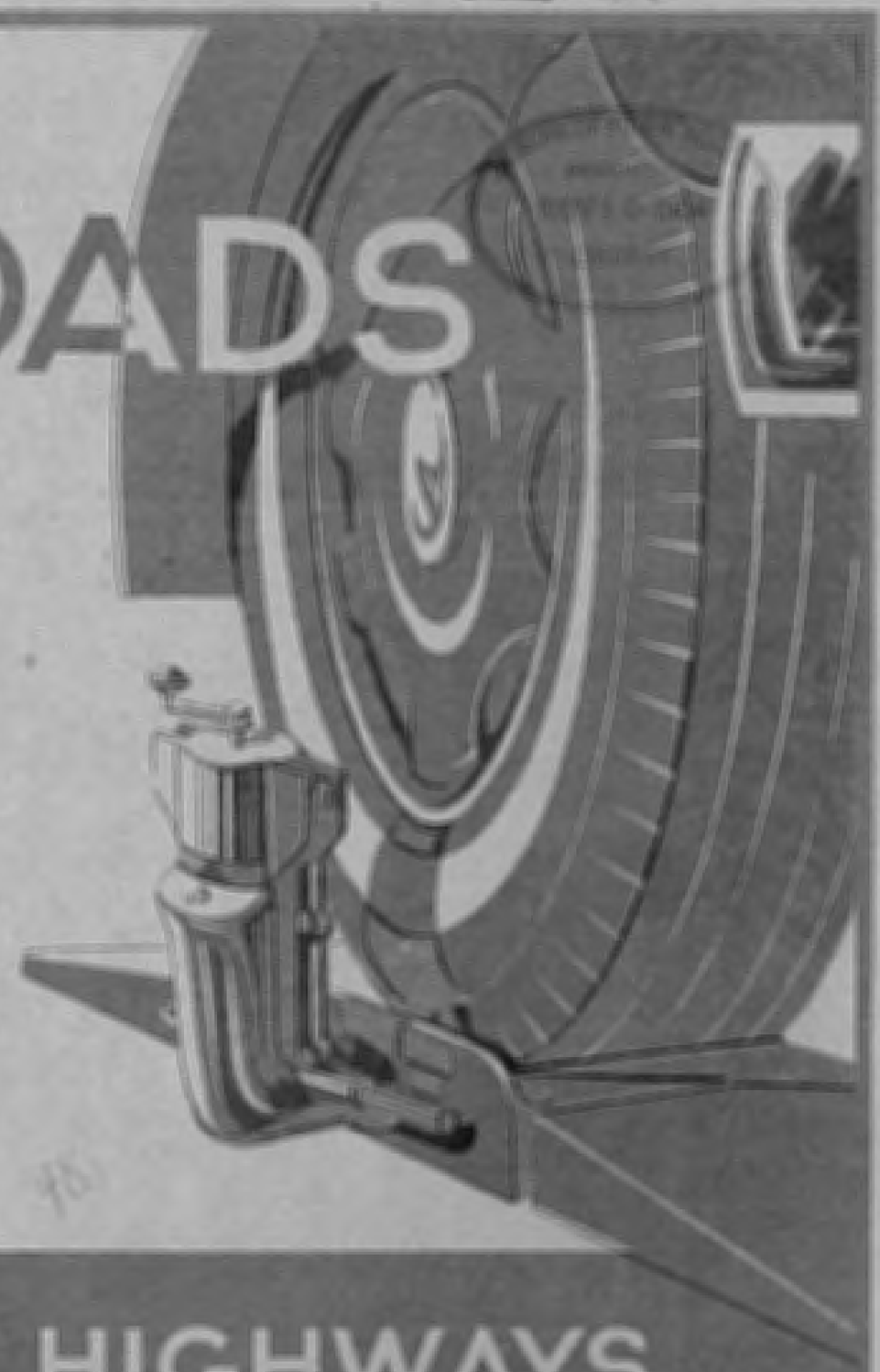
WHEEL LOADS



ON TEXAS HIGHWAYS

TRUCK WEIGHT STUDIES ON STATE HIGHWAYS AND FARM-TO-MARKET ROADS

INTRODUCTION

Weights, dimensions, commodities carried and other operating characteristics of single-unit trucks and truck combinations have been studied by the Highway Planning Survey since 1936. Developing trends concerning weights, wheel loads, etc. were for the State Highway System as a whole and were not readily applicable to individual highways until 1948, when the first wheel load map was published showing weights on individual highways and Farm-to-Market roads.

Truck studies have been continued at representative locations on the Highway System, and from data obtained at these locations, publication of a new wheel load book using 1953 traffic as a base is made possible.

General comments concerning the basis for the selection of the design wheel load have been included as a matter of interest. It is beyond the scope of this book to present detailed data concerning the design of pavements for various wheel loads.

1/ Discussion relative to design by Design Division of Texas Highway Department.

Tables 1 through 5 inclusive are of considerable interest in an analysis of the increase in gross weight limit since 1951.

BASIS FOR SELECTION OF DESIGN WHEEL LOAD 1/

The average of the ten heaviest daily wheel loads was selected as the basis of design. Preliminary study indicated that while the maximum wheel load could be expected to fluctuate considerably from day to day, the average of a few of the heaviest wheel loads would probably furnish a stable figure. The problem then was how to determine the fewest number of the heaviest daily wheel loads, which, when averaged, would furnish a figure both stable and useful in design.

The average of the ten heaviest wheel loads resulted in a stable figure. Its adaptability to design was established as a result of the following considerations:

Concrete Pavement

If it is considered that ten wheel loads with magnitude equal to the average of the ten heaviest wheel loads

expected daily are repeated daily on a concrete pavement for a thirty-year period, the resulting number of repetitions in each direction is about 50,000. Limited research on the fatigue of sound concrete in flexure indicates that if a concrete pavement is constructed with a thickness to withstand, initially, a single application of a load approximately double the repeated load, the pavement at the end of the thirty-year period and 50,000 applications of the load in each lane, will have a strength greater than the stress due to the repeated load. Hence, the pavement could be said to be economically designed, with an initial safety factor of 2.0, if loaded exactly as assumed.

Actually, however, two load conditions not previously considered will most certainly arise during the life of the pavement. These are:

(1) Millions of applications of loads lighter than the design load will occur.

(2) Approximately 25,000 applications of loads heavier than the design load will occur in each lane.

Research has indicated that the light load applications should have no detrimental effect on the concrete. There is also experimental evidence that the concrete may be expected to withstand the 25,000 heavier applications in the absence of any future increase in the average of the ten heaviest wheel loads expected daily.

Actually the trend in axle loads in excess of 18,000 pounds, as shown in Table 4, is downward. It is noted in this table in 1950 there were 27 such loads per 100 combination vehicles. In 1953 there were 17 axles exceeding 18,000 pounds. This downward trend is undoubtedly due to the increase in the proportion of tandem axles.

Flexible Pavement

Data presented in the maps on the following pages can be used directly in the design of a flexible base by those districts equipped with triaxial testing devices. If, in special cases, a marked increase in wheel loads is expected to occur within the design life of the pavement due to local development, the reported wheel load should be increased accordingly.

VARIATION OF PAVEMENT DEPTH WITH WHEEL LOAD

The following simple relationships between required depths of flexible or rigid single-layer pavements resting on deep, uniform formations may prove useful in interpreting the data on the district wheel load maps:

Assume that the correct depth of a given type of pavement subjected to wheel loads falling within the "8,000 and under" category is known for a given set of conditions. For comparative purposes; represent this depth by unity. Then it may be shown that the theoretical depth of this pavement type required in any of the other wheel load categories, if all other conditions remain unchanged, is the depth given in the following table:

Wheel Load Category (Lbs.)	Probable Wheel Load (Lbs.)	Relative Depth
8,000 & Under	7,000	1.00
8,001 - 10,000	9,000	1.13
10,001 - 12,000	11,000	1.25
12,001 & Over	13,000	1.36

A more detailed discussion of the application of wheel load data to the design of pavements appears in the "Texas Highway Department Plan Preparation Manual - Book II."

DISCUSSION OF BASIC DATA

The tabulation on the following page is of interest in comparing the average weights of axles on trucks of different types. These data were obtained from loadometer stations at which trucks were weighed at all hours during the year 1953. The average weight of each axle of each vehicle type was obtained by weighing 65,881 axles on both loaded and empty trucks.

In the first column of the tabulation the average weight of trucks of each type is shown. The next column, "Axle A," denotes the front axle of the truck, "Axle B" the second axle from the front, etc. Average wheel load for each axle is obtained by dividing the average axle load by two.

AVERAGE AXLE WEIGHT OF EACH AXLE
ON EACH TRUCK TYPE IN 1953

Truck Type	Average Truck Weight	Average Axle Weight				
		Axle A	Axle B	Axle C	Axle D	Axle E
Single - Unit 2-Axle	12026	4060	7966			
% Distribution	100%	34%	66%			
Single - Unit 3-Axle	27114	7268	10502	9344		
% Distribution	100%	28%	38%	34%		
Combination 3-Axle	26136	4858	10880	10398		
% Distribution	100%	18%	42%	40%		
Combination 4-Axle	39884	6420	12638	10278	10548	
% Distribution	100%	16%	32%	26%	26%	
Combination 5-Axle	47700	6094	9646	10996	10452	10512
% Distribution	100%	13%	20%	23%	22%	22%

EFFECT OF INCREASE IN GROSS WEIGHT LIMIT OF TRUCK-TRACTOR SEMI-TRAILER COMBINATION VEHICLES

Through an analysis of loadometer survey data made in September 1950, it was predicted by the Planning Survey that an increase in gross weight limit would encourage the use of combination vehicles of four or more axles by allowing an addition to the pay load in an amount to justify the cost and required dead load weight of additional axles. The three axle combination vehicles were producing an excessive proportion of axle loads exceeding 18,000 pounds and were then in preponderance.

The increase of gross weight from 48,000 pounds to 58,420 pounds by the Legislature in 1951 has produced the anticipated result. There is more tonnage being carried by truck-tractor semi-trailer combinations, with a moderate increase in the proportion of these vehicles occurring in the make-up of rural traffic, without appreciable increase in the proportion of illegal axle weights.

The data on the following page as extracted from Loadometer Survey records indicate the trend.

Table 1

TRUCK-TRACTOR SEMI-TRAILER COMBINATIONS
EXPRESSED AS A PERCENTAGE
OF TOTAL VEHICLES OF ALL TYPES APPEARING
AT 125 MANUAL COUNT STATIONS

Year	3-Axle	4-Axle	5-Axle	Total
1947	5.11%	0.90%	0.02%	6.03%
1948	4.58%	1.42%	0.04%	6.04%
1949	4.33%	1.65%	0.04%	6.02%
1950	4.05%	2.37%	0.06%	6.48%
1951	3.74%	2.72%	0.07%	6.53%
1952	2.94%	3.62%	0.07%	6.63%
1953	2.82%	4.51%	0.18%	7.51%

Table 2

TYPE OF TRUCK-TRACTOR SEMI-TRAILER
COMBINATIONS EXPRESSED AS PERCENTAGE
OF ALL TRUCK-TRACTOR COMBINATIONS
APPEARING AT 125 MANUAL COUNT STATIONS

Year	3-Axle	4-Axle	5-Axle	Total
1947	84.8%	14.9%	0.03%	100.0%
1948	75.8%	23.5%	0.70%	100.0%
1949	71.9%	27.4%	0.70%	100.0%
1950	62.5%	36.6%	0.90%	100.0%
1951	57.3%	41.6%	1.10%	100.0%
1952	44.3%	54.6%	1.10%	100.0%
1953	37.6%	60.1%	2.30%	100.0%

From Table 1, which is related to all rural traffic, there appears a decided drop in the percentage of 3-axle combinations from 1950 forward with a corresponding increase in 4-axle combinations, while except for the year 1953, the percentage of all types of combinations shows a nominal increase. Part of the increase in 1953 could be attributed to the apparent decrease in total traffic during 1953.

Table 2, related to combinations only, shows a reversal in the proportion of 3-axle to 4-axle combinations between 1950 and 1953. The growth in 5-axle combinations, which were in a minor position prior to 1950, is significant between 1950 and 1953.

Data concerning gross weight and axle loads hereinafter presented are based on loadometer operations which have been maintained at 20 fixed locations on representative highways over a period of years.

Table 3

TRUCK-TRACTOR SEMI-TRAILER COMBINATIONS
GROSS WEIGHT IN EXCESS OF 40,000 POUNDS PER
100 LOADED AND EMPTY COMBINATIONS OF ALL TYPES

Year	3-Axle	4-Axle	5-Axle	Total
1947	4.4	4.8	-	9.2
1948	9.2	10.5	-	19.7
1949	11.8	10.8	0.3	22.9
1950	9.6	16.8	0.5	26.9
1951	8.7	21.5	0.7	30.9
1952	5.0	28.6	1.0	34.6
1953	2.9	30.5	1.5	34.9

The increase in proportion of the heavier loads is indicated in Table 3. This table is based on a gross weight of 40,000 pounds, which is the maximum weight which was in the past and is now allowed to register on 3-axle combinations. The decrease of gross weights exceeding registered weights since 1950, indicated in Column 2 applying to 3-axle combinations, is due to the decrease in the proportion of 3-axle combinations previously set out in Table 2. The

increase in the proportion of gross weights exceeding 40,000 pounds as applied to 4 and 5-axle combinations indicated in Columns 3 and 4, could be obtained under legal registration and is not significant. However, an 8 per cent increase in weights of all types of combinations exceeding 40,000 indicates that total weights have been increased as could be expected.

