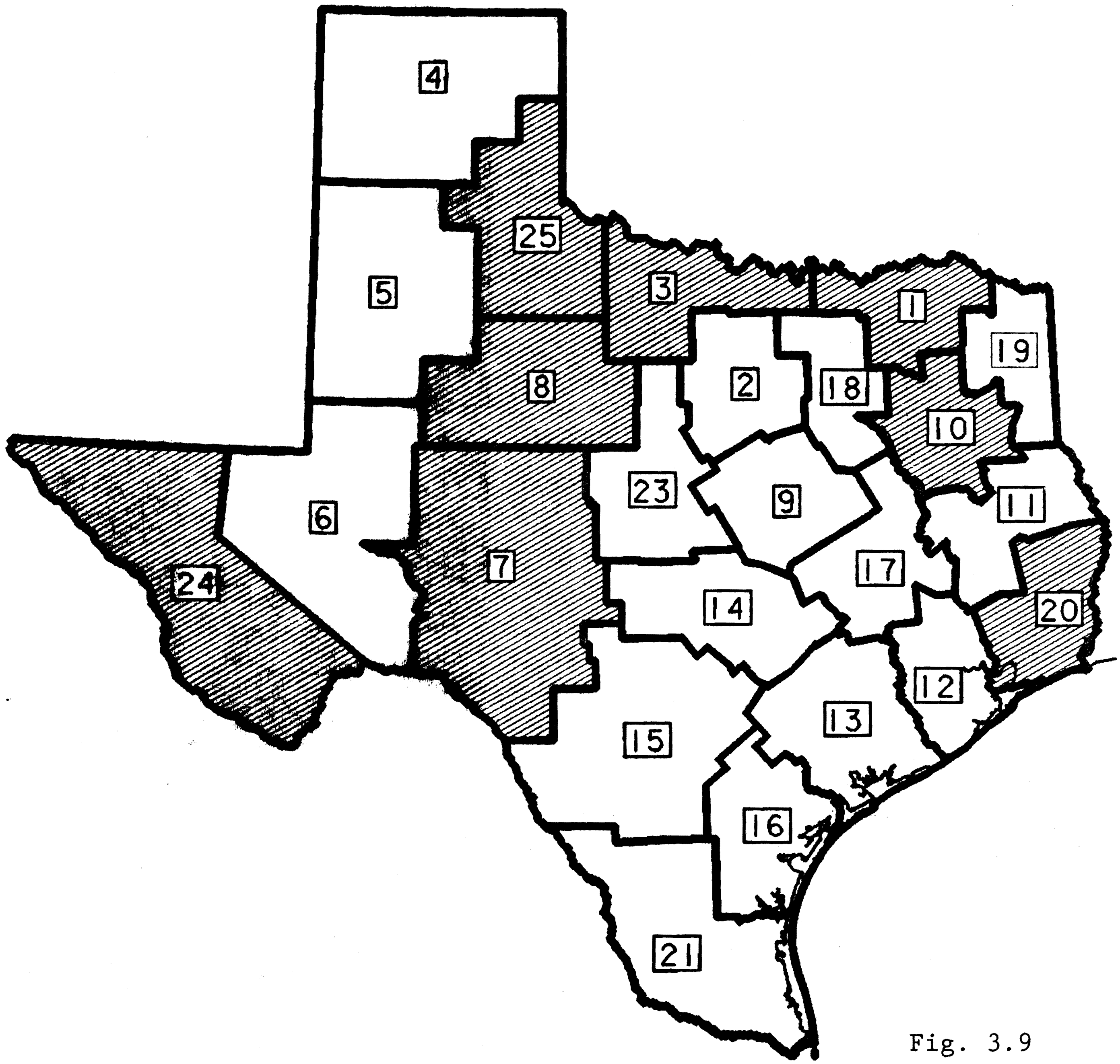


Fig. 3.9

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Severe Patching
1984 PES--All Flexible Pavements

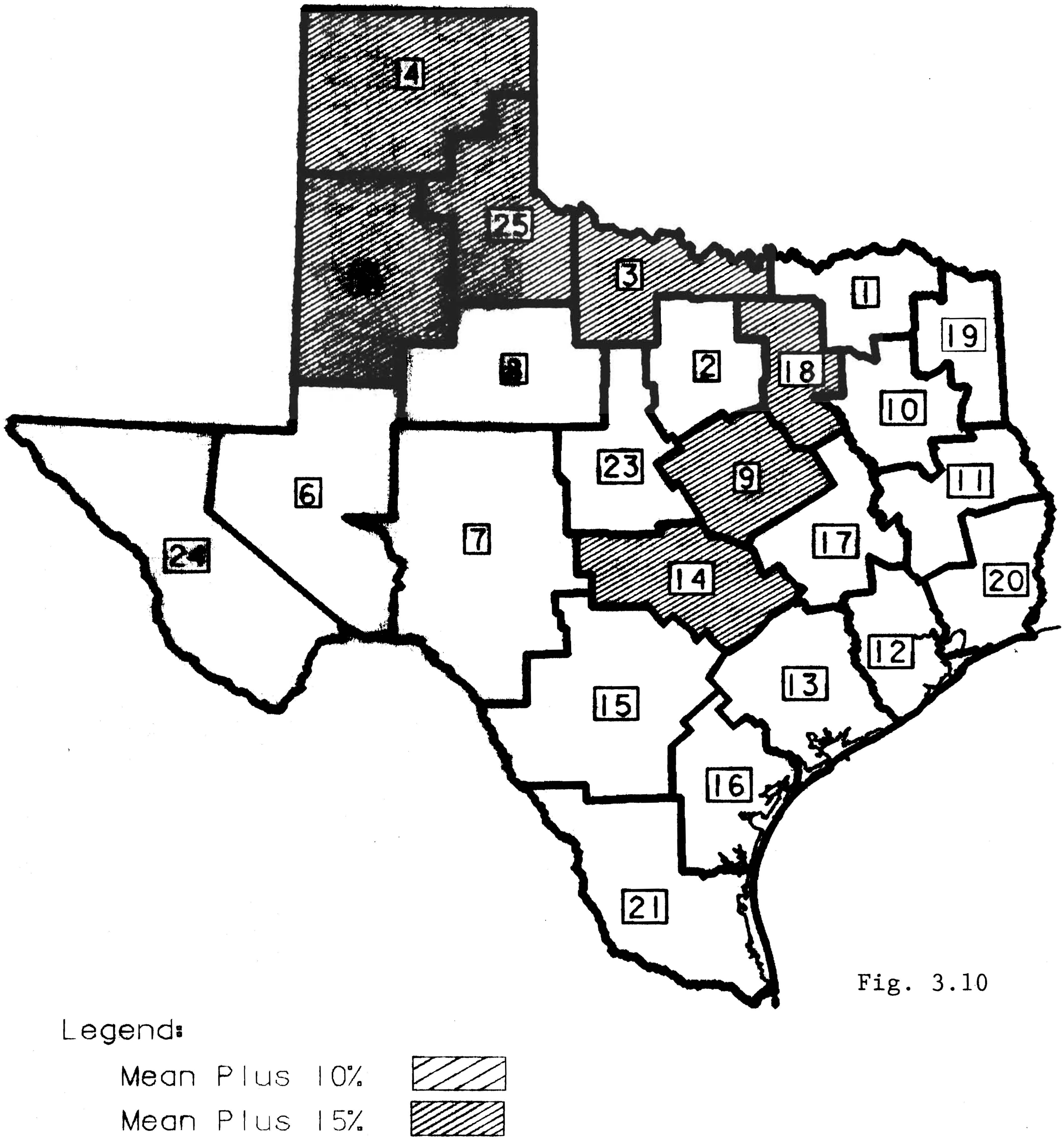


Fig. 3.10

Districts with Severe Failures
1984 PES--All Flexible Pavements

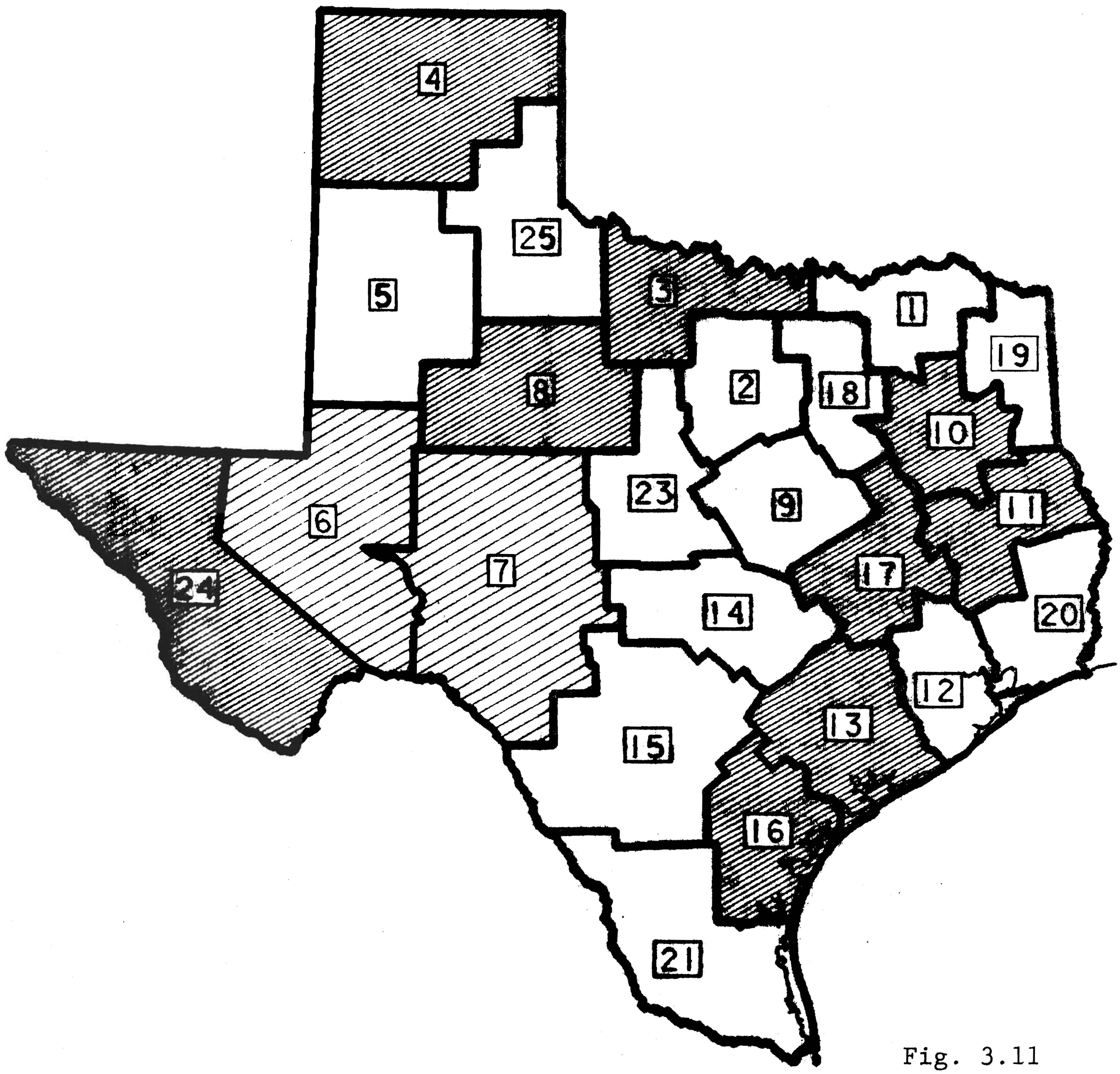


Fig. 3.11

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Severe Alligator Cracking

1984 PES--All Flexible Pavements

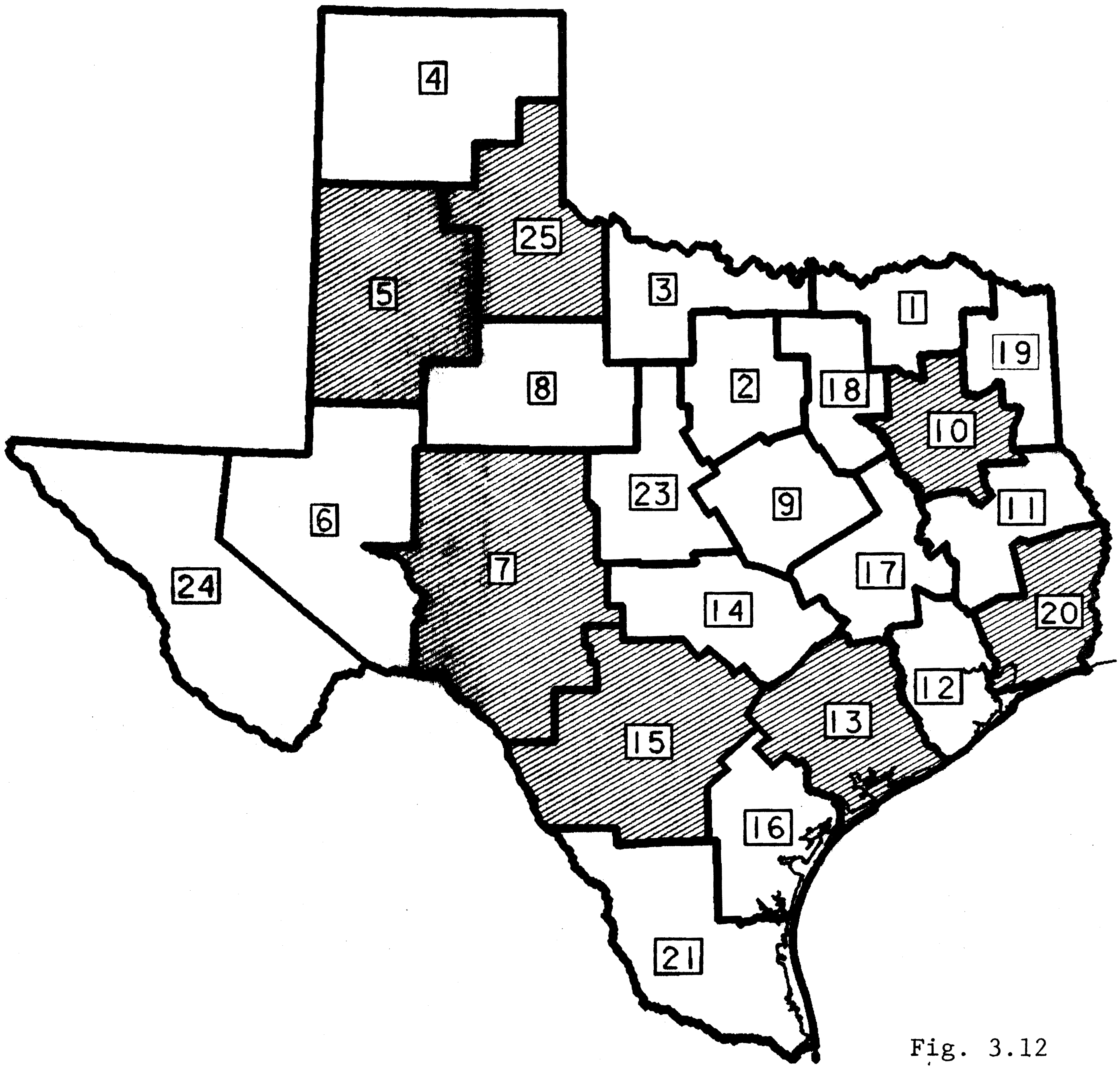


Fig. 3.12

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Severe Longitudinal Cracking
1984 PES--All Flexible Pavements

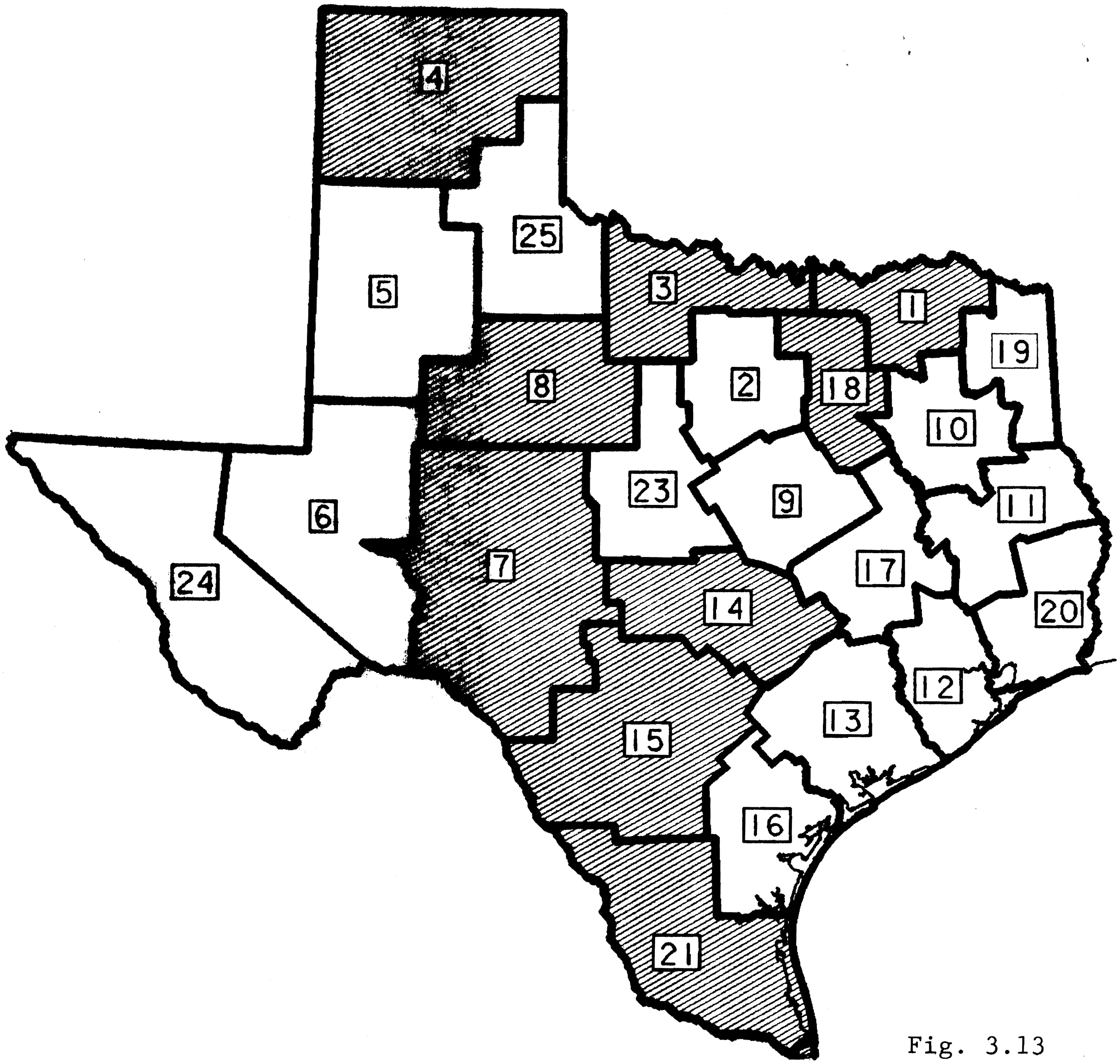


Fig. 3.13

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Severe Transverse Cracks
1984 PES--All Flexible Pavements

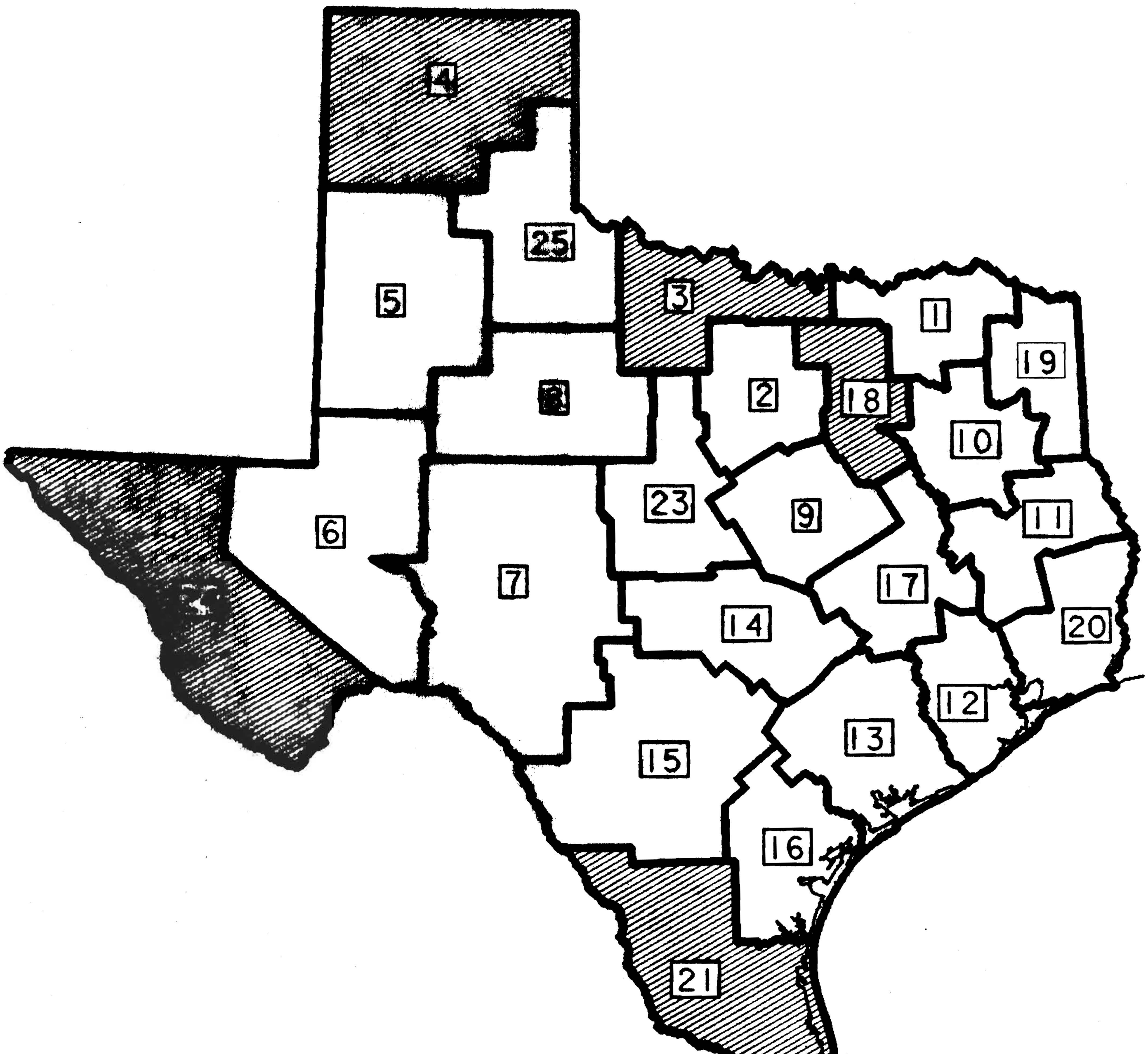


Fig. 3.14

Legend:

Mean Plus 10%

Mean Plus 15%

NOTES

Districts with Rough Flexible Pavements
1984 PES--All Systems

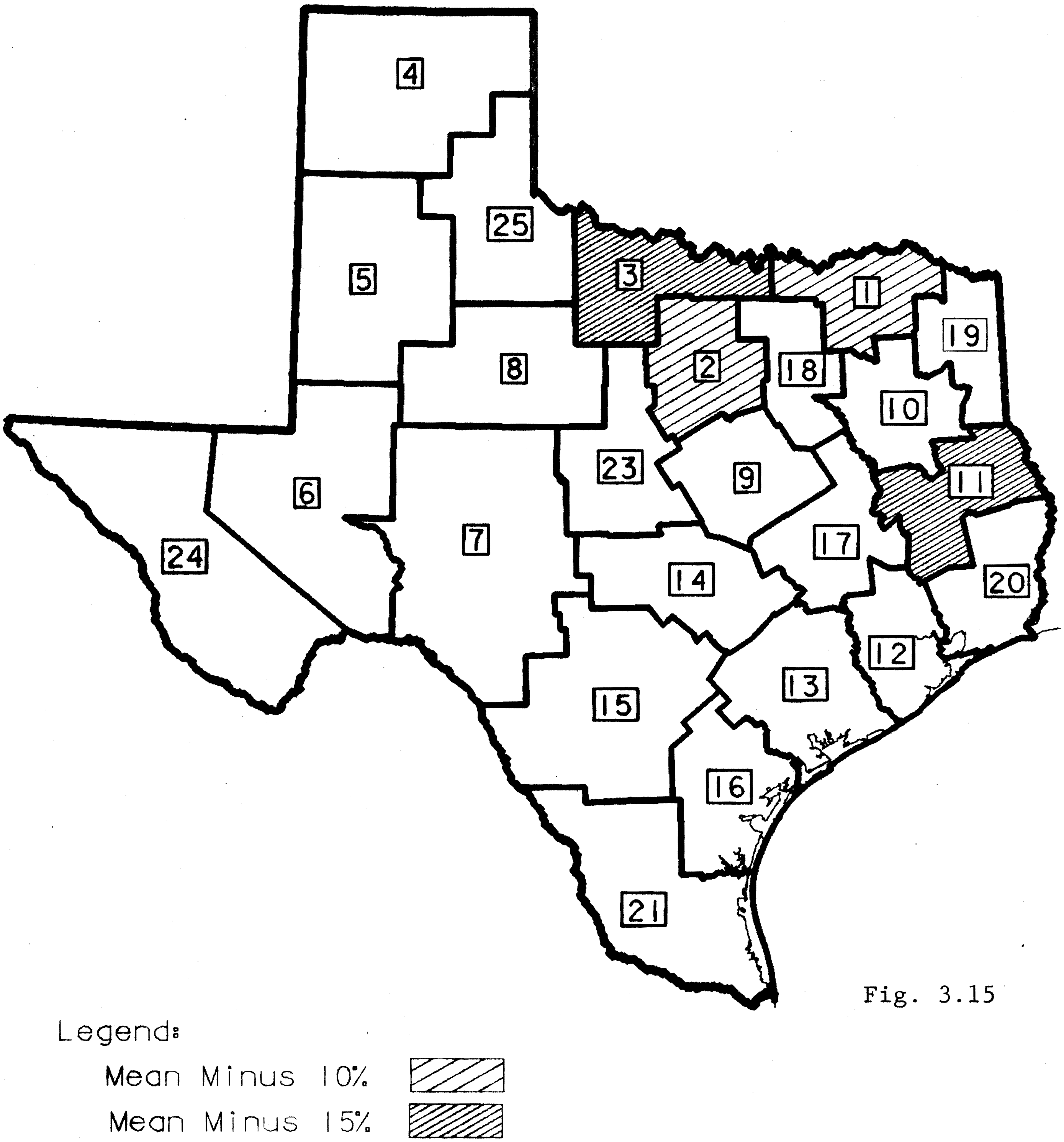


Fig. 3.15

Districts with Rough Flexible Pavements
1984 PES--IH System

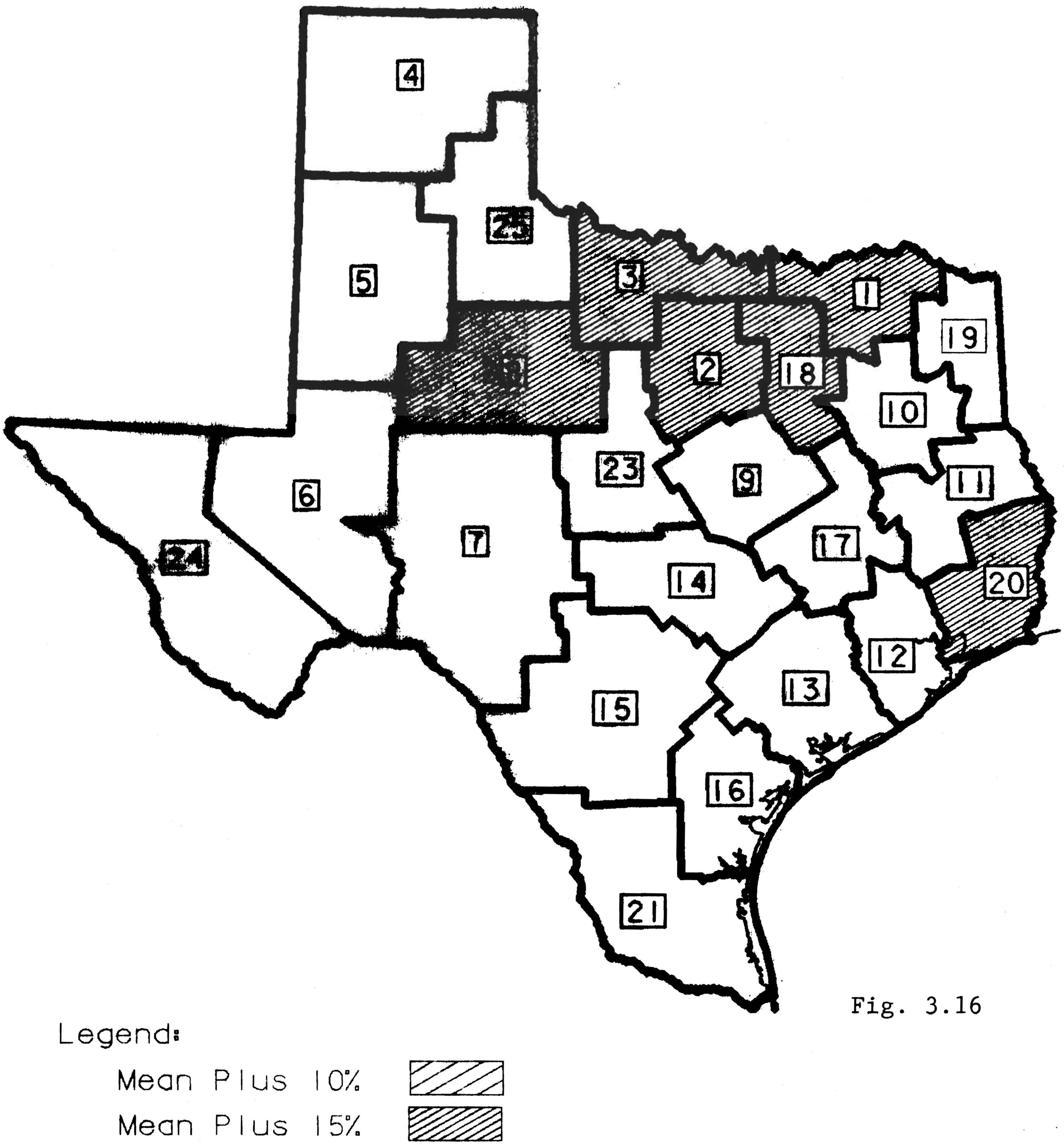


Fig. 3.16

Districts with Rough Flexible Pavements
1984 PES--US System

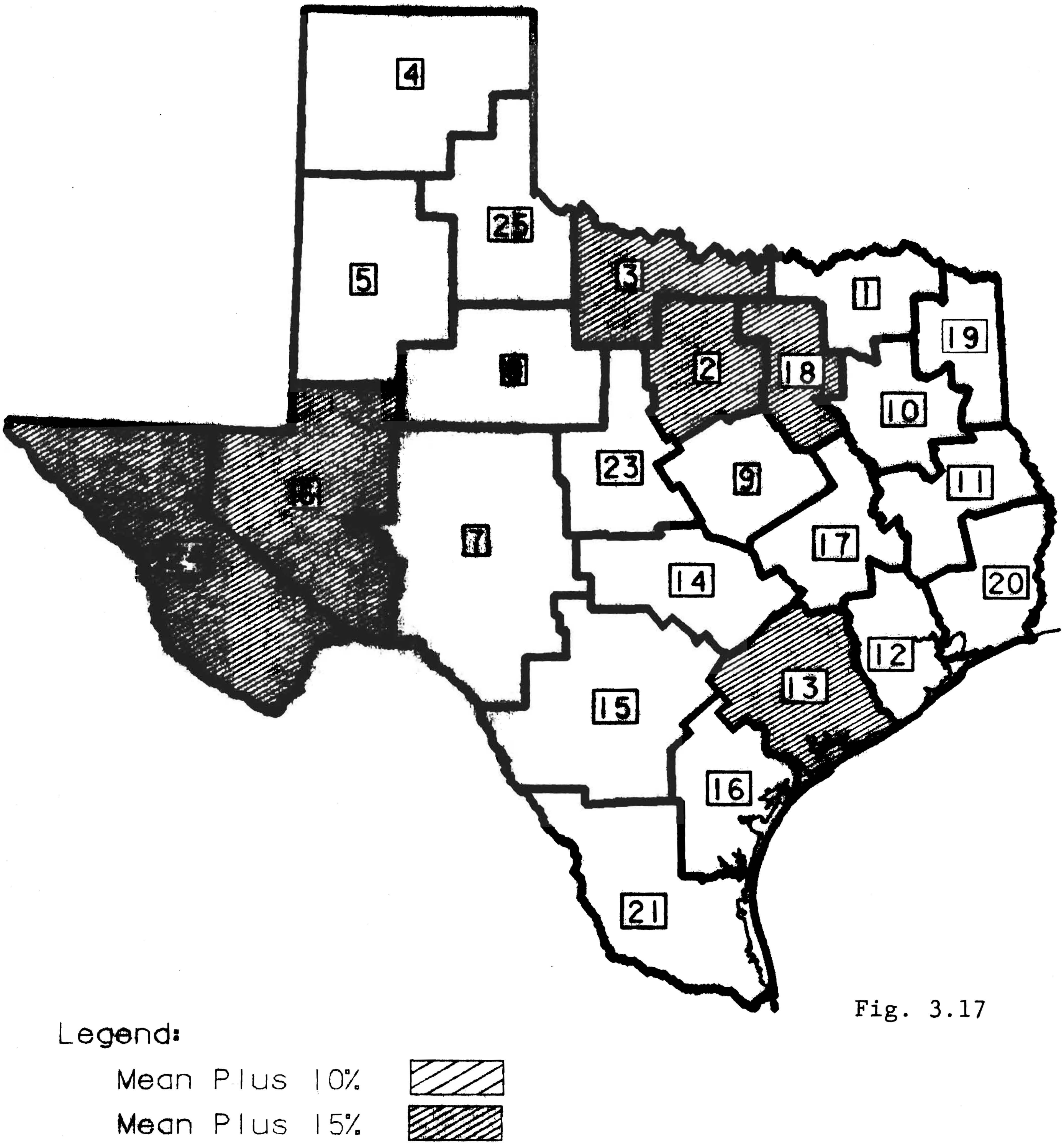


Fig. 3.17

Districts with Rough Flexible Pavements
1984 PES--SH System

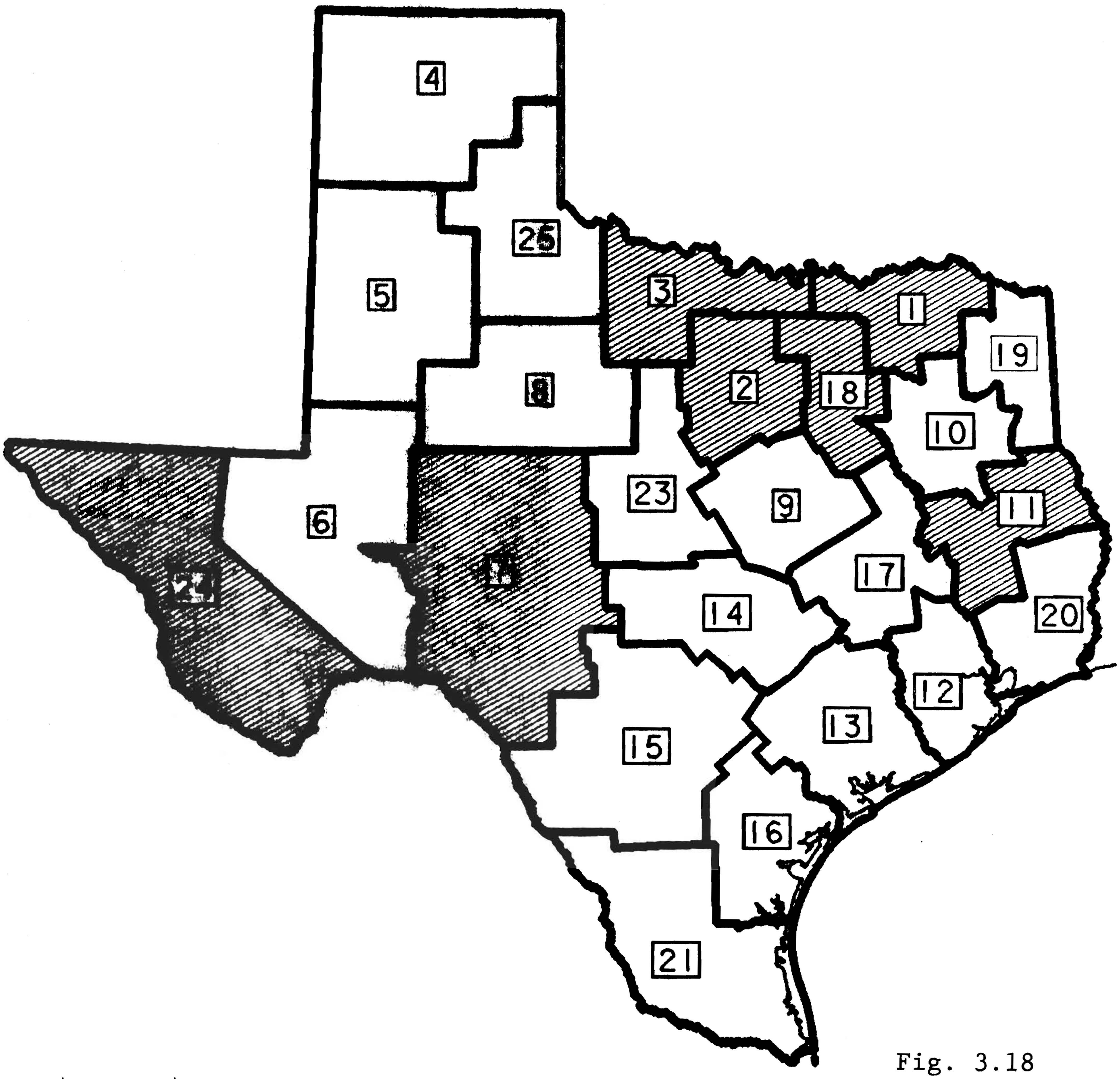


Fig. 3.18

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Rough Flexible Pavements
1984 PES--FM System

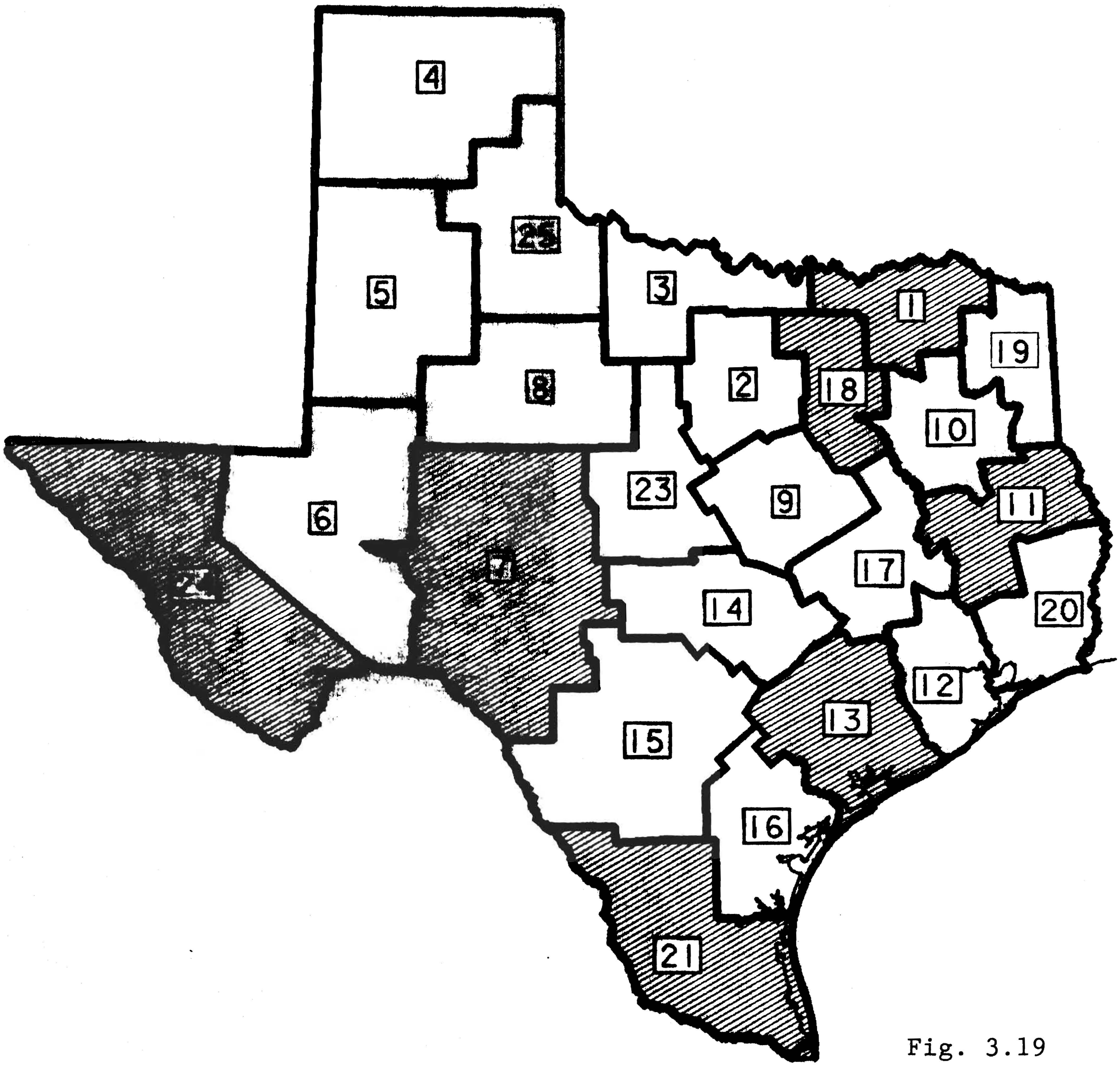


Fig. 3.19

Legend:

Mean Plus 10%

Mean Plus 15%

NOTES

Districts with Low Flexible Pavement Scores

1984 PES--All Flexible Pavements

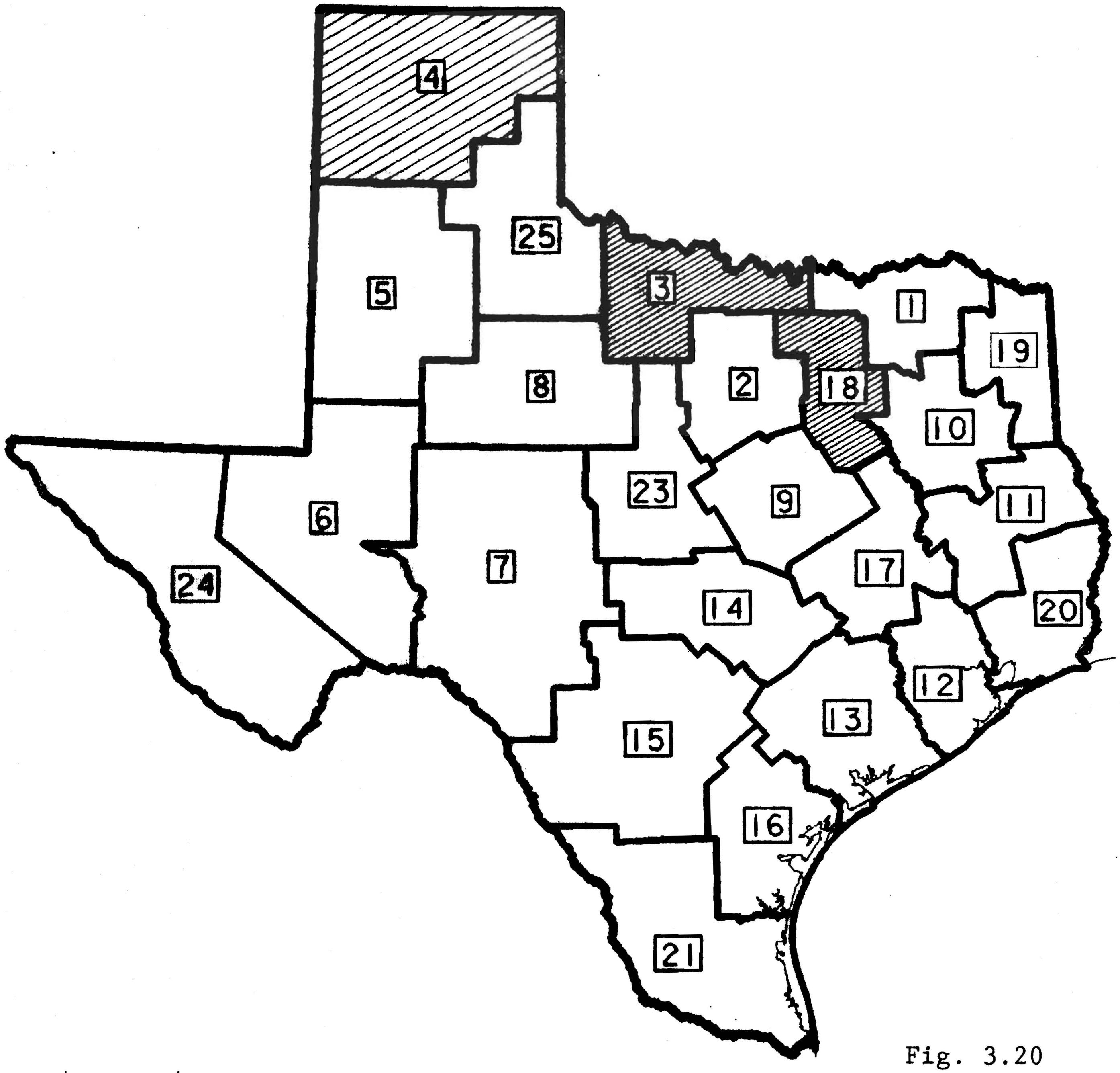


Fig. 3.20

Legend:

Mean Minus 10%

Mean Minus 15%

Districts with Low Flexible Pavement Scores
1984 PES--IH System

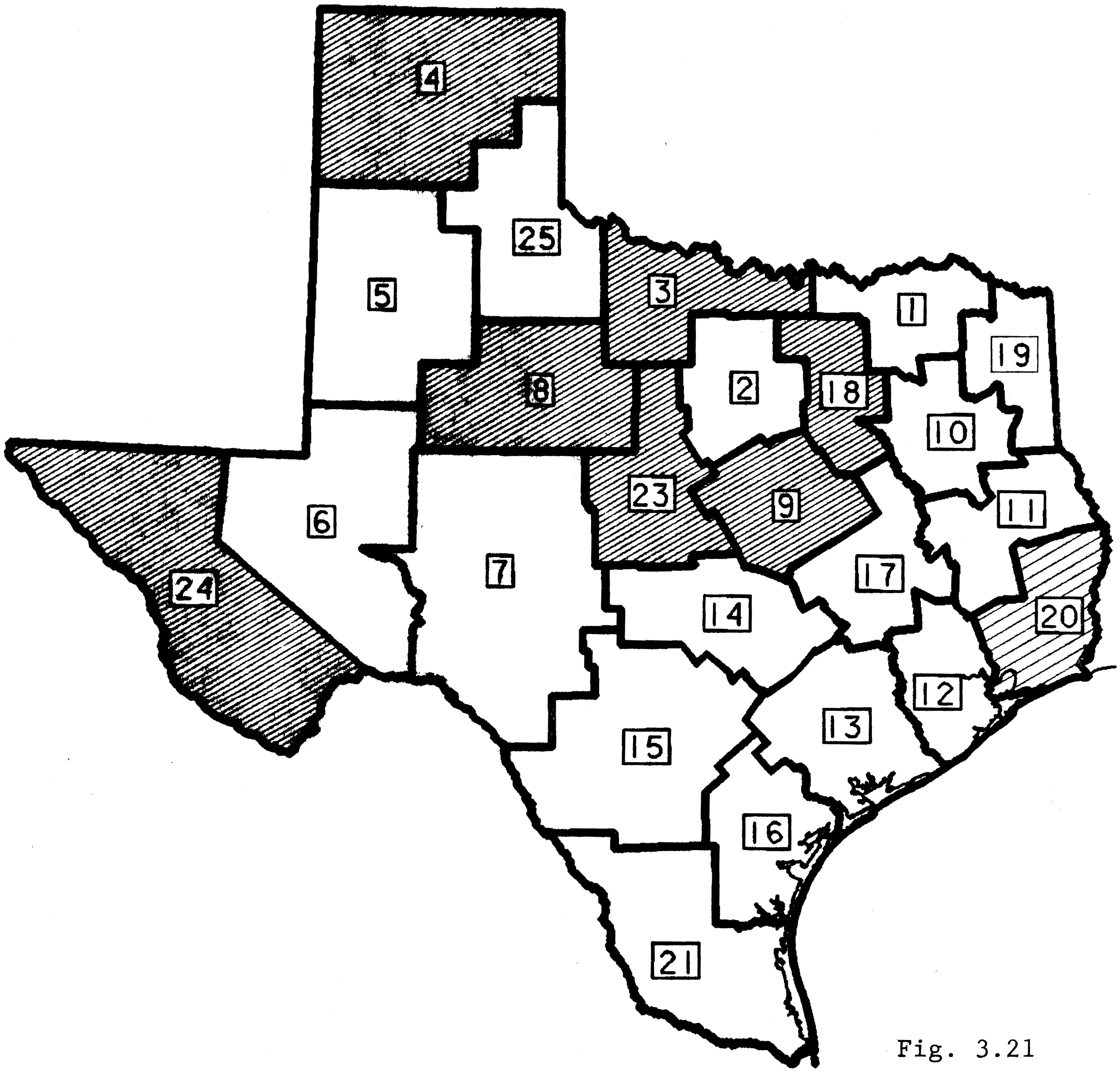


Fig. 3.21

Legend:
Mean Plus 10%
Mean Plus 15%

Districts with Low Flexible Pavement Scores
1984 PES--US System

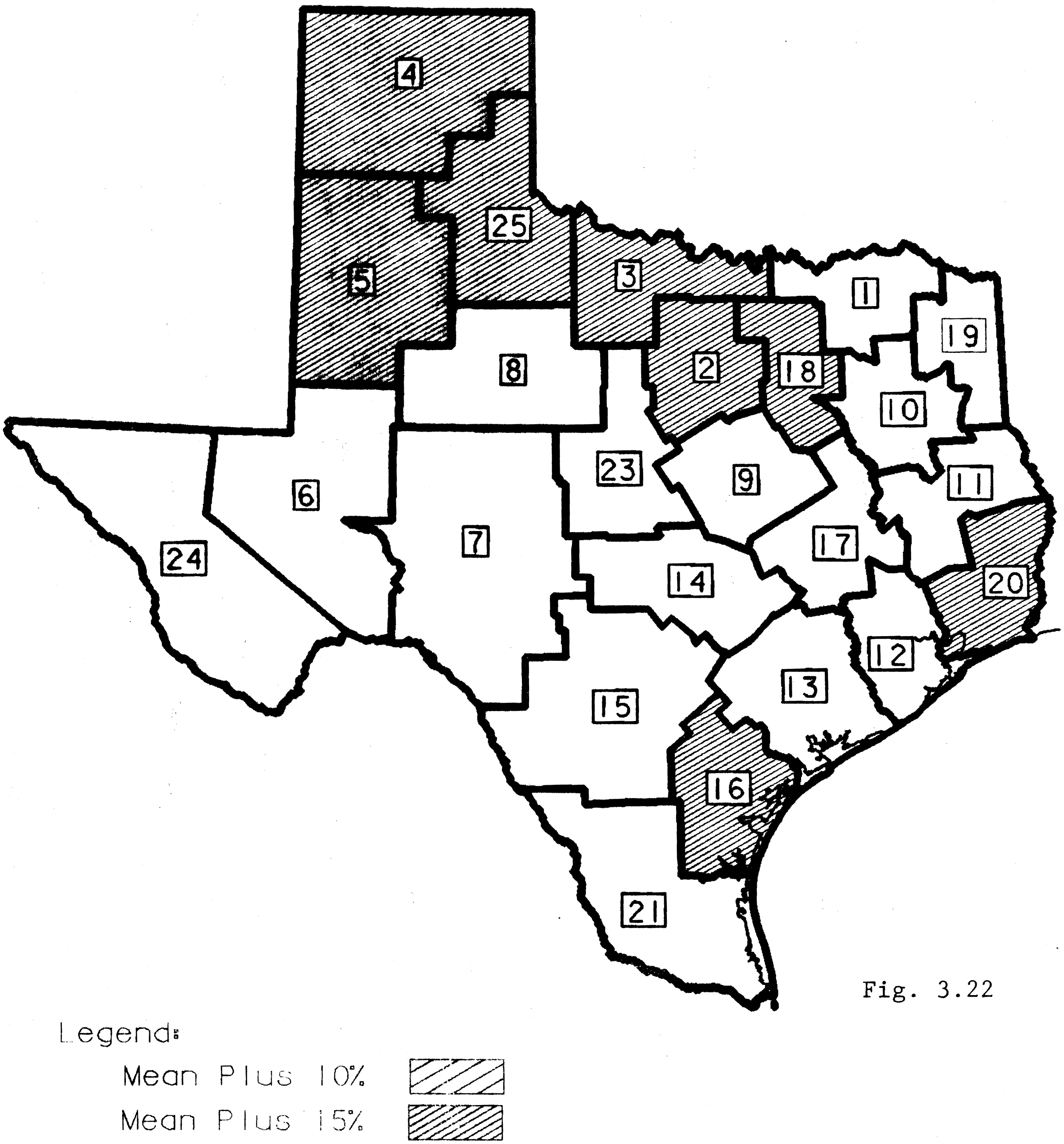


Fig. 3.22

Districts with Low Flexible Pavement Scores
1984 PES--SH System

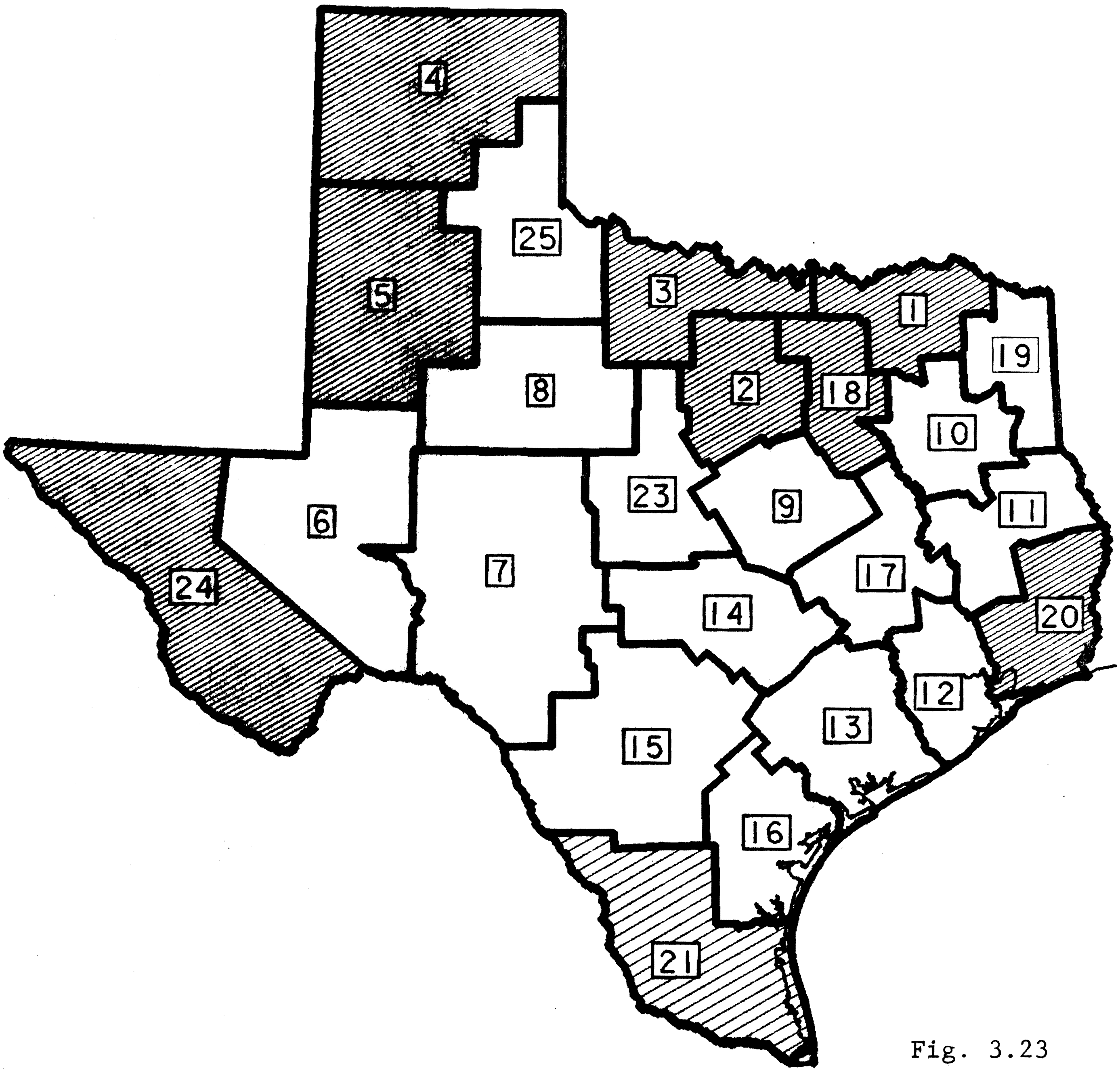


Fig. 3.23

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Low Flexible Pavement Scores
1984 PES--FM System

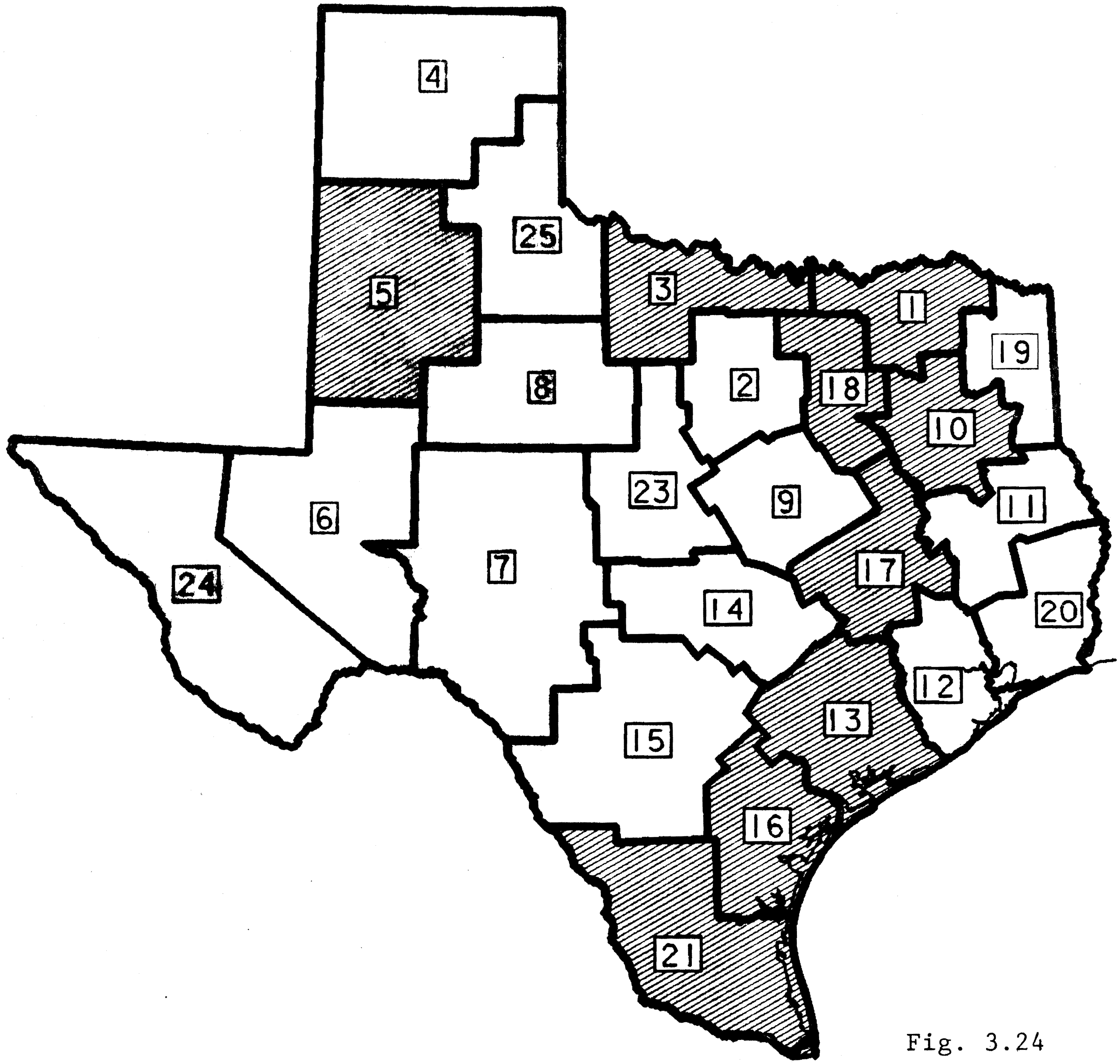


Fig. 3.24

Legend:

