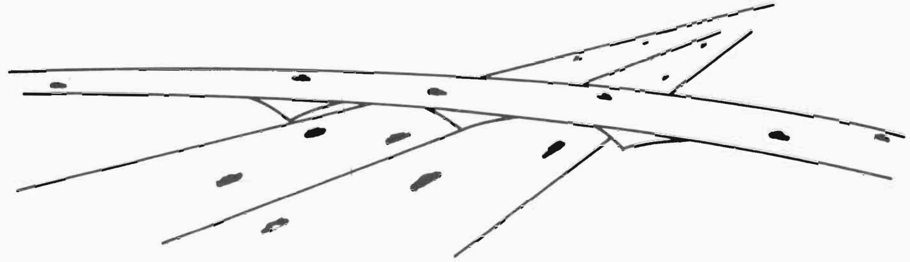


DEPARTMENTAL RESEARCH

Report Number: SS 11.6

MAINTENANCE OPERATIONS OF THE SKID TEST TRAILERS

June 1969 —— May 1970

TEXAS HIGHWAY DEPARTMENT

MAINTENANCE OPERATIONS OF THE SKID TEST TRAILERS

(June 1969 through May 1970)

by

Jon P. Underwood

Report Number SS 11.6

Conducted by

The Research Section of
The Highway Design Division
The Texas Highway Department

August 1970

ACKNOWLEDGEMENTS

Acknowledgement is extended to the Texas Highway Department Maintenance Division for directing the operation of these three skid test trailers, and to the Texas Highway Department districts for the information supplied to complete the forms of analysis given in this report. Special thanks are extended to Mr. Joe Young of the Highway Design Division for all data analysis and graph plotting by computer.

ABSTRACT

This report covers the results of the skid tests performed in various districts by the three Texas skid test trailers from June 1969 to June 1970. This report indicates results for various pavement types and surfaces, and studies the effect of the amount of binder and aggregate gradation upon the coefficient of friction. This report will be of specific interest to District, Maintenance, Design, and Resident Engineers and all other engineers interested in the friction performance of pavements.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

REPORT III

(June 1969-May 1970)

MAINTENANCE OPERATIONS OF THE SKID TEST TRAILERS

Background

In May 1968, three skid test trailers, under the supervision of the Texas Highway Department Maintenance Operations Division, began testing operations throughout the state. These trailers are permanently stationed in the districts where the major supply warehouses are located. At this time, the trailers were correlated on several test sections in the Austin and Bryan area and the results of this calibration were used in the computer program prepared by the Highway Design Division in order to obtain consistant skid resistance results regardless of the trailer used. In December 1968 and November 1969 the trailers were again correlated over the same test sections and the necessary changes made in the skid resistance computer program.

The Research Section of the Highway Design Division maintains a state wide file of skid resistance results to aid in plan preparation between D-8 and the Districts.

This is the third report prepared on the statewide status of pavement surfaces in relation to skid resistance. This report will be prepared each year in order to summarize the past years pavement surface test information.

General Information

As mentioned in the two previous reports (SS 11.4 and SS 11.5), the results of this report may be biased due to the manner of selection of the surfaces to be tested. The District making the skid tests selects the section to be studied. Some districts test nearly all roadways within their boundaries, others test only sections considered "slick" while others test different pavement surface types. Therefore, the statistics given in this report may not be a true representation of actual statewide conditions.

All skid tests were performed at 40 mph with a standard quantity of test water.

STATE WIDE AVERAGE

In the one year period covered herein, 3357 pavement sections were tested. The sections reported included six pavement types, various coarse aggregate types, binder contents and aggregate gradations. The friction values of these sections ranged from 0.11 to 0.83 with an average coefficient of 0.41. The average coefficient for the year preceeding the period of this report was 0.40 with a range of 0.14 to 0.80.

Graph I indicates approximately 29% of the pavements tested are below the suggested minimum value of 0.32.

Table I and Graphs 2 through 8 present skid resistance information concerning pavement type.

Table II compares coarse aggregate material types used in Asphaltic Concrete Pavements and Surface Treatments. In this comparison, wear or traffic applications, and age of surface have not be considered.

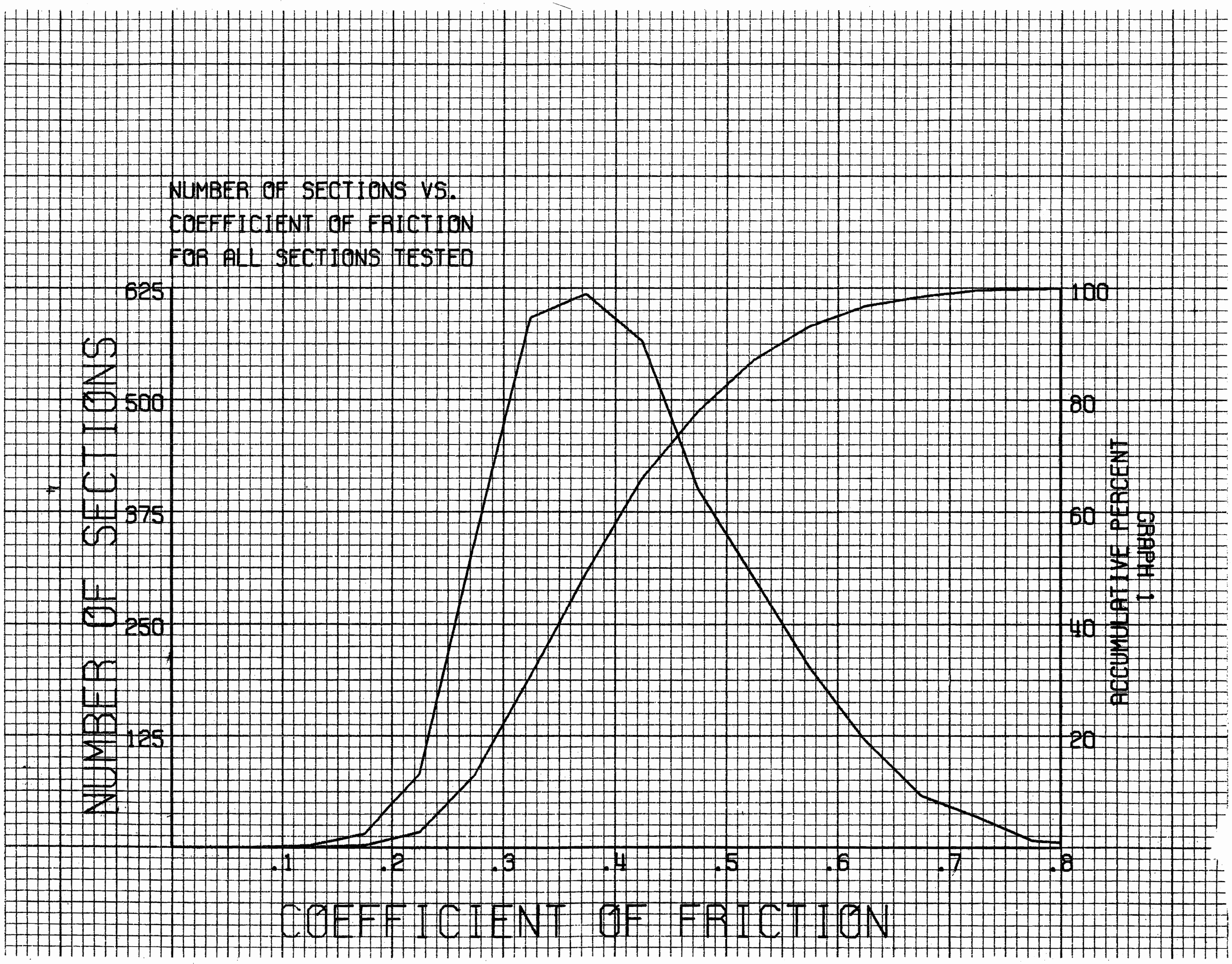

NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR ALL SECTIONS TESTED
GRAPH 1
ACCUMULATIVE PERCENT
100
80
60
40
20
625
500
375
250
125
NUMBER OF SECTIONS
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION

Table I

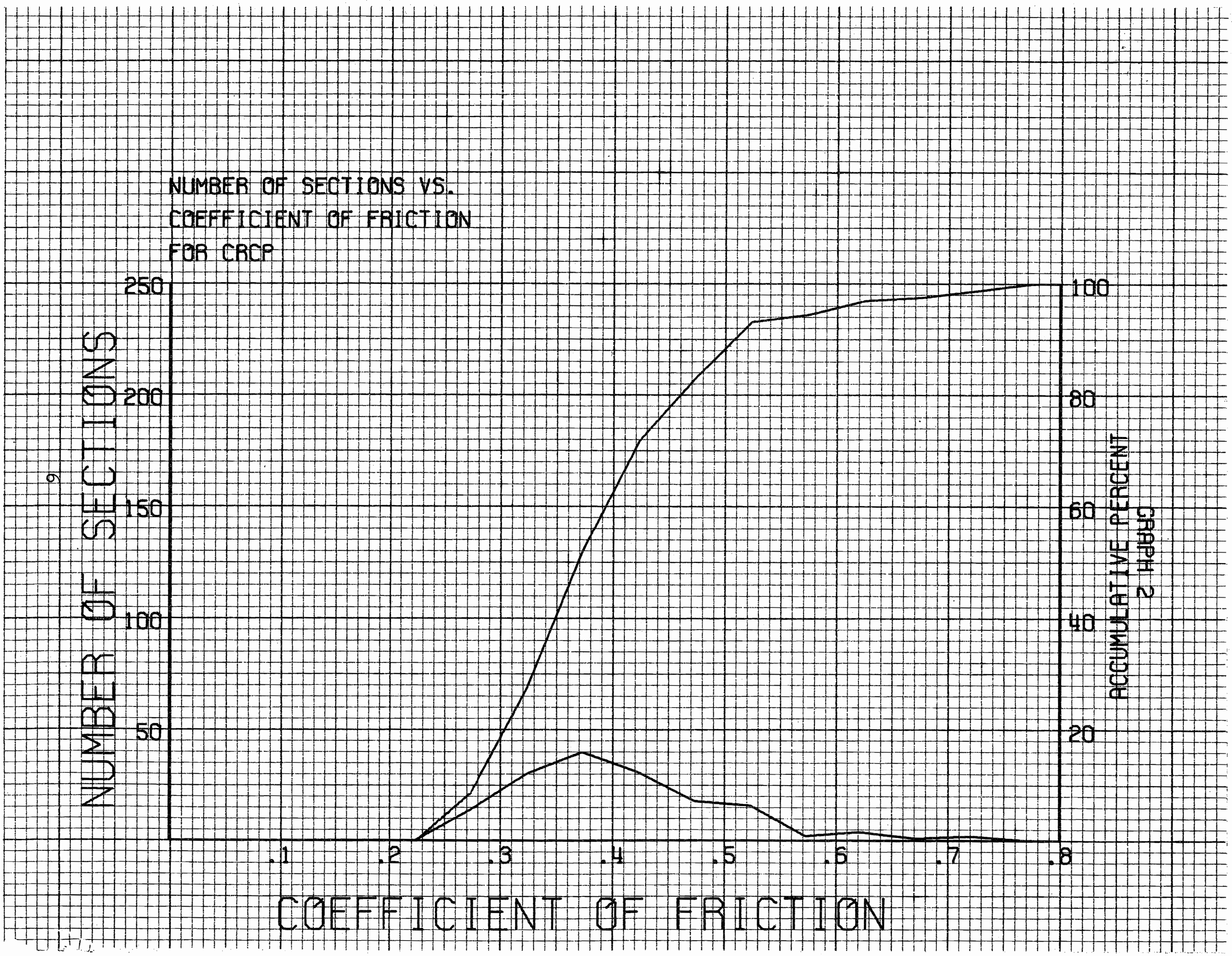
Summary Of General Information

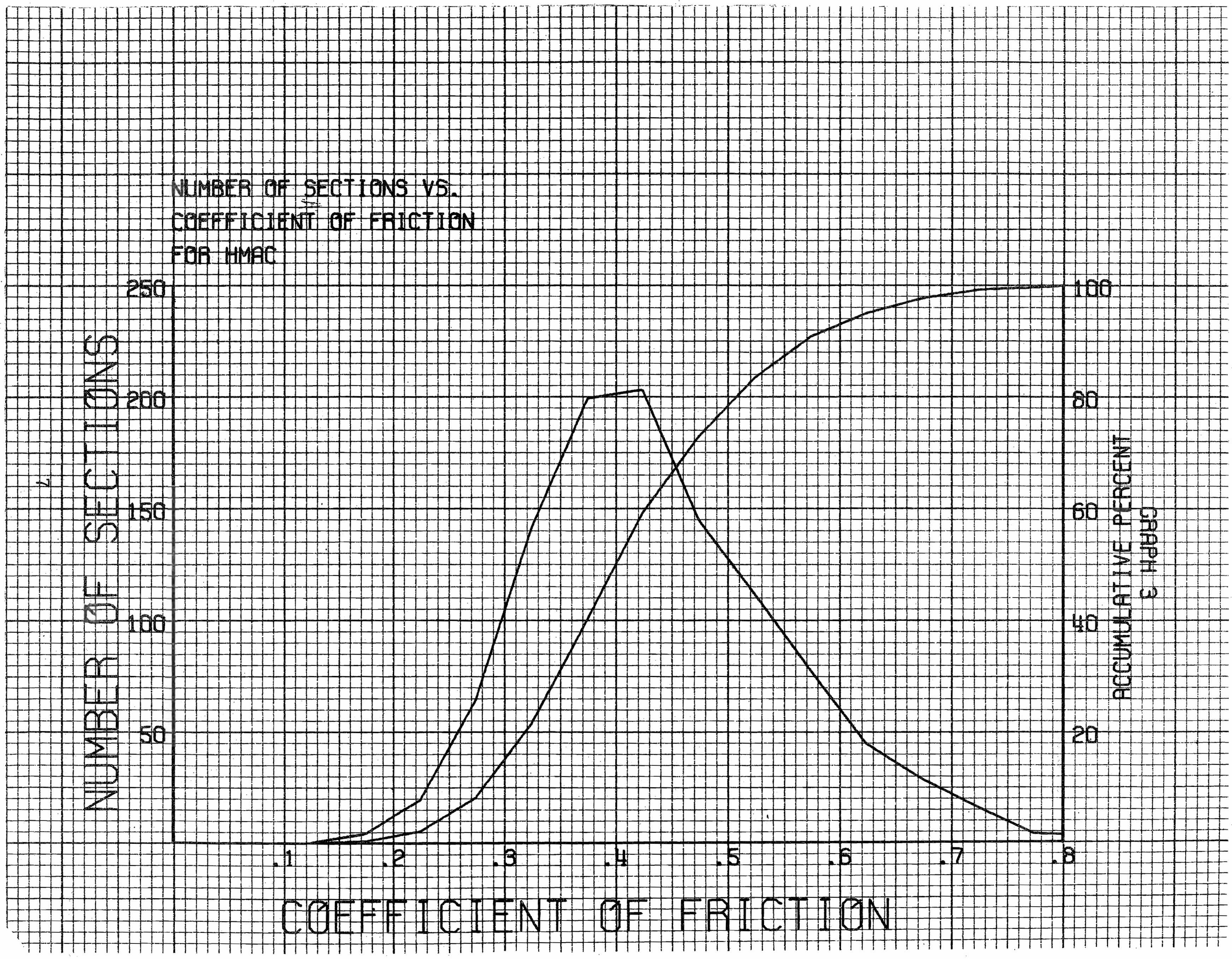
A Study - Number of Sections Tested vs. Coef. of Friction

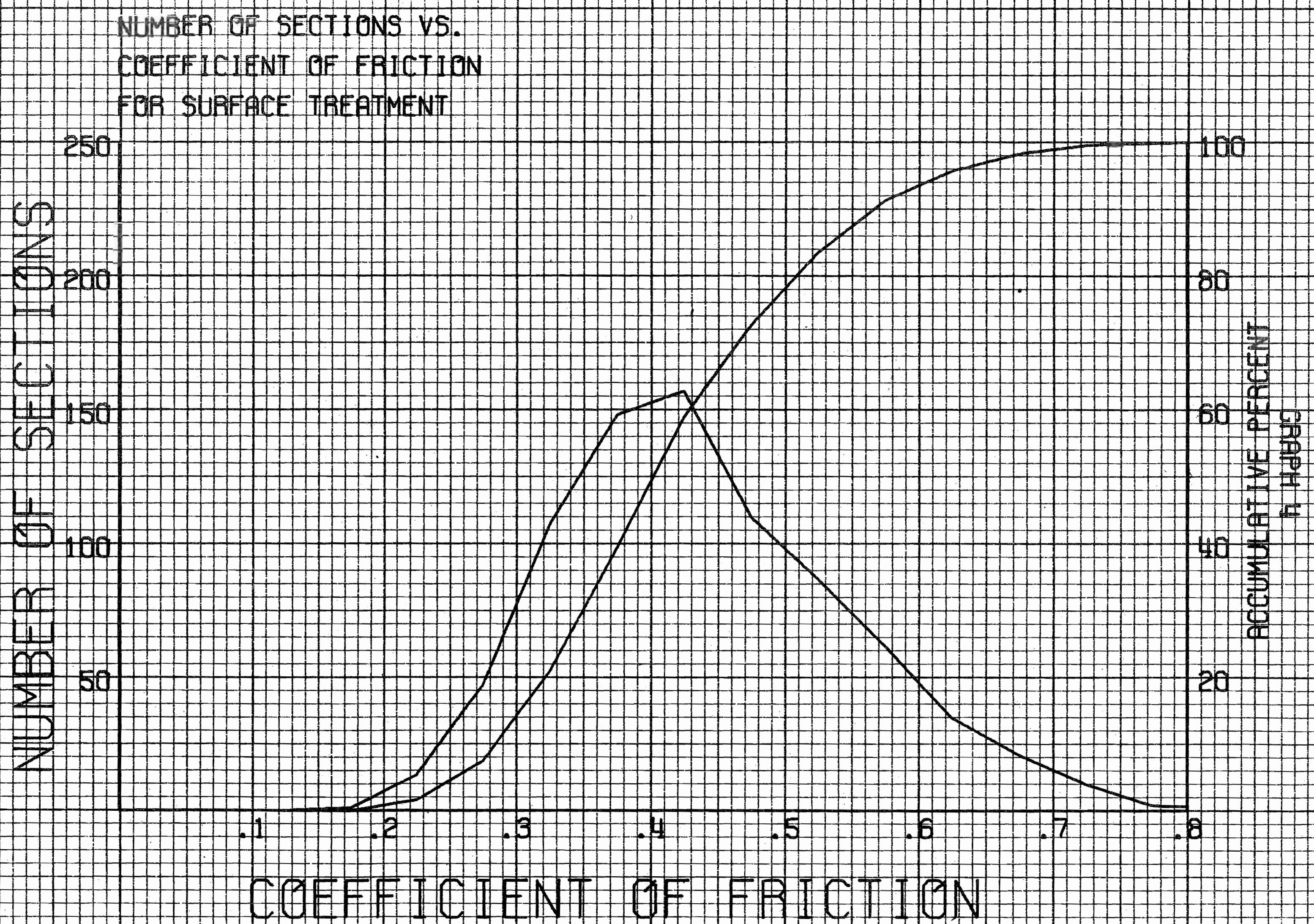
(Correlate To Graphs 1 Through 8)

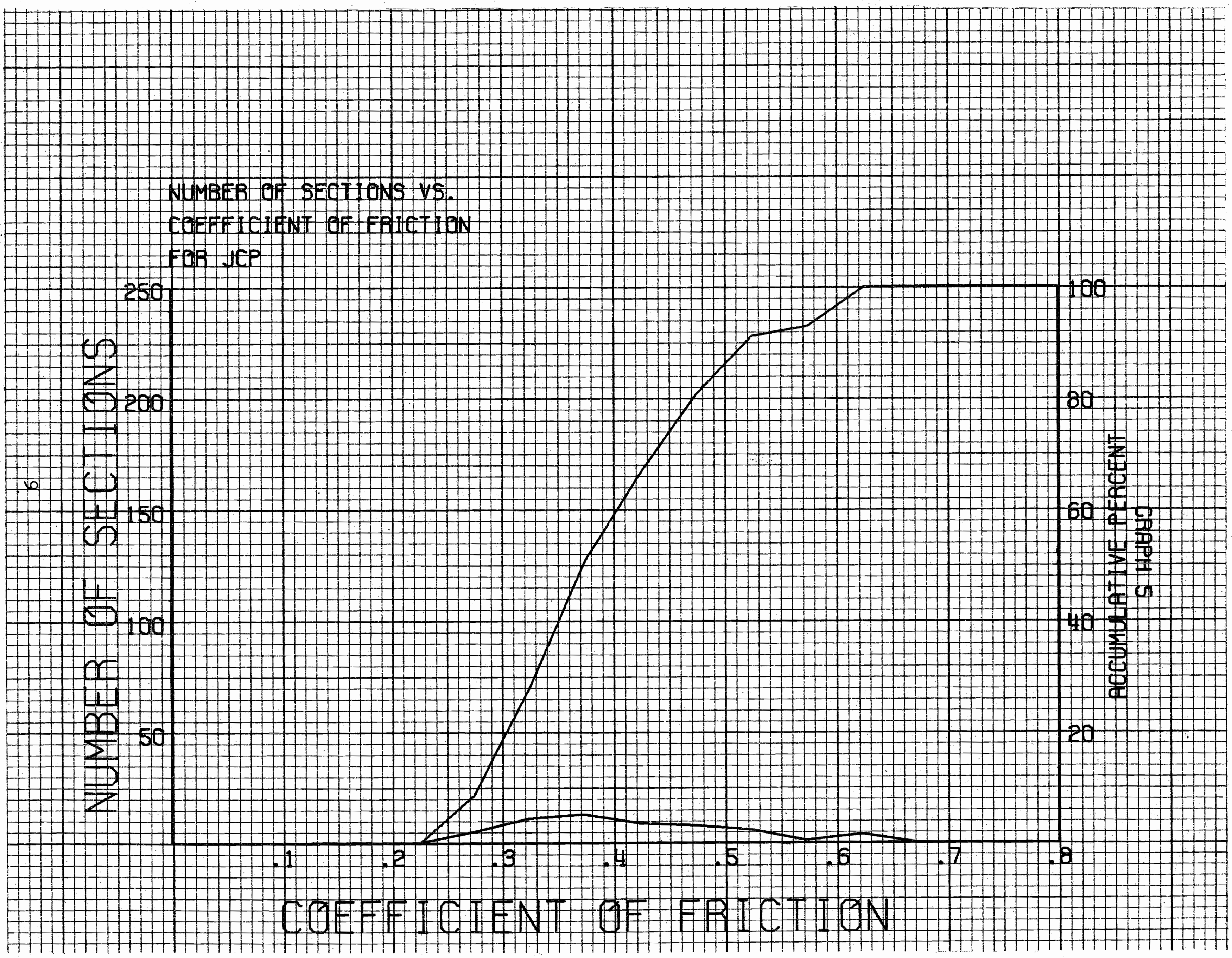
Pavement Type	No. Sec. Tested	Aver. Coef.	Range	Stan. Dev.
All Sections Tested	3357	0.41	.11-.83	0.11
CRCP	160	0.39	.19-.69	0.10
HMAC	1062	0.42	.15-.82	0.12
Surface Treatment	801	0.41	.11-.83	0.12
JCP	57	0.39	.21-.63	0.11
Slurry Seals	4	0.24	.23-.26	0.01
Cold Mix LMSTN RK Asph.	22	0.40	.19-.59	0.09

Hot Mix-Cold Laid A.C. - No Sections Tested

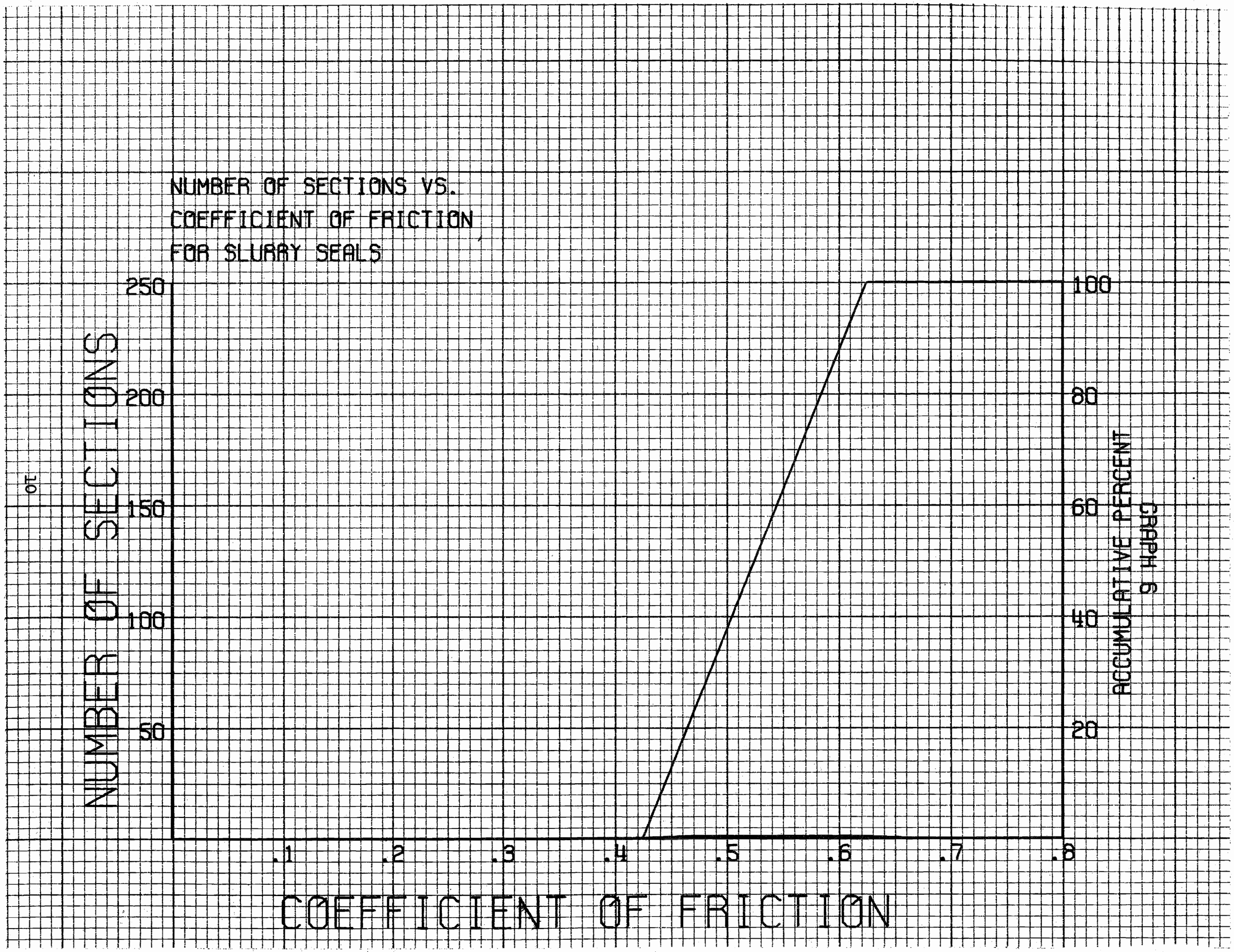

NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR CRCP
250
200
150
100
50
NUMBER OF SECTIONS
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION
100
80
60
40
20
ACCUMULATIVE PERCENT
GRAPH 2

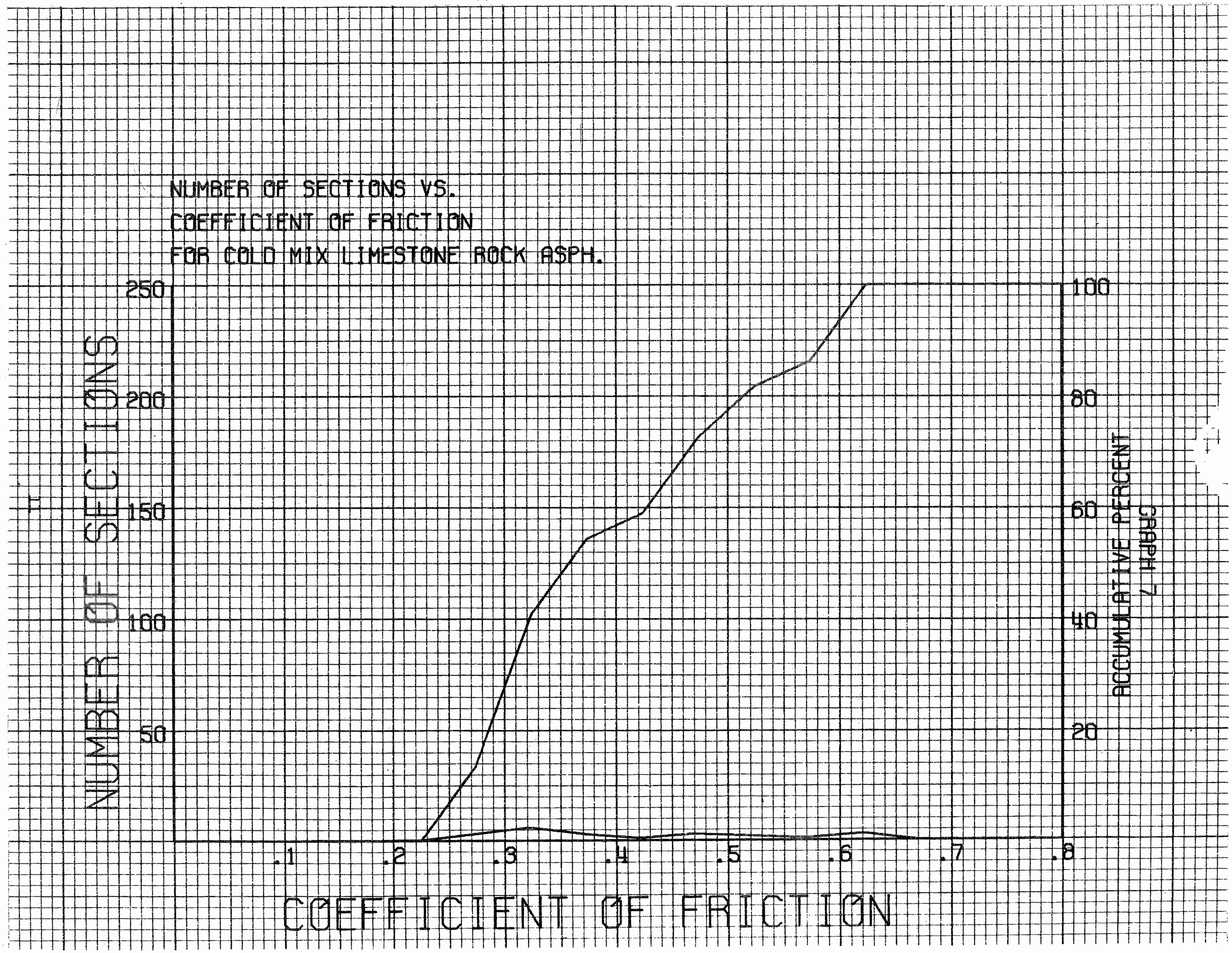

NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR HMAC
NUMBER OF SECTIONS
250
200
150
100
50
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION
100
80
60
40
20
ACCUMULATIVE PERCENT
GRAPH 3


NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR SURFACE TREATMENT
GRAPH 4
ACCUMULATIVE PERCENT
NUMBER OF SECTIONS
COEFFICIENT OF FRICTION
250
200
150
100
50
100
80
60
40
20
.1
.2
.3
.4
.5
.6
.7
.8



NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR JCP
GRAPH 5
ACCUMULATIVE PERCENT
NUMBER OF SECTIONS
COEFFICIENT OF FRICTION
250
200
150
100
50
100
80
60
40
20
.1
.2
.3
.4
.5
.6
.7
.8


NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR SLURRY SEALS
250
200
150
100
50
NUMBER OF SECTIONS
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION
100
80
60
40
20
ACCUMULATIVE PERCENT
GRAPH 6


NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
FOR COLD MIX LIMESTONE ROCK ASPH.
250
200
150
100
50
NUMBER OF SECTIONS
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION
100
80
60
40
20
ACCUMULATIVE PERCENT
GRAPH 7

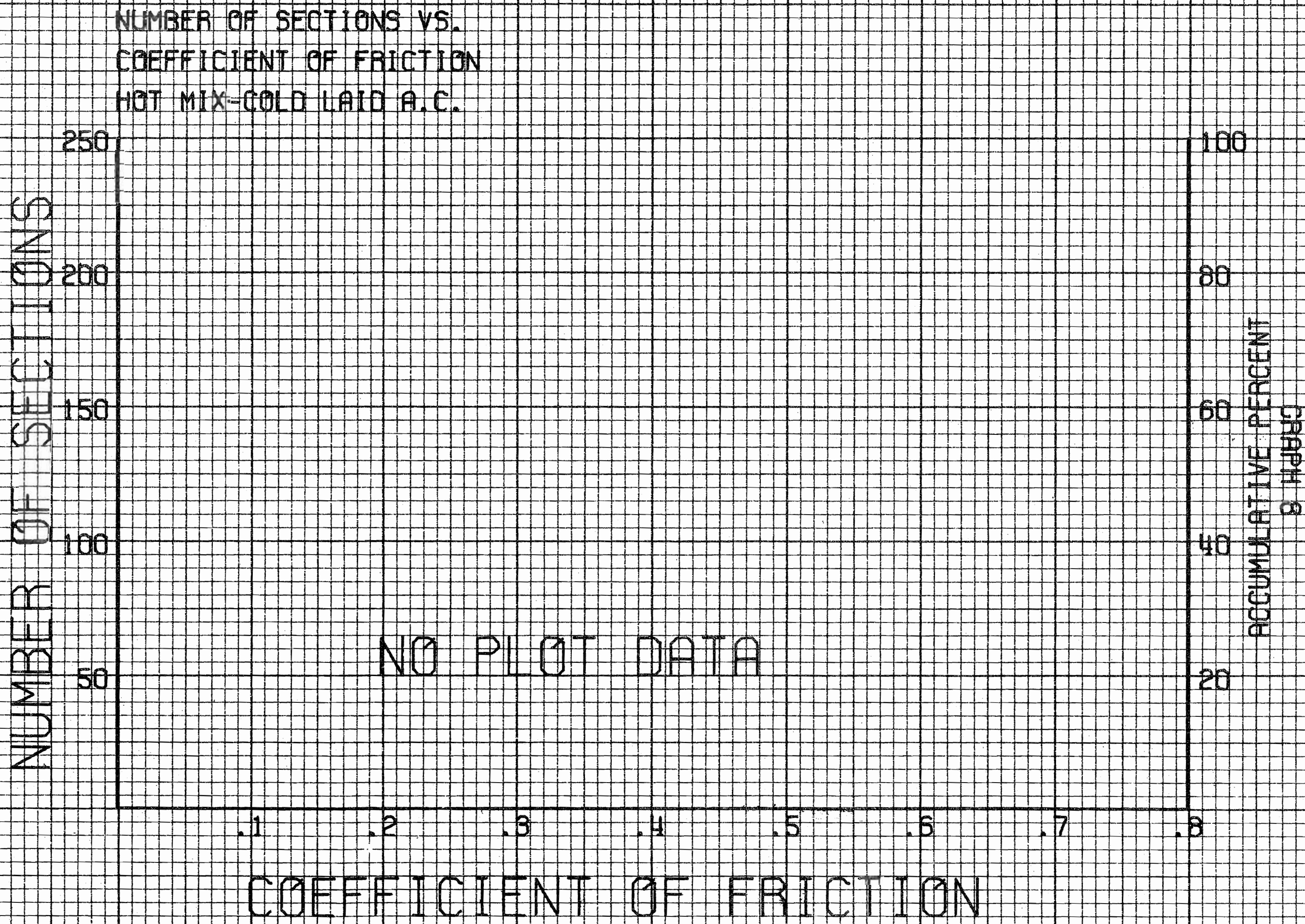

NUMBER OF SECTIONS VS.
COEFFICIENT OF FRICTION
HOT MIX-COLD LAID A.C.
GRAPH 8
NUMBER OF SECTIONS
250
200
150
100
50
ACCUMULATIVE PERCENT
100
80
60
40
20
NO PLOT DATA
.1
.2
.3
.4
.5
.6
.7
.8
COEFFICIENT OF FRICTION

Table II

Summary Of General Information

Study Of Aggregate Material Types

Material Types	HMAC				Surface Treatment			
	No. Tested	Aver. Coef.	Range	Stan. Dev.	No. Tested	Aver. Coef.	Range	Stan. Dev.
All Sections	1062	0.42	.15-.82	0.12	801	0.41	.11-.83	0.12
Silicious	71	0.40	.24-.77	0.13	241	0.37	.18-.61	0.06
Limestone	300	0.44	.22-.74	0.13	174	0.41	.19-.68	0.11
Lightweight	82	0.54	.27-.82	0.11	73	0.51	.30-.73	0.11
Slag	188	0.46	.20-.68	0.10	63	0.58	.28-.83	0.12
Trap Rock	17	0.39	.28-.68	0.13	3	0.37	.33-.42	****
Rock Asphalt	3	0.66	.63-.68	****	84	0.34	.11-.59	0.09
Shell	1	0.37	.37-.37	****	None			
Rock Asph-Shell	None							

PAVEMENT SURFACE WEAR

The following plots obtained from the information completed by the Districts are an attempt to study the relationship of pavement surfacing materials and skid resistance. The information used in these plots was taken from the code sheets completed by the Districts.

The total traffic has been determined by multiplying the number of days between placement and testing by the ADT. This is not an exact method for determining total traffic application, but other methods require a much more complicated calculation. It is believed that this method of calculation is sufficient to reveal the wear (polish) characteristics of roadway surface materials and to compare these materials.

Continuously Reinforced Concrete

Graph 9 is a plot of coefficient of friction vs total traffic for continuously reinforced concrete pavement. Twenty eight sections (28) are shown on this graph. The other CRCP sections tested are not shown because insufficient information about those sections was received from the Districts, ie; code sheet only partially completed. This plot shows very considerable data scatter at any traffic location, therefore no wear characteristic trend can be developed.

Jointed Concrete Pavement

Very little traffic data was available from the information received from the districts. Graph 10 shows 11 sections lie on the total traffic scale with more than three points off scale (greater than 24 million traffic). This plot shows what is believed to be a slight decrease in friction with cumulative traffic applications.

Hot Mix Asphaltic Concrete

Graph 11 is a plot of all material types used in the HMAC sections tested. Graphs 12 through 19 are wear plots of several coarse materials used in HMAC. As indicated by Graph 11, these graphs show widely scattered data points but also show a definite influence of the coarse aggregate on the coefficient of friction.

The only apparent trend shown on these graphs is that silicious aggregates are generally lower in friction, at any traffic, than other materials. Limestone is again surprisingly high considering the large amount of traffic applications on several sections. As shown on Graph 13 the coefficient of friction of limestone surfaces can be as low as those with silicious materials or as high as those with lightweight materials in their surfaces.

Surface Treatment

Graph 20 is a general plot for all surface treatment sections tested. Graphs 21 through 26 are plots which study the coarse aggregate material types.

Again a wide data scatter is found. The wear rate for all coarse aggregate material types used in surface treatments is approximately the same. These graphs again indicate that silicious coarse aggregates used in surface treatments are generally lower in coefficient of friction than most other materials used. As shown in graph 22 limestone coarse aggregates can be lower than silicious materials or higher than surface treatments using slag. Graph 23 indicates that the coefficient of friction of lightweight surface treatments is generally higher than all other surface materials especially at higher total traffics.

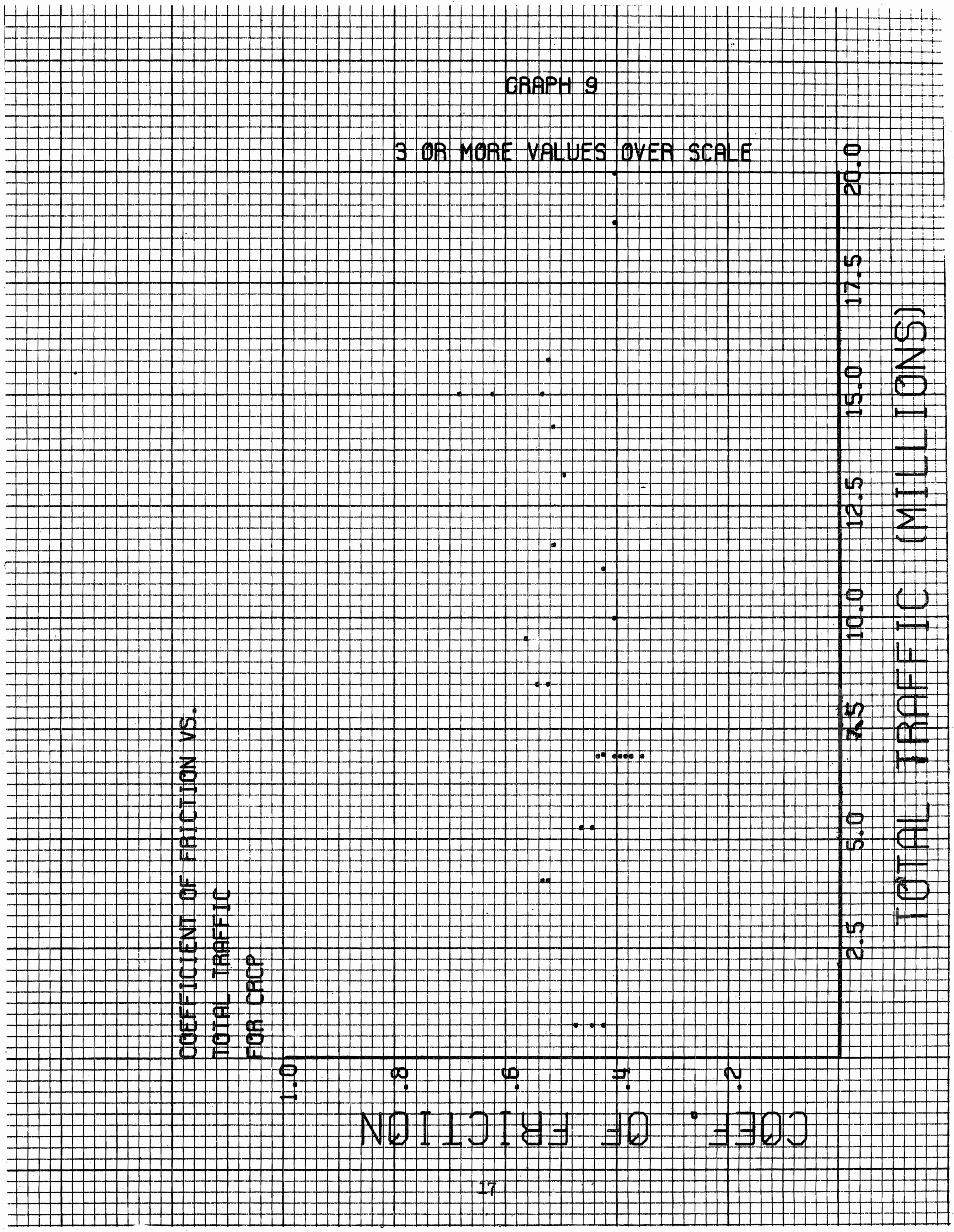
Graph 25 is a plot of coefficient of friction vs total traffic for surface treatments using trap rock as the coarse aggregate. Only three points are shown due to incomplete inforamtion reported from the Districts.

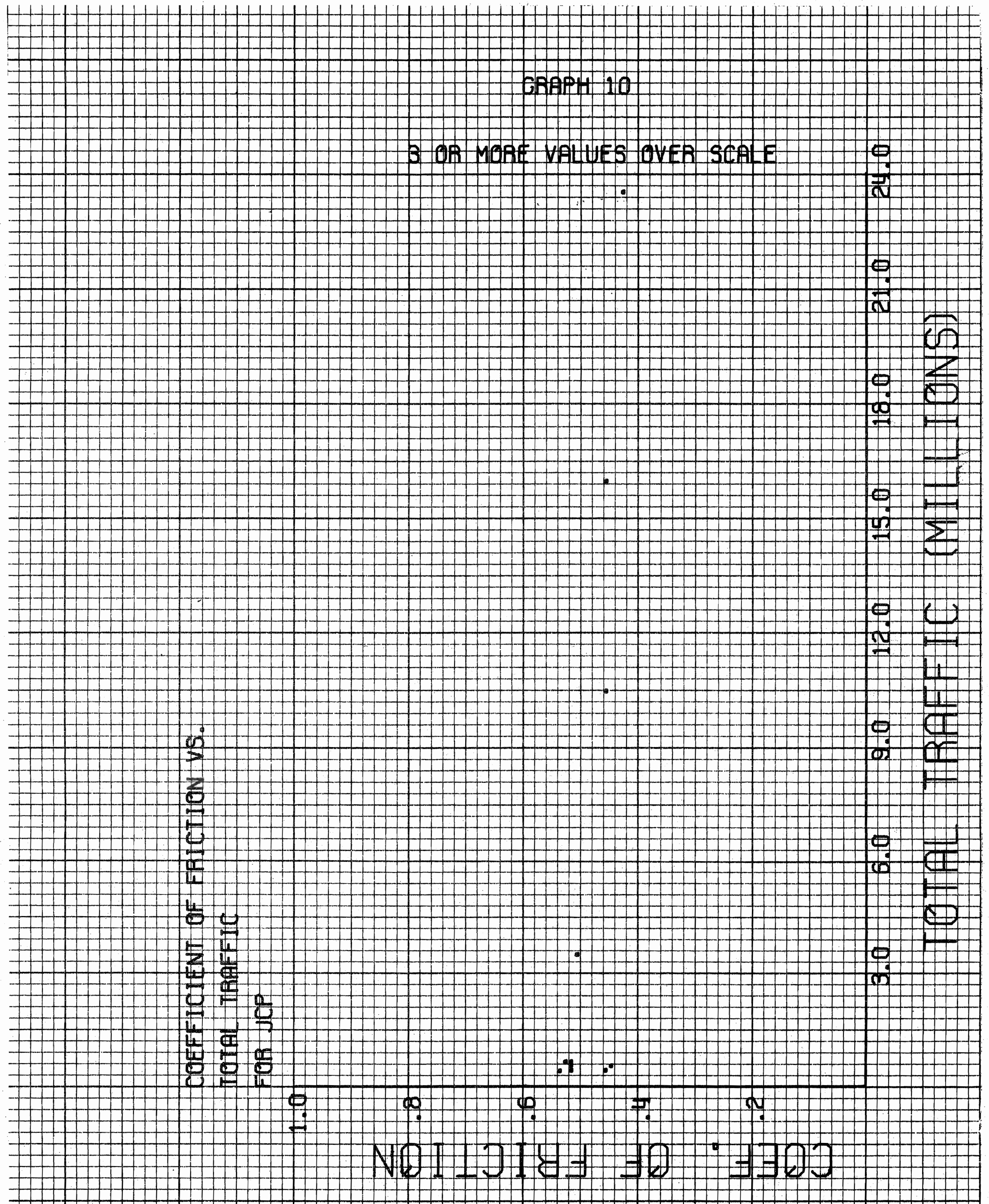
Slurry Seals

Again due to incomplete reporting of sections tested, no points appear on this graph, Graph 27.

Cold-Laid Limestone Rock Asphalt

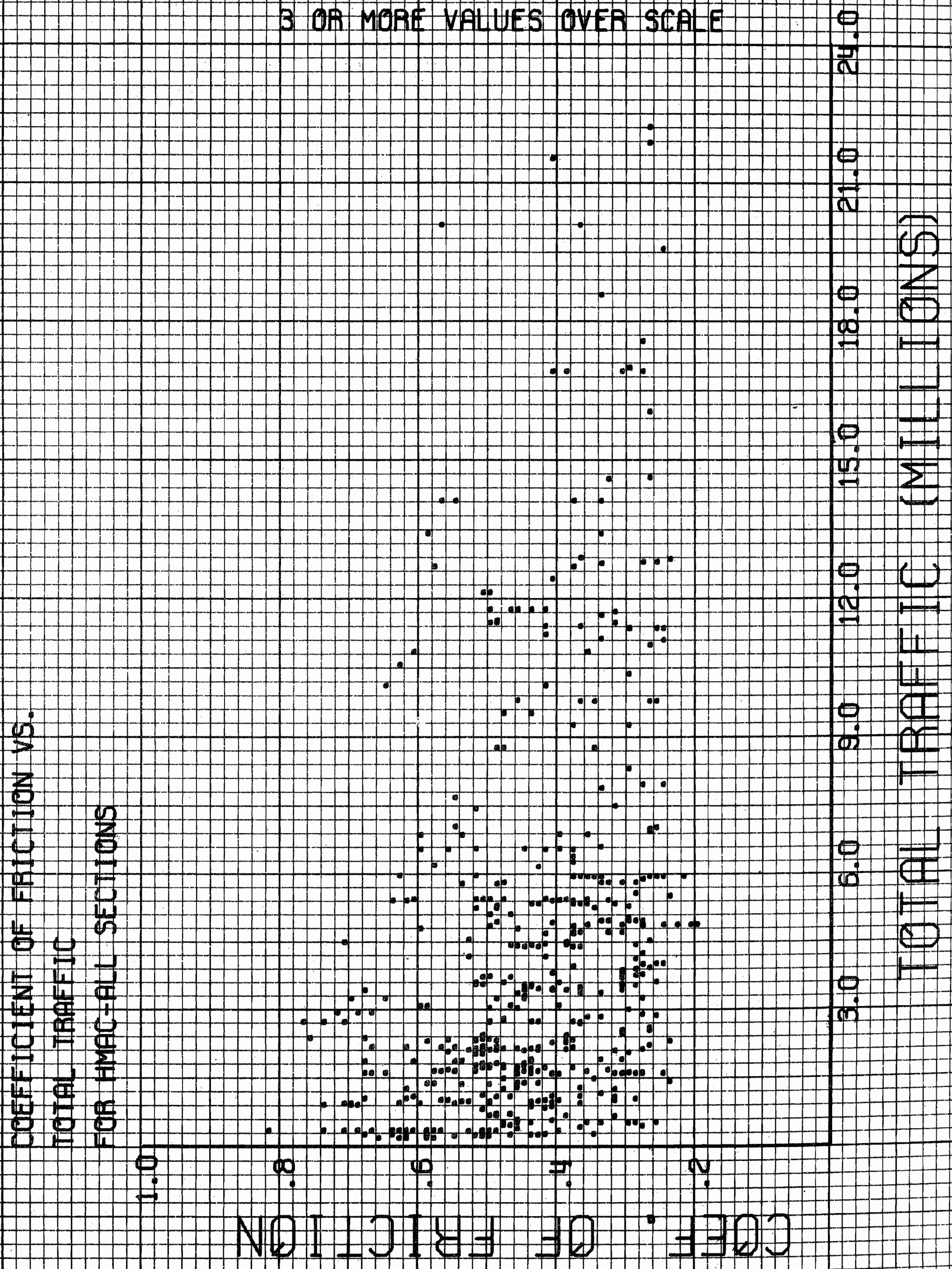
The small number of data points in Graph 28 make any type of analysis impossible. Therefore because of these few points no trend is developed for this pavement surface.


GRAPH 9
3 OR MORE VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR CRCP
TOTAL TRAFFIC (MILLIONS)
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
COEF. OF FRICTION
1.0
.8
.6
.4
.2


GRAPH 10
3 OR MORE VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR JCP
TOTAL TRAFFIC (MILLIONS)
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
COEF. OF FRICTION
1.0
.8
.6
.4
.2