Table 4

TRUCK-TRACTOR SEMI-TRAILER COMBINATION AXLE LOADS IN EXCESS OF 18,000 POUNDS PER 100 LOADED AND EMPTY COMBINATIONS OF ALL TYPES
(Dual Axles Considered as 2 Single Axles)

Year	3-Axle	4-Axle	5-Axle	Total
1947	9	2	-	11
1948	17	5	-	22
1949	19	5	-	24
1950	18	9	-	27
1951	14	10	-	24
1952	9	12	-	22
1953	5	12	-	17

Previous to 1950, tandem axles as applied to 4 and 5-axle combinations, appeared in insignificant amounts. The 18,000-pound axle load was the breaking point in analyses of Texas traffic. Table 4 immediately preceding indicates a decrease in the proportion of combinations of all classes bearing axle loads in excess of 18,000 pounds between 1950 and 1953 (Column 5). A decrease from 27 to 17 axles exceeding 18,000 for each 100 combinations is indicated.

Table 5 has been prepared from machine tabulations to determine the effect of the gross weight increase on legal axle loads. Single axles are limited to 18,000 pounds and tandem axle groups to 32,000 pounds.

Table 5

TRUCK-TRACTOR SEMI-TRAILER COMBINATION AXLE LOADS IN EXCESS OF 18,000 POUNDS FOR SINGLE AXLES AND 16,000 POUNDS PER AXLE IN TANDEM AXLE GROUPS PER 100 LOADED AND EMPTY COMBINATIONS OF ALL TYPES

Year	3-Axle	4-Axle	5-Axle	Total
1950	18	12	-	30
1951	14	15	-	29
1952	9	20	-	29
1953	5	19	1	25

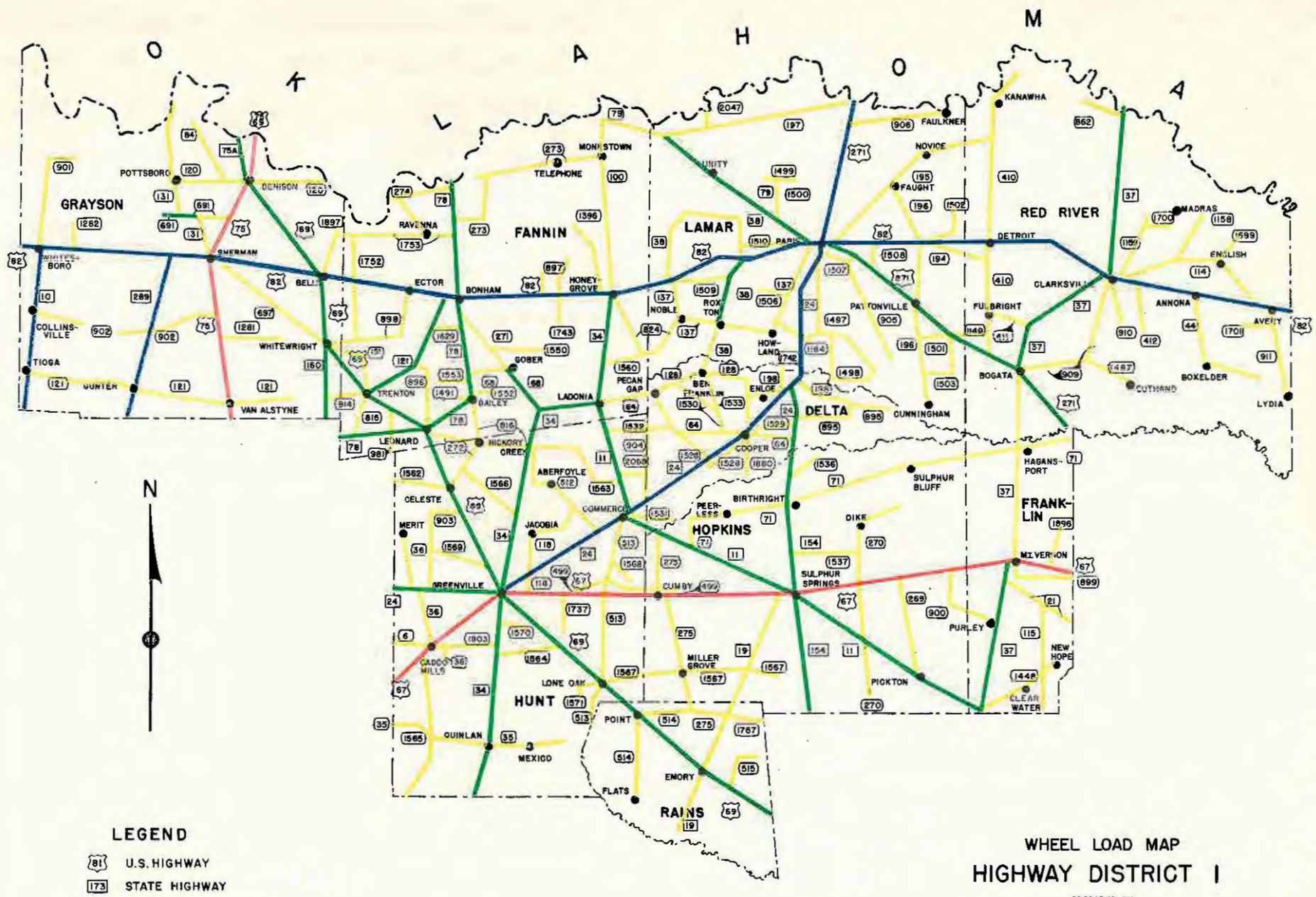
The 3-axle combinations, Table 5, Column 2, all in excess of the 18,000-pound axle group have decreased in the proportion of overloaded axles corresponding to decrease in proportion of these units traveling. The 4-axle combinations, Column 3, with one tandem group carrying in excess of 16,000 pounds on each axle have increased in proportion between 1951 and 1953 but at a lesser rate than indicated for the decrease in proportion shown for the 3-axle combinations although the increase in proportion of 4-axle combinations found traveling equaled the decrease in 3-axle combinations traveling. A drop in the proportion of illegal axles between 1950 and 1953 is indicated in Column 5.

DESCRIPTION OF MAPS

After the establishment of critical wheel loads for design purposes, it was necessary to develop a method of presentation that would be applicable to individual highways. On Highway District maps the average of the ten heaviest wheel loads for an average day has been shown by color. Highways shown in yellow on the maps are those with wheel loads under 8,000 pounds; green represents highways with wheel loads from 8,001 to 10,000 pounds; blue, wheel loads from 10,001 to 12,000 pounds, and red 12,001 pounds and over. This presentation is not made for the purpose of showing violations of the State load law. The primary purpose is to establish wheel load groups which will furnish acceptable design criteria for various highways.

It should be noted that due to restricted bridges on the highway system, existing wheel loads at such points do not always indicate the wheel loads for which the road should be designed. Many restricted bridges are now carrying wheel loads far above the restrictions, while others, where the restrictions are enforced, are in line with the restrictions.

In a study as broad as this there is the possibility of some inconsistencies. Much time and effort have been expended to make the study as accurate as possible. It is hoped that the wheel load maps will be of real value to Designing and District Engineers in interpreting the behavior of existing pavements and in determining the most economical depth and type for new construction.



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

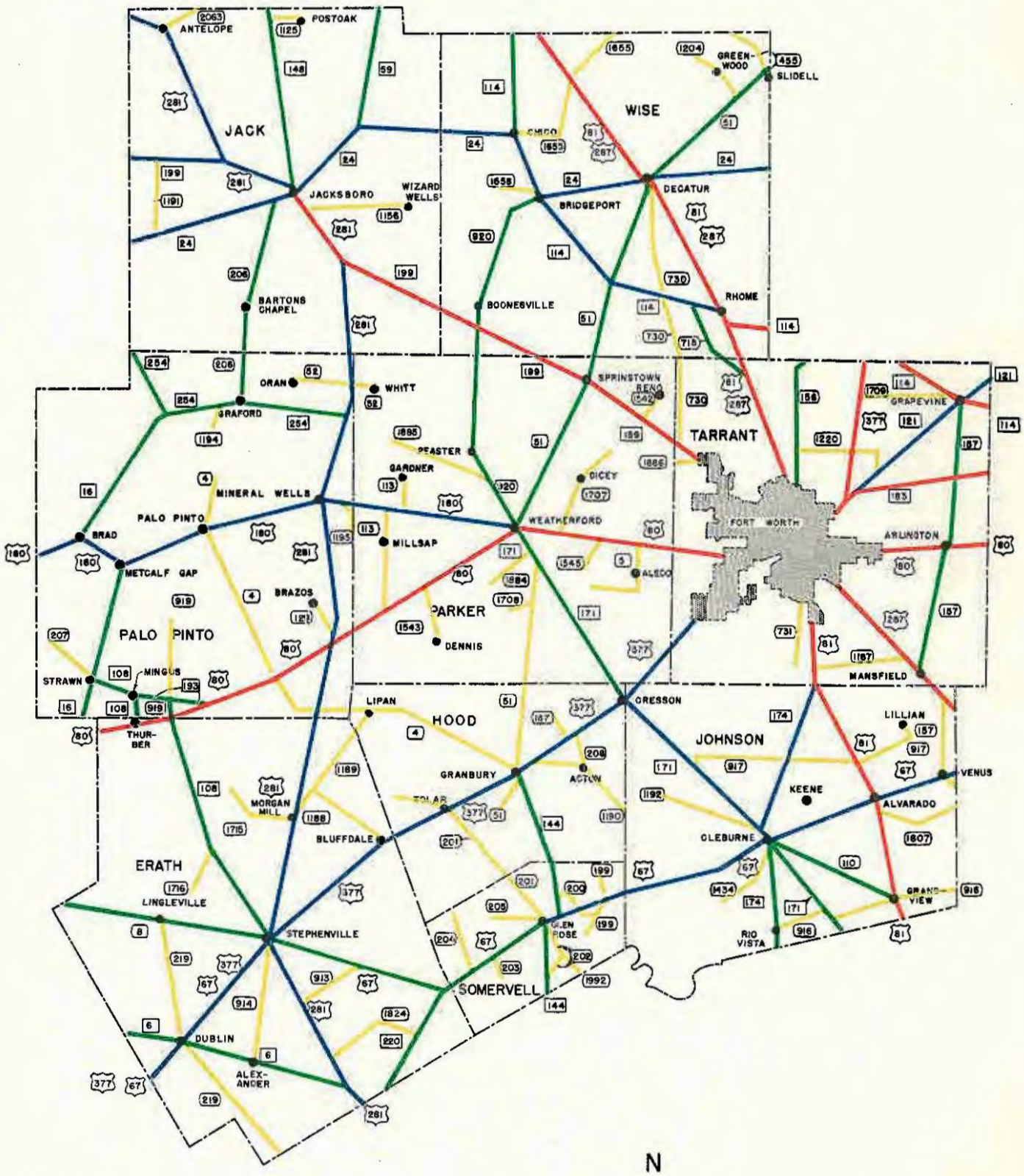
POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 1

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- 81 U.S. HIGHWAY
- 173 STATE HIGHWAY
- 142 FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