Mean Plus 10%

Mean Plus 15%

NOTES

Districts with Excessive Spalled Cracks
1984 PES--All CRCP Sections

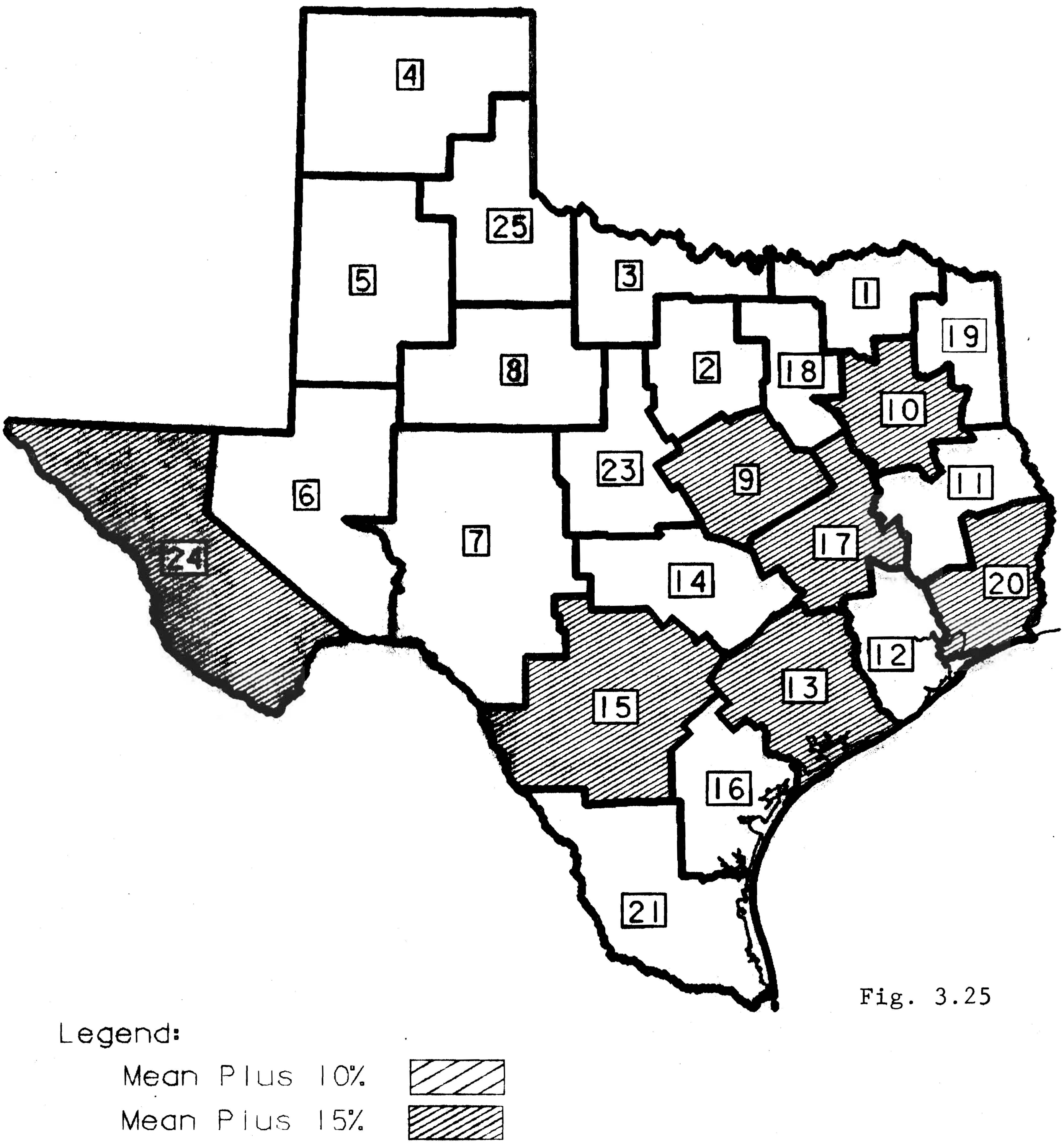


Fig. 3.25

Districts with Excessive PC Patches
1984 PES--All CRCP Sections

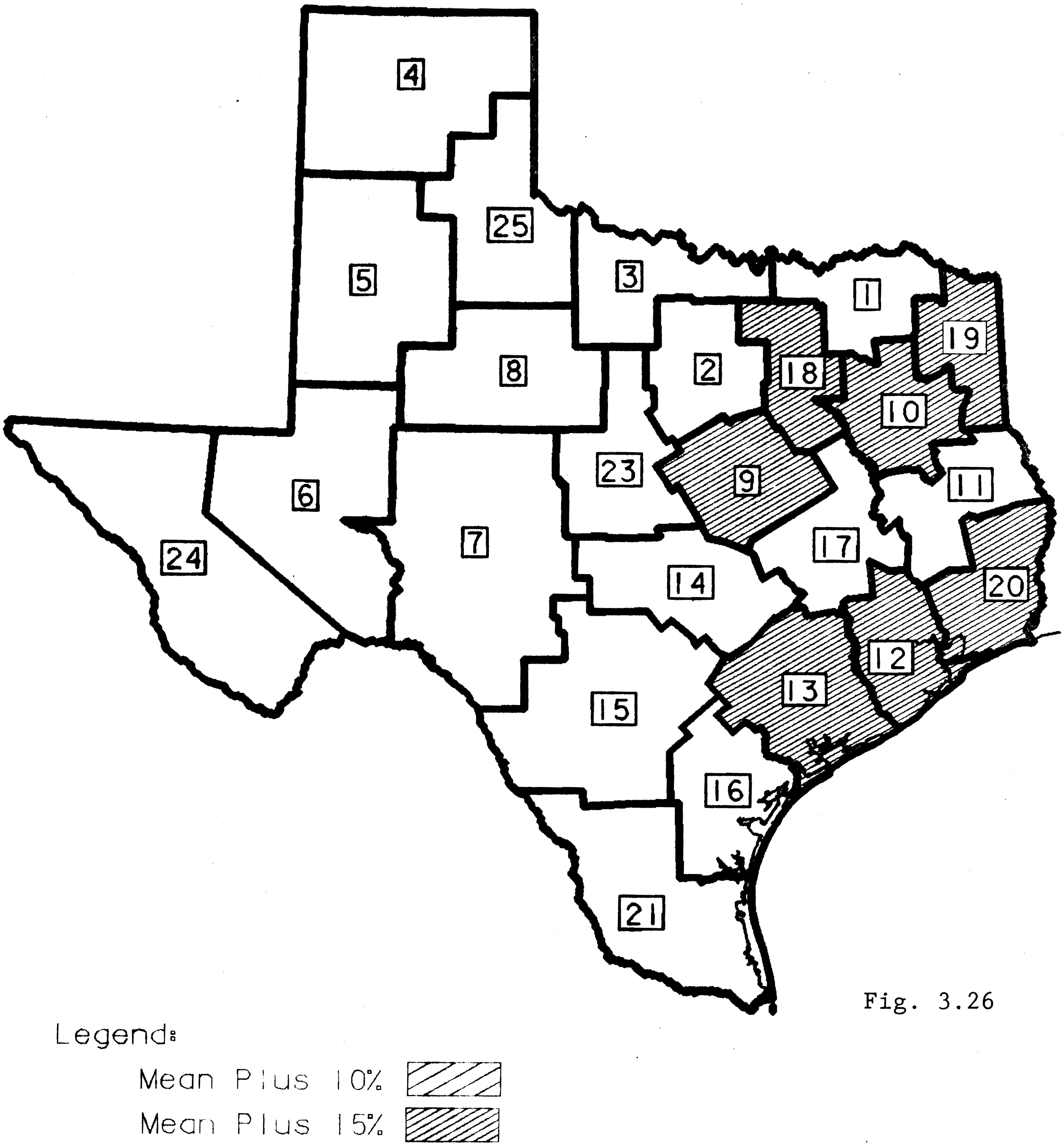


Fig. 3.26

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive Punchouts
1984 PES--All CRCP Sections

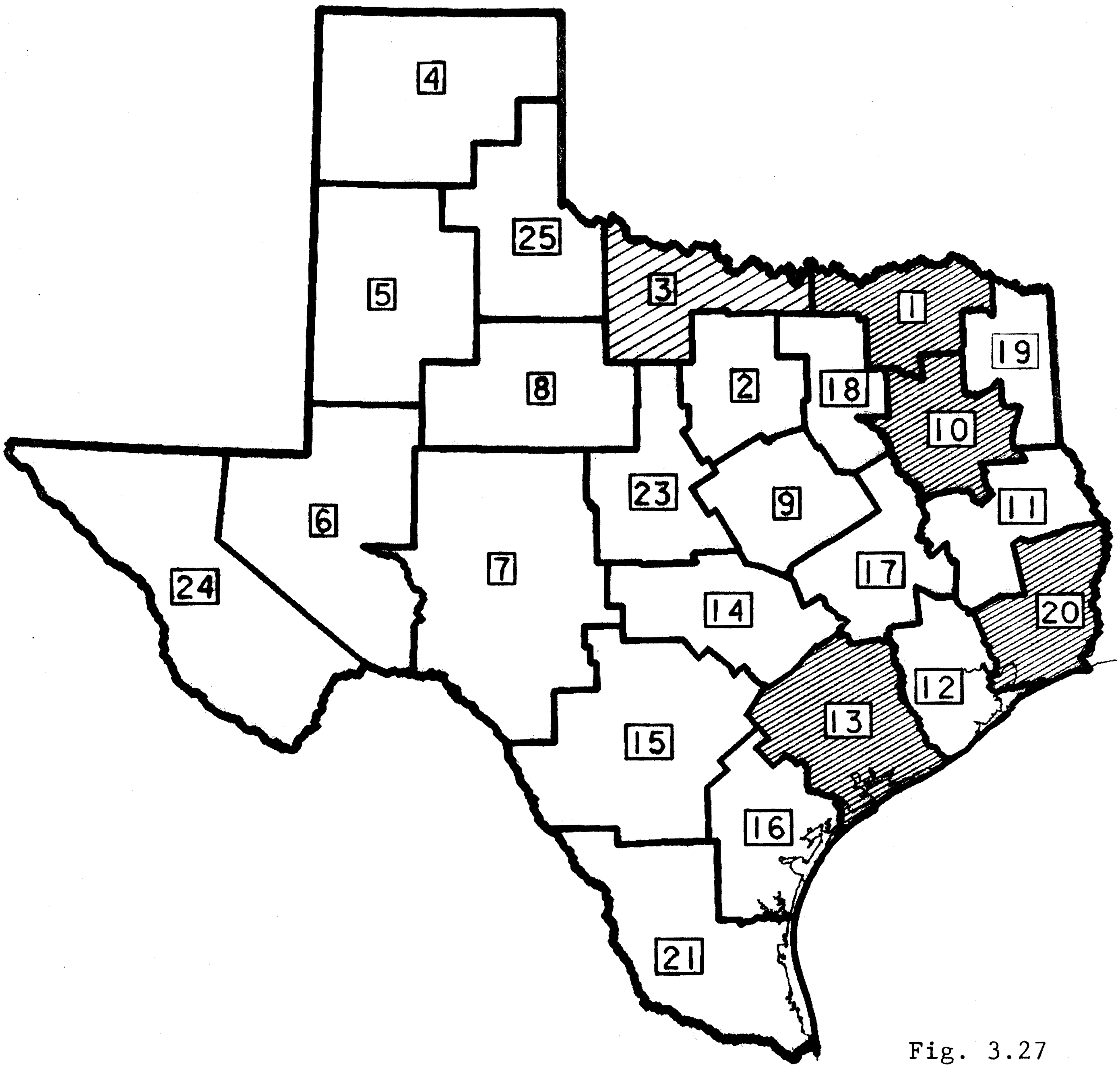


Fig. 3.27

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive AC Patches

1984 PES--All CRCP Sections

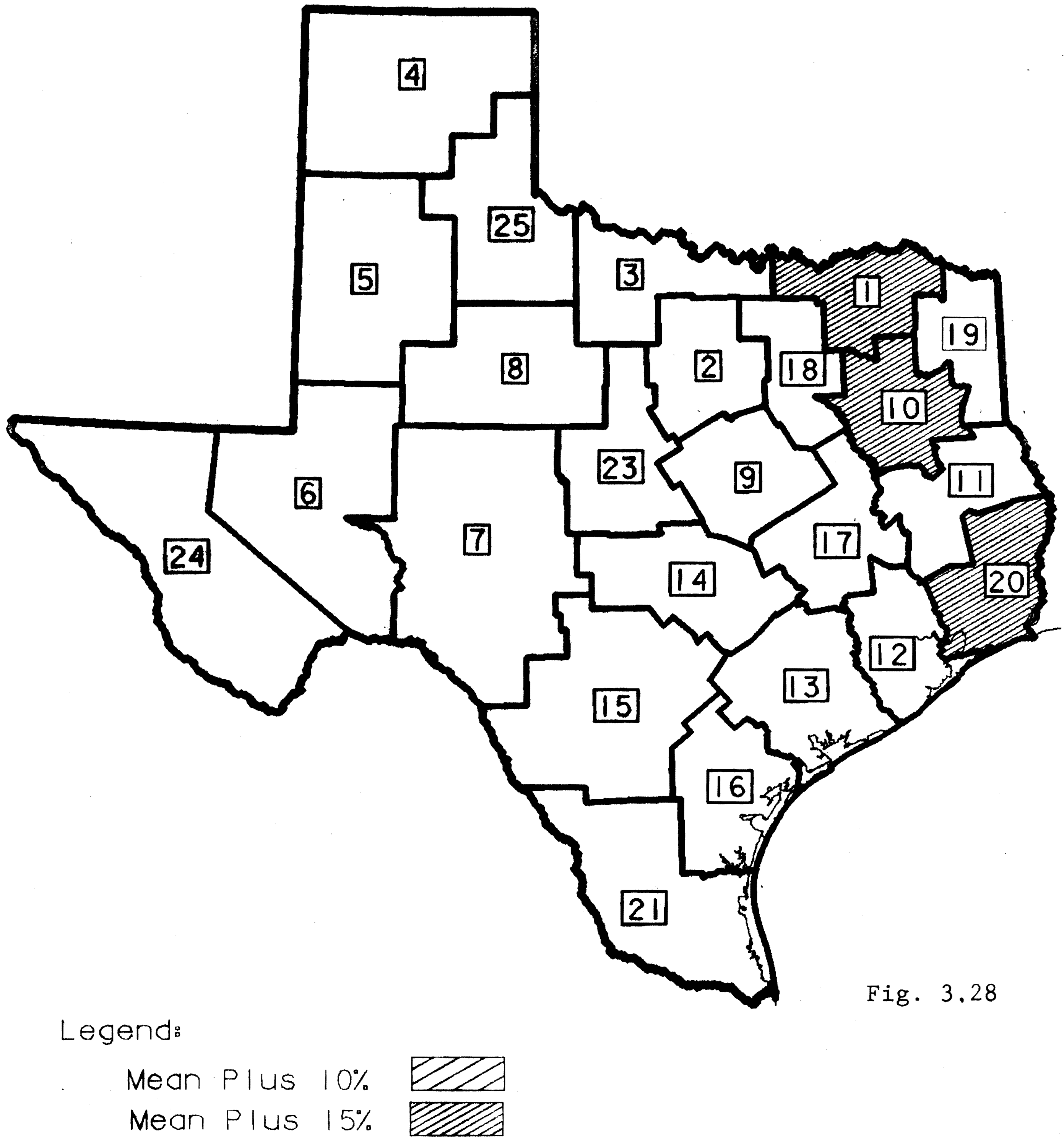


Fig. 3.28

Districts with Rough CRCP Sections
1984 PES--All Systems

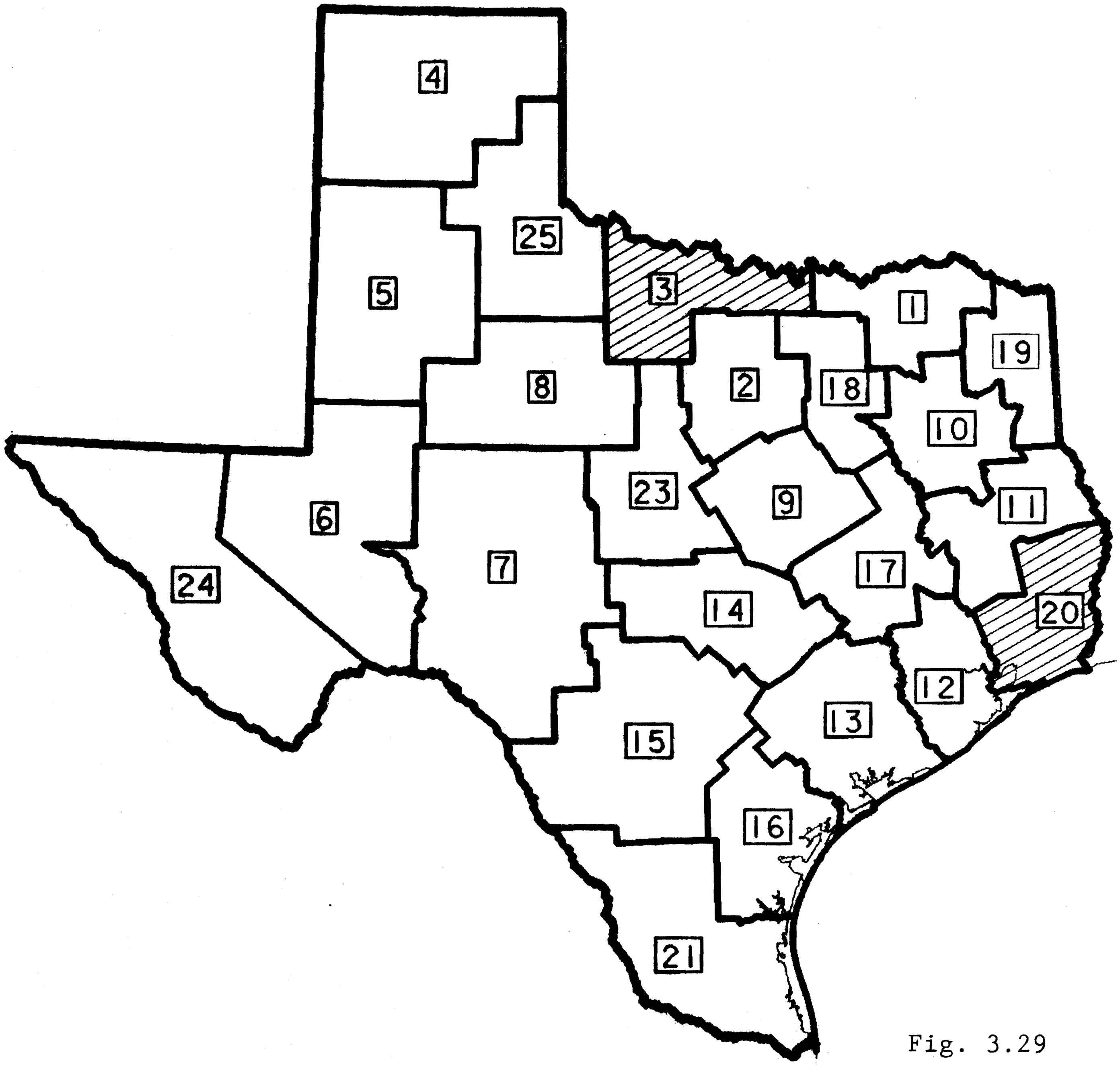


Fig. 3.29

Legend:

Mean Minus 10%

Mean Minus 15%

Districts with Rough CRCP Sections
1984 PES--IH System

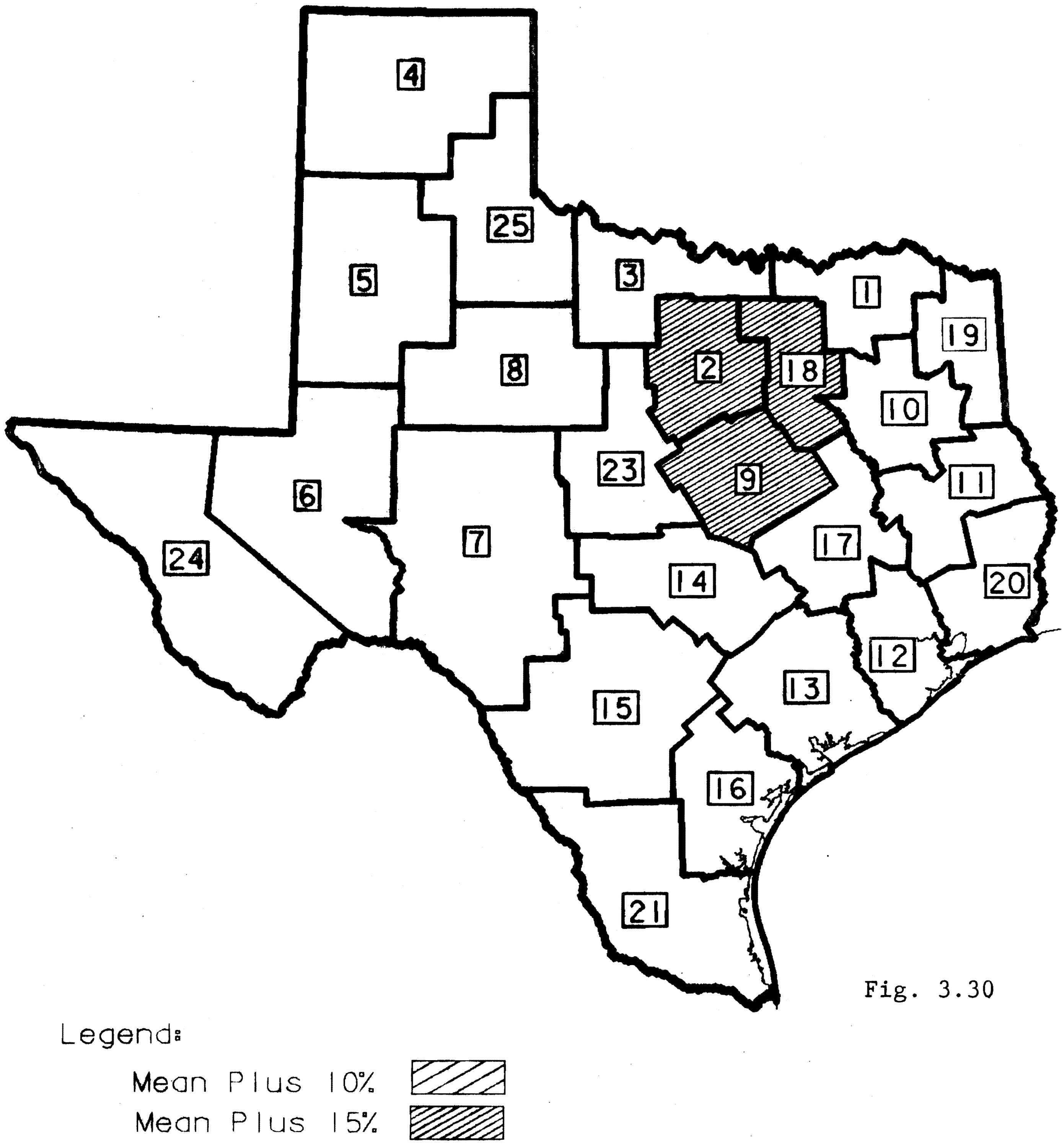


Fig. 3.30

Districts with Rough CRCP Sections
1984 PES--US System

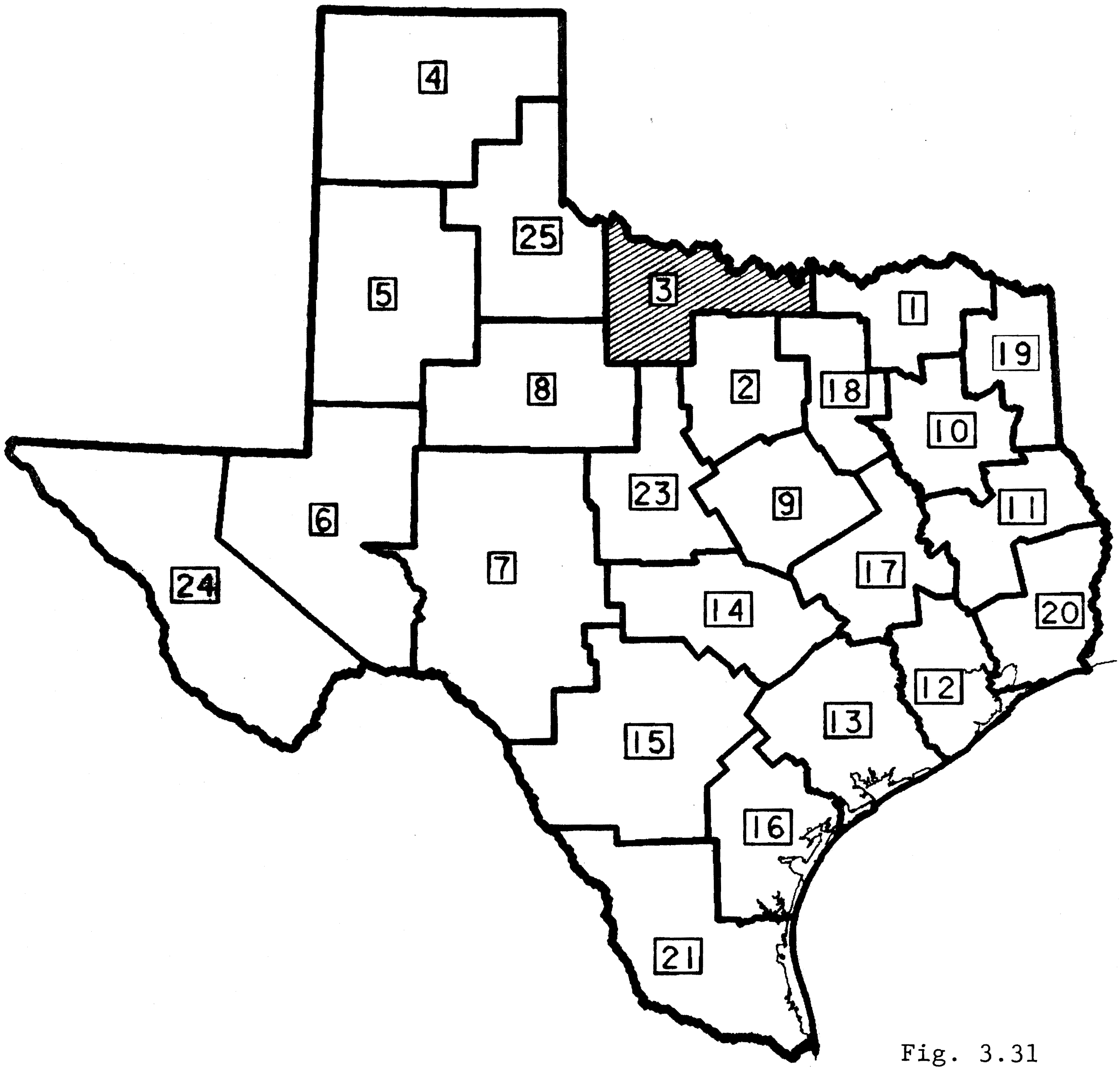


Fig. 3.31

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Rough CRCP Sections
1984 PES--SH System

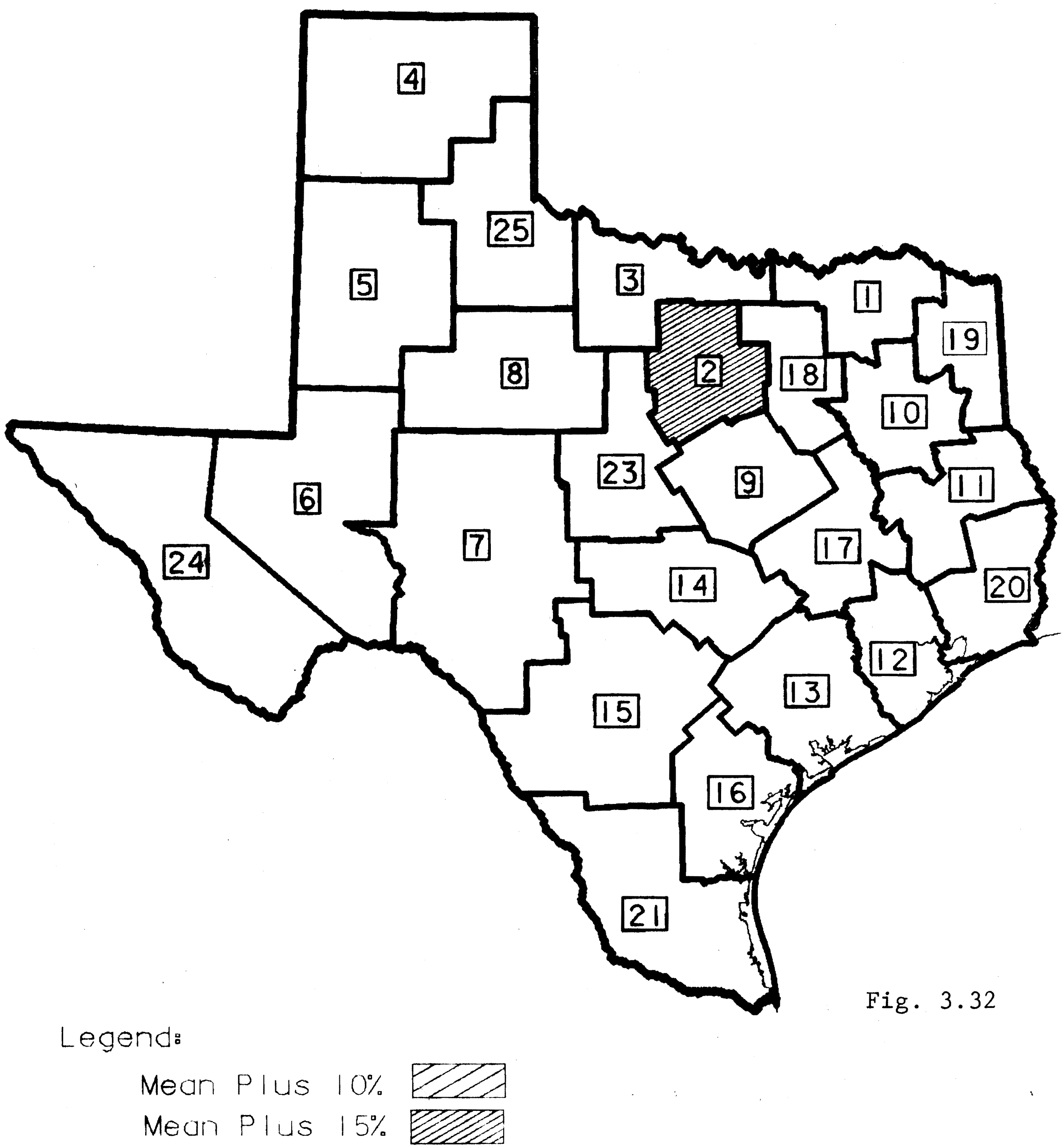


Fig. 3.32

Districts with Low CRCP Pavement Scores
1984 PES--All Systems

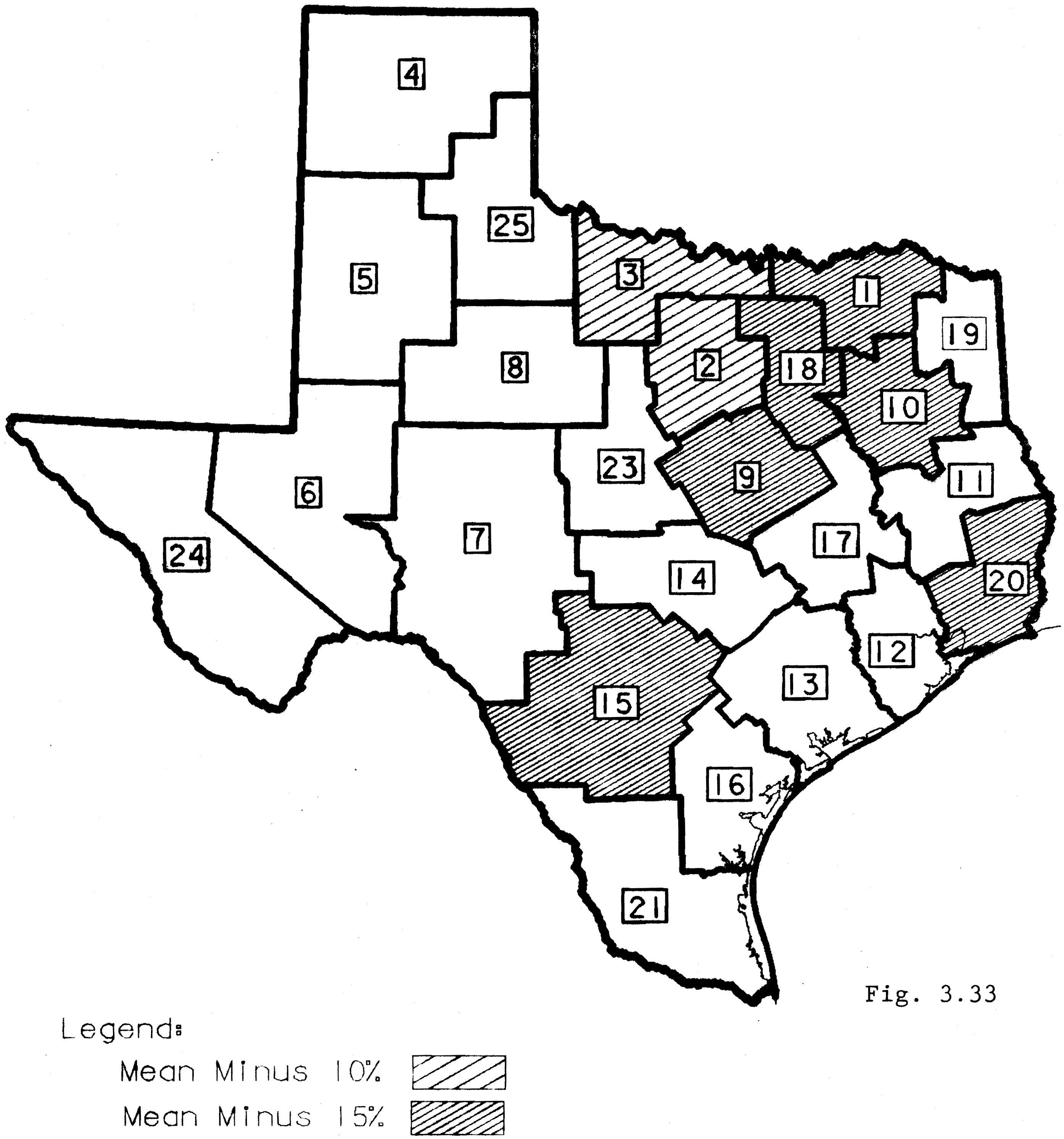


Fig. 3.33

Districts with Low CRCP Pavement Scores
1984 PES--IH System

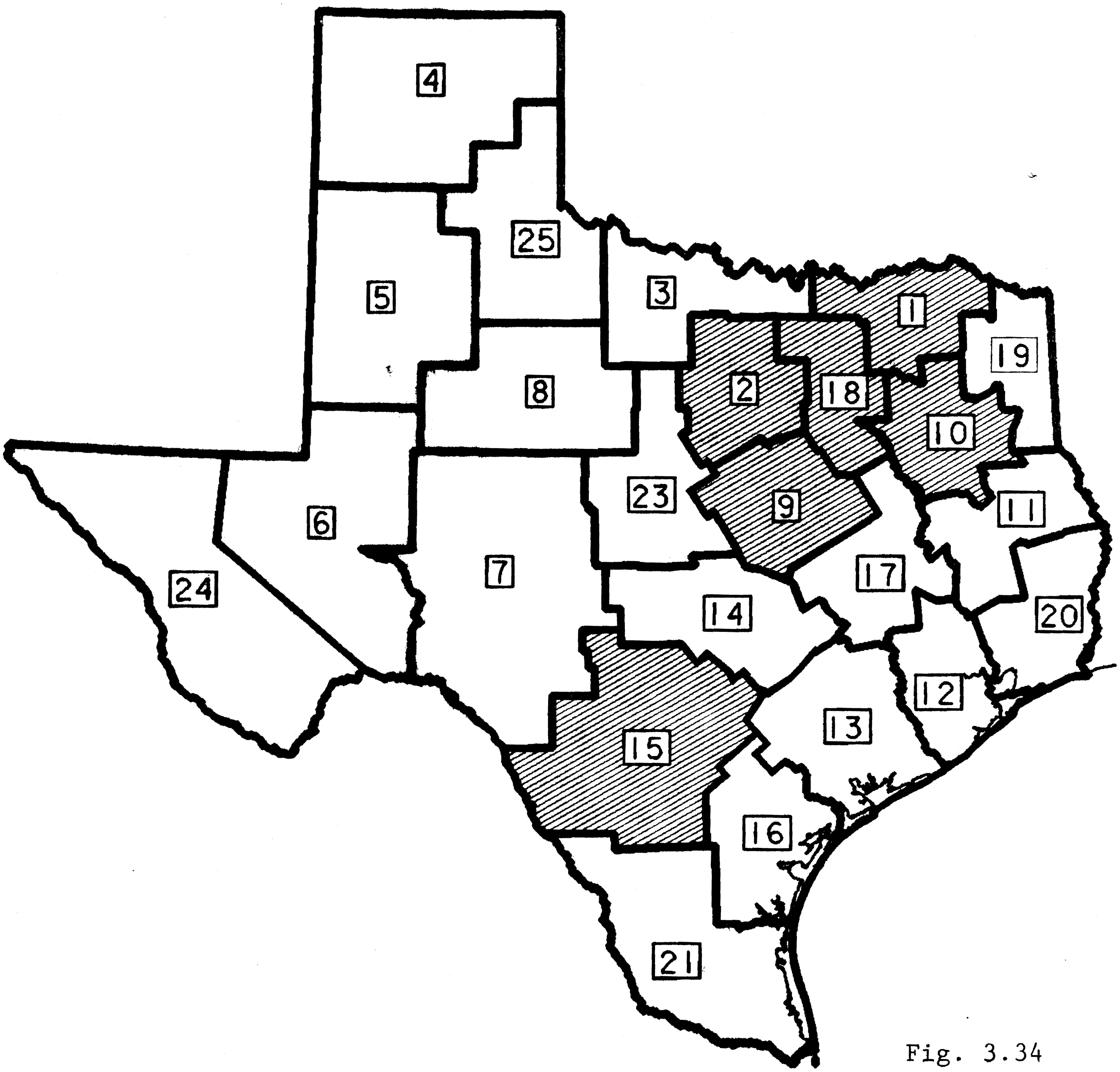


Fig. 3.34

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Low CRCP Pavement Scores
1984 PES--US System

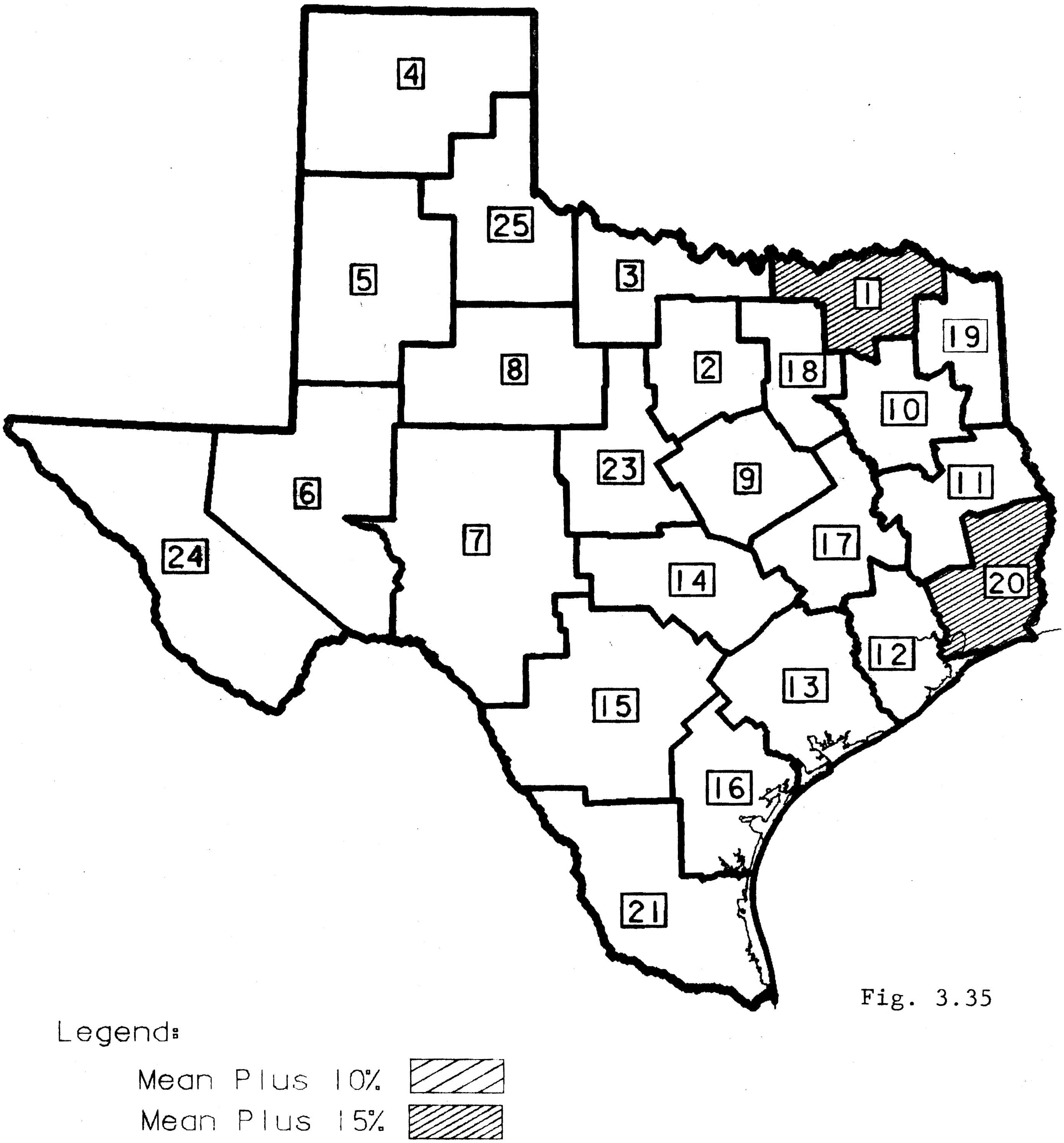


Fig. 3.35

Districts with Low CRCP Pavement Scores

1984 PES--SH System

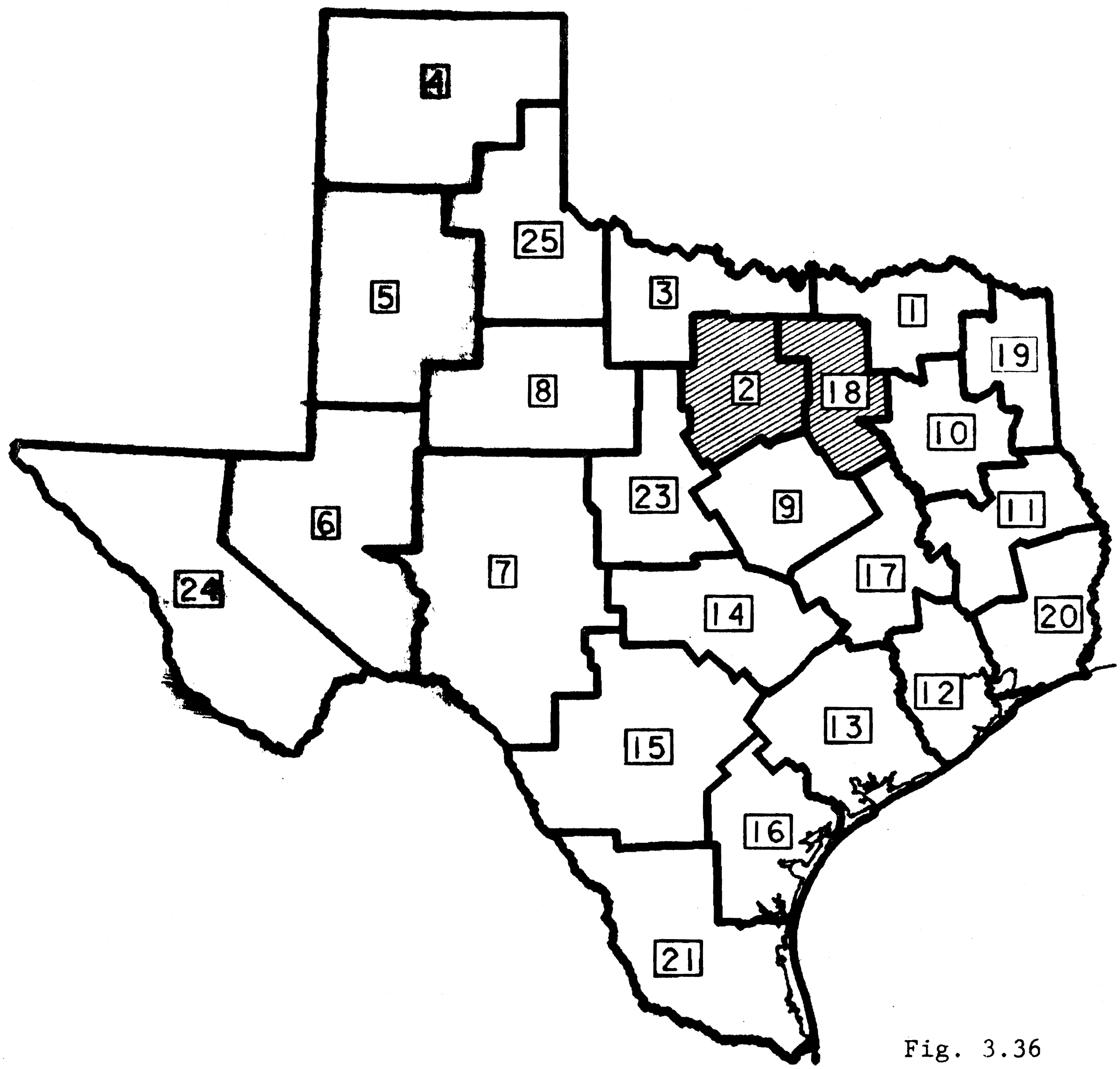


Fig. 3.36

Legend:

Mean Plus 10%

Mean Plus 15%

NOTES

Districts with Excessive Spalled Cracks

1984 PES--All JCP Sections

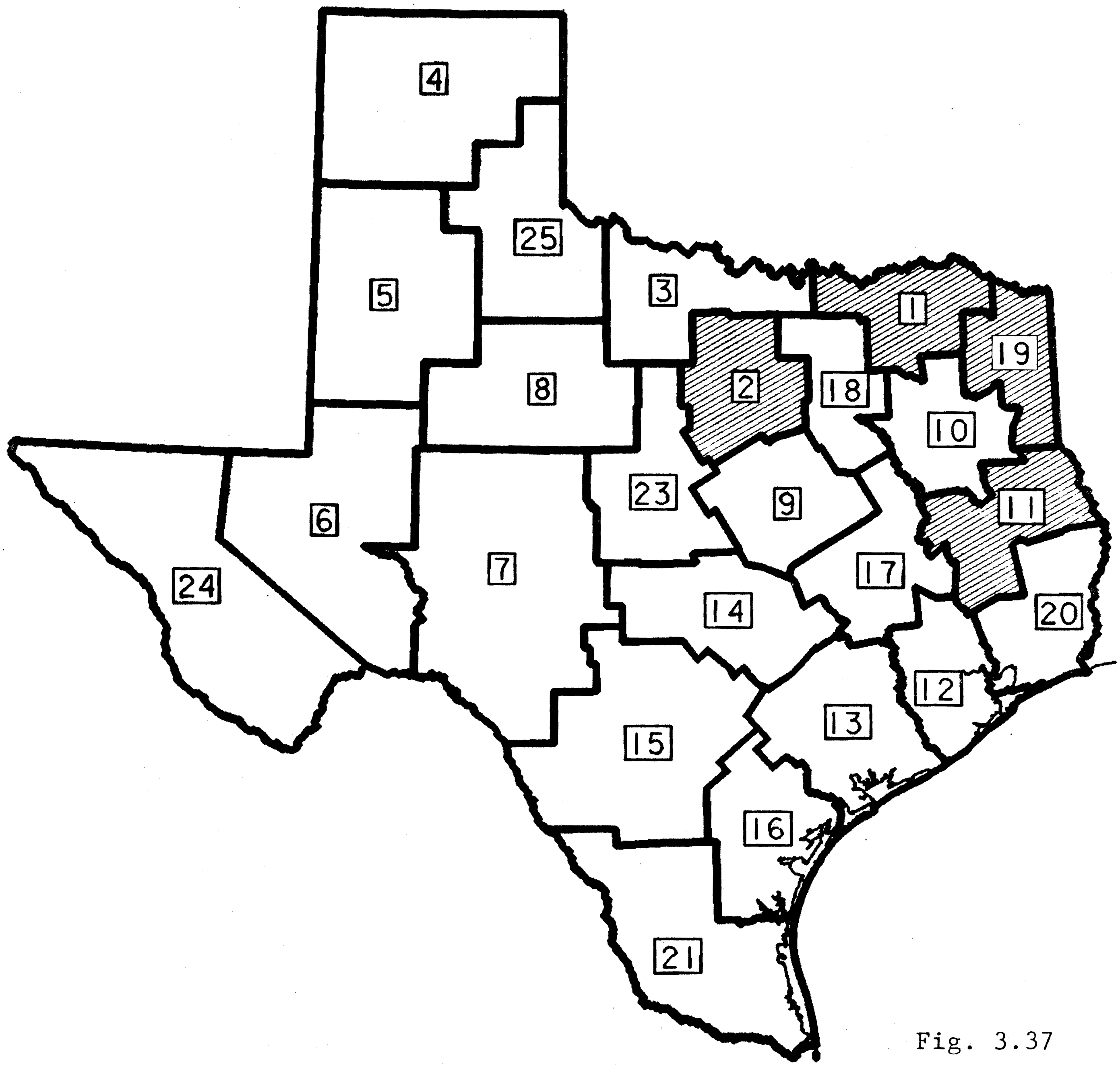


Fig. 3.37

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive Longitudinal Cracks

1984 PES--All JCP Sections

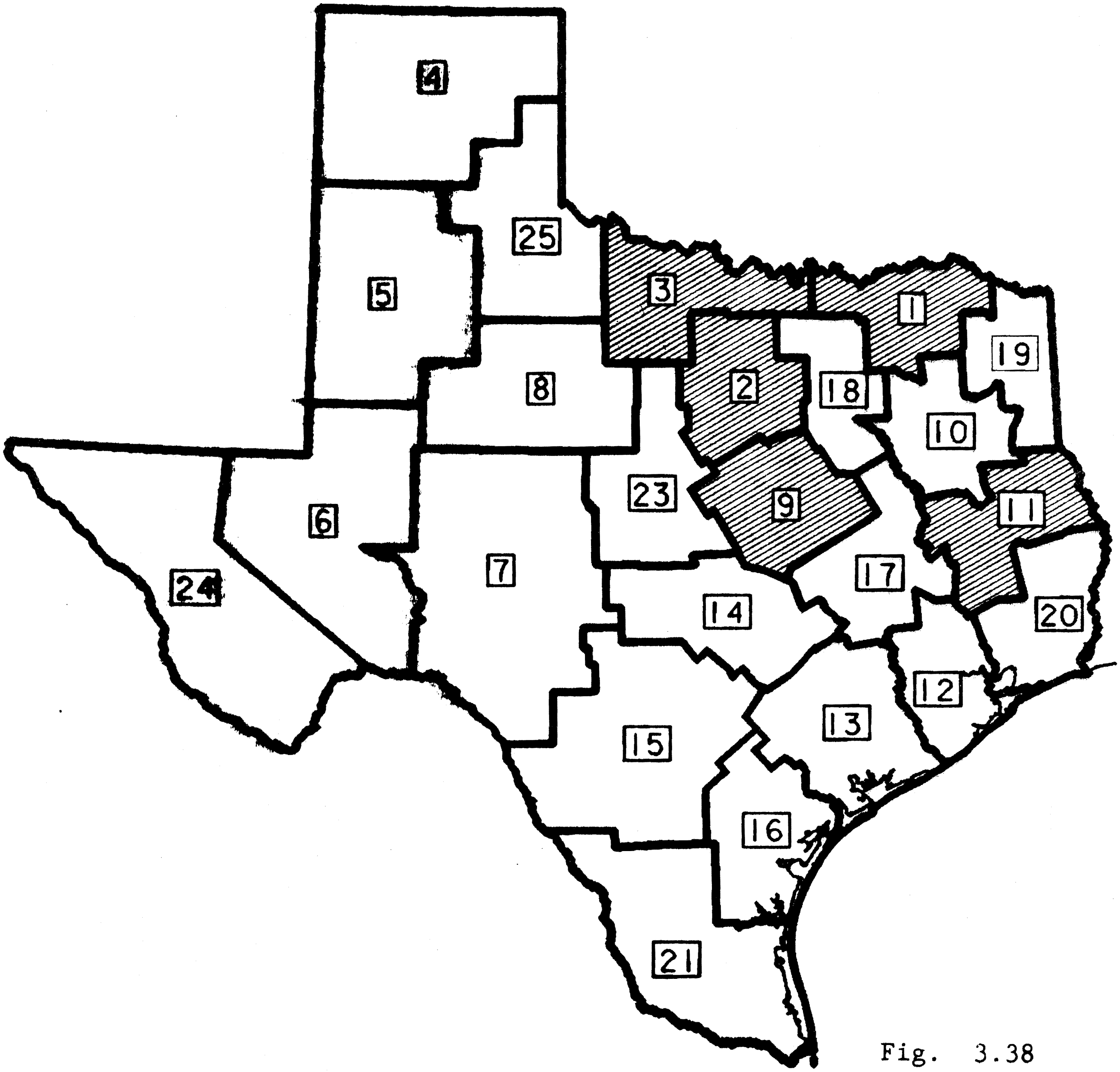


Fig. 3.38

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive Transverse Cracks
1984 PES--All JCP Sections

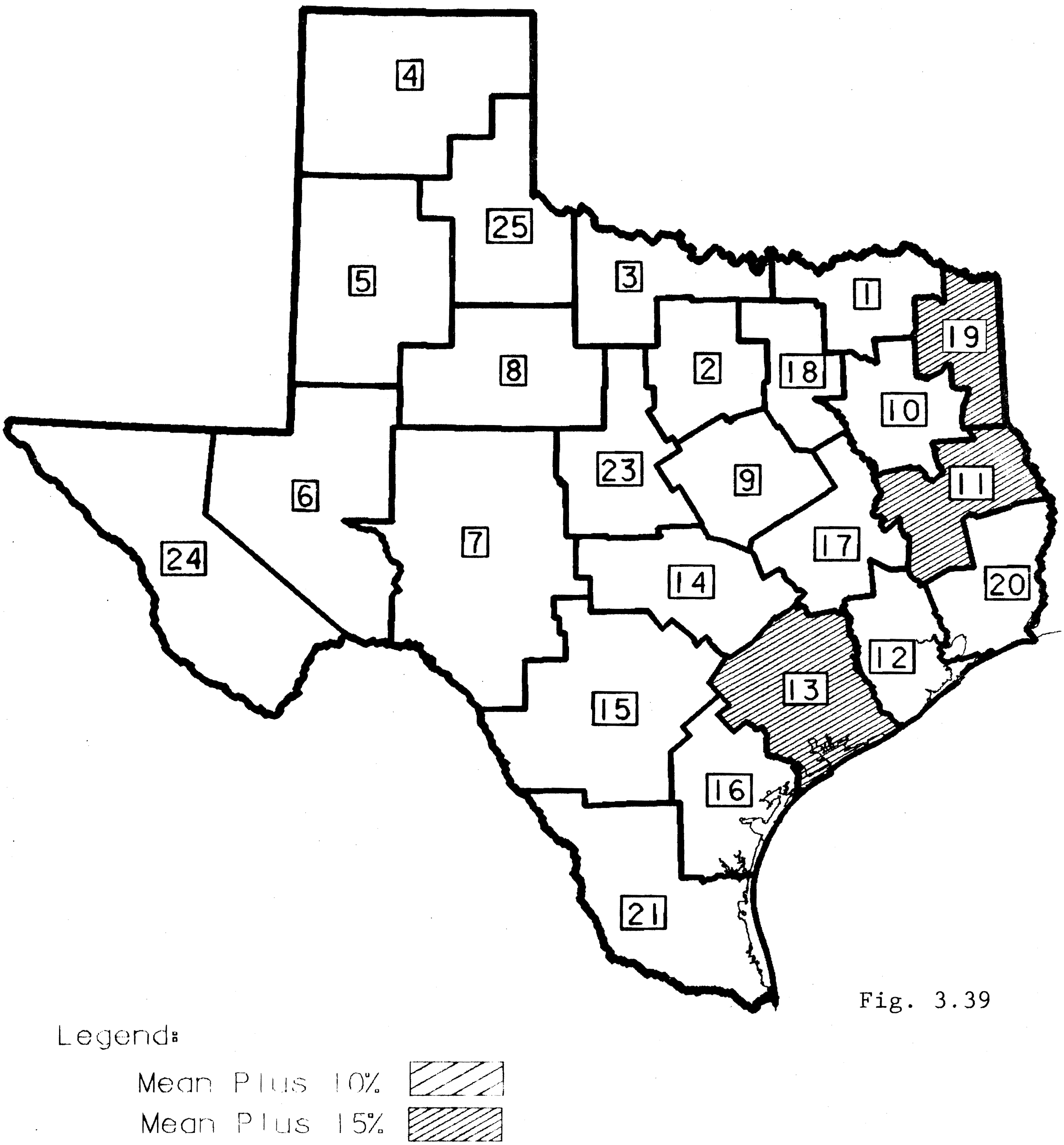


Fig. 3.39

Districts with Excessive Corner Breaks and Punchouts

1984 PES--All JCP Sections

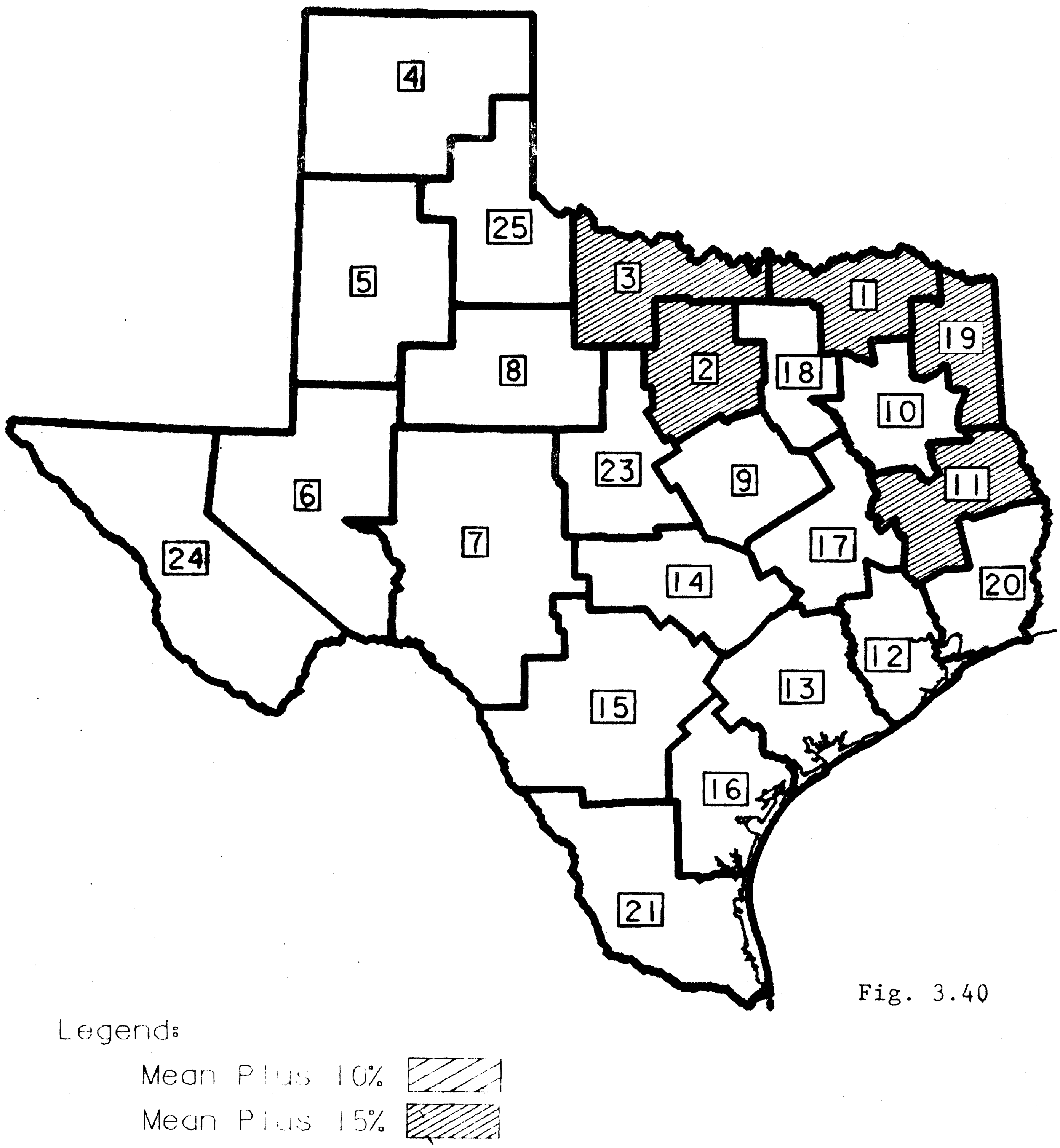


Fig. 3.40

Districts with Excessive AC Patches
1984 PES--All JCP Sections

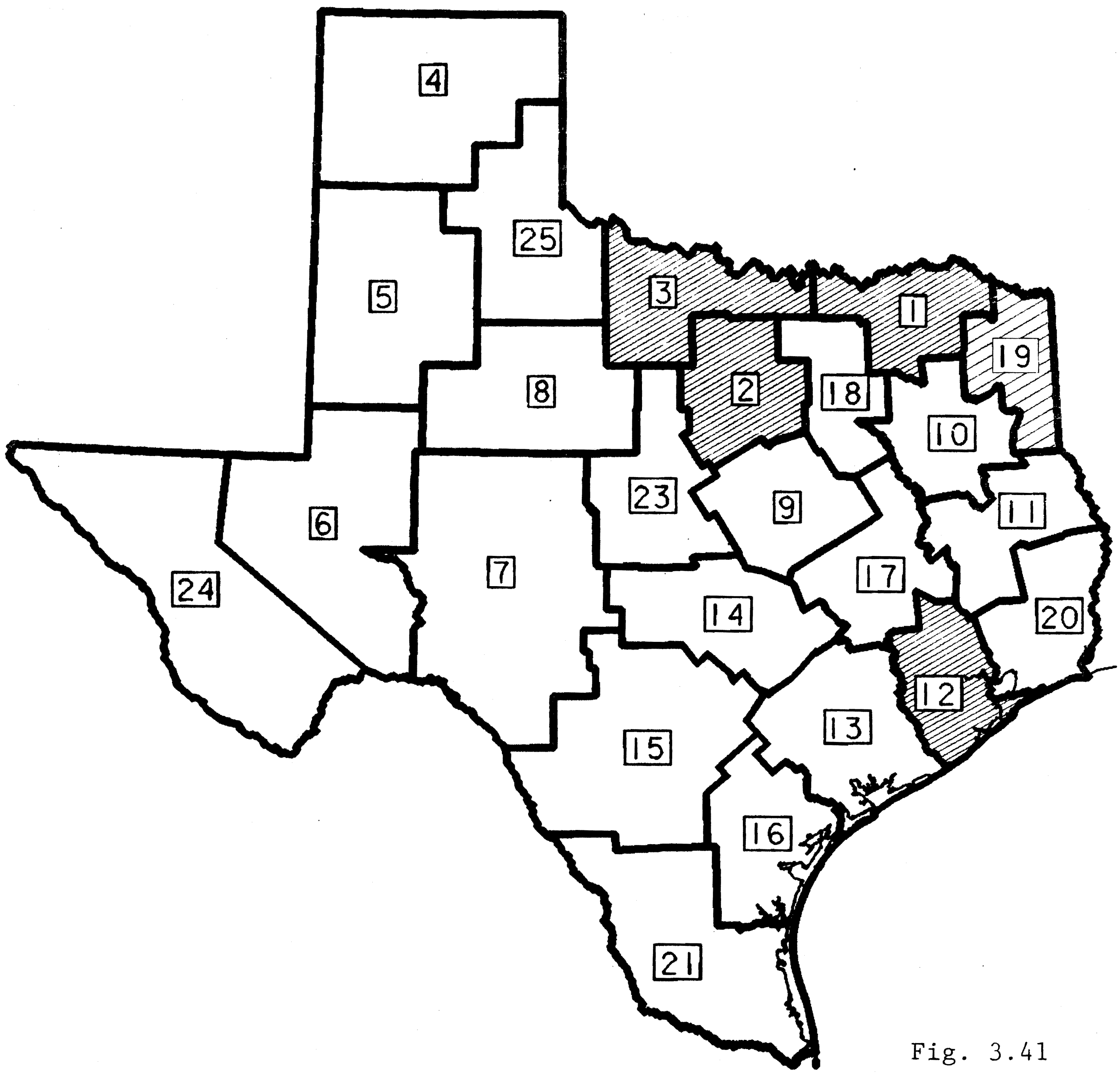


Fig. 3.41

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Excessive PC Patches
1984 PES--All JCP Sections

