Cletus R. Mercier

A Sufficiency Rating System for Secondary Roads in Iowa

Volume II

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ERI Project 1654
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report

College of Engineering
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Chapter I

RESEARCH PROCEDURE

The goal of this study is to develop a usable sufficiency rating system for secondary roads. There are several assumptions that have been made at the outset. These are:

1. County engineers currently use at least a limited set of decision criteria to make decisions regarding project priorities.
2. Some degree of consensus exists among the county engineers in terms of which are the most important criteria and that there is some agreement on their relative importance.

Accordingly, a questionnaire was developed which could be used as a survey tool. The results of the survey were used to develop a final list of weighted rating elements which were used as part of the proposed sufficiency rating system.

State and local jurisdictions from other states were also surveyed to determine the status of the use of sufficiency rating systems for secondary roads outside of Iowa and to gather some applicable data.

1.1 SURVEY DESIGN

Data used in this study were responses from questionnaires sent out to county engineers from all 99 counties in Iowa plus a total of nine sent to engineers in the Planning Division and Local Systems offices of the Iowa Department of Transportation. All county engineers were contacted by telephone before[1] the questionnaire was mailed and provided a brief explanation of the purpose of the questionnaire.

1.2 QUESTIONNAIRE

The purpose of the questionnaire was to determine whether any degree of consensus exists among the county engineers in the form of preference for a set of rating criteria and the relative importance of each. If such a consensus exists, it could be used as a basis for choosing the rating criteria and their relative weights for use in a proposed sufficiency rating system for county roads.

The rating criteria list included in the questionnaire represented a composite list of criteria used by twelve states currently using sufficiency rating systems. They were arranged by the categories of condition, safety,[2] and service. Two lists of the criteria were provided in the questionnaire, one for roads with the functional classifica-

[1] Except for those on the Iowa Highway Research Board, who were aware of the project.

[2] These were the categories first used in the Arizona rating system and also used in most rating systems developed since that time.

tion of either trunk or trunk collector, and one for roads classified as area service.[3] It was anticipated that county engineers would show different preferences of rating criteria for the different functional classes.

One additional element was included in the questionnaire. Most systems developed to date have grouped the rating criteria into the categories of Condition, Safety, and Service. Each respondent was asked to place the categories in rank order first and then to designate how they perceived their relative importance by inclusion of a weighting factor.[4]

This portion was included in case there was no consensus on the ranking and weighting of the rating criteria. A measure of agreement in the ranking and/or weighting of the rating categories might prove useful in identifying the most appropriate criteria to use. A copy of the questionnaire is included in Appendix A. A brief description of each of the rating elements was enclosed with the questionnaire to aid the respondents in completing it. A copy of the description follows the questionnaire in Appendix A.

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[3] Most of the paved secondary roads in Iowa are classified as trunk or trunk collector, while very little of the mileage of area service roads are paved (Iowa DOT).

[4] Respondents were asked to rank the categories as 1, 2, or 3, designating the most important as #1, followed by the other two in rank order. Relative importance was to be indicated by assigning the relative weight of ten (10) to the most important category, and smaller relative weights for the other two categories, ranging from nine (9) to as low as one (1).

1.3 SURVEY - OTHER STATES

It was anticipated that sufficiency rating systems might already be in use for evaluating secondary roads. A review of literature identified such systems in California, Indiana, Michigan, and Kentucky. These states were added to a list of other states using sufficiency rating systems and all were contacted for information regarding any rating system for secondary roads in use. The local jurisdictions were also contacted for information on their systems.

1.4 THE QUESTIONNAIRE - OTHER STATES

A brief questionnaire was developed in order to assure completeness of information and administered by means of a telephone interview. The first contact made was with a state highway official, generally the local systems engineer or state-aid engineer. A copy of the questionnaire that was used has been enclosed in Appendix B.

The initial question posed to the respondent was to determine whether a numerical evaluation system (sufficiency rating or other similar system) was in use in that state to prioritize secondary road projects for planning and/or budgeting. If the answer was affirmative, then additional questions were asked to determine:

1. who used the system (state or local jurisdiction),
2. who gathered the data for the system and how, and
3. what the data sources were.

If a local jurisdiction used the rating system, the appropriate local official was contacted to ascertain;

1. how it is used,
2. whether the state had access to the results,
3. whether the state used the results in any way, and
4. if so, how.

A request was also made for copies of written procedures, forms used and/or any written reports covering any details and/or conclusions drawn from the analysis. Information of this type could prove to be useful in the development of a new rating system.

There were three additional questions included in the state survey. They are listed below, along with brief explanations of their purpose.

1. Who has jurisdiction over secondary roads in that state? If the state has jurisdiction, the appropriate administrator was contacted for further information.
2. Is there any attempt to formally evaluate the surface condition of non-paved roads? If so, an attempt was made to get details. There is a serious shortage of information regarding this important part of sufficiency rating systems.
3. What design standards are used for secondary road design? If a local standard is used, a copy was requested. One question that needs to be addressed in

this study is "what is sufficient?" and does this standard apply equally to all classes of use.

The goal of this survey was to gather any information that could prove to be useful in developing a sufficiency rating system for secondary roads in Iowa. Experience that has been gained by other jurisdictions in the application of their system(s) could make the new system easier to develop and easier to use.