N

WHEEL LOAD MAP
HIGHWAY DISTRICT 2

PREPARED BY
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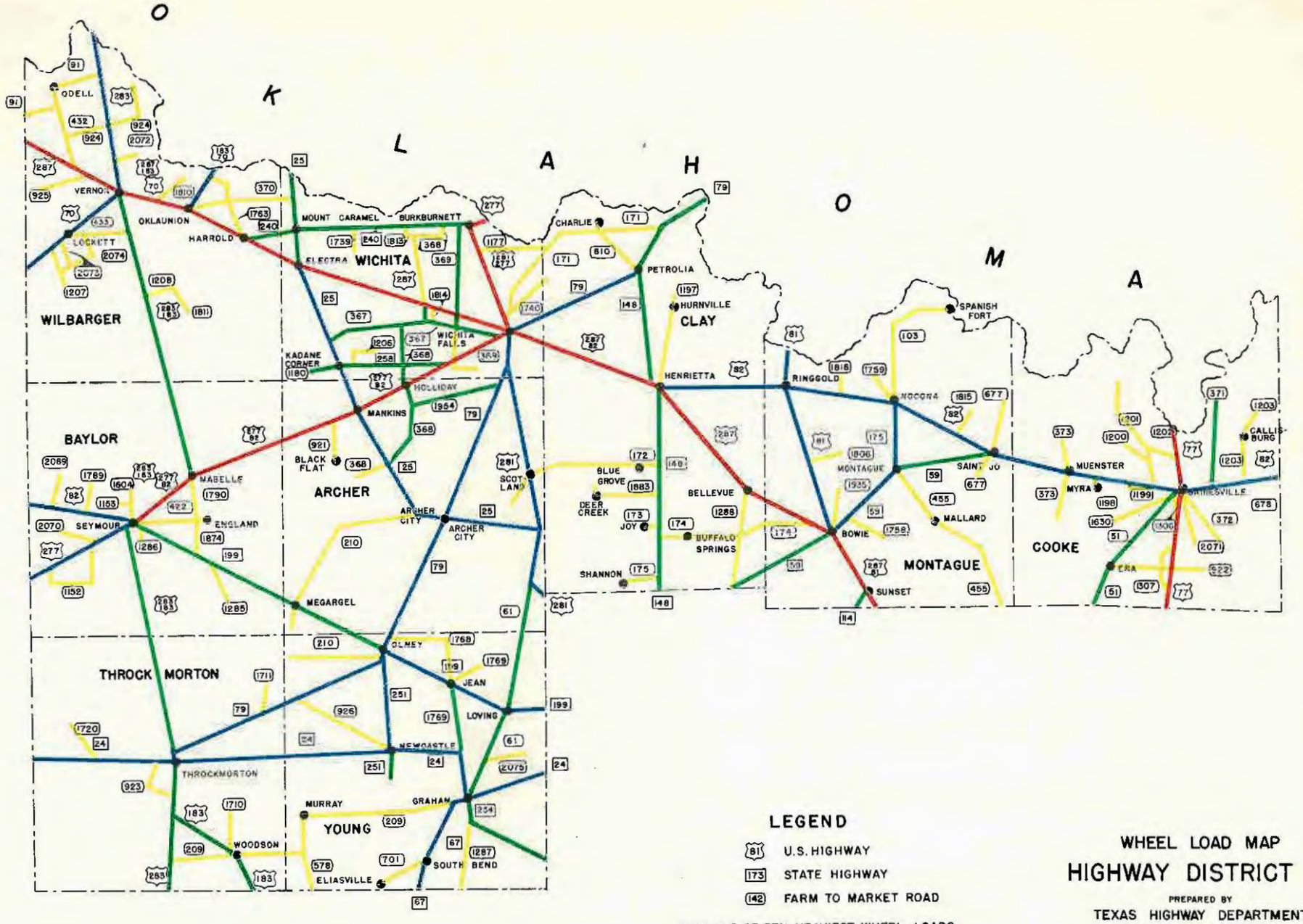
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 - 10,000
- 10,001 - 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 3

PREPARED BY
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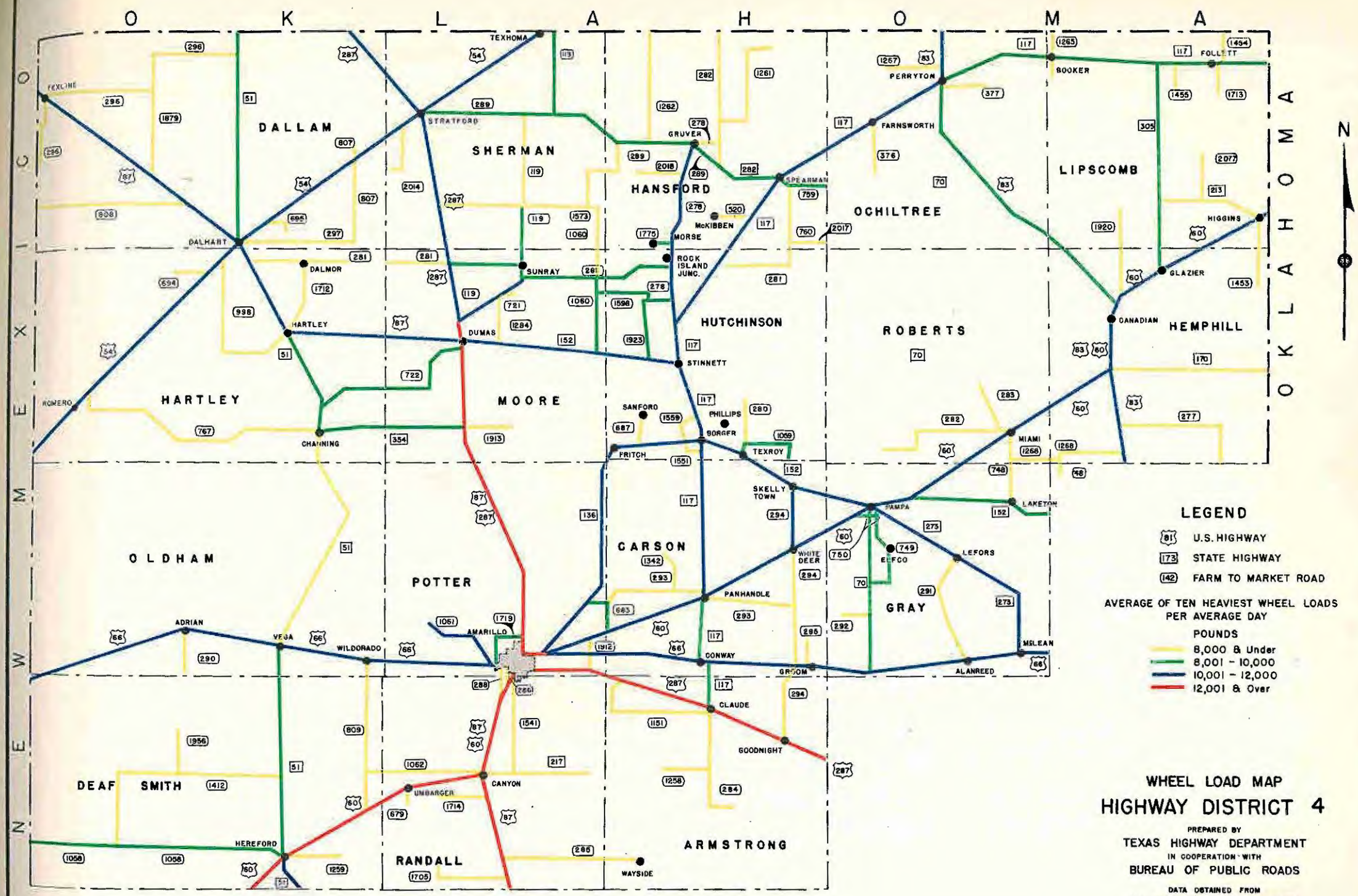
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 4

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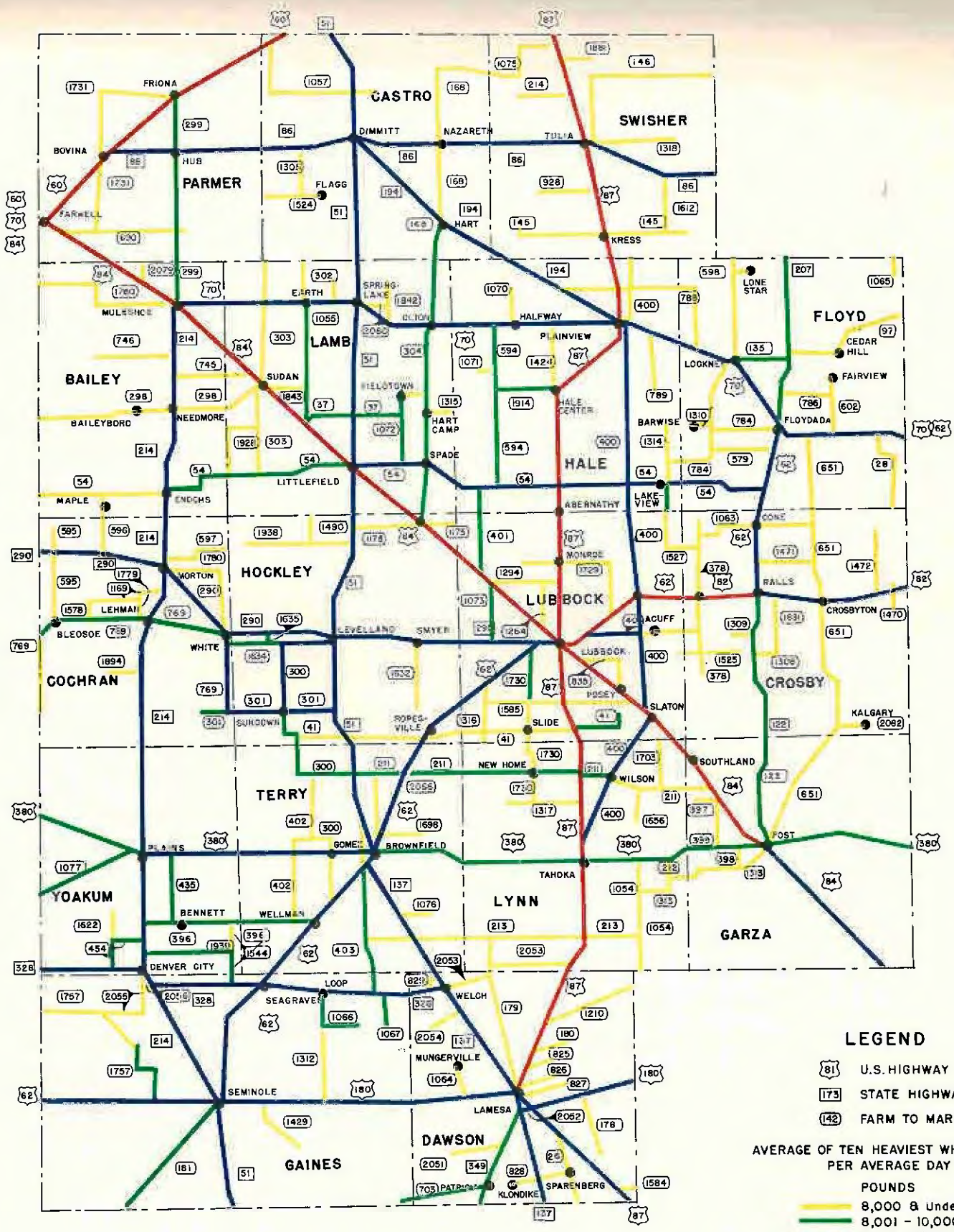
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 5

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IN COOPERATION WITH
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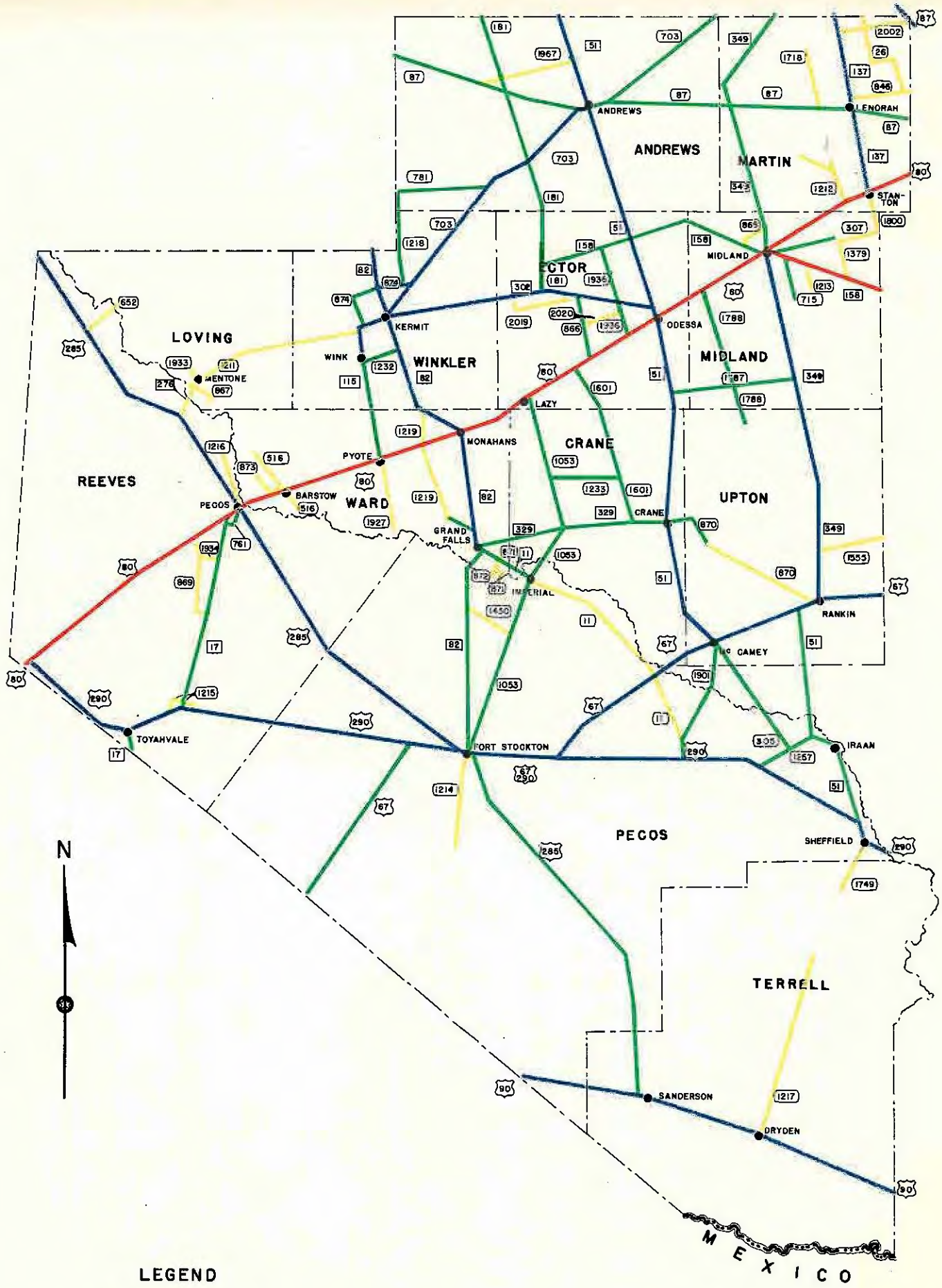
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 6