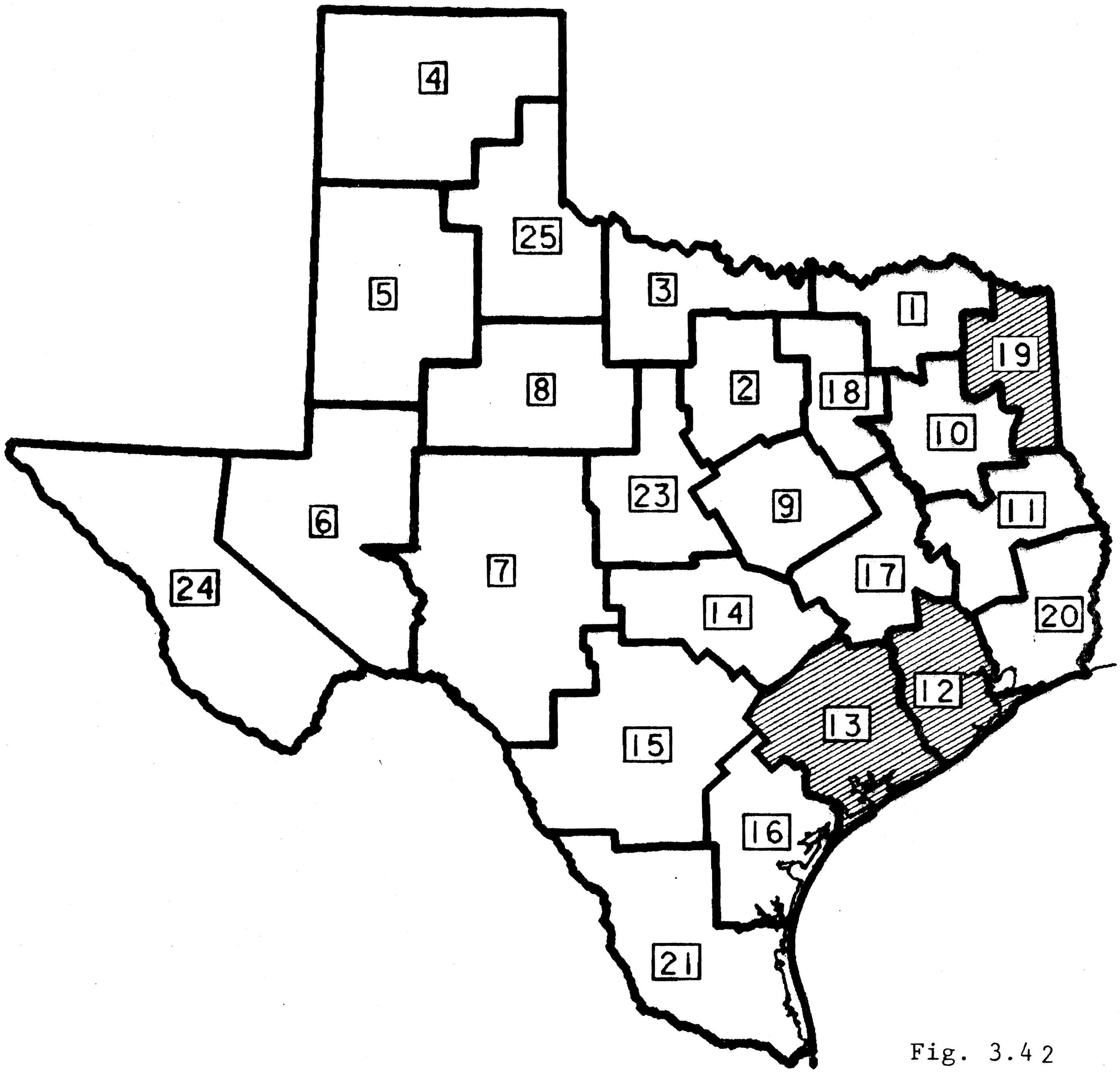


Fig. 3.42

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Rough JCP Sections
1984 PES--All Systems

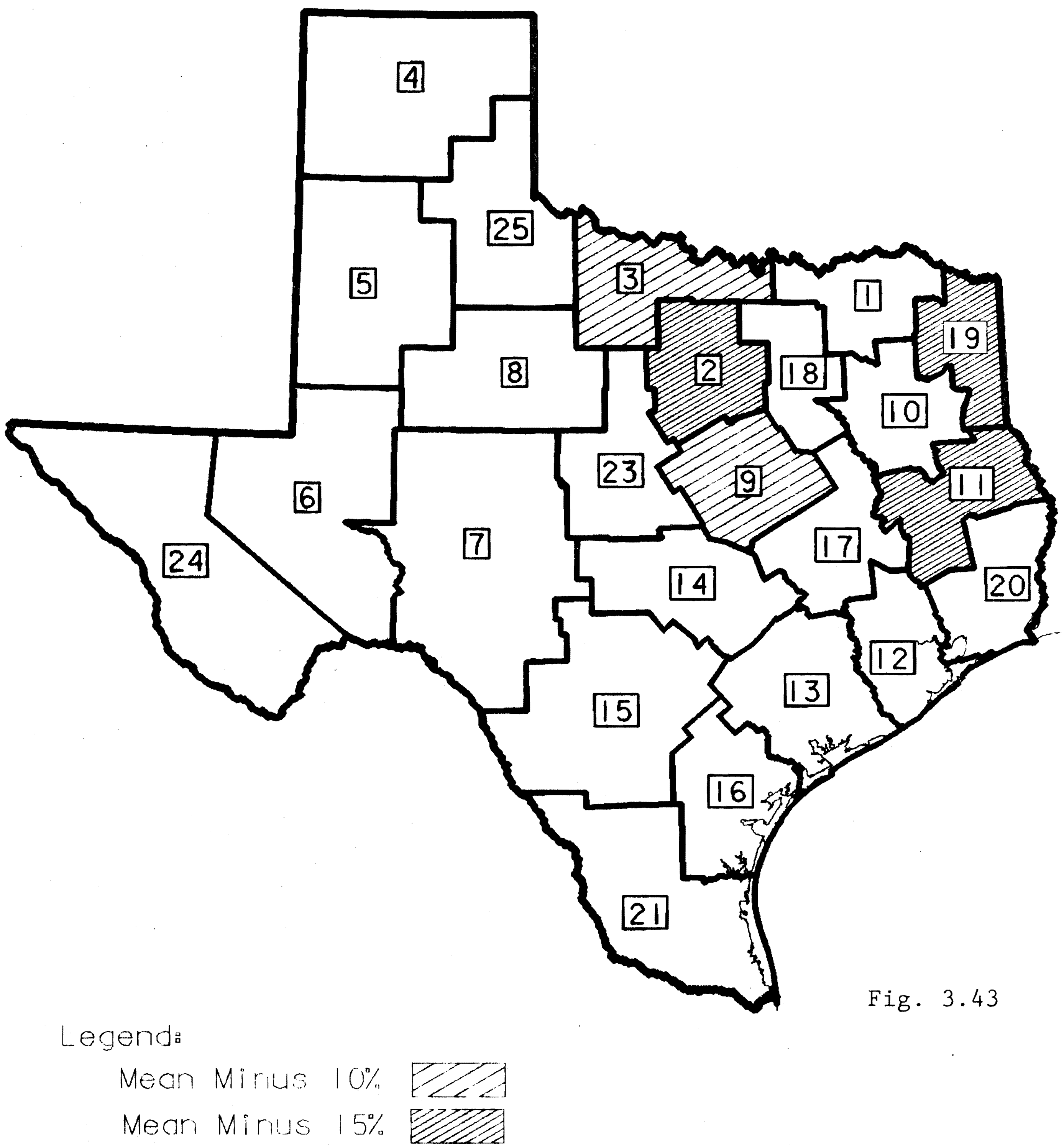


Fig. 3.43

Districts with Rough JCP Sections
1984 PES--IH System

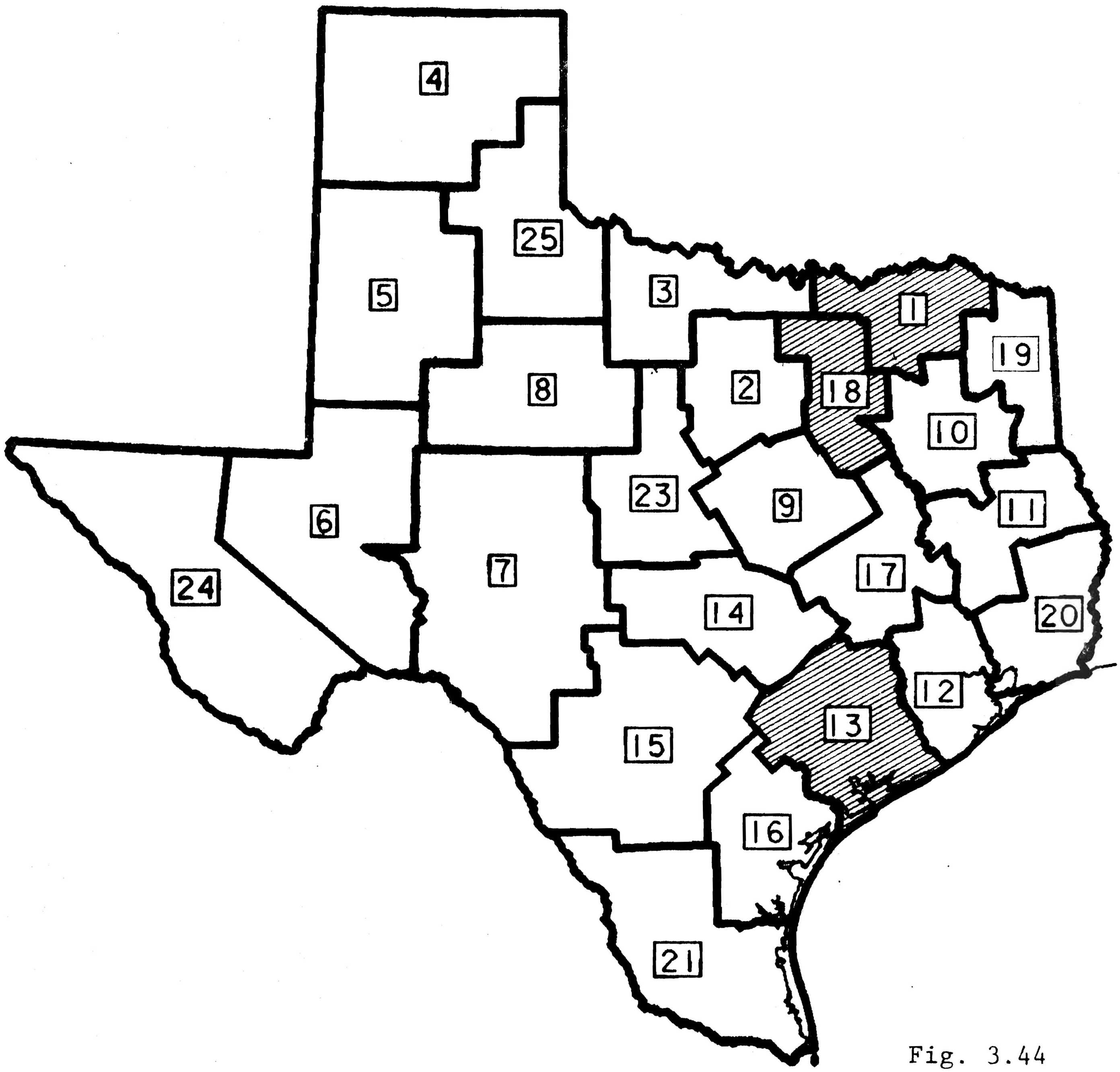


Fig. 3.44

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Rough JCP Sections

1984 PES--US System

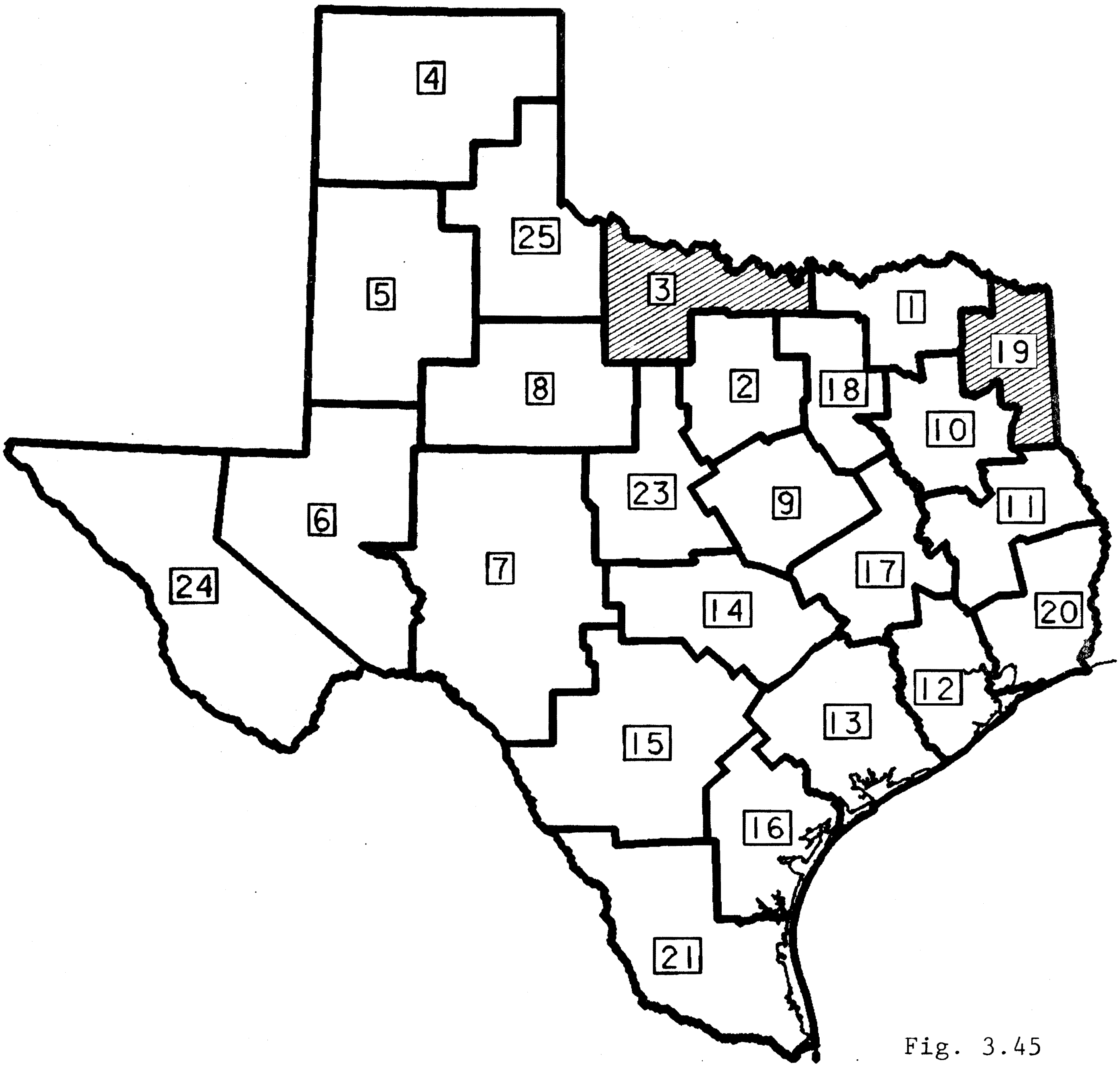


Fig. 3.45

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Rough JCP Sections
1984 PES--SH System

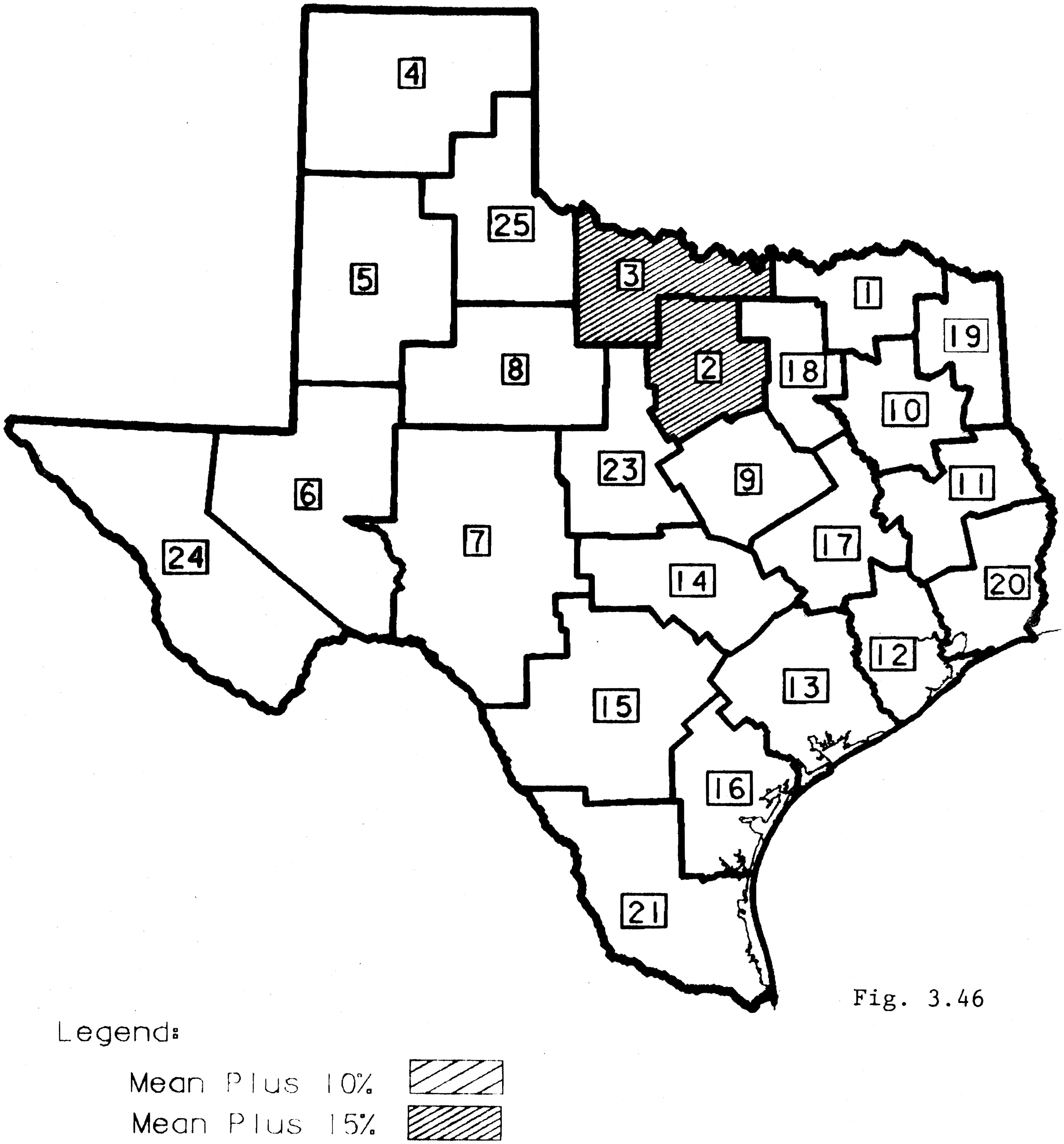


Fig. 3.46

Districts with Low JCP Pavement Scores
1984 PES--All Systems

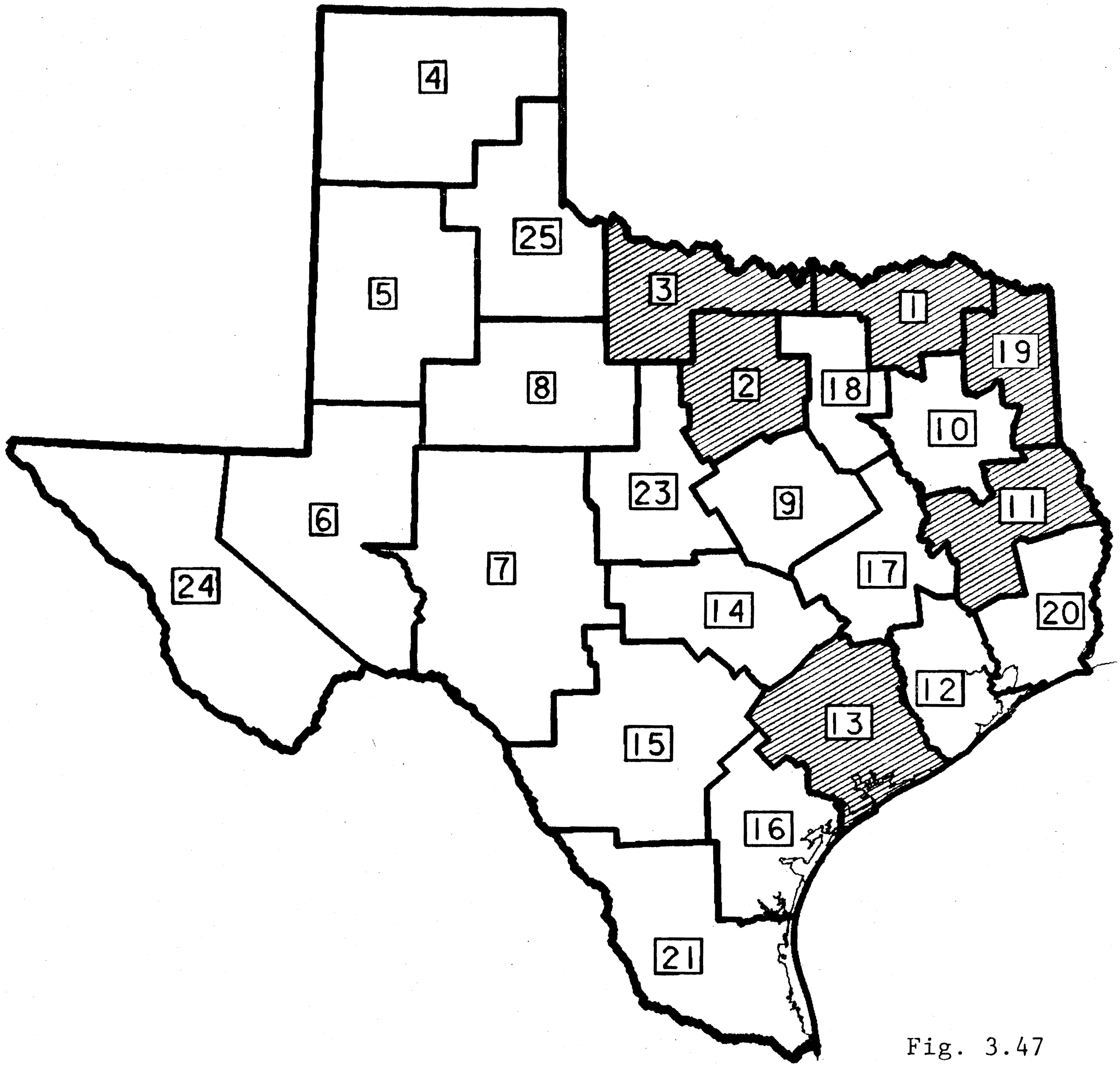


Fig. 3.47

Legend:

Mean Minus 10%

Mean Minus 15%

Districts with Low JCP Pavement Scores
1984 PES--IH System

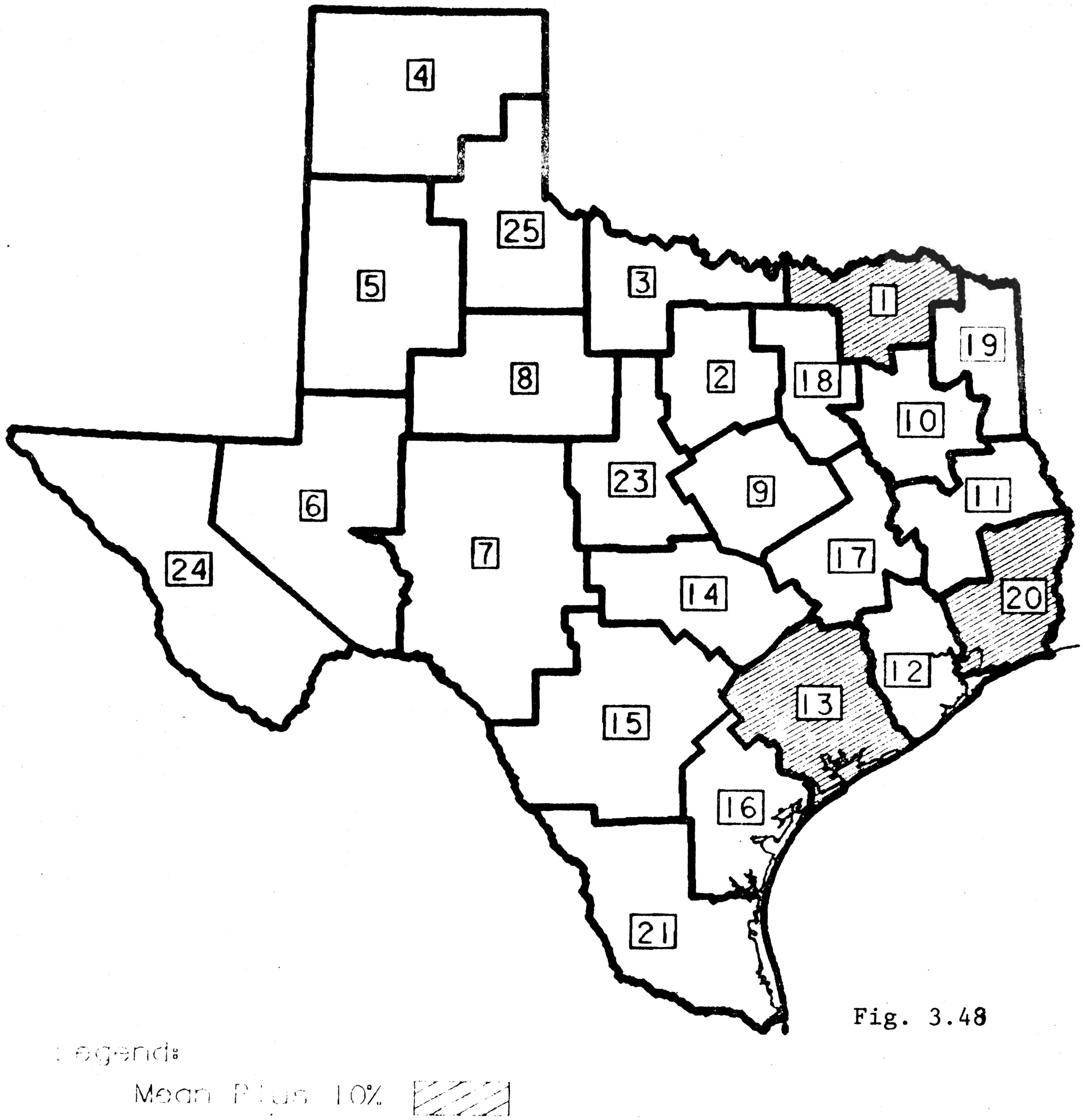


Fig. 3.48

Legend:

Mean Plus 10%

Mean Plus 15%

Districts with Low JCP Pavement Scores
1984 PES--US System

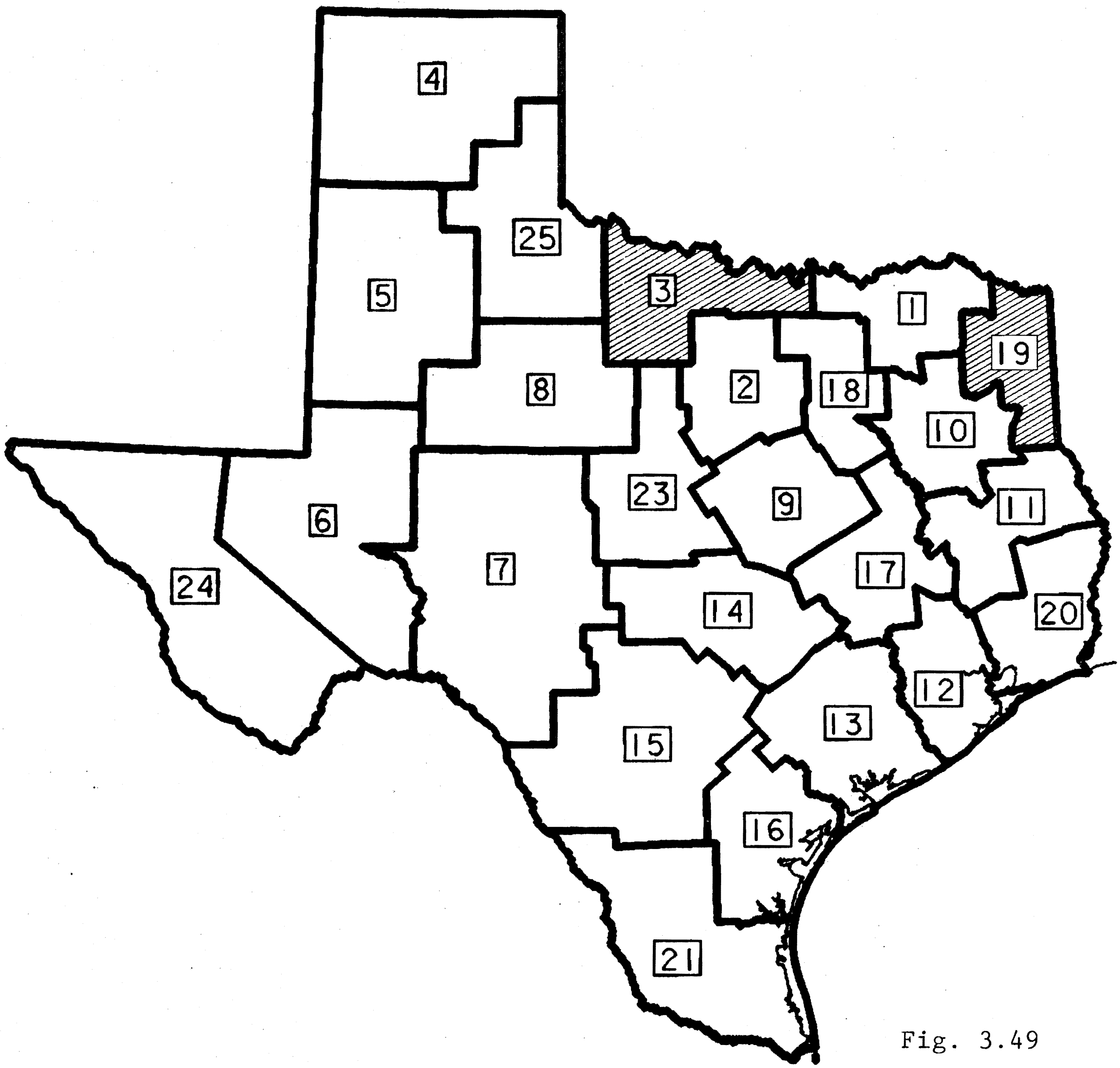
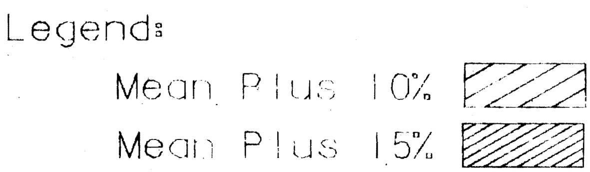


Fig. 3.49



Districts with Low JCP Pavement Scores
1984 PES--SH System

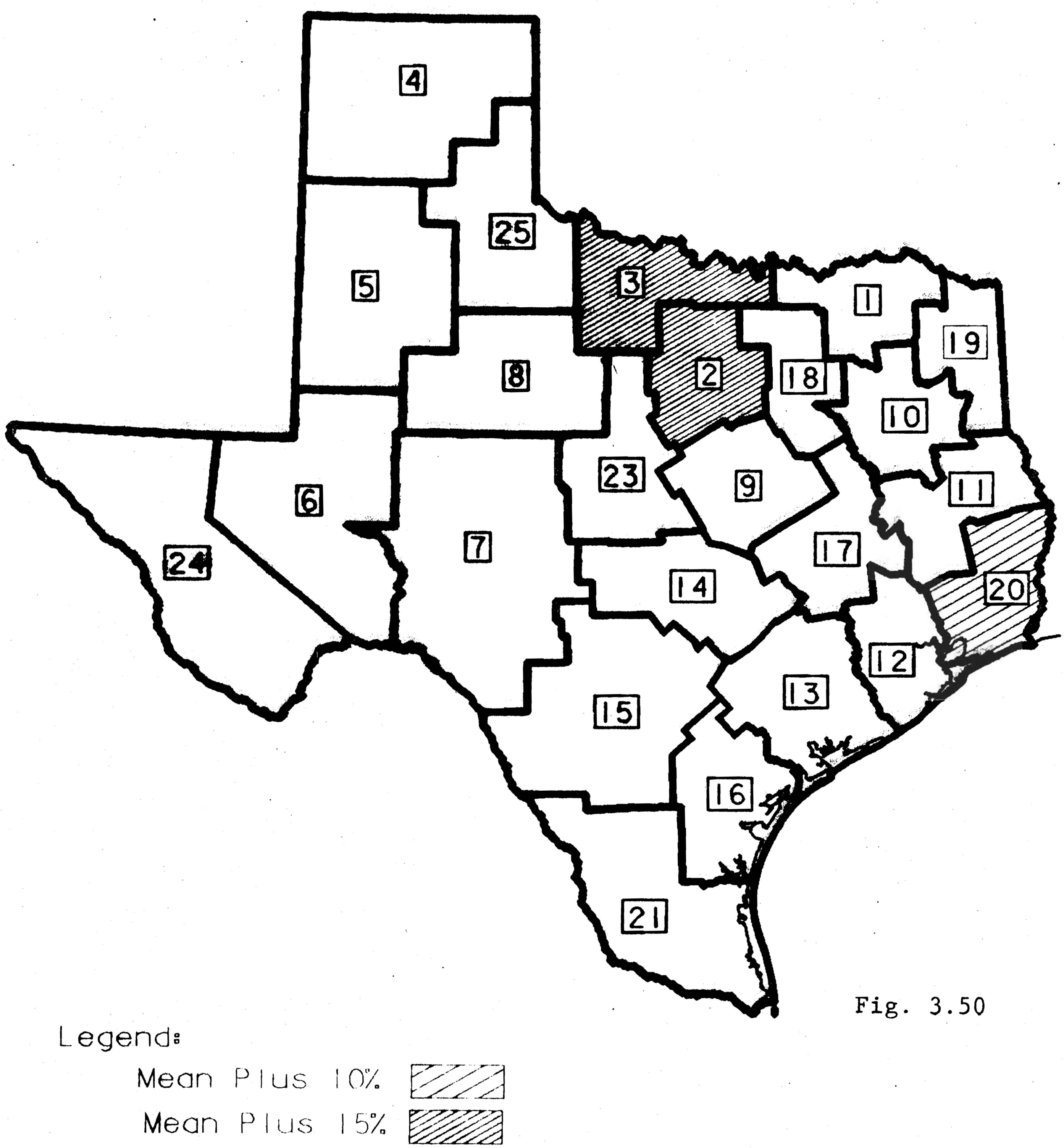


Fig. 3.50

NOTES

CHAPTER 4

FREQUENCY DISTRIBUTIONS FOR RIDE QUALITY, UNADJUSTED VISUAL UTILITY, AND PAVEMENT SCORE

Figures depict the range of values observed for each major descriptor of pavement condition. The distributions have been developed for ACP, CRC, and JCP sections. 1983 figures are also provided to emphasize trends in statewide condition.

This chapter contains figures which show the range of values reported for PSI, UVU, and pavement score during the 1984 and 1983 PES surveys. These frequency distributions provide general descriptions of pavement condition for ACP, CRC, and JCP sections statewide.

RIDE QUALITY (PSI)

Figure 4.1 depicts the statewide range of PSI values, including flexible and rigid pavement sections. This curve is tightly distributed around the mean PSI value of 3.35, although some 28 percent of the sections fall below 3.0 -- a general limit for tolerable ride quality.

For all ACP sections, comparison of Figure 4.2 (1984) and Figure 4.3 (1983) indicates an improvement in ride quality from 1983 to 1984. This is also reflected in the mean PSI, which increased from 3.26 in 1983 to 3.38 in 1984.

Although historical data for rigid pavements was not available, Figure 4.4 (CRC) and Figure 4.5 (JCP) do make significant statements about ride quality on rigid pavements. The most dramatic contrast is in the overall ride quality of CRC when compared to JCP. The mean values (CRC = 3.24 and JCP = 2.76) hint at this difference but the frequency distributions emphasize it. In addition, CRC values are tightly distributed from 2.5 to 4.0, whereas JCP values cover a wider range from 1.0 to 4.0.

UNADJUSTED VISUAL UTILITY (UVU)

UVU describes the amount of surface distress, on a scale of 1 (continuous distress) to 100 (no distress), giving a visual condition rating of the pavement as the average driver would perceive it. Figure 4.6 depicts the statewide distribution of UVU values during the 1984 PES survey. As expected, most sections (53 percent) lie in the upper range between 90 and 100, however some sections (10 percent) were evaluated in the lower ranges from 0 to 50.

Distributions for ACP sections (Figures 4.7-4.8) illustrate a gradual increase in the amount of surface distress. This decline in UVU is not substantial -- only five or ten points on average.

Comparisons between UVU in CRC and JCP sections are the same as those made for ride quality. Figure 4.9 indicates that most CRC sections are in excellent condition, however a few isolated sections lie on a broad range from 0 to 80. For JCP, the trend is even more obvious. Figure 4.10 shows the presence of some high-quality JCP from 90 to 100, in addition to isolated sections at all of the other values.

PAVEMENT SCORE

The pavement score distributions (Figures 4.11-4.15) are similar to the UVU distributions in that they suggest a five to ten point drop in value from 1983 to 1984. Statewide increases in ride quality point to the combined effects of surface distress and traffic (ADT and 18-k ESAL) as being responsbile for the overall drop in pavement score on flexible pavements.

The rigid pavement distributions (Figures 4.14 and 4.15) suggest that high traffic volume has an impact on pavement score (subsequent chapters will demonstrate that pavement score is extremely sensitive to high traffic volumes). The CRC distribution is barely a distribution at all, since the values lie almost uniformly between 0 and 90. Although CRC ride quality is slightly lower than flexible ride quality, traffic volumes are five times higher. With regards to JCP, the pavement score distribution is reversed, with more sections at the lower values. This is due to low PSI, excessive surface distress, and high traffic volumes on JCP sections.

NOTES

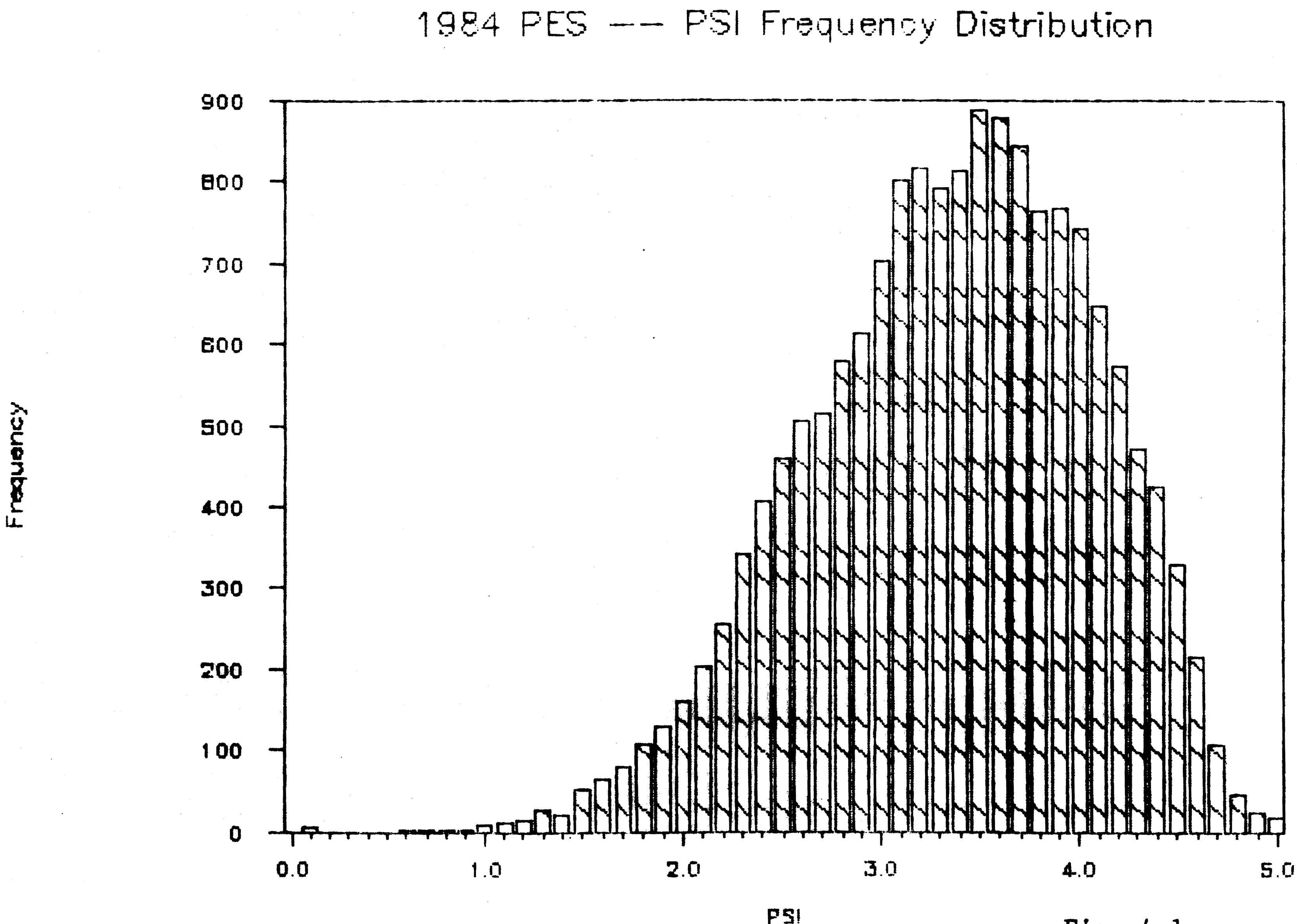

1984 PES -- PSI Frequency Distribution
Frequency
900
800
700
600
500
400
300
200
100
0
0.0
1.0
2.0
3.0
4.0
5.0
PSI

Fig. 4.1

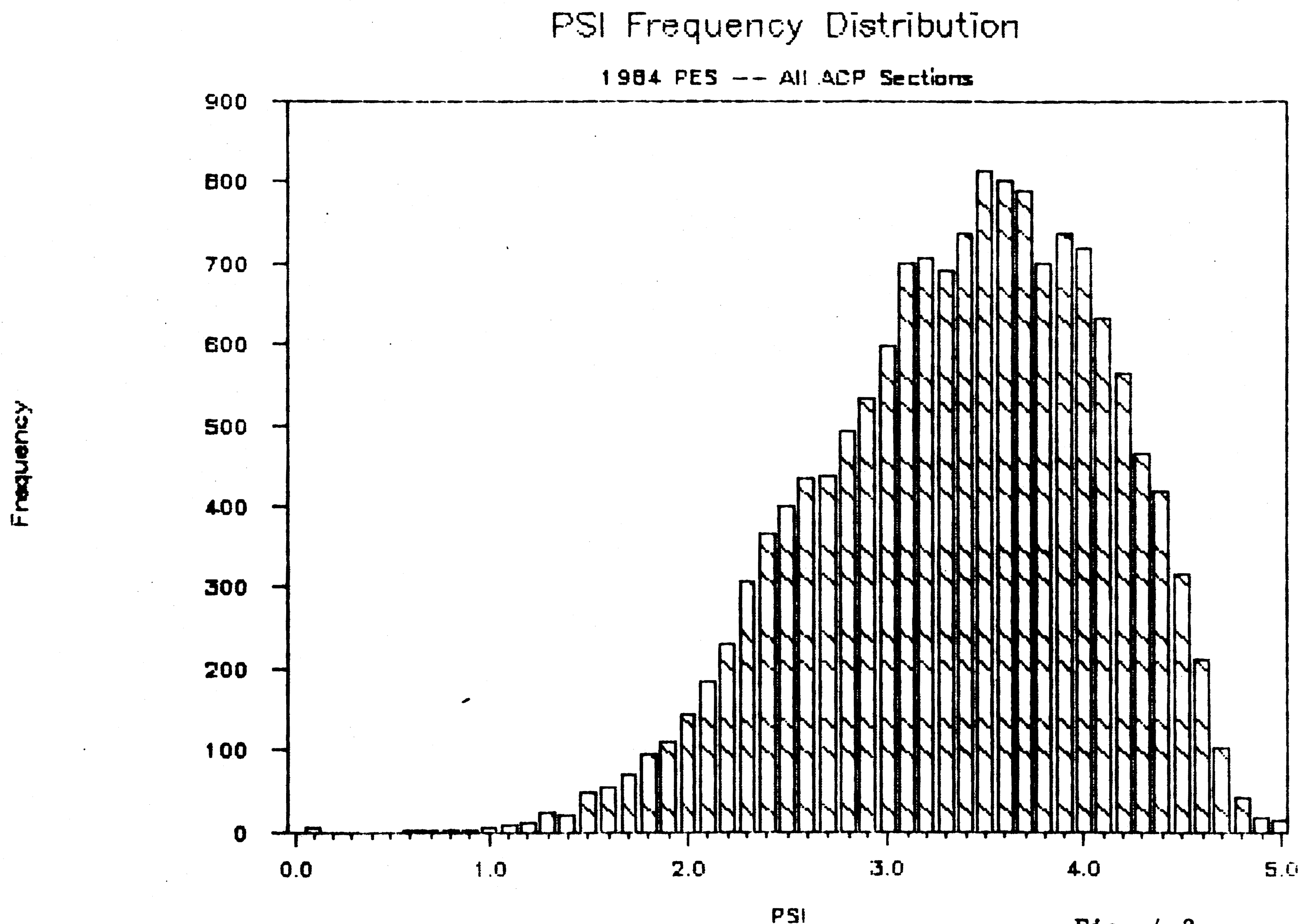

PSI Frequency Distribution
1984 PES -- All ACP Sections
Frequency
900
800
700
600
500
400
300
200
100
0
0.0
1.0
2.0
3.0
4.0
5.0
PSI

Fig. 4.2

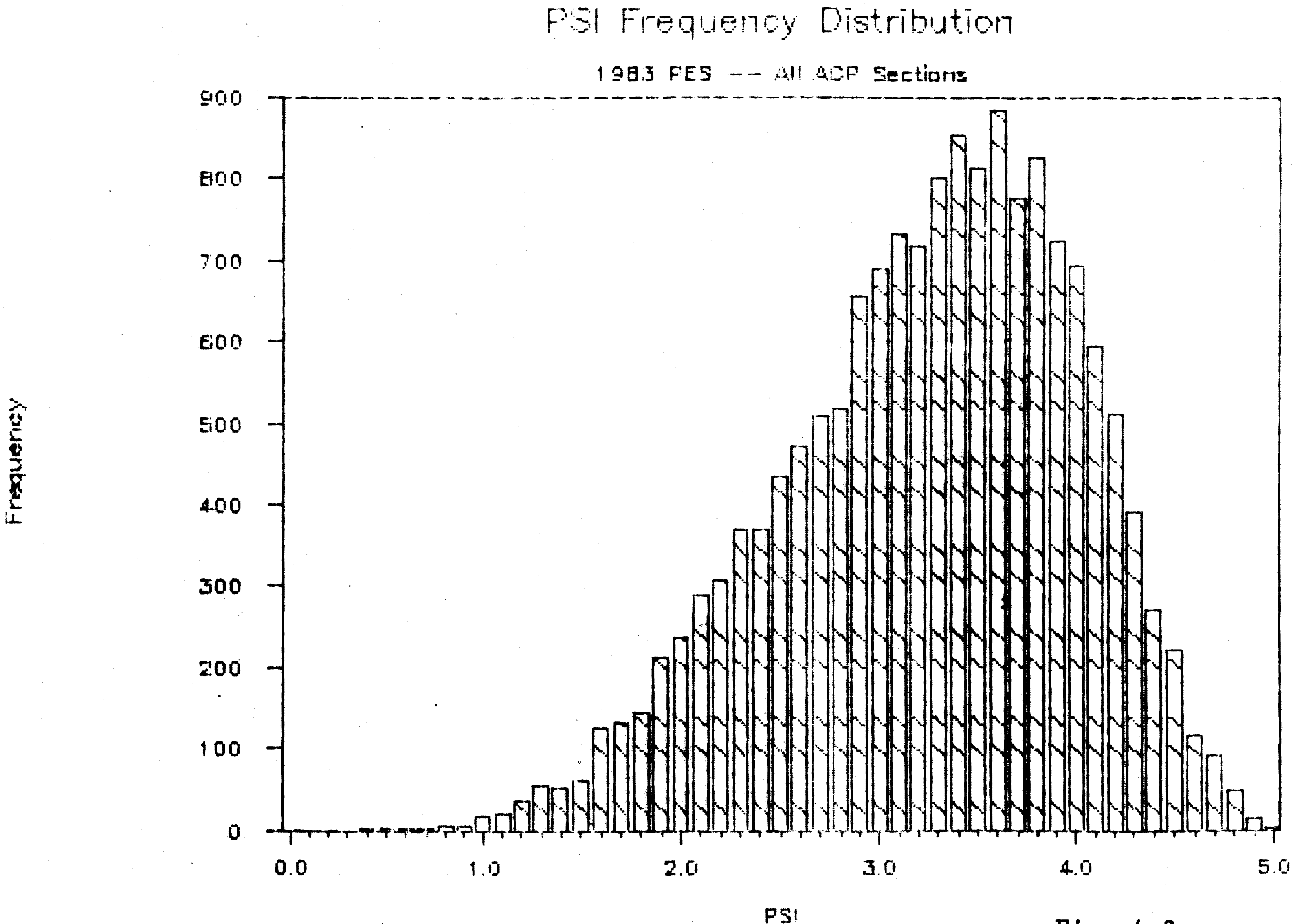

PSI Frequency Distribution
1983 PES -- All ACP Sections
Frequency
PSI
900
800
700
600
500
400
300
200
100
0
0.0
1.0
2.0
3.0
4.0
5.0

Fig. 4.3

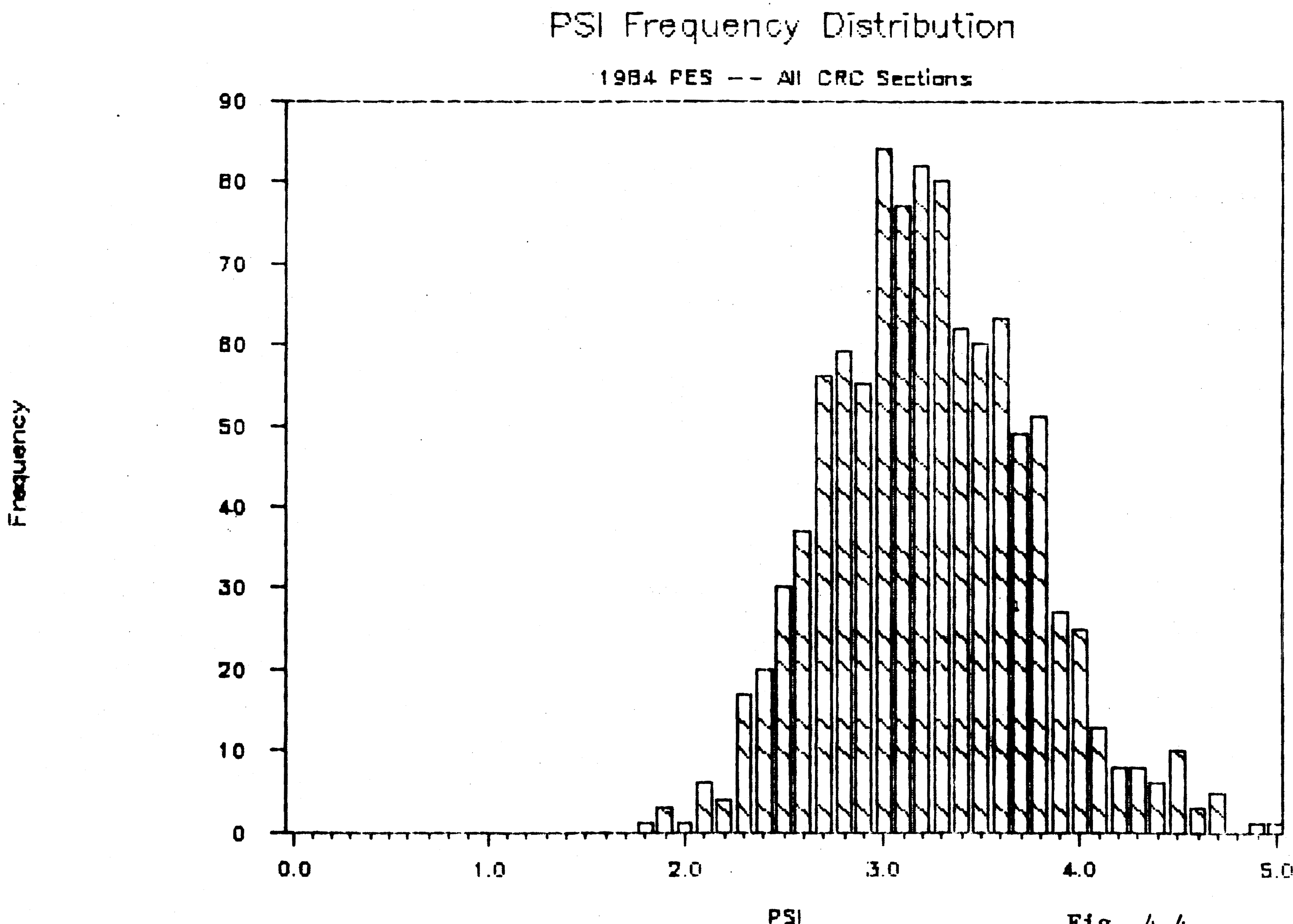

PSI Frequency Distribution
1984 PES -- All CRC Sections
Frequency
90
80
70
60
50
40
30
20
10
0
0.0
1.0
2.0
3.0
4.0
5.0
PSI