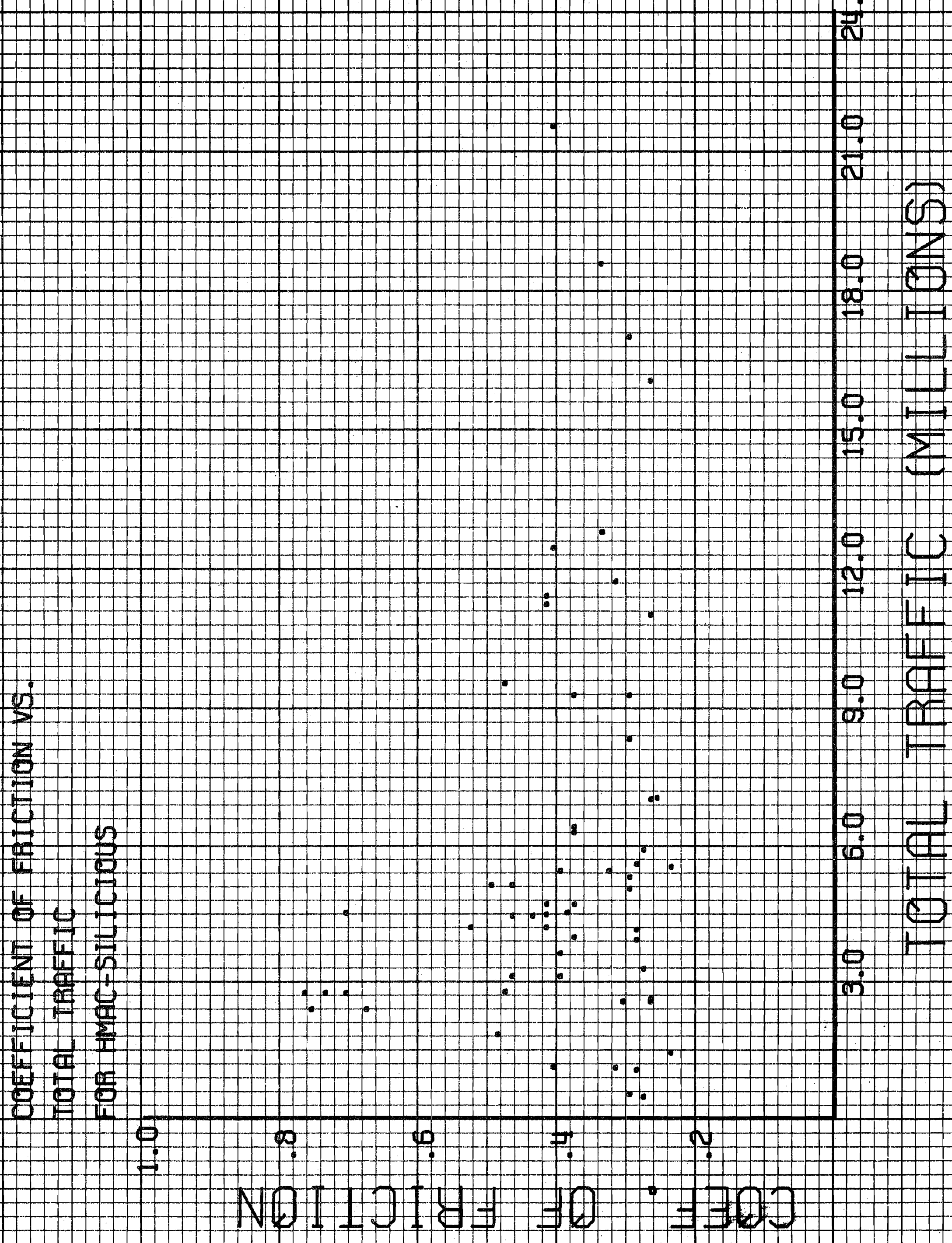
GRAPH 11

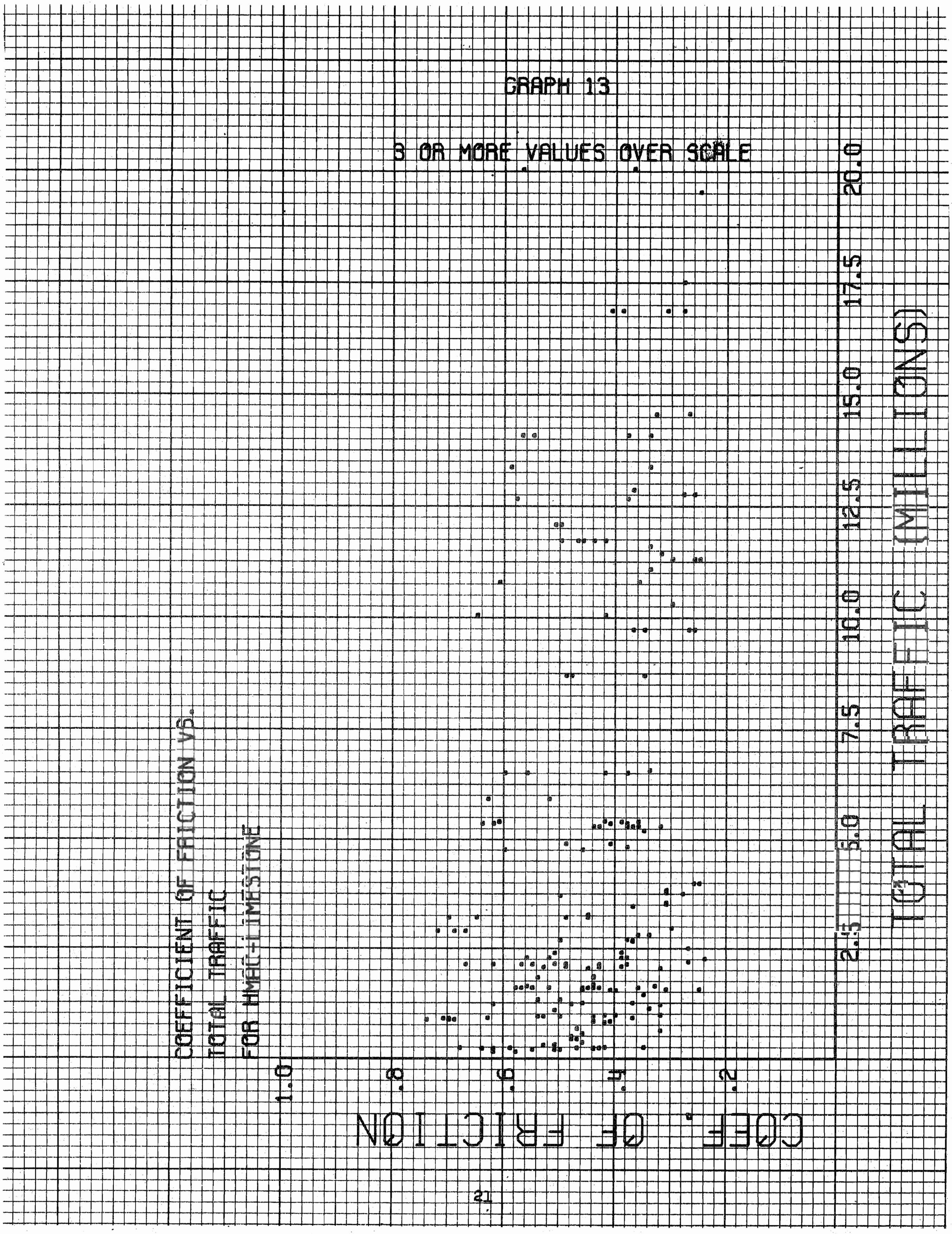
3 OR MORE VALUES OVER SCALE

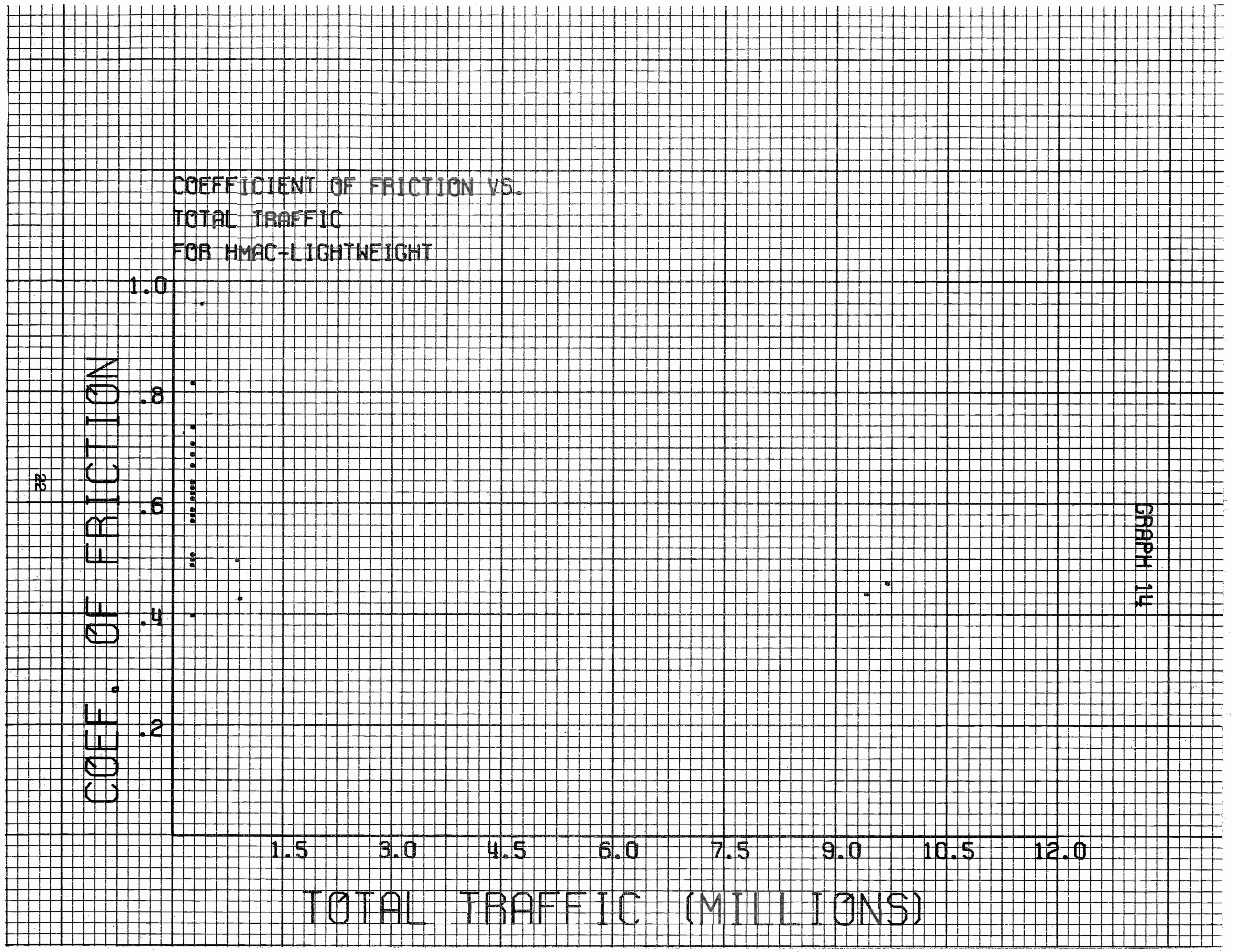


GRAPH 12

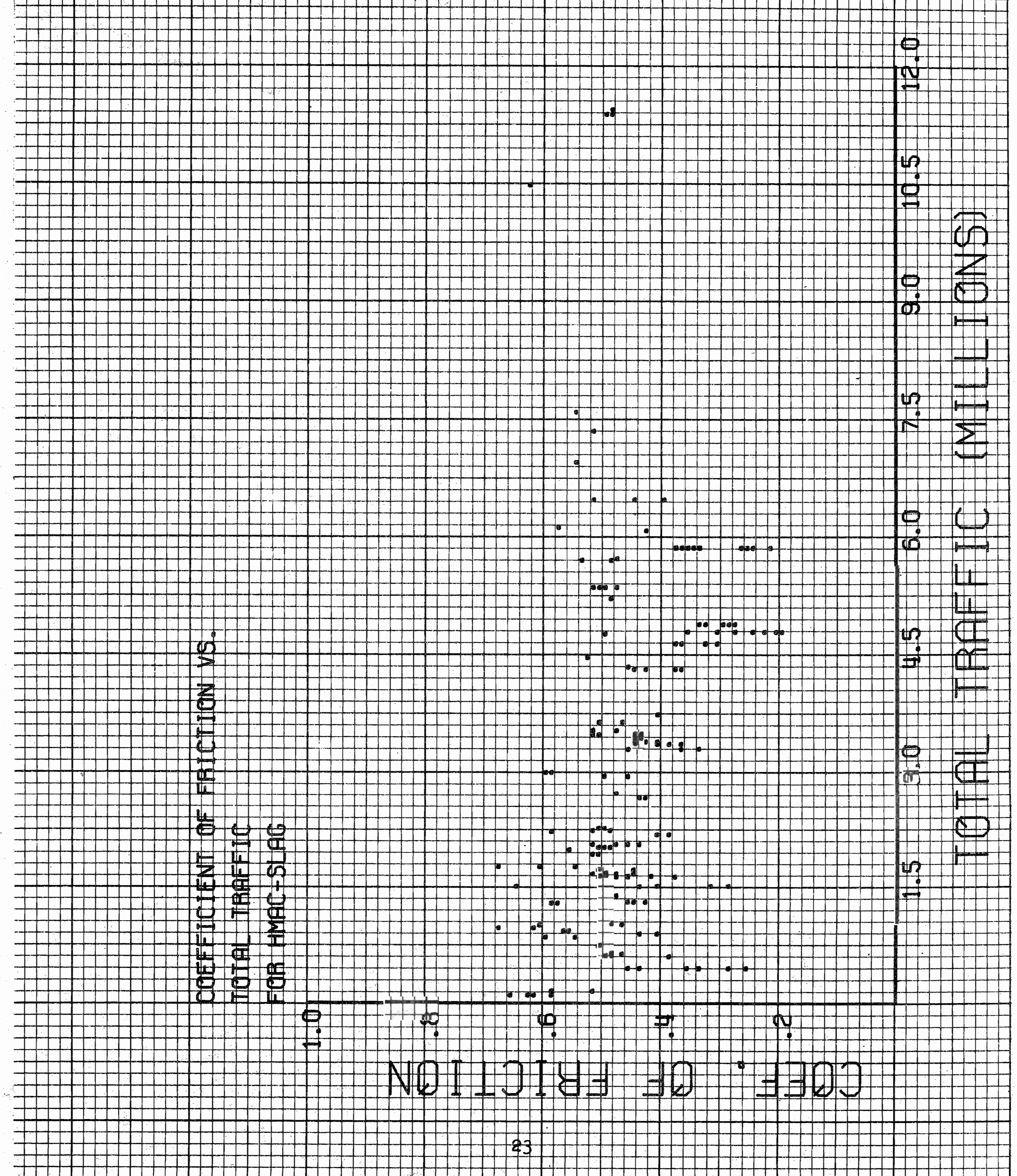
TWO VALUES OVER SCALE

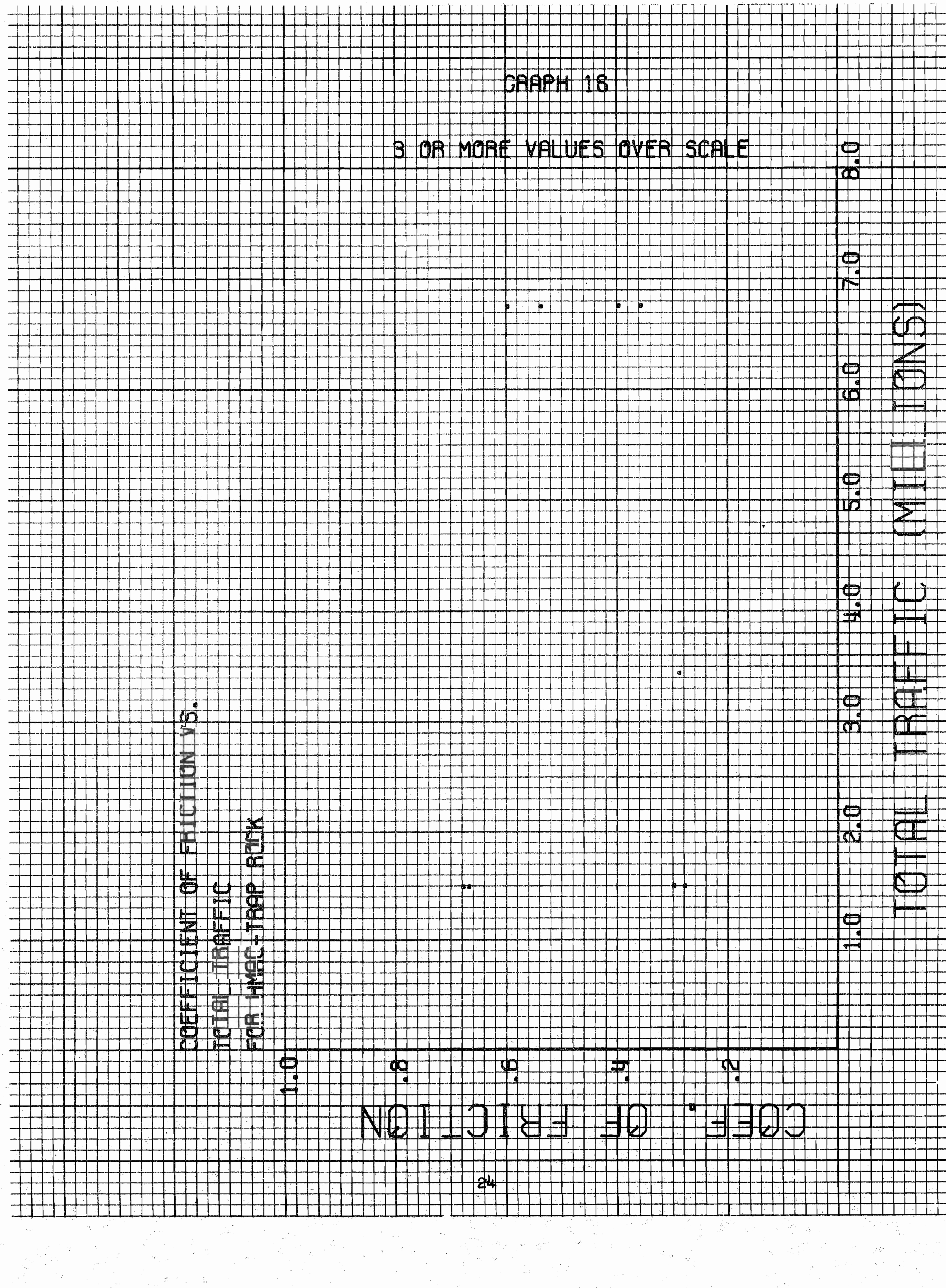



GRAPH 13
3 OR MORE VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-LIMESTONE
1.0
.8
.6
.4
.2
COEF. OF FRICTION
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
TOTAL TRAFFIC (MILLIONS)


GRAPH 14
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-LIGHTWEIGHT
COEF. OF FRICTION
1.0
.8
.6
.4
.2
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
TOTAL TRAFFIC (MILLIONS)

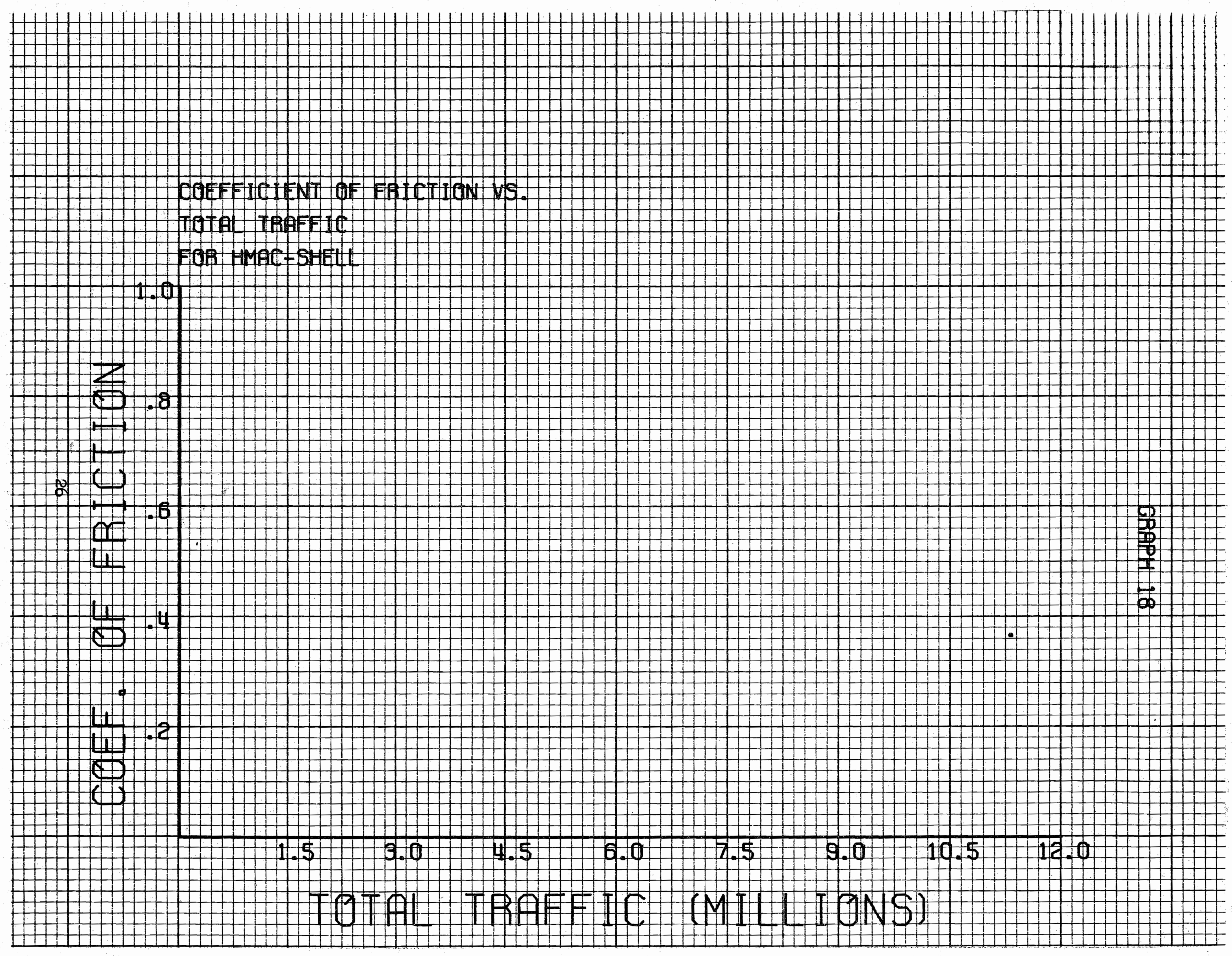
GRAPH 15

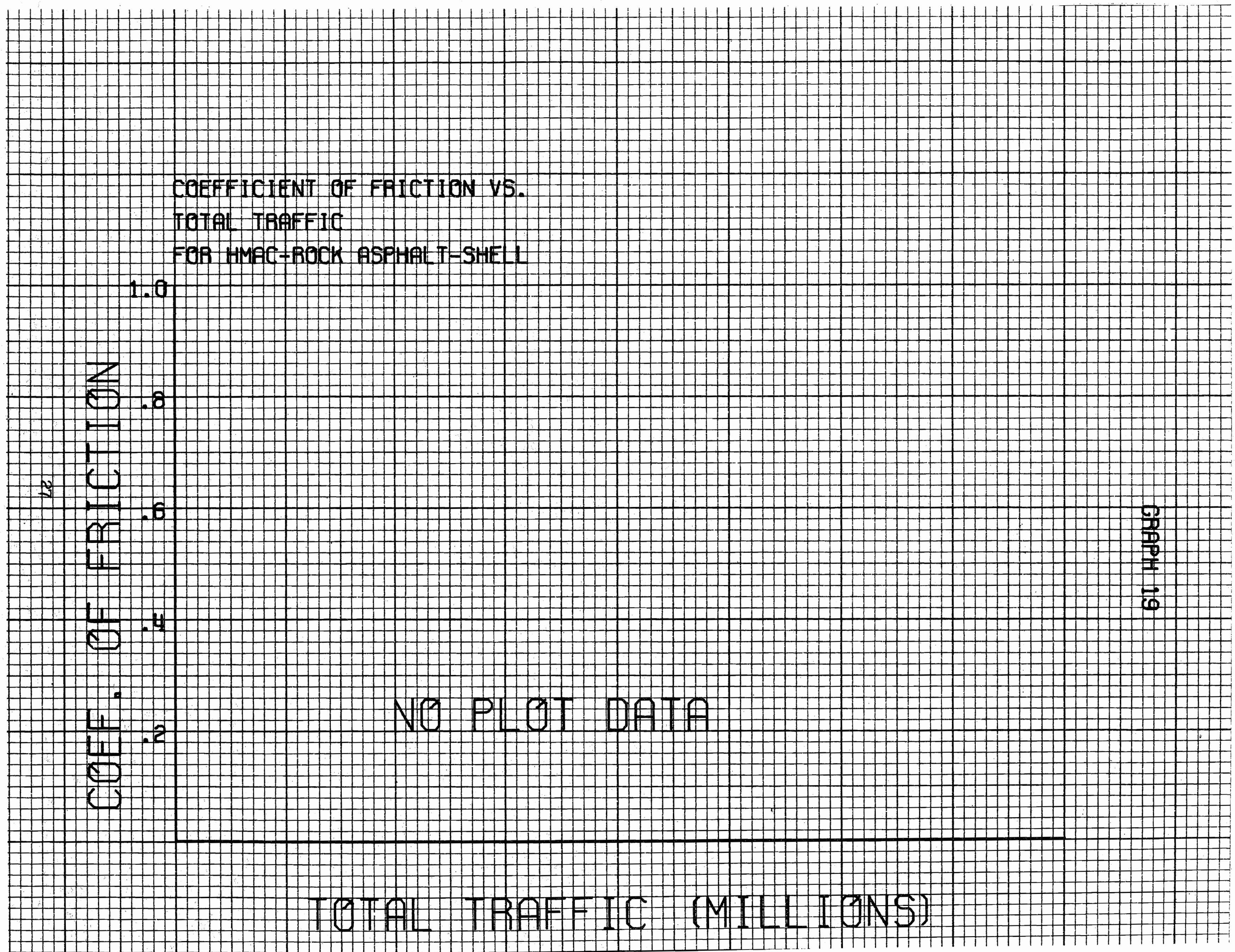

COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-SLAG
TOTAL TRAFFIC (MILLIONS)
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
COEF. OF FRICTION
1.0
.8
.6
.4
.2

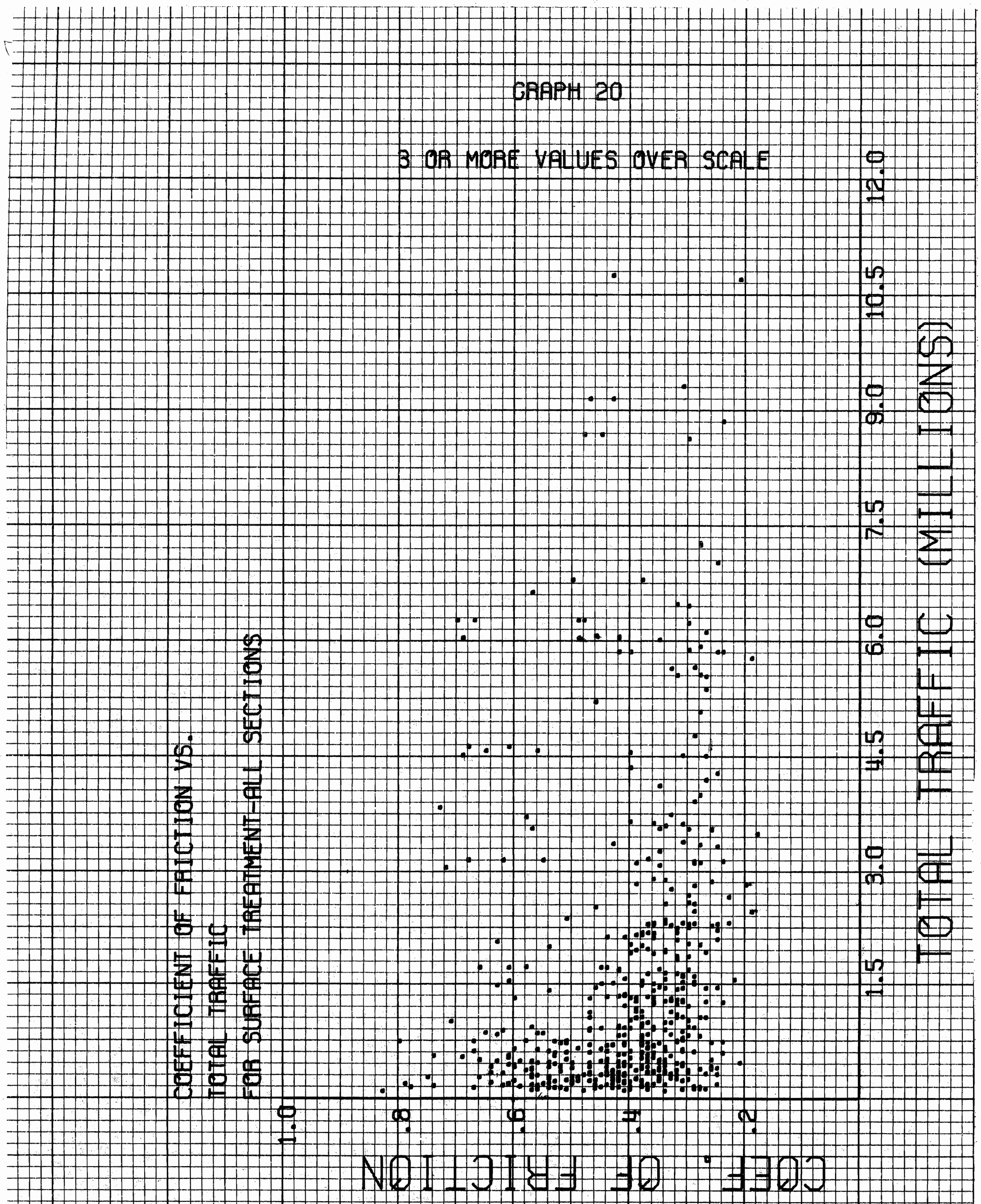

GRAPH 16
3 OR MORE VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-TRAP ROCK
1.0
.8
.6
.4
.2
COEF. OF FRICTION
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
TOTAL TRAFFIC (MILLIONS)

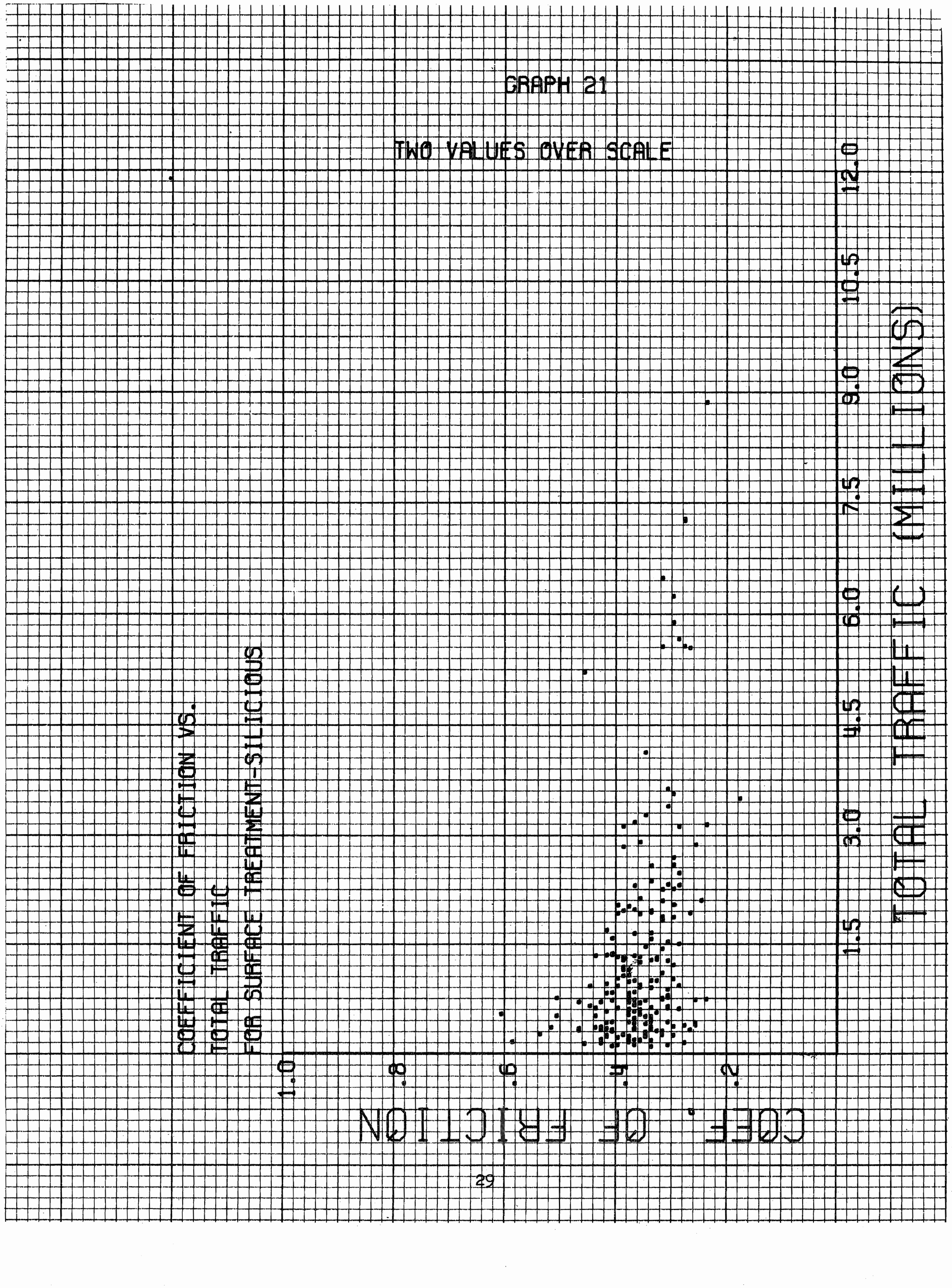
GRAPH 17

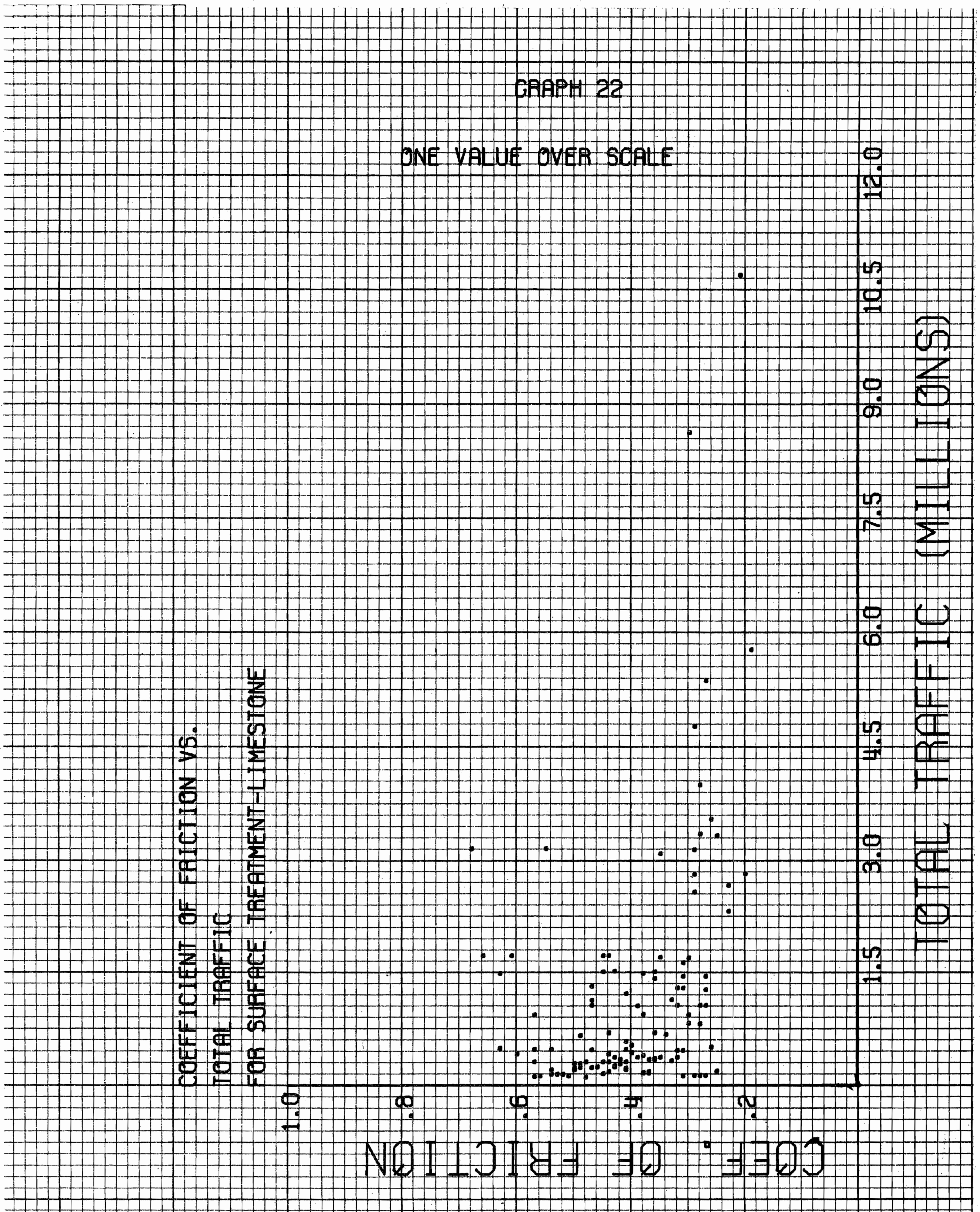
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-ROCK ASPHALT
1.0
.8
.6
.4
.2
COEF. OF FRICTION
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TOTAL TRAFFIC (MILLIONS)