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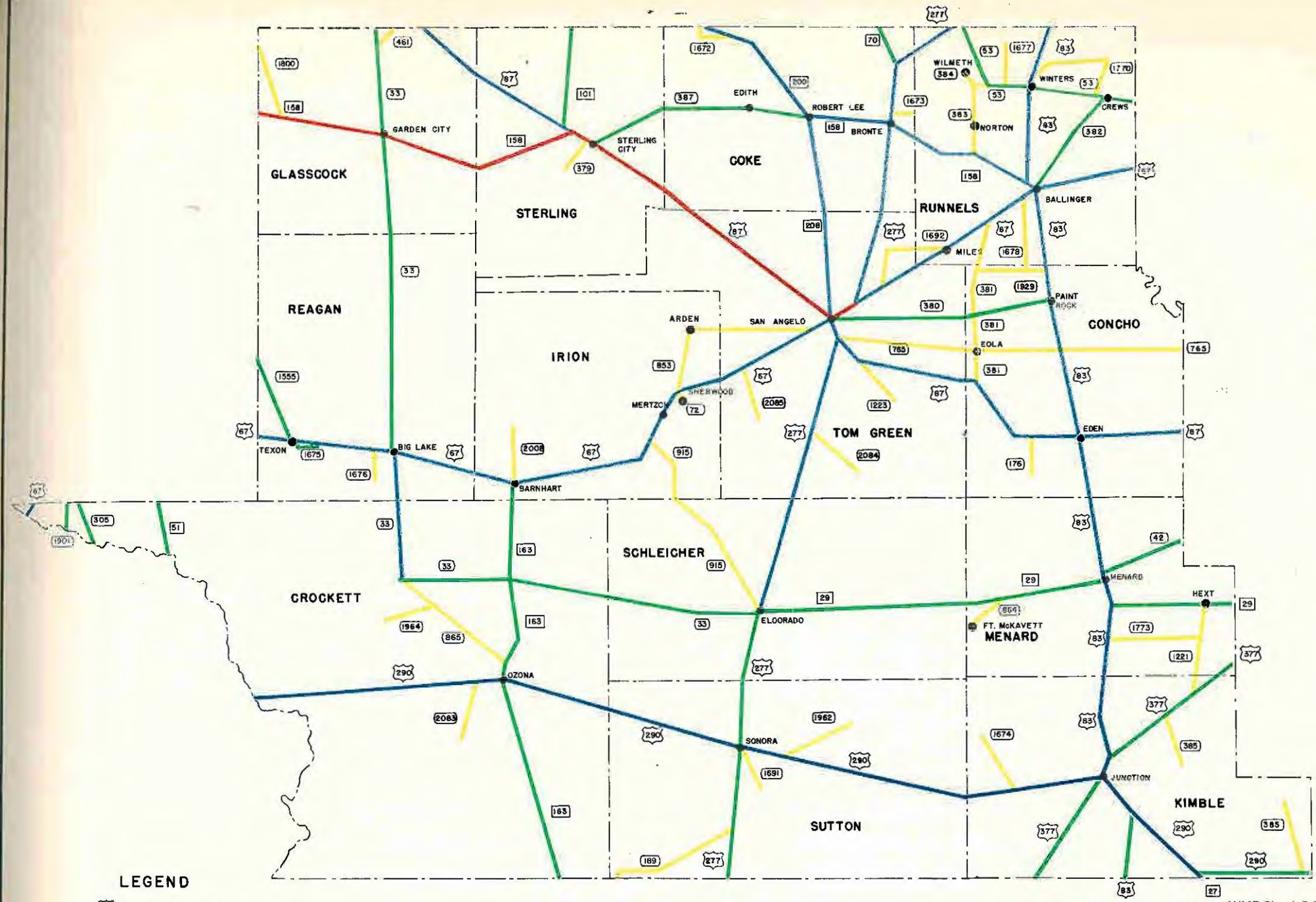
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 7

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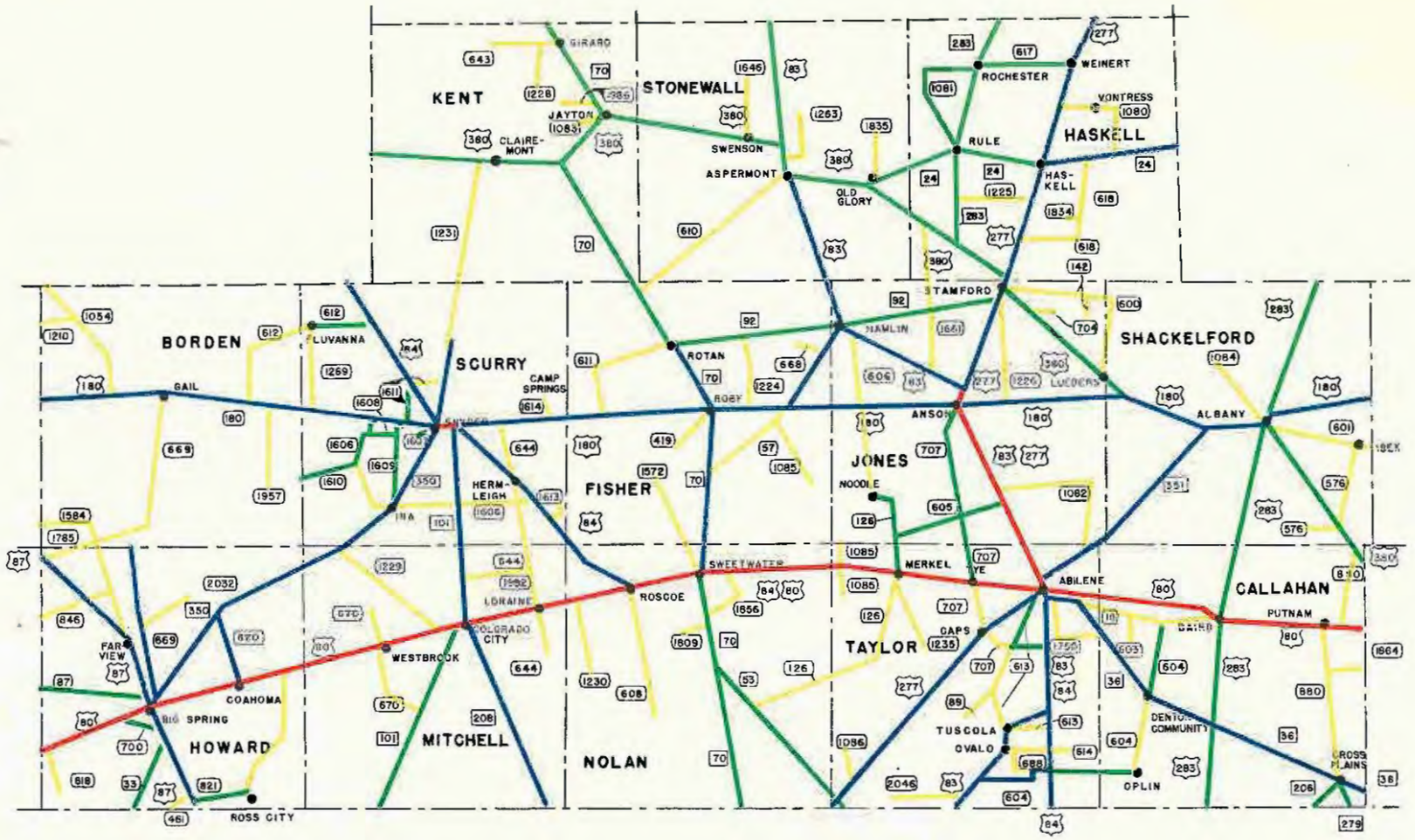
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

N

WHEEL LOAD MAP
HIGHWAY DISTRICT 8

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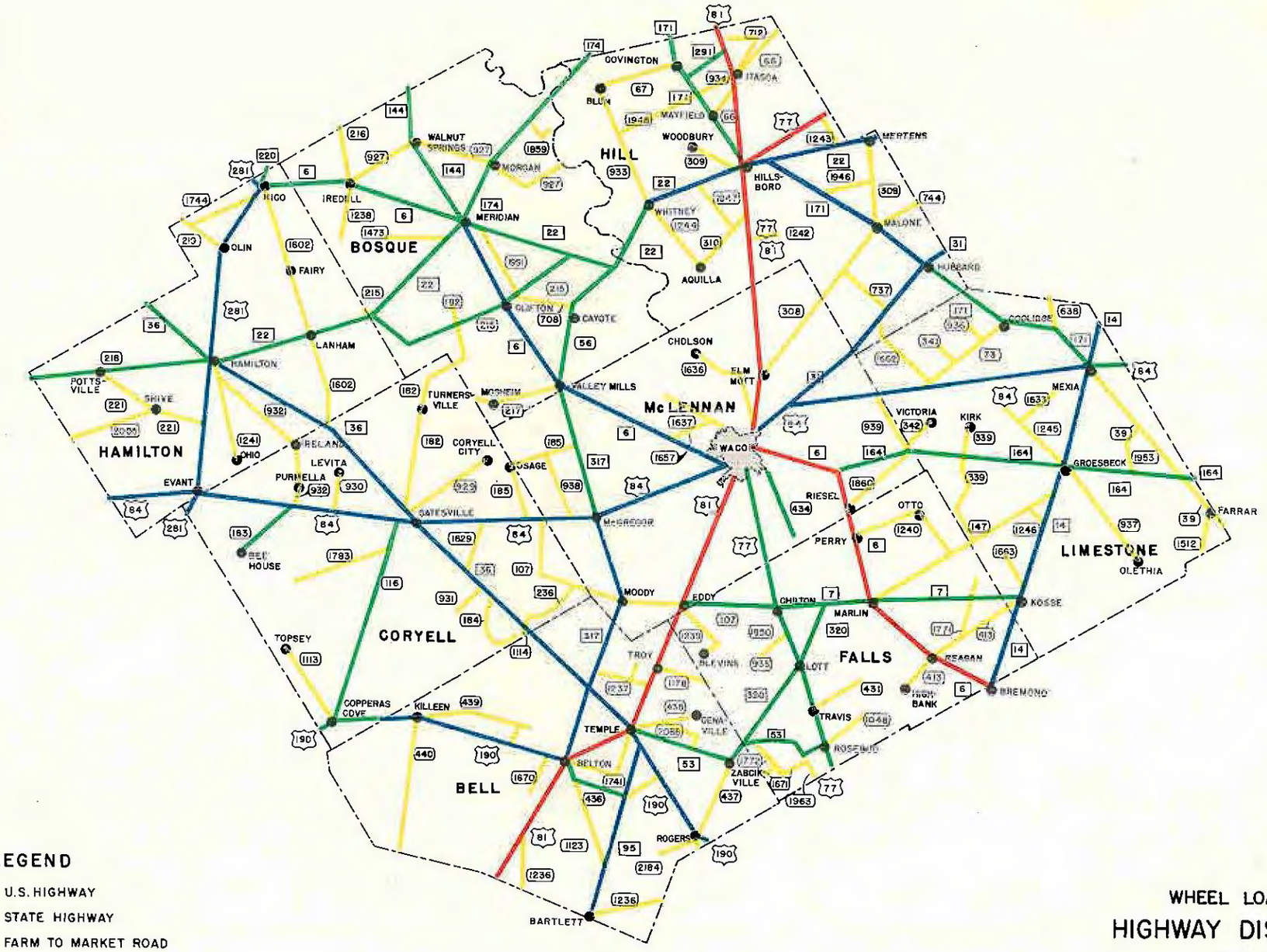
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 - 10,000
- 10,001 - 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 9