1.5 DEVELOPMENT OF MODEL

Results of the county engineers survey were used to develop a model which could be used to compute sufficiency ratings for a given county road network. Details of the model were reviewed by an advisory committee composed of four county engineers and an engineer from the Local Systems Department of the Iowa DOT. Suggestions made by the committee were incorporated into the model's final form.

In addition, a package of written materials has been prepared in anticipation of use of the model by county engineers. Included in in the package is:

1. a complete description of the model and instructions on its use,
2. suggestions on how the necessary data for use with the model might be gathered, and
3. appropriate sample forms which could be used with the model.

A sample of the package has been enclosed in Appendix C.

1.6 TRIAL RUN OF SYSTEM

A limited number of road segments were evaluated to provide an abbreviated trial run of the model and sample forms. The roads evaluated were located in a central Iowa county and ranged from a heavily traveled trunk road to lightly used area service roads. The sample was chosen with the expectation that the sufficiency ratings for these roads would encompass scores ranging from excellent to scores suggesting critical needs.

Minor changes were made in the model and evaluation forms based on the trial run. The revised model and forms were then utilized in a more extensive test of the model in another Iowa county. This 'more extensive test' is described in the next section.

1.7 PILOT TEST

A second county in Iowa was chosen for a more extensive test of the model and rating forms prepared for use with the model. A sample of about 20 percent of the county's secondary roads were rated and the results used to derive the final form of the model and rating forms recommended in this project report.

Chapter II

DATA ANALYSIS

2.1 QUESTIONNAIRE RESPONSE - COUNTY ENGINEERS SURVEY

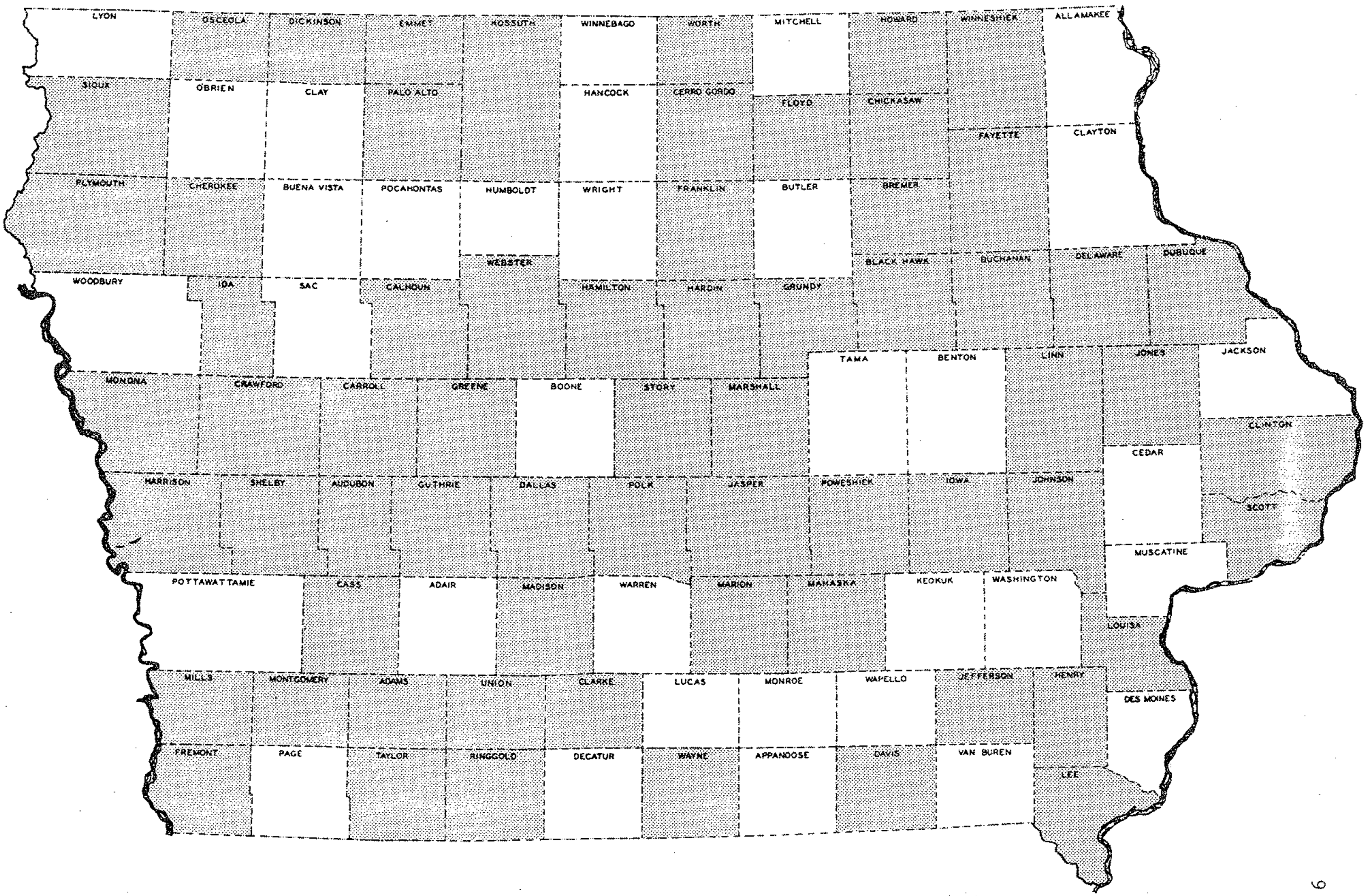
A total of 108 questionnaires were mailed to county engineers and engineers from the Iowa DOT. Of these 108, 71 were completed and returned, providing a return rate of 67 percent. The 71 received included 66 from county engineers (return rate=67 percent) and five (5) from Iowa DOT engineers (56 percent return). A map of the State of Iowa, showing the political boundaries of the 99 counties, is shown on the next page. Responses were received from engineers in those counties that are shaded.