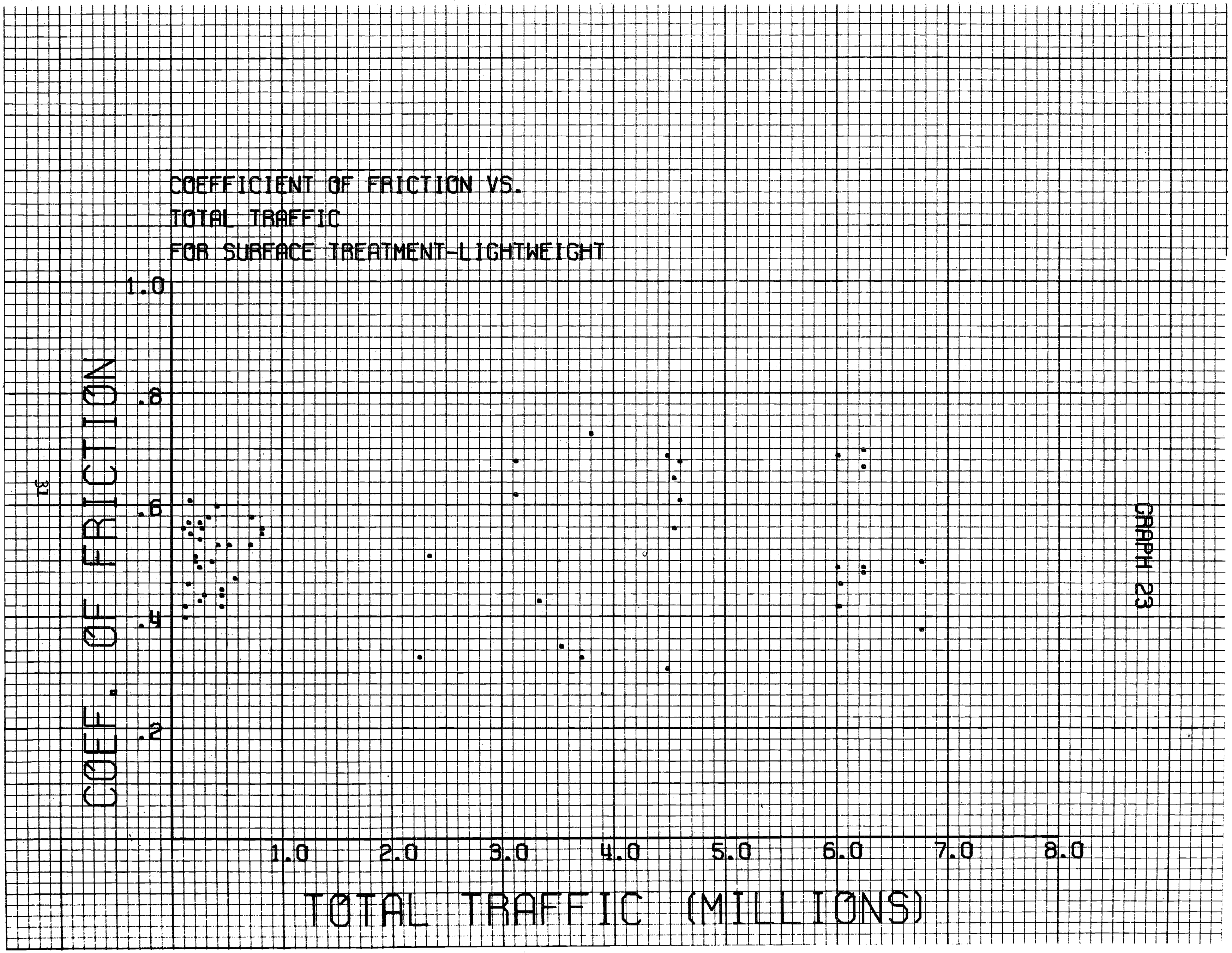

GRAPH 18
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-SHELL
1.0
.8
.6
.4
.2
COEF. OF FRICTION
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
TOTAL TRAFFIC (MILLIONS)


GRAPH 19
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR HMAC-ROCK ASPHALT-SHELL
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
TOTAL TRAFFIC (MILLIONS)

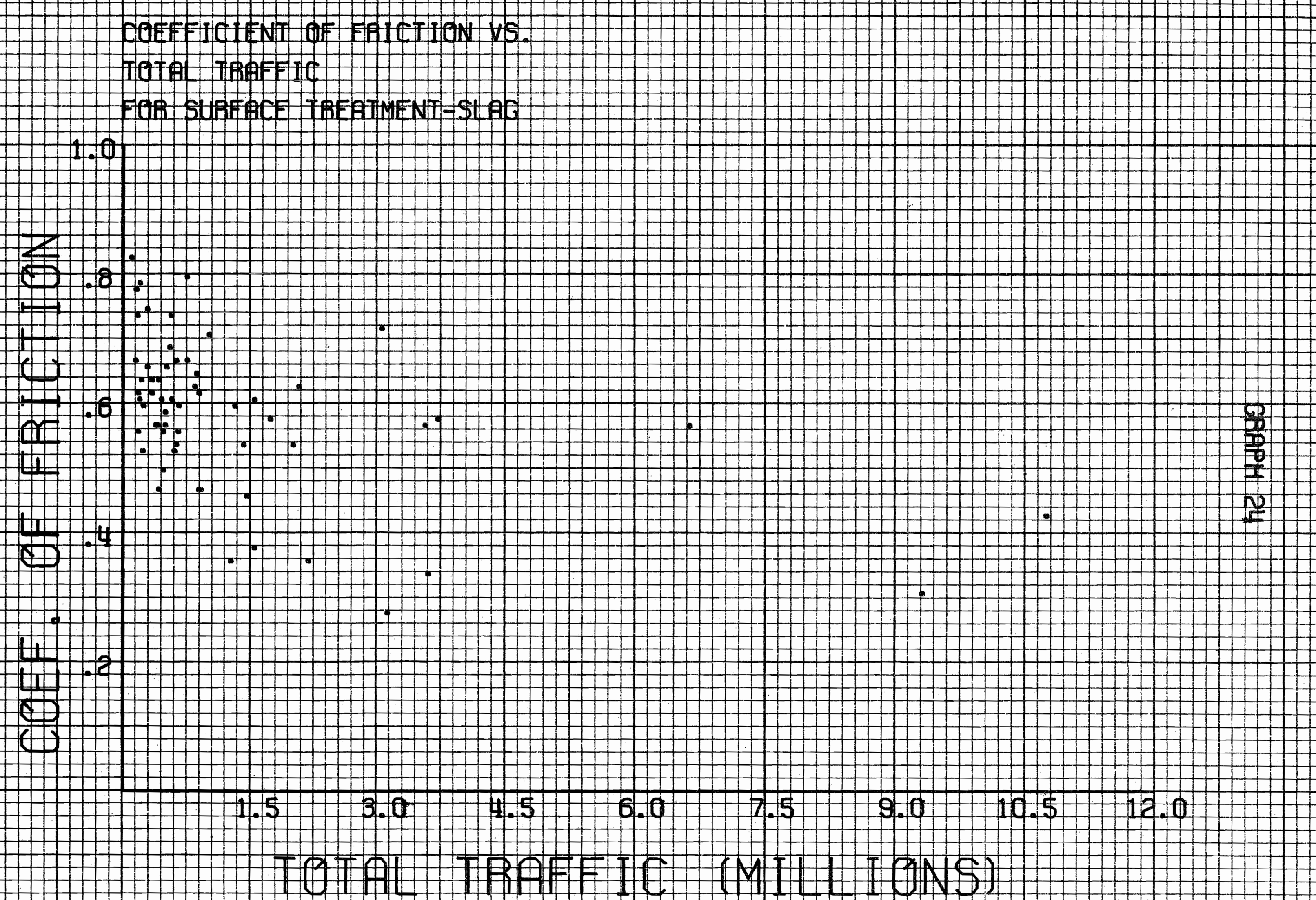

GRAPH 20
3 OR MORE VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-ALL SECTIONS
TOTAL TRAFFIC (MILLIONS)
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
COEF. OF FRICTION
1.0
.8
.6
.4
.2

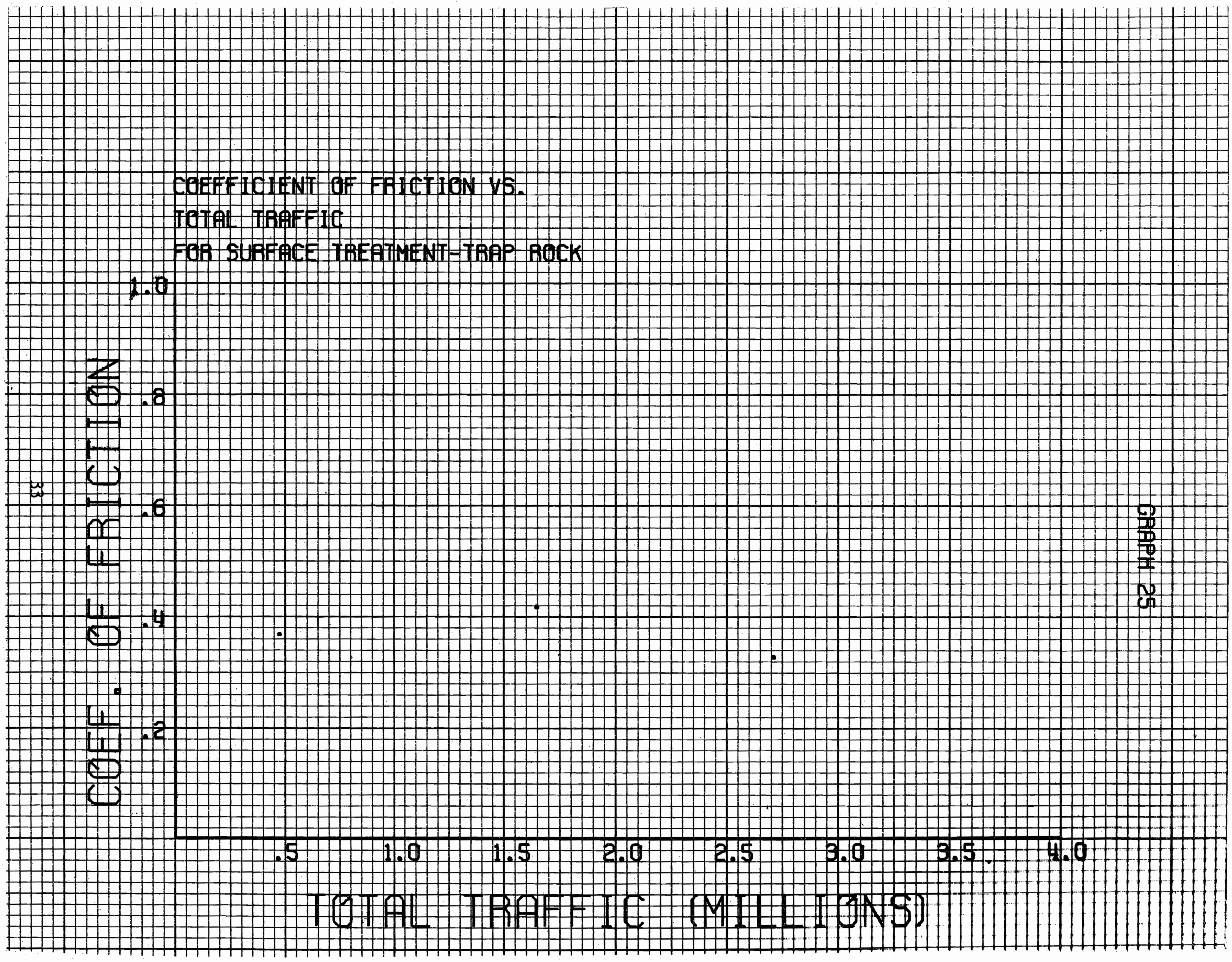

GRAPH 21
TWO VALUES OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-SILICIOUS
1.0
.8
.6
.4
.2
COEF. OF FRICTION
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
TOTAL TRAFFIC (MILLIONS)


GRAPH 22
ONE VALUE OVER SCALE
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-LIMESTONE
TOTAL TRAFFIC (MILLIONS)
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
COEF. OF FRICTION
1.0
.8
.6
.4
.2

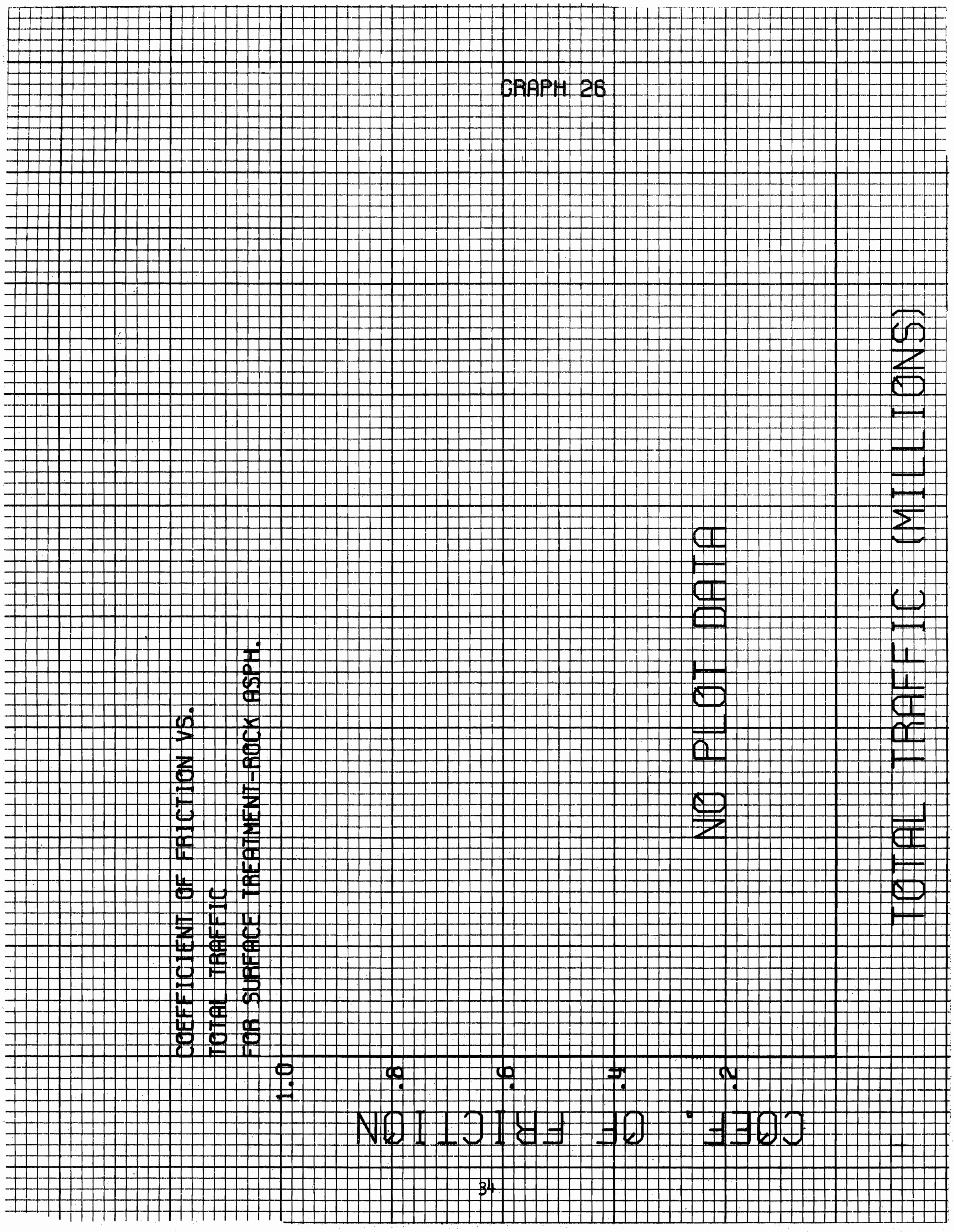

GRAPH 23
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-LIGHTWEIGHT
COEF. OF FRICTION
1.0
.8
.6
.4
.2
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
TOTAL TRAFFIC (MILLIONS)

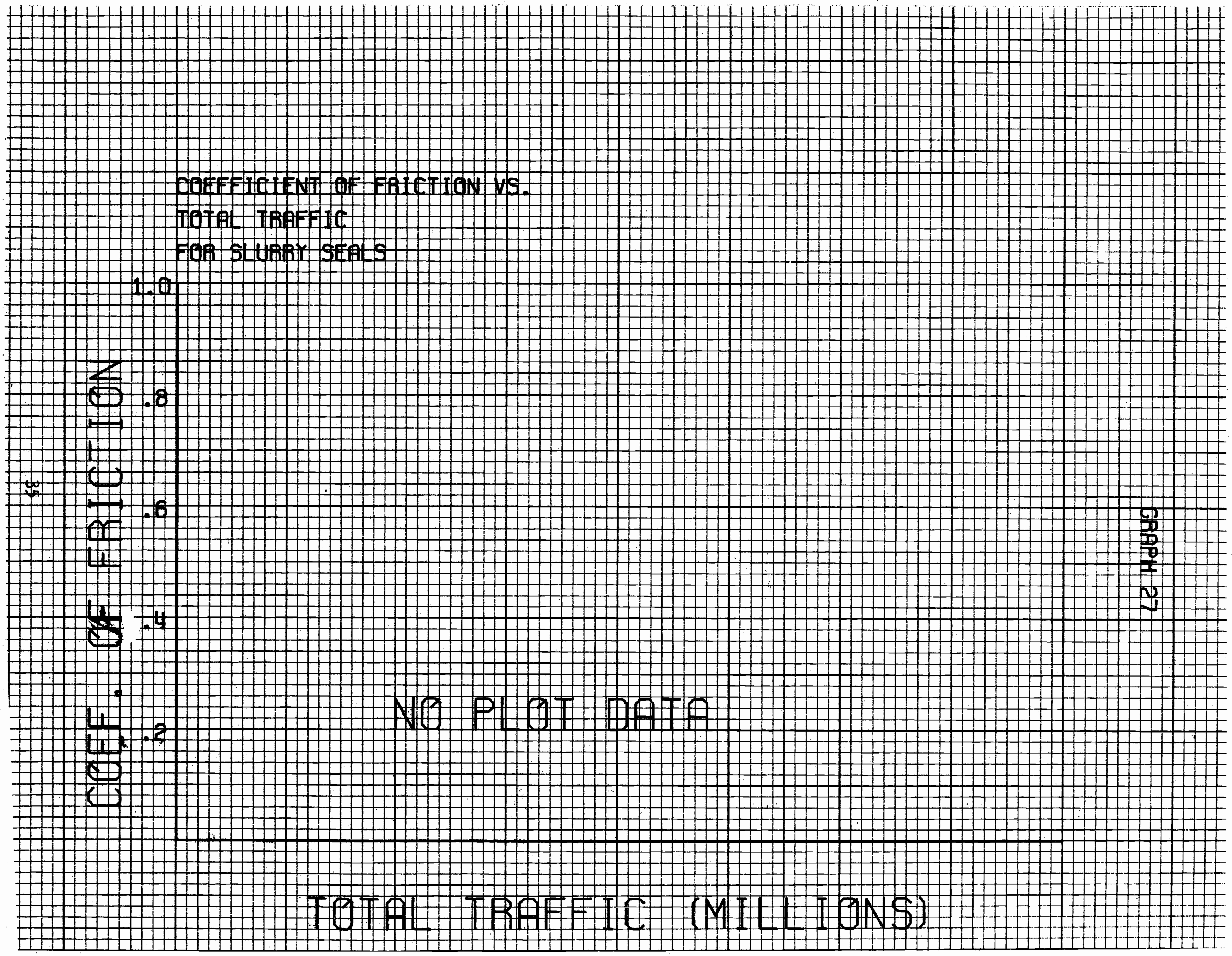
GRAPH 24

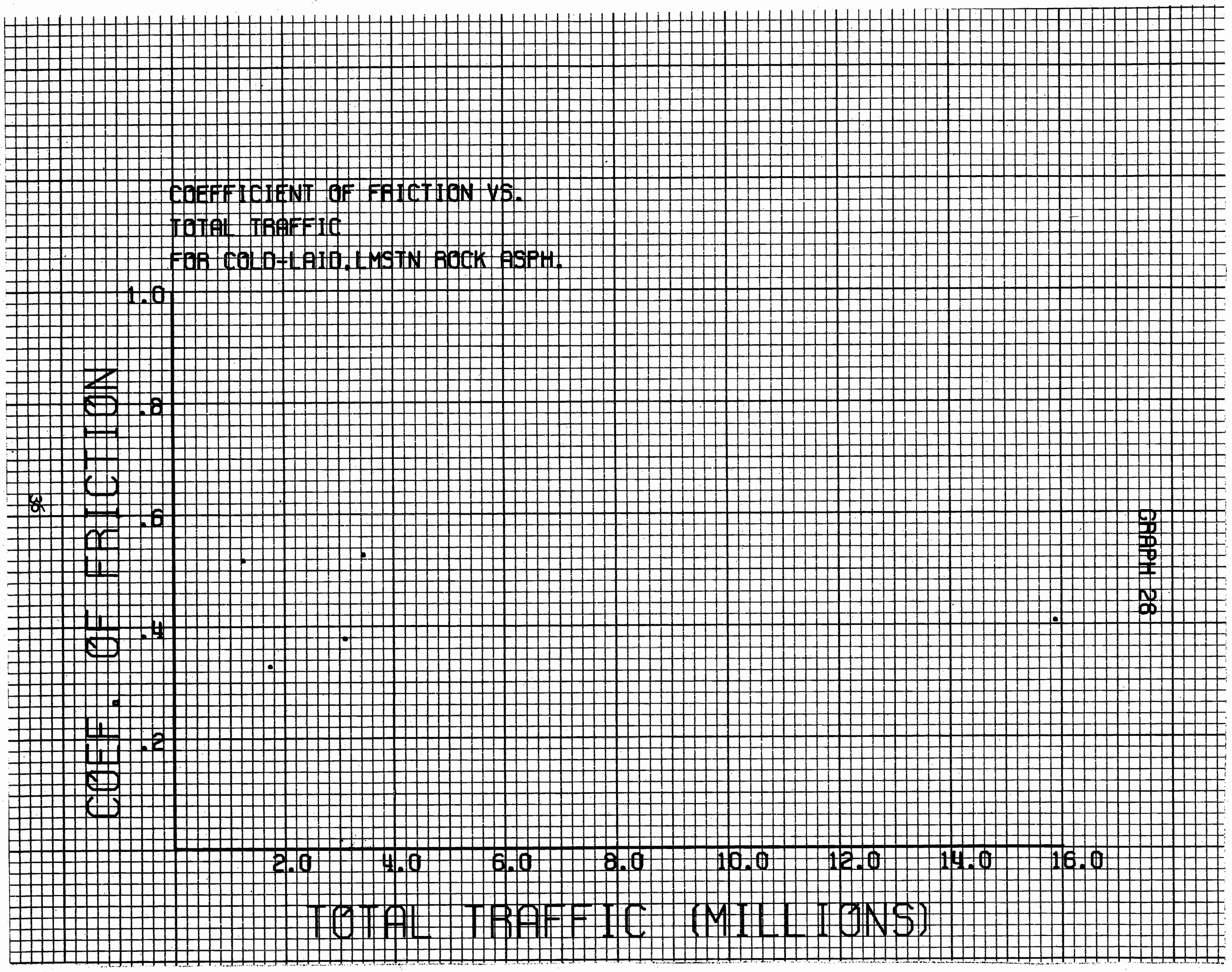

COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-SLAG
COEF. OF FRICTION
1.0
.8
.6
.4
.2
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
TOTAL TRAFFIC (MILLIONS)


GRAPH 25
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-TRAP ROCK
COEF. OF FRICTION
1.0
.8
.6
.4
.2
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TOTAL TRAFFIC (MILLIONS)

GRAPH 26


COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SURFACE TREATMENT-ROCK ASPH.
NO PLOT DATA
TOTAL TRAFFIC (MILLIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2


GRAPH 27
COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR SLURRY SEALS
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
TOTAL TRAFFIC (MILLIONS)


COEFFICIENT OF FRICTION VS.
TOTAL TRAFFIC
FOR COLD-LAID,LMSTN ROCK ASPH.
GRAPH 28
1.0
.8
.6
.4
.2
COEF. OF FRICTION
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
TOTAL TRAFFIC (MILLIONS)

PAVEMENT MATERIAL

The following plots are an attempt to study the pavement surfacing materials more closely. These plots study the effect of gradation of the aggregate and the amount of binder at a selected traffic range for a given material and pavement type. Graphs 29 through 50 study the effect of binder and graphs 51 through 61 study the effect of aggregate gradation. Each plot of all information obtained for pavement type is followed by specific inforamtion of the material types used in the pavement type.

THE EFFECT OF BINDER

For this study two traffic ranges have been selected, they are (1) 0-4 million applications and (2) 4-8 million applications for Hot Mix Asphaltic Concrete, and (1) 2 million (2) greater than 2 million for surface treatments. Please note that the total traffic used in this study as in past studies is not the actual traffic applications each lane has received because the ADT was used in the calculation of total traffic. Most authorities generally agree that all HMAC aggregates "polish" to some friction level at approximately 4.0 to 4.5 million vehicle applications and remain approximately constant after that. These two ranges of traffic were chosen because the aggregate is polishing from 0-4 million applications and the coefficient of friction appears to have leveled off in the 4-8 million range. The different surface treatment ranges were chosen because most surface treatments are resurfaced, for one reason or another, before they have received two million traffic applications.

Hot Mix Asphaltic Concrete

Graph 29 is a general plot of all HMAC pavements tested. Graphs 30 through 39 are related to specific aggregate types used in HMAC. Again as in the two previous reports (SS 11.4 and SS 11.5) what seems to be excessive asphalt contents does not appear to hinder friction values. There is probably an optimum asphalt content but it is not apparent from these plots.

Surface Treatments

Graph 40 is a general plot of all surface treatment pavements tested. Graphs 41 through 46 are related to specific aggregate types.

As in the HMAC studied there appears to be no optimum asphalt content for skid resistance. In this analysis it must be remembered that the binder content on some pavements has been varied to match the surface condition before surfacing.

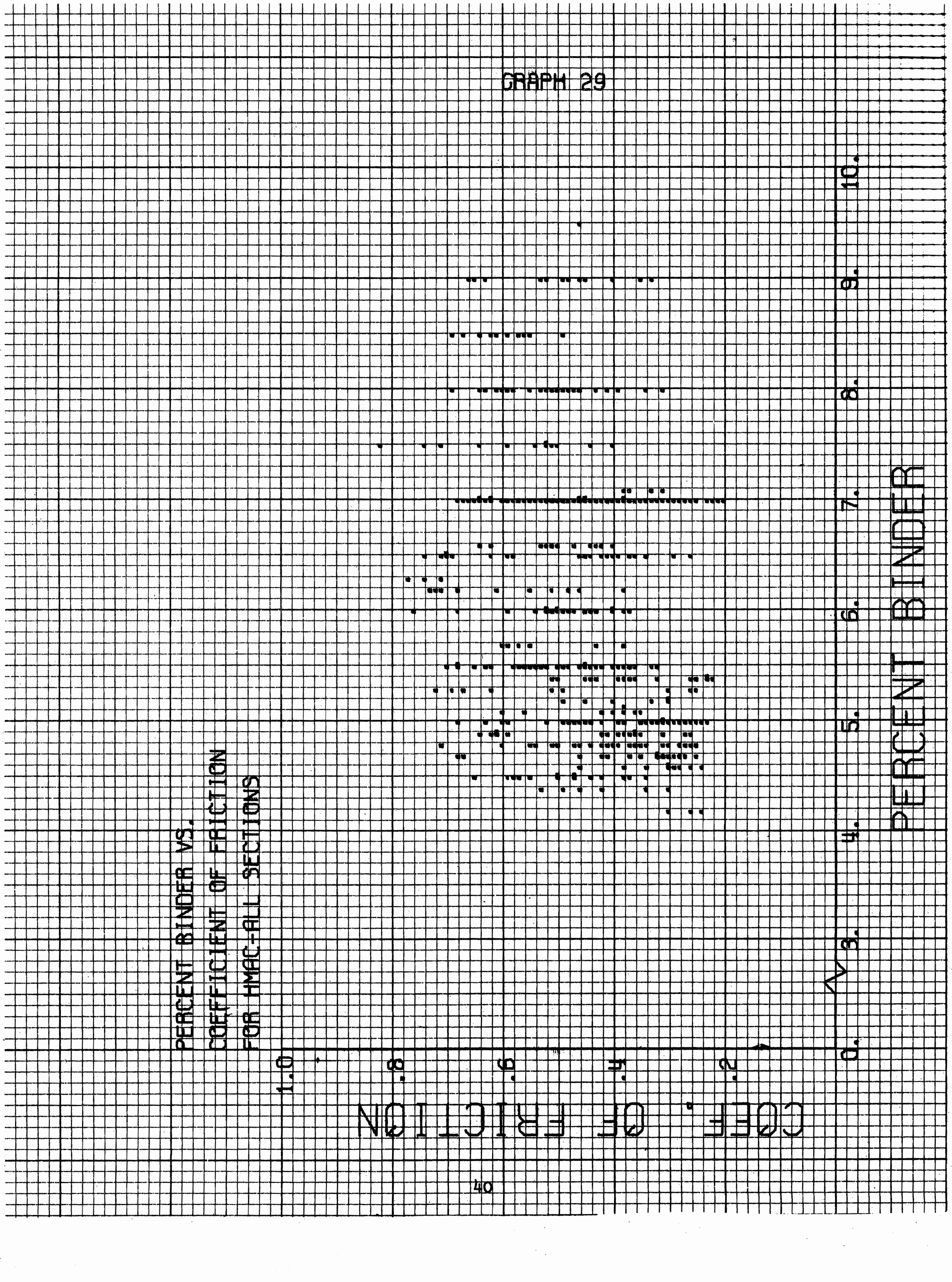
Graphs 41 and 42 show no sections of surface treatments in the required traffic ranges were tested. A considerably large amount of siliceous aggregate is in use throughout the state, but does not appear due to incomplete data received from the Districts.