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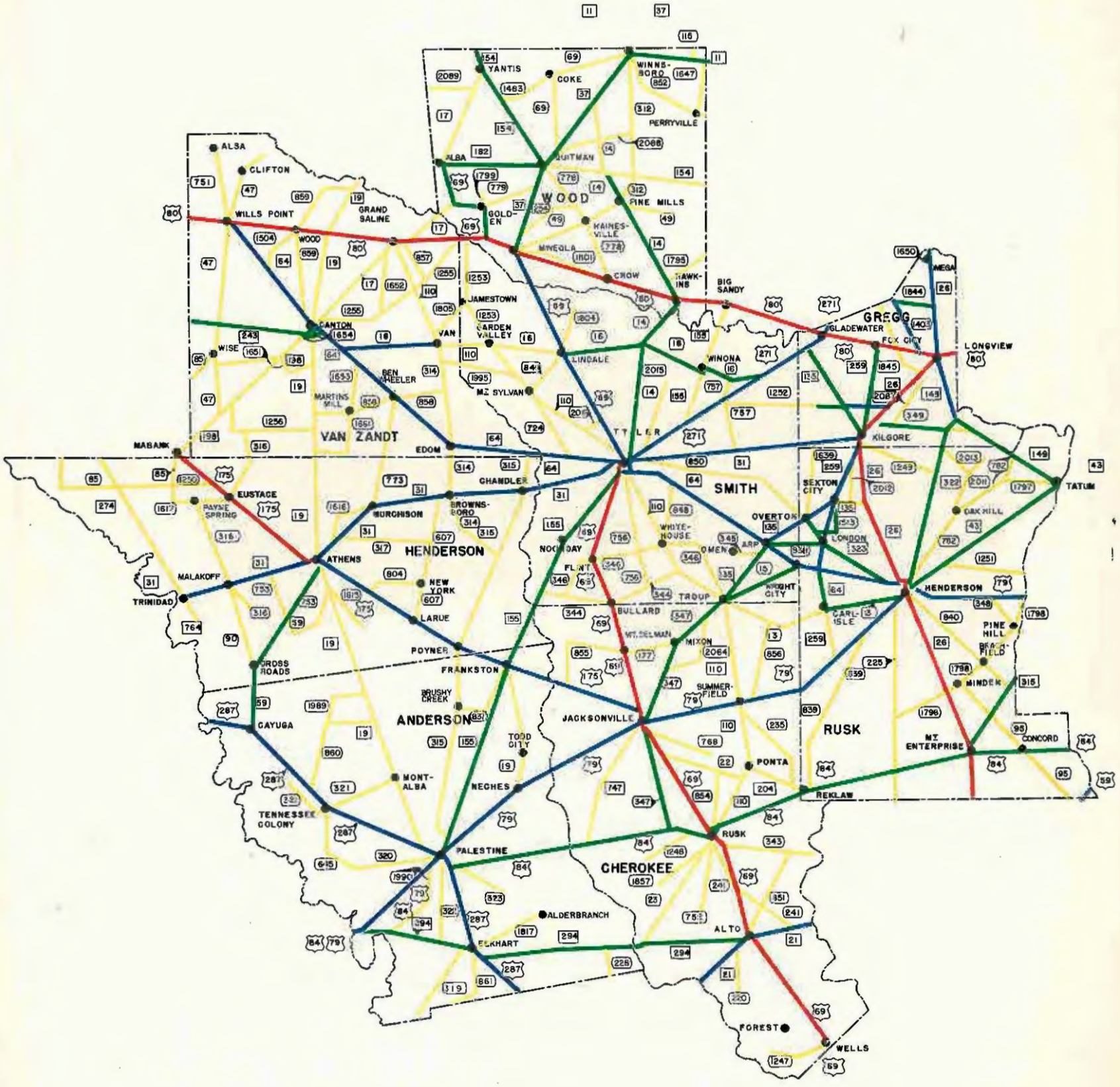
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- 81 U.S. HIGHWAY
- 173 STATE HIGHWAY
- 142 FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

N

WHEEL LOAD MAP
HIGHWAY DISTRICT 10

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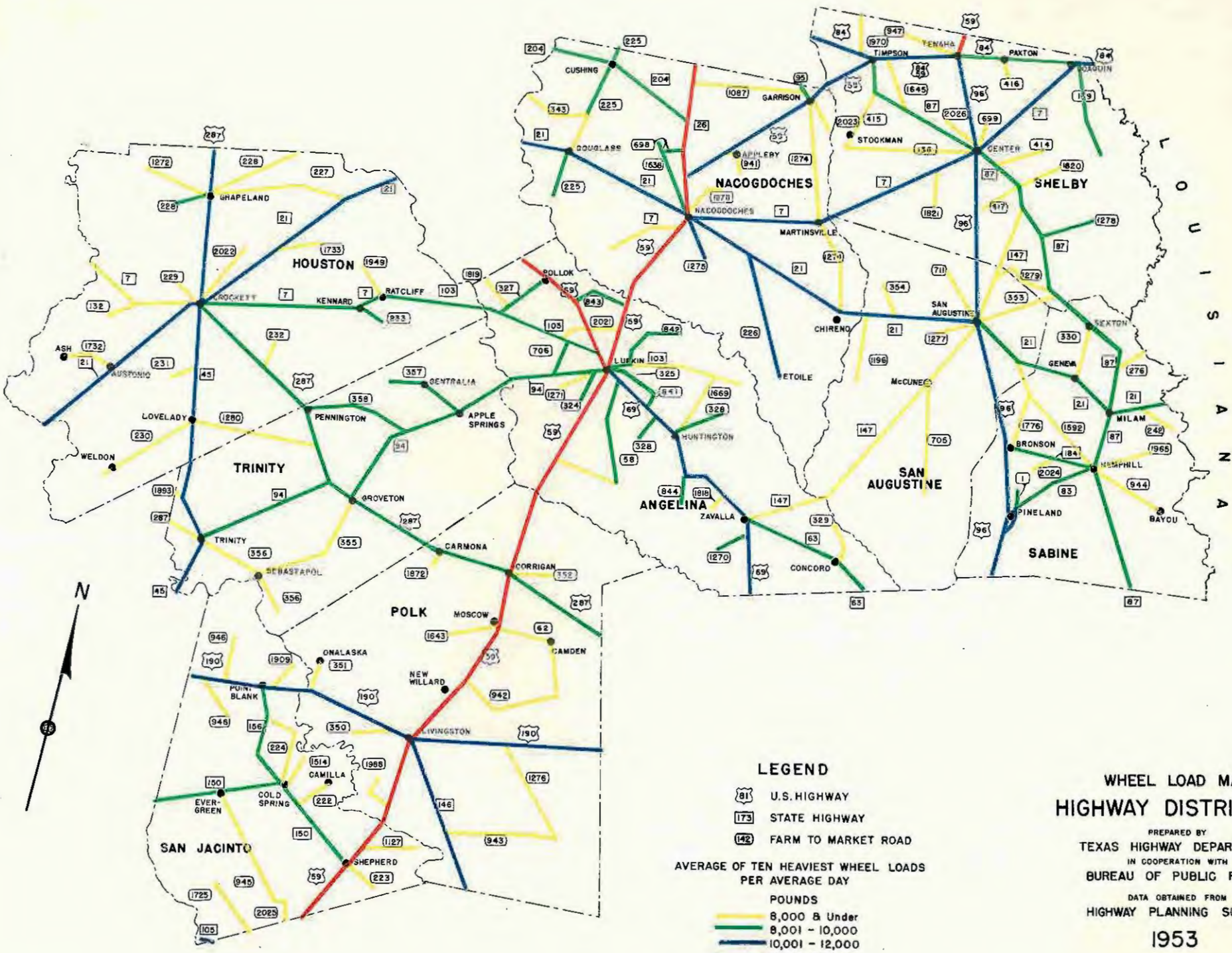
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT II

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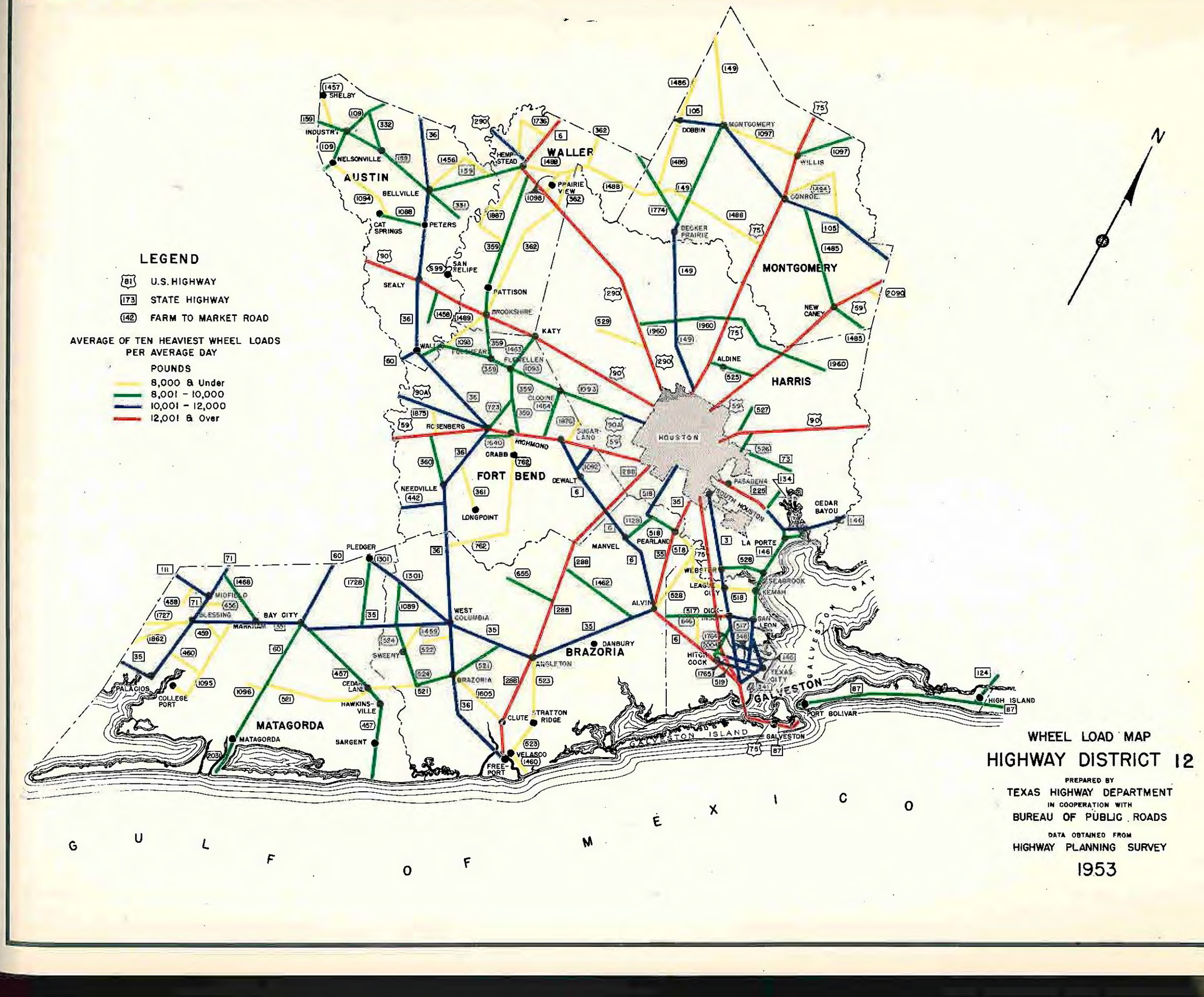
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 12

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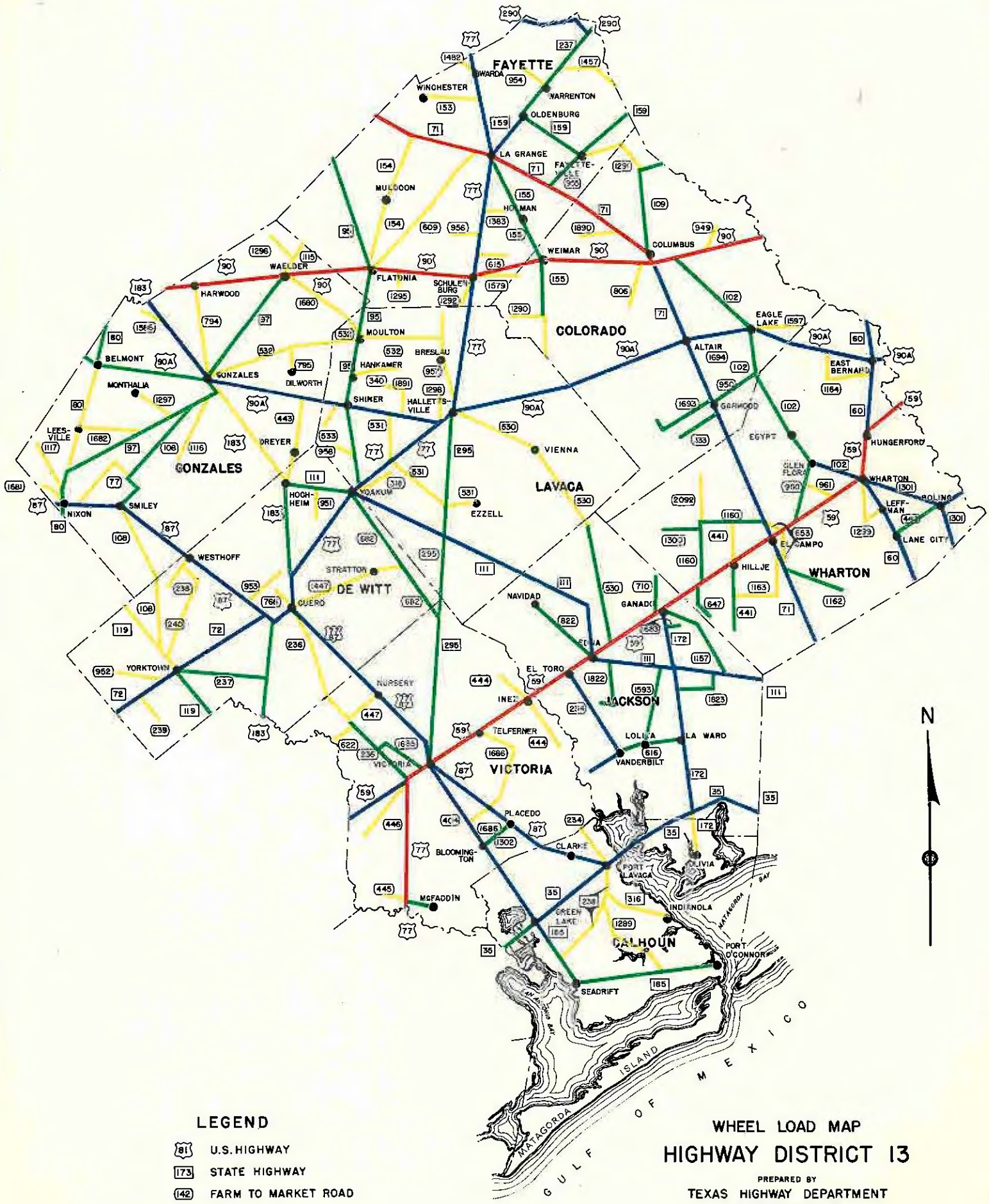
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