Fig. 4.4

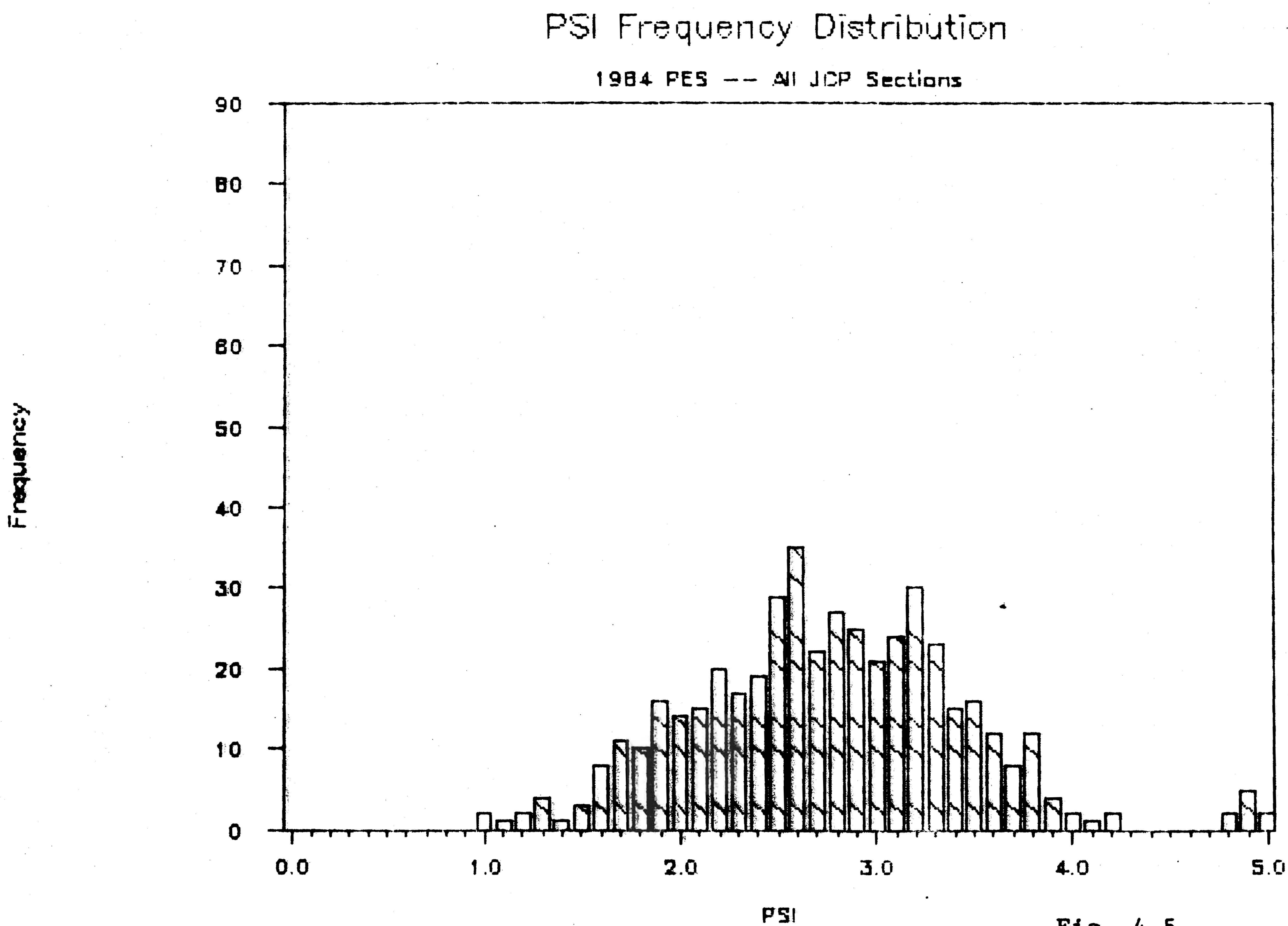

PSI Frequency Distribution
1984 PES -- All JCP Sections
Frequency
90
80
70
60
50
40
30
20
10
0
0.0
1.0
2.0
3.0
4.0
5.0
PSI

Fig. 4.5

NOTES

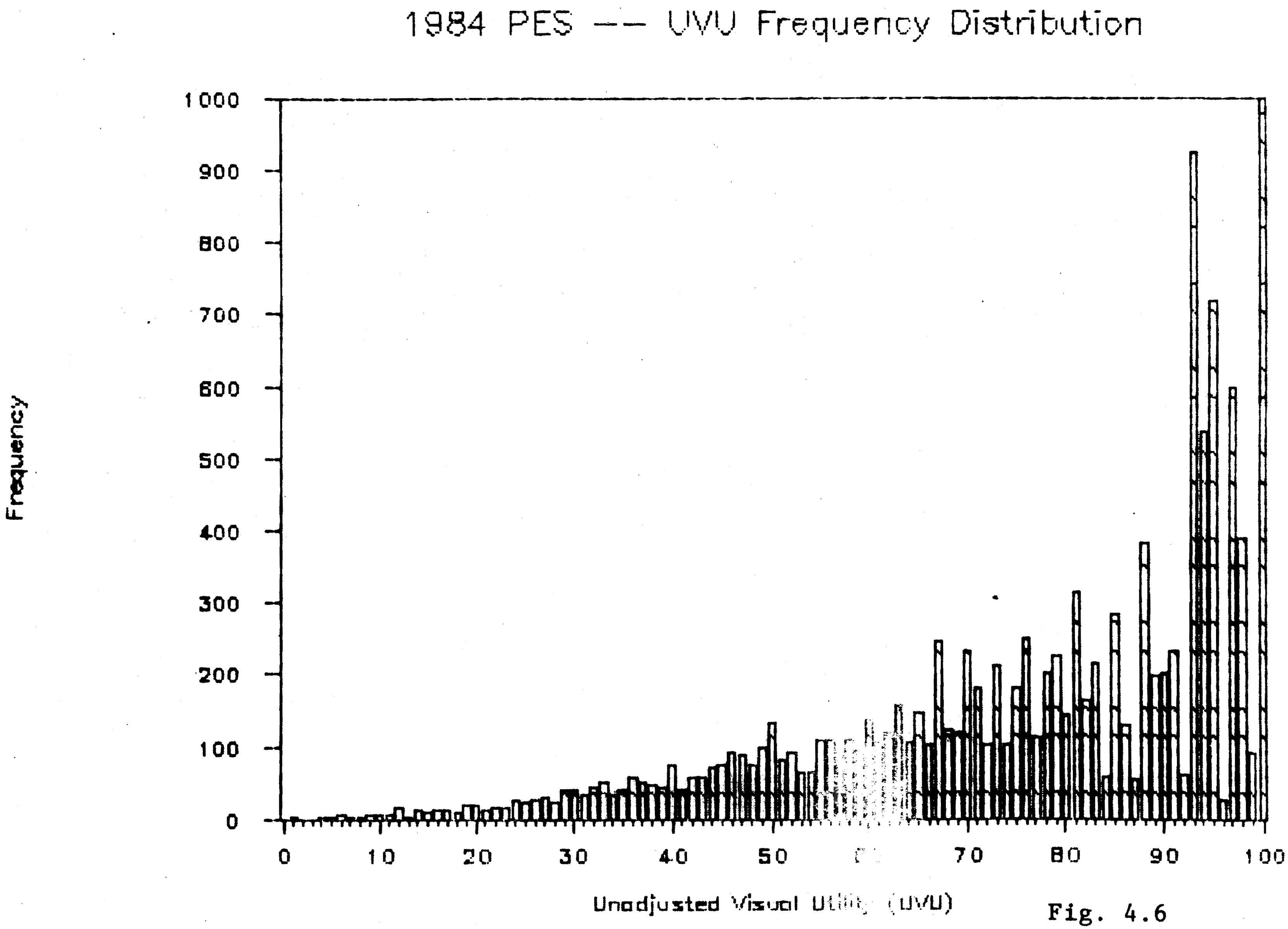

1984 PES -- UVU Frequency Distribution
Frequency
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
70
80
90
100
Unadjusted Visual Utility (UVU)

Fig. 4.6

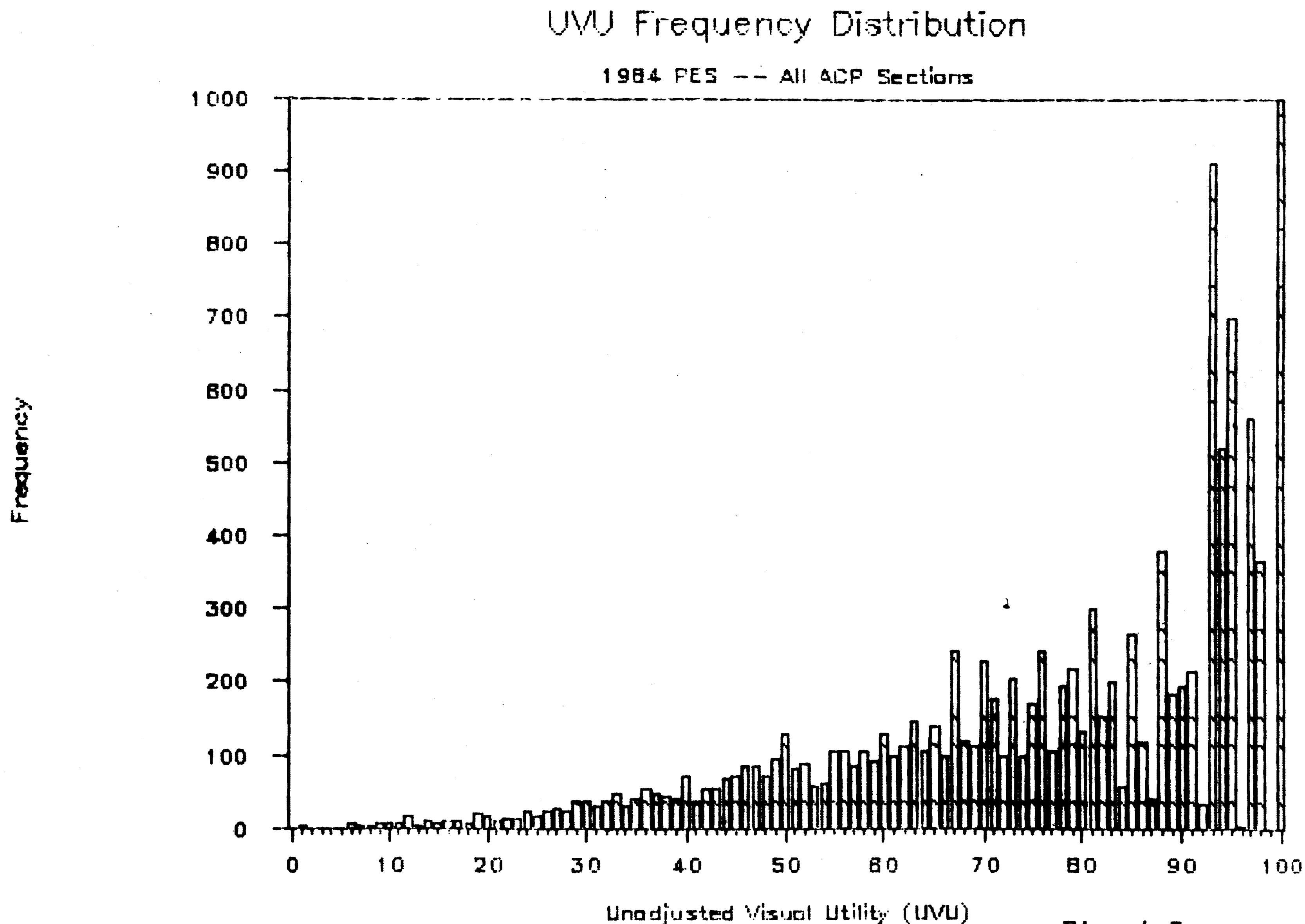

UVU Frequency Distribution
1984 PES -- All ACP Sections
Frequency
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Unadjusted Visual Utility (UVU)

Fig. 4.7

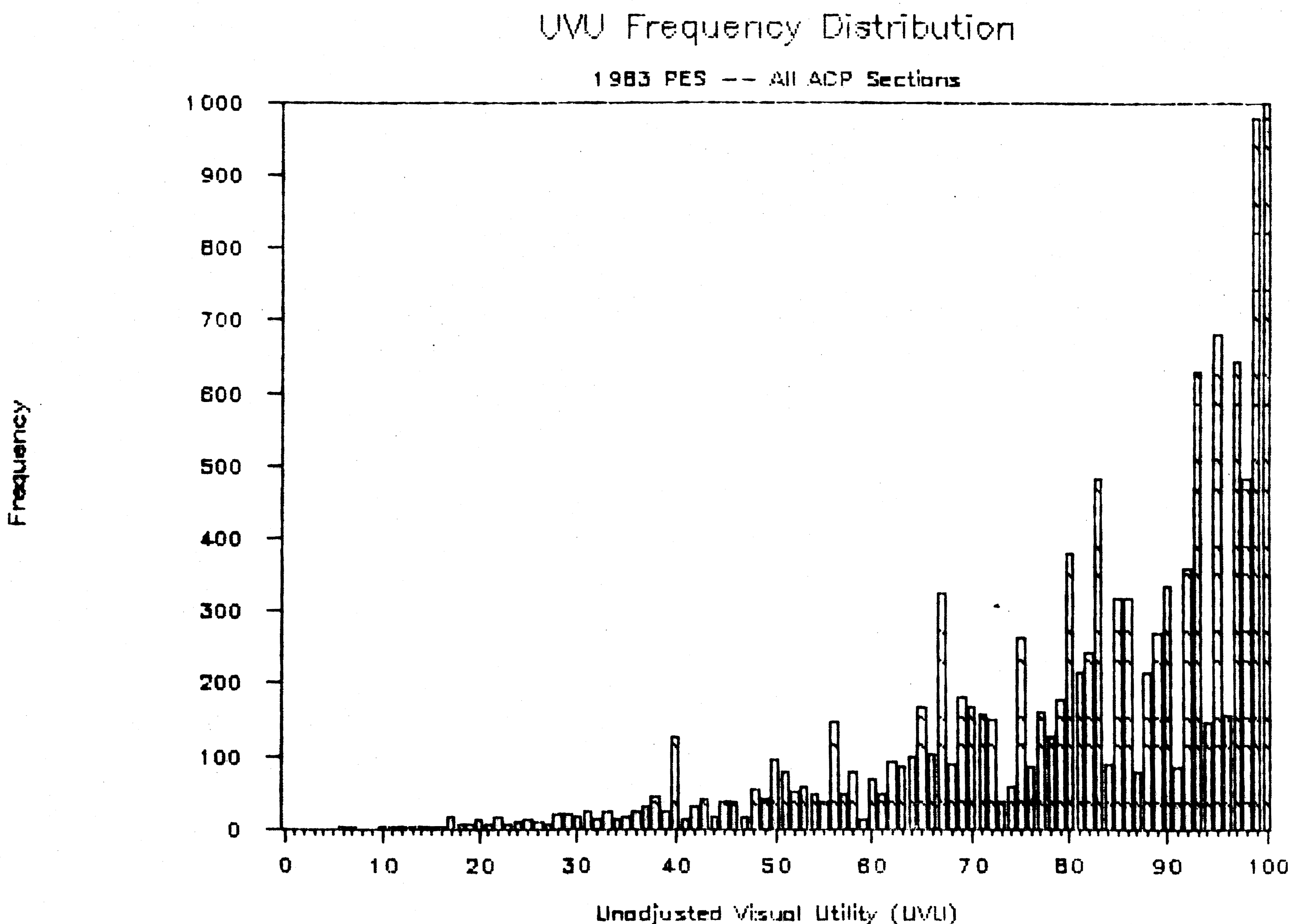

UVU Frequency Distribution
1983 PES -- All ACP Sections
Frequency
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Unadjusted Visual Utility (UVU)

Fig. 4.8

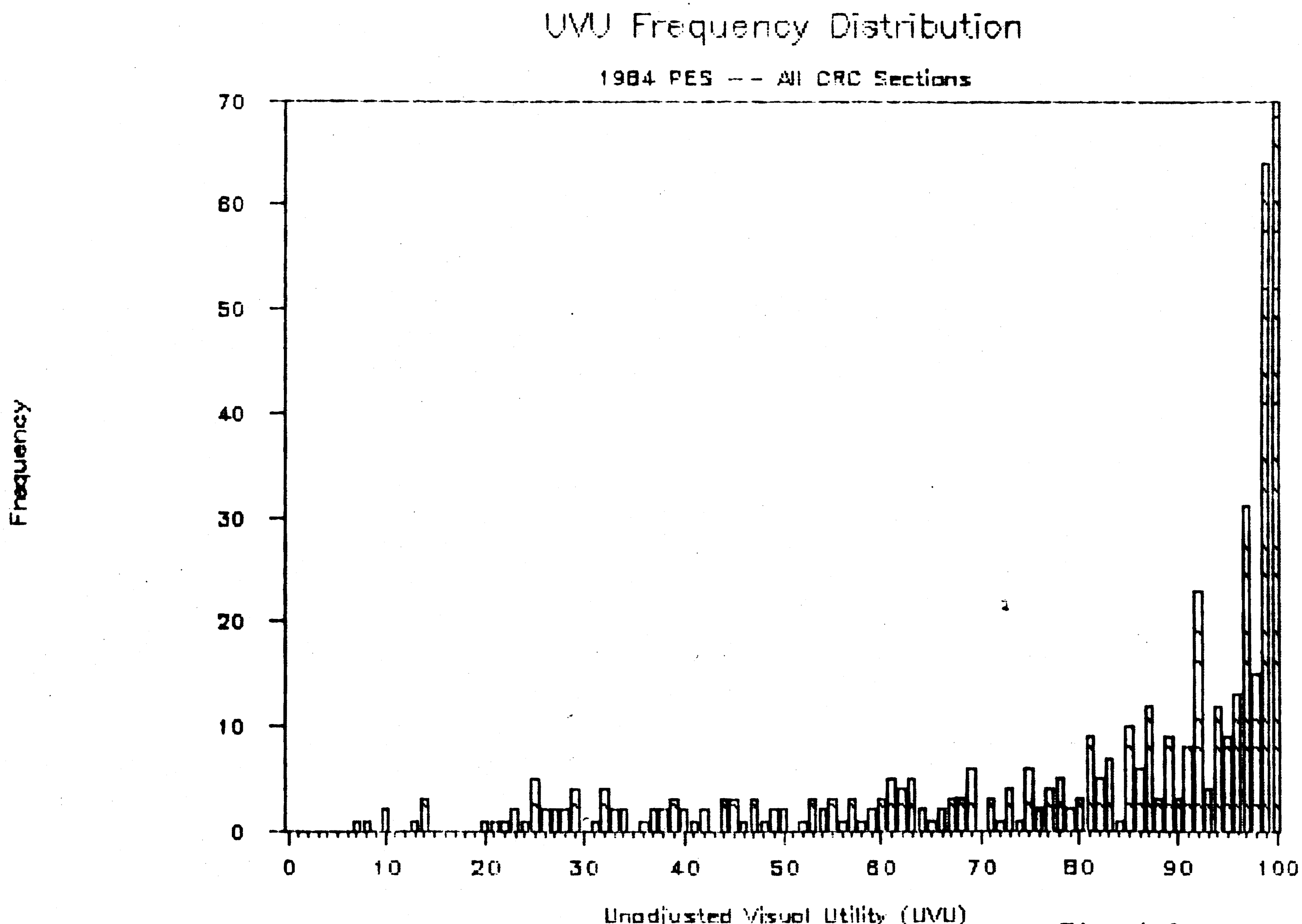

UVU Frequency Distribution
1984 PES -- All CRC Sections
Frequency
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
Unadjusted Visual Utility (UVU)

Fig. 4.9

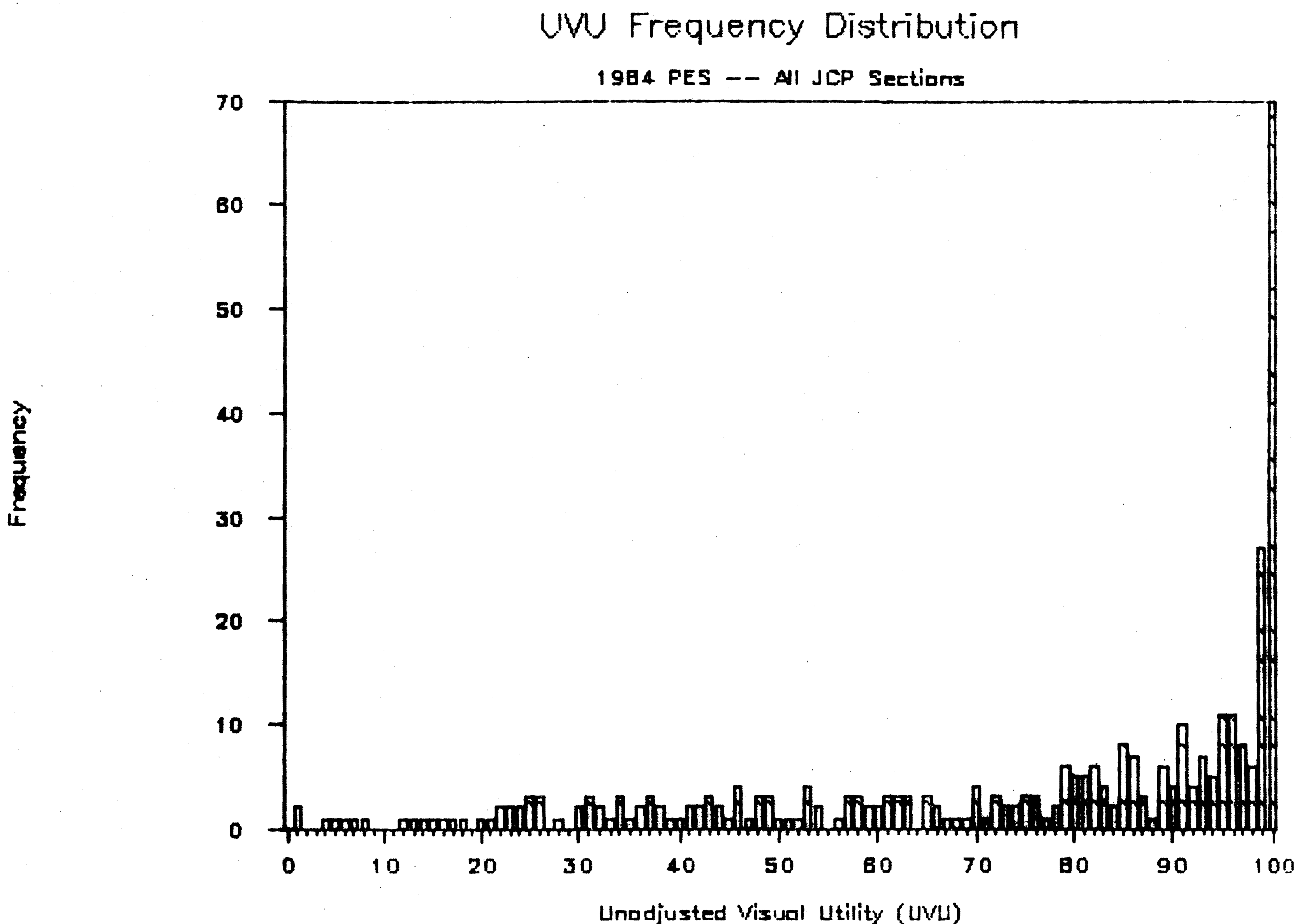

UVU Frequency Distribution
1984 PES -- All JCP Sections
Frequency
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
Unadjusted Visual Utility (UVU)

Fig. 4.10

NOTES

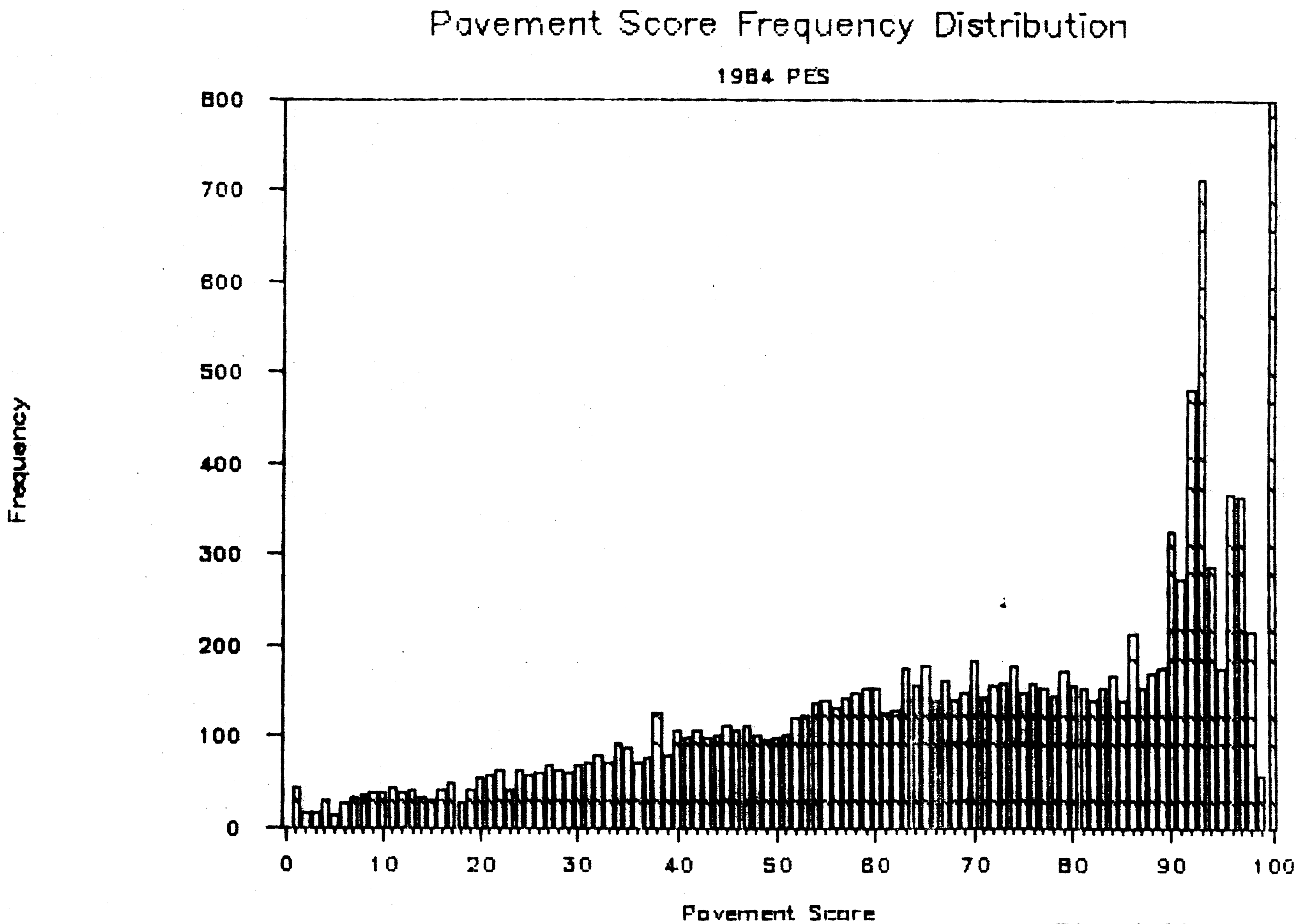

Pavement Score Frequency Distribution
1984 PES
Frequency
0
100
200
300
400
500
600
700
800
0
10
20
30
40
50
60
70
80
90
100
Pavement Score

Fig. 4.11

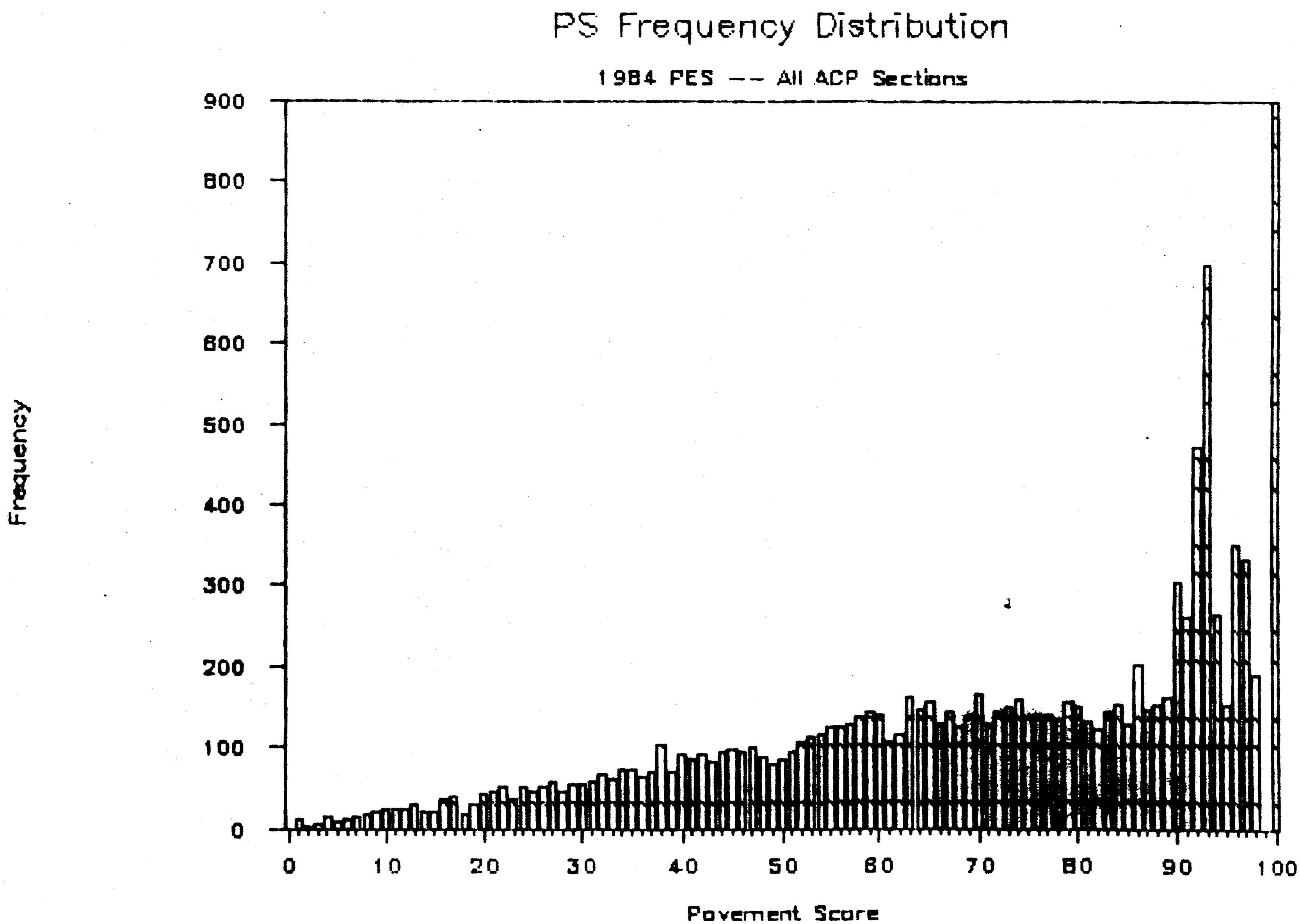

PS Frequency Distribution
1984 PES -- All ACP Sections
Frequency
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Povement Score

Fig. 4.12

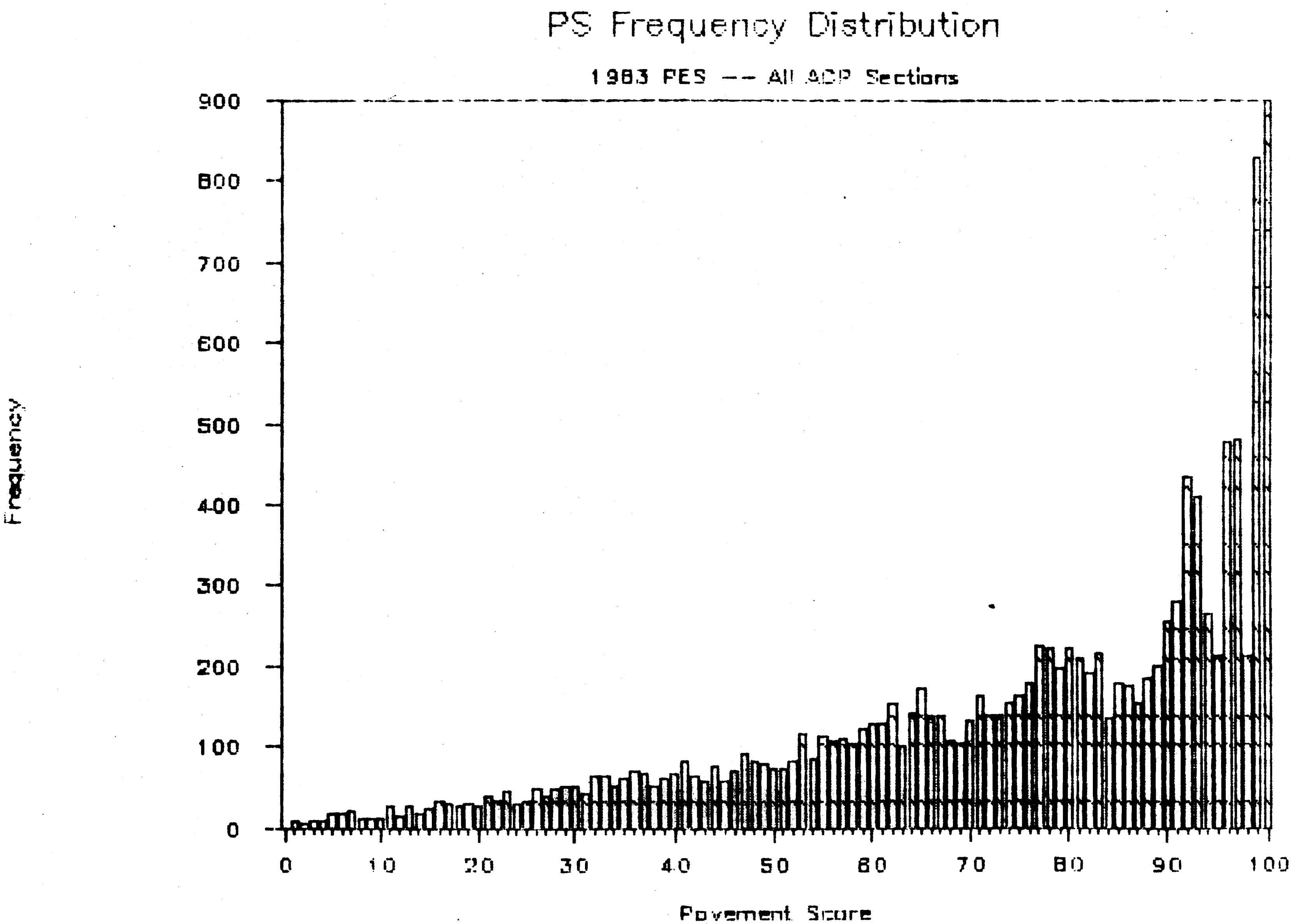

PS Frequency Distribution
1983 PES -- All ACP Sections
Frequency
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Pavement Score

Fig. 4.13

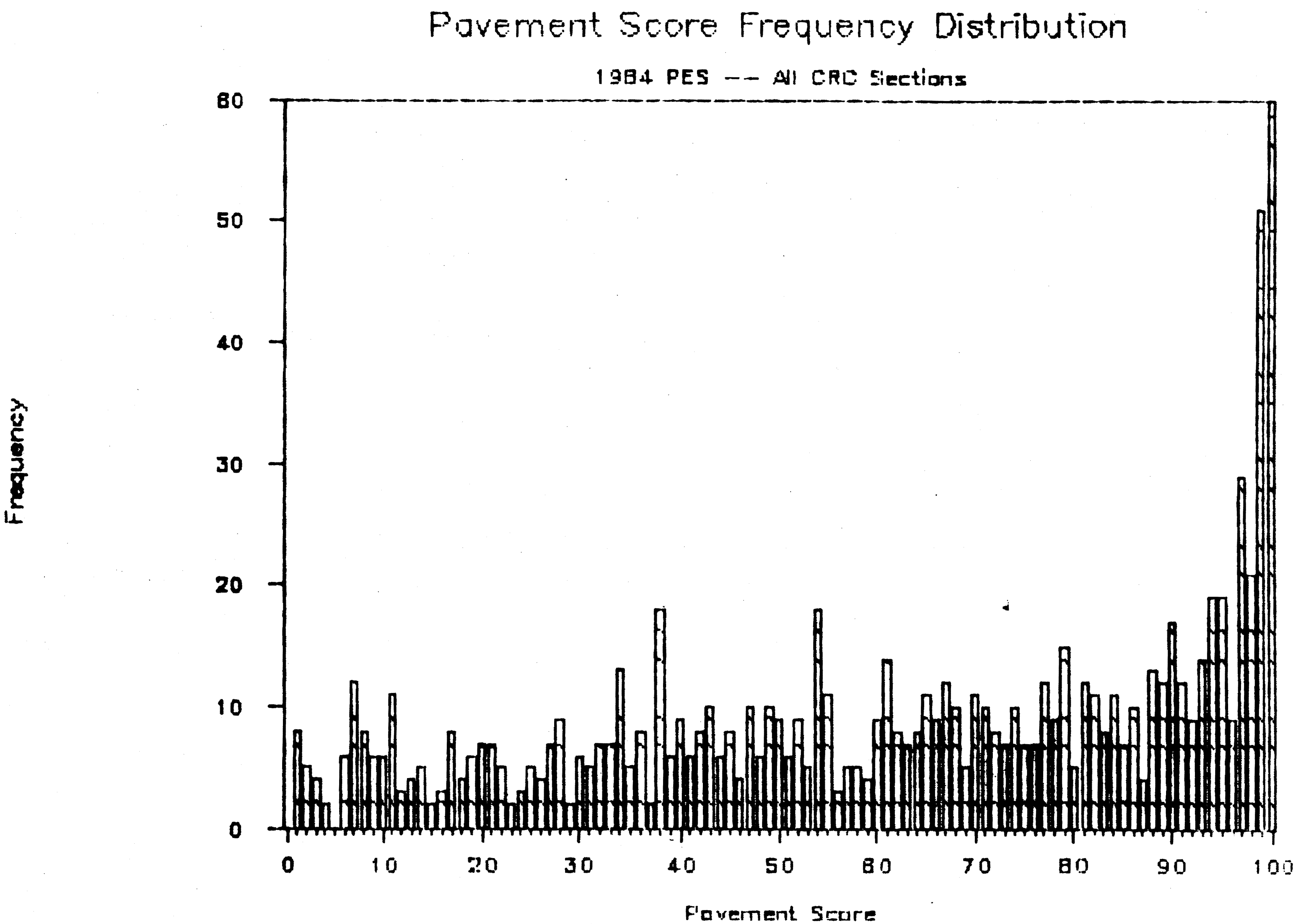

Pavement Score Frequency Distribution
1984 PES -- All CRC Sections
Frequency
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80
90
100
Pavement Score

Fig 4.14

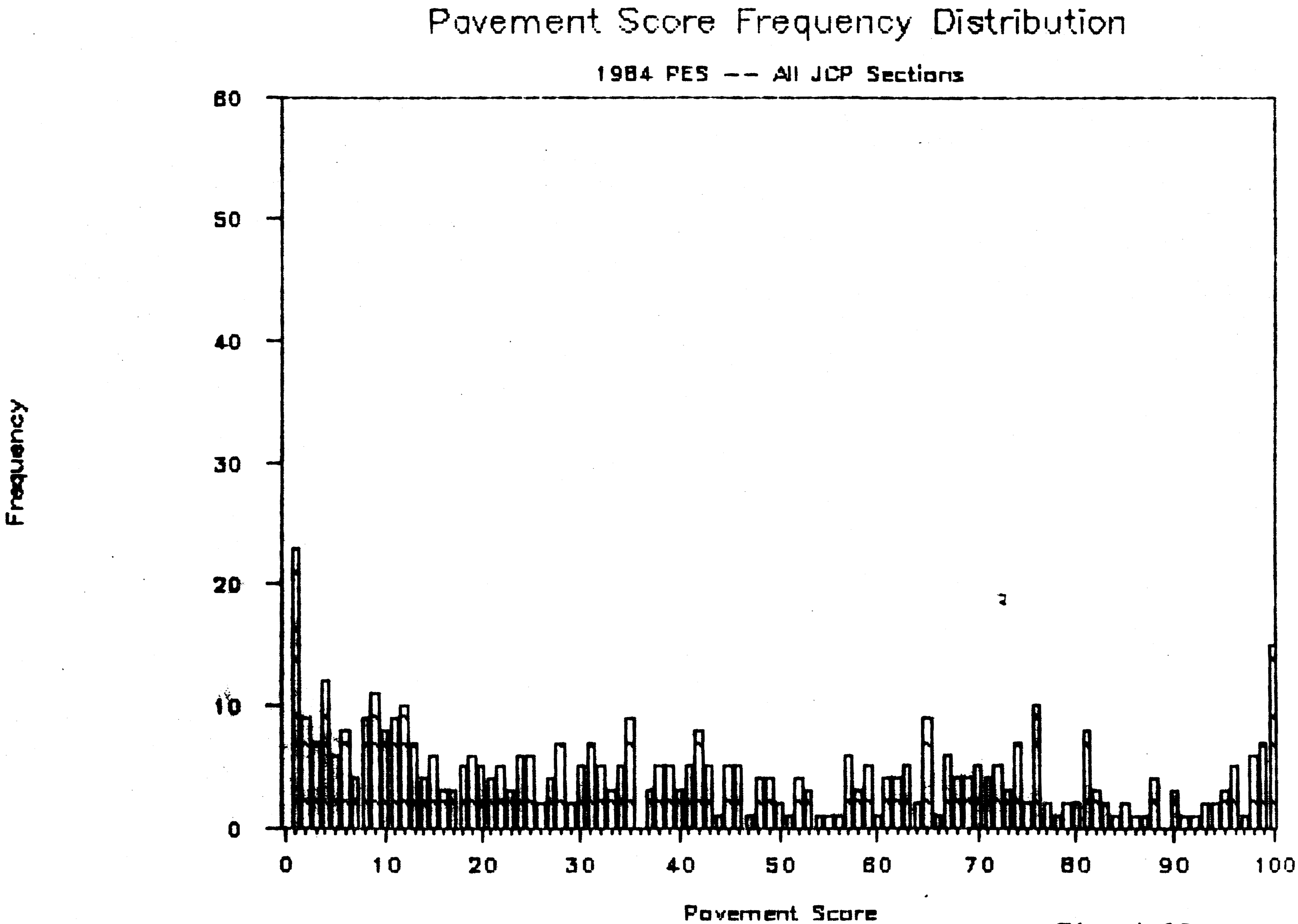

Pavement Score Frequency Distribution
1984 PES -- All JCP Sections
Frequency
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80
90
100
Pavement Score

Fig. 4.15

NOTES

CHAPTER 5

FREQUENCY DISTRIBUTIONS FOR FLEXIBLE AND RIGID PAVEMENT DISTRESS TYPES

Figures depict the progress being made ,towards reducing the amount of distress on state-maintained highways by comparing values from the 1984 and 1983 surveys (for flexible pavements only). Distributions for rigid pavement sections indicate the range of distress levels observed.

Previous chapters have examined the general measures of pavement condition: ride quality, unadjusted visual utility, and pavement score. This chapter contains a study of individual distress types, in an attempt to identify the most predominant forms of distress on Texas highways.

ACP SECTIONS

PES survey results from 1983 and 1984 were analyzed to determine if any distress types have increased (or been reduced) in occurrence on rated sections. Figures 5.1-5.9 are frequency histograms for each flexible pavement distress type considered during the past two years. It must be noted that two distress types were changed in 1984. Patching and block cracking (Figures 5.6 and 5.7) replaced raveling and flushing (Figures 5.8 and 5.9). As a result, two-year results are only available for five of the seven distress types. Table 5.1 contains definitions for each of the flexible pavement distress rating values shown in Figures 5.1-5.9.

Figures 5.1-5.5 depict increases in rutting, longitudinal cracking, and transverse cracking. Failures and alligator cracking have been slightly reduced. Of these five distresses, rutting is progressing into the biggest problem. Figure 5.1 identifies the following trends:

1. More sections have rutting -- approximately 25 percent of the 1983 sections had rutting, compared to over 30 percent in 1984.

2. Increased area of "minor" rutting -- all three PES values for rutting less than one inch ("100", "010", and "001") have increased in excess of the five percent necessary to account for newly-rutted sections.

3. Increased area of "severe" rutting -- "200" rutting (one-inch ruts covering less than 25% of the two wheelpaths) has decreased, only to be replaced by increases in "020" and "002" rutting.

Longitudinal cracking and transverse cracking are also becoming more common, but only at the first-stage "100" level.

Figures 5.6 and 5.7 are distributions for patching and block cracking, respectively. Patching, as shown in Figure 5.6 (as well as Table 3.1), is a very commonly-observed distress type, especially at the "100" level. Block cracking, as shown in Table 3.1, is relatively rare at the state level (90.40 percent of the sections had none) but is common in some of the Districts.

Figures 5.8 and 5.9 are distributions for raveling and flushing, respectively. These two were replaced in the 1984 survey by patching and block cracking.

CRC SECTIONS

Figures 5.10-5.13 reflect the distribution of values for CRC distress types. PES survey results were divided by the mean section length to determine the number of occurrences per mile for each distress type. As expected, most sections have very low levels of distress. However, these figures were drawn to determine typical levels for each CRC distress type. The figures depict frequency curves which level off at approximately the following values: 10 spalled cracks per mile, 5 punchouts per mile, 5 asphalt patches per mile, and 7 concrete patches per mile. Of these, only the values for punchouts and asphalt patches are excessive.

JCP SECTIONS

Figures 5.14-5.19 reflect the distribution of values for JCP distress types. PES survey results were divided by the mean section length to determine the number of occurrences per mile for each distress type. The figures indicate that JCP distress levels are much higher than CRC distress levels. The frequency curves level off at approximately the following values: 25 spalled cracks per mile, 25 transverse cracks per mile, 18 slabs per mile with longitudinal cracks, 15 corner breaks and punchouts per mile, 13 asphalt patches per mile, and 11 concrete patches per mile. Of these, the values for longitudinal cracks, corner breaks and punchouts, and asphalt patches are excessive.

Table 5.1 -- Definitions of PES Rating Values for Flexible Pavement Distress Types.

Distress Type	Rating Value	Definition
Rutting	100	Depth > 0.5", 1-25 % area of both wheelpaths.
	010	Depth > 0.5", 26-50 % area of both wheelpaths.
	001	Depth > 0.5", > 50 % area of both wheelpaths.
	200	Depth > 1.0", 1-25 % area of both wheelpaths.
	020	Depth > 1.0", 26-50 % area of both wheelpaths.
	002	Depth > 1.0", > 50 % area of both wheelpaths.
Failures	100	1-5 failures/mile, or less.
	010	5-10 failures/mile.
	001	11 failures/mile, or more.
Alligator Cracking	100	1-10 % area of both wheelpaths.
	010	11-50 % area of both wheelpaths.
	001	> 50 % area of both wheelpaths.
Longitudinal Cracking	100	10-99 lineal ft./100 ft. station.
	010	100-200 lineal ft./100 ft. station.
	001	> 200 lineal ft./100 ft. station.
Transverse Cracking	100	1-4 full-width cracks/100 ft. station.
	010	5-10 full-width cracks/100 ft. station.
	001	> 10 full-width cracks/100 ft. station.
Patching	100	1-10 % area of lane.
	010	11-50 % area of lane.
	001	> 50 % area of lane.
Block Cracking	100	1-10 % area of lane.
	010	11-50 % area of lane.
	001	> 50 % area of lane.
Raveling	100	1-25 % area of both wheelpaths.
	010	26-50 % area of both wheelpaths.
	001	> 50 % area of both wheelpaths.
Flushing	100	1-25 % area of both wheelpaths.
	010	26-50 % area of both wheelpaths.
	001	> 50 % area of both wheelpaths.

Note: Rating value "000" indicates absence of distress.

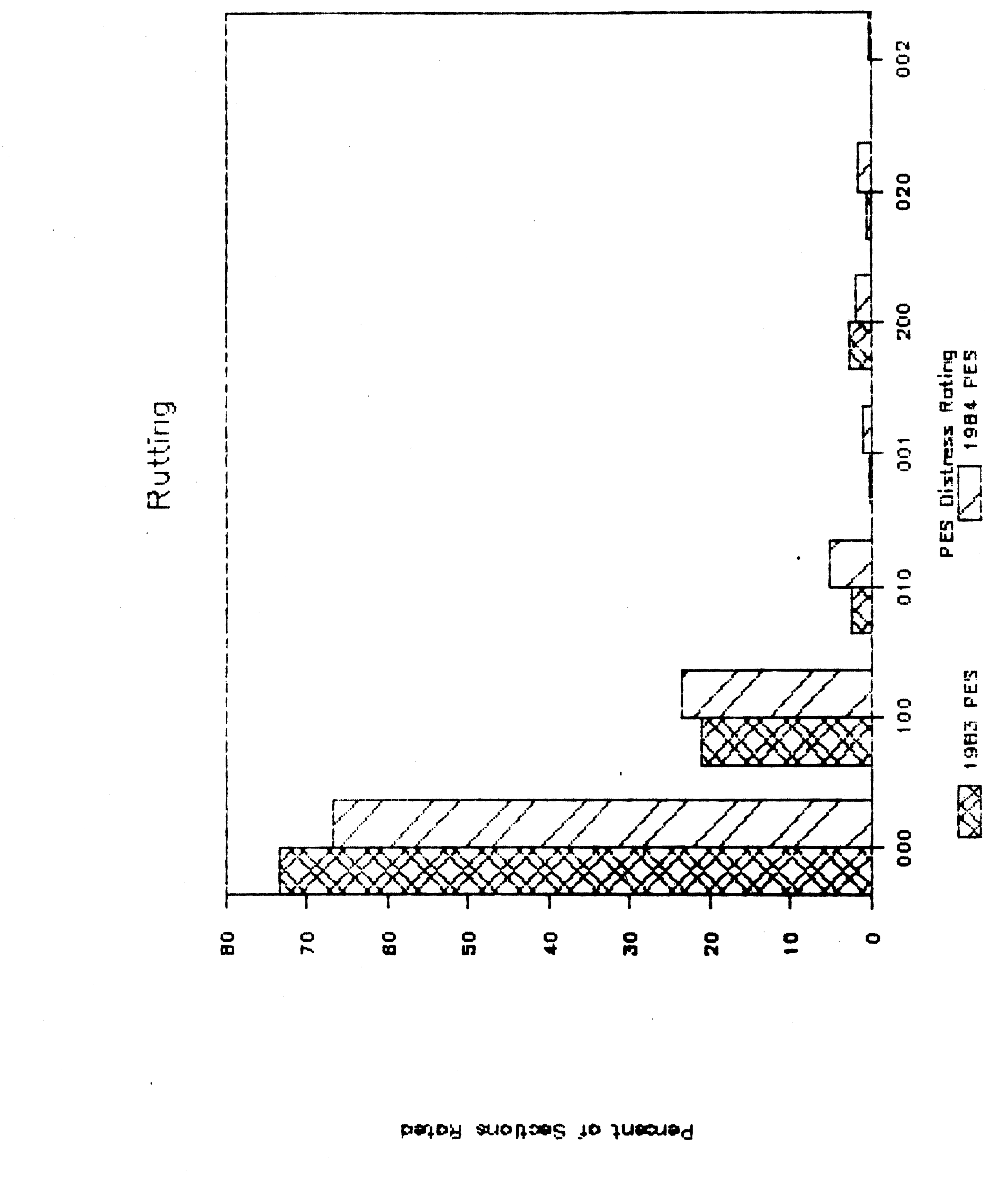

Rutting
Percent of Sections Rated
0
10
20
30
40
50
60
70
80
000
100
010
001
200
020
002
PES Distress Rating
1983 PES
1984 PES

Fig. 5.1

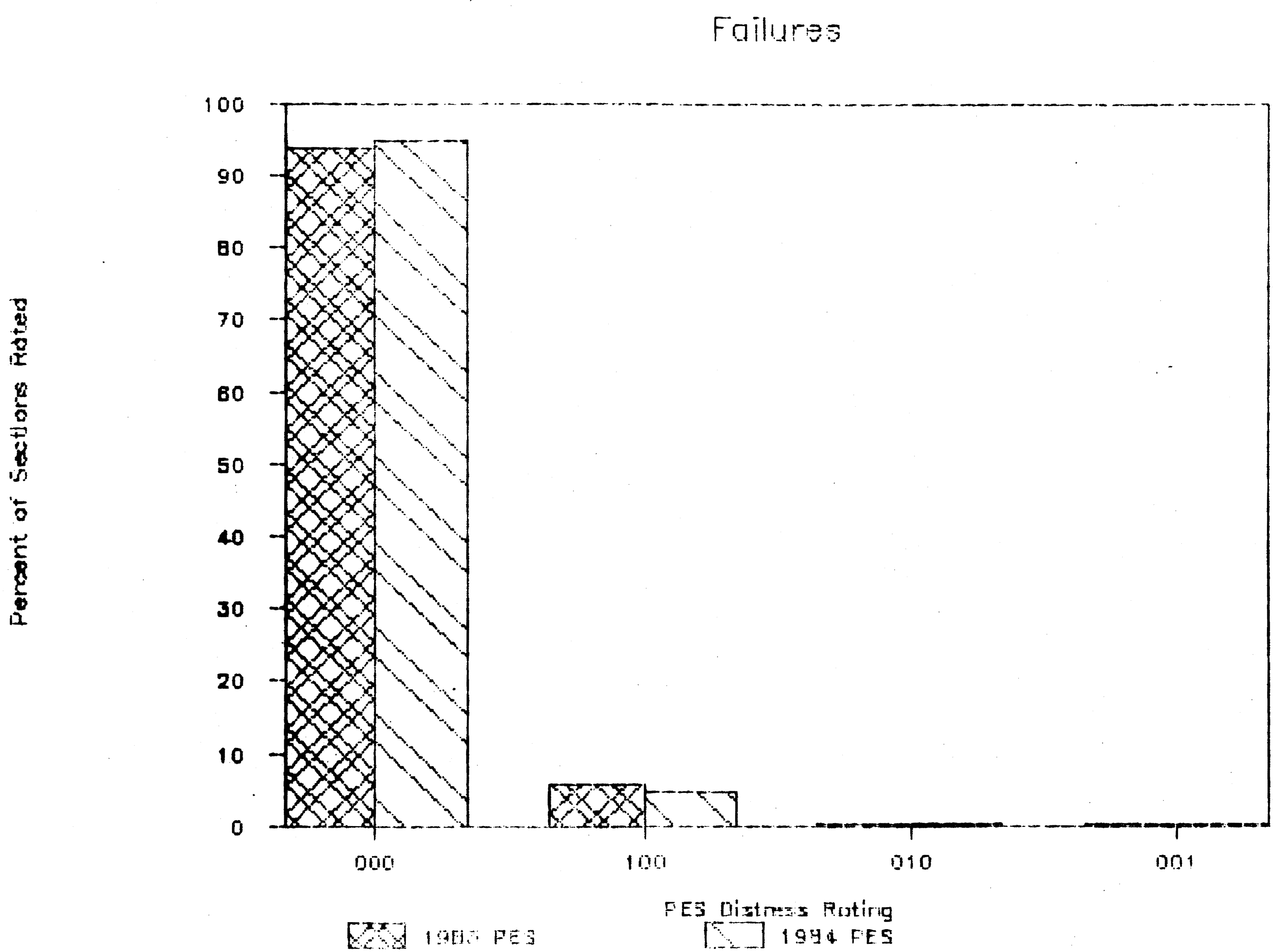

Failures
Percent of Sections Rated
100
90
80
70
60
50
40
30
20
10
0
000
100
010
001
PES Distress Rating
1994 PES

Fig. 5.2

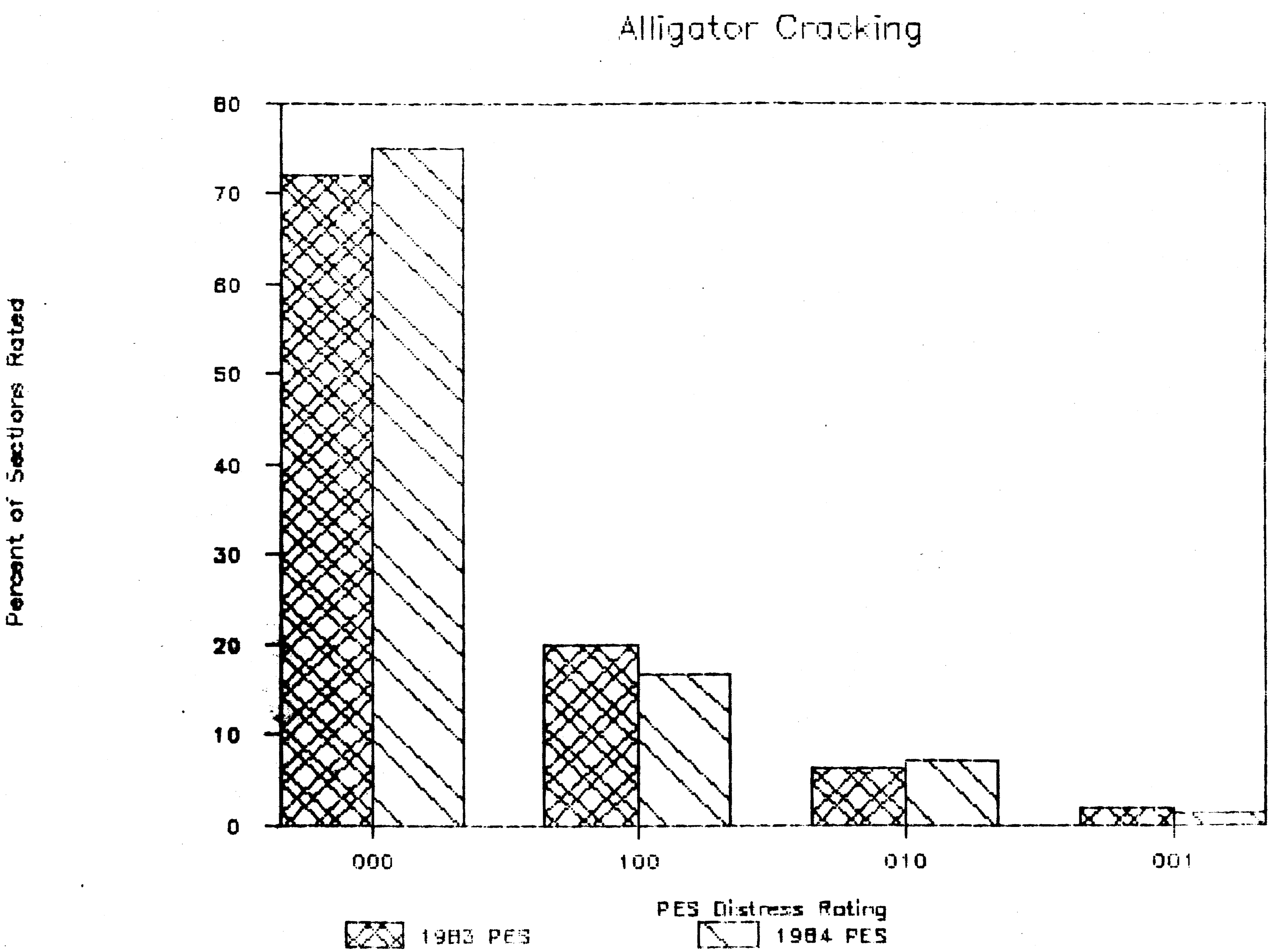

Alligator Cracking
Percent of Sections Rated
80
70
60
50
40
30
20
10
0
000
100
010
001
PES Distress Rating
1983 PES
1984 PES

Fig. 5.3

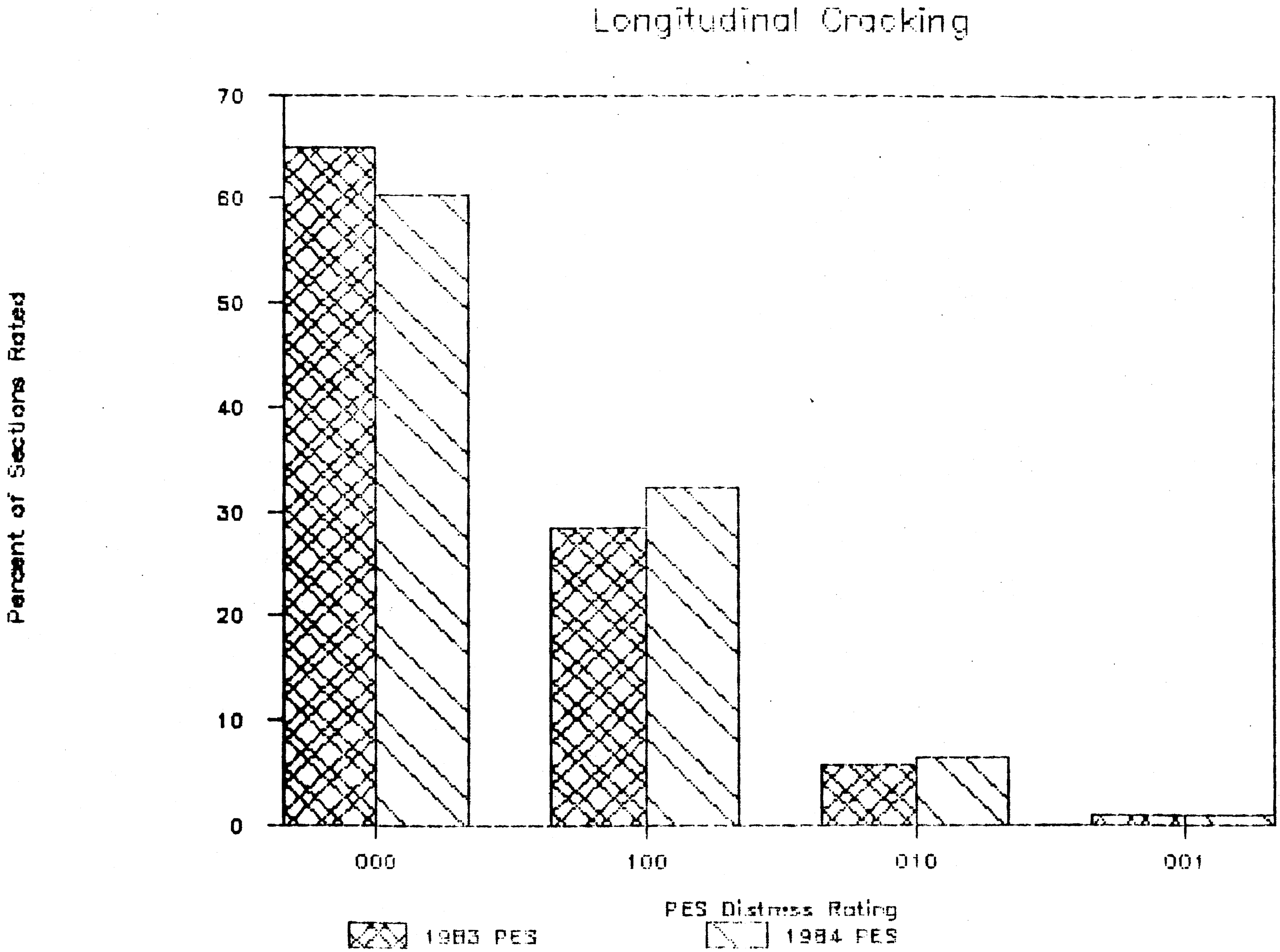

Longitudinal Cracking
Percent of Sections Rated
70
60
50
40
30
20
10
0
000
100
010
001
PES Distress Rating
1983 PES
1984 PES