Slurry Seals

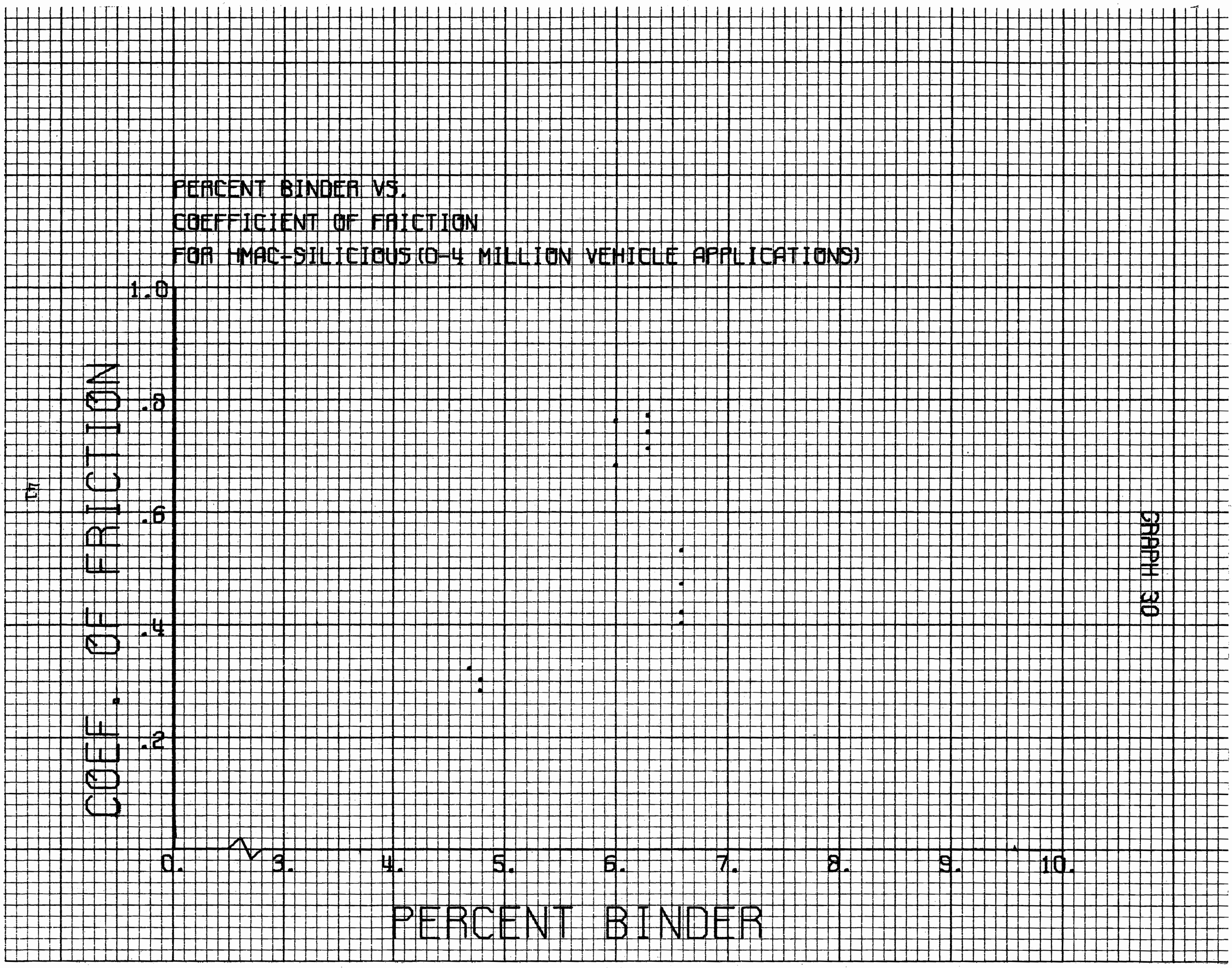
As indicated by Graph 47 no Slurry Seals were tested.

Hot Mix Cold Laid Asphaltic Concrete

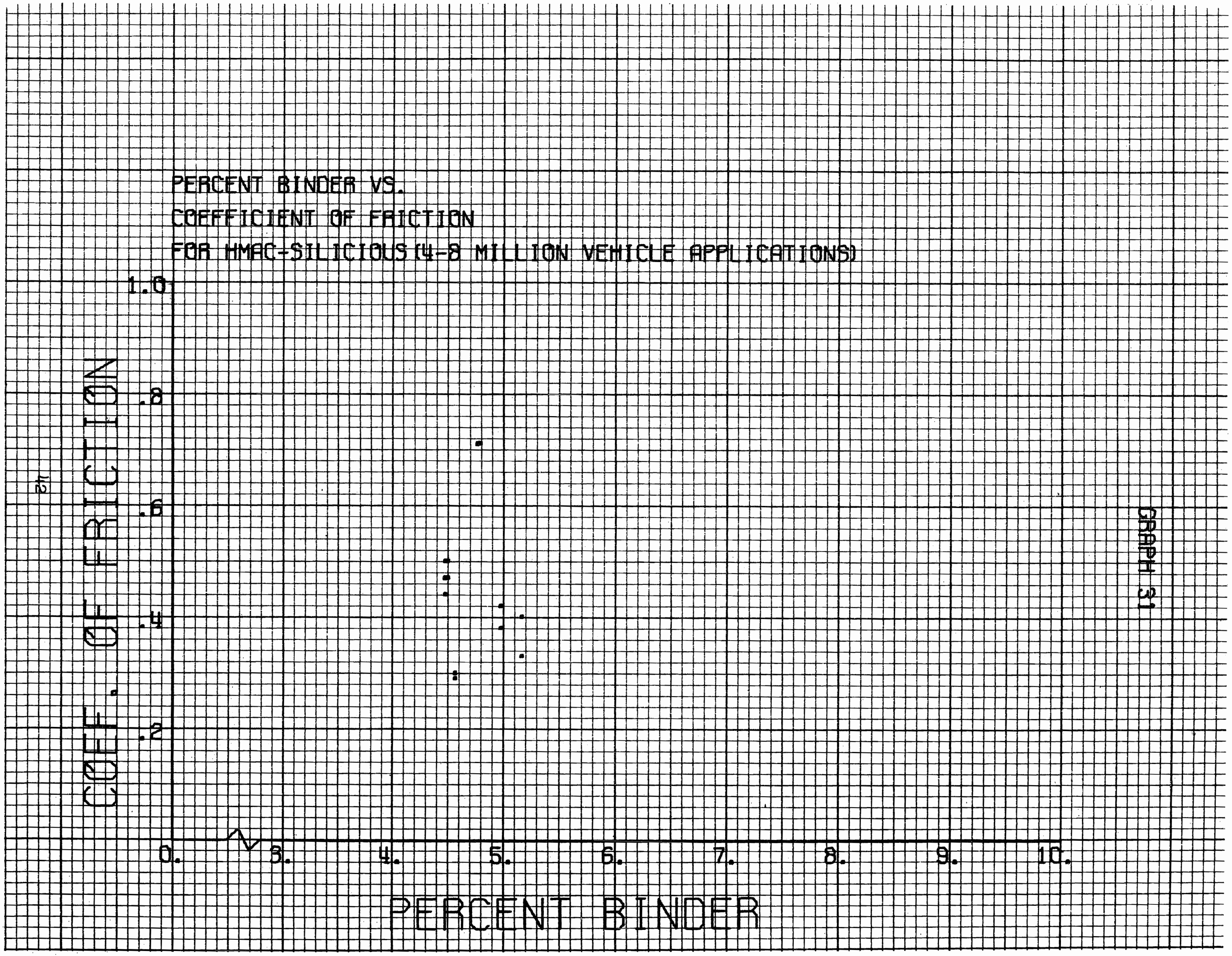
Again no points are shown because there were no sections tested.

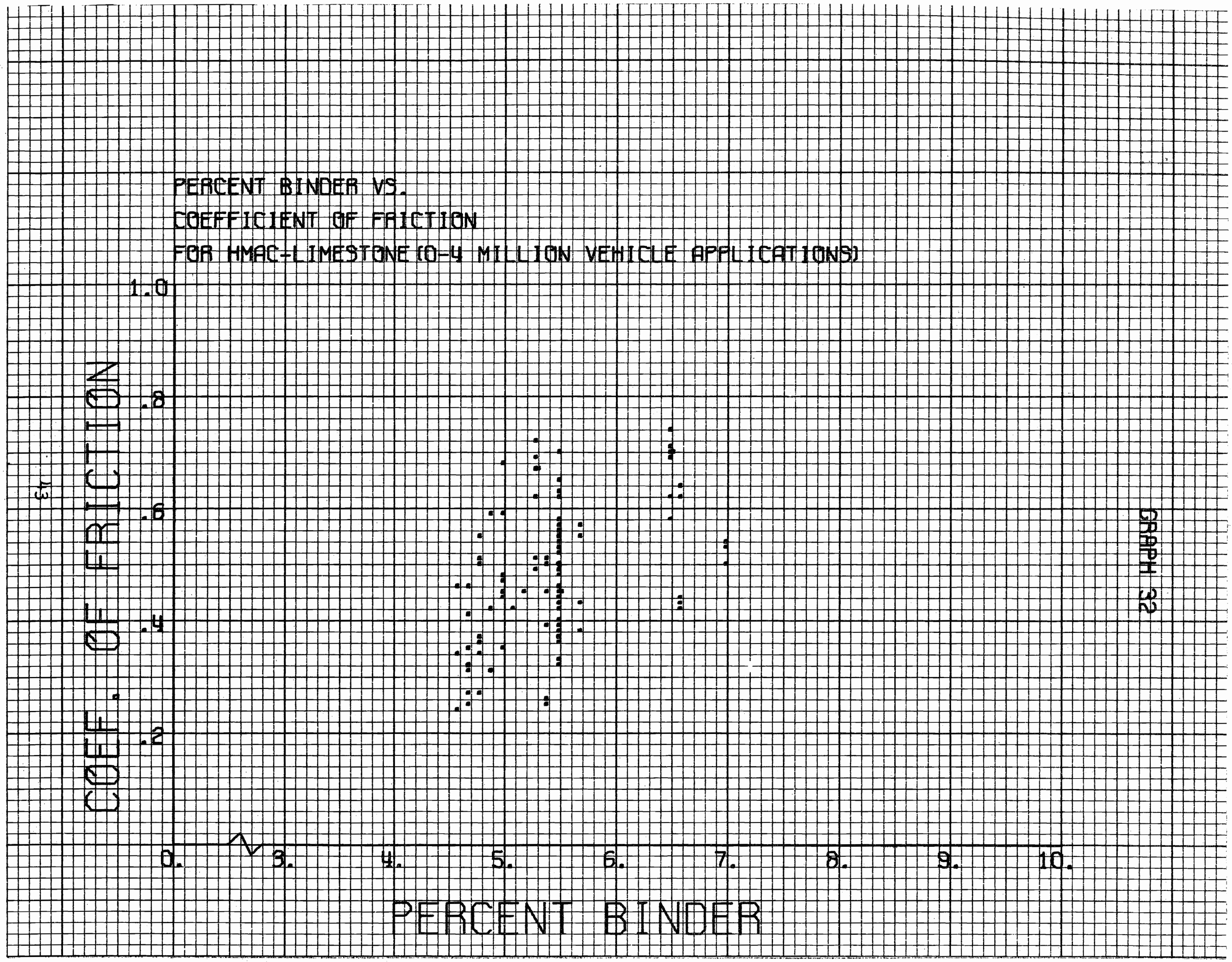


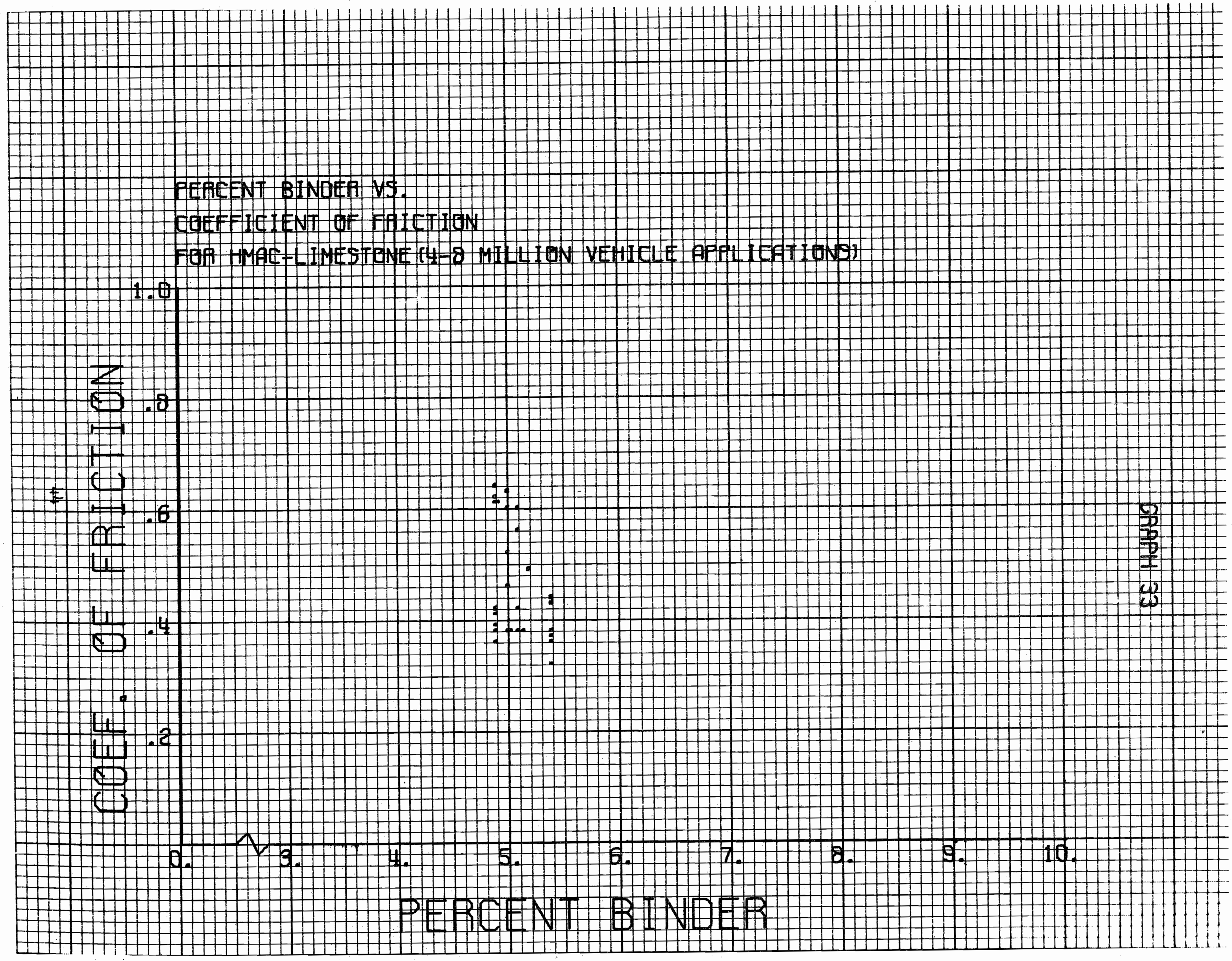
GRAPH 29
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-ALL SECTIONS
COEF. OF FRICTION
1.0
.8
.6
.4
.2
PERCENT BINDER
0.
3.
4.
5.
6.
7.
8.
9.
10.

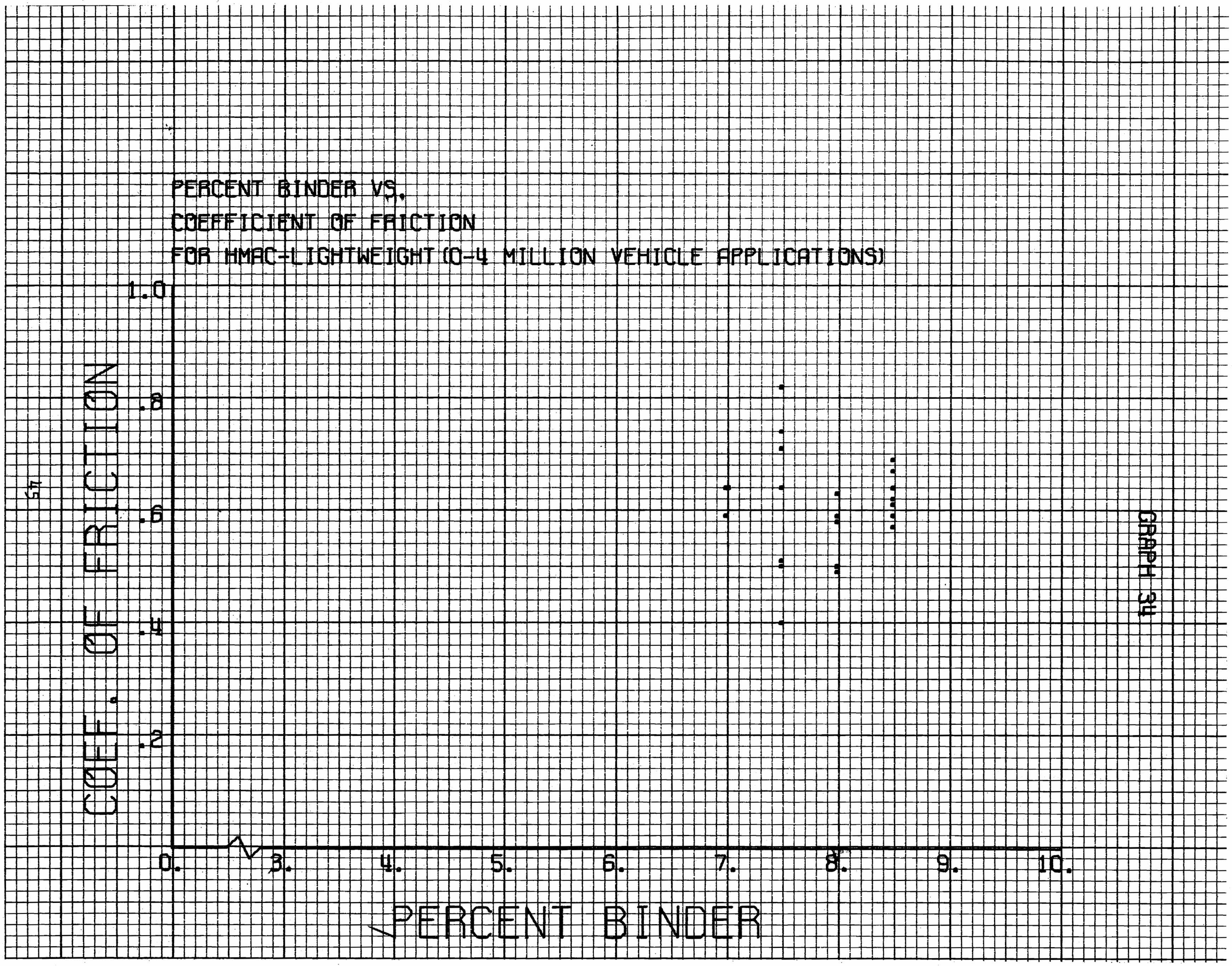


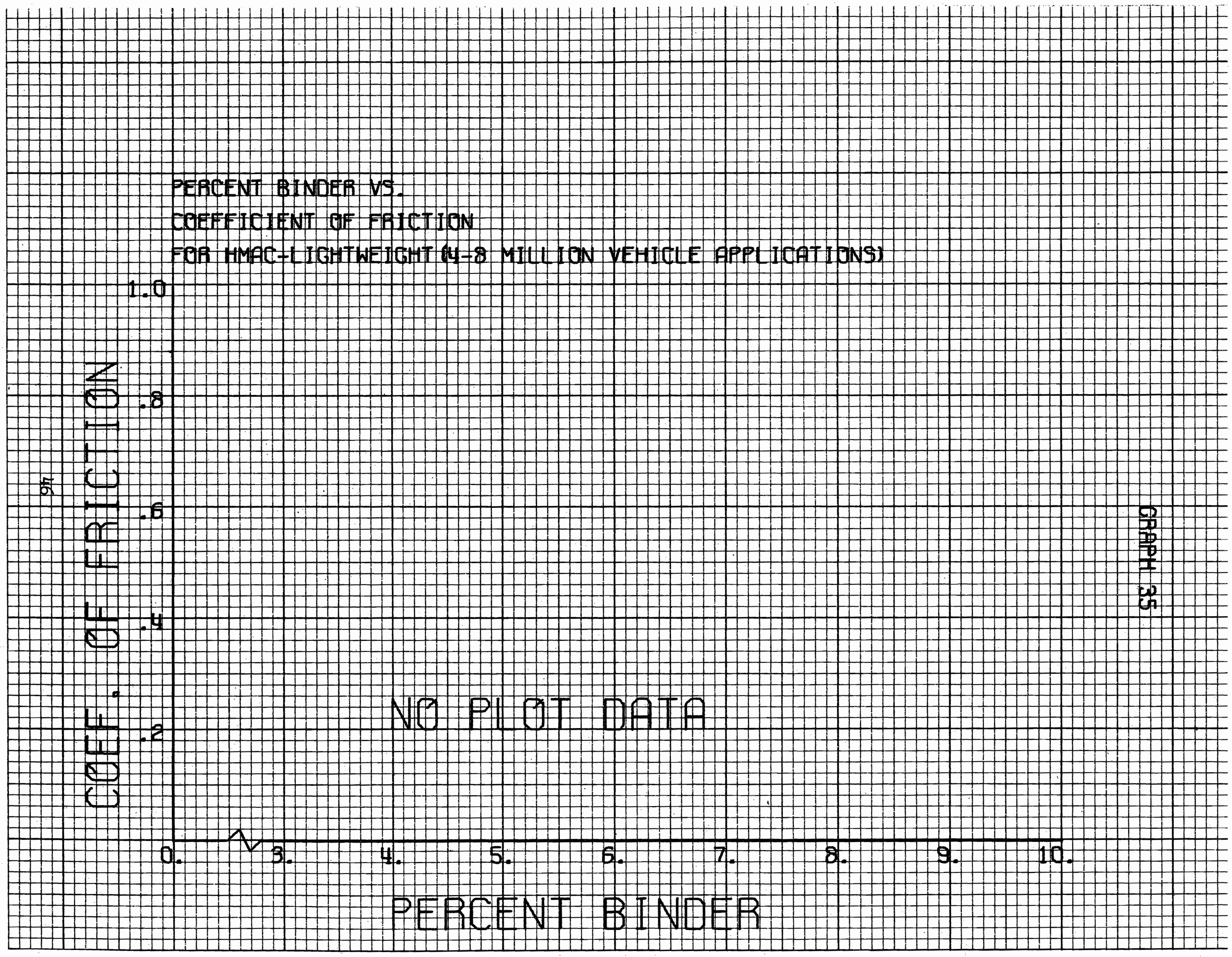
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-SILICIOUS(0-4 MILLION VEHICLE APPLICATIONS)
GRAPH 30
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER

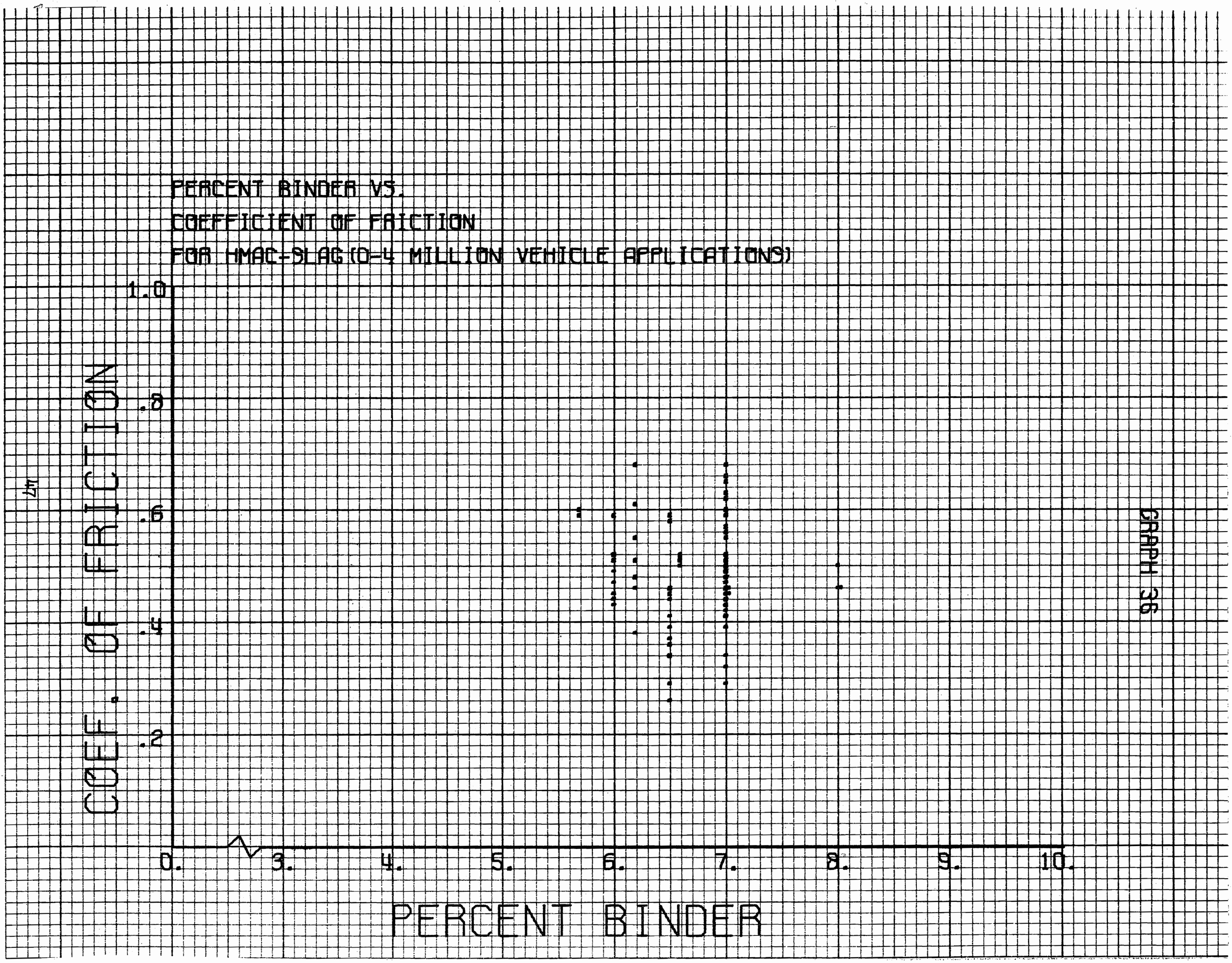

GRAPH 31
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-SILICIOUS (4-8 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER

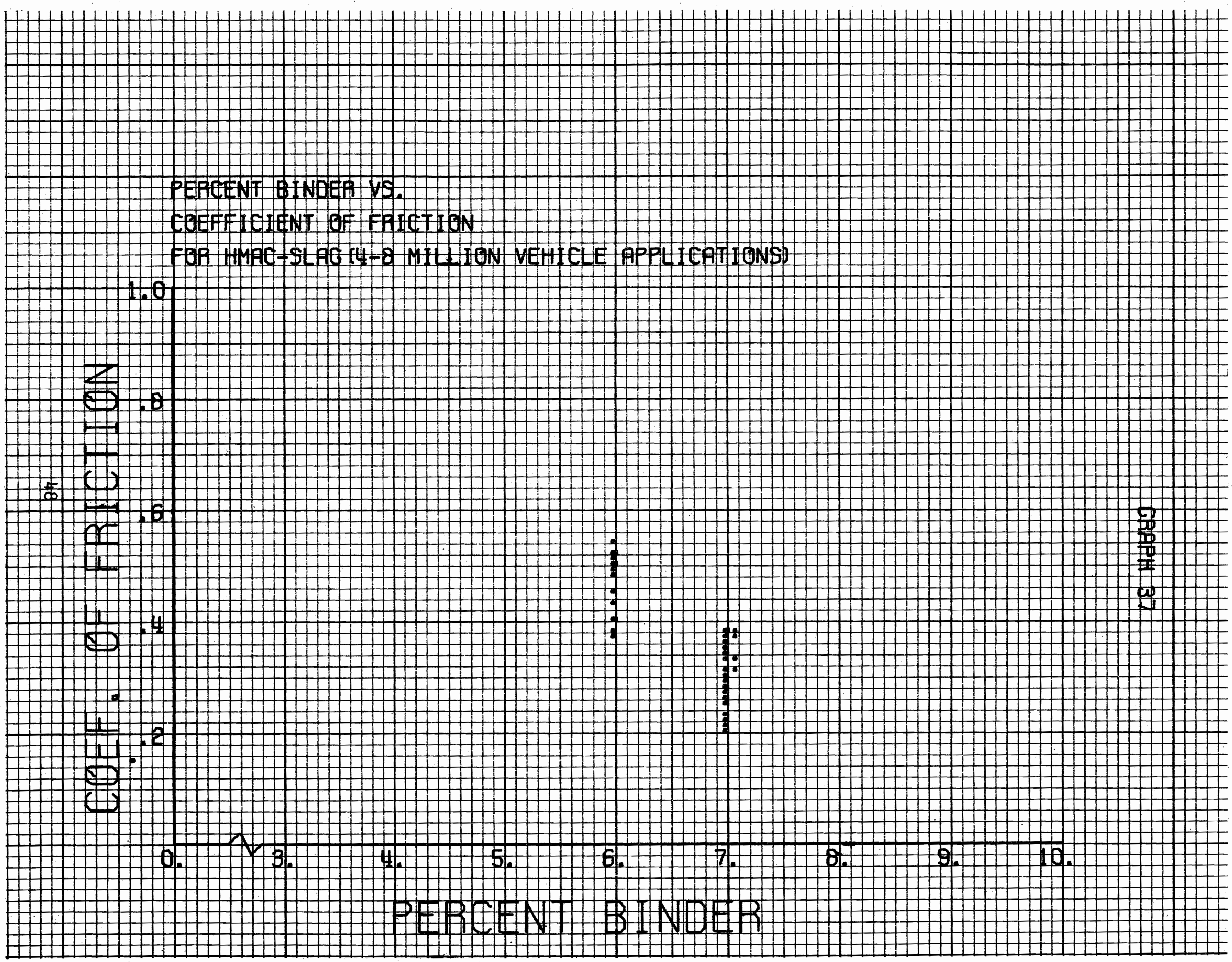

GRAPH 32
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIMESTONE (0-4 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER

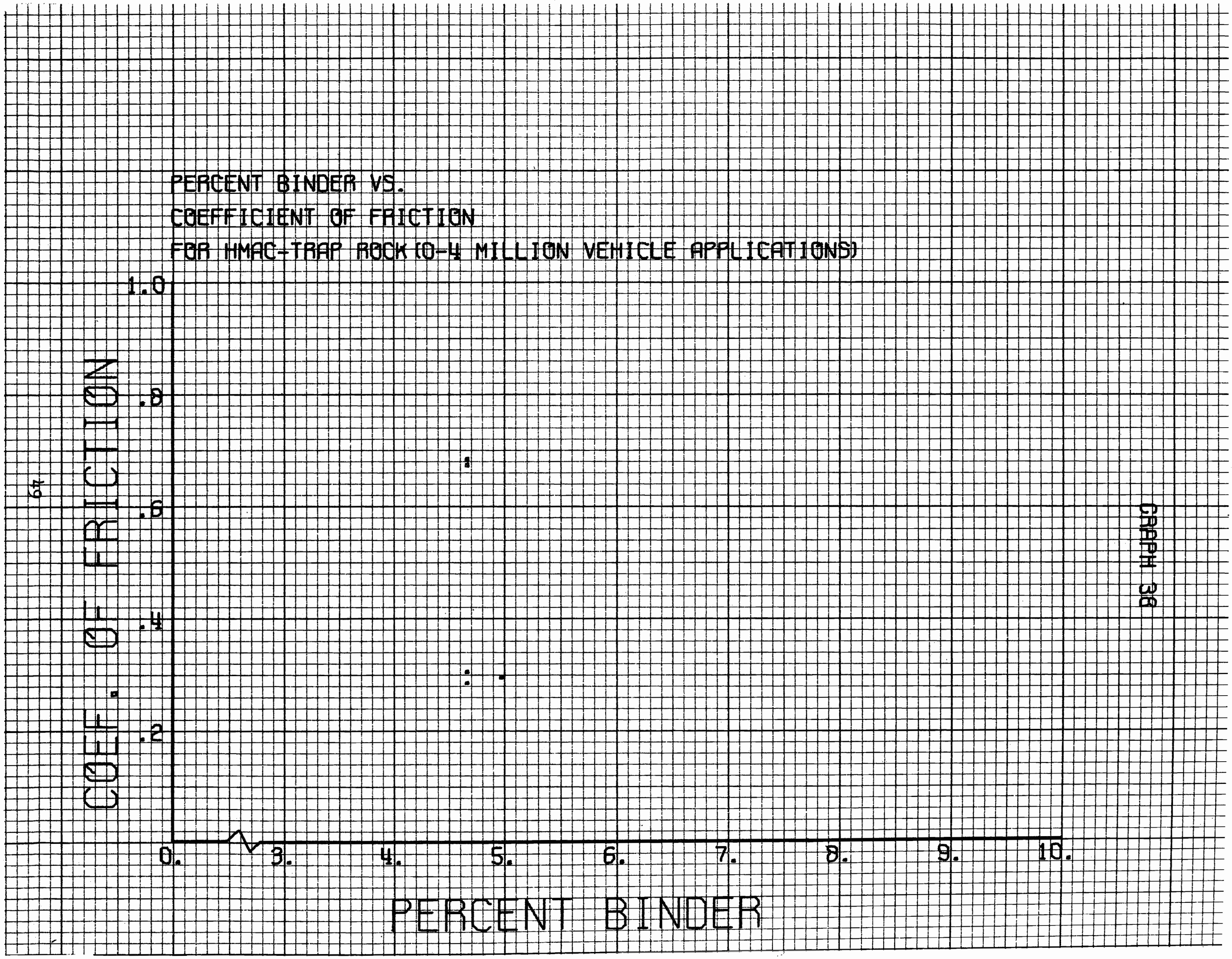

GRAPH 33
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIMESTONE (4-8 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
COEF. OF FRICTION
PERCENT BINDER

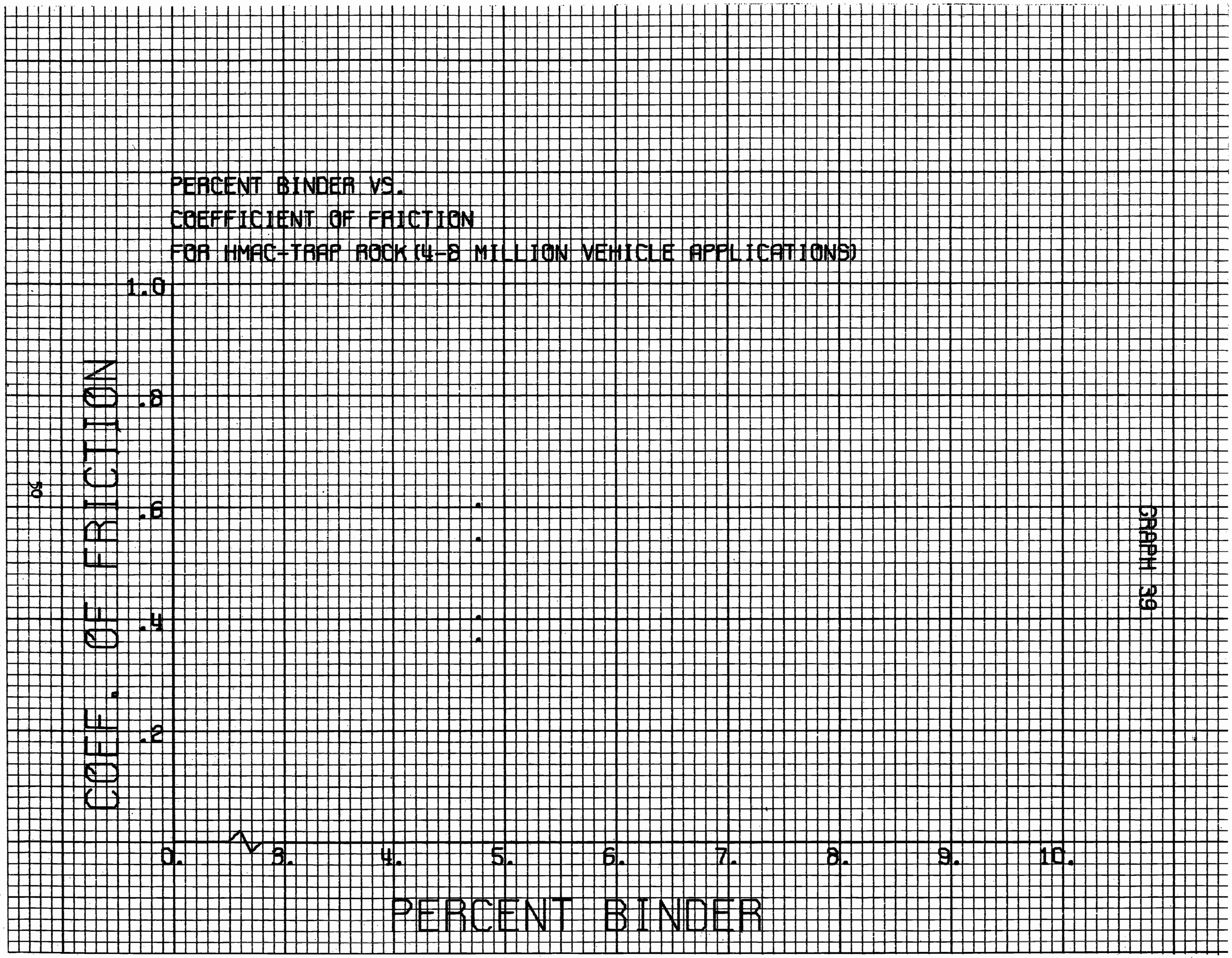

GRAPH 34
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIGHTWEIGHT (0-4 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER


GRAPH 35
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIGHTWEIGHT (4-8 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER

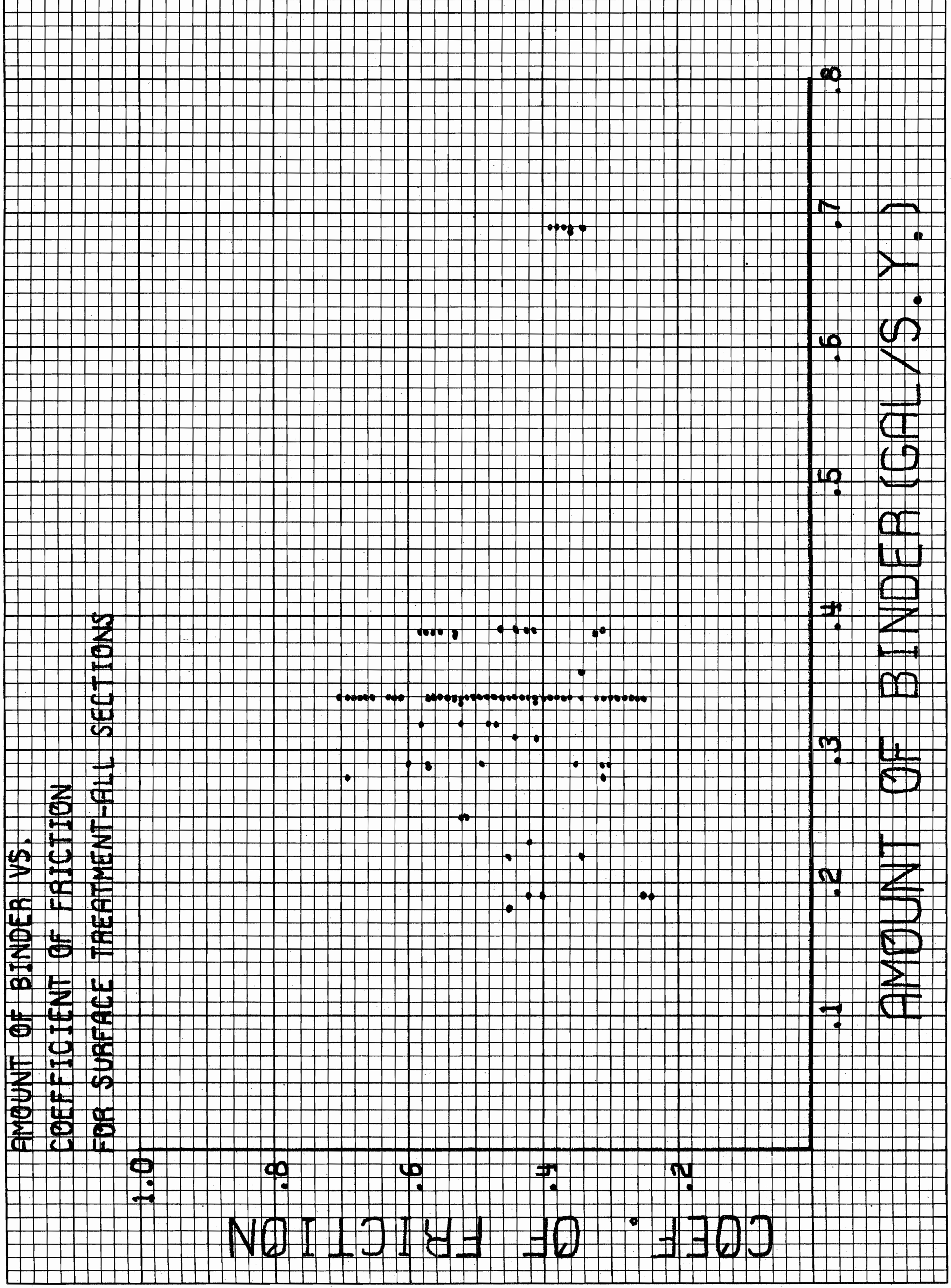

PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-SLAG (0-4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER
GRAPH 36

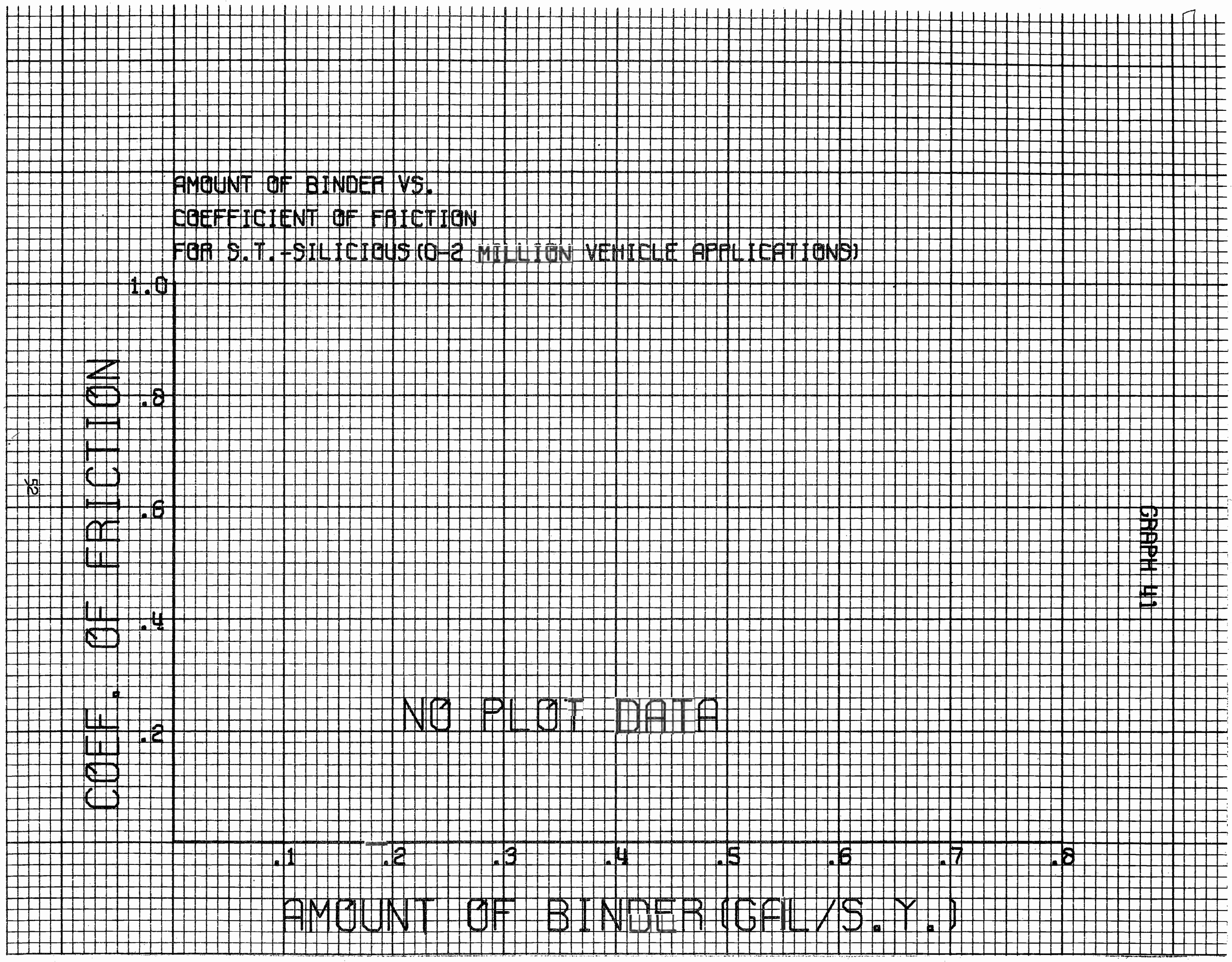

GRAPH 37
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-SLAG (4-8 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER


GRAPH 38
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-TRAP ROCK (0-4 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER

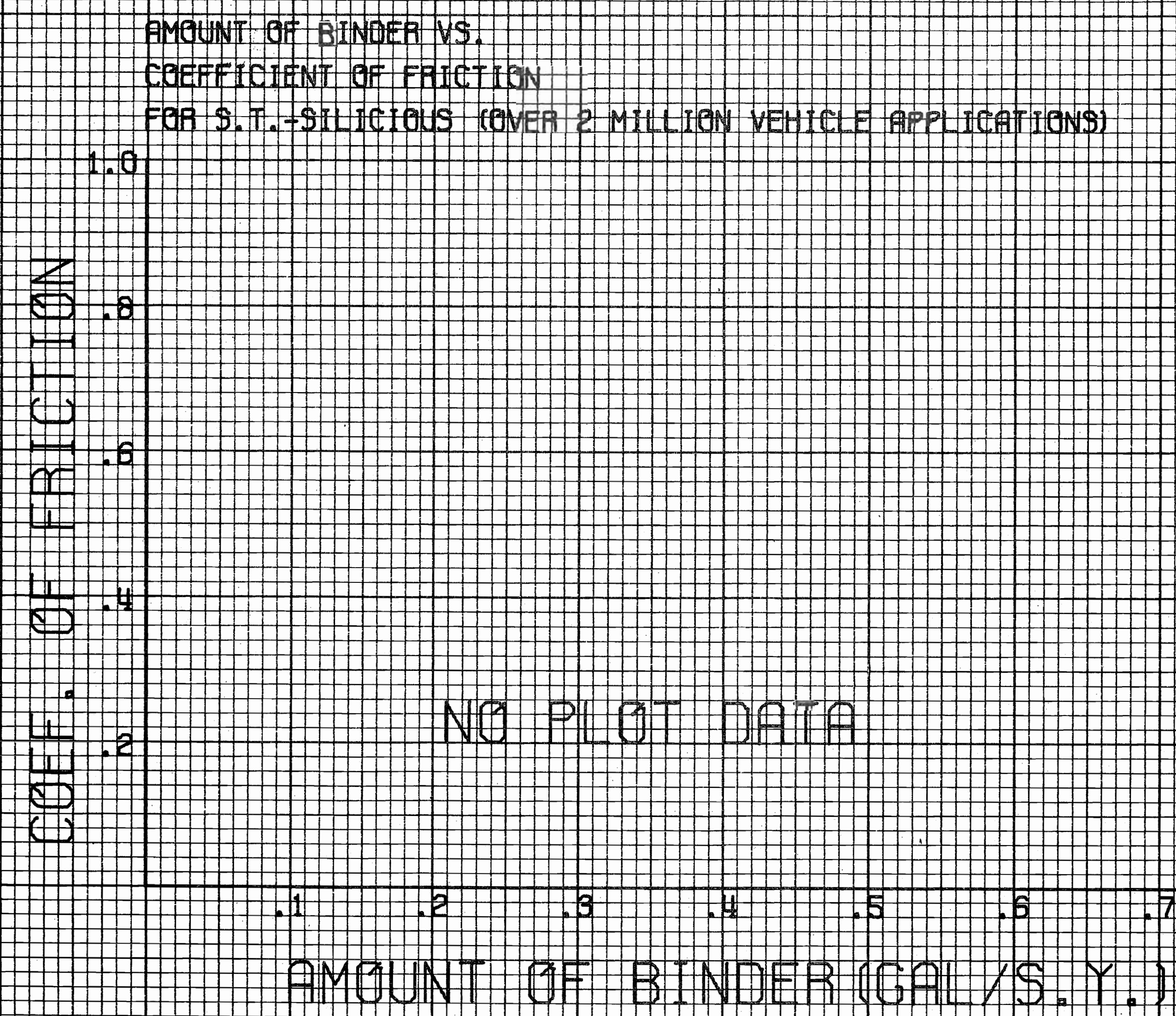

PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR HMAC-TRAP ROCK (4-8 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
0.
3.
4.
5.
6.
7.
8.
9.
10.
PERCENT BINDER
GRAPH 39

GRAPH 40


AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR SURFACE TREATMENT-ALL SECTIONS
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)
1.0
.8
.6
.4
.2
COEF. OF FRICTION

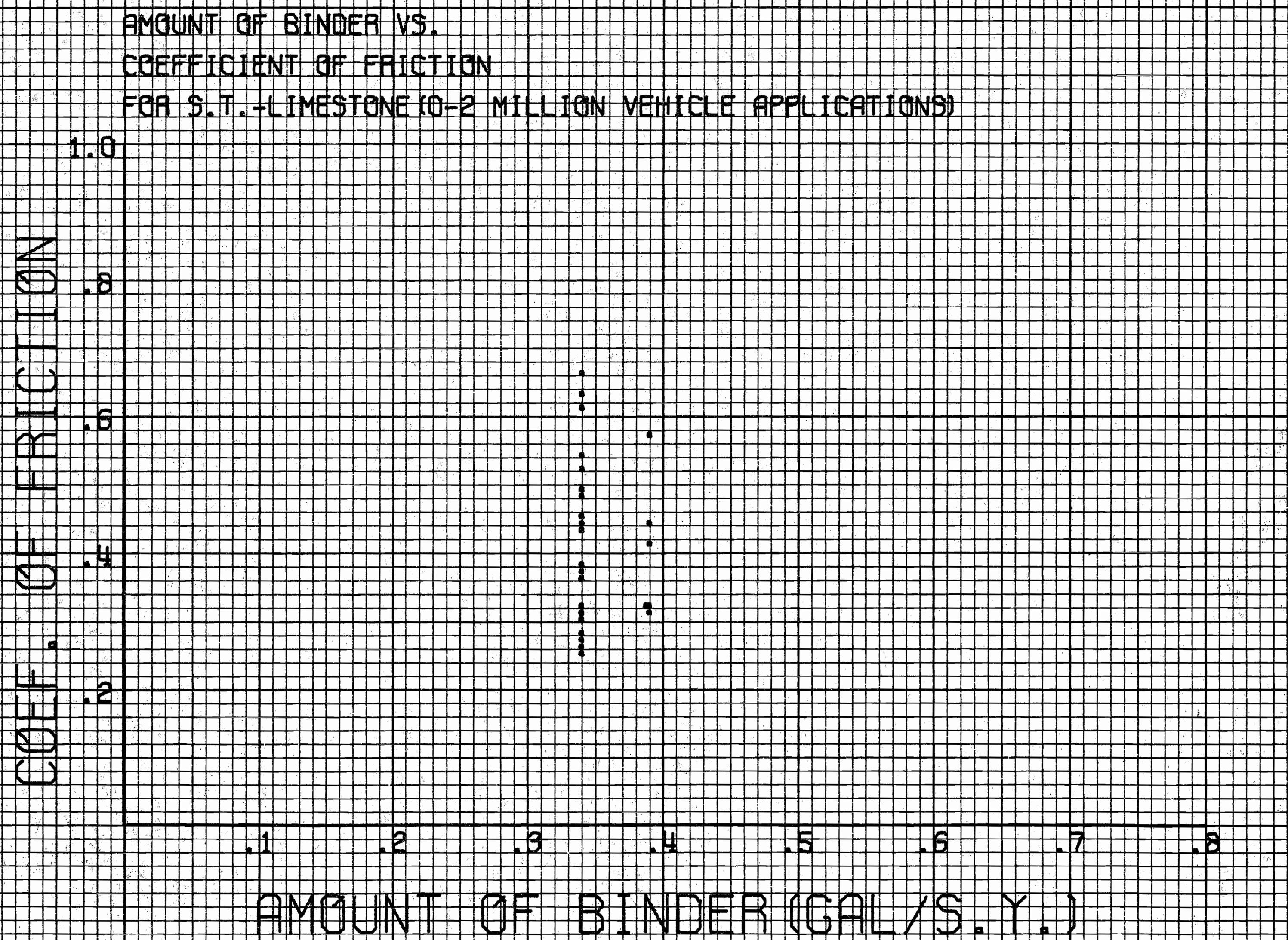

GRAPH 41
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-SILICIOUS(0-2 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER(GAL/S.Y.)