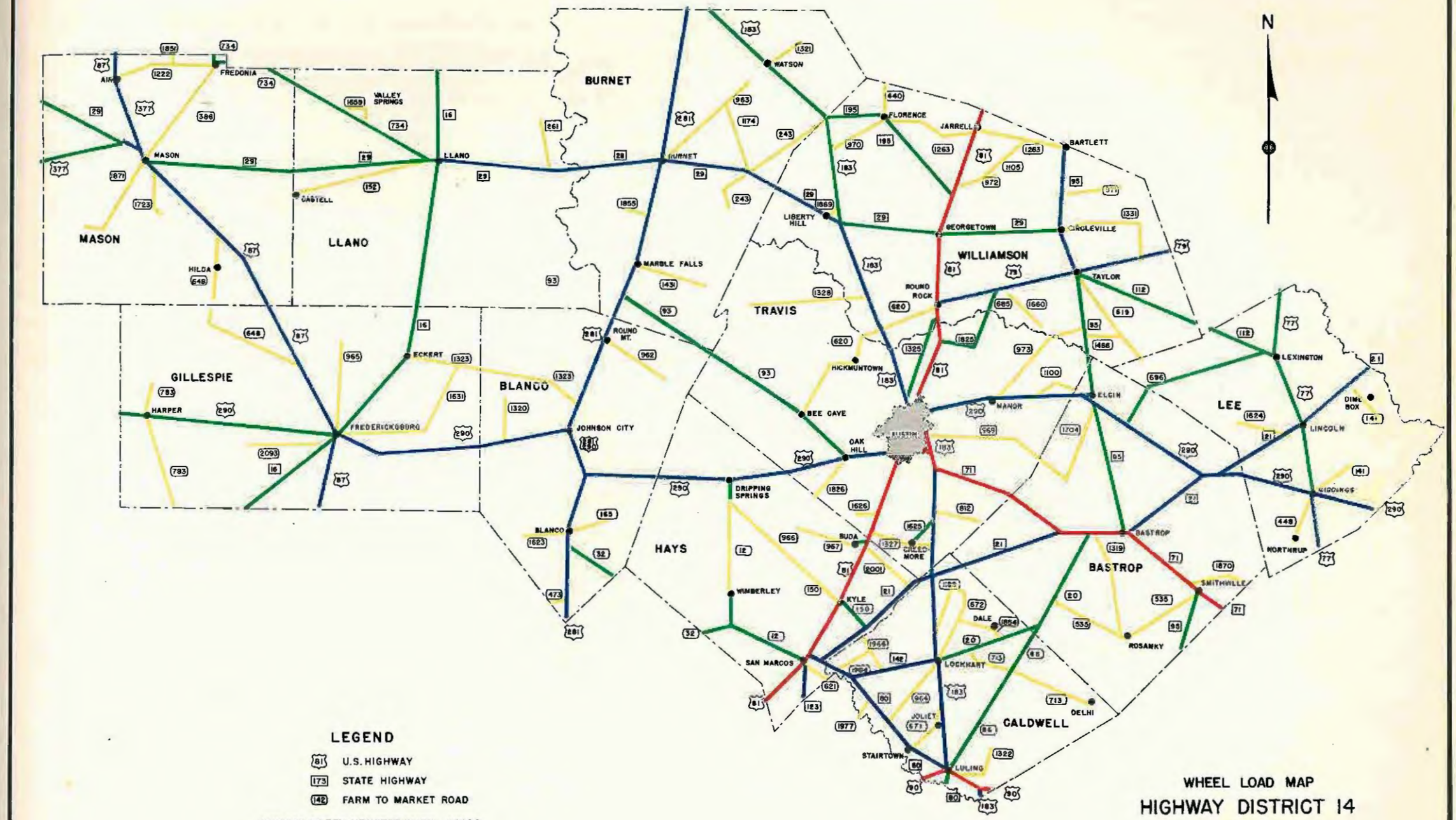
- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 13

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 14

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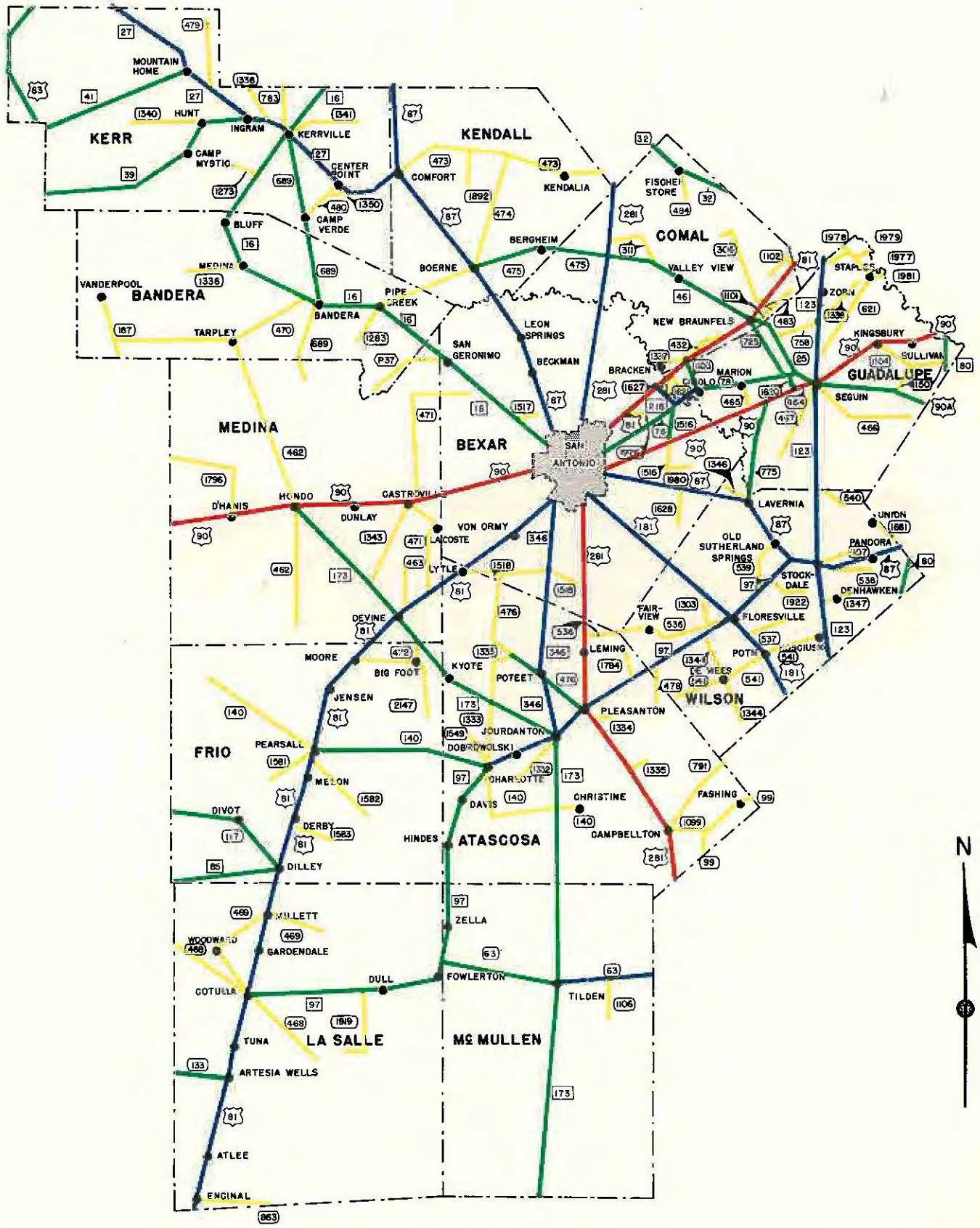
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- 81 U.S. HIGHWAY
- 173 STATE HIGHWAY
- 142 FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 15

PREPARED BY
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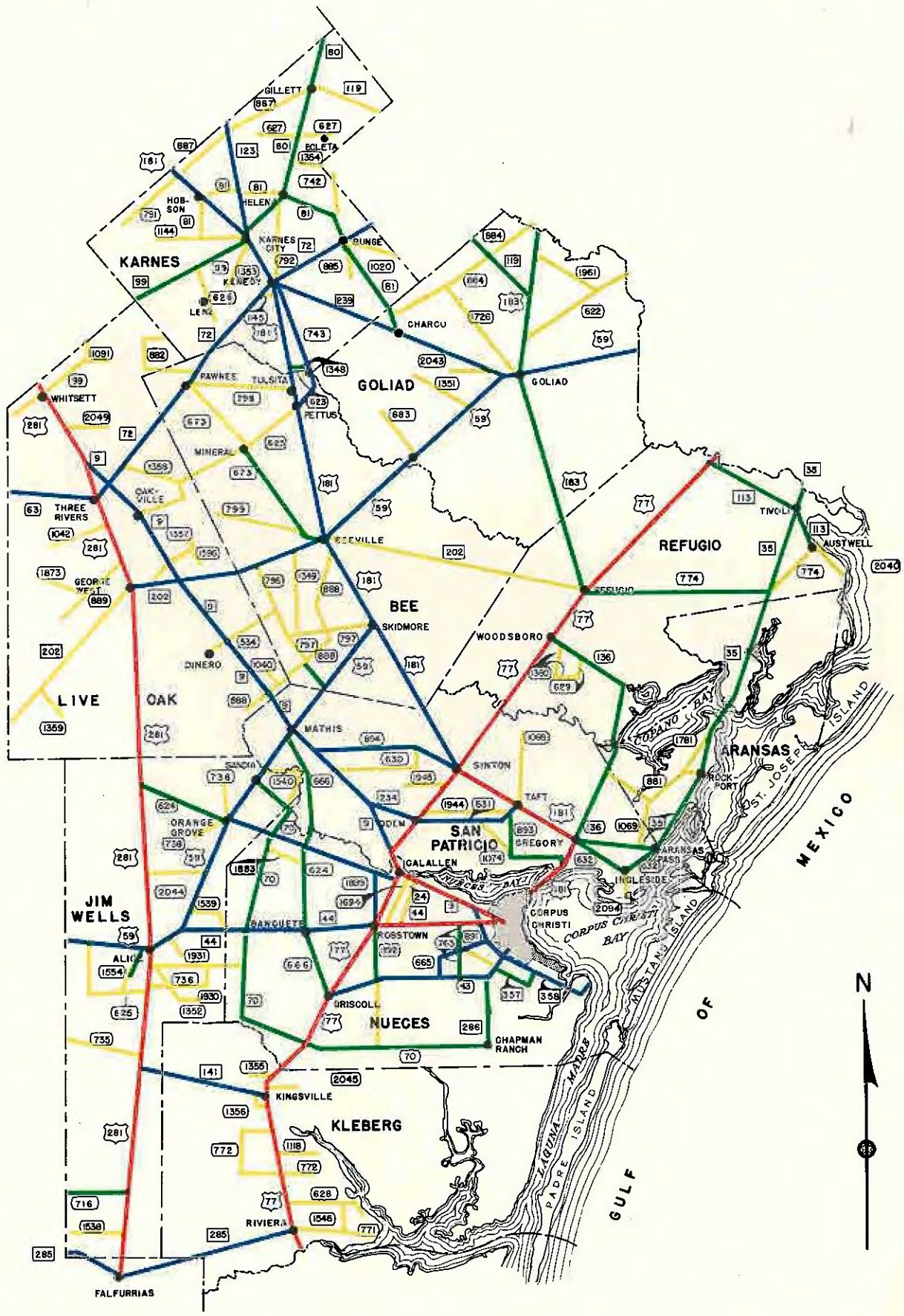
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- 81 U.S. HIGHWAY
- 173 STATE HIGHWAY
- 142 FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