Fig. 5.4

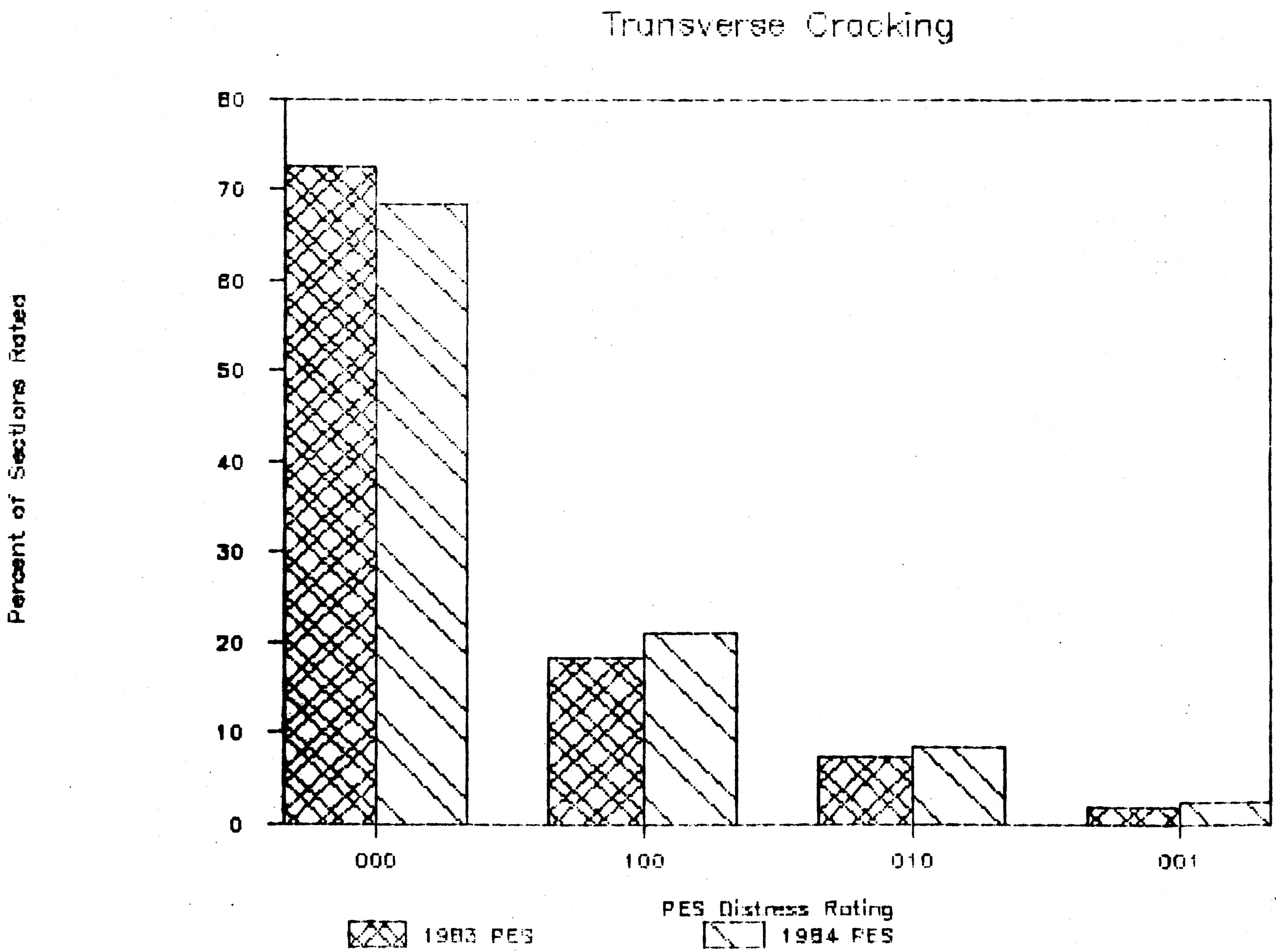

Transverse Cracking
Percent of Sections Rated
0
10
20
30
40
50
60
70
80
000
100
010
001
PES Distress Rating
1983 PES
1984 PES

Fig. 5.5

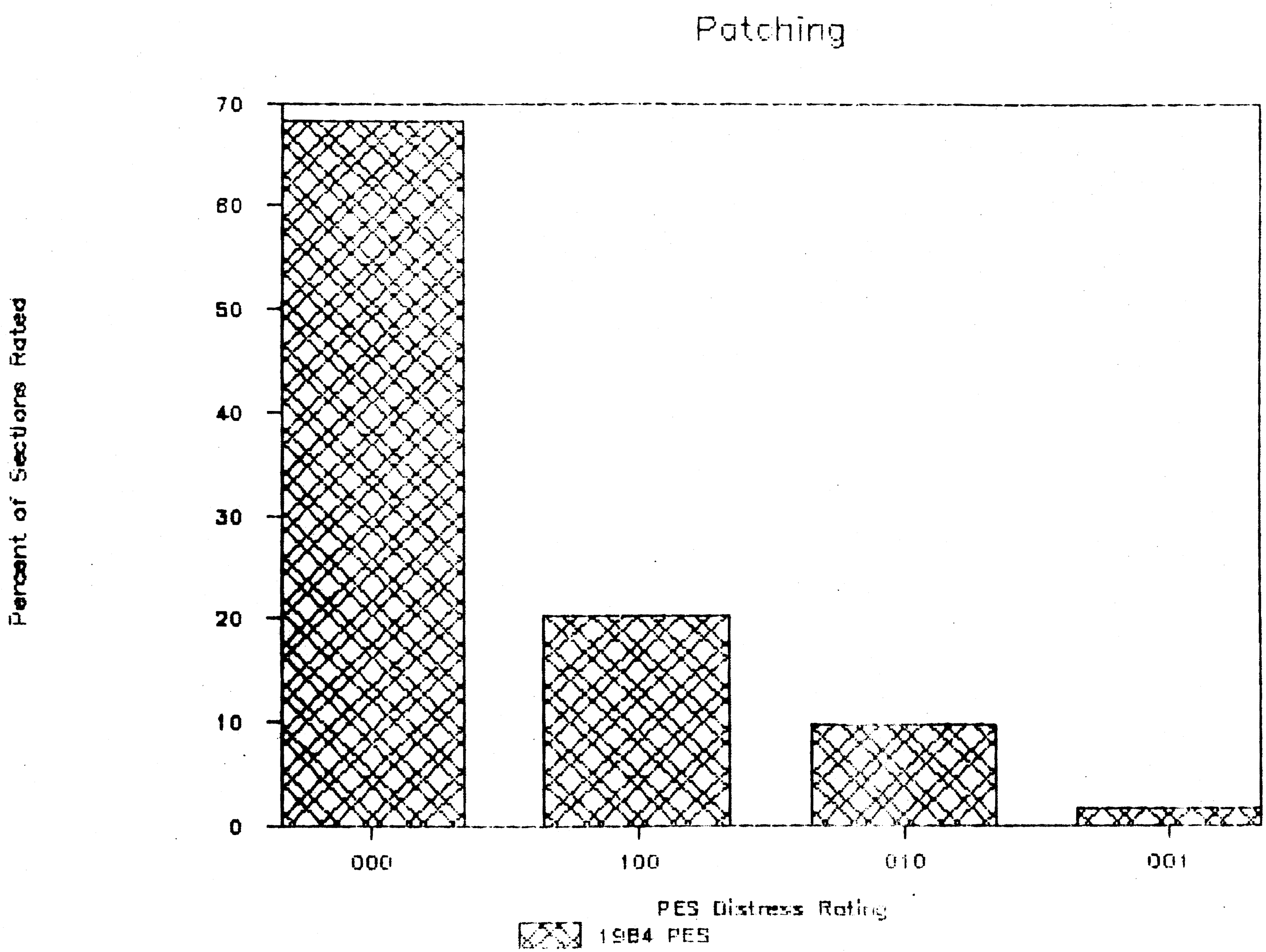

Patching
70
60
50
40
30
20
10
0
Percent of Sections Rated
000
100
010
001
PES Distress Rating
1984 PES

Fig. 5.6

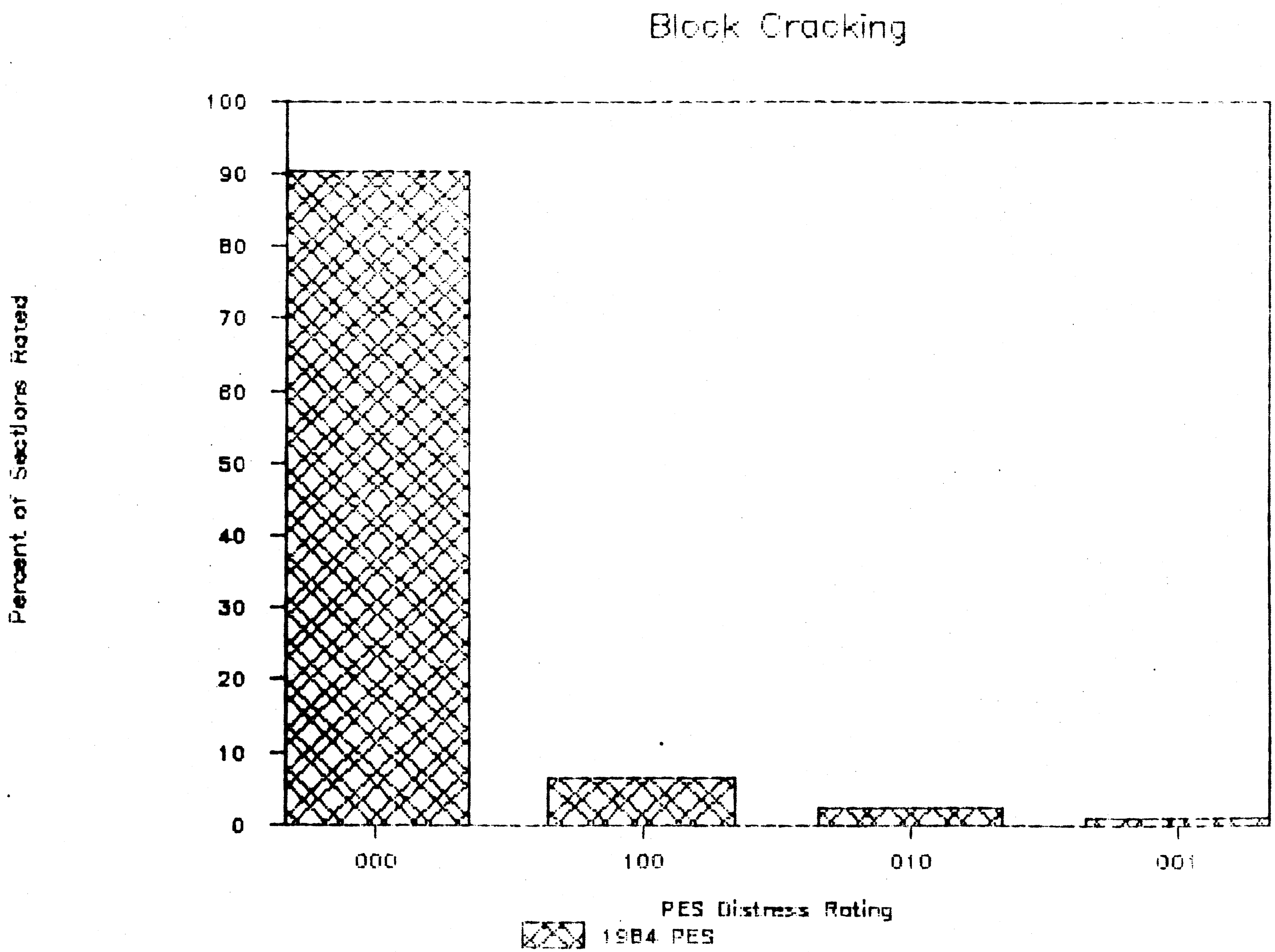

Block Cracking
100
90
80
70
60
50
40
30
20
10
0
Percent of Sections Rated
000
100
010
001
PES Distress Rating
1984 PES

Fig. 5.7

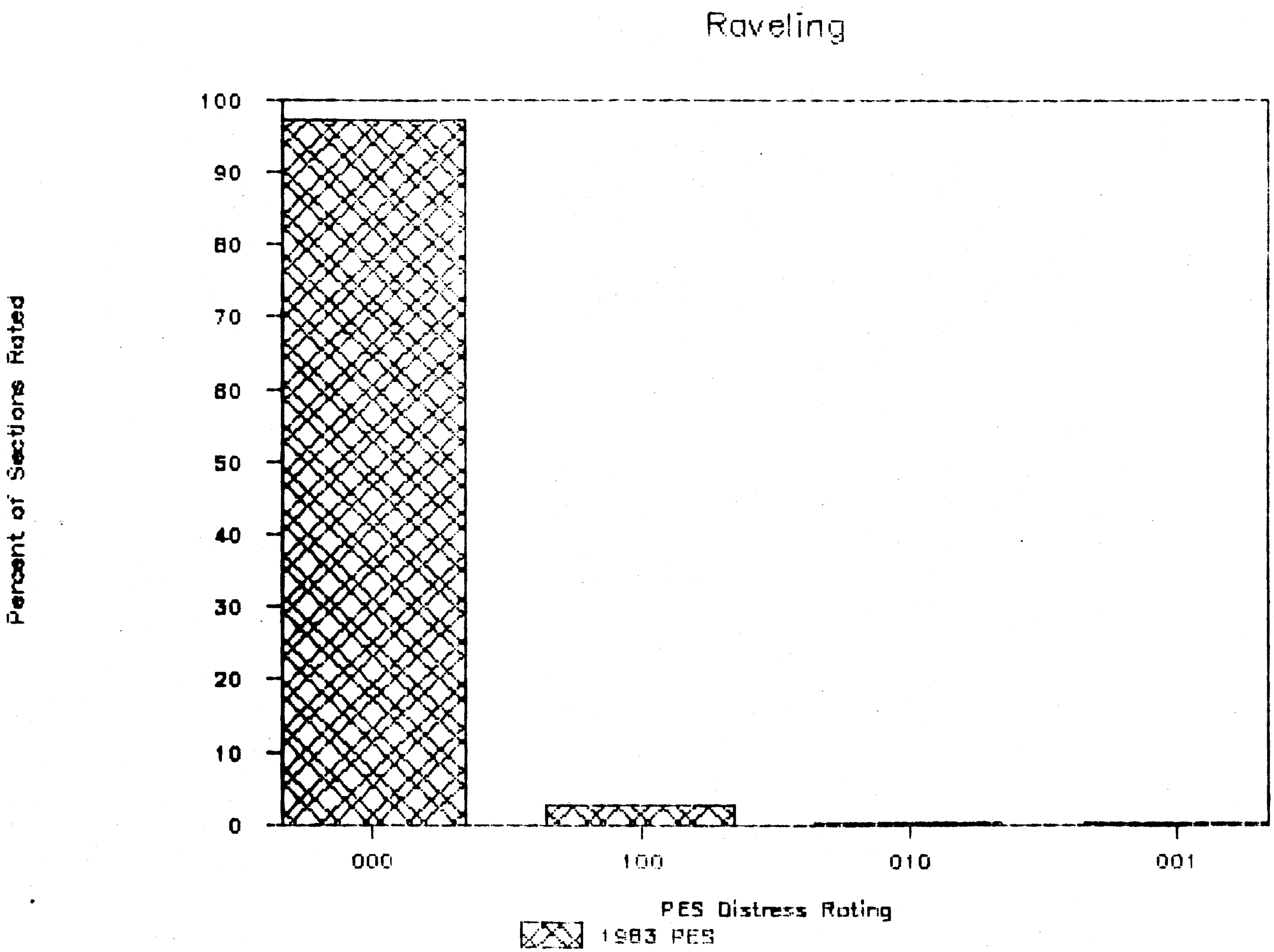

Raveling
Percent of Sections Rated
100
90
80
70
60
50
40
30
20
10
0
000
100
010
001
PES Distress Rating
1983 PES

Fig. 5.8

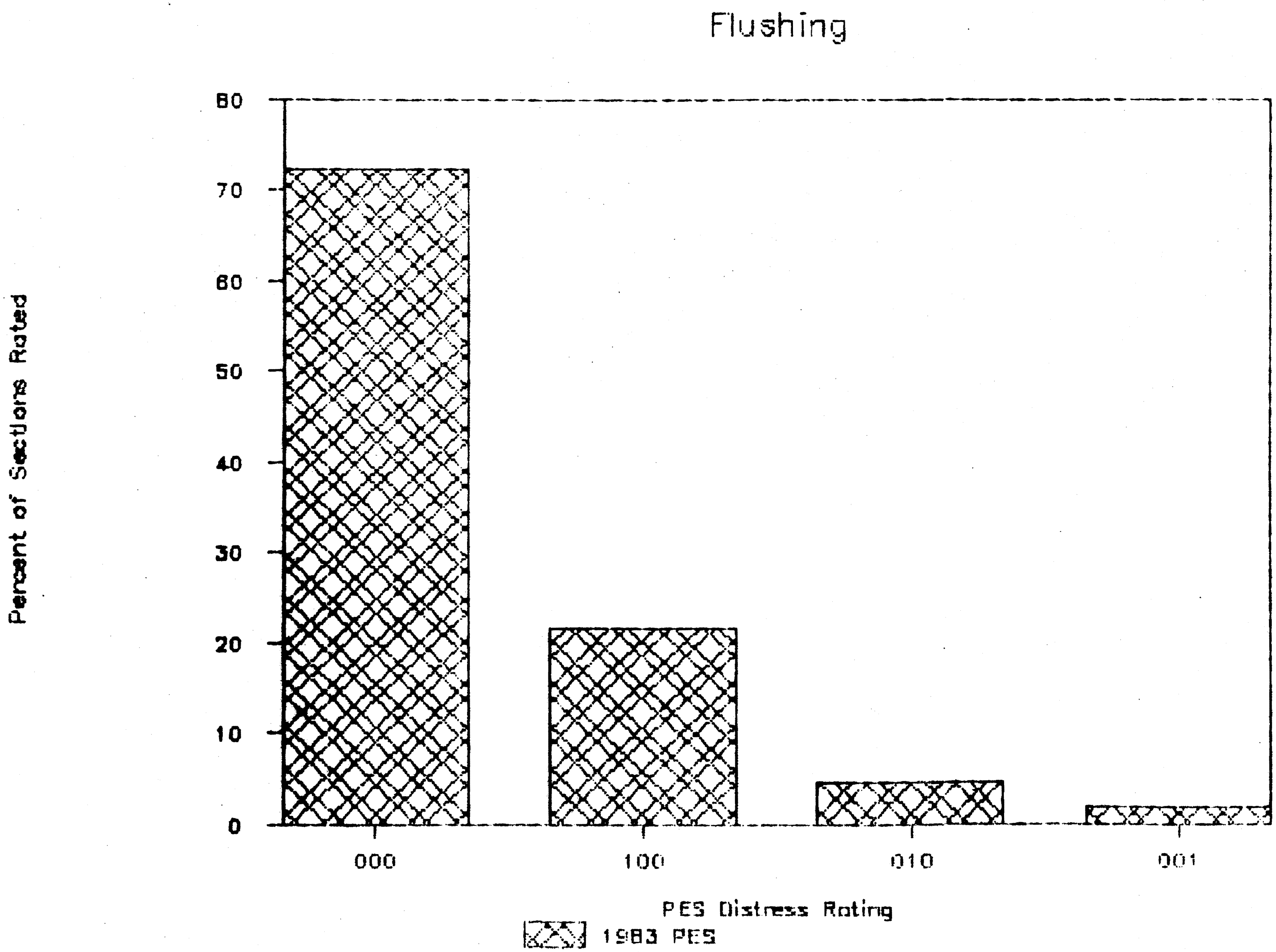
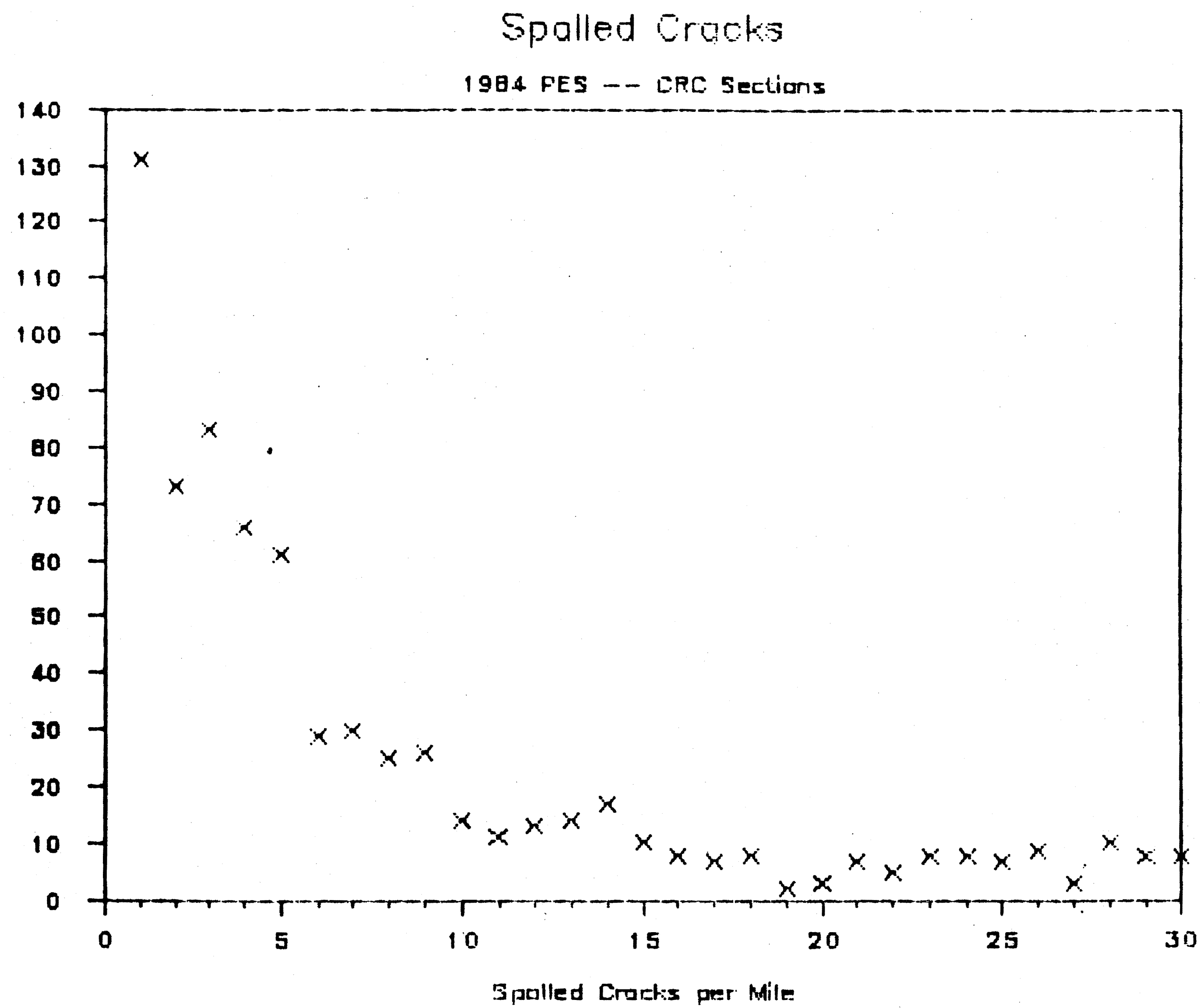

Flushing
Percent of Sections Rated
80
70
60
50
40
30
20
10
0
000
100
010
001
PES Distress Rating
1983 PES

Fig. 5.9



Spalled Cracks
1984 PES -- CRC Sections
Frequency
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
0
5
10
15
20
25
30
Spalled Cracks per Mile

Fig. 5.10

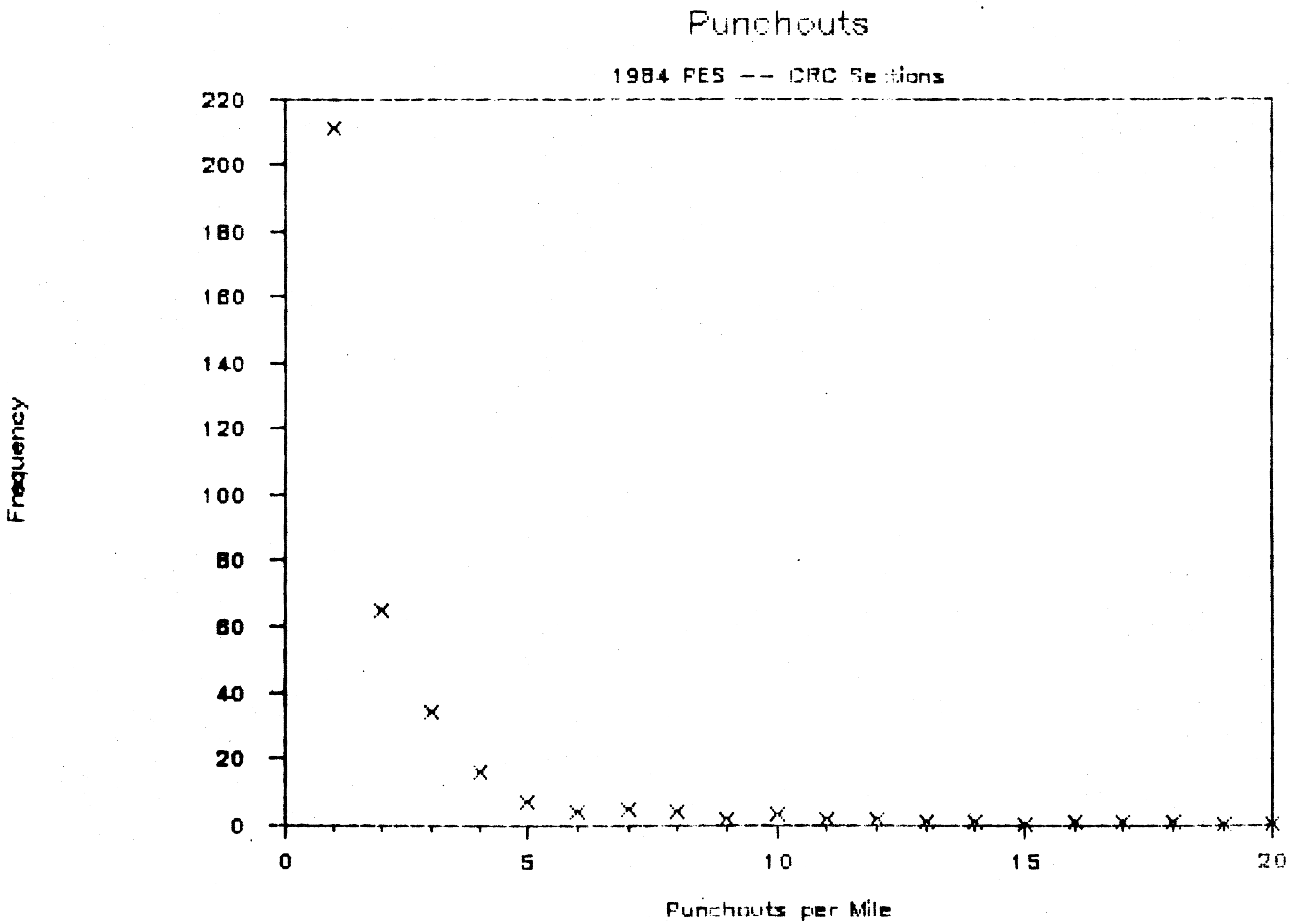

Punchouts
1984 PES -- CRC Sections
Frequency
220
200
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
Punchouts per Mile

Fig. 5.11

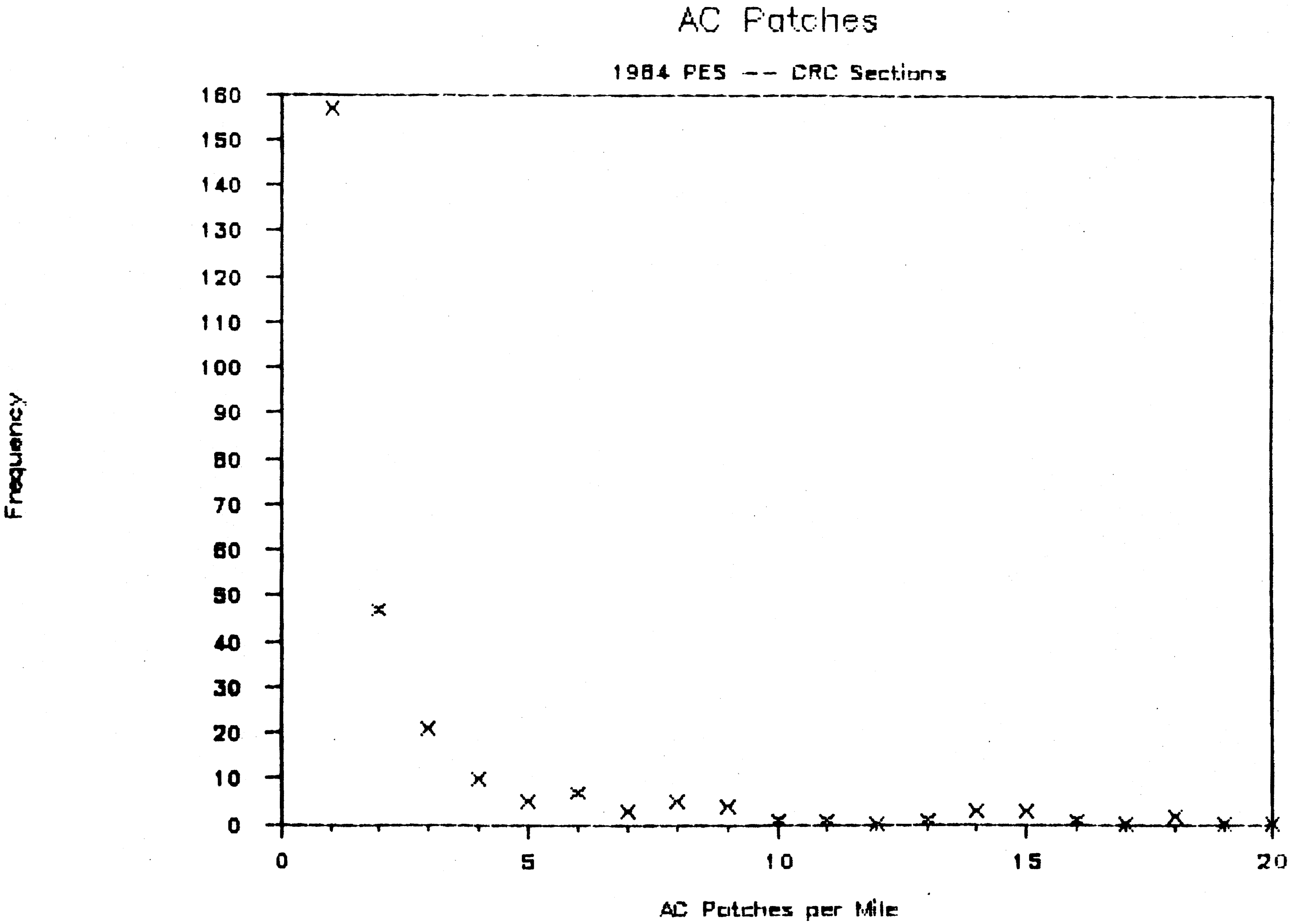

AC Patches
1984 PES -- CRC Sections
Frequency
AC Patches per Mile
0
5
10
15
20
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

Fig. 5.12

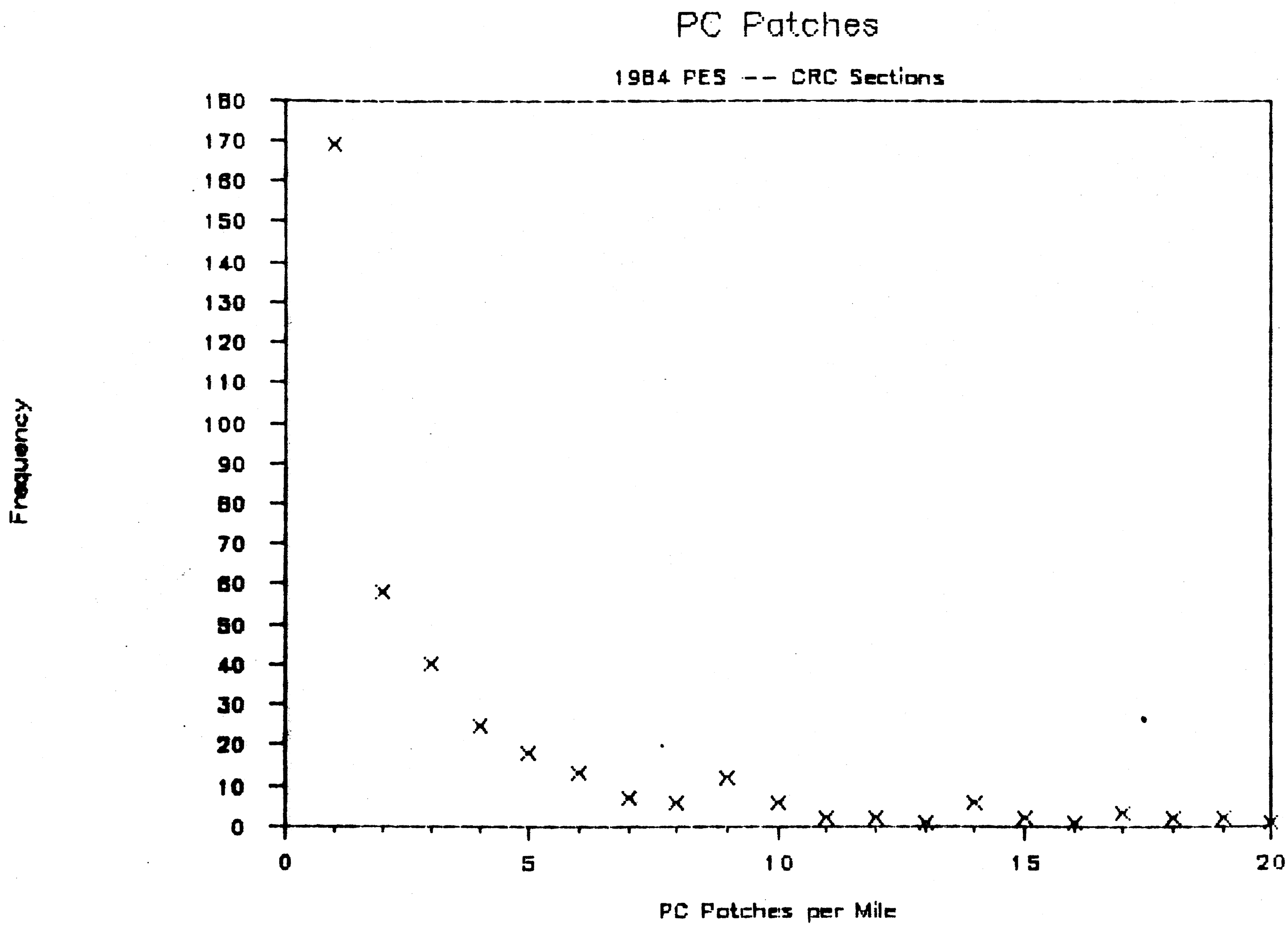

PC Patches
1984 PES -- CRC Sections
Frequency
PC Patches per Mile
0
5
10
15
20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Fig. 5.13

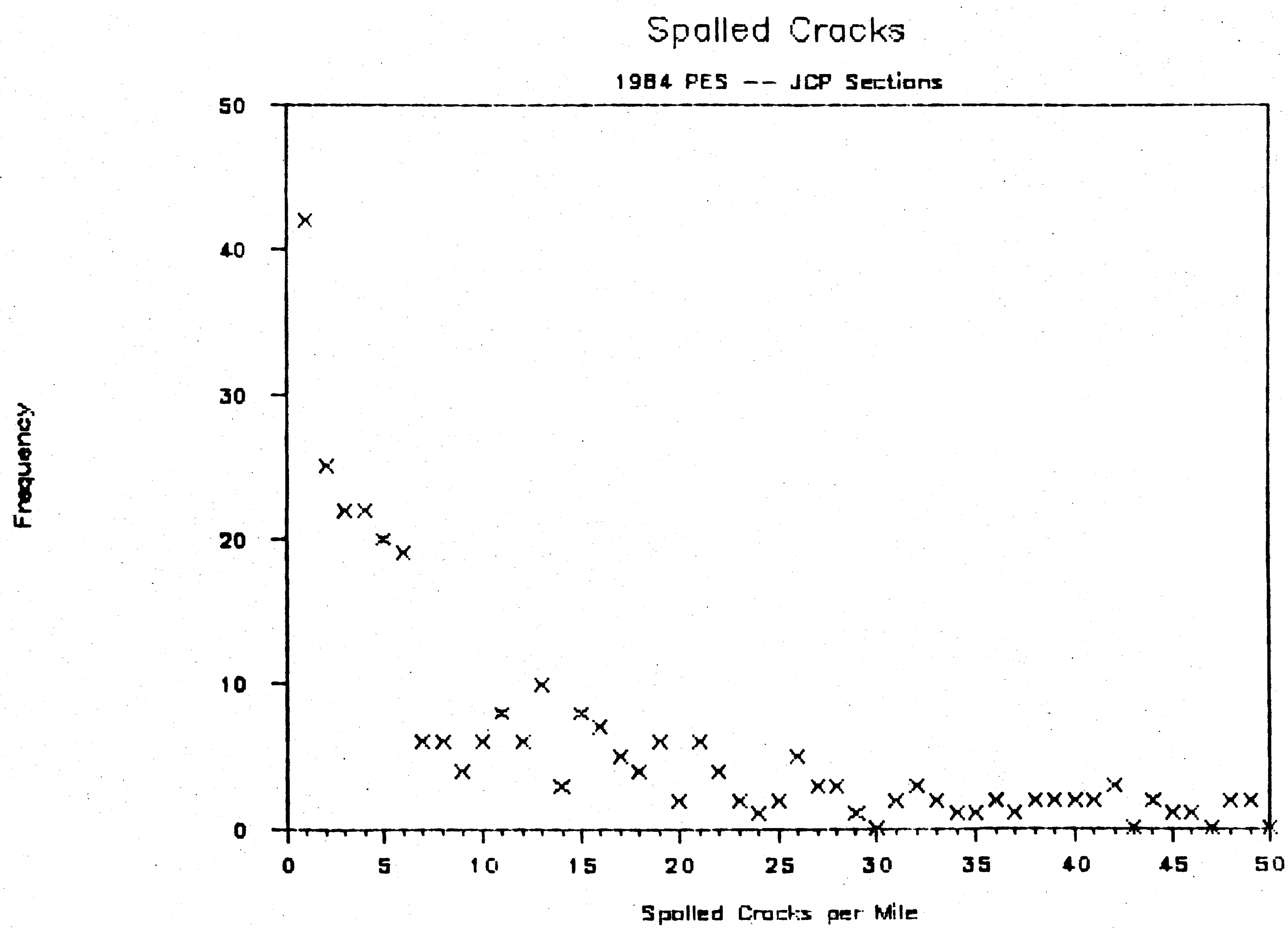

Spalled Cracks
1984 PES -- JCP Sections
Frequency
Spalled Cracks per Mile
0
10
20
30
40
50
0
5
10
15
20
25
30
35
40
45
50

Fig. 5.14

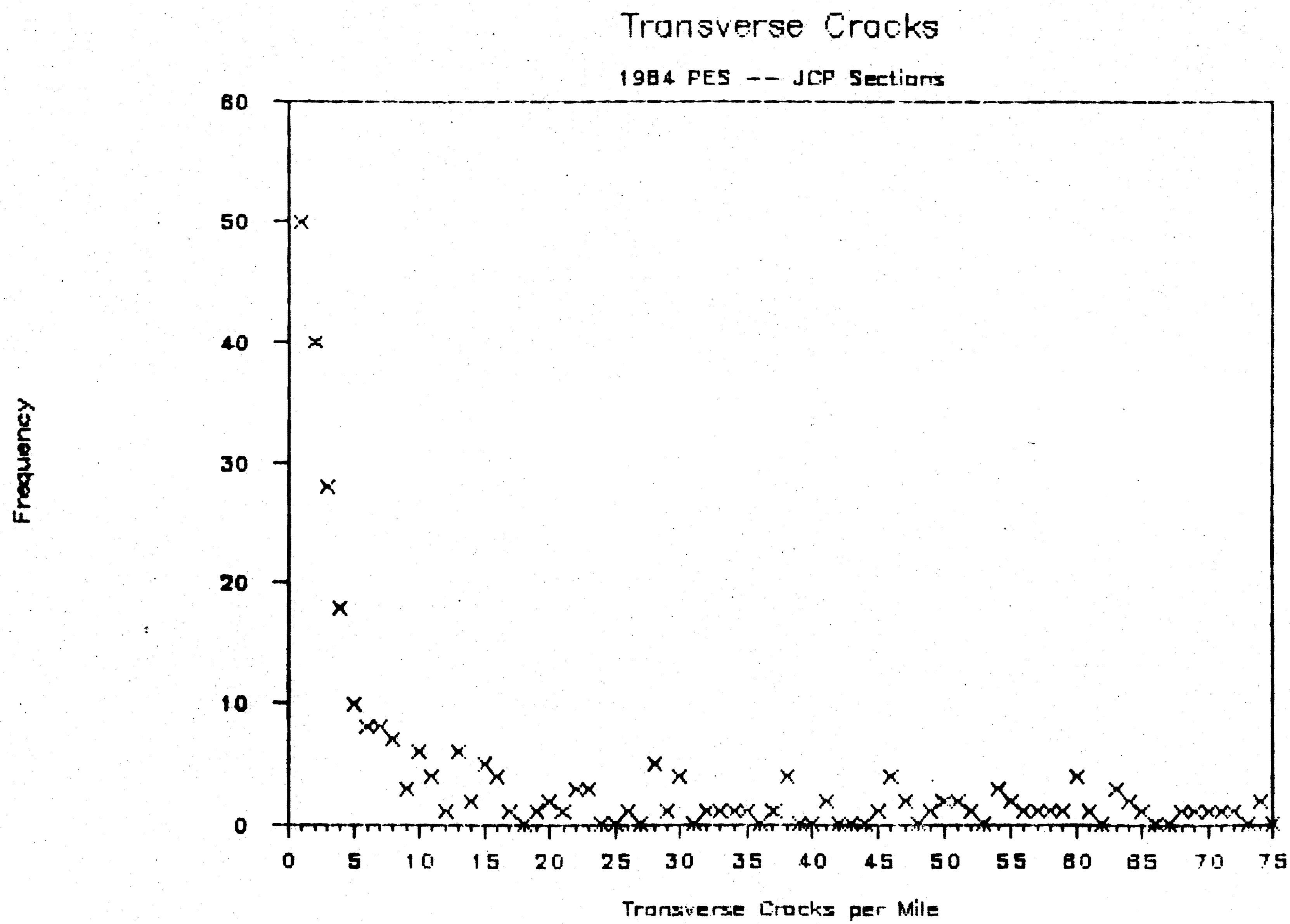
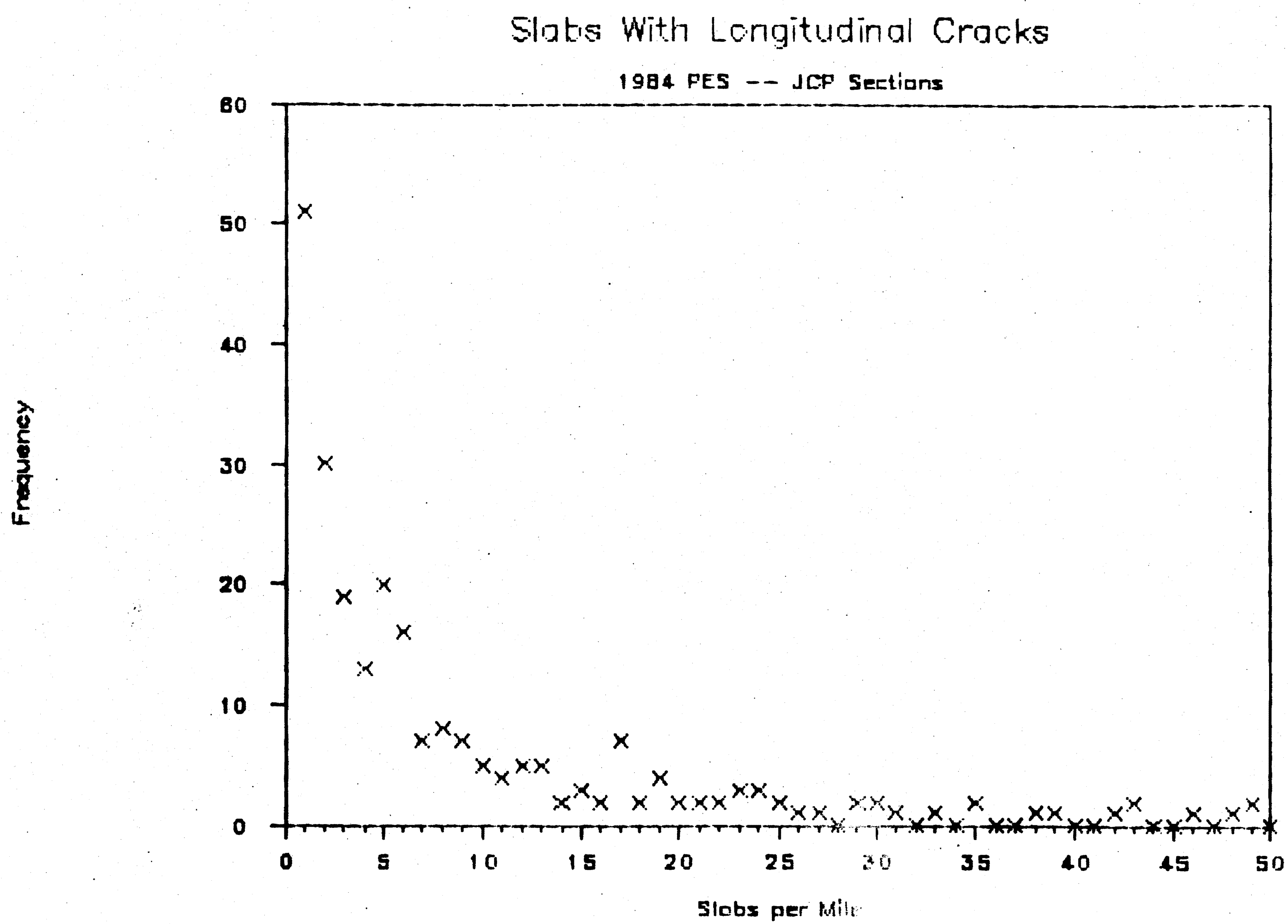

Transverse Cracks
1984 PES -- JCP Sections
Frequency
0
10
20
30
40
50
60
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
Transverse Cracks per Mile

Fig. 5.15



Slabs With Longitudinal Cracks
1984 PES -- JCP Sections
Frequency
Slabs per Mile
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40
45
50

Fig. 5.16

Corner Breaks and Punchouts

1984 PES -- JCP Sections

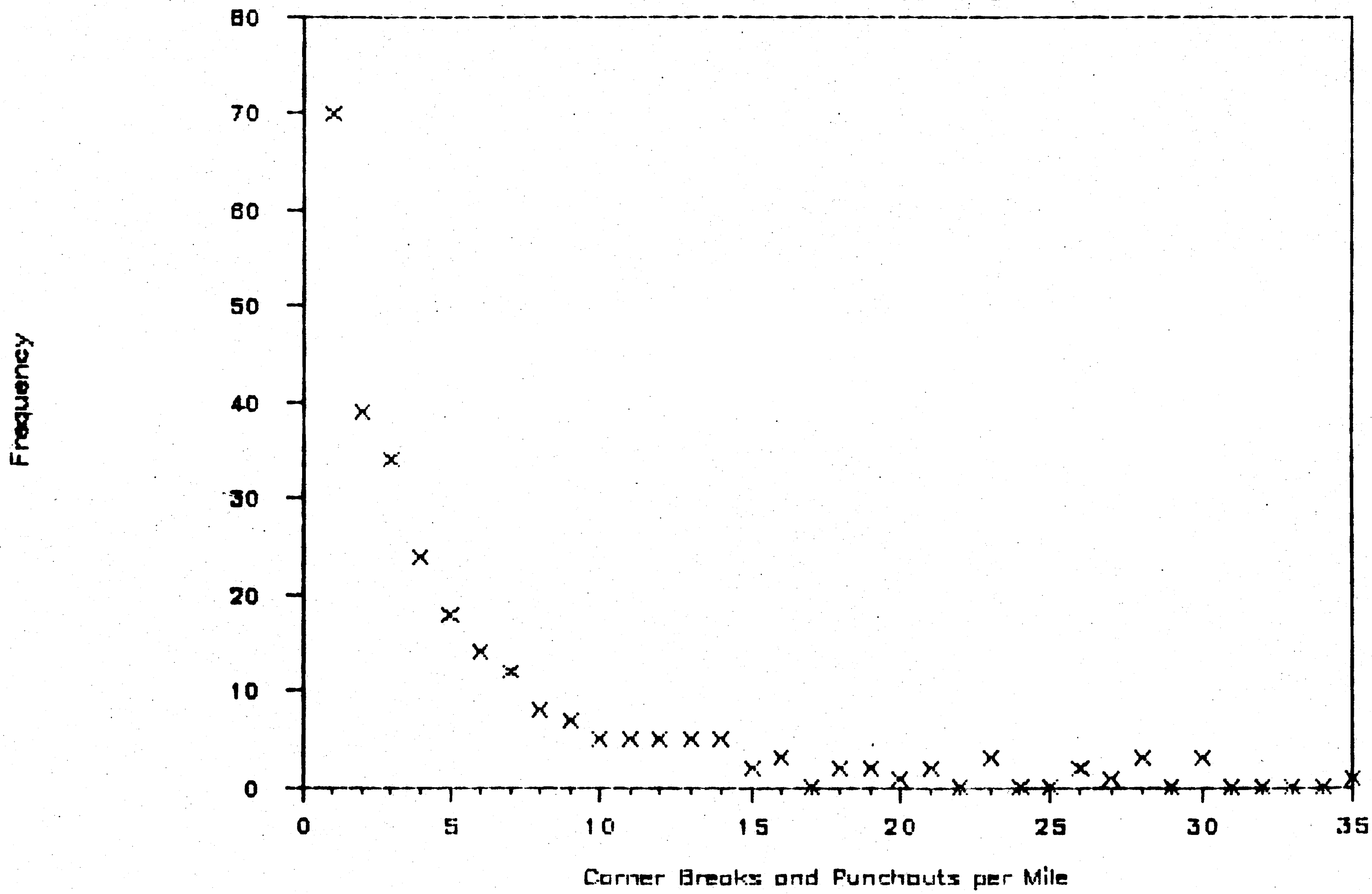


Fig. 5.17

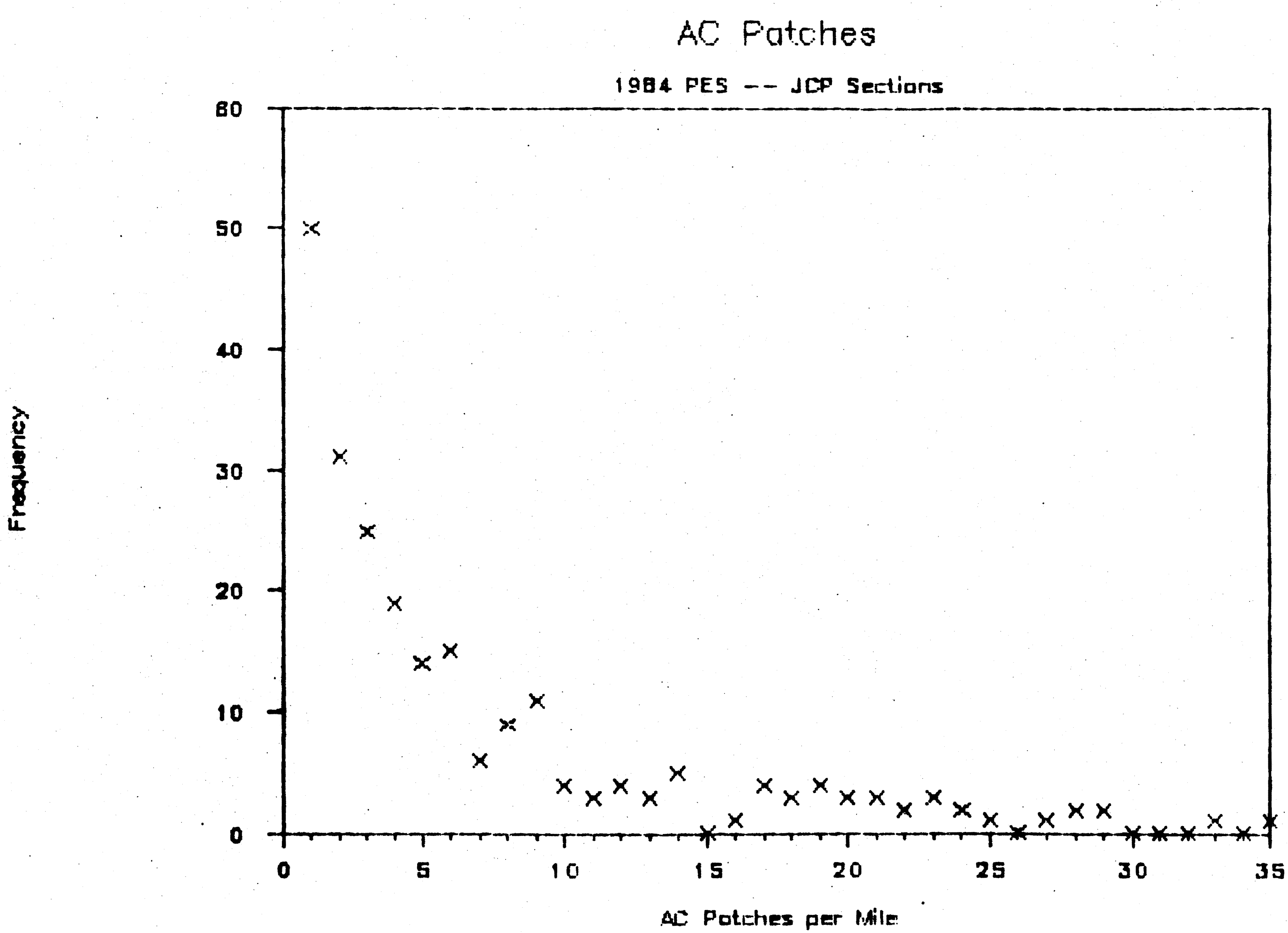
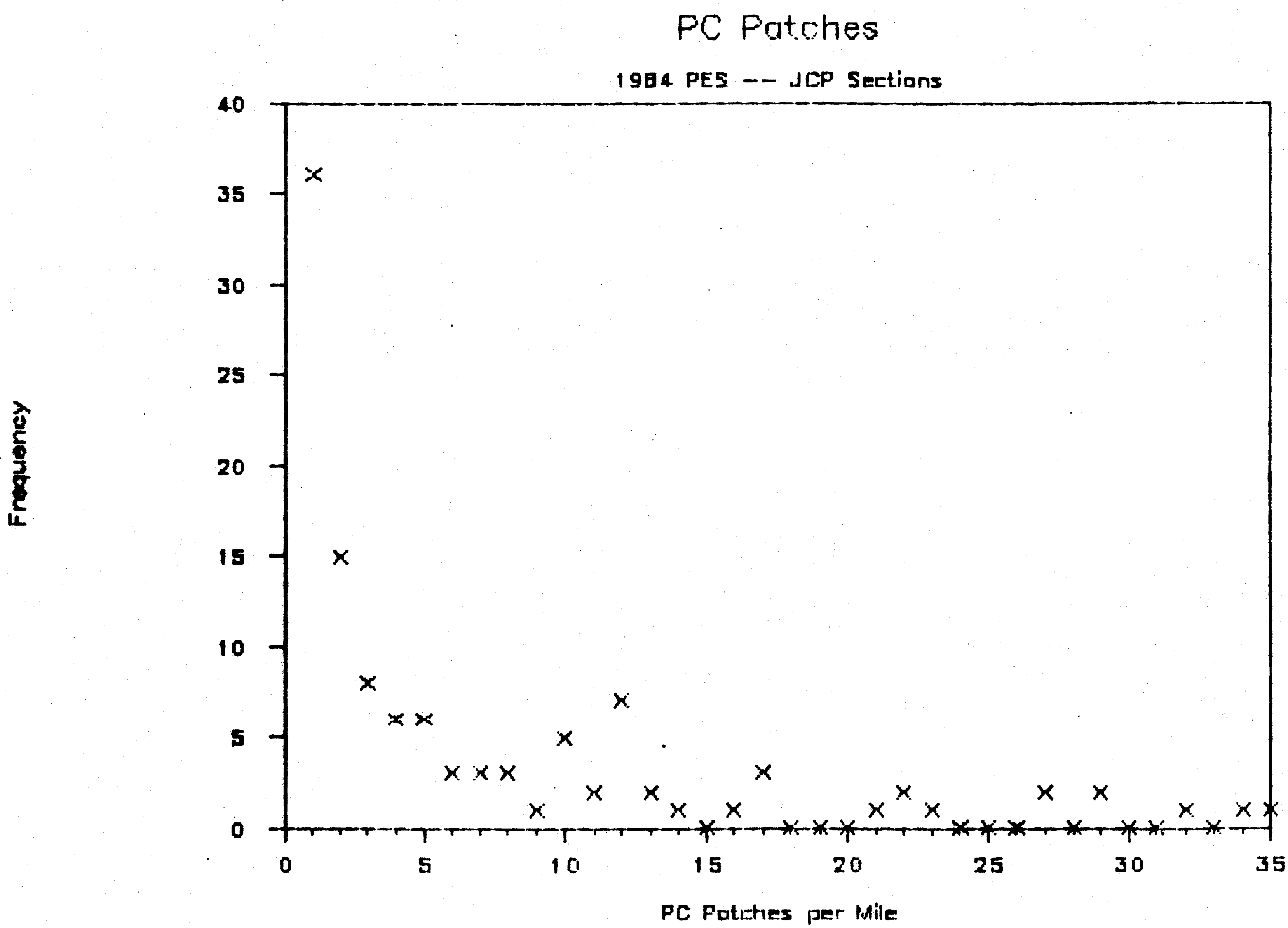

AC Patches
1984 PES -- JCP Sections
Frequency
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
AC Patches per Mile

Fig. 5.18



PC Patches
1984 PES -- JCP Sections
Frequency
PC Patches per Mile
0
5
10
15
20
25
30
35
40

Fig. 5.19

NOTES

CHAPTER 6

CONDITION OF INTERSTATE HIGHWAY SYSTEM

Contains average condition values for 14 Interstate highways in Texas. Also contains figures which depict continuous profiles (for ride quality, unadjusted visual utility, pavement score, ADT, and 18-k ESAL) for the following major routes: IH 10, IH 20, IH 35 (through Dallas), IH 35 (through Fort Worth), and IH 45.

The Interstate System consists of the most important highways in the state. The annual PES survey includes evaluations of all of the Interstate mileage, providing detailed information on the specific and overall condition of all Interstate highways.

Table 6.1 contains average pavement condition values for each Interstate highway (except for IH 820, which was not evaluated during the 1984 survey). These values indicate the overall excellent quality of the Interstate system. More important, however, are the traffic values. Average ADT and 18-k ESAL reflect the heavy traffic activity in Houston and the Dallas-Fort Worth area (as described by IH 610, IH 45, and IH 635). Other high-traffic corridors are IH 30, IH 35 (through Dallas), and IH 410.