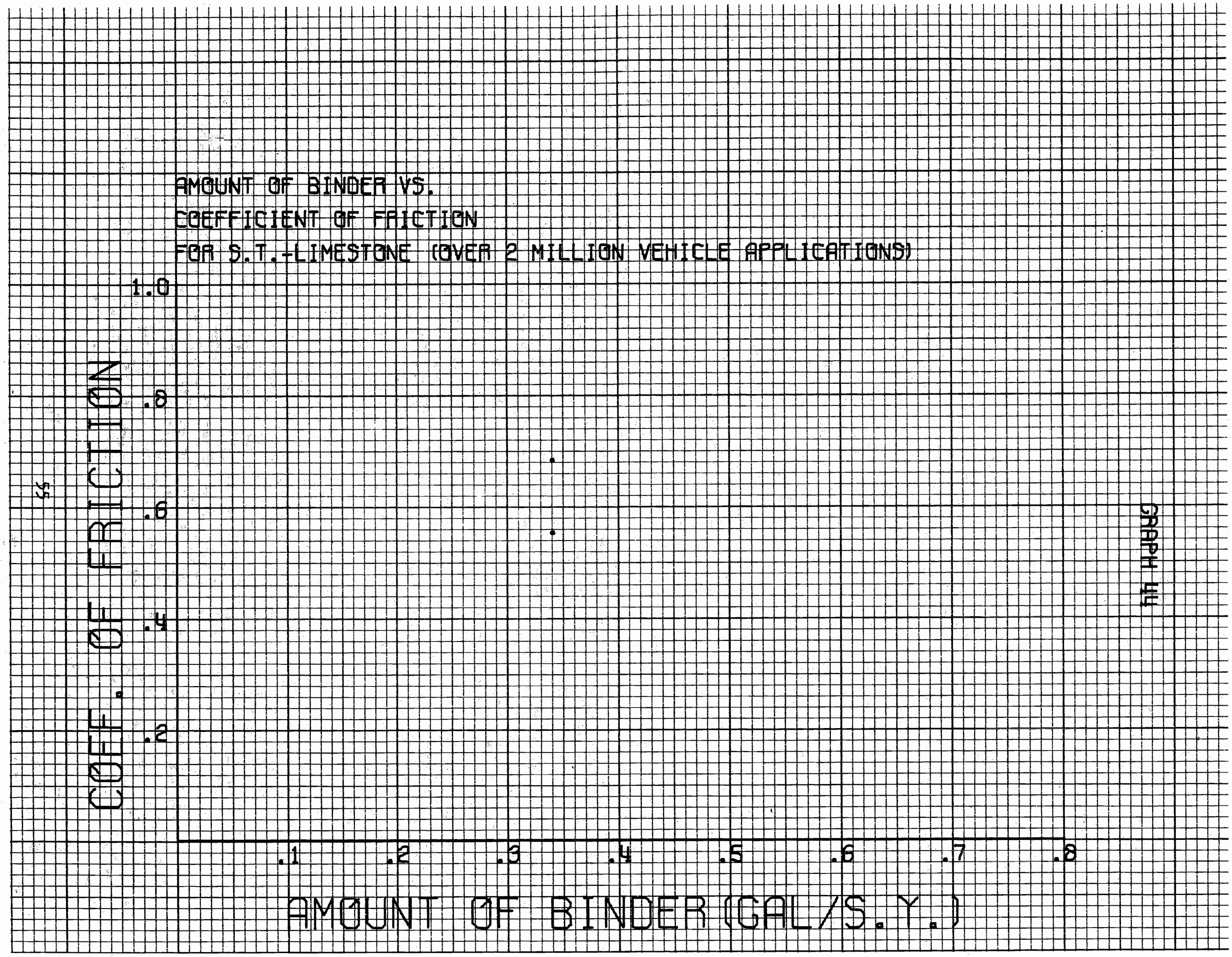
GRAPH 42

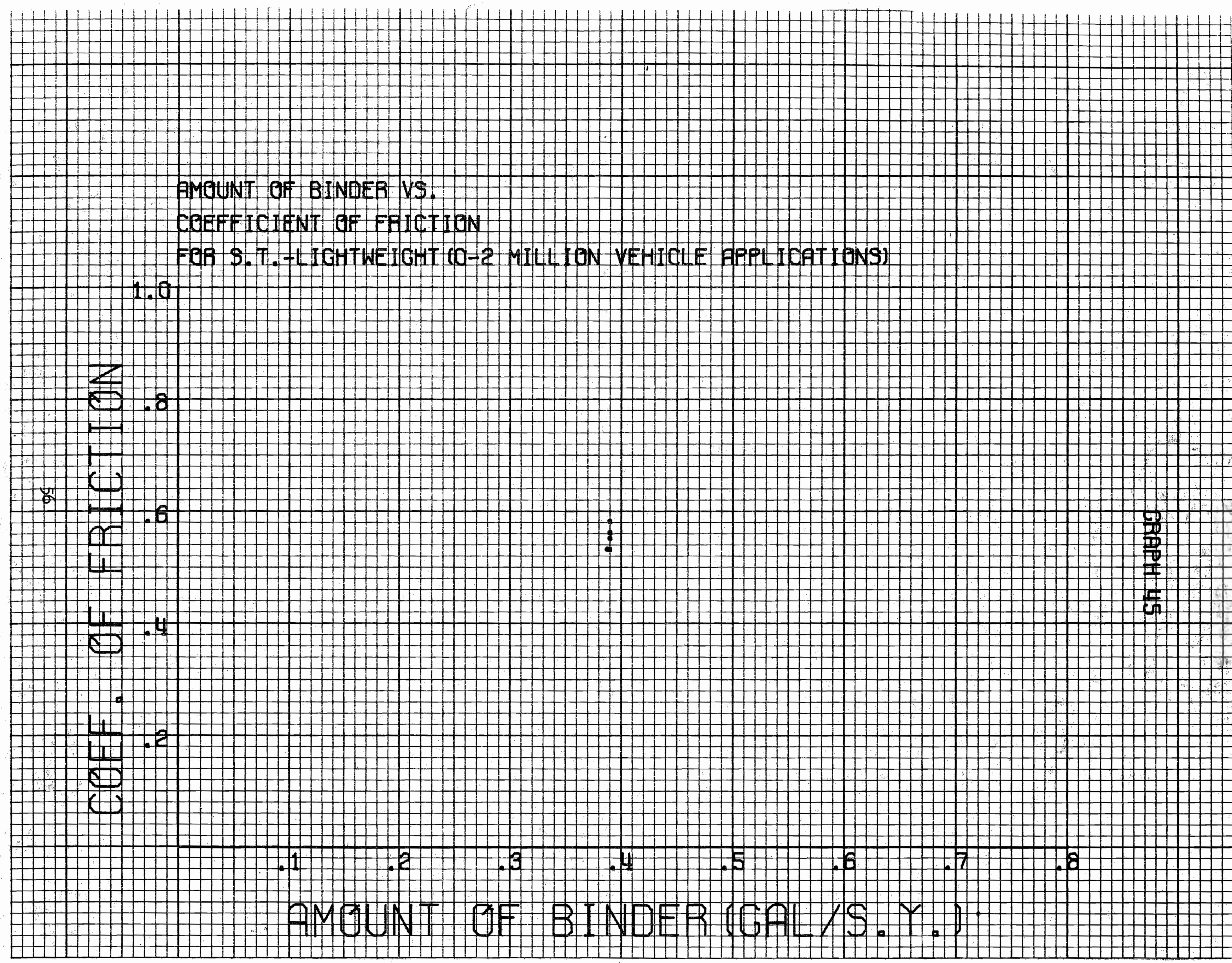


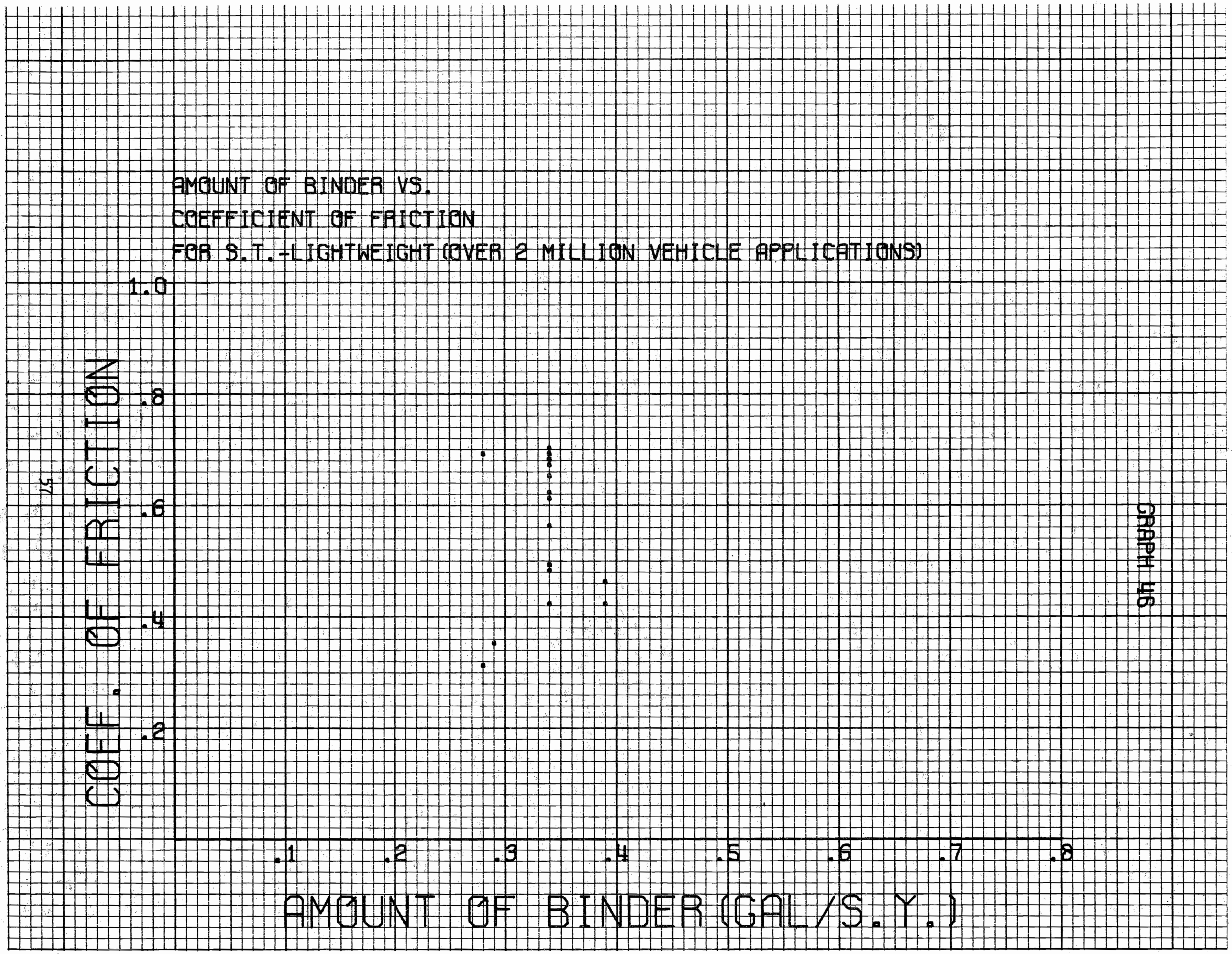
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-SILICIOUS (OVER 2 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)

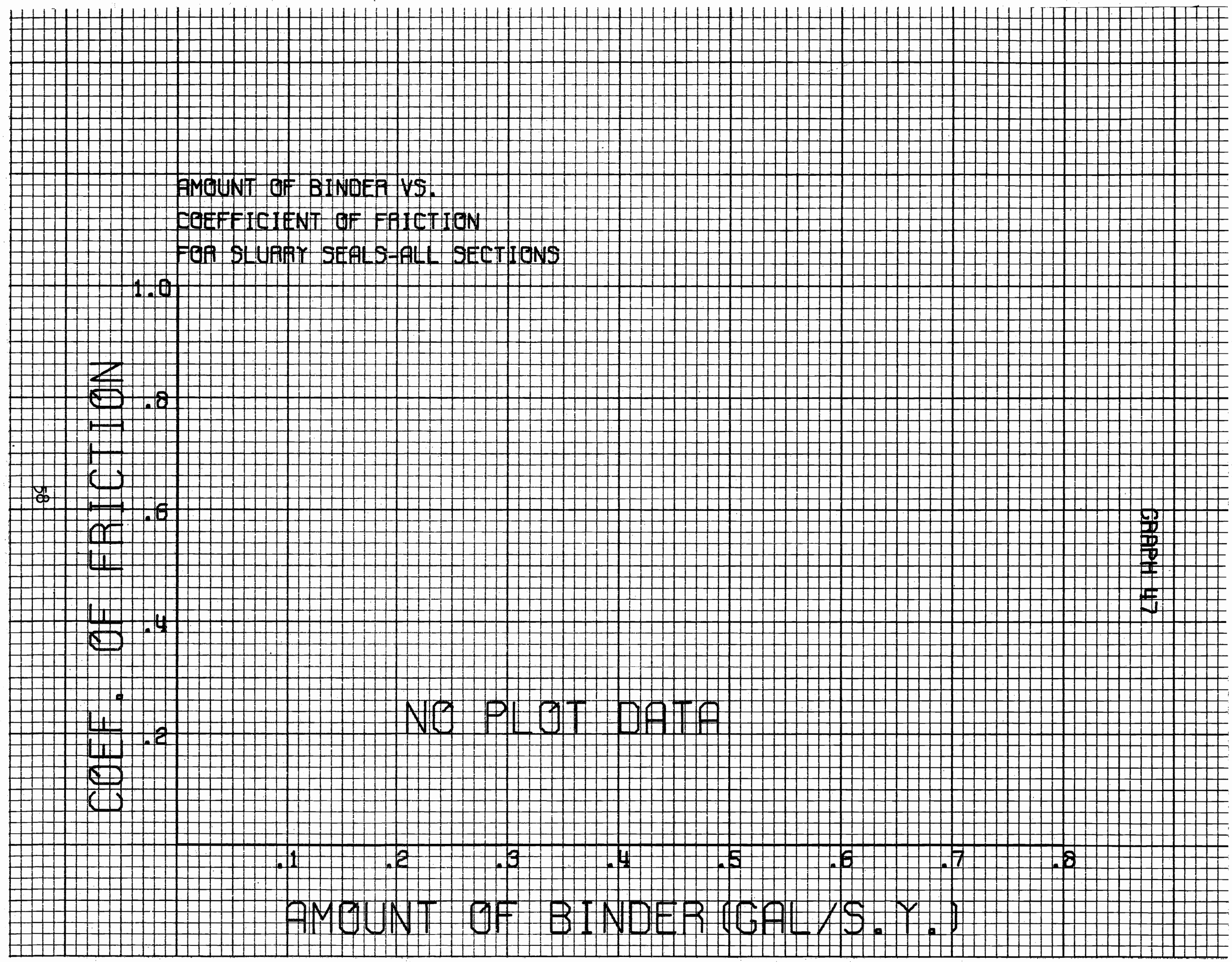
GRAPH 43

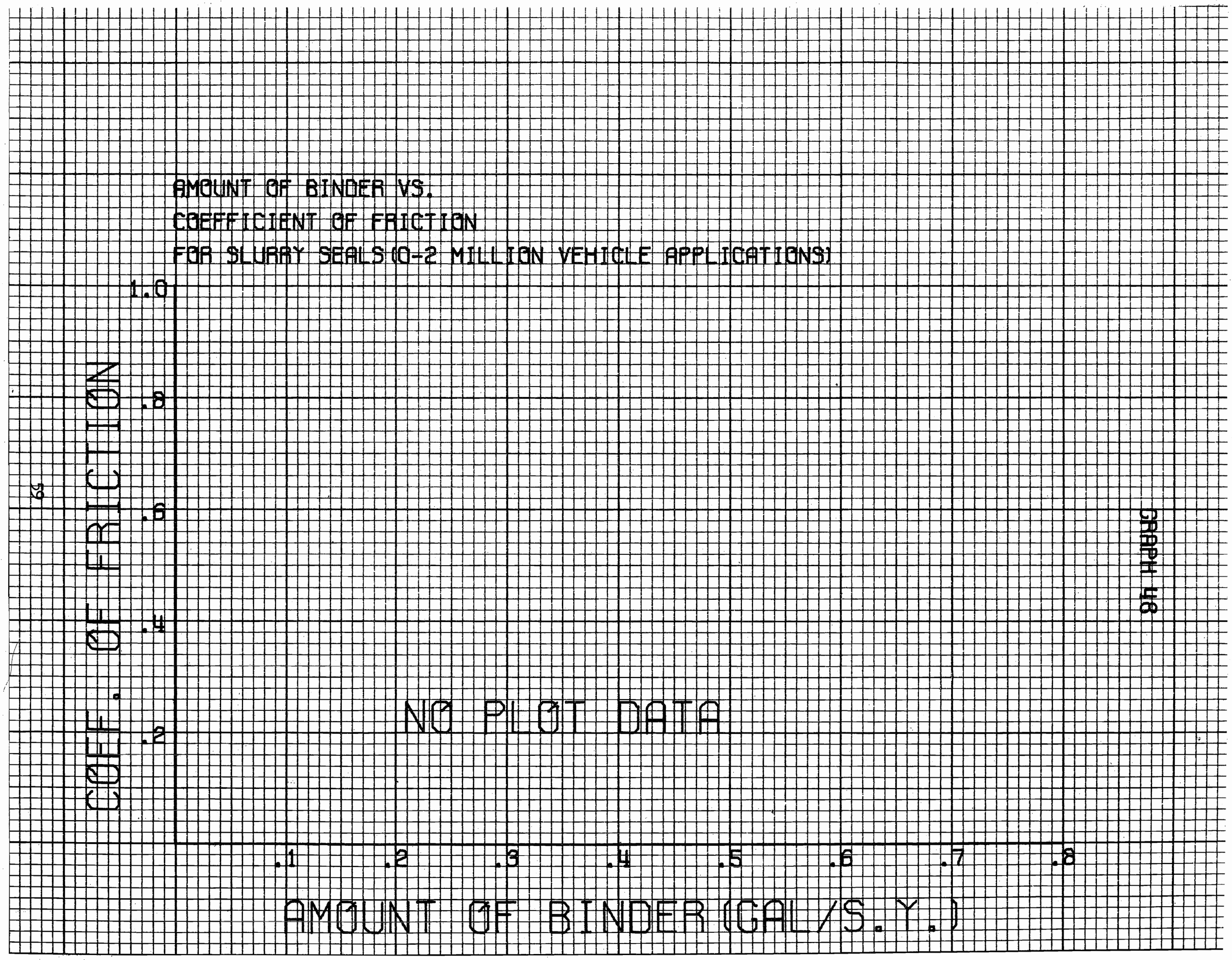

AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIMESTONE (0-2 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)


GRAPH 44
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIMESTONE (OVER 2 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)


GRAPH 45
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIGHTWEIGHT (0-2 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)

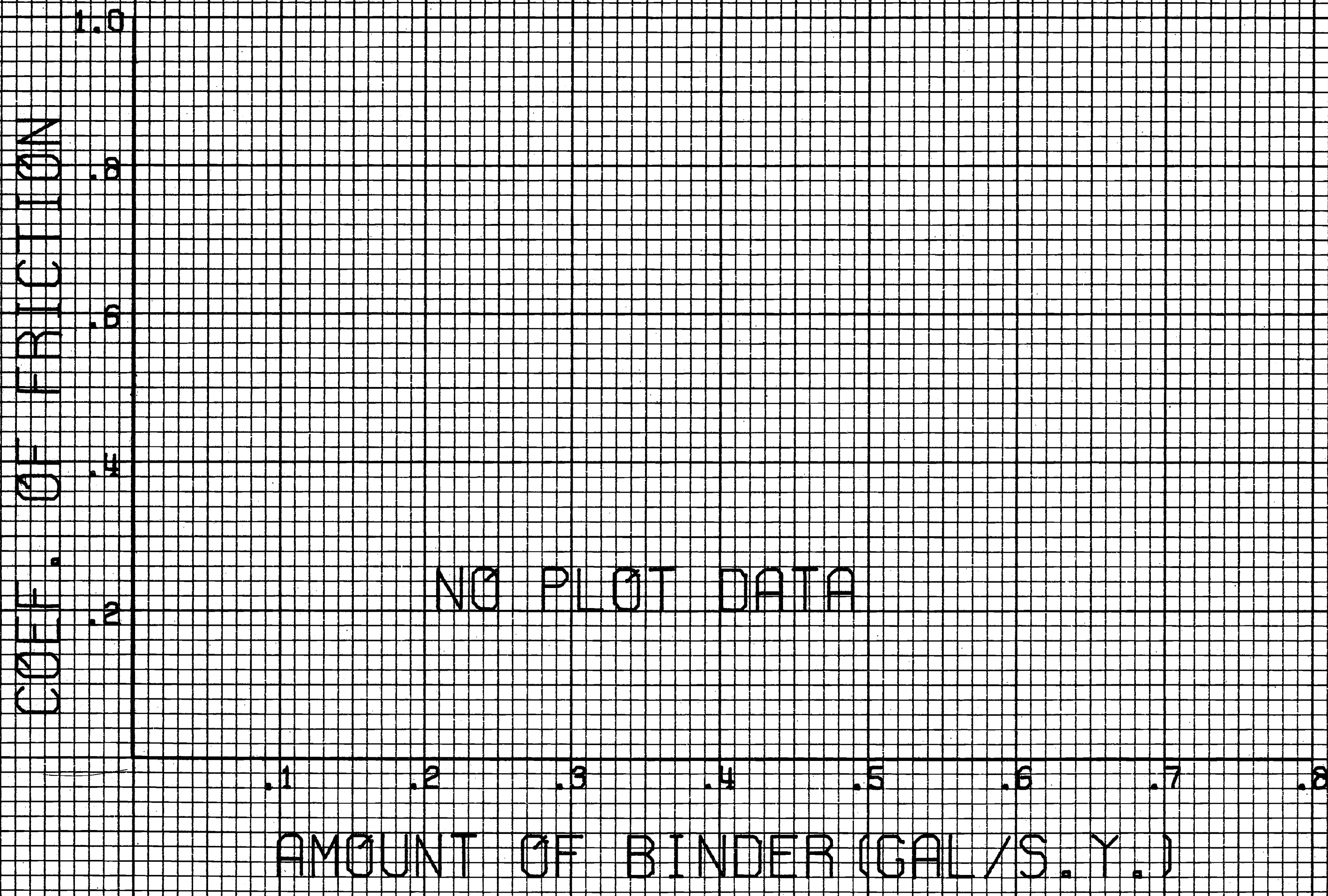

GRAPH 46
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIGHTWEIGHT (OVER 2 MILLION VEHICLE APPLICATIONS)
COEF. OF FRICTION
1.0
.8
.6
.4
.2
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)


GRAPH 47
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR SLURRY SEALS-ALL SECTIONS
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER (GAL/S.Y.)


GRAPH 48
AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR SLURRY SEALS(0-2 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
NO PLOT DATA
.1
.2
.3
.4
.5
.6
.7
.8
AMOUNT OF BINDER(GAL/S.Y.)

GRAPH 49

AMOUNT OF BINDER VS.
COEFFICIENT OF FRICTION
FOR SLURRY SEALS (OVER 2 MILLION VEHICLE APPLICATIONS)




GRAPH 50
PERCENT BINDER VS.
COEFFICIENT OF FRICTION
FOR COLD LAID ASPHALTIC CONCRETE-ALL SECTIONS
NO PLOT DATA
PERCENT BINDER
0. 3. 4. 5. 6. 7. 8. 9. 10.
COEF. OF FRICTION
1.0 .8 .6 .4 .2

THE EFFECT OF GRADATION

This study of the effects of gradation is similar to the study of the effect of the amount of binder.

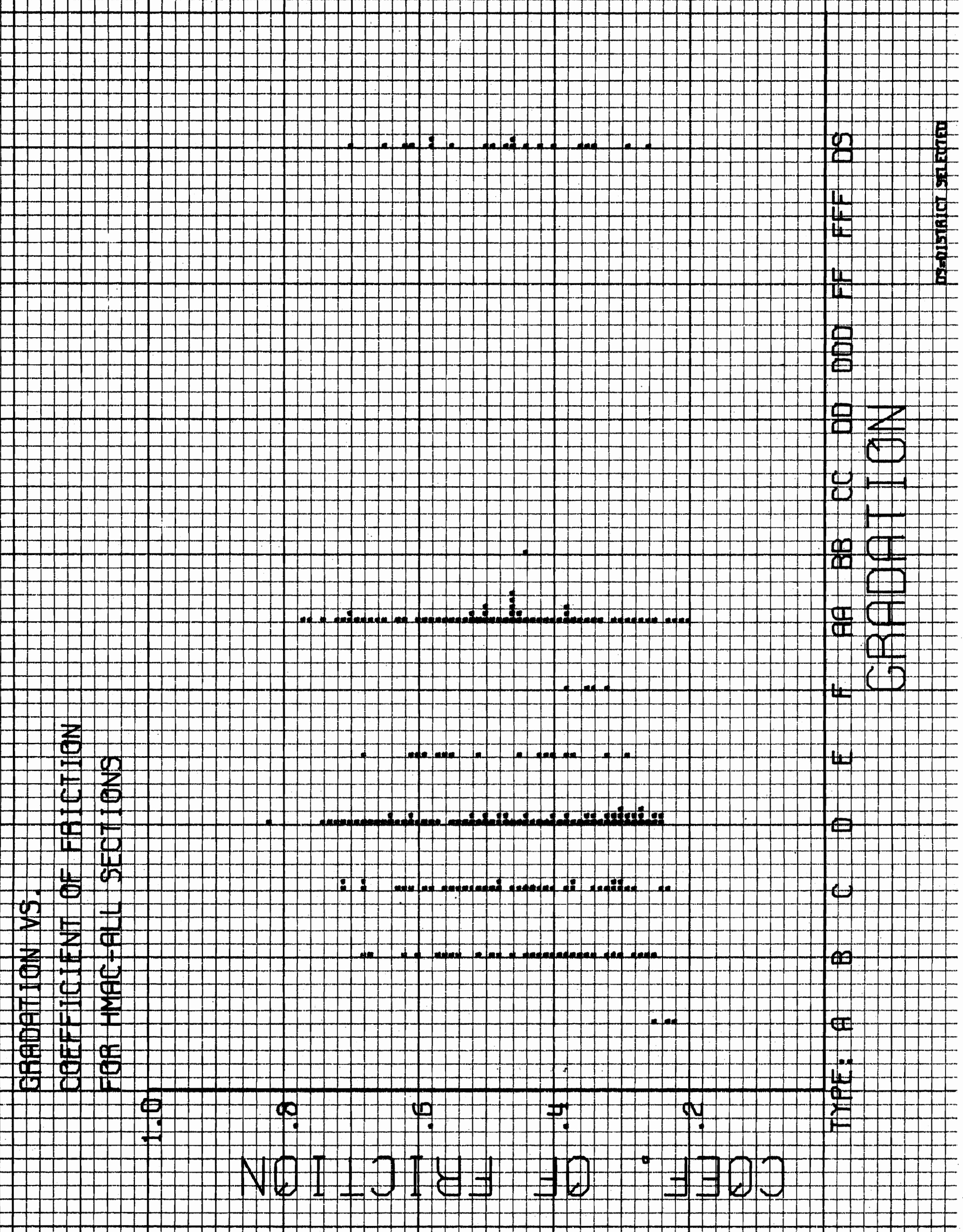
Hot Mix Asphaltic Concrete

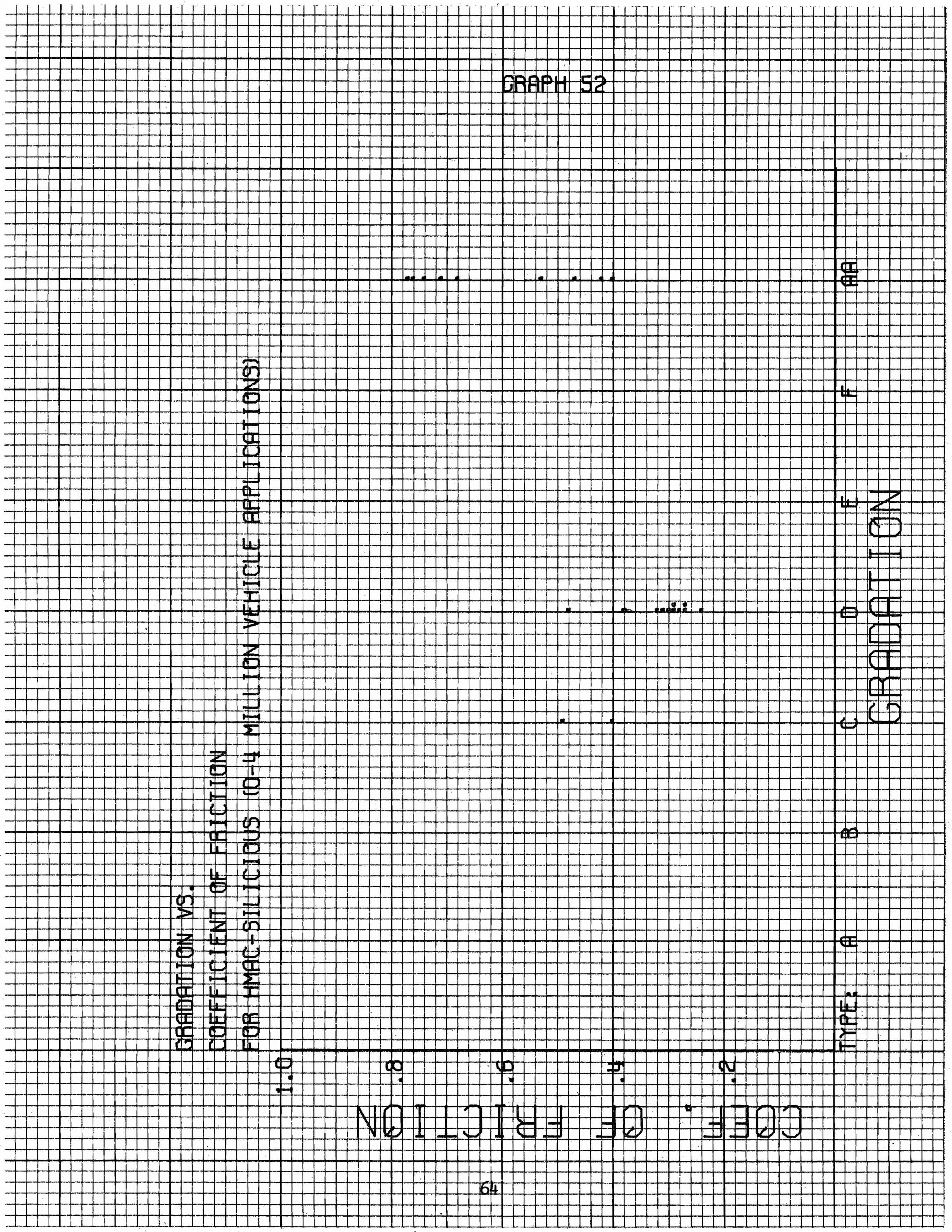
As indicated in Graph 51 there is no optimum gradation to use for optimum coefficient of friction. Graphs 52 through 57 are concerned with various material types and traffic ranges.