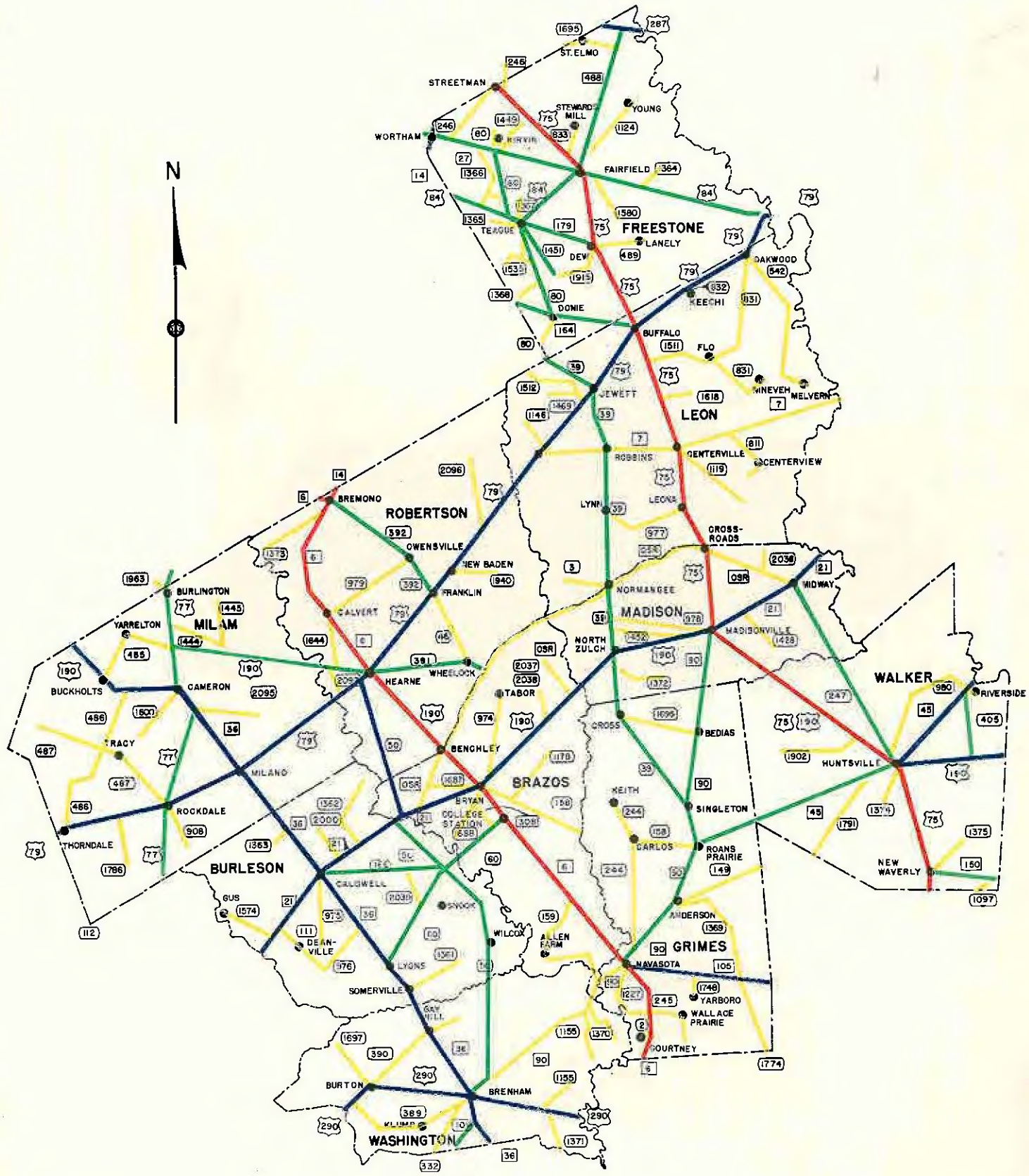
- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 16

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- (81) U.S. HIGHWAY
- [173] STATE HIGHWAY
- (142) FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

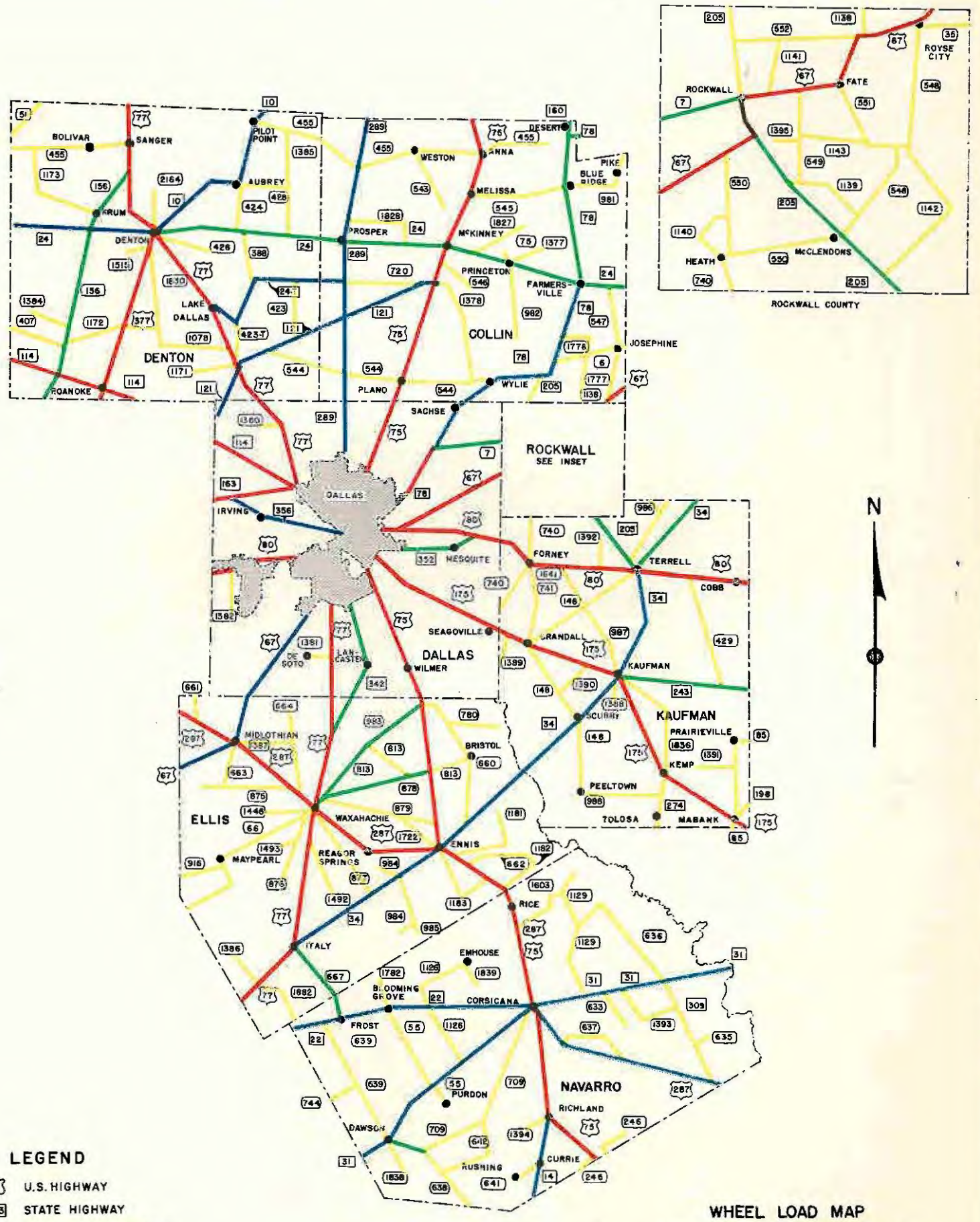
- 8,000 & Under
- 8,001 - 10,000
- 10,001 - 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 17

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

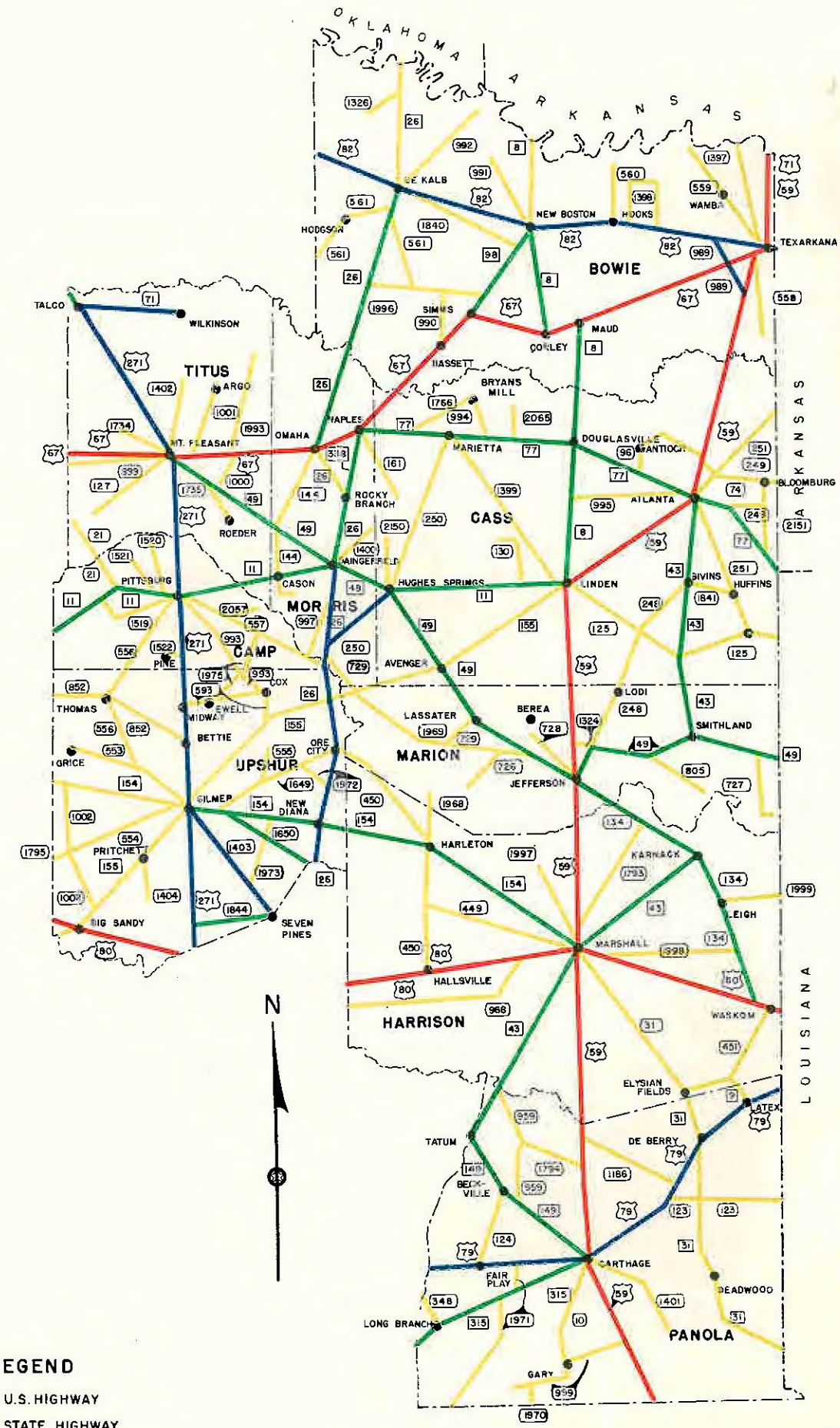
POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 18

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

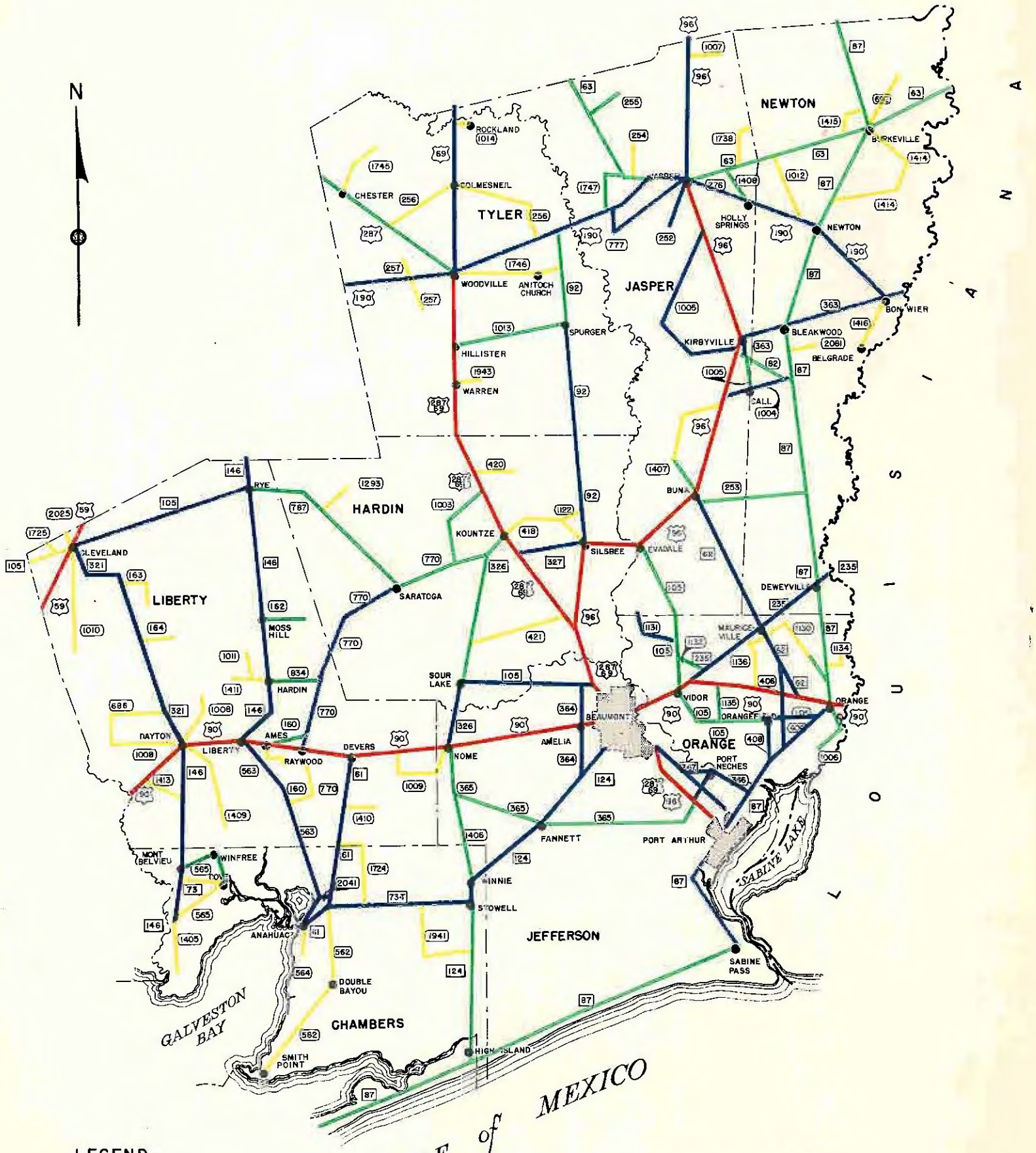
- 8,000 & Under
- 8,001 - 10,000
- 10,001 - 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 19