The map also shows how the responses were distributed geographically. Most of the counties with larger urban areas returned completed questionnaires. In addition, most rural sections of the state are well represented.

2.2 ADVISORY COMMITTEE REVIEW

The completed questionnaires were examined to determine the existence of any consensus among the respondents in the form of preference for a given set of rating criteria. A rough draft of the initial findings and recommendations was presented to the advisory committee for review. The committee

Form 000501
12-73



consisted of county engineers from four (4) counties and an engineer from the Office of Local Systems of the Iowa DOT.

The function of this committee was to review the material presented and to provide comments. Suggestions emerging from this review were incorporated into the final form of the model, and outlined later in this report. This final form will be tested on actual road segments to determine their 'sufficiency'.

A draft of the proposed system to be used in 'scaling' the rating elements was also presented to the committee. Committee members were asked to review it and provide written comments to aid in the revision of the final document.

2.3 IDENTIFICATION OF PREFERRED RATING ELEMENTS

The initial step in processing the raw data was to place it in a computer file, using a data processing format.

Frequency distributions were then computed for each rating criterion from Tables 2 and 3 of the questionnaires by category, rank, and weighted rank. The list provided in Table 1 is identical to Table 2 of the questionnaire for trunk and trunk collector roads.[5]

Mean and median scores were also computed for each criterion plus the standard deviation from the mean. Although the mean, median, and standard deviation were of value, frequency distributions were the most useful in isolating those

[5] Table 3 in the questionnaire for area service roads was nearly identical to Table 2.

TABLE 1

Rating Element Weights-Trunk & Trunk Collector Roads

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	____	____	____
Wearing surface	____	____	____
Shoulder	____	____	____
Drainage	____	____	____
Remaining life	____	____	____
Maintenance economy	____	____	____
____________	____	____	____
SAFETY			
Pavement width (surface)	____	____	____
Shoulder width	____	____	____
Right-of-way width	____	____	____
Stopping sight distance	____	____	____
Passing sight distance	____	____	____
Hazards (safety)	____	____	____
Alignment consistency	____	____	____
Traffic control	____	____	____
Accident rate	____	____	____
____________	____	____	____
SERVICE			
Alignment (horizontal)	____	____	____
Alignment (vertical)	____	____	____
Pavement width (surface)	____	____	____
Improvement continuity	____	____	____
Ride quality	____	____	____
Surface type	____	____	____
Shoulder width	____	____	____
Snow problems	____	____	____
____________	____	____	____

rating elements deemed most important by the respondents. As expected, the weighted rank of the rating elements identified the 'preferred' rating elements most clearly. Distribution of the responses are shown in summary form via the bar graphs in Figures 1 through 23 in Appendix[6] D.

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[6] The bar graphs correspond to the frequency distribution of the ranking by respondents for each of the 23 rating elements listed.

The frequency distributions were carefully examined to identify a set of rating elements which consistently ranked high in comparison to all those suggested. Although provision was made on the questionnaire to write in additional rating elements, only one respondent did so. Therefore, only those elements listed on the questionnaire were considered.

An examination of the frequency distributions produced some fairly conclusive findings, in terms of selection of a set of 'preferred' rating elements. The results are described below.

2.4 SELECTION OF PREFERRED RATING ELEMENTS

A total of fourteen (14) rating elements were consistently ranked high by questionnaire respondents. They were regarded as important in evaluating trunk and trunk collector roads as well as area service roads, although there was some variation in ranking for the different road classifications.

Six of the most preferred rating elements received consistently high weighted rankings from respondents for all secondary roads. They were:

1. maintenance economy,
2. foundation,
3. wearing surface,
4. drainage,
5. hazards, and

6. stopping sight distance.

Though not equal, they consistently ranked high in comparison to all other rating elements.

Two additional rating elements were also ranked high for all secondary roads, though at a lower level. They were:

1. traffic control, and
2. pavement width.

However, pavement width was double-listed on the questionnaire, being included under both Safety and Service. An evaluation of the responses showed (when both listings were considered) pavement width (roadbed width) should be considered one of the most important of the rating elements.

A third cluster of rating elements on the 'preferred' list were ranked differently for area service roads than for trunk and trunk collector. These include:

1. passing sight distance,
2. accident rate,
3. ride quality,
4. horizontal alignment,
5. vertical alignment, and
6. snow problems.

The first five were considered to be slightly more important in evaluating trunk and trunk collector roads than for area service roads. On the other hand, snow problems were considered fairly important for area service roads, but somewhat less so for trunk and trunk collector roads. One additional rating element, surface type, was ranked high by respondents for area service roads, but not for trunk and trunk collector roads.

This suggests that there should be some variance between the sufficiency rating system proposed for trunk and trunk collector roads and the system for area service roads. These variations were considered when developing the suggested scales for the rating elements, discussed in the next section.

However, before proceeding, it would be appropriate to make a determination of the logical rating category for each element. This will simplify the weighting procedure.