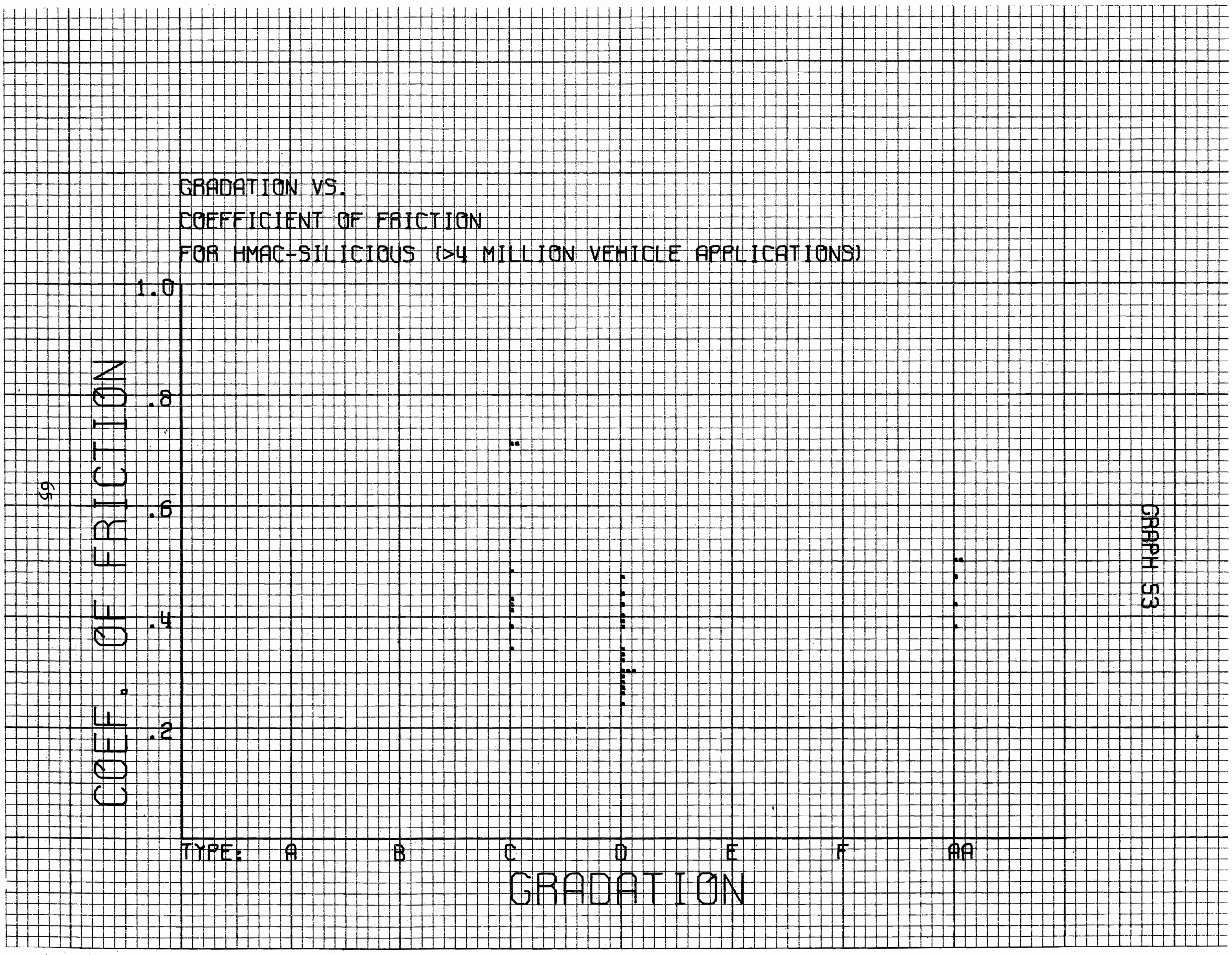
Surface Treatment

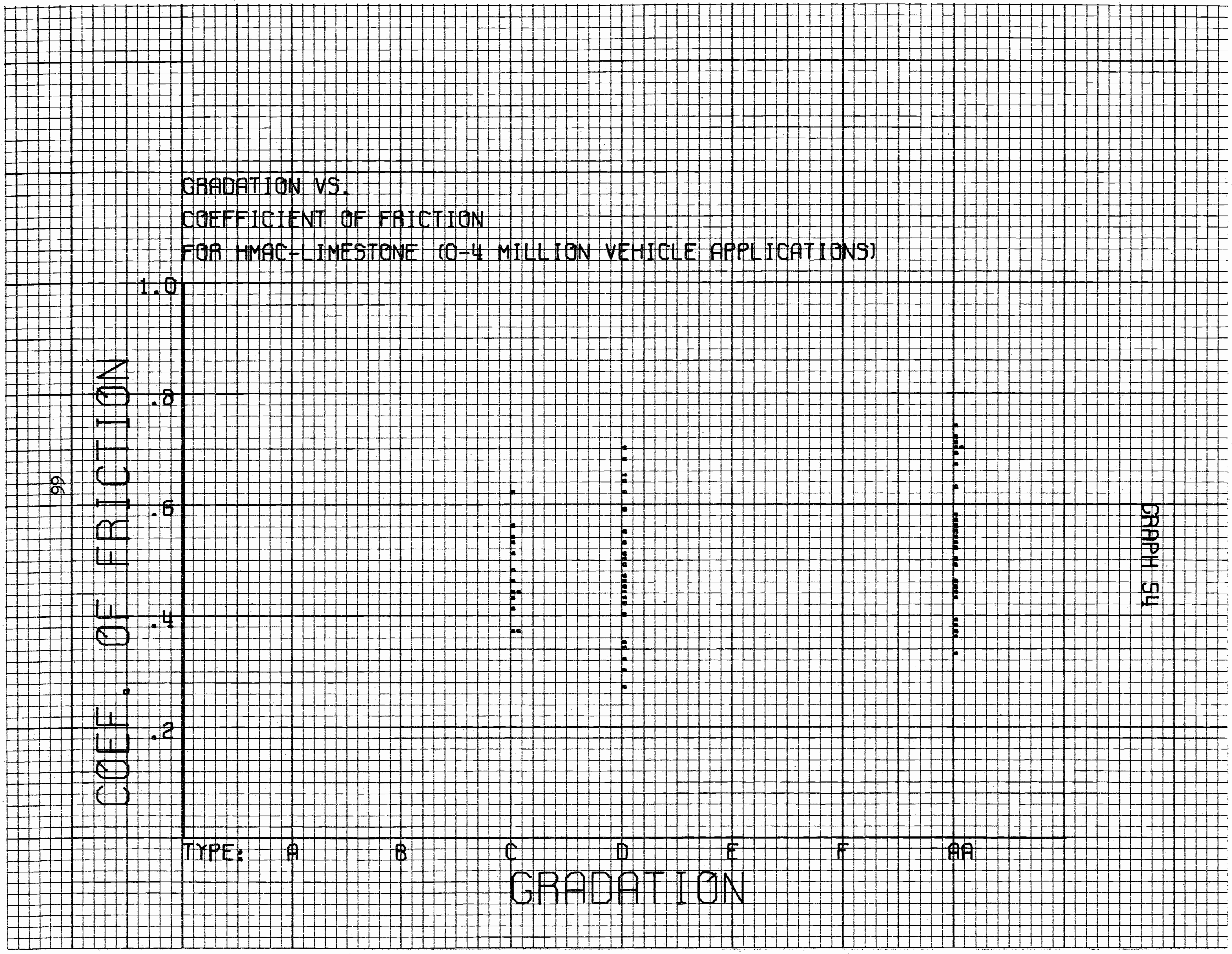
Graph 58 shows the general plot of all surface treatment sections studied. Again no optimum gradation is readily apparent from the plot. Graphs 59 through 61 indicate gradation used for the material types studied.

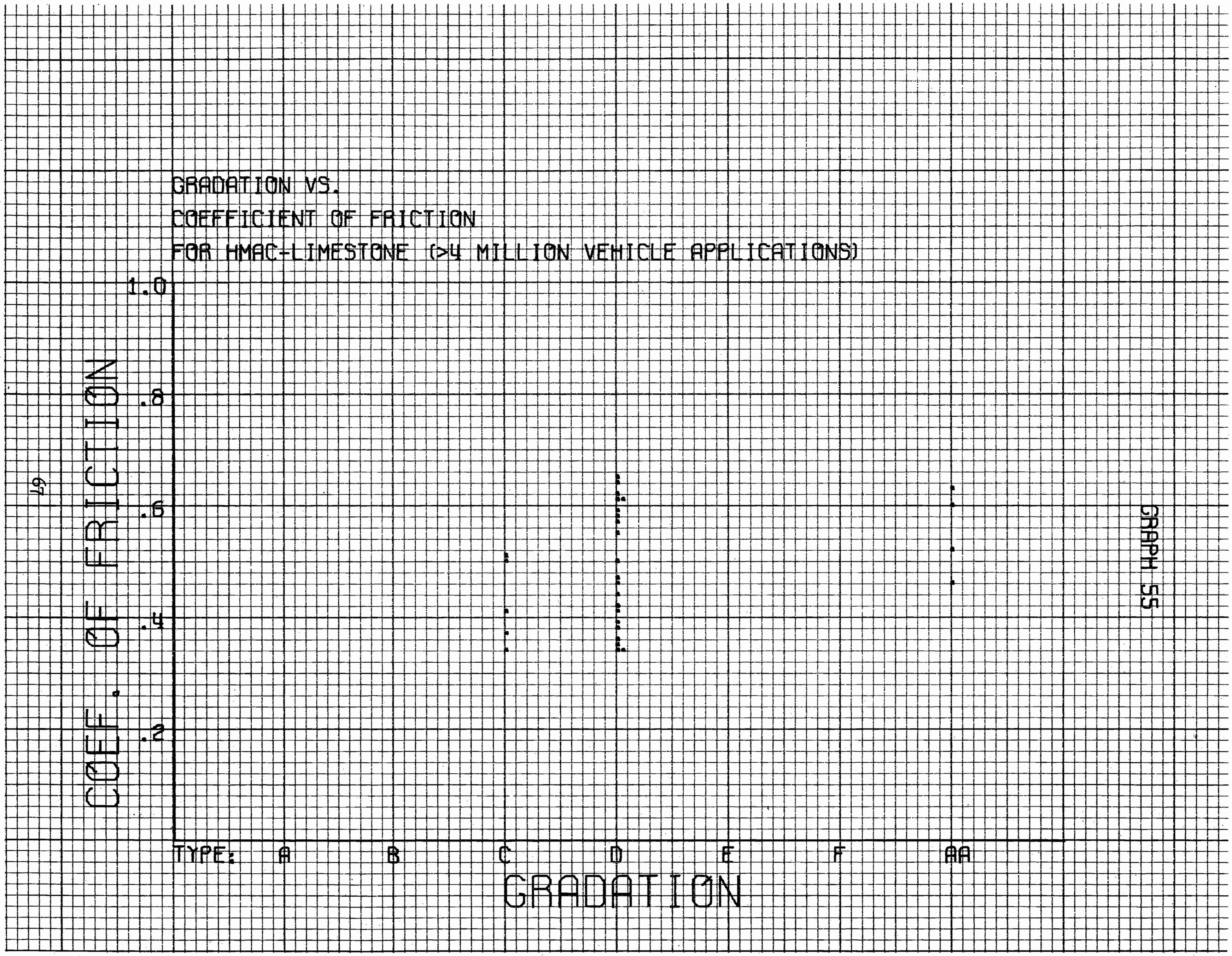
GRAPH 51


GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-ALL SECTIONS
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA BB CC DD DDD FF FFF DS
GRADATION
DS=DISTRICT SELECTED

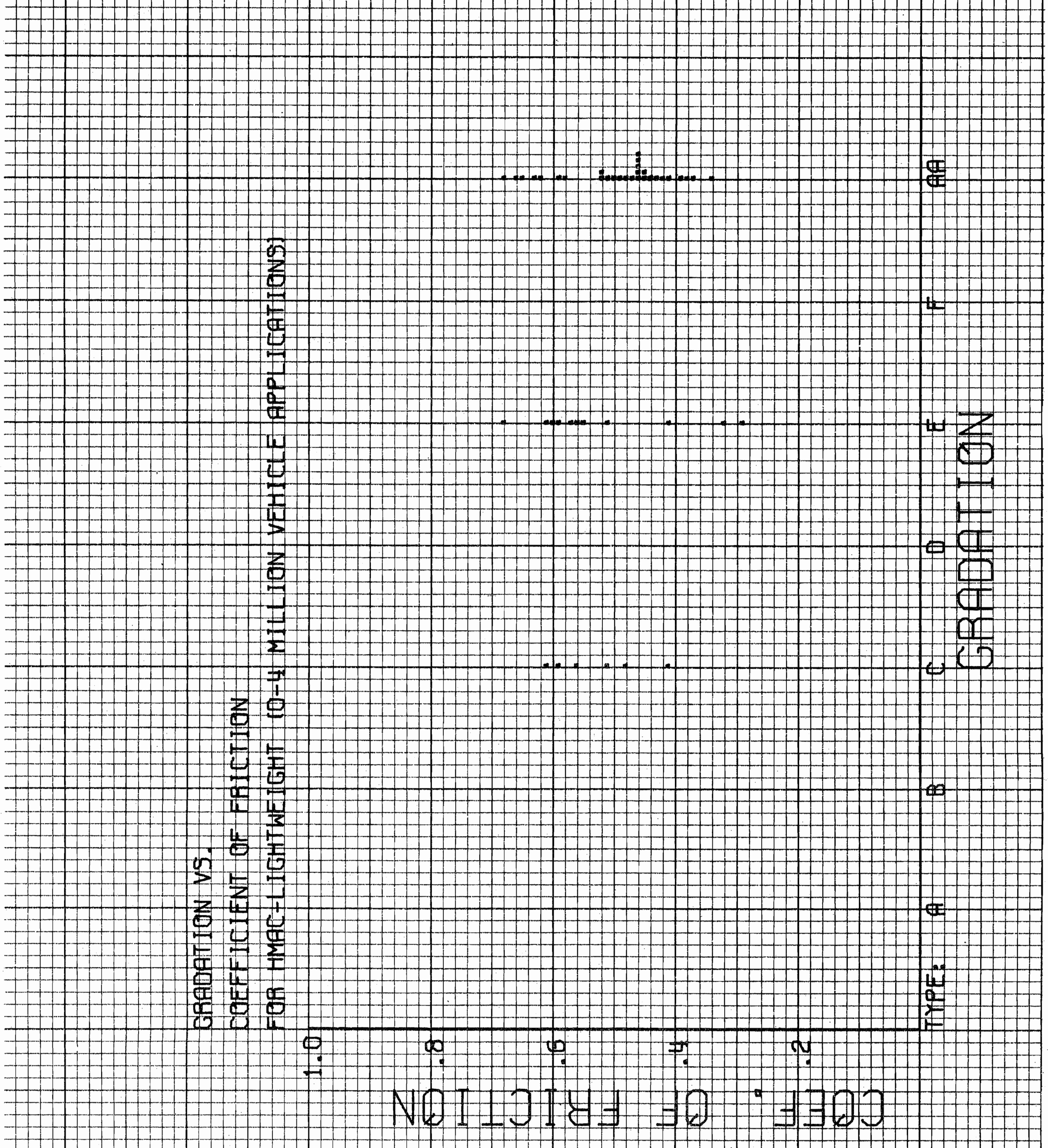

GRAPH 52
GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-SILICIOUS (O-4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA
GRADATION


GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-SILICIOUS (>4 MILLION VEHICLE APPLICATIONS)
GRAPH 53
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA
GRADATION


GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIMESTONE (0-4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA
GRADATION
GRAPH 54

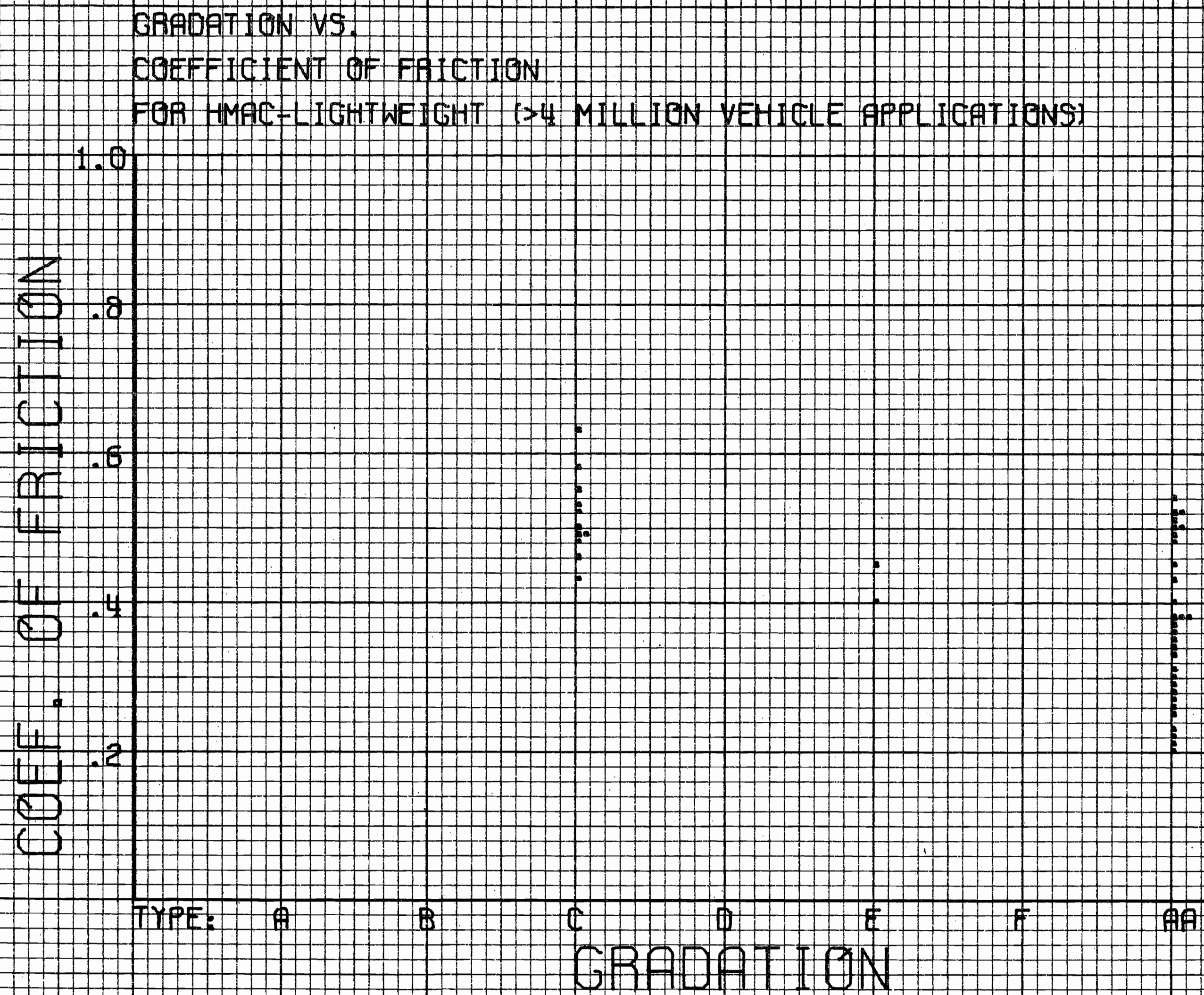

GRAPH 55
GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIMESTONE (>4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA
GRADATION

GRAPH 56

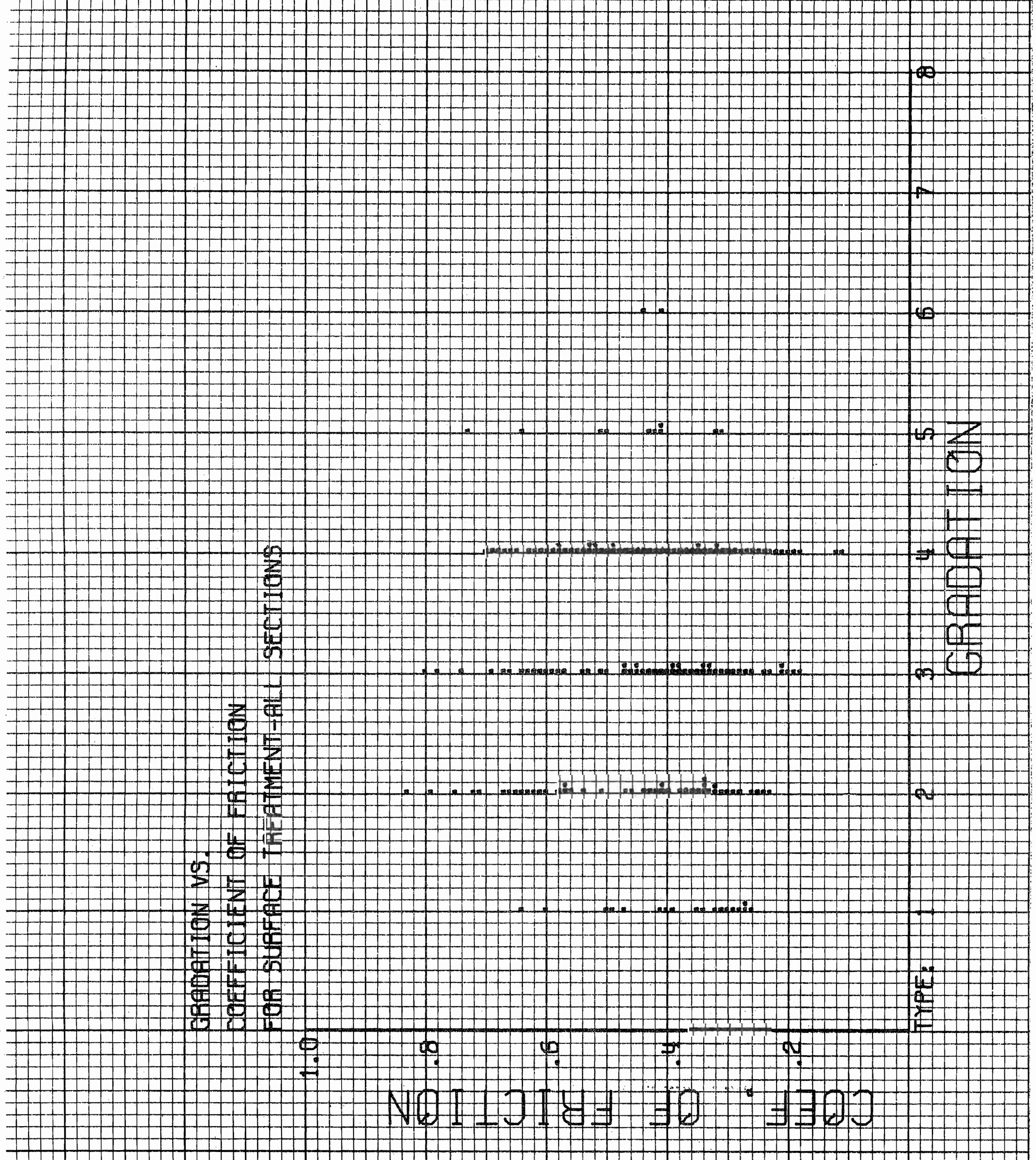


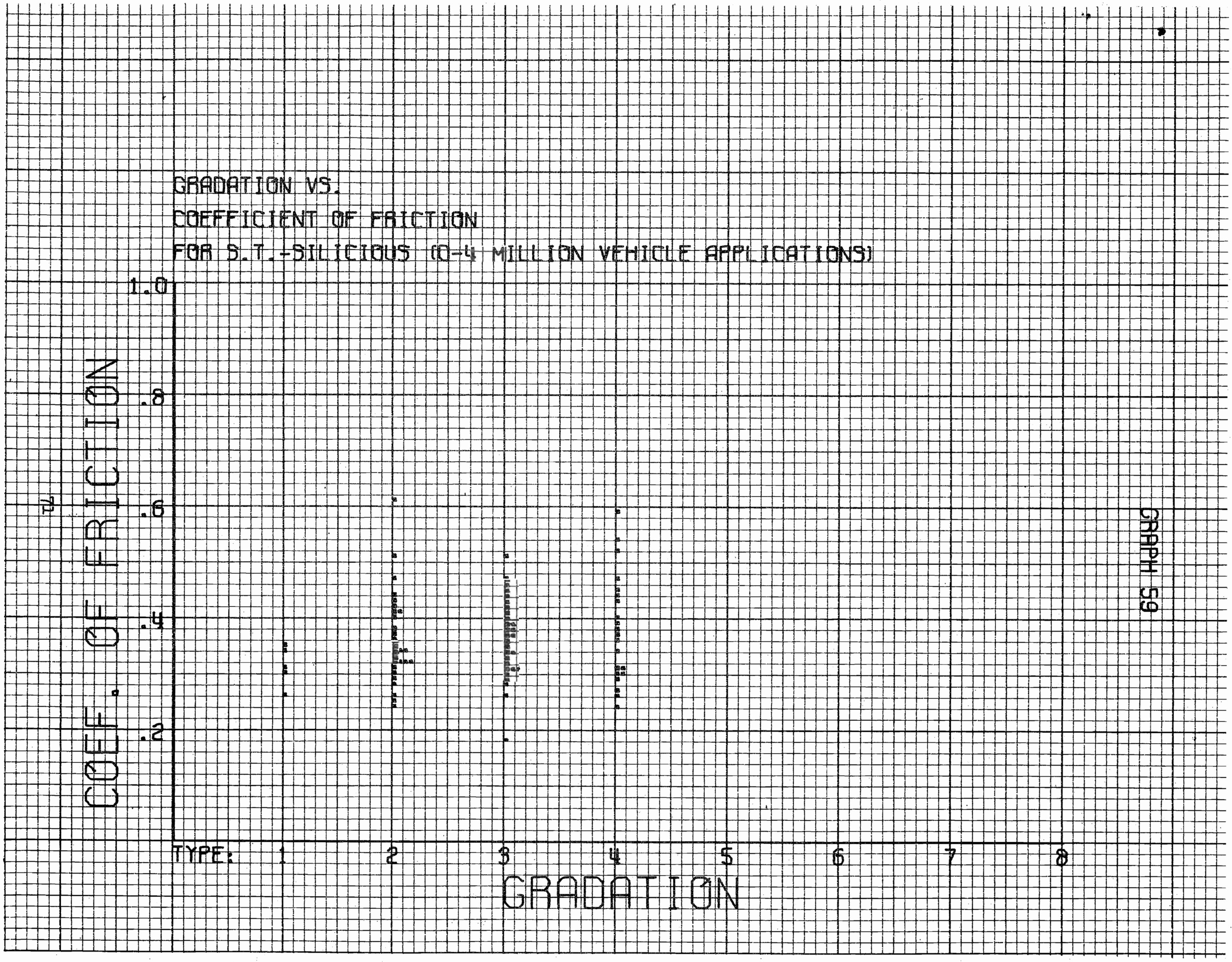
GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIGHTWEIGHT (0-4 MILLION VEHICLE APPLICATIONS)
TYPE: A B C D E F AA
GRADATION
1.0
.8
.6
.4
.2
COEF. OF FRICTION

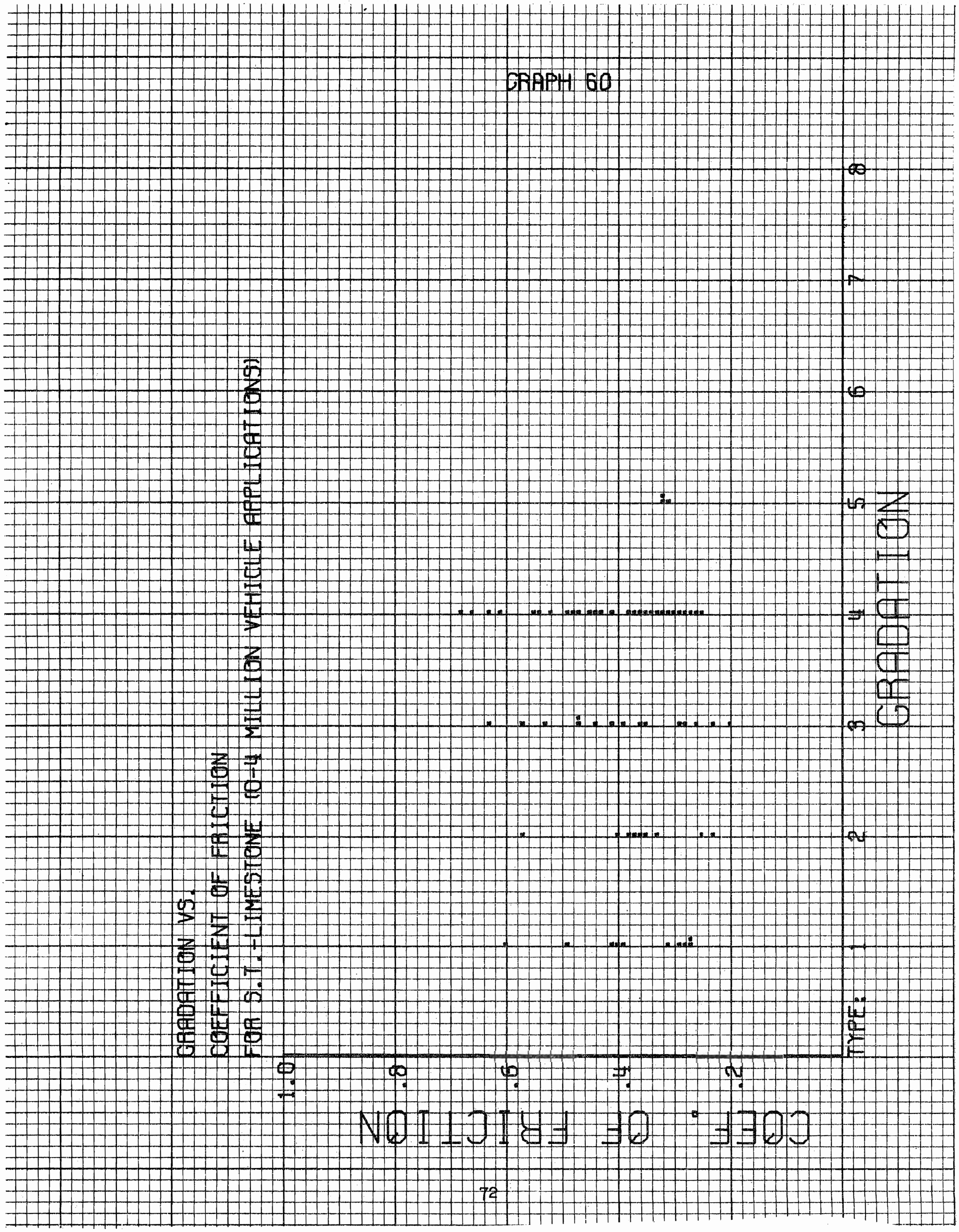
GRAPH 57


GRADATION VS.
COEFFICIENT OF FRICTION
FOR HMAC-LIGHTWEIGHT (>4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: A B C D E F AA
GRADATION

GRAPH 56


GRADATION VS.
COEFFICIENT OF FRICTION
FOR SURFACE TREATMENT-ALL SECTIONS
GRADATION
TYPE: 1 2 3 4 5 6 7 8
COEF OF FRICTION
1.0 .8 .6 .4 .2


GRAPH 59
GRADATION VS.
COEFFICIENT OF FRICTION
FOR S.T.-SILICIOUS (0-4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE:
1
2
3
4
5
6
7
8
GRADATION



GRAPH 60
GRADATION VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIMESTONE (0-4 MILLION VEHICLE APPLICATIONS)
1.0
.8
.6
.4
.2
COEF. OF FRICTION
TYPE: 1
2
3
4
5
6
7
8
GRADATION

GRADATION VS.
COEFFICIENT OF FRICTION
FOR S.T.-LIGHTWEIGHT (0-4 MILLION VEHICLE APPLICATIONS)