Four Interstate highways can be considered as major cross-state routes: IH 10, IH 20, IH 35, and IH 45. Continuous pavement condition profiles were developed for each of these highways in an attempt to identify regional variations in condition and traffic. The profiles are organized as shown below:

* Figure 6.1 -- Mileposts for selected locations on the Interstate system.
* Figures 6.2-6.6 -- IH 10 profiles (PSI, UVU, pavement score, ADT, and 18-k ESAL).
* Figures 6.7-6.11 -- IH 20 profiles.
* Figures 6.12-6.16 -- IH 35 (through Dallas) profiles.
* Figures 6.17-6.21 -- IH 35 (through Fort Worth) profiles.
* Figures 6.22-6.26 -- IH 45 profiles.

IH 10 PROFILES

The PSI profile (Figure 6.2) indicates that ride quality is consistently highest between IH 20 and San Antonio. Most of the rough sections are east of San Antonio, especially from milepost 600. Surface distress (Figure 6.3) and pavement score (Figure 6.4) are lowest at three areas: Sierra Blanca mountain pass, city of Junction, and city of Sealy. The ADT and 18-k ESAL profiles (Figures 6.5 and 6.6, respectively) show several trends: (1) drop in traffic west of IH 20 interchange, (2) high traffic volumes in El Paso, Fort Stockton, San Antonio, Houston, and Beaumont, and (3) high truck traffic, even in the more remote areas between IH 20 and San Antonio.

IH 20 PROFILES

Ride quality along IH 20 is lowest along a 150-mile stretch beginning at milepost 370 and continuing through the Dallas-Fort Worth area. Other isolated areas of roughness lie between Big Spring and Abilene. Isolated areas of high surface distress are also indicated between Big Spring and Abilene, however the stretch from milepost 370 is relatively free of distress. High traffic volumes, especially between mileposts 400 and 500 (through Dallas-Fort Worth) cause the pavement score profile to drop far below the UVU profile. IH 20 is also a major truck corridor, as indicated by the 18-k ESAL profile.

IH 35 PROFILES

Table 6.1 indicates that IH 35 is in the best condition (in terms of average PSI and pavement score) of the four major cross-state routes. This analysis will describe profiles for IH 35 both through Dallas (along IH 35E) and Fort Worth (along IH 35W).

Ride quality on IH 35 shows an overall slight increase from Laredo to about milepost 280 and a more substantial decline from milepost 280 to Oklahoma (although PSI does increase through the Dallas area from milepost 430 to 460). UVU and pavement score follow these same trends. The ADT profile clearly identifies the major urban areas along IH 35: Laredo, San Antonio, Austin, Belton-Temple, Waco, and Dallas. This profile also demonstrates that the average ADT increases from about 5,000 between Laredo and San Antonio to about 25,000 between San Antonio and Dallas. 18-k ESAL levels also increase from 5,000 to 25,000 with these same ranges.

Two sets of profiles were developed for IH 35 to assess the relative conditions of IH 35E and IH 35W. Comparison of each profile indicates the following trends:

* PSI -- Generally lower along IH 35W.
* UVU -- Little or no difference.
* Pavement Score -- Generally lower along IH 35W.
* ADT and 18-k ESAL -- Little or no difference.

IH 45 PROFILES

PSI on IH 45 drops within the Houston area and from Corsicana to Dallas. UVU and pavement score also drop in these areas. UVU returns to very high levels within Dallas, however pavement score continues to decline because of the low ride quality and high traffic volumes. ADT and 18-k ESAL profiles indicate that IH 45 is a major truck corridor -- 18-k ESAL values average about 25 million repetitions, even in the more remote rural areas.

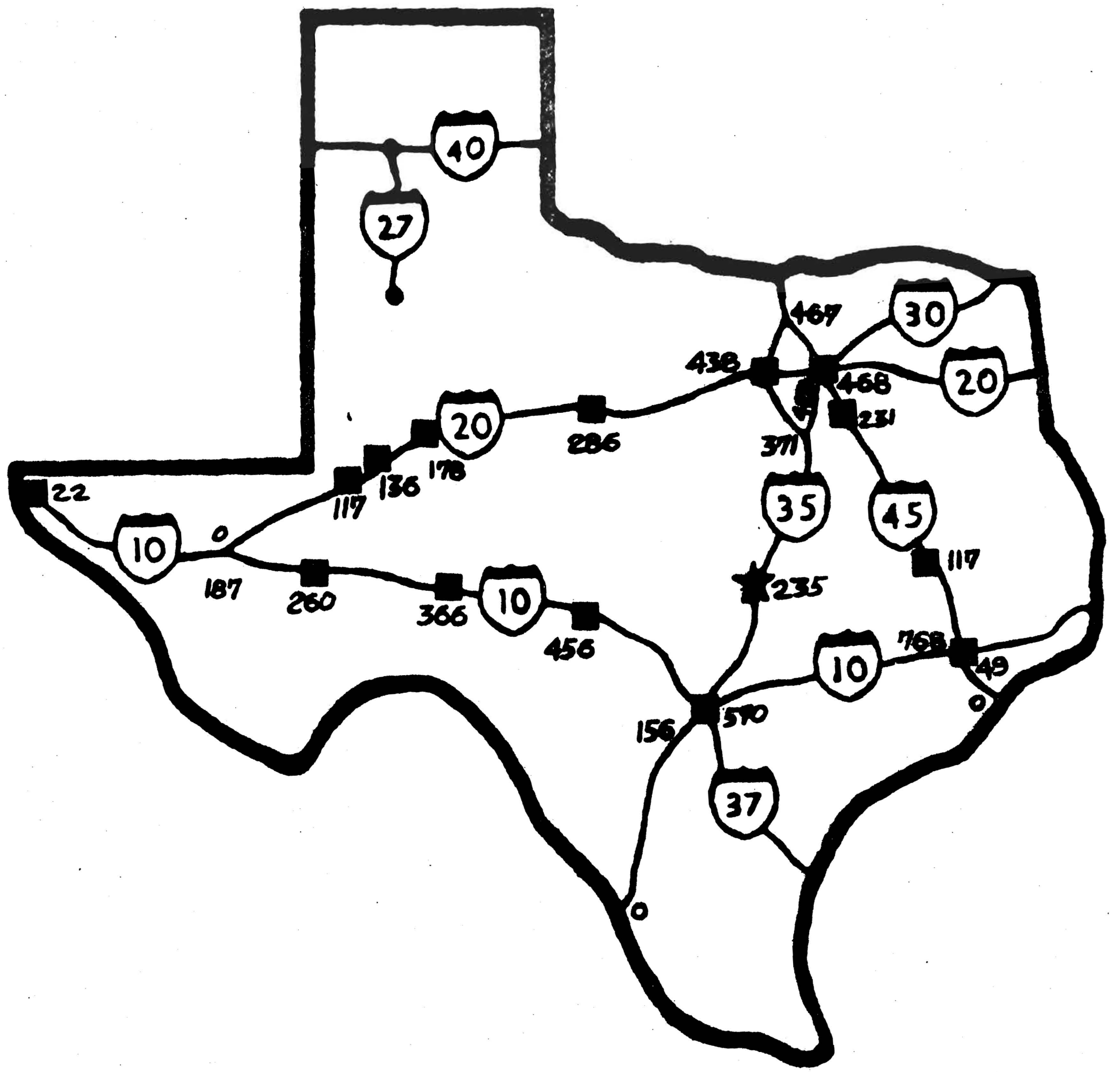
This chapter has explored the use of continuous pavement condition profiles to identify local and regional condition trends for four major Interstate highways. The profiles provide reliable documentation of both commonly-known and newly-discovered facts about these major cross-state routes. Total surveys can yield similar results for other equally-important routes such as US or other Interstate highways. One such route, US 59, will be analyzed in Chapter 9.

Table 6.1

1984 PES -- AVERAGE CONDITIONS ON TEXAS INTERSTATE HIGHWAYS All Rated Mainlane Sections N = 2,726 Sections						
Highway	PSI	UVU	PS	ADT	18-k	N
IH 10	3.91	92.34	85.64	17224	16668	808
IH 20	3.71	88.96	77.77	16531	20894	603
IH 27	3.85	96.11	93.39	11170	14316	46
IH 30	3.42	85.73	71.51	32853	27589	205
IH 35	3.93	91.67	86.53	25959	18636	352
IH 35E	3.35	91.73	73.81	55029	26953	84
IH 35W	3.24	86.95	61.73	20967	22364	73
IH 37	4.18	93.96	91.88	17683	16574	75
IH 40	4.00	88.11	82.24	13428	18432	106
IH 45	3.59	90.24	78.82	42034	26754	267
IH 345	1.95	100.00	7.50	45000	17132	2
IH 410	4.05	92.86	89.59	52464	18891	44
IH 610	3.36	97.82	85.24	149294	39585	34
IH 635	3.19	99.70	45.56	111222	41903	27
Mean	3.76	90.74	81.05	25999	20734	2726

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from 20-year projected values.

Figure 6.1


40
27
30
20
20
467
438
468
231
371
35
45
22
10
0
117
136
178
286
187
260
366
10
456
235
117
10
768
49
0
156
570
37
0

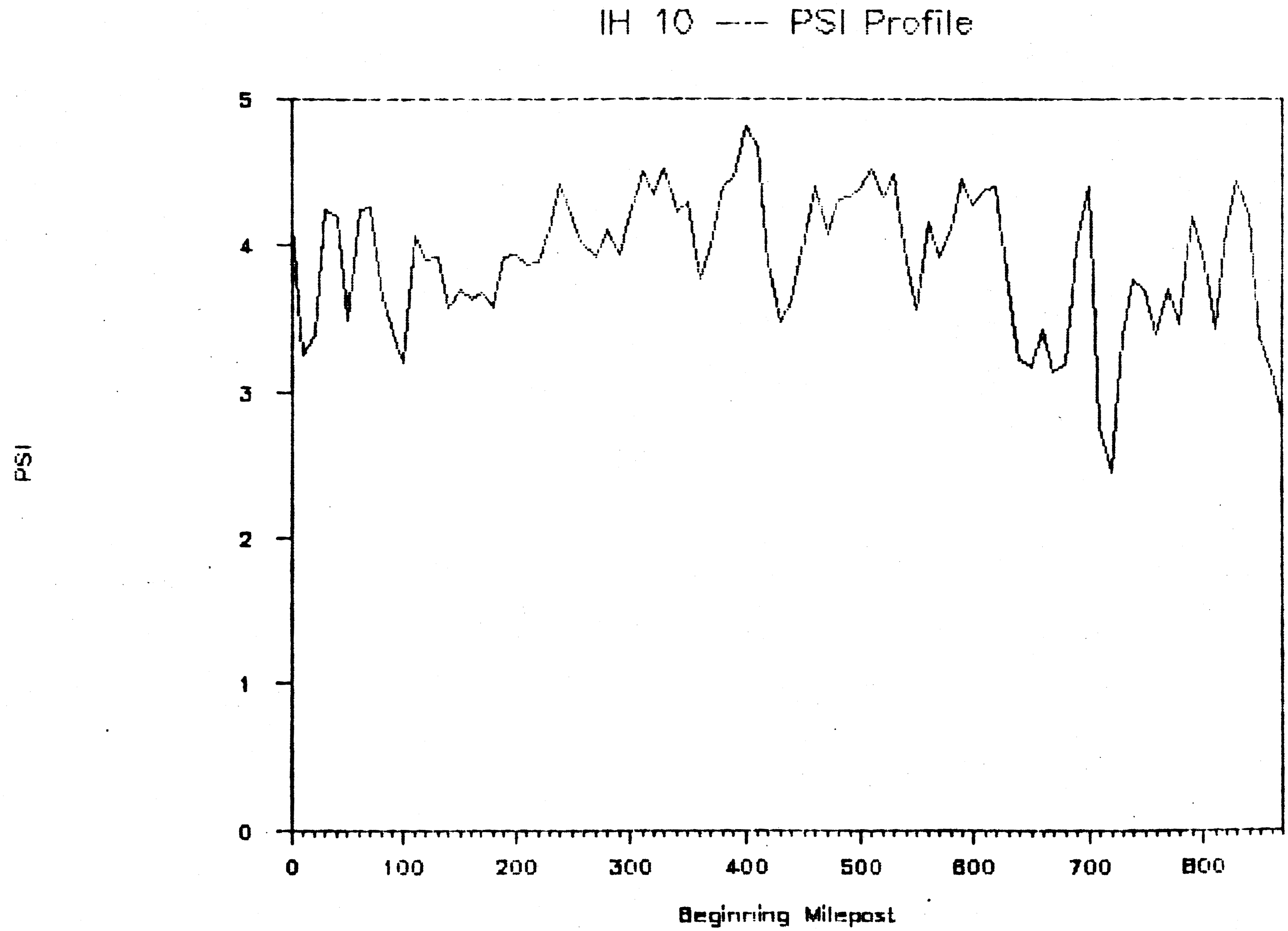

IH 10 --- PSI Profile
PSI
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
Beginning Milepost

Fig. 6.2

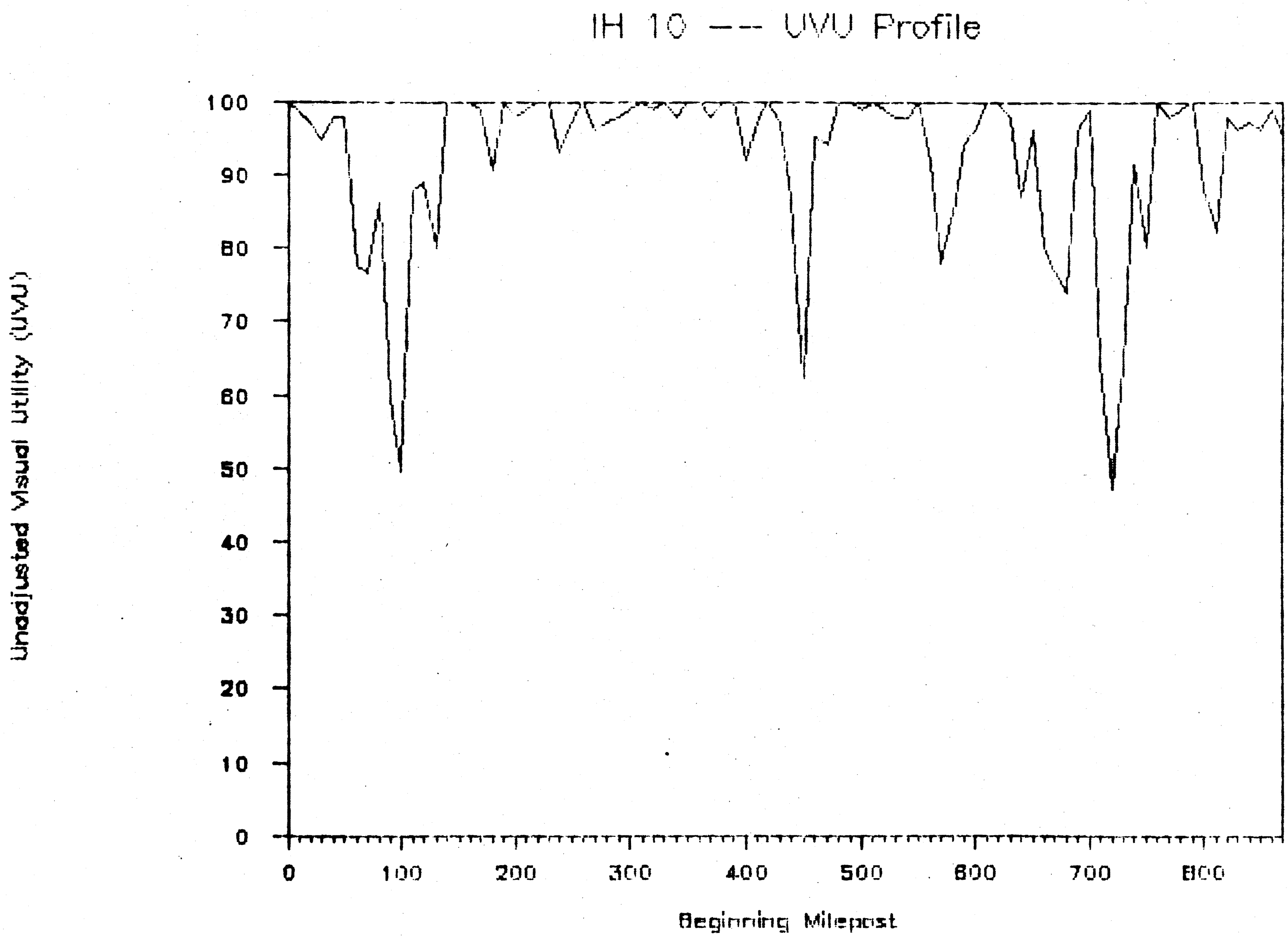

IH 10 -- UVU Profile
Unadjusted Visual Utility (UVU)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
Beginning Milepost

Fig. 6.3

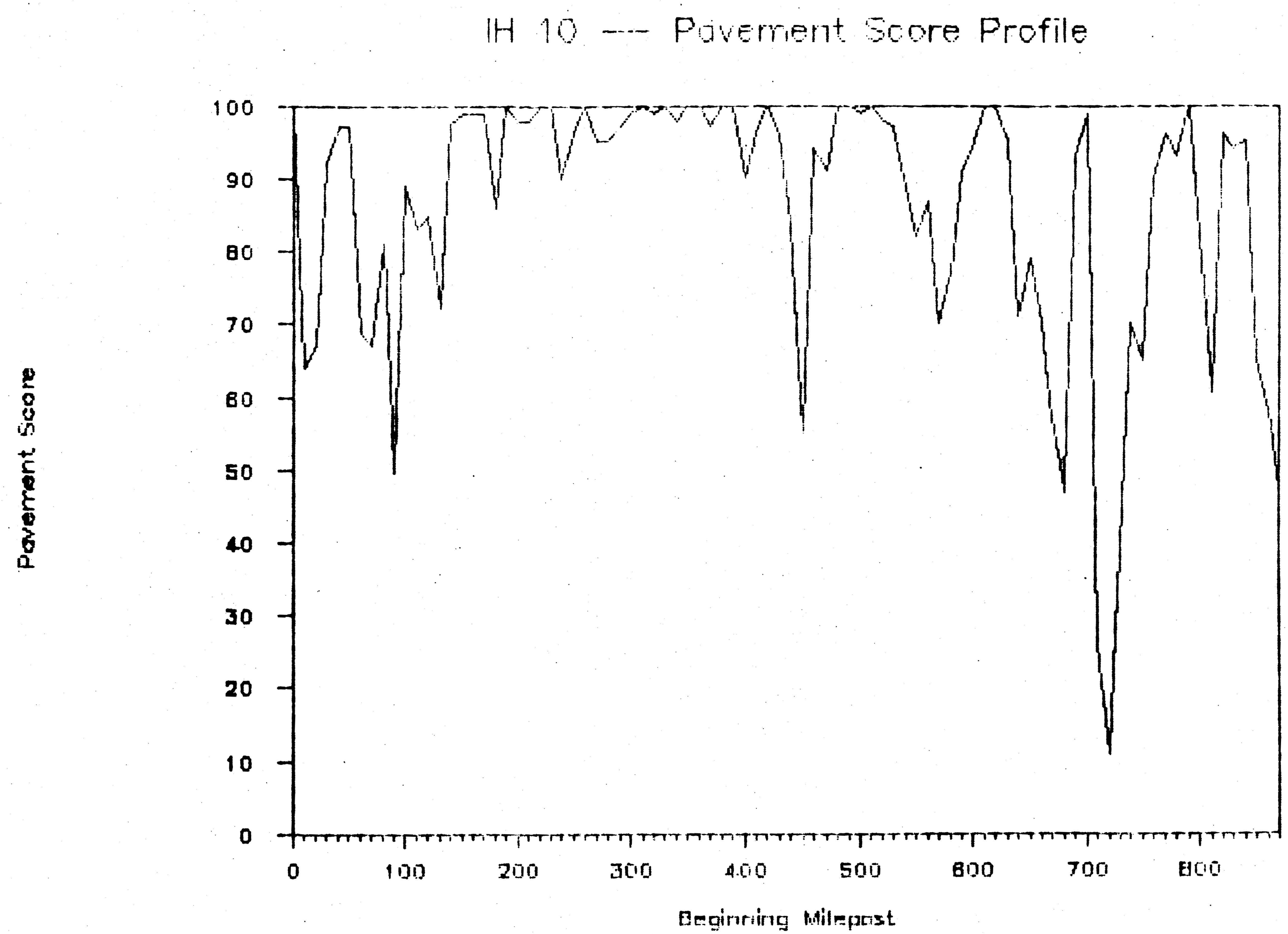

IH 10 --- Pavement Score Profile
Pavement Score
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
Beginning Milepost

Fig. 6.4

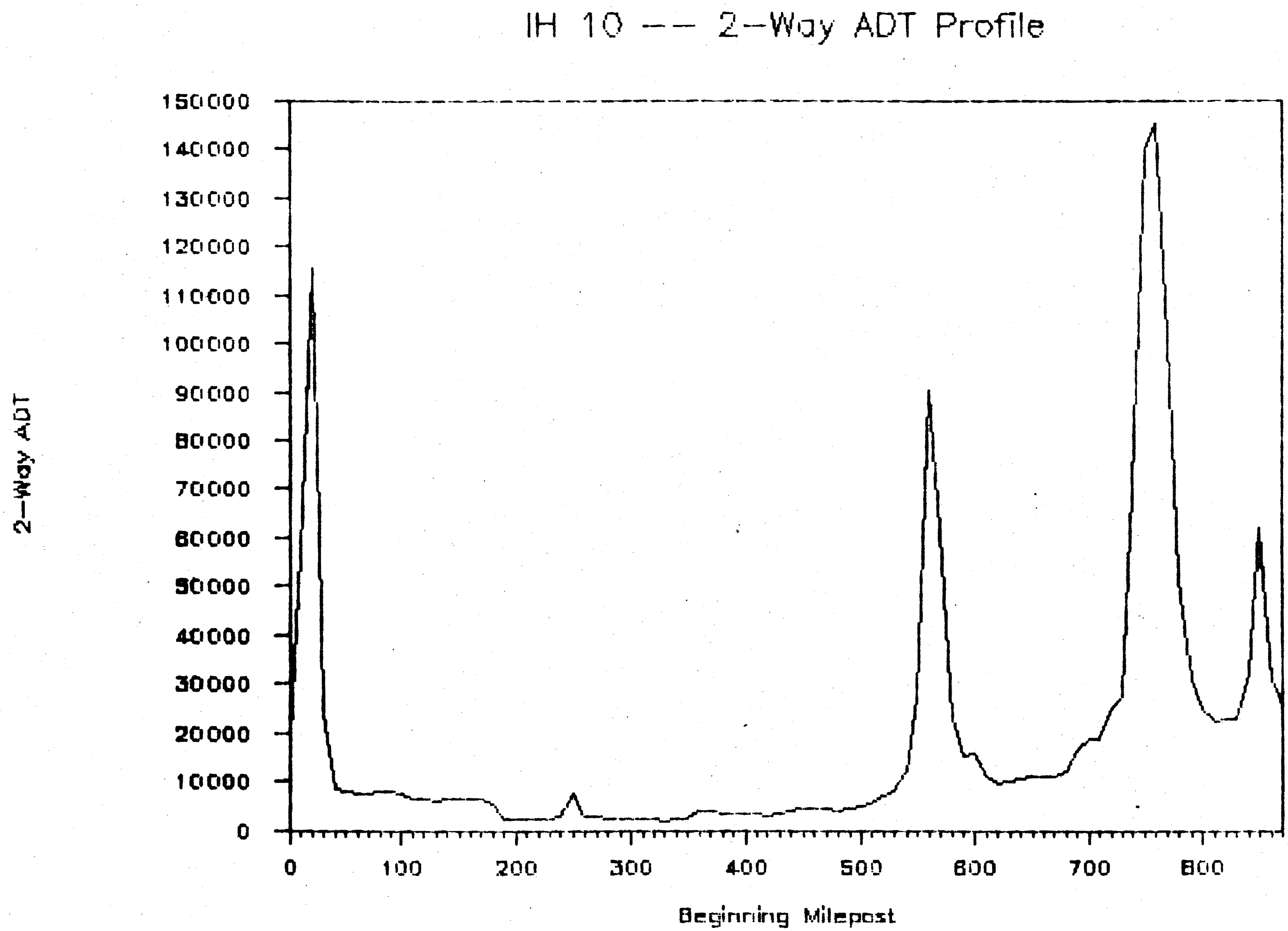

IH 10 -- 2-Way ADT Profile
2-Way ADT
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
700
800
Beginning Milepost

Fig. 6.5

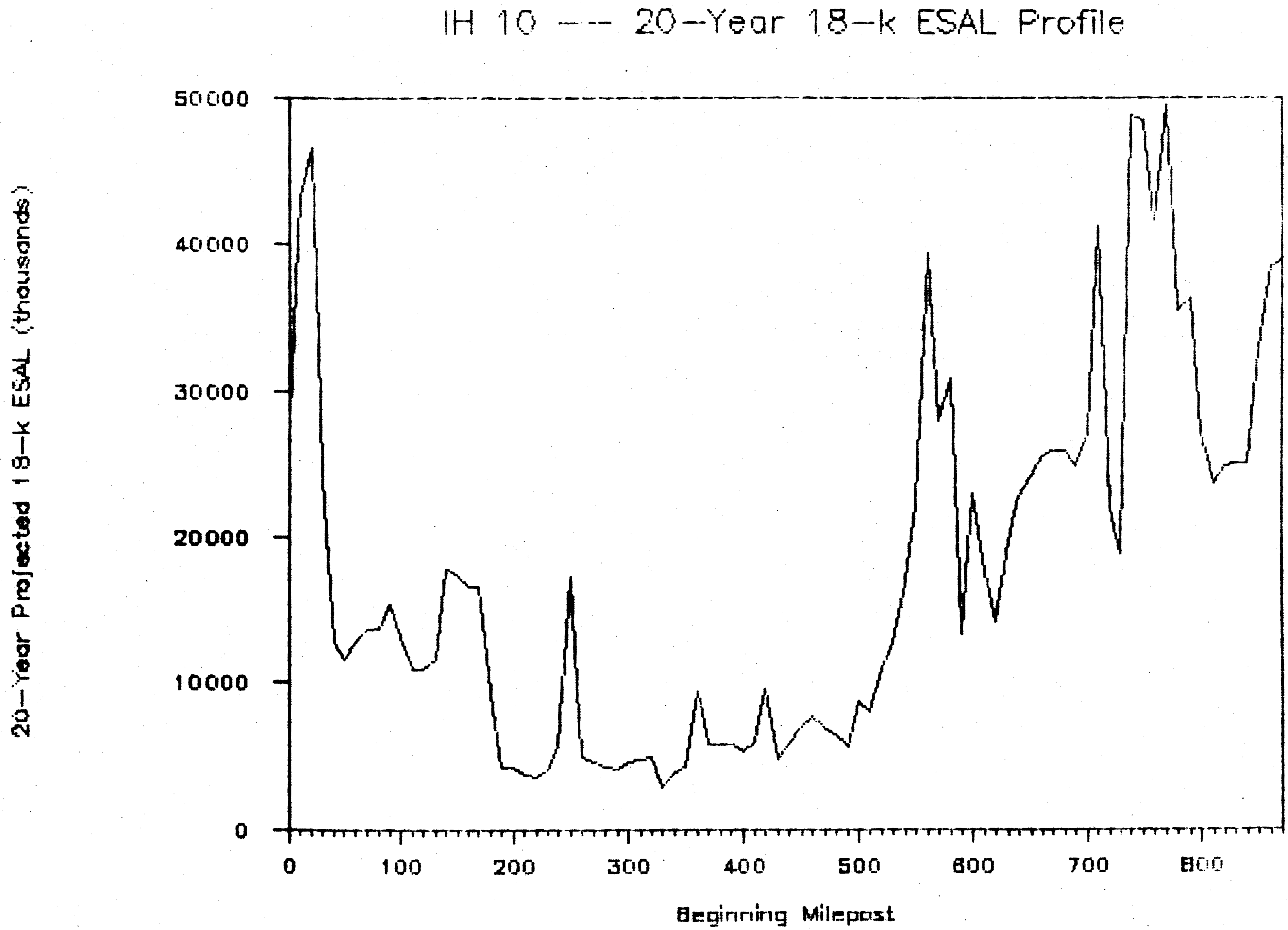

IH 10 --- 20-Year 18-k ESAL Profile
20-Year Projected 18-k ESAL (thousands)
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
700
800
Beginning Milepost

Fig. 6.6

NOTES

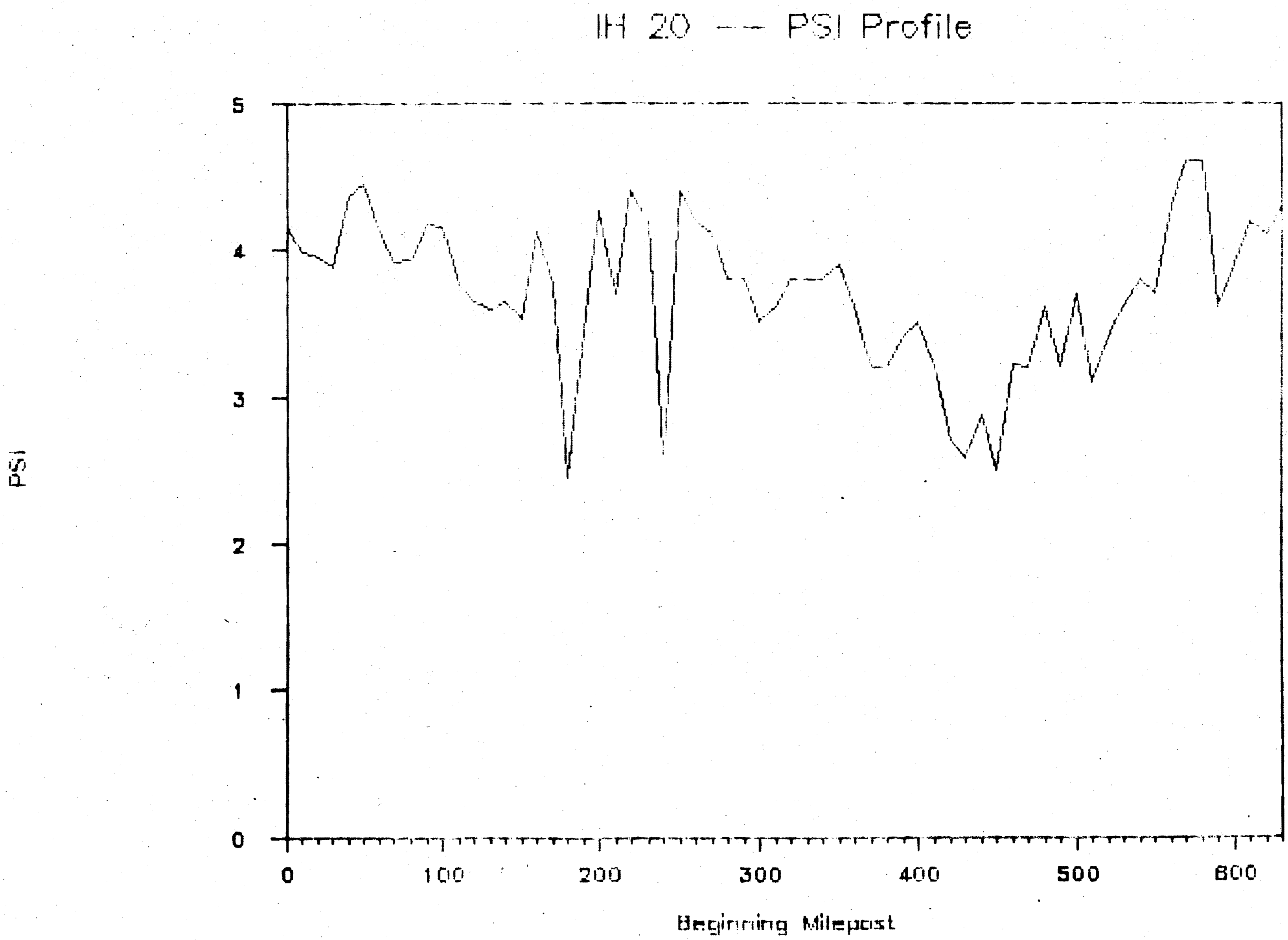

IH 20 -- PSI Profile
5
4
3
2
1
0
PSI
0
100
200
300
400
500
600
Beginning Milepost

Fig. 6.7

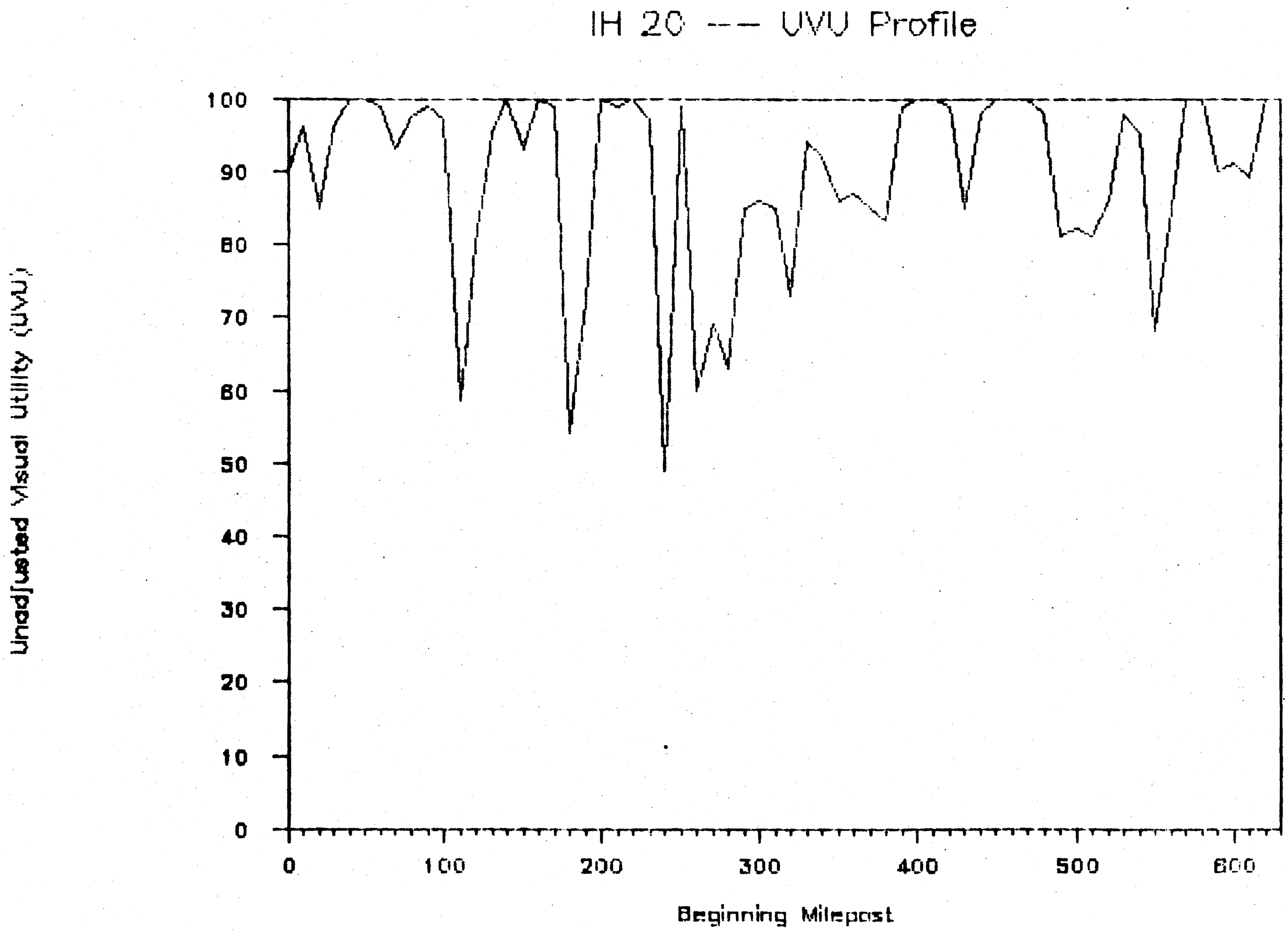

IH 20 --- UVU Profile
Unadjusted Visual Utility (UVU)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
Beginning Milepost

Fig. 6.8

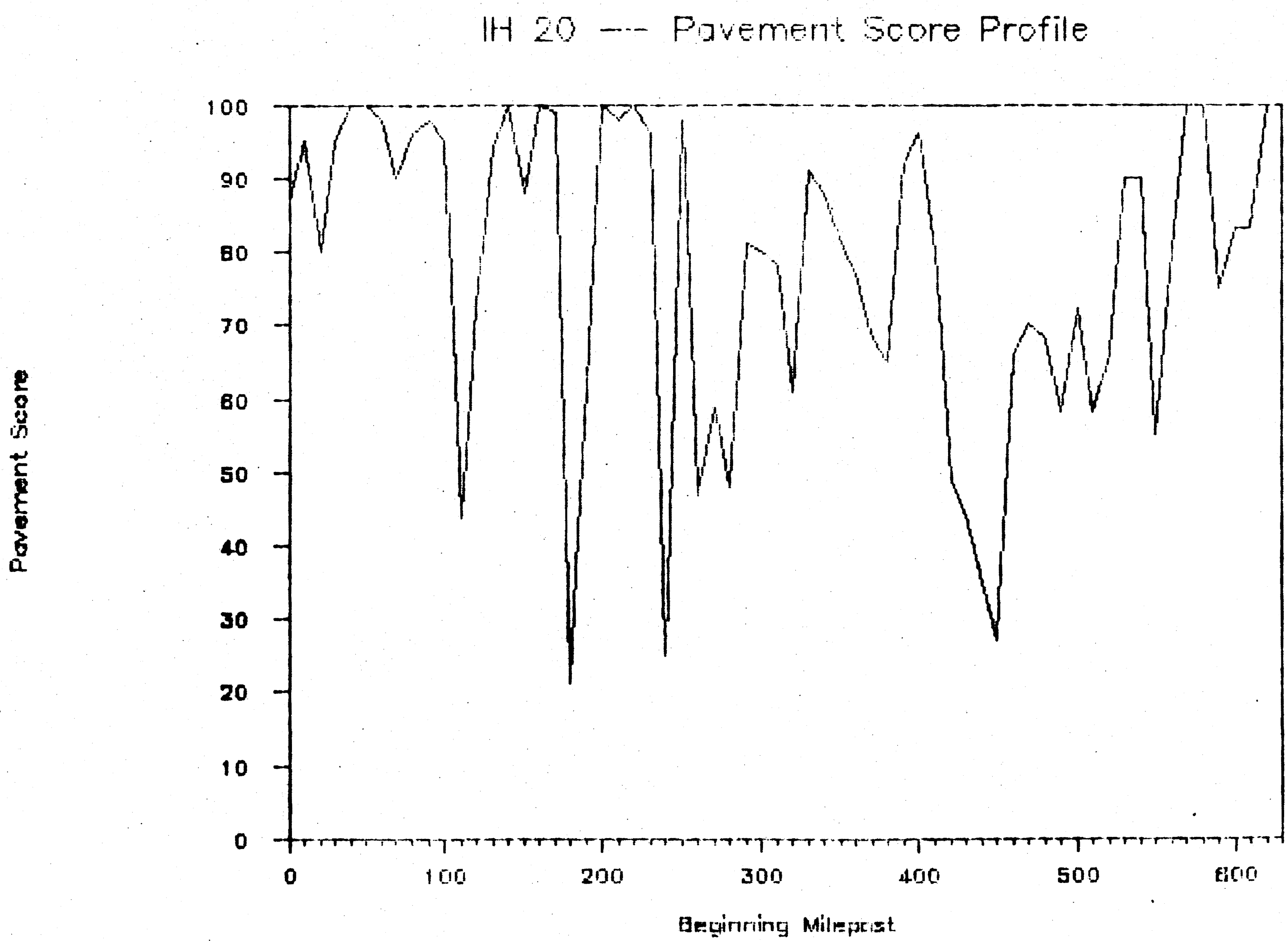

IH 20 --- Pavement Score Profile
Pavement Score
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
Beginning Milepost

Fig. 6.9

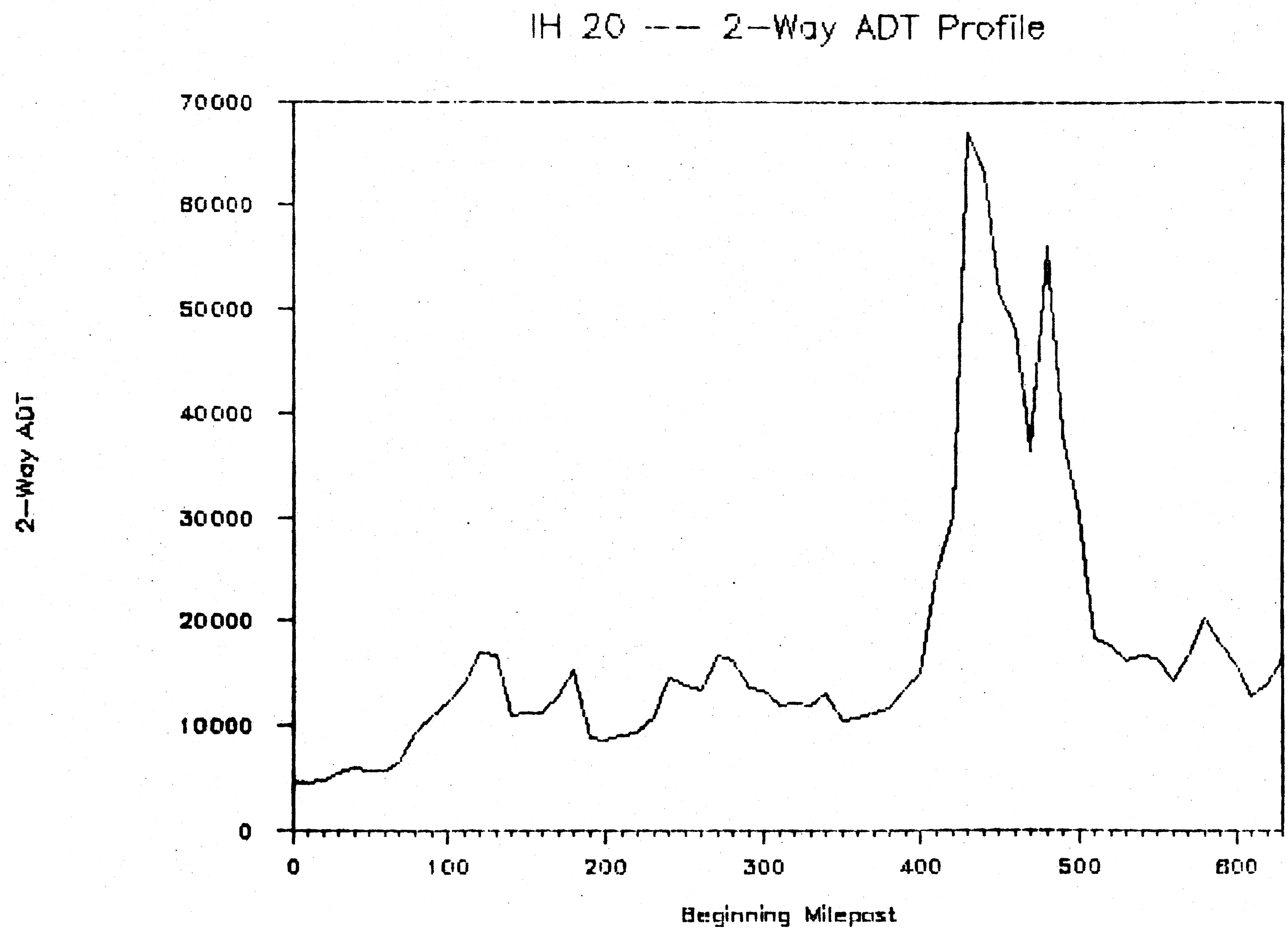
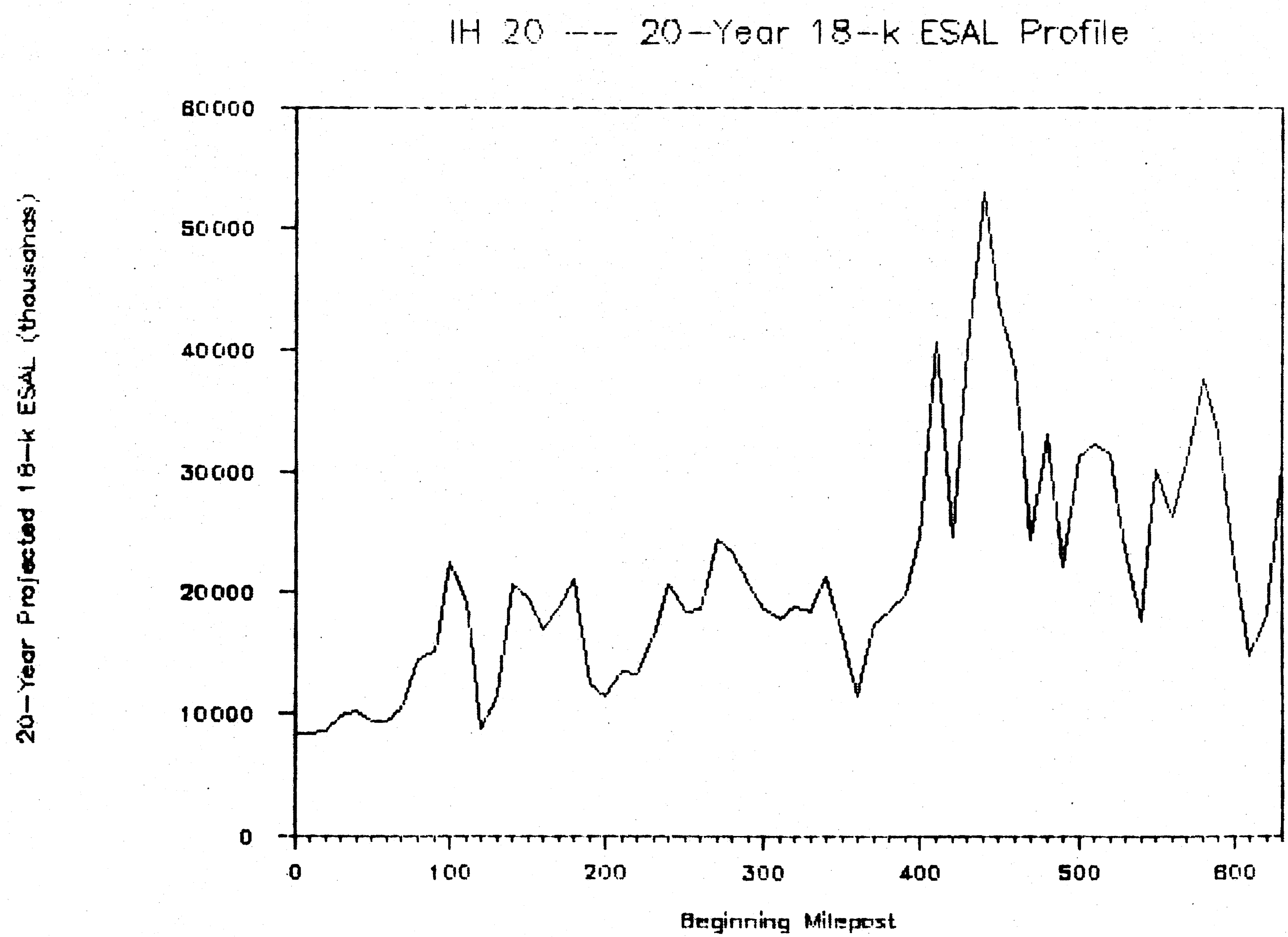

IH 20 --- 2-Way ADT Profile
2-Way ADT
70000
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
Beginning Milepost

Fig. 6.10



IH 20 --- 20-Year 18-k ESAL Profile
20-Year Projected 18-k ESAL (thousands)
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
Beginning Milepost

Fig. 6.11

NOTES

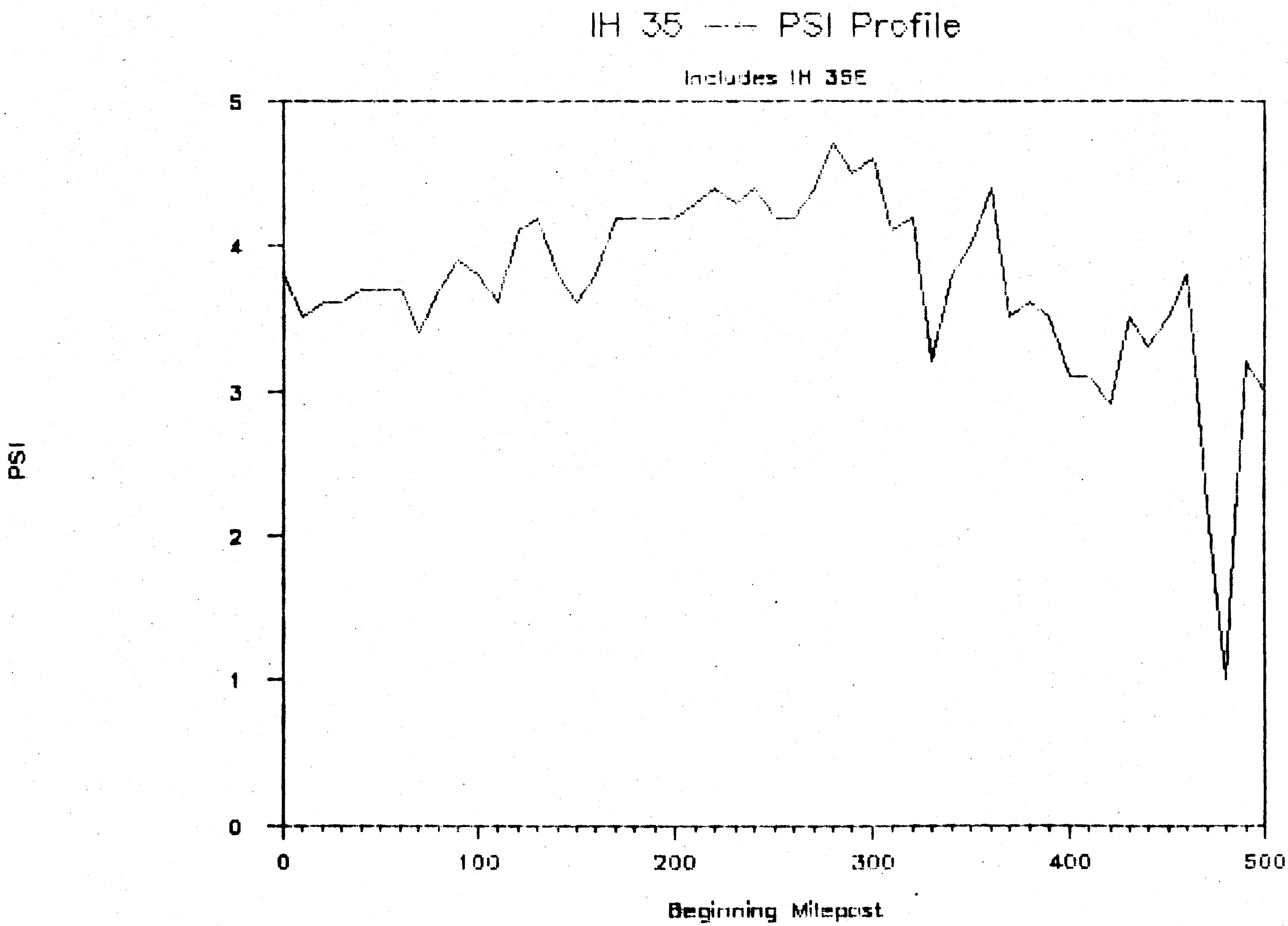

IH 35 --- PSI Profile
Includes IH 35E
PSI
5
4
3
2
1
0
0
100
200
300
400
500
Beginning Milepost

Fig. 6.12

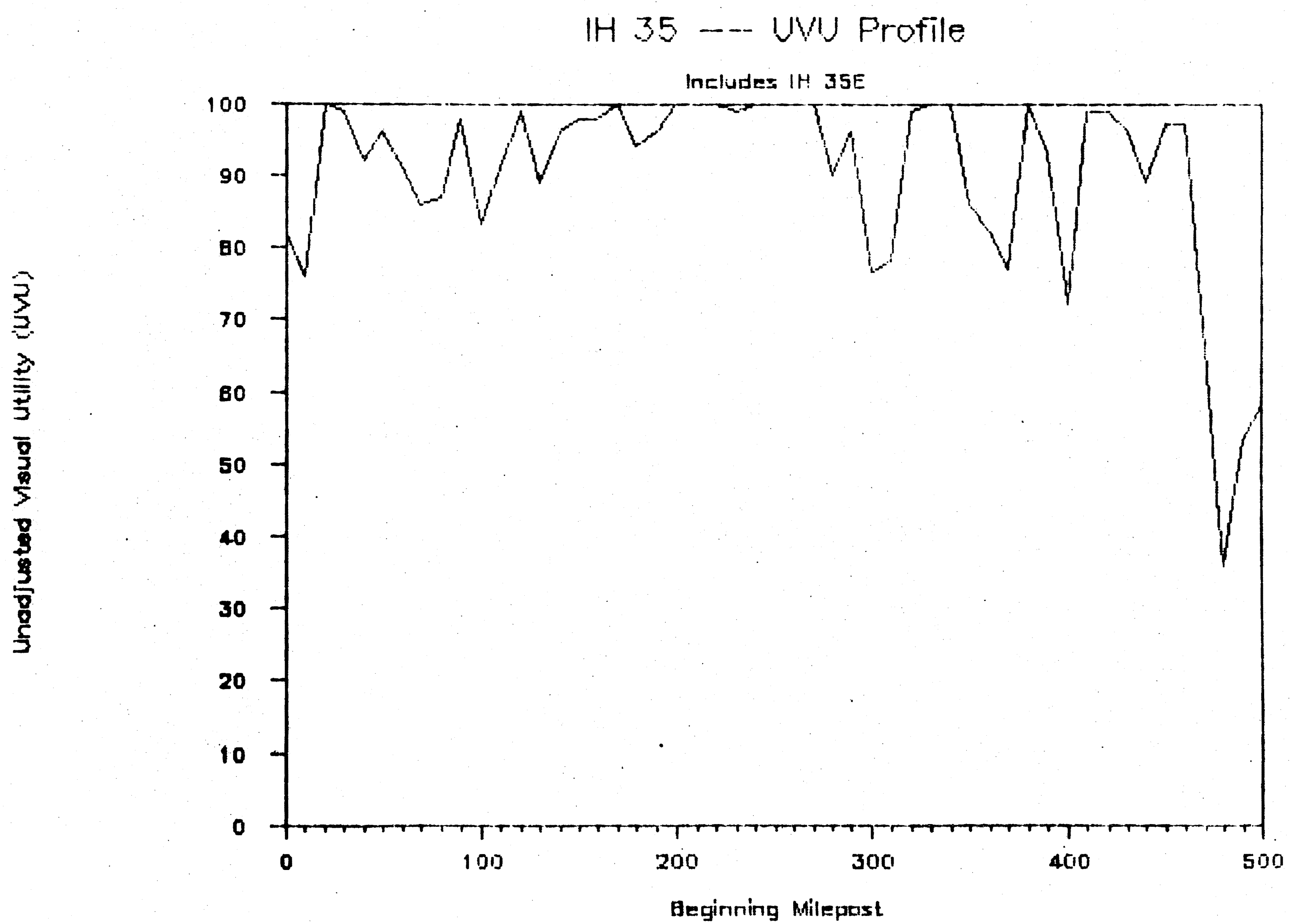

IH 35 --- UVU Profile
Includes IH 35E
Unadjusted Visual Utility (UVU)
Beginning Milepost
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500

Fig. 6.13

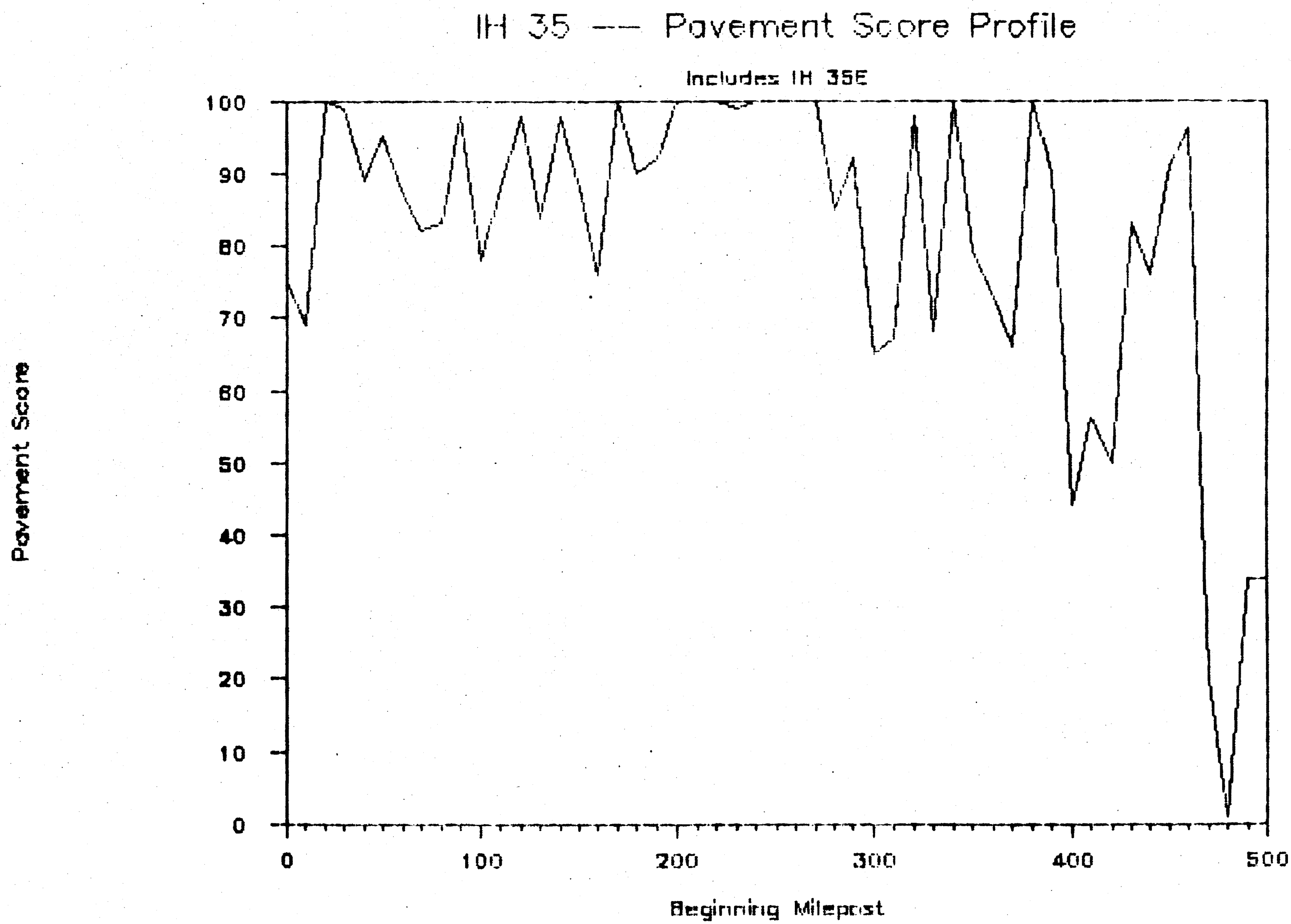
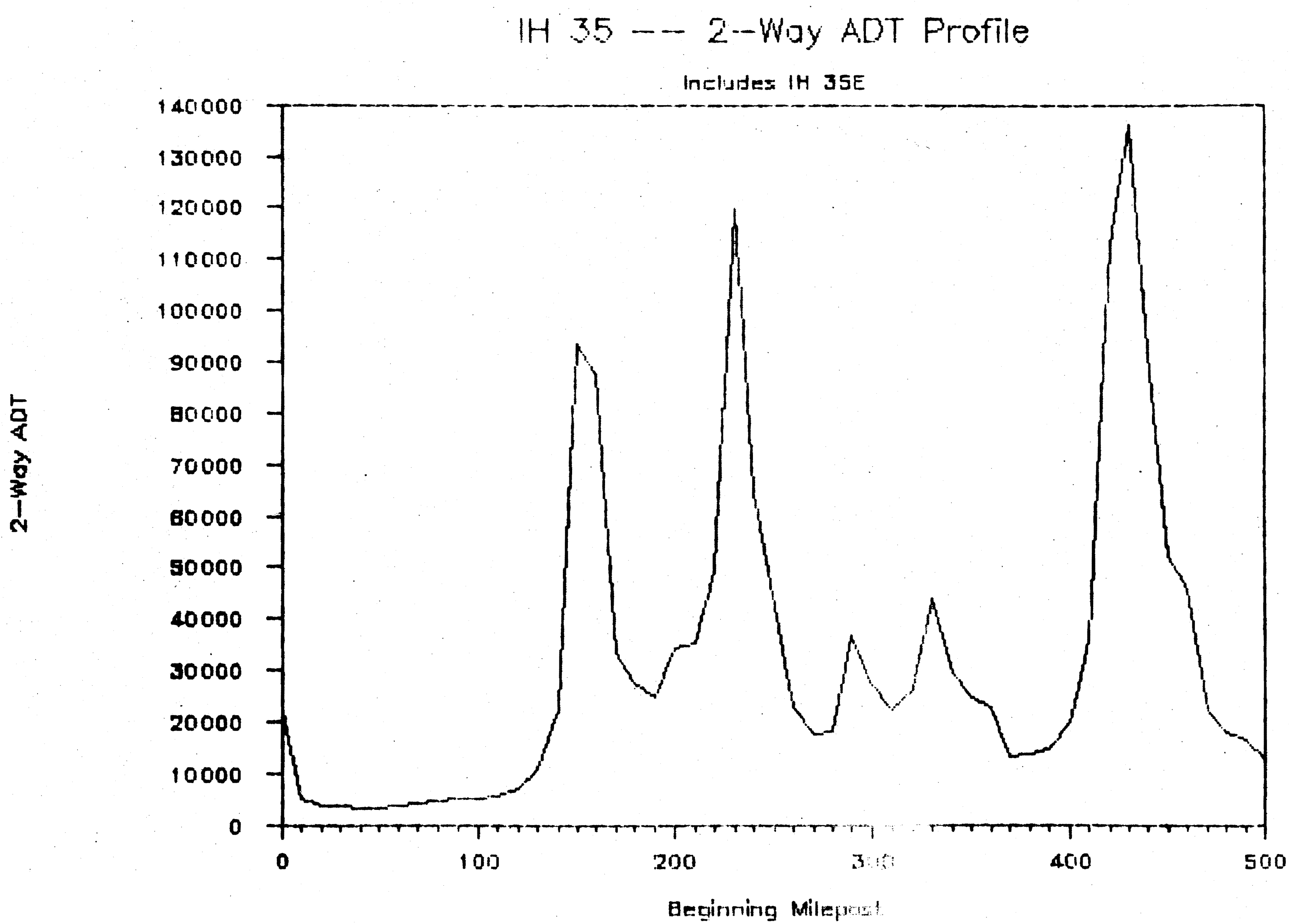