The first four rating elements - maintenance economy, foundation, wearing surface, and drainage - all relate quite well to the category of Condition. They all are strongly associated with the 'Condition' of the roadbed. Logically, all four should be included with that rating category.

Most of the rest of the 'preferred' rating elements represent some characteristic of safety, and it would be consistent with the premise advanced earlier to include them in that category. The list of rating elements of that type are listed below, together with a brief explanation of the rationale for inclusion.

1. Accident rate is an obvious choice for inclusion under Safety.

2. Hazards is also an obvious choice to be included under Safety. By definition, a hazard represents an accident risk.
3. Stopping sight distance represents a potential for accident, in that, at normal operating speed, a driver cannot see far enough to make an emergency stop.
4. Restricted passing sight distance could present two different problems - one related to Service, in its constraint to traffic capacity, and the other to Safety, in that a driver could take an unnecessary risk in attempting to pass a slower vehicle. Of the two conditions, the threat to safety represents the greatest potential problem (since traffic is usually light on secondary roads), so it has been included under Safety.
5. Traffic control as a rating element is simply the existence of any problem traffic control sites - as potential safety problems.
6. Pavement width or roadbed width has an effect on both Safety and Service. Being too narrow can make driving somewhat hazardous, but it also affects driving comfort and traffic capacity. A decision to place this rating element in either category is arbitrary, but including it under Service seems more appropriate.

7. Ride quality relates mostly to Service, so it has been placed in that category.
8. Horizontal alignment is another rating element that can affect both a road segment's relative safety (by reducing visibility and/or forcing a reduction in speed to safely negotiate a curve) and Service (affecting driver comfort and road capacity). As it was with pavement width, placement is somewhat arbitrary, but the decision in this instance was to include it in the category of Safety.
9. Inclusion of vertical alignment in a rating category presents a dilemma. Poor vertical alignment can result in portions of a road segment with safe stopping sight distance and/or safe passing sight distance problems, but these are elements already included in the proposed rating system. Even though vertical alignment can affect Service (lowered capacity, higher operating costs, and lessened driver comfort), these factors are less important for secondary roads. With the concurrence of the advisory committee, this rating element was <u>not</u> included in the proposed model.
10. Snow problems are associated mostly with Service, in that they can restrict access to a road.
11. Surface type, like ride quality, relates mostly to Service.

The advisory committee suggested the inclusion of one additional rating element, shoulder width. Even though it was not ranked particularly high by questionnaire respondents, the committee felt strongly that it should be included. Therefore, it has been included, under the category of Service.

If the rating elements are placed in rating categories as previously suggested, there would be four (4) under Condition, six (6) under Safety, and four (4) under Service. Table 2 below shows the suggested breakdown by rating category.

TABLE 2

Proposed Rating Elements - Secondary Roads

RATING CATEGORY	ITEM RATED
Condition and Maintenance Experience	Foundation
	Wearing Surface
	Drainage
	Maintenance Economy
Safety	Accident Rate
	Hazards
	Stopping Sight Distance
	Passing Sight Distance
	Traffic Control
	Horizontal Alignment
Service	Pavement (roadbed) Width
	Ride Quality
	Snow Problems
	Surface Type (unpaved roads)
	Shoulder Width (paved roads)

2.5 PROPOSED RELATIVE WEIGHTS-RATING CATEGORIES

As noted in the Review of Literature, most rating organizations use a maximum composite rating of 100, with each criterion rated assigned a maximum value. Each of the three rating categories were assigned a share of the 100 points, with the rating elements allocated a fraction of that share.

It is proposed that the new rating system also be based on a maximum value of 100, again because it is familiar to most highway engineers. What remains is how to determine the relative share that should be assigned to each category.

The completed questionnaires contain sufficient information to approach this problem from three directions. They are described briefly below as:

1. an analysis of the respondents suggested category rank. Respondents were asked to rank the three rating categories in order of perceived importance. Tables 5 and 6 on the questionnaire were used for that purpose.
2. an analysis of the respondents suggested category weights. After the respondents ranked the rating categories, they were asked to weight each category, relative to the other two.
3. a weighted average, using the 'preferred' rating elements and their relative weights. Some of the rating elements were considered to be more important to the rating system than others. An evaluation of these

differences in 'relative' weights of the rating elements, as combined with others in the most logical rating category, could serve as a guide to the appropriate weights of the three rating categories.

An evaluation of the three approaches yields a reasonable range of values. The following range of values for share of the 100 points were suggested:

1. Condition - 30 to 38 points
2. Safety - 32 to 47 points
3. Service - 20 to 32 points

The first approach suggests a breakdown of 38-37-25 (for trunk and trunk collector roads) and 37-32-31 (for area service roads). An evaluation using the second approach results in a proposed breakdown of 35-35-30 (trunk and trunk collector) and 36-32-32 (area service). The third approach utilized the 'preferred' rating elements, with the rating element of horizontal alignment shifted from Service to Safety. This results in a suggested scale of 30-47-23 (trunk and trunk collector) and 30-44-26 (area service).

The method used in approach #2 best reflects the opinion of the respondents to the questionnaire, in that they were able to 'weight' the rating categories as well as rank them. Moving horizontal alignment from Service to Safety and the deletion of vertical alignment from Service would change the proportions of Safety and Service from 35-30 to 40-25, which comes close to that suggested by the third approach. Therefore, the proposed scale would be:

1. Condition - 35 points,
2. Safety - 40 points, and
3. Service - 25 points.

Analysis of the completed questionnaires did suggest a slightly different point breakdown for the model between trunk and trunk collector roads and for area service roads. This resulted in a slightly higher total for the category of Service than for Safety. This variance was reflected in the model and forms for the first trial run, but its effect was negligible on the resulting ratings. Therefore, the same point breakdown is proposed for all secondary roads to be rated.