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

POUNDS

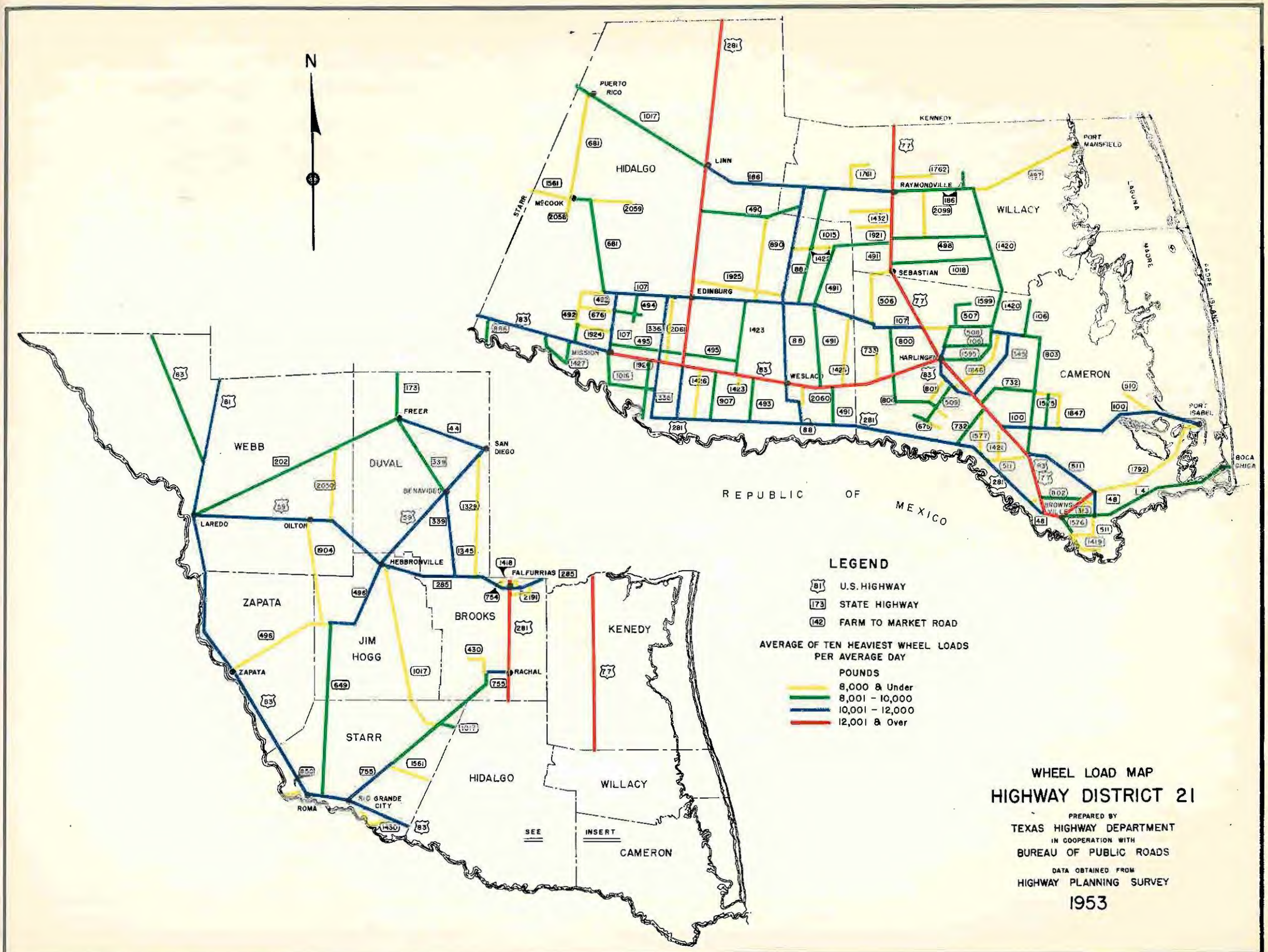
- 8,000 & Under
- 8,001 - 10,000
- 10,001 - 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 20

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY

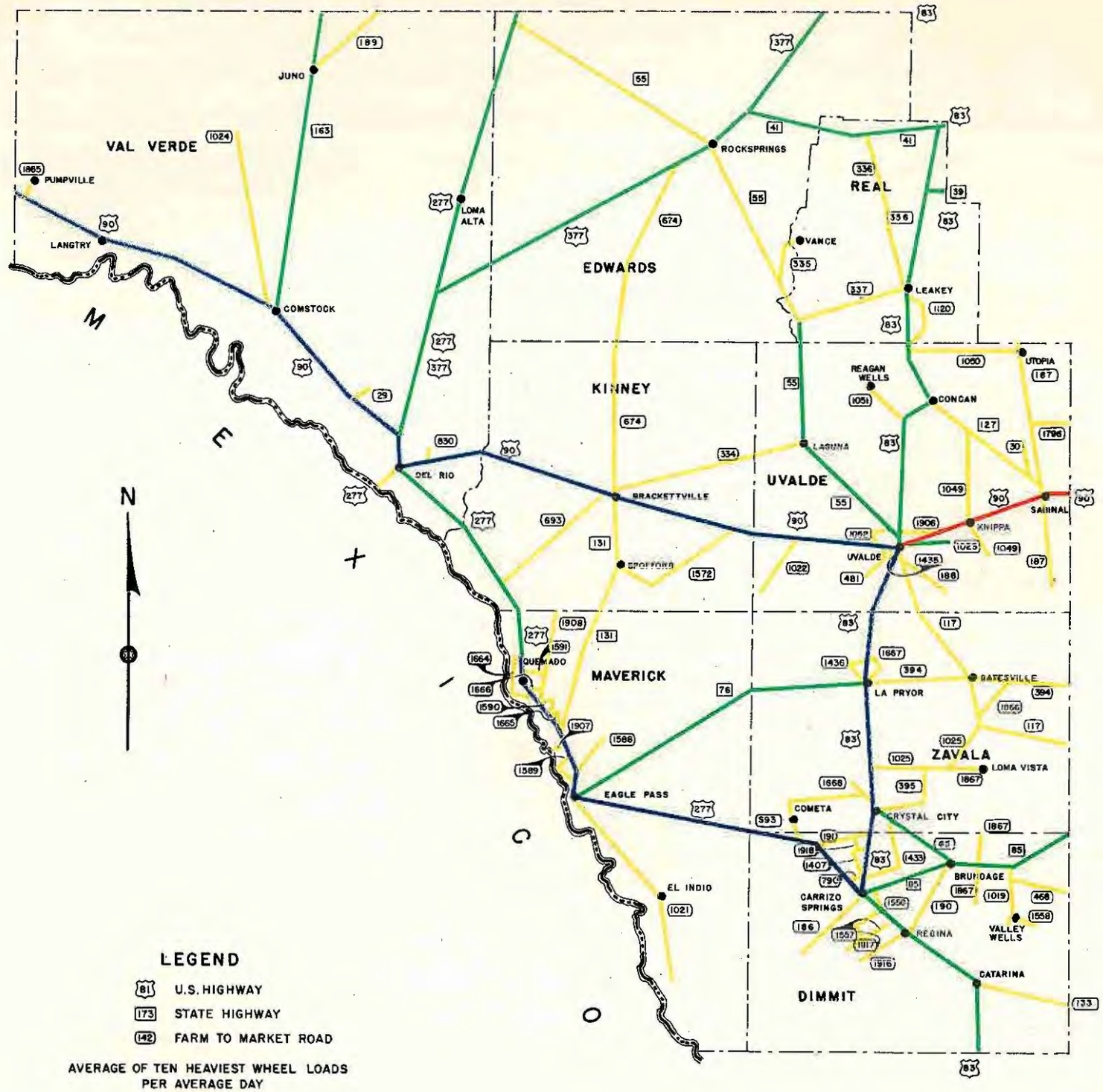
1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 21

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



LEGEND

- U.S. HIGHWAY
- STATE HIGHWAY
- FARM TO MARKET ROAD

AVERAGE OF TEN HEAVIEST WHEEL LOADS PER AVERAGE DAY

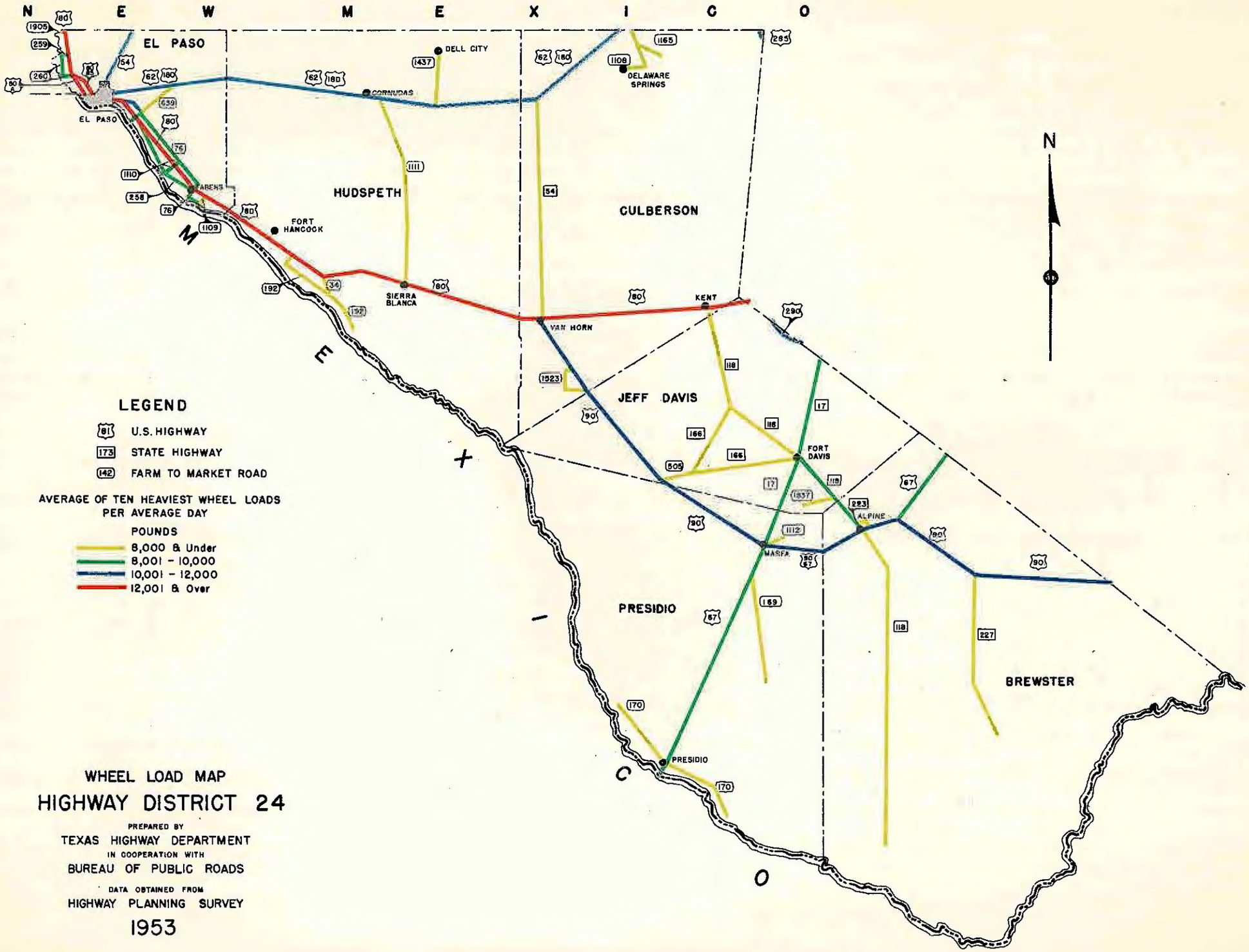
POUNDS

- 8,000 & Under
- 8,001 – 10,000
- 10,001 – 12,000
- 12,001 & Over

WHEEL LOAD MAP
HIGHWAY DISTRICT 22

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953



WHEEL LOAD MAP
HIGHWAY DISTRICT 24

PREPARED BY
TEXAS HIGHWAY DEPARTMENT
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS

DATA OBTAINED FROM
HIGHWAY PLANNING SURVEY
1953