IH 35 — Pavement Score Profile
Includes IH 35E
Pavement Score
Beginning Milepost
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500

Fig. 6.14



IH 35 -- 2-Way ADT Profile
Includes IH 35E
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2-Way ADT
0
100
200
400
500
Beginning Milepost

Fig. 6.15

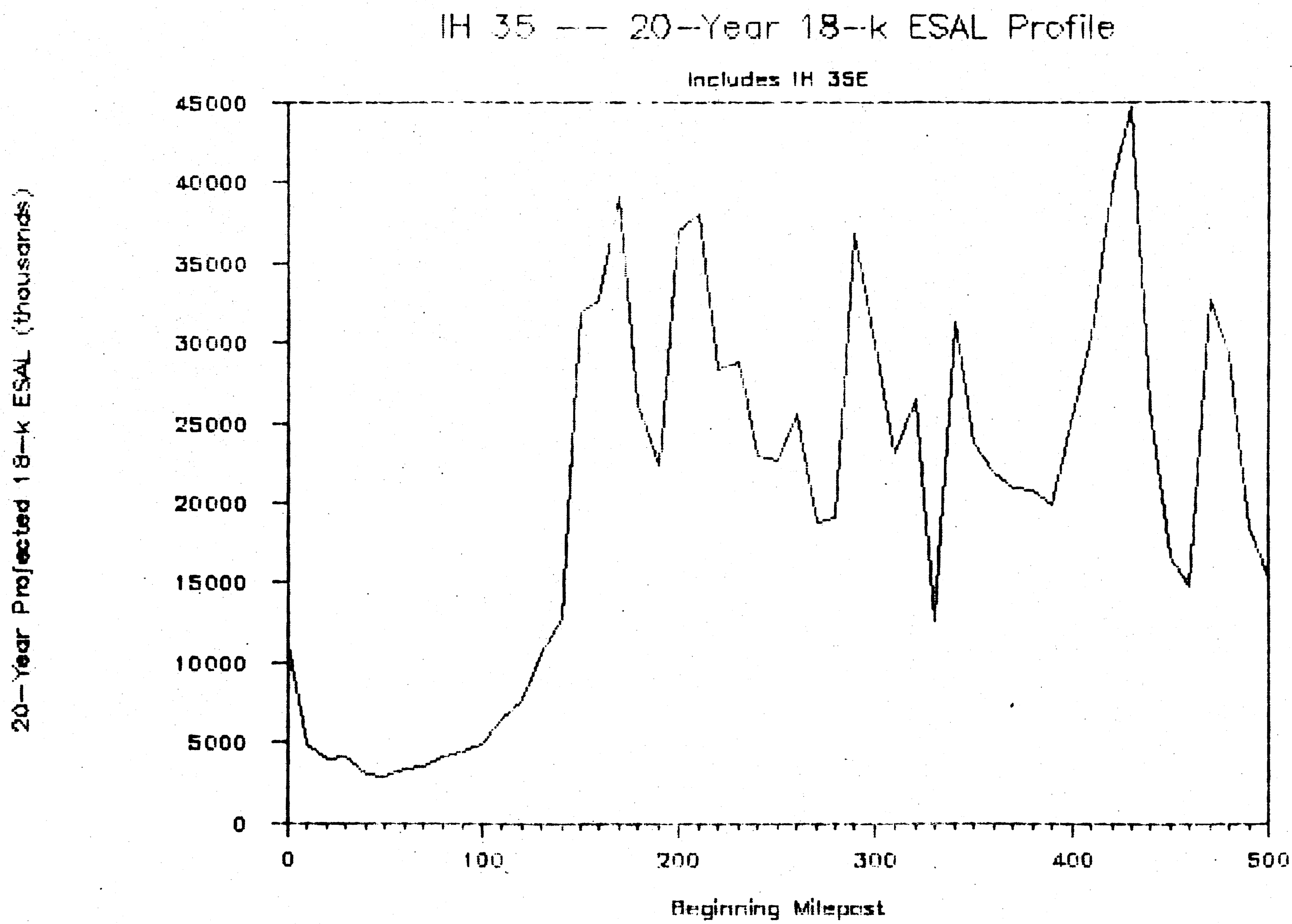

IH 35 -- 20-Year 18-k ESAL Profile
Includes IH 35E
20-Year Projected 18-k ESAL (thousands)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
100
200
300
400
500
Beginning Milepost

Fig. 6.16

NOTES

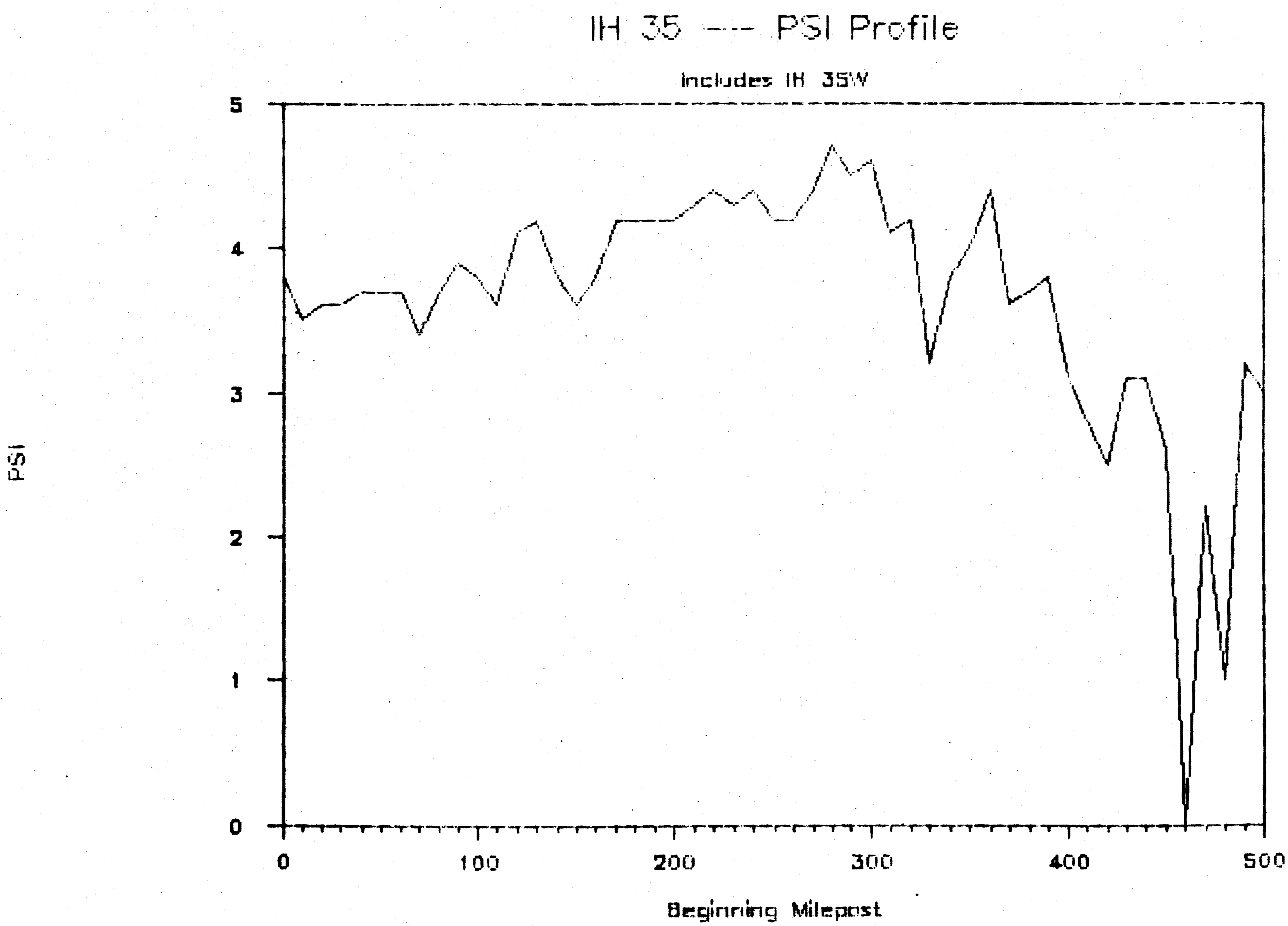

IH 35 --- PSI Profile
Includes IH 35W
PSI
5
4
3
2
1
0
0
100
200
300
400
500
Beginning Milepost

Fig. 6.17

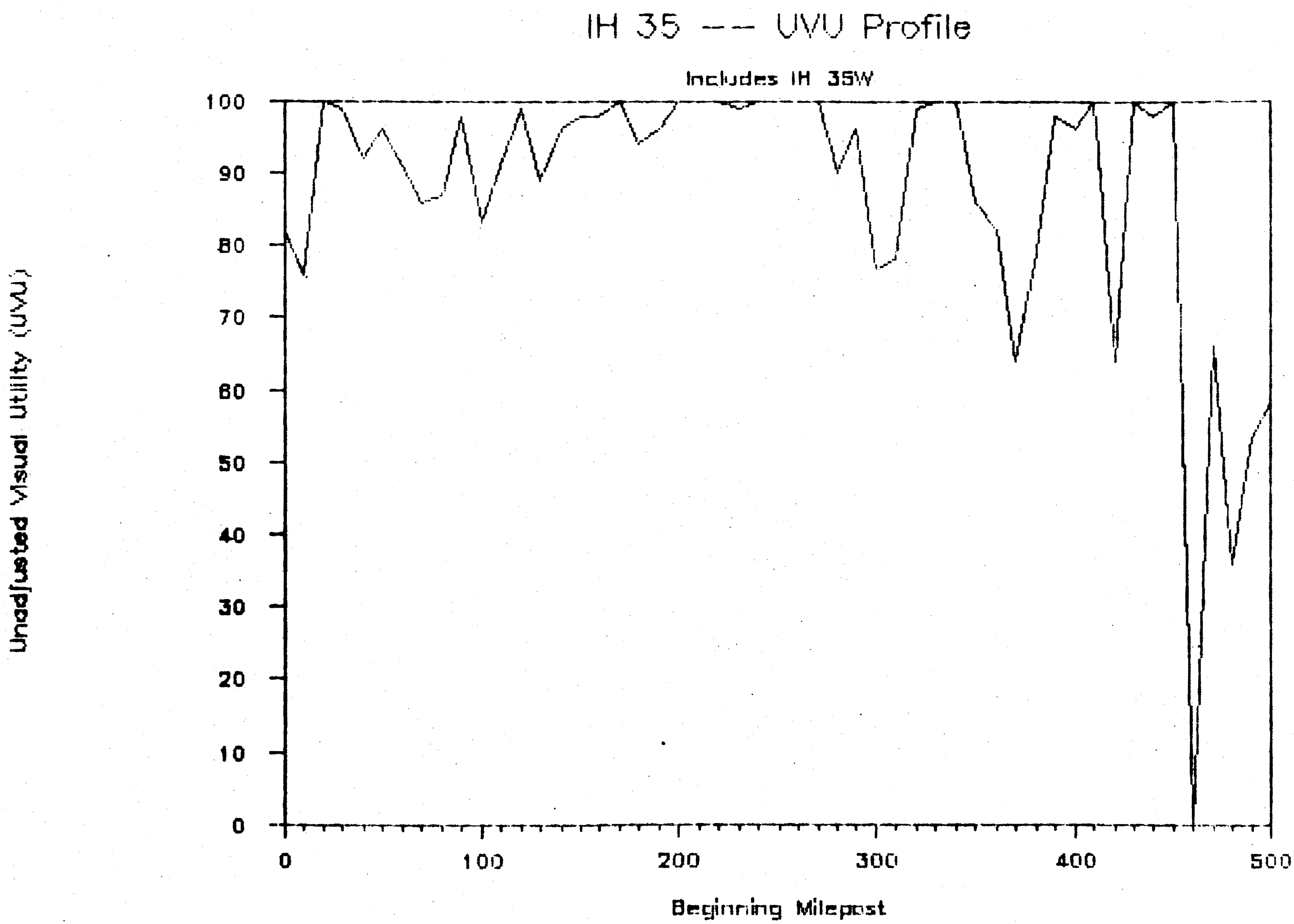

IH 35 -- UVU Profile
Includes IH 35W
Unadjusted Visual Utility (UVU)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
Beginning Milepost

Fig. 6.18

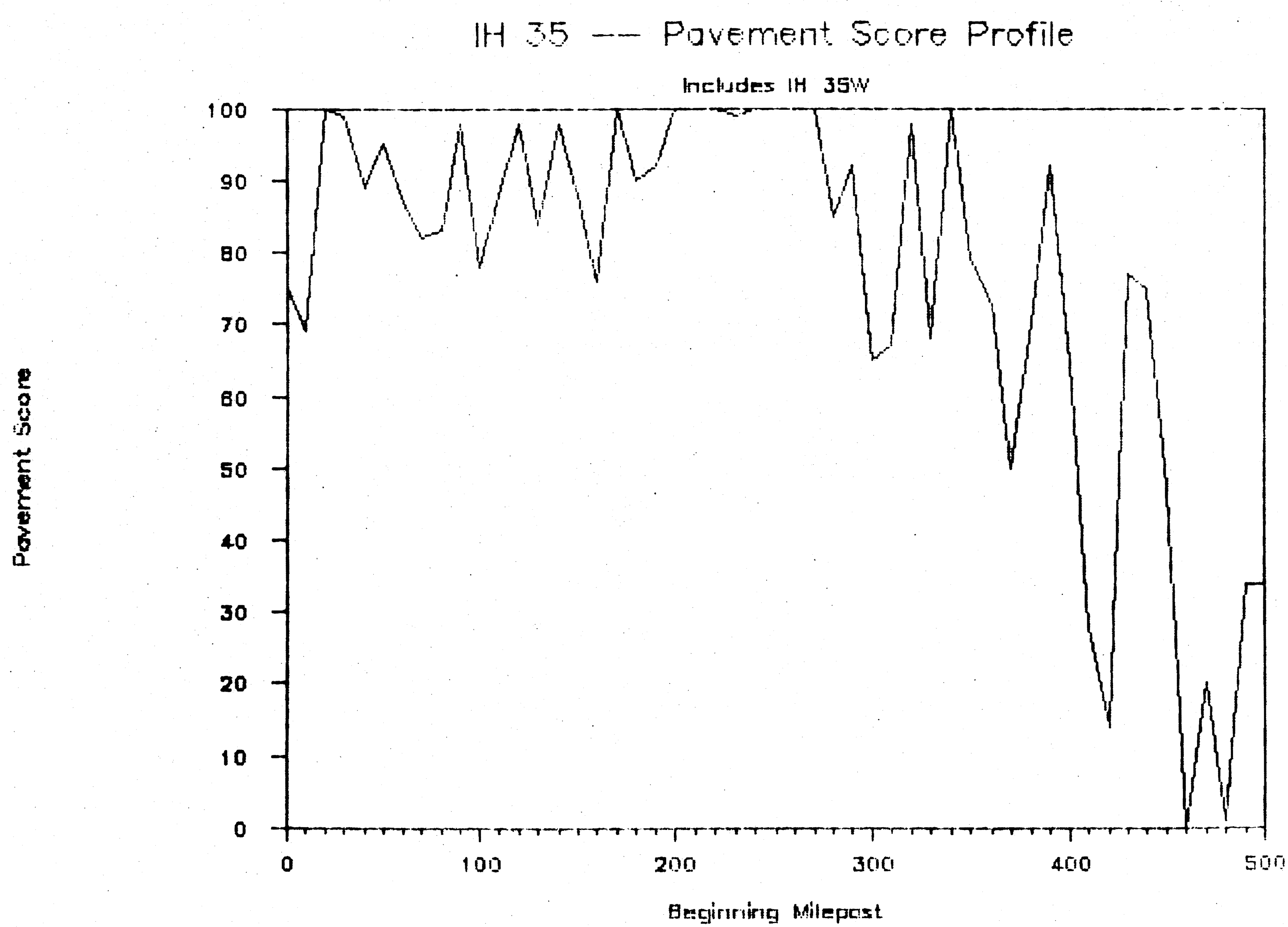

IH 35 -- Pavement Score Profile
Includes IH 35W
Pavement Score
Beginning Milepost
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500

Fig. 6.19

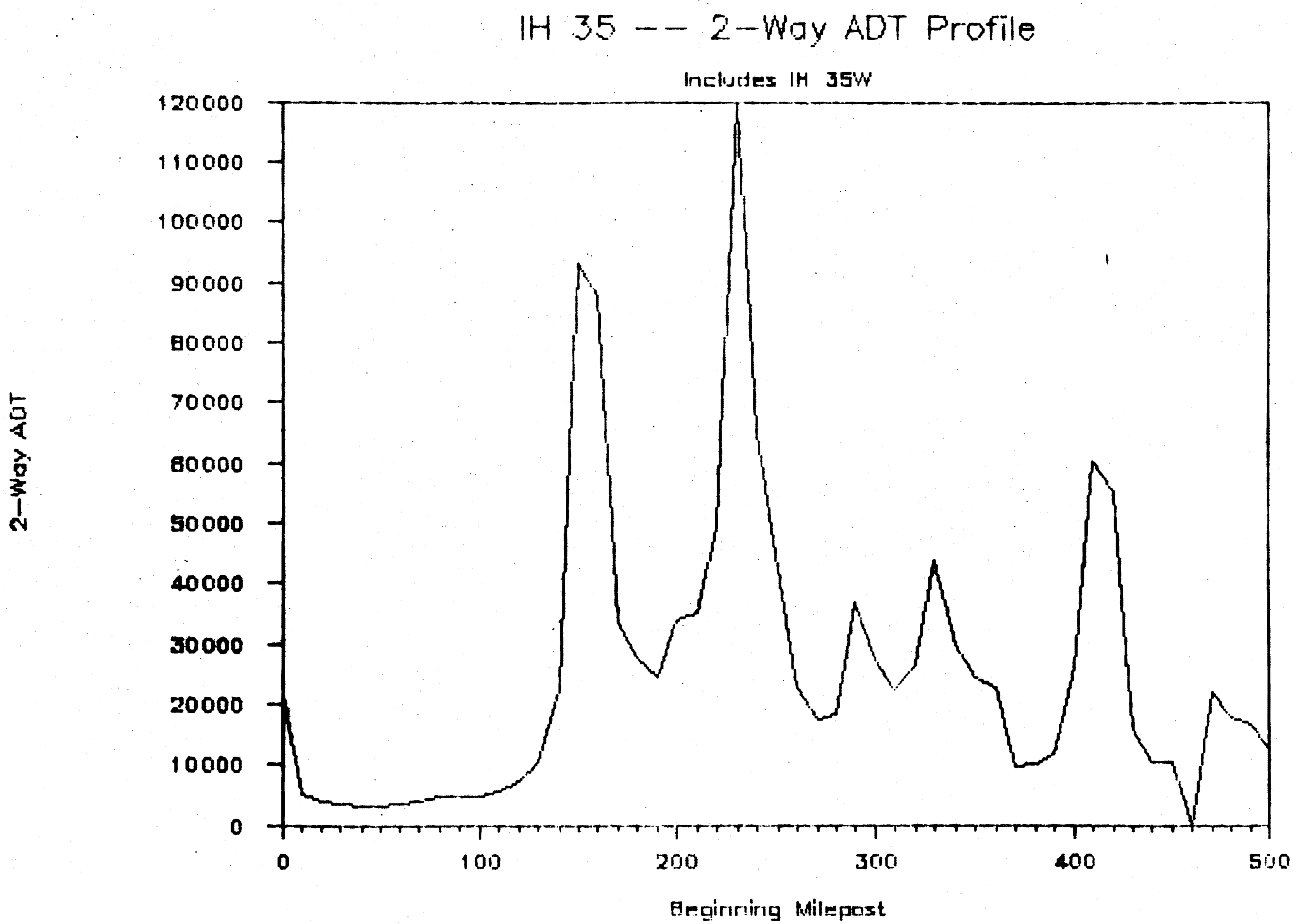

IH 35 -- 2-Way ADT Profile
Includes IH 35W
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2-Way ADT
0
100
200
300
400
500
Beginning Milepost

Fig. 6.20

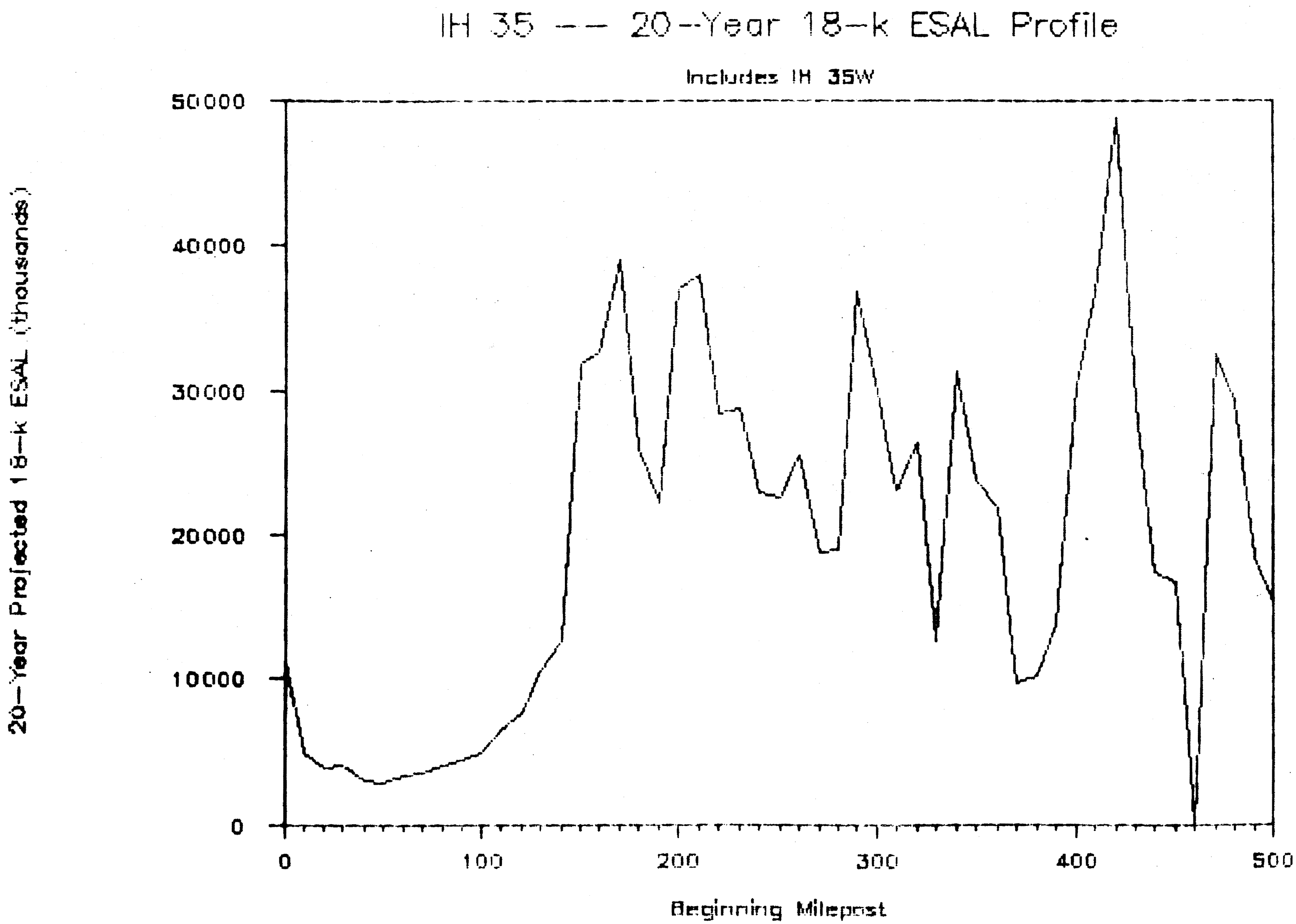
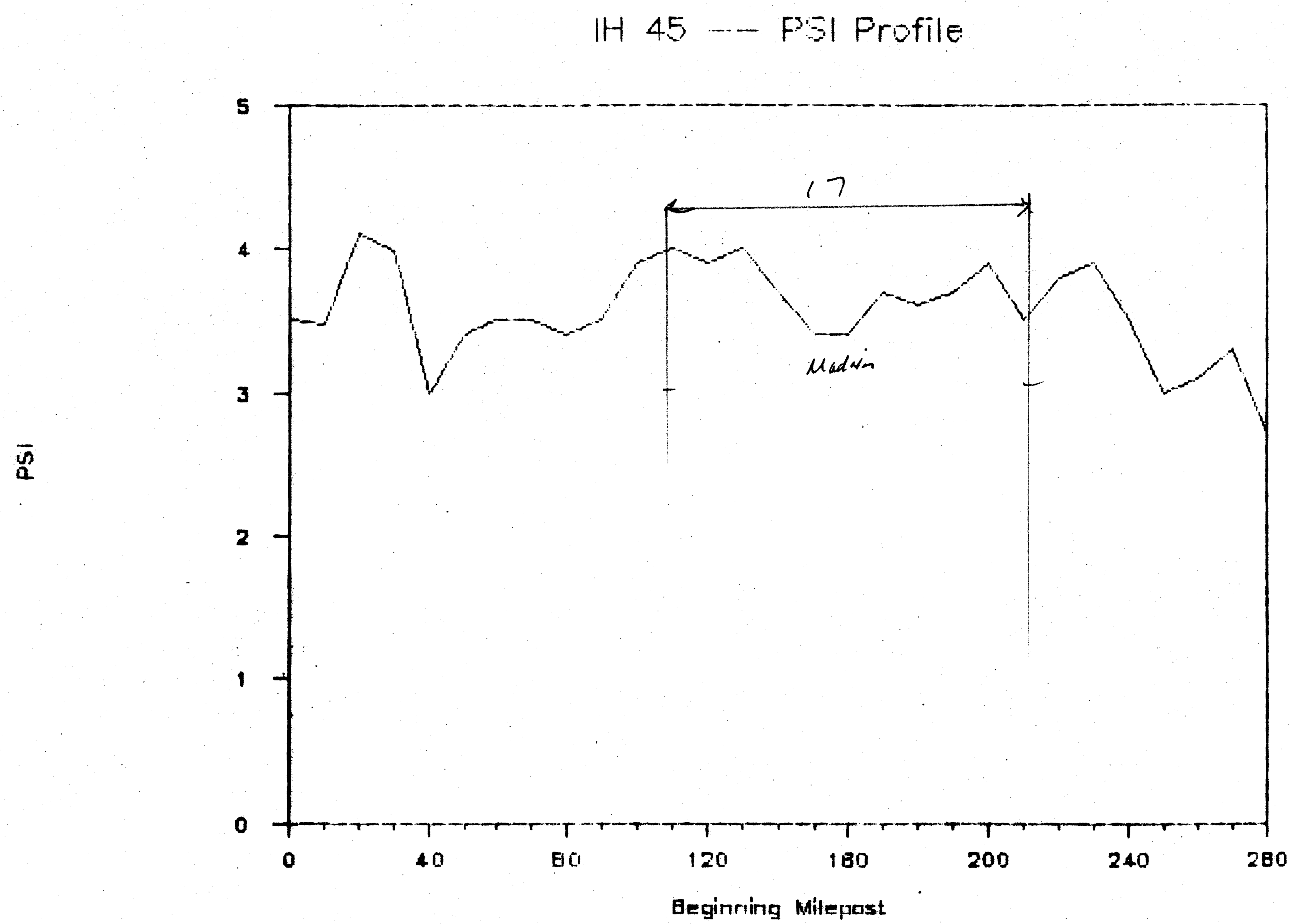

IH 35 -- 20-Year 18-k ESAL Profile
Includes IH 35W
20-Year Projected 18-k ESAL (thousands)
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
Beginning Milepost

Fig. 6.21

NOTES



IH 45 -- PSI Profile
PSI
5
4
3
2
1
0
0
40
80
120
160
200
240
280
Beginning Milepost
17

Fig. 6.22

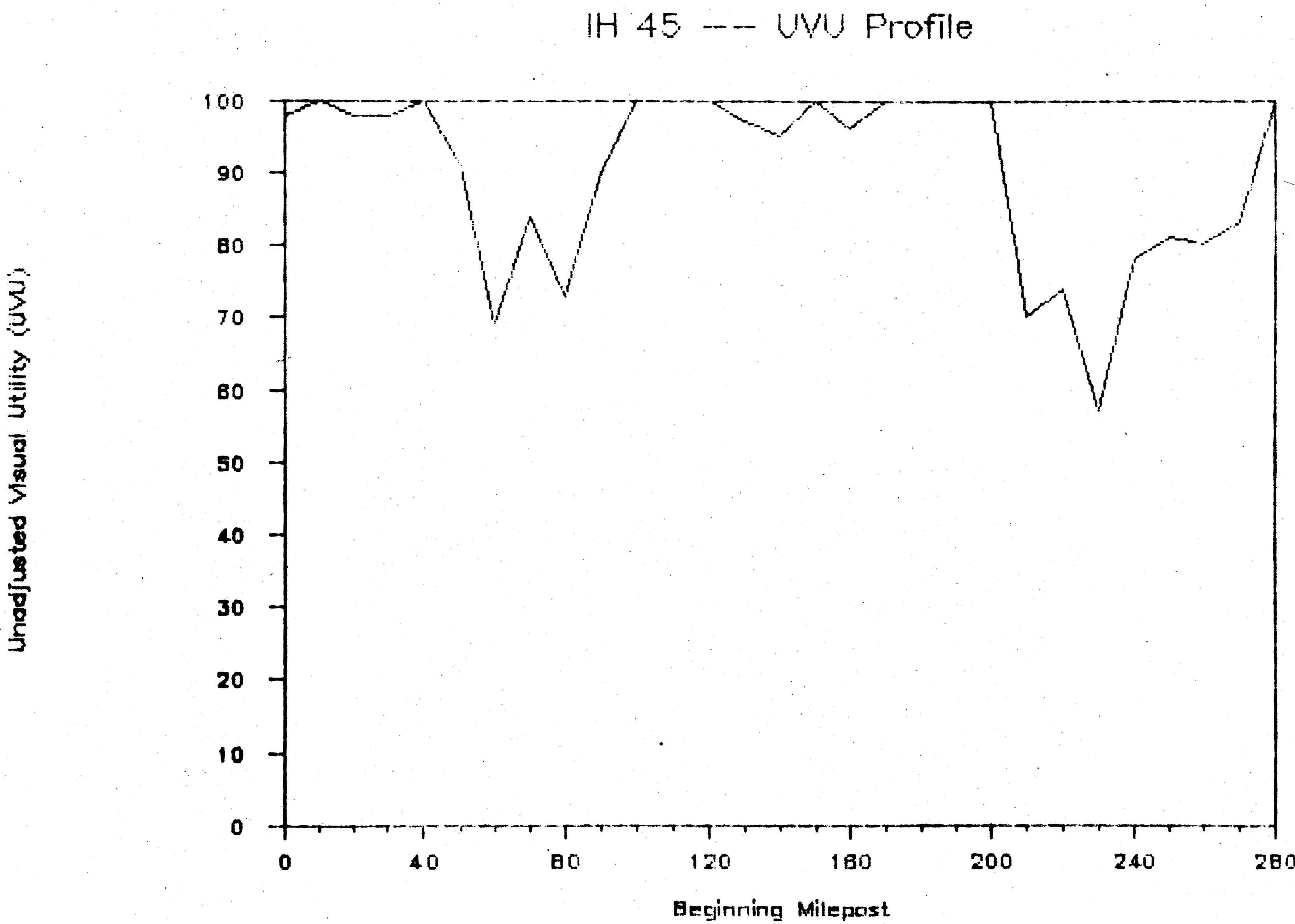

IH 45 --- UVU Profile
Unadjusted Visual Utility (UVU)
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
Beginning Milepost

Fig. 6.23

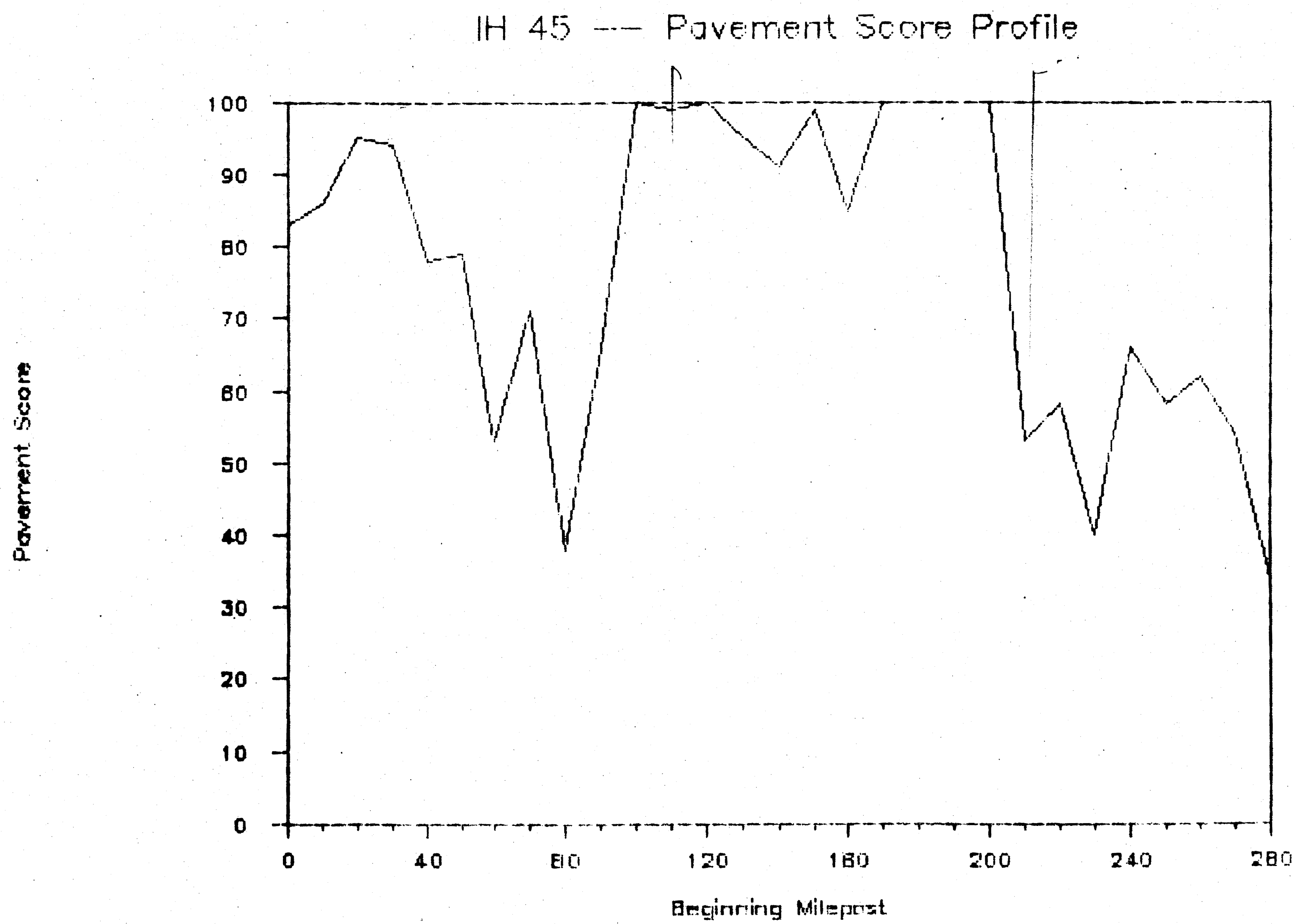

IH 45 — Pavement Score Profile
Pavement Score
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
Beginning Milepost

Fig. 6.24

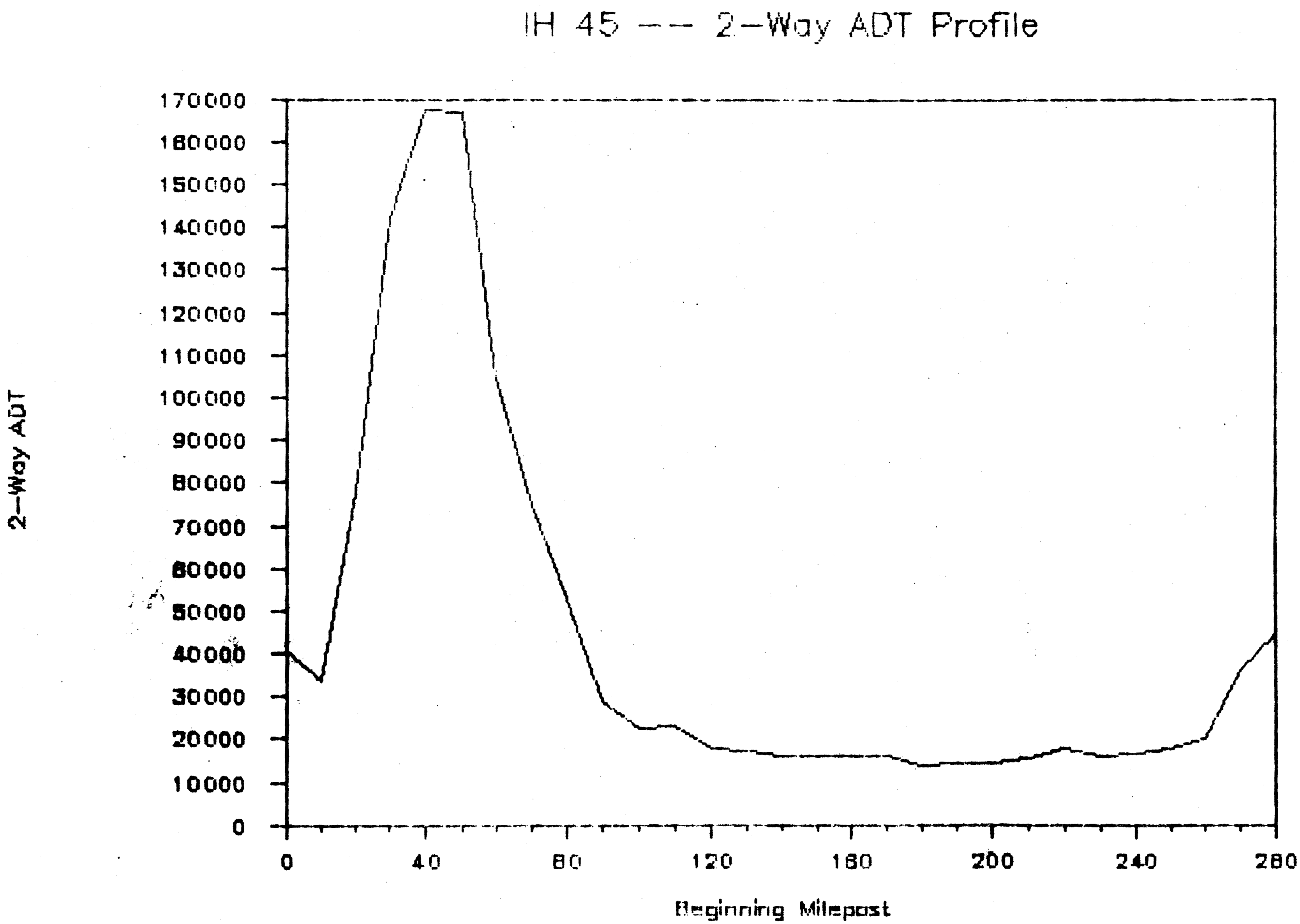

IH 45 -- 2-Way ADT Profile
2-Way ADT
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
40
80
120
160
200
240
280
Beginning Milepost

Fig. 6.25

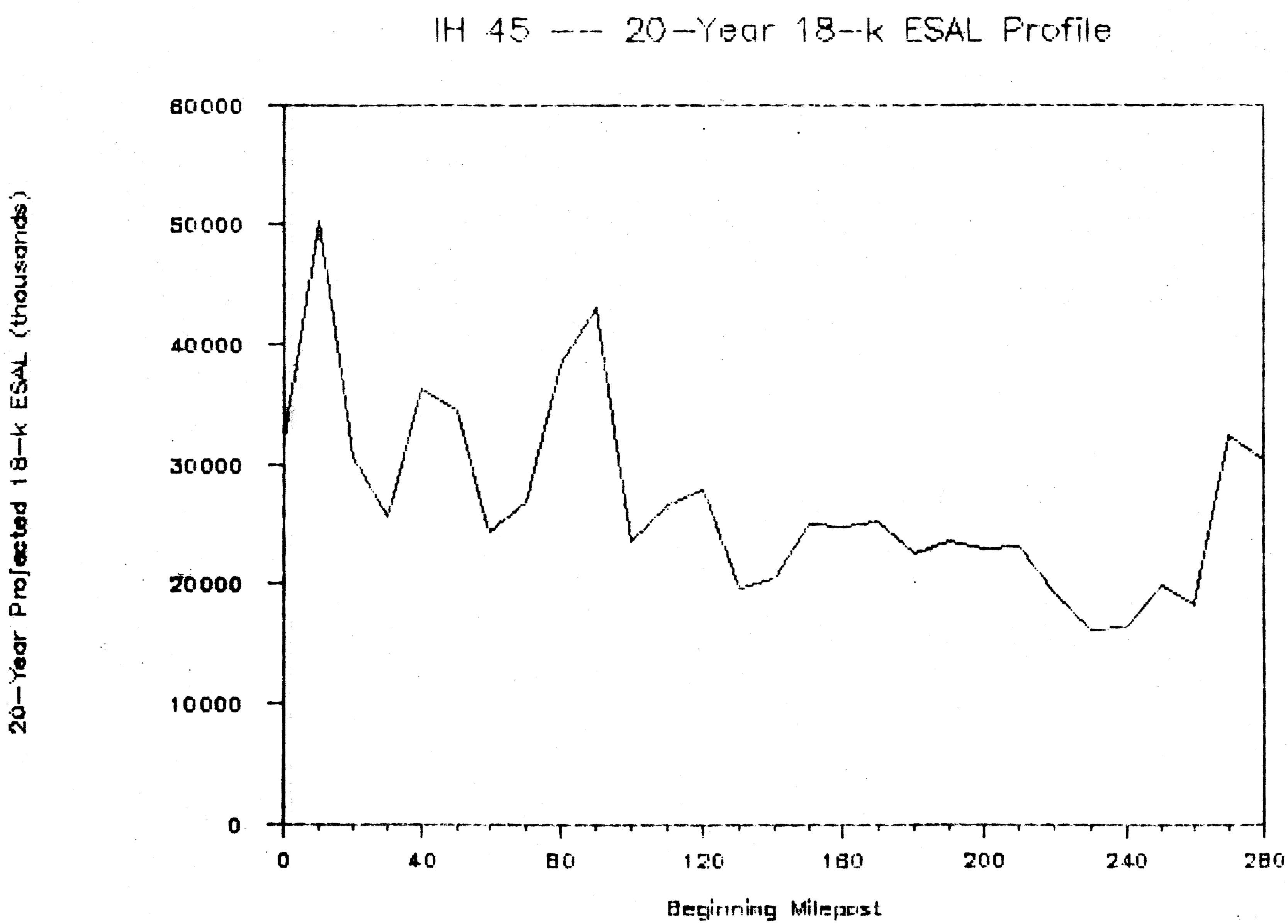

IH 45 --- 20-Year 18-k ESAL Profile
20-Year Projected 18-k ESAL (thousands)
60000
50000
40000
30000
20000
10000
0
0
40
80
120
160
200
240
280
Beginning Milepost

Fig. 6.26

CHAPTER 7

EFFECT OF ADT AND 18-K ESAL ON RIDE QUALITY, UNADJUSTED VISUAL UTILITY, AND PAVEMENT SCORE

Determines if the highest-volume roads are in the best condition. Also emphasizes the impact of high-traffic volumes on pavement score (as opposed to just distress).

NOTES

Pavement condition values for the Interstate system, given in Chapter 6, show that the high-volume urban loops (IH 410, IH 610, and IH 635) have good ride quality and display very little surface distress. This suggests that pavements in the highest ADT ranges are in the best condition. The following analysis will determine the actual effect of ADT and 18-k ESAL on the condition of the rated sections.

Table 7.1 contains statewide average PSI, UVU, and pavement score values for each one of seven arbitrarily-defined ADT groups. Table 7.2 contains similar values for seven arbitrarily-defined 18-k ESAL groups. Mean values are the same in both tables because of the relative similarity in ADT and 18-k ESAL values. In other words, ADT group 1 contained the same number of sections as 18-k ESAL group 1. Since the PSI, UVU, and pavement score values were the same, the mean values were also the same. Dividing the groups in half (for a total of 13 groups) did not even solve the problem.

Both ADT and 18-k ESAL affect the average values in a similar manner. Ride quality peaks at groups 4 and 5 (from 2,001 to 25,000) for both ADT (as shown in Figure 7.1) and 18-k ESAL (as shown in Figure 7.2). Actual level of surface distress (i.e. UVU) decreases as ADT and 18-k ESAL increase, while pavement score drops drastically (as shown in Figures 7.3 and 7.4). These four figures identify several significant trends:

1. Ride quality -- PSI is the highest for medium-traffic (ADT and 18-k ESAL) highways. These roads are important enough to justify continued maintenance, but traffic is still low enough to permit safe and rapid work. This is in marked contrast with high-volume urban roads (which are certainly important but difficult to work on) and low-volume rural roads (which are easier to work on but more difficult to justify expenditures for).

2. UVU -- Surface distress is least common on the high-volume groups 6 and 7 (25,001 and up). This seems to suggest that high traffic volumes do not cause extensive surface distress (or that traffic avoids highly-distressed roads). Conscientious maintenance and rehabilitation is partially responsible for this trend but another factor is the increasing number of concrete sections in these groups. Concrete is suspected for several reasons:
   * Average UVU value for CRC is 91.30, compared to 82.45 statewide.
   * Average ADT for concrete is 33,902 for CRC and 30,568 for JCP, compared to 8,374 statewide.
   * Average 18-k ESAL for concrete is 27,240 for CRC and 22,484 for JCP, compared to 6,844 statewide.
   * PSI values for concrete are 3.24 for CRC and 2.76 for JCP, compared to 3.35 statewide, which accounts for the slight drop in ride quality for groups 6 and 7.

Finally, in Chapter 6, the four highest UVU Interstate highways (IH 345, IH 635, IH 610, and IH 27) are constructed with concrete.

3. Pavement score -- Pavement score is extremely sensitive to ADT and 18-k ESAL values above 5000. Figures 7.3 and 7.4 demonstrate that, for groups 5-7, traffic considerations even overshadowed reductions in surface distress as the final measure of relative pavement condition.

The results of this analysis seem reasonable. Low volume roads are the roughest and most severly-distressed, yet they are at the lowest priority levels. High-volume roads are rough (but not the roughest), yet only lightly-distressed. Despite this, they are the most important roads and are always high on the list of priority sections.

NOTES

Table 7.1 -- Effect of ADT on Ride Quality, Unadjusted Visual Utility (UVU), and Pavement Score.

1984 PES -- ALL RATED MAINLANE SECTIONS N = 16,214 Sections				
ADT Range	Group	Avg. PSI	Avg. UVU	Avg. PS
0 - 500	1	2.93	77.52	73.92
501 - 1000	2	3.17	80.05	76.57
1001 - 2000	3	3.40	82.12	76.96
2001 - 5000	4	3.56	83.90	78.56
5001 - 25000	5	3.56	84.41	73.03
25001 - 50000	6	3.47	89.08	66.84
> 50000	7	3.42	93.06	68.12
MEAN		3.35	82.45	74.88

Note: ADT values are for 2-way traffic.

Table 7.2 -- Effect of 18-k ESAL on Ride Quality, Unadjusted Visual Utility (UVU), and Pavement Score.

1984 PES -- ALL RATED MAINLANE SECTIONS N = 16,214 Sections				
18-k ESAL Range	Group	Avg. PSI	Avg. UVU	Avg. PS
0 - 500	1	2.93	77.52	73.92
501 - 1000	2	3.17	80.05	76.57
1001 - 2000	3	3.40	82.12	76.96
2001 - 5000	4	3.56	83.90	78.56
5001 - 25000	5	3.56	84.41	73.03
25001 - 50000	6	3.47	89.08	66.84
> 50000	7	3.42	93.06	68.12
MEAN		3.35	82.45	74.88

Note: 18-k ESAL values, in thousands, are from 20-year projected values.

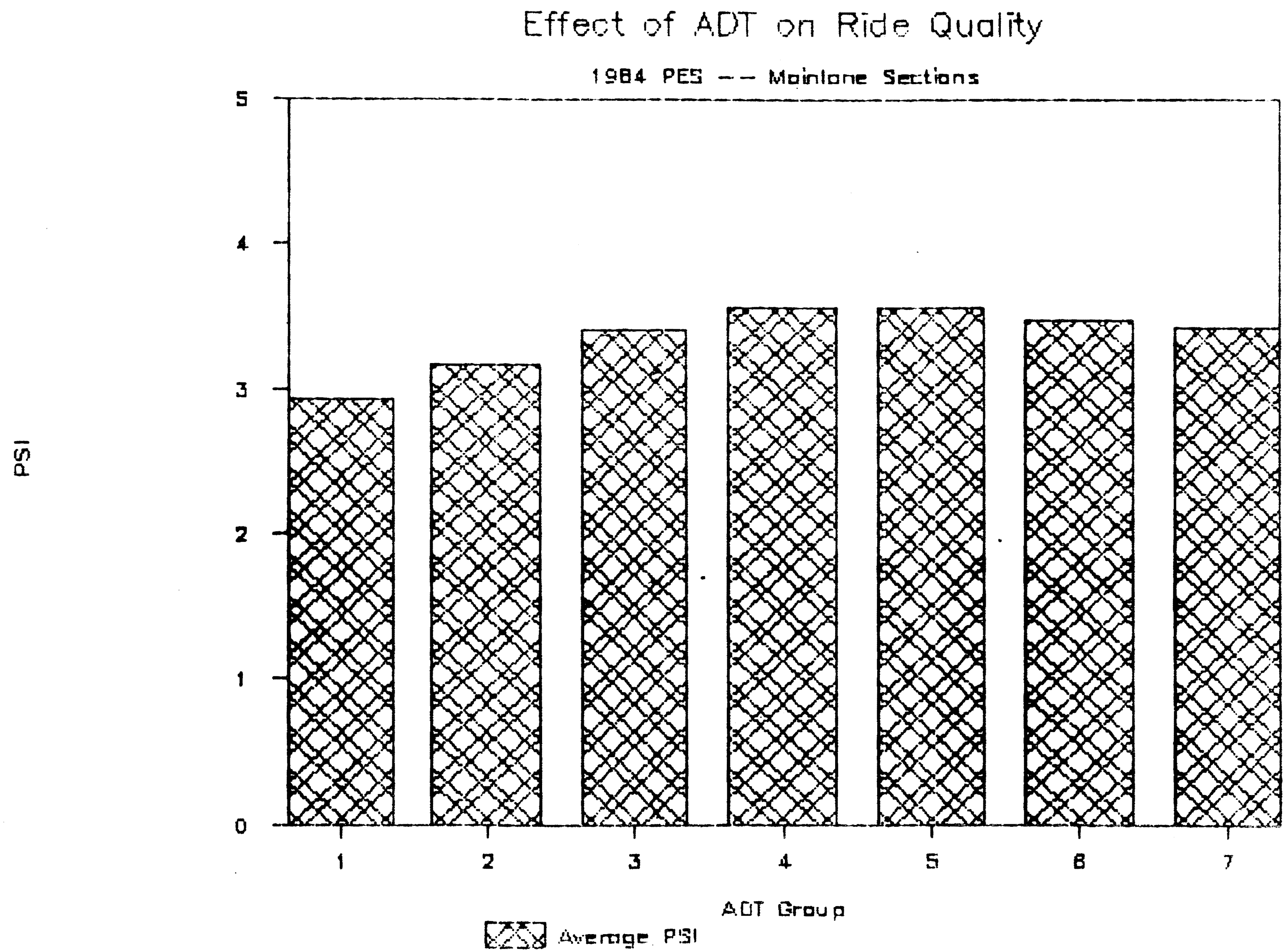

Effect of ADT on Ride Quality
1984 PES -- Mainlane Sections
PSI
5
4
3
2
1
0
1
2
3
4
5
6
7
ADT Group
Average PSI

Fig. 7.1

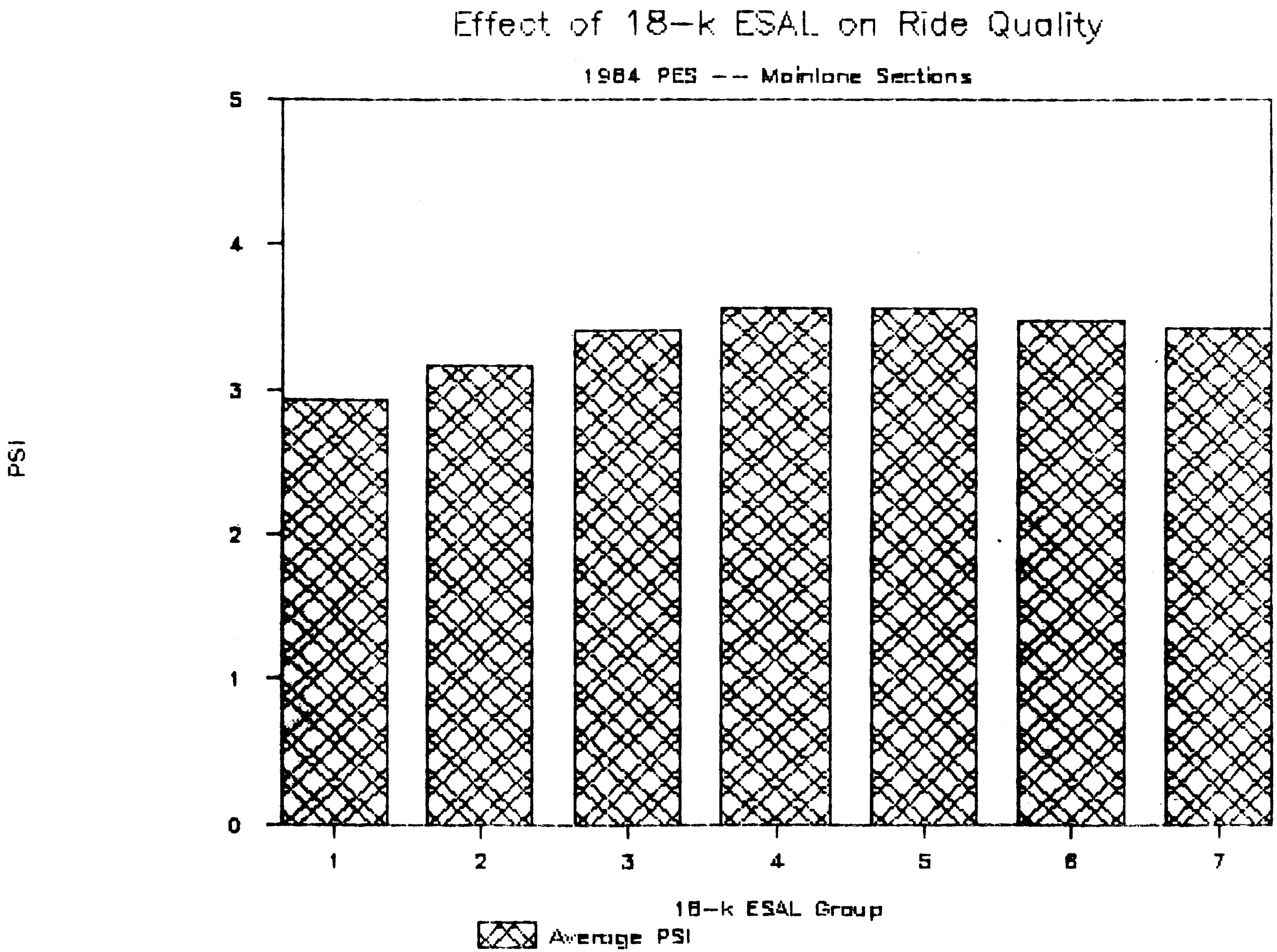

Effect of 18-k ESAL on Ride Quality
1984 PES -- Mainlane Sections
PSI
0
1
2
3
4
5
1
2
3
4
5
6
7
18-k ESAL Group
Average PSI

Fig. 7.2

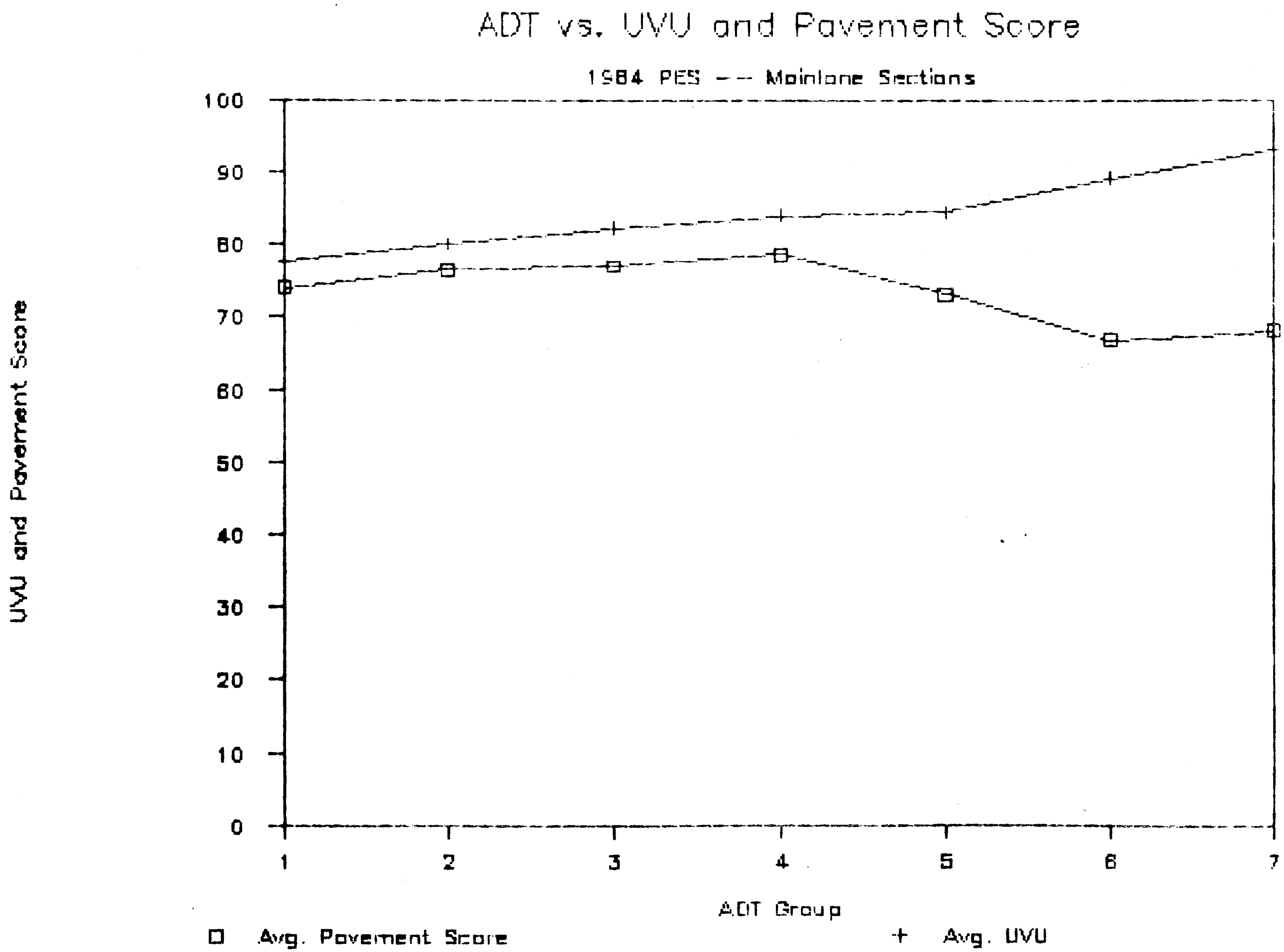
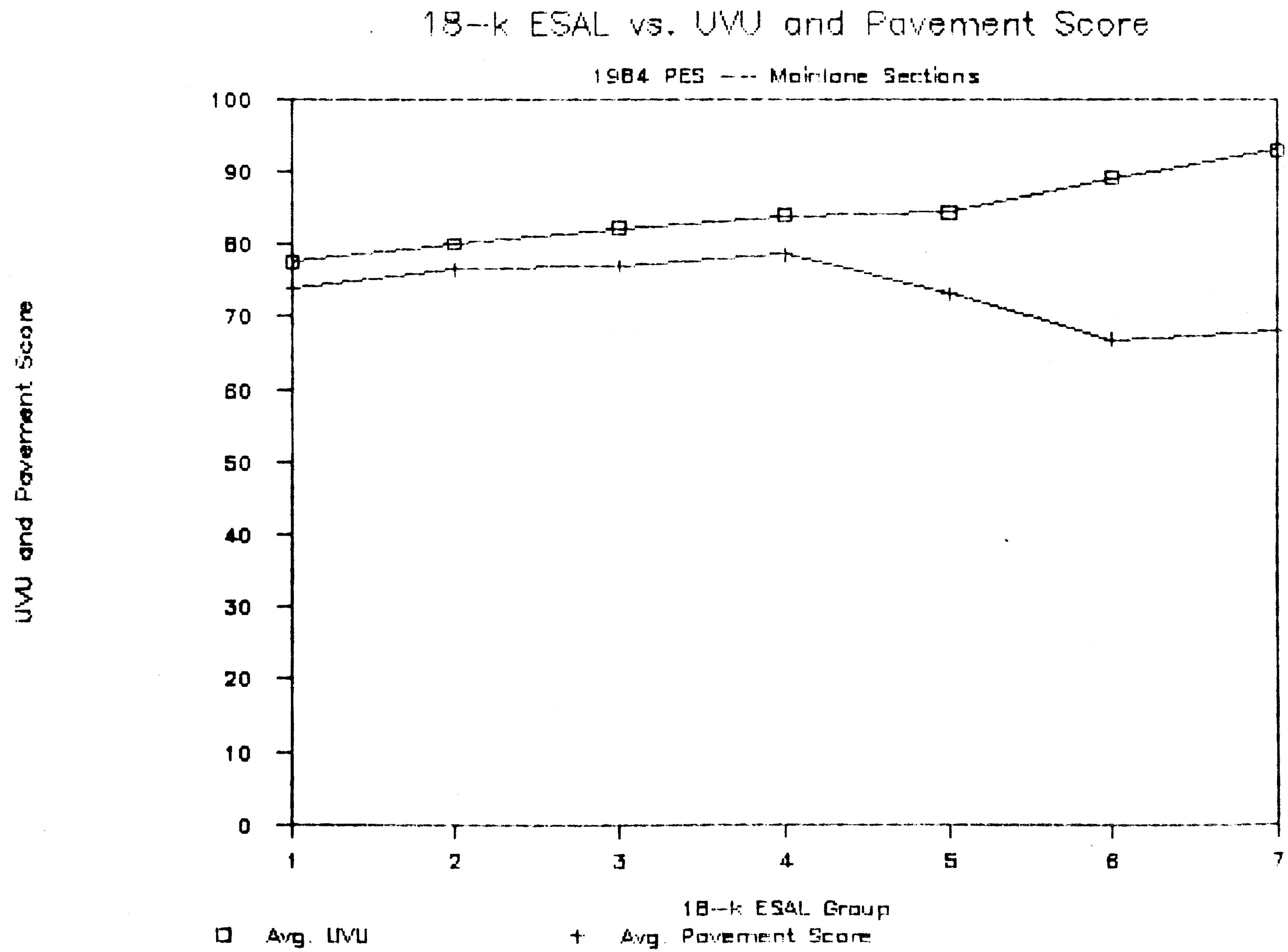

ADT vs. UVU and Pavement Score
1984 PES -- Mainlane Sections
UVU and Pavement Score
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
ADT Group
Avg. Pavement Score
Avg. UVU

Fig. 7.3



18--k ESAL vs. UVU and Pavement Score
1984 PES --- Mainlane Sections
UVU and Pavement Score
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
18--k ESAL Group
Avg. UVU
Avg. Pavement Score

Fig. 7.4

NOTES

CHAPTER 8

EFFECT OF SAMPLE SIZE ON RESULTS OF PES SURVEY

Divides District 11's 100 percent evaluation into a partial (mandatory sections only) group and a total (all mileage) evaluation group, and then compares the average values obtained from each group.