2.6 PROPOSED RELATIVE WEIGHTS-RATING ELEMENTS

The final step in the formation of the proposed models is to ascertain the appropriate maximum point value for each included rating element. The list of 'preferred' rating elements and their relative weights, referred to earlier, were used to resolve this last problem. All that remains is to make such adjustments as necessary to the individual weights to match the category weights in the proposed models.

For example, the proposed weight to be applied to the category of Condition is 35 points (of a possible 100). Four rating elements were included in that category - foundation, wearing surface, drainage, and maintenance economy. Respondents ranked foundation, wearing surface, and maintenance economy about equal, with drainage ranked slightly lower. Dividing the 35 points that were allocated to that rating category among the four rating elements resulted in the following breakdown:

1. foundation - 9 points,
2. wearing surface - 9 points,
3. drainage - 8 points, and
4. maintenance economy - 9 points.

A similar procedure was utilized for the rest of the model. Respondents did weight snow problems slightly heavier for area service roads than for trunk and trunk collector roads, with a corresponding decrease of the rating element 'ride quality'. This minor adjustment in relative weights was utilized in using the model for the first trial run. However, its effect was negligible on the resulting ratings. Therefore, except for variations relating to surface type, the same basic model is proposed for all rated secondary roads.

It should be noted, however, that some minor variations in its use are applicable, depending on the road's surface. These variations are described below.

1. If the road is paved, Pavement (roadbed) Width refers to pavement width. However, if the road is unpaved, then this rating element refers to the width of the traveled way. This width is the distance between the top of the foreslope on one side of the roadway to

TABLF 3

Final Proposed Sufficiency Rating System Model

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition and Maintenance Experience 35 points	Foundation	9
	Wearing Surface	9
	Drainage	8
	Maintenance Economy	9
Safety 40 points	Accident Rate	6
	Hazards	9
	Stopping Sight Distance	8
	Passing Sight Distance	5
	Traffic Control	6
	Horizontal Alignment	6
Service 25 points	Pavement (roadbed) Width	9
	Ride Quality	5
	Snow Problems	6
	Surface Type (unpaved)	5
	Shoulder Width (paved)	(5)

the top of the foreslope on the other side. For sufficiency ratings, this distance will be compared to the design standard for that particular functional classification expressed as the sum of all lane widths and shoulder widths.

2. If the road is unpaved, shoulder width becomes part of the roadbed width. Therefore, it will not be rated separately, but becomes part of the traveled way and is rated as part of the Pavement (roadbed) Width.
3. If the road is unpaved, its surface type will be rated. A paved road would receive the maximum rating (in terms of surface type), no matter what design standard applies. Therefore, inclusion of this rat-

ing element would not result in any loss of points and this element need not be included. Any road surface of a lesser quality existing on the rated road segment will result in the inclusion of the 'surface type' rating element, so it could be compared to the design standard.

Complete results are described in Table 3. Scale factors and proposed procedures for use with the model will be discussed in the next part of this report.

2.7 RESULTS OF STATE SURVEY

A total of ten (10) states were contacted. A telephone survey was conducted, using the questionnaire discussed earlier. A sample of the questionnaire has been included in Appendix B.

The states contacted were selected on the basis of:

1. revelation of the previous use of some sort of sufficiency rating system for secondary roads in that state (as the result of the literature review), or
2. state jurisdiction over some or all of the secondary roads within that state.

Not all of the representatives of the state highway organizations contacted were able to respond to the questionnaire and little useful information was received. The information of value that was gathered is summarized briefly below.

1. Two states, Missouri and Kentucky, reported using a sufficiency rating system for secondary roads. Only a small portion of the secondary roads are actually evaluated by the states, generally the Federal Aid Secondary (F.A.S.) under state jurisdiction. No local jurisdictions are reported as using a sufficiency rating system for their secondary roads. Written material was requested and received from these states and proved to be useful in developing the new model.
2. Five of the states reported no use of a sufficiency rating system (or similar system) for secondary roads, including Indiana. Apparently Allen County in Indiana has dropped the system used earlier in that county and no other county in the state has adopted it. Virginia, which has jurisdiction over all secondary roads in the state (except for two urban counties) does not use a sufficiency rating system as such. They do use a 'tolerable - intolerable' rating system which relates ADT with surface width/surface type.
3. Two other states were contacted. Repeated efforts to reach a person that might have knowledge of possible systems in use failed.
4. Most of the states reported the use of AASHTO design standards for secondary roads in their state or a combination of AASHTO standards and some local standards.

Some of the information received from Kentucky was useful in developing the model and forms included in this report. Most of the information gathered from the state survey was not of value for this project, except to suggest that there is little use of sufficiency rating systems for secondary roads in the United States. Some interest was expressed in the proposed system for Iowa.

Chapter III

AN EMPIRICAL MODEL

The original model developed by the Arizona Highway Department was 'empirical', or experience based. Subsequent models developed and used by other state highway organizations utilized the Arizona format, with local variations influenced by a combination of local conditions and personal experience.

The model proposed for secondary roads is also empirically based - based on the Arizona format <u>and</u> the experience of local engineering practitioners.

3.1 <u>RATING ELEMENTS SELECTED</u>

Fourteen rating elements have been selected for use with the proposed sufficiency rating system. They have been organized into three categories and assigned relative weights. Table 3 shows the proposed list of rating elements, complete with their suggested weights.

3.2 FORM OF MODEL

The basic model for the sufficiency rating system is a simple mathematical model, which can be expressed in the following form:

SR = Sum of Scores of (CRE + SaRE + SeRE)

where SR = the Sufficiency Rating for a given road segment, CRE = all Condition Rating Elements, SaRE = all Safety Rating Elements, and SeRE = all Service Rating Elements.

The maximum possible scores for the selected rating elements have been determined -- from the analysis of the data received. What remains is to solve the problem of how to assign scores when the rated road segment fails to meet the expected standard for a given rating element. To do this requires the answer to two questions.

1. What is a defensible set of standards which could be applied to the rating elements selected?
2. Is there a scaling calibration which can be used with each rating element and that would yield meaningful scores when the rated road segment fails to meet the desired standard?

The answers to these two questions are critical to the problem of the assignment of scores. The next two sections will address the issues raised by the questions and suggest appropriate answers.

3.3 STANDARDS FOR RATING ELEMENTS

The issue of determination of appropriate standards to apply to the rating elements is intermixed with economic and social issues -- what level of financial commitment is the public willing to make to build and maintain the state's transportation infrastructure and what is the dollar value of personal comfort, pain and suffering (due to traffic injury), and human life (when a person is killed in a a traffic accident)?

Though these issues will probably never be really settled, engineering practitioners have adopted standards that are reasonably consistent with prevailing public opinion. Evidence of public opinion is provided in the form of the level of funding which legislative bodies have allocated and in the force of public opinion in the form of individual and group pressures.

The result is a set of design standards which has been adopted by a highway agency (in this case, the Iowa DOT) for use with all the different classes of roads throughout its jurisdiction.[7] The design standards represent prevailing professional opinion on appropriate standards or norms for building a given road to serve expected traffic needs.

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[7] Comparable sets of design standards have been adopted by other state highway organizations, similar in many respects, but also reflecting local conditions.

For the most part, the design standards call for higher standards of construction for roads carrying heavier volumes of traffic (and costing more) and concomitant lower standards for roads carrying less traffic.[8] The lowered standards include the provision for reduced design speeds, with the expectation that vehicles using the road would not be moving at as high a rate of speed as on a road carrying a heavier volume of traffic and built to higher standards.

All this infers that the lowered standards are acceptable to the public and that there is little reason to exceed those standards, except when it can be done at little extra cost. By the same token, an evaluation for 'sufficiency' -- a comparison to established 'ideals,' should be based on the current design standard for that road classification.

Therefore, the proposed sufficiency rating model for secondary roads incorporates applicable design standards from the design guide developed by Iowa DOT staff for the 1982-2001 Quadrennial Needs Study. The guide was developed in consultation with the State Functional Classification Review Board, members of the County Engineers Association,[9]

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[8] One of the distinguishing characteristics of the hierarchy of road classifications is the volume of traffic using the facility.

[9] This Guide was chosen in spite of the fact that many county utilize the FARM TO MARKET DESIGN GUIDES. It was chosen because of its breakdown of Area Service Roads into three categories, based on ADT. This provides for lower standards for lightly traveled Area Service Roads. It also represents what is expected to be the design standards of the future.

and the League of Iowa Municipalities.

Failure of a rated road segment to meet a given standard would cause a lowered score for that rating element. Established 'ideals' for rating elements not covered by a design standard are based on current practices as evidenced by a combination of 'standards' utilized with other sufficiency rating systems currently in use and local practices.

3.4 SCALING FACTORS

An assessment of the maximum point value for a given rating element is made when the road segment meets or exceeds the current standard. However, a given rated road segment will meet the current standard for each of the rating elements to a varying degree, making it necessary to develop some sort of scale to describe how close it comes to meeting that standard. Maximum point values for each of the rating elements are listed in Table 3, so what is needed is a set of graduated scales for each.

Existing systems utilize, for the most part, a sequence of point values which are approximately linear in character. In most instances, there is a score (often at about the middle of the scale) which represents an 'average' value, below which is considered 'intolerable'. The concept of tolerability, discussed in Volume 1 of this report, is based on the supposition that, for each rating element, there is a 'tolerable' standard which is less desirable than the 'ideal', but still considered to be safe, or at least provides good service. It is at the lowest point on the scale permissible under current highway transportation requirements. Below that level, the rated road segment is considered to be 'intolerable' with regard to that rating element.

The calibration system used by the Iowa DOT has established tolerable levels for each rating element in the system used to evaluate primary roads. In each instance, it is 50% of the maximum point value, rounded down to the next digit when the maximum point value is not an even number.

This calibration method is used for the proposed model, graduated linearly with decreasing values below the maximum score. Accompanying statements have utilized descriptors of excellent, good, fair (at 'tolerable' scales) and poor, together with status descriptions for each score. A summary of the proposed scoring method has been included in the next section.

However, there are some rating elements in the proposed model that do not lend themselves as well to the 'linear' scale concept discussed earlier. They include elements grouped under the category of Safety. They are like an 'accumulation of potential safety risks, or hazards' occurring along the rated road segment. Their existence represents a possible safety hazard, or 'deficiency', and tend to be site specific, instead of occurring regularly along the road. The rating elements are the type which could be 'counted' (two narrow bridges are more hazardous than one).

This suggests that part of the score for a rated road segment under the category of Safety could be based on the results of an evaluation of its relative safety. Deductions from a maximum value would be made for the existence of 'conditions that exist on the road segment that constitute a possible threat to safe operation of the motor vehicle on that road'.

Under this system, deficiency points would be assessed for the existence of a list of 'threats to safe driving', using a predetermined point deduction for each deficiency. Road segments of varying length would be made comparable by adjusting for length. There would be no negative scores, but a given road segment could receive a zero (0) score.

The next section details the proposed scaling system for the complete model. A brief description of each of the rating elements has been included for clarification.

3.5 RATING SCALE CALIBRATION

A set of scales has been developed for the proposed rating system. This set of scales is described below, arranged in a format similar to the model as shown in Table 3

CONDITION AND MAINTENANCE EXPERIENCE

1. Foundation - evaluated by considering adequacy of drainage ditches, breakup of surface, non-uniform settlement and lateral support, and condition of foreslopes. Maximum score = 9.

Excellent 8-9. No evidence of base failure, foreslopes in excellent condition.

Good 6-7. Occasional evidence of minor base failure, fully correctable by spot repairs. No need for extensive reworking.

Fair 5. Frequent base failure, requiring heavy maintenance. Causes reduction in traffic speeds below design speed. Should be considered for reconstruction. 'Tolerable.'

Poor 1-4. Severe base failure throughout rated section, extreme 'wash-board' condition. Traffic speeds substantially reduced. Reconstruction necessary.

2. Wearing Surface - evaluated by considering physical defects. For P.C. concrete paved roads, the defects include joint-faults, transverse and longitudinal cracks, non-uniform slab displacement, spalling and disintegration of concrete. Asphaltic concrete pavement defects include transverse and longitudinal cracks, irregular profile and cross-section, alligator cracks, raveling, bleeding, and rutting. Granular surfaces defects include formation of potholes, locations with regular formation of ruts, and transverse 'washboarding'. Maximum score = 9.

Excellent 8-9. Very satisfactory condition. Pavement or granular surface smooth. Granular surface requires only routine blading. No surface failure.

Good 6-7. Occasional spots of surface failure, correctable satisfactorily through normal maintenance. Resurfacing not absolutely necessary.

Fair 5. Frequent spots of surface failure, correctable only by heavy maintenance. Rough surface reduces traffic speeds somewhat below design speed. 'Tolerable.'

Poor 1-4. Severe surface failure over all of rated segment. Resurfacing or reconstruction necessary due to surface condition. Traffic speeds substantially reduced from design speed.

3. Drainage - evaluation based on occurrence of ponding, ditch erosion, culvert silting, scouring of culvert outlets, condition of pipes, and their hydraulic capacity. For unpaved roads, this should include existence of portions of the road with inadequate cross-drainage due to lack of adequate crown (as evidenced by weakened foundation due to rain) or too steep cross-slopes, causing excessive erosion. Maximum score = 8.

Excellent 7-8. Drainage satisfactory. No silting, scouring, significant erosion or ponding. Culverts of adequate design, good condition.

Good 5-6. Occasional ponding due to heavy rains, but quickly drains afterward. Some silting or scouring of culverts occurring which requires light maintenance. Occasional flat (or too steep) crown which needs regrading.

Fair 4. Ponding substantial during heavy rains, sometimes during light rains. Some problems for traffic due to ponding or rough or softened surface or foundation. Maintenance of road and/or drainage facilities becoming excessive. Expensive correction or improvements indicated. 'Tolerable.'

Poor 1-3. Excessive ponding, inadequate drainage, not correctable through maintenance. "Intolerable."

4. Maintenance Economy - based on historical knowledge of the maintenance requirements of the road segment. Maximum score=9.

Excellent 8-9. No expenditures, other than strictly routine. Patching of pavement rarely required. Addition of granular material needed occasionally due to traffic, but not in extraordinary amounts. Blading of non-surfaced road done regularly, but not a particular problem.

Good 6-7. Some expenditures, but not excessive. Some patching required annually. Resurfacing of pavement would help, but not absolutely necessary. Addition of granular material over most of section desirable, but also not absolutely necessary. Spot re-grading of non-surfaced road required. Extra dragging required periodically.

Fair 5. Considerable expenditures of money and material. Considerable patching and crack filling. Addition of supplemental granular material required annually or continuously. Road should be candidate for resurfacing and/or reconstruction. Considered to be 'tolerable'. Many spots of non-surfaced roads need special attention during blading.

SAFETY

Scores for these rating elements are to be derived somewhat differently. For the most part, the rating score is obtained by subtracting 'deficiency' points from the maximum score. Since the rated road segments will vary in length, it is likely that rating scores will not be a whole number. Should that be the case, round the score down to the next whole number.

1. Accident Rate. This rating element relates to the occurrence of accidents along the rated road segment. Using available records, compute deficiency points as follows:

- For each property damage accident over the past five (5) years, one (1) deficiency point,

- For each personal injury accident over the past five (5) years, four (4) deficiency points, and

- For each recorded fatal accident over the past five years, twelve (12) deficiency points.

The deficiency points multipliers used are taken from the severity indices used by the Iowa DOT as part of its Accident Locator Analysis System (ALAS). Rating score is based on the average number of deficiency points per mile of roadway. Maximum score = 6. Determine the rating score by using the following formula:

Rating = 6 - (n/L)

where n = the total of all deficiency points assessed, and L = the length of the rated road segment in miles. Round down to the nearest whole number. Rating should not be less than zero (0).

2. Hazards. This element relates to hazards not included elsewhere. They are listed below.

- Structure (bridge or culvert) which restricts roadbed width (20 feet or less in width).

- Structure with bad approach alignment. (Horizontal and/or vertical alignment which restricts visibility and/or requires significant changes in speed or multiple maneuvers.)

- R.R. crossing at grade without automatic signals.

- Other fixed structure extending onto roadbed (for unpaved roads) or to within ten (10) feet of edge of pavement (for paved roads).

- Abrupt or severe grade changes. (Short vertical curves combined with major algebraic differences in grades.)

Scores are based on the average number of hazards per mile of roadway. Maximum score = 9. Determine the rating by using the following formula:

Rating = 9 - 2(N/L)

where N = the number of hazards encountered, and L = the length of the rated road segment in miles. Round down to the next whole number. Rating should not be less than zero (0).

3. Stopping Sight Distance. This is evaluated by first determining the number of stopping sight restrictions along the rated road segment. The minimum safe stopping sight distance used is determined by the road's design speed (see the appropriate design standard). Maximum score = 8. Determine the rating by using the following formula:

Rating = 8 - (N/L)

where N = the number of occurrences of stopping sight restrictions on the rated road segment and L = the length of the road segment in miles. Round down to the next whole number. Rating should not be less than zero (0).

4. Traffic Controls. Traffic controls installed in accordance with applicable warrants and guidelines set by the 'Manual on Uniform Traffic Control Devices (MUTCD)' receive the full rating. Failure to comply with applicable warrants and/or guidelines would result in a lower rating score. Also included are instances of inadequate vision at uncontrolled intersections. Relevant cases are listed below.

- Inadequate pavement markings.
- Less than adequate warning sign distance.

- Failure to place warning sign.

- Inadequate vision at uncontrolled intersections.

- Consistency of sign placement.

Scores are based on the number of occurrences per mile of roadway. Maximum score = 6. Determine the rating by using the following formula:

Rating = 6 - 2(N/L)

where N = the number of occurrences on the rated road segment and L = the length of the road segment in miles. Round down to the next whole number. Rating should not be less than zero (0).

5. Horizontal Alignment. This evaluation is based on the occurrence of horizontal curves on the rated road segment. If none exists or if the existing curve(s) meet(s) design standards, the full rating score applies. Less than full rating scores should be allocated when either of the following circumstances are encountered.

- Trunk and trunk collector roads: each curve encountered which requires drivers to slow to less than design speed will be assessed deficiency points. More severe speed reduction would result in additional deficiency points. Guidelines are:

  5 mph < speed reduction < 10 mph=one (1) point

  10 mph < speed reduction < 15 mph=two (2) points

  15 mph < speed reduction < 20 mph=three (3) points

- Area service roads: each curve encountered which requires drivers to slow to less than 30 mph will be assessed deficiency points. More severe reduction would result in additional deficiency points. Guidelines are:

5 mph < speed reduction < 10 mph=one (1) point

10 mph < speed reduction < 15 mph=two (2) points

15 mph < speed reduction < 20 mph=three (3) points

Scores are based on the average number of deficiency points per mile of rated roadway. Maximum score = 6. Determine the rating by using the following formula:

Rating = 6 - (n/L)

where n= the total of all deficiency points assessed, and L = the length of the road segment in miles. Round down to the next whole number. Rating should not be less than zero (0).

6. Passing Sight Distance. Restrictions to passing are caused by roadway geometrics and opposing traffic. The rating is based on both - by evaluating the geometrics (to determine the extent of restricted passing) and considering the density of opposing traffic. This is accomplished by determining the percent of the total length of the rated road segment over which safe passing sight distance is available and relating it to the applicable design standard.[10] Maximum score = 5. See page 4 of the Guide for Preparation of Worksheets for complete details.

[10] The design standard combines functional classification, average daily traffic, and terrain in specifying minimum standards for roadway geometrics.

SERVICE

1. Pavement Width (Roadbed Width) - used to reflect inadequate traveled way widths as determined by a comparison with the appropriate design standard. Though also related to safety, it has been included only under the category of Service. Maximum score = 9.

Excellent 9. Width of pavement or traveled way meets or exceeds the width specified in the appropriate design standard.

Good 6-7. Width of pavement or width of traveled way is not more than two feet (.6 m) less than the design standard.

Fair 5. A 'tolerable' width. Width of pavement or traveled way is two feet (.6 m) to four feet (1.2 m) less than the design standard.

Poor 1-4. Not tolerable. Needs to be wider. Width falls short of design standard by at least four feet (1.2 m).

2. Ride Quality - an evaluation of surface quality -- waviness, irregular surface, corrugations, and/channeling. Maximum score = 6.

Excellent 6. Smooth riding at design speed or above.

Good 4-5. Minor roughness of surface causes little discomfort in riding. Occasional irregularities, corrugations, or channeling causes the driver to slow down (below design speed) for short distances.

Fair 3. Roughness of surface causes some noticeable discomfort in riding. Occasional pavement cracking and failures require extensive patching. 'Wash-board' on granular surfaced road requires frequent grading. Tolerable.

Poor 0-2. Heavy