District raters presently evaluate approximately one-third of the state-maintained highway system. Most Districts completed the visual and ride quality surveys in six months during the 1984 PES survey. This one-third sample, while being statistically representative, does not provide pavement condition information on every highway section. The resulting lack of information becomes most apparent when determining project-level maintenance and rehabilitation needs. If pavement condition is the primary criterion in selecting maintenance and rehabilitation, then a full pavement condition survey is required before individual projects can be selected.

In 1982, Districts 8, 11, and 15 conducted full evaluations of their highway systems during the first PES survey. In 1983 and 1984, District 11 has continued to evaluate all of their mileage during the annual PES survey. This chapter compares the 1984 District 11 results with those which would have been obtained from a partial, mandatory sections only, survey. The objective is to identify major differences between the two samples.

Table 8.1 compares a partial survey with the actual total survey. The computed partial survey of 971.8 miles represents only 34.5 percent of the District's total mileage. This figure is typical, and approximates the full extent of the statewide survey. Percentages by pavement type are similar to the PES sampling values (100 % IH, 50 % US, 50 % SH, and 20 % FM). This is because hot-mix pavements are usually reserved for US and State highways while surface-treated pavements are typically used on the FM system. The most obvious difference is in the JCP sections, where only one of the six sections was mandatory.

Tables 8.2 and 8.3 contain values for pavement distress (percent of sections with no distress and severe distress, respectively). These tables indicate that the partial survey consistently underestimates the amount and overestimates the severity of rutting, patching, failures, and alligator cracking. Differences in rutting values range from 7.9 percent to 11.3 percent (Table 8.2) and 0.08 percent to 1.03 percent (Table 8.3).

In Table 8.4, the partial survey overestimates average ride quality for all flexible pavements and for hot-mix and surface-treated pavement sections in District 11. It also underestimates the percent of rough flexible and surface-treated sections on the SH and FM systems.

Table 8.5 also identifies discrepancies between the partial and total surveys. On the average, the partial survey underestimates overall pavement score, and overestimates the percent of flexible, hot-mix, and surface-treated SH and FM sections with low pavement scores.

Table 8.6 lists, more for general information than actual analysis, the partial and total survey results for JCP sections.

Table 8.1

1984 PES -- DISTRICT 11 RESULTS Comparison of Mandatory and Total Evaluations						
	Number of Sections			Number of Miles		
Pavement Type	Mand.	Total	Pct.	Mand.	Total	Pct.
ALL ACP SECTIONS	486	1435	33.9%	970.3	2812.7	34.5%
Hot-Mix	85	146	58.2%	169.8	290.8	58.4%
Composite	2	5	40.0%	4.2	8.6	48.8%
Surface-Treated	252	993	25.4%	504.1	1945.8	25.9%
ALL CRCP SECTIONS	0	0	---	0.0	0.0	---
ALL JCP SECTIONS	1	6	16.7%	1.5	3.6	41.7%
DISTRICT TOTAL	487	1441	33.8%	971.8	2816.3	34.5%

Definitions: "Hot-Mix" -- Pavement Types 4, 5, 6
"Composite" -- Pavement Type 7
"Surface-Treated" -- Pavement Type 10

Table 8.2 -- Percent of Sections With No Distress

	Percent		Number of Sections	
	Mandatory	Total	Mandatory	Total
ALL FLEXIBLE PAVEMENTS				
Rutting	55.6	44.3	486	1435
Block Cracking	89.5	92.5	486	1435
Patching	66.5	57.5	486	1435
Failures	90.5	87.7	486	1435
Alligator Cracking	75.9	72.6	486	1435
Longitudinal Cracking	67.3	73.1	486	1435
Transverse Cracking	67.9	76.6	486	1435
FLEXIBLE HOT-MIX PAVEMENTS				
Rutting	64.7	54.1	85	146
Block Cracking	88.2	88.4	85	146
Patching	76.5	69.9	85	146
Failures	97.6	91.8	85	146
Alligator Cracking	76.5	69.2	85	146
Longitudinal Cracking	55.3	47.3	85	146
Transverse Cracking	51.8	56.2	85	146
FLEXIBLE COMPOSITE PAVEMENTS				
Rutting	50.0	80.0	2	5
Block Cracking	50.0	80.0	2	5
Patching	100.0	100.0	2	5
Failures	100.0	100.0	2	5
Alligator Cracking	100.0	80.0	2	5
Longitudinal Cracking	50.0	40.0	2	5
Transverse Cracking	50.0	40.0	2	5
FLEXIBLE SURFACE-TREATED PAVEMENTS				
Rutting	46.4	38.5	252	993
Block Cracking	92.1	96.0	252	993
Patching	53.2	49.2	252	993
Failures	86.9	86.3	252	993
Alligator Cracking	74.6	72.2	252	993
Longitudinal Cracking	78.2	83.2	252	993
Transverse Cracking	86.9	90.8	252	993

Table 8.3 -- Percent of Sections With Severe Distress

	Percent		Number of Sections	
	Mandatory	Total	Mandatory	Total
ALL FLEXIBLE PAVEMENTS				
Rutting	3.50	3.42	486	1435
Block Cracking	0.00	0.07	486	1435
Patching	1.24	1.12	486	1435
Failures	0.21	0.21	486	1435
Alligator Cracking	0.41	0.35	486	1435
Longitudinal Cracking	0.41	0.28	486	1435
Transverse Cracking	1.85	0.98	486	1435
FLEXIBLE HOT-MIX PAVEMENTS				
Rutting	4.71	4.80	85	146
Block Cracking	0.00	0.00	85	146
Patching	1.18	0.69	85	146
Failures	0.00	0.00	85	146
Alligator Cracking	0.00	0.00	85	146
Longitudinal Cracking	1.18	0.69	85	146
Transverse Cracking	0.00	0.69	85	146
FLEXIBLE COMPOSITE PAVEMENTS				
Rutting	0.00	0.00	2	5
Block Cracking	0.00	0.00	2	5
Patching	0.00	0.00	2	5
Failures	0.00	0.00	2	5
Alligator Cracking	0.00	0.00	2	5
Longitudinal Cracking	0.00	0.00	2	5
Transverse Cracking	50.00	20.00	2	5
FLEXIBLE SURFACE-TREATED PAVEMENTS				
Rutting	4.76	3.73	252	993
Block Cracking	0.00	0.10	252	993
Patching	1.59	1.21	252	993
Failures	0.40	0.30	252	993
Alligator Cracking	0.79	0.40	252	993
Longitudinal Cracking	0.00	0.10	252	993
Transverse Cracking	0.00	0.10	252	993

Table 8.4 -- Percent of Sections Having Rough Surfaces

	Percent		Number of Sections	
	Mandatory	Total	Mandatory	Total
ALL FLEXIBLE PAVEMENTS				
Average PSI	3.05	2.84	486	1435
IH System	0.00	0.00	0	0
US System	0.00	0.00	139	246
SH System	2.06	3.48	194	345
FM System	2.63	2.73	152	843
ALL FLEXIBLE HOT-MIX PAVEMENTS				
Average PSI	3.60	3.45	85	146
IH System	0.00	0.00	0	0
US System	0.00	0.00	34	54
SH System	0.00	3.39	45	59
FM System	0.00	0.00	6	33
ALL FLEXIBLE COMPOSITE PAVEMENTS				
Average PSI	2.65	2.94	2	5
IH System	0.00	0.00	0	0
US System	0.00	0.00	1	1
SH System	0.00	0.00	1	4
FM System	0.00	0.00	0	0
ALL FLEXIBLE SURFACE-TREATED PAVEMENTS				
Average PSI	2.69	2.59	252	993
IH System	0.00	0.00	0	0
US System	0.00	0.00	8	14
SH System	4.08	4.55	98	176
FM System	2.76	2.87	145	802
ALL JOINTED CONCRETE PAVEMENTS				
Average PSI	1.90	1.67	1	6
IH System	0.00	0.00	0	0
US System	100.00	100.00	1	2
SH System	0.00	66.67	0	3
FM System	0.00	100.00	0	1

Table 8.5 -- Percent of Sections Having Low Scores

	Percent		Number of Sections	
	Mandatory	Total	Mandatory	Total
ALL FLEXIBLE PAVEMENTS				
Average PS	74.22	74.38	486	1435
IH System	0.00	0.00	0	0
US System	9.35	10.98	139	246
SH System	9.28	8.99	194	345
FM System	15.13	7.71	152	843
ALL FLEXIBLE HOT-MIX PAVEMENTS				
Average PS	76.60	73.19	85	146
IH System	0.00	0.00	0	0
US System	8.82	11.11	34	54
SH System	24.44	22.03	45	59
FM System	33.33	9.09	6	33
ALL FLEXIBLE COMPOSITE PAVEMENTS				
Average PS	70.50	80.00	2	5
IH System	0.00	0.00	0	0
US System	0.00	0.00	1	1
SH System	0.00	0.00	1	4
FM System	0.00	0.00	0	0
ALL FLEXIBLE SURFACE-TREATED PAVEMENTS				
Average PS	73.23	74.97	252	993
IH System	0.00	0.00	0	0
US System	0.00	0.00	8	14
SH System	4.08	3.98	98	176
FM System	14.48	7.48	145	802
ALL JOINTED CONCRETE PAVEMENTS				
Average PS	2.00	11.00	1	6
IH System	0.00	0.00	0	0
US System	100.00	100.00	1	2
SH System	0.00	66.67	0	3
FM System	0.00	100.00	0	1

Table 8.6 -- Mean Number of Distress Occurrences Per Mile

	Percent		Number of Sections	
	Mandatory	Total	Mandatory	Total
ALL JOINTED CONCRETE PAVEMENTS				
Spalled Cracks	144.00	34.56	1	6
Longitudinal Cracks	20.67	24.00	1	6
Transverse Cracks	333.33	84.58	1	6
C. Breaks & Punchouts	22.67	10.58	1	6
AC Patches	0.00	1.39	1	6
PC Patches	0.67	0.39	1	6

Comparison of the partial and total survey results suggests that the partial survey contained an unusually high percent of the poorer sections (especially those with low pavement scores) in District 11. For example, in Table 8.5, 21 (14.48 percent of 145) mandatory surface-treated FM sections are identified as having pavement scores below the FM terminal value of 35. The total survey identifies only 60 sections (7.48 percent of 802). District 11 raters surveyed 657 additional surface-treated FM sections to complete their total survey. This additional survey should have identified 95 (14.48 percent of 657) more sections with low scores. Table 8.5, however, indicates that they only found 39 more sections (60 - 21 = 39). The implication is that most of the "poor-condition" sections were already identified in the mandatory survey.

One justification for the partial survey is that it provides sufficient data for network-level decisions. The pavement condition maps developed in Chapter 3 may be thought of as one such "network-level" analysis tool. District 11 values for these maps were taken from the total survey. Using mandatory survey values would have changed the appearance of some of the maps. Table 8.7 summarizes the changes brought about by using the partial survey results instead of the total survey results.

Table 8.7 -- Comparison of Partial Versus Total Survey for Chapter 3 Pavement Condition Maps.

Subject	No.	Type of Survey: Partial	Type of Survey: Total
Districts with Excessive Distress	2	MAJOR	MAJOR
	1	minor	MAJOR
	3		MAJOR
	1	MAJOR	minor
Districts with Severe Distress	3	MAJOR	MAJOR
Districts with Rough Sections	2	MAJOR	MAJOR
	1	minor	MAJOR
	4		MAJOR
Districts with Low Pav. Scores	1	MAJOR	MAJOR
	3	MAJOR	
SUMMARY FOR DISTRICT 11	8	MAJOR	MAJOR
	2	minor	MAJOR
	7		MAJOR
	1	MAJOR	minor
	3	MAJOR	

Note: Composite ACP, JCP, and CRC sections not considered because of insufficient sample size (i.e. 5 or fewer sections surveyed).

"MAJOR" indicates use of dense crosshatching in map, "minor" indicates use of light crosshatching.

The summary indicates that District 11 would have been marked in 14 maps with the partial survey, as compared to the 18 maps in which it appears with the total survey. In general, the total survey for District 11 provides indications of additional surface distress and roughness problems which are not as easily recongized from the partial survey. The partial survey also tends to overemphasize the problem of low pavement scores. These inconsistencies in the sample results, while not critical at the statewide or network-level, should discourage any ironclad interpretations of the pavement condition maps in Chapter 3.

The actual nature of any sample inconsistencies depend on the samples chosen. At present, PES samples are chosen at random according to specific mileage, highway prefix, and historical criteria. Pavement condition or surface type is not considered in the sampling process. It is entirely possible, then, to obtain samples which may seem to be biased towards one or more particular problems (such as rutting, low PSI, or low pavement score). A total survey eliminates these uncertainties.

District 11 financial records quote the final cost of the 1984 PES survey as approximately $53,000. This figure covers expenditures for the visual, ride, and skid surveys. An itemized cost summary provided by the District suggests that a total survey (PES visual and ride) could be conducted during 8-hour days at a cost of $11/mile. From a maintenance and rehabilitation viewpoint, the project-level benefits obtained from a total survey outweigh any financial burden incurred.

NOTES

CHAPTER 9

CONTINUOUS PROFILE OF PAVEMENT CONDITION

FOR US 59 IN ANGELINA COUNTY

Demonstrates the use of 100 percent evaluation data to develop a continuous pavement condition profile which locates regions of unusual pavement condition needs or traffic demands.

One advantage of collecting PES data on all highway sections is that it enables the development of continuous pavement condition profiles, such as those shown in Chapter 6 for several Interstate highways. These profiles depict pavement condition on a continuous basis, as the average motorist would see it. Administrative personnel can use the profiles to obtain a quick and reliable overview of one highway's condition. Maintenance personnel can use them as documentation in support of proposed maintenance or rehabilitation schedules. This chapter considers one such set of profiles, developed for US 59 in Angelina County, District 11.

Tables 9.1 and 9.2 contain the PES survey data used to generate profiles for the southbound and northbound lanes, respectively. These profiles include the city of Lufkin, approximated by sections 5 and 6 (mileposts 6 + 1.6 to 10 +1.2). US 59 is a four-lane divided highway, except within the city when it becomes four- (and five-) lanes undivided.

Figure 9.1 is the PSI profile, which identifies two sections of rough composite pavement in the southbound lanes (sections 4 and 7) just north and south of Lufkin. The northbound lanes vary slightly between 3.5 and 4.0, except within the city, where ride quality is even higher.

Figure 9.2, the UVU profile, is similar to the PSI profile. Again, sections 4, 7, and 8 are older composite surfaces exhibiting definite surface distress. Sections 3 and 5 also appear to be in need of surface maintenance. Figure 9.3 indicates very low pavement score values for these sections. This figure also suggests that the southbound lanes are almost always in poorer condition than the northbound lanes. However, the difference, though consistent, is not very large, which suggests that one-way heavy traffic (for example, to Houston) is not to blame.

Figures 9.4 and 9.5 compare UVU and pavement score for the northbound and southbound lanes, respectively. As before, sections 7 and 8 are of particular interest. Section 7 has a much lower pavement score on the southbound lanes (UVU of about 65) than on the northbound lanes (UVU of about 62). Section 8 is the worst part of the northbound lanes, and just as bad on the southbound lanes.

Figures 9.6 and 9.7 depict ADT and 18-k ESAL trends, respectively. The ADT profile is predictable, however the 18-k ESAL profile shows extremely high projected truck repetitions; at levels which rival even some Interstate highways. Chapter 6 profiles indicate that the 32 million repetitions projected for US 59 through Lufkin exceed the values projected for most of IH 10, most of IH 20, half of IH 35 (east and west), and most of IH 45.

These continuous pavement condition profiles are by no means intended to replace the opinions of experience field personnel engaged in project-level work. However, they do provide a quick and reliable overview of pavement condition at the broader network level which is of use to administrators hoping to become more familiar with overall highway needs.

Table 9.1

1984 PES -- DISTRICT 11 RESULTS Pavement Condition Profile for SB US 59 -- Angelina County							
Sect.	Mileposts		PSI	UVU	PS	ADT	18-k
1	000+00	002+00	3.4	79	67	17000	17795
2	002+00	004+00	4.2	81	71	18800	18861
3	004+00	006+00	3.8	73	58	19000	19654
4	006+00	006+16	2.9	67	41	19600	18426
5	006+16	010+00	4.2	71	57	27000	25692
6	010+00	010+12	4.0	83	73	26000	31726
7	010+12	014+00	2.2	65	16	26000	31726
8	014+00	016+00	3.8	56	41	16300	15966
9	016+00	018+00	4.3	90	84	16300	16117
10	018+00	020+00	3.9	77	66	17300	17626
11	020+00	022+00	4.5	98	97	17000	17594
12	022+00	022+20	4.0	93	90	13400	12956

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from
20-year projected values.

Table 9.2

1984 PES -- DISTRICT 11 RESULTS Pavement Condition Profile for NB US 59 -- Angelina County							
Sect.	Mileposts		PSI	UVU	PS	ADT	18-k
1	000+00	002+00	3.5	90	84	17000	17795
2	002+00	004+00	3.5	79	67	18800	18861
3	004+00	006+00	3.6	79	67	19000	19654
4	006+00	006+16	3.6	83	74	19600	18426
5	006+16	010+00	4.2	71	57	27000	25692
6	010+00	010+12	4.0	83	73	26000	31726
7	010+12	014+00	3.7	61	42	26000	31726
8	014+00	016+00	3.6	40	23	16300	15966
9	016+00	018+00	3.6	98	97	16300	16117
10	018+00	020+00	4.0	80	69	17300	17626
11	020+00	022+00	3.6	98	97	17000	17594
12	022+00	022+20	4.0	81	72	13400	12956

Note: ADT values are for 2-way traffic.
18-k ESAL values, in thousands, are from
20-year projected values.

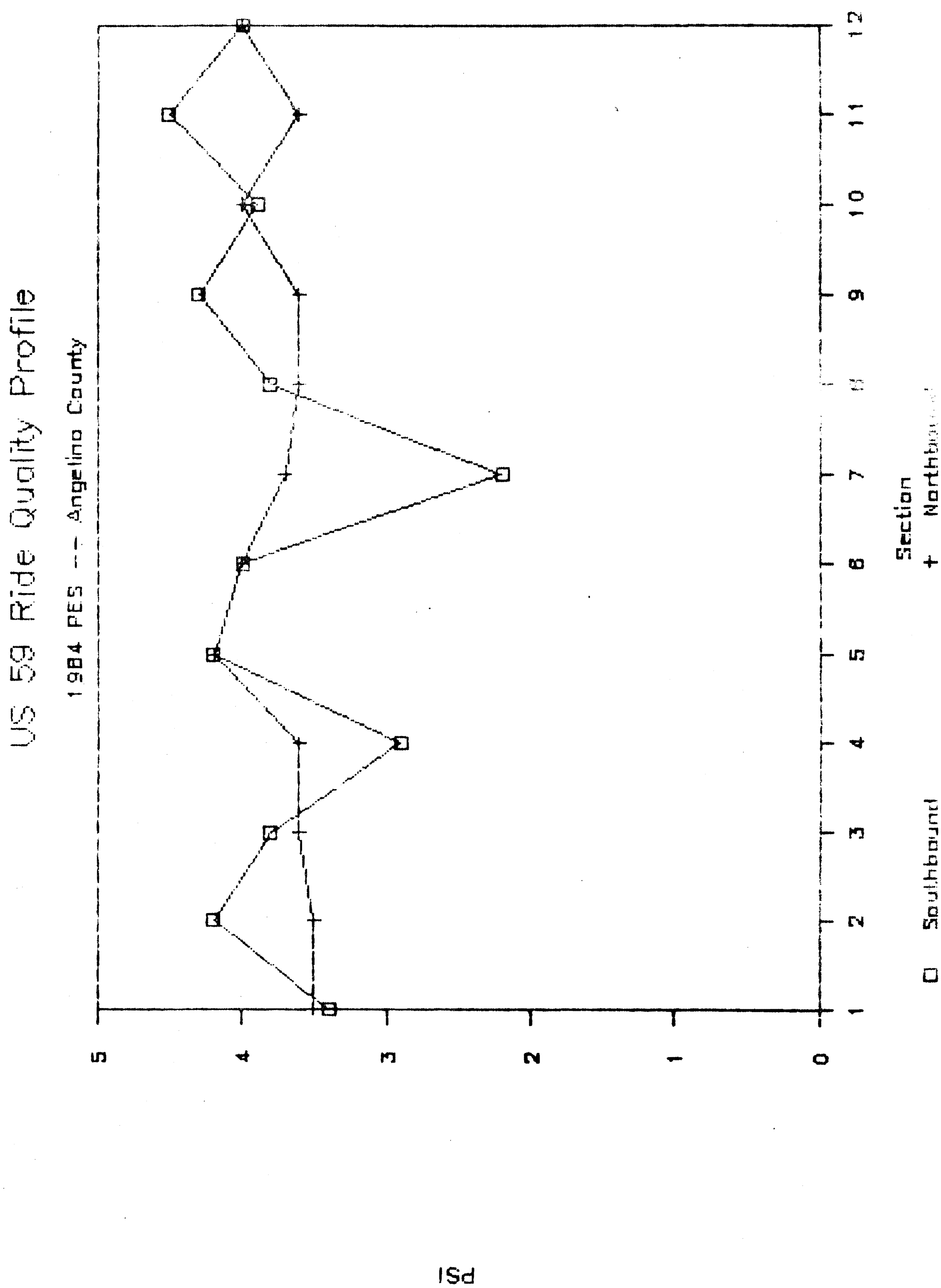

US 59 Ride Quality Profile
1984 PES -- Angelina County
PSI
Section
Southbound
Northbound
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 9.1

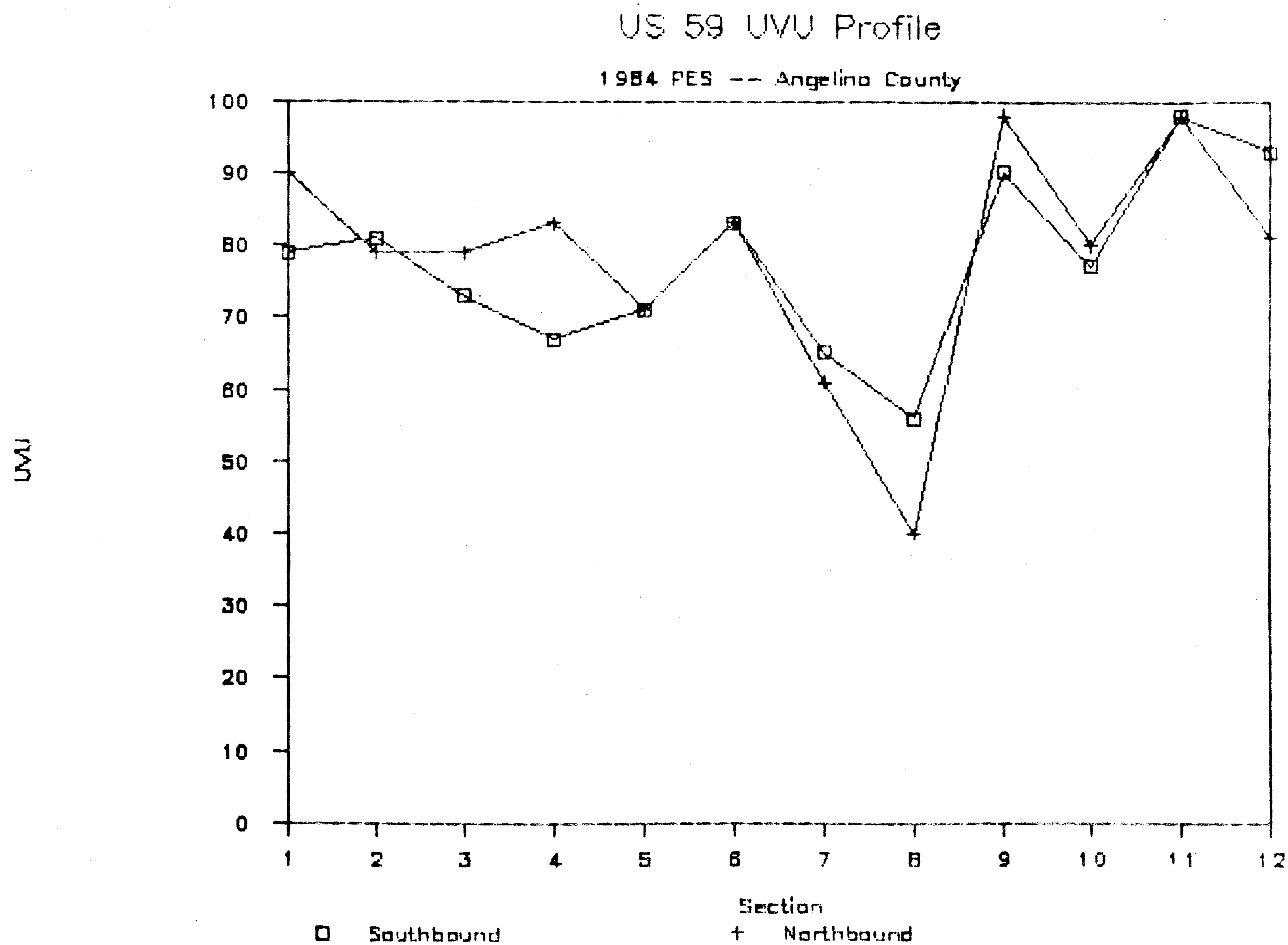

US 59 UVU Profile
1984 PES -- Angelino County
100
90
80
70
60
50
40
30
20
10
0
UVU
1
2
3
4
5
6
7
8
9
10
11
12
Section
Southbound
Northbound

Fig. 9.2

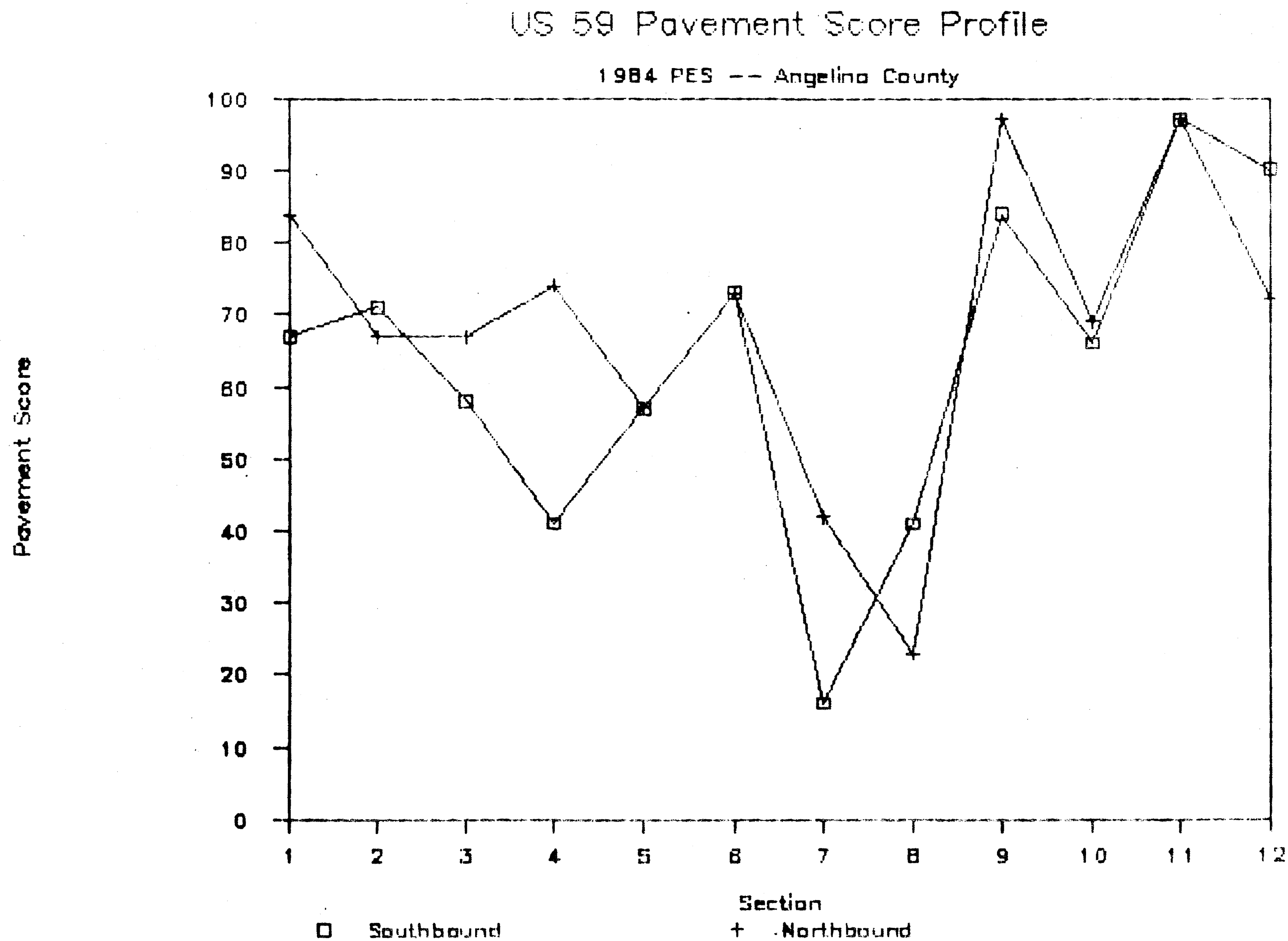
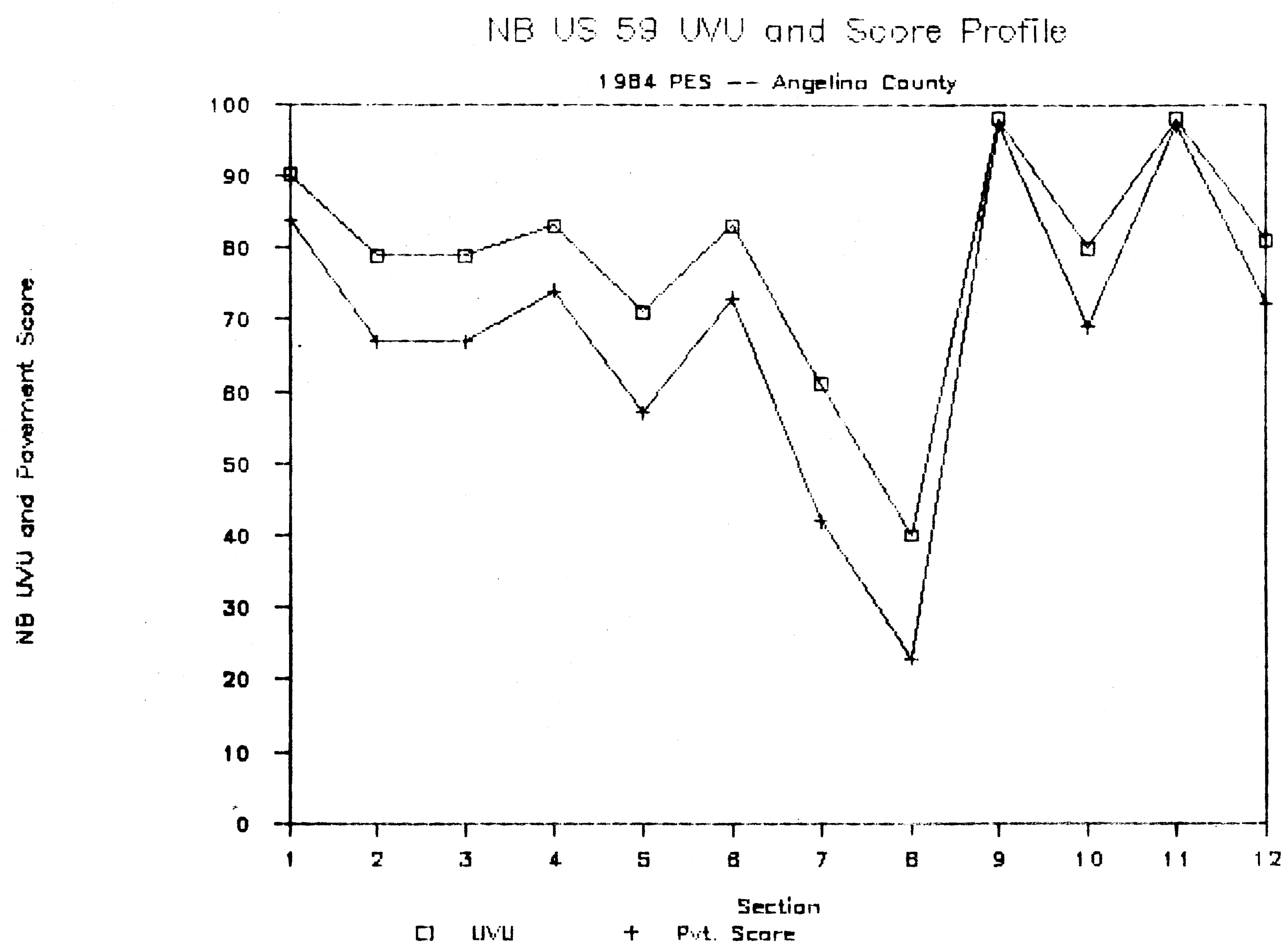

US 59 Pavement Score Profile
1984 PES -- Angelina County
Pavement Score
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Section
Southbound
Northbound

Fig. 9.3



NB US 59 UVU and Score Profile
1984 PES -- Angelina County
NB UVU and Pavement Score
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Section
UVU
Pvt. Score

Fig. 9.4

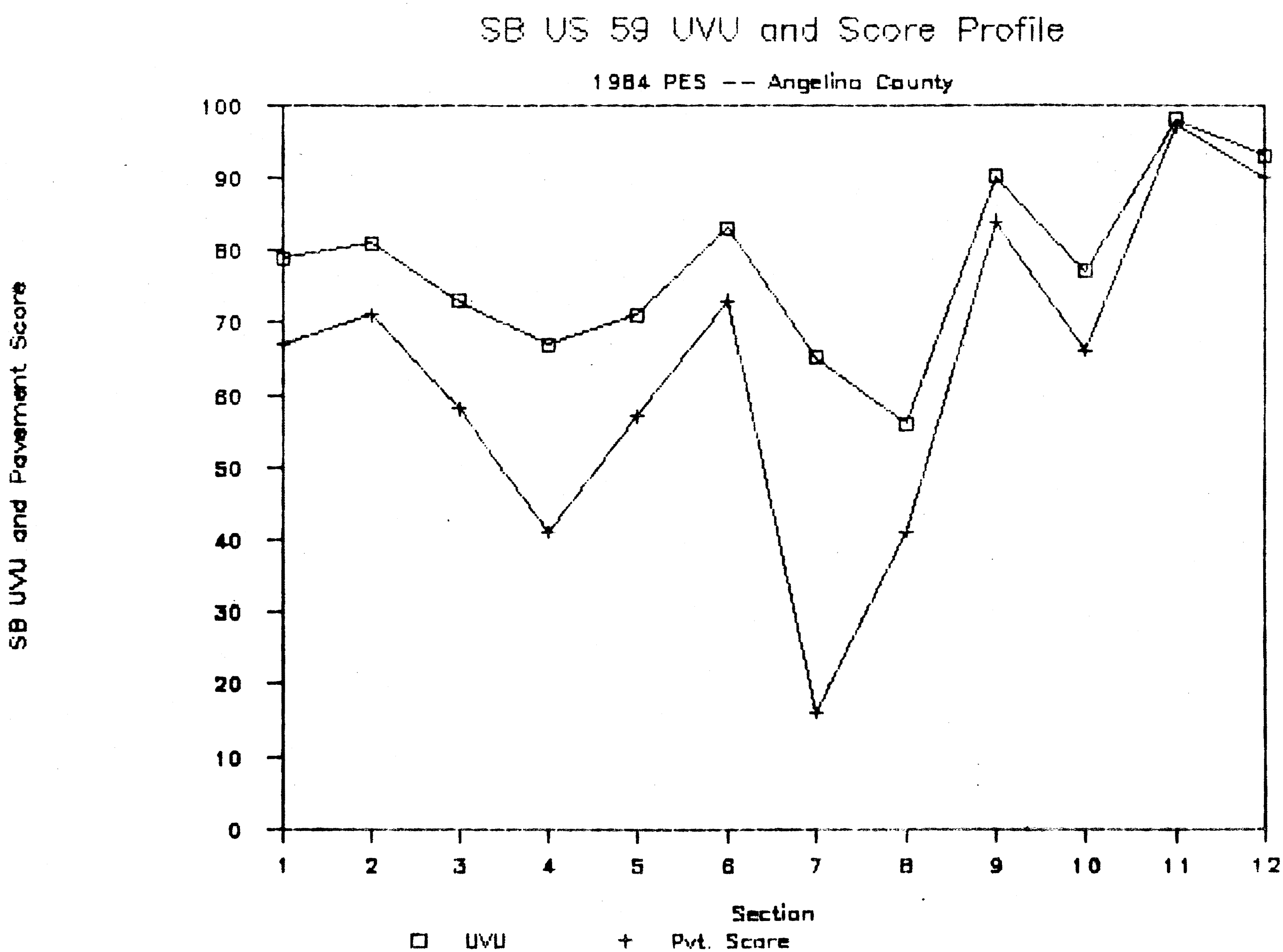

SB US 59 UVU and Score Profile
1984 PES -- Angelina County
SB UVU and Pavement Score
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Section
UVU
Pvt. Score

Fig. 9.5

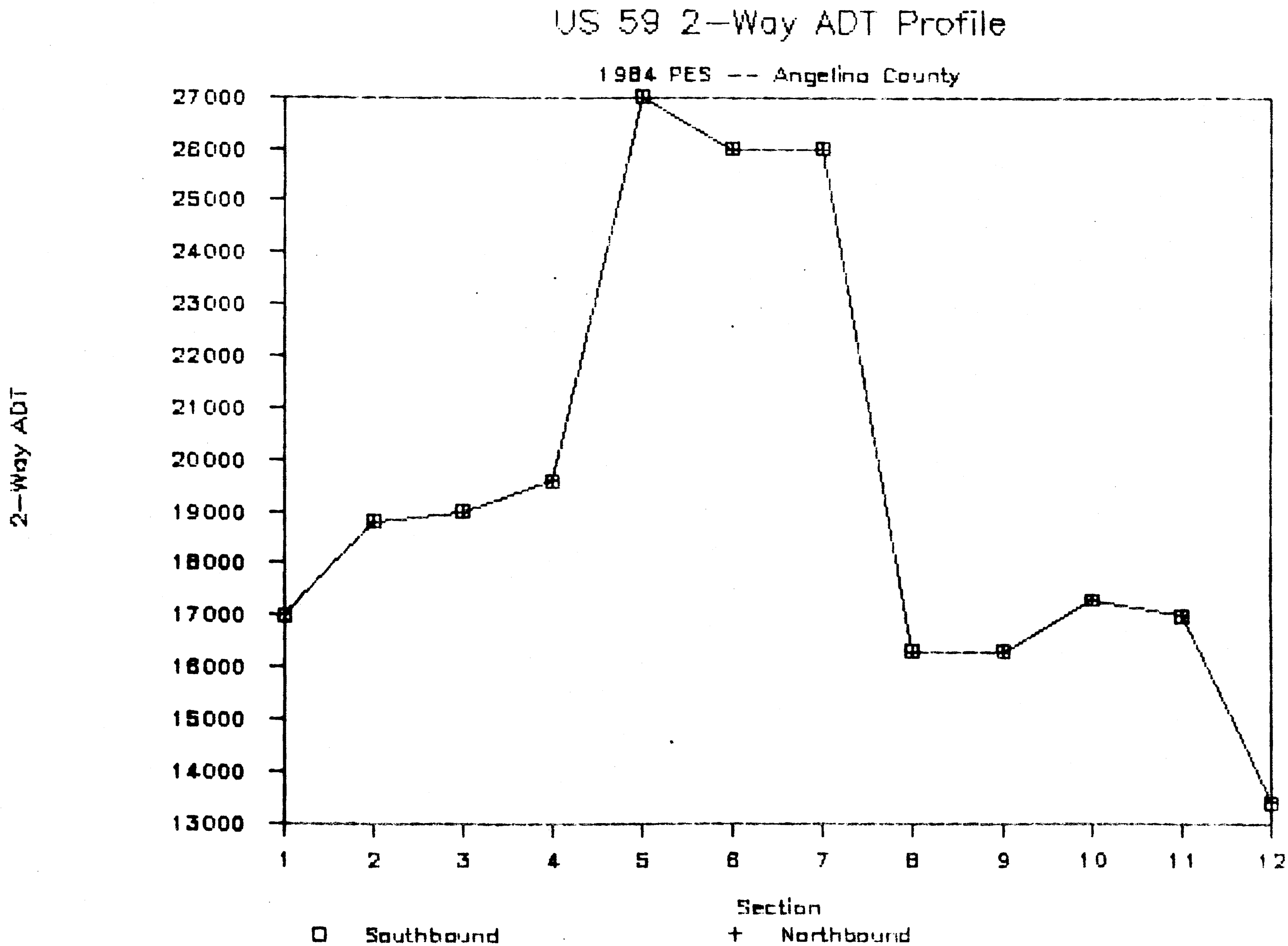

US 59 2-Way ADT Profile
1984 PES -- Angelina County
2-Way ADT
27000
26000
25000
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
1
2
3
4
5
6
7
8
9
10
11
12
Section
Southbound
Northbound

Fig. 9.6

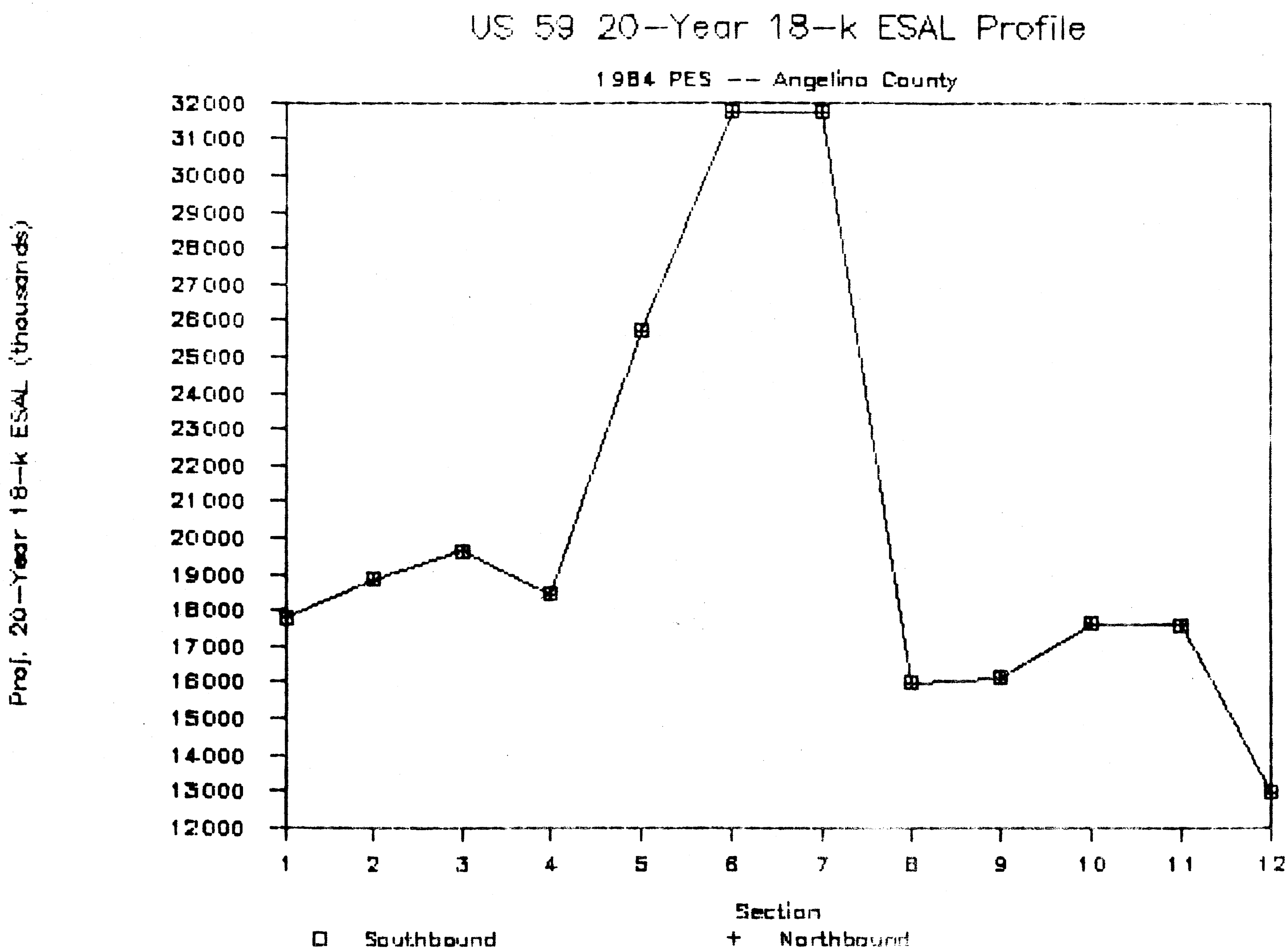

US 59 20-Year 18-k ESAL Profile
1984 PES -- Angelina County
32000
31000
30000
29000
28000
27000
26000
25000
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
Proj. 20-Year 18-k ESAL (thousands)
1
2
3
4
5
6
7
8
9
10
11
12
Section
Southbound
Northbound

Fig. 9.7

NOTES

CHAPTER 10

FUTURE IMPROVEMENTS TO PES

Discusses current limitations of PES as well as efforts aimed at eliminating those limitations.

This report has explored many different uses of PES data. The number of chapters in this report hints at the many possible applications of PES data in maintenance and rehabilitation planning. Additional applications will continue to be introduced as PES is refined into a more reliable pavement condition information system.

CURRENT LIMITATIONS

Conversations with District personnel after the 1984 Rater Training Schools have emphasized several current PES limitations:

1. Subjectivity of Pavement Evaluations -- The present pavement rating procedure greatly depends on the rater's own interpretation. It is quite common for two raters, even from the same District, to evaluate the same section in two noticeably different ways. Although this problem is addressed during the Rater Training Schools it is never completely eliminated. The most important aspect, however, is that each rater be able to identify severe distress as severe, even if it is called by two different names.

2. Rater Safety in Urban Areas -- Both flexible and rigid pavement surveys pose serious safety problems to raters working in high-traffic urban areas. Districts 2 and 12 have experimented with photologging and videotaping, respectively, during the 1984 survey in an effort to maintain rater safety during the evaluation process. Other urban areas, such as Dallas, San Antonio, Austin, and El Paso, would surely benefit from the development of such a procedure.

3. Excessive Dependence on Surface Condition Descriptors -- PES evaluations consider only conditions which can be identified at the pavement surface. Many distress types, such as rutting, failures, or punchouts, reflect sub-surface condition. Several Districts have specifically stated that some of their recent seal coat jobs show up as being in excellent condition during the PES survey, although maintenance personnel fully realize that the section will require additional extensive work within a year.

4. Inability to Run Standard Reports From Previous Years -- Standard PES reports can only be run using data from the current year's survey. This poses problems for those who attempt to retrieve evaluation records from previous years. At present, two solutions are available: (1) run and keep all standard reports for each year's survey, and (2) request that D-18P write and execute a special program from the "old" tape files.

5. Lack of Historical Analysis -- This is similar to the

previous item, but is far more involved since it has a direct impact on selection of maintenance and rehabilitation projects. In general, maintenance personnel base many of their project-level decisions on past experience. This implies that the maintenance engineer or foreman knows the trend in pavement condition over time. Such a capability has not been incorporated into PES. PES presently selects rehabilitation projects based upon whether or not the pavement score has fallen below a specified value in the current year. Using their historical knowledge, maintenance personnel can often project pavement condition into the future. This allows them to justify performing minor work now on a section to avoid major work which is sure to come in the near future.

In its defense, PES is an evolutionary system, still in the early years of development. Each year has brought new refinements, aimed at increasing the system's reliability. In addition, PES provides a means of actually documenting pavement condition. Although evaluations of pavement condition may not be completely consistent, PES is capable of measuring general condition at the project-level and relative condition at the network-level.

PES raters are trained in the art of pavement evaluation. An end result of this training is that they become more aware of some of the interactions between pavement structure, traffic, and environment. These skills make the PES raters valuable assets in identifying current and potential pavement problems. District maintenance engineers may wish to consider PES condition rating as a year-round process, especially at troublesome sections. Such a practice would prove helpful in documenting monthly or seasonal variations in condition, as well as provide time-measurements of condition before and after routine maintenance or rehabilitation work.

FUTURE DEVELOPMENTS

District and Division personnel have identified several limitations in the present version of PES. Work is currently underway on several fronts to correct these limitations:

1. Use of Video in PES Surveys -- The short-term objective is to provide a van which urban Districts can use to videotape high-volume sections during the 1985 PES survey. The van will include a high-resolution camera and recorder capable of producing quality images at speeds up to 30 mph. Long-term (2-3 years) objectives include the development of visual and ride quality equipment which will automatically collect <u>and analyze</u> evaluation data in the field, thus eliminating the need for manual rating and office keypunching. Other

pavement testing devices are being developed for use with this automated pavement condition vehicle. Such a vehicle should enable the evaluation of all state-maintained mileage every year.

2. Incorporation of Structural Adequacy into PES -- Several Districts have already had experience with the Falling Weight Deflectometer, which is currently being considered as the method for evaluating structural adequacy. Continuing field testing is providing data which will be used to develop a descriptive index for pavement structural adequacy. This index, which will probably be similar to UVU, is intended to reflect the section's structural adequacy under projected ADT and 18-k ESAL. Researchers at the University of Texas are developing additional devices aimed at assessing structural adequacy. Results from this work should be ready for implementation within 2 years.

3. Maintenance and Rehabilitation Project Selection -- PES Standard Report R06, which provides current rehabilitation projects for rated flexible pavement sections, is the only tool currently available to assess project-level needs. Researchers at Texas A&M University have already developed test programs which use PES data to select both routine maintenance and rehabilitation projects. These programs can be tailored to reflect each District's unique costs and strategies. In addition, the programs are capable of modelling future pavement performance and developing multi-year maintenance and rehabilitation needs estimates. These programs are still being evaluated and refined, but they should be ready for implementation during the 1986 PES survey.

4. New JCP Survey -- Last year's JCP survey procedure was not well-received because it was too complicated and too time-consuming. Work is underway to develop a simpler and quicker survey for JCP. This work will be completed in time for the 1985 Rater Training Schools in August.

As mentioned earlier, PES is an evolutionary system, and each year brings new refinements and improvements. District, Division, and Administration personnel are encouraged to express their opinions and suggested improvements concerning PES, at any time, to section D-18P.

CHAPTER 11

SUMMARY OF 1984 PES SURVEY

Summarizes the results of the 1984 PES survey and the issues discussed in this report.

The 1984 PES survey provided data concerning the condition of pavement sections across the state. Subsequent analysis, described in this report, has provided insight into many different aspects of statewide pavement condition.

Statewide averages indicate that ride quality increased slightly in 1984. However, overall surface condition and priority (as measured by UVU and pavement score, respectively) worsened by about five percent. Traffic load (as measured by ADT and 18-k ESAL) increased 66 percent statewide, thus overshadowing any improvements in ride quality. The increased traffic values reflect the addition of rigid pavements, which are usually in high-traffic or urban areas, into the PES survey. However, high-quality pavements are still predominant, with over half of the 16,214 rated sections having a ride quality value greater than 3.4, a UVU greater than 93, and a pavement score greater than 84.

Pavement distress figures indicate that rutting is becoming more common on flexible pavements. Both "minor" (0.5-inch) and "major" (1.0-inch) rutting increased in area in 1984. Longitudinal and transverse cracking are also becoming more of a problem. Alligator cracking and failures were less frequently observed during the 1984 survey. This is particularly encouraging since these distress types can deteriorate rapidly into heavy maintenance or even rehabilitation problems. Patching and block cracking -- first introduced during the 1984 survey -- are a widespread problem, with sixteen of the Districts having excessive or severe levels of one or the other.

Evaluation of rigid pavement sections was included for the first time in the 1984 survey. The survey indicated that, on the statewide average, ride quality on rigid pavements is generally less than that for flexible pavements, even though the rigid pavements had an average of less surface distress (i.e. higher UVU). Ride quality problems were especially apparent on jointed concrete sections, where the average PSI was 0.62 below that for a flexible pavement with essentially the same amount of surface distress. This 0.62 drop in ride quality is certainly noticeable to the average motorist. Pavement scores for CRC and JCP are much lower than those for flexible sections, in part due to an average five-fold increase in ADT and 18-k ESAL repetitions. With regards to surface distress, punchouts and asphalt patches were unusually common on CRC sections. For JCP sections, slabs with longitudinal cracks, corner breaks and punchouts, and asphalt patches were unusually common.

The 1984 PES survey data enabled a special analysis of the Interstate system in Texas. This analysis not only confirmed the overall high-quality of the system, but also identified the relative condition of each Interstate highway. The high average values for the "major" routes (IH 10, IH 20, IH 35, and IH 45) are especially noteworthy, as are the values for the urban loops (IH 410, IH 610, and IH 635). The highway averages, however, do not compare favorably with the 50th percentile values quoted earlier for all rated sections. Six highways have an average PSI less than 3.4, nine highways have an average UVU less than 93, and eight highways have an average pavement score less than 84. However, these highways carry, on average, four times the ADT and 18-k ESAL of other non-Interstate highways.

Continuous pavement condition profiles identified regional pavement and traffic trends for IH 10, IH 20, IH 35, and IH 45. These profiles illustrated, above anything else, the drastic traffic increases associated with major urban areas. In addition, urban sections could be reliably associated with drops in pavement score (usually accompanied by increases in ride quality and UVU caused by increased maintenance and rehabilitation activity).

Analysis of all rated mainlane sections resulted in a similar correlation between condition (PSI, UVU, and pavement score) and traffic (ADT and 18-k ESAL). Ride quality was highest in the medium-traffic ranges from 2,001 to 25,000. Surface distress (i.e. UVU) decreases with increasing traffic, but pavement score declines, especially for traffic values above 5000. (It bears repeating that this value represents an ADT of 5000 vehicles per day, or a 20-year projected 18-k ESAL of 5,000,000 repetitions.) The ride quality and UVU trends partially reflect the incorporation of rigid pavements into the survey, while the decline in pavement score is an indication of the importance which PES places on traffic as a means of identifying priority.

Evaluation of all Interstate highway mileage enabled more detailed analysis of overall and regional trends in pavement condition. Comparison of mandatory and total evaluations for District 11 emphasized the need for a complete evaluation of all highway sections prior to the selection of rehabilitation projects. The PES mandatory section survey is sufficient, however, for statewide or network-level assessments of relative District need. Subsequent analysis of continuous pavement condition profiles for US 59 illustrated just some of the potential benefits of a total survey.

This report has not discussed all of the possible uses for PES survey data. Additional uses are either being developed or are awaiting the resolution of current PES limitations. Work is presently underway on several tasks aimed at reducing or eliminating some of the most commonly-cited limitations. For example, video equipment is being examined as a means of collecting visual evaluation data in urban areas with greater speed and safety. The short-term objective is to develop a manual process but eventually, such equipment will be able to collect and analyze the visual and ride quality data automatically. Another project seeks to derive a measure of sub-surface structural adequacy for PES which will look below surface condition to predict future remaining service life. Analytical procedures are also being developed which will use PES data to provide estimates of current and future maintenance and rehabilitation project needs. Another project concerns the development of a new JCP survey for the 1985 survey which will be quicker and simpler than the 1984 version. Such a procedure would be similar to the CRC survey procedure.

PES is an evolutionary tool, still in the early stages of development. Each year has produced new improvements which yield more reliable results. These results, in turn, raise new questions and limitations to be answered by new improvements. This iterative process will eventually produce a pavement evaluation system which District, Division, and Administration personnel can reliably use to identify pavement condition needs and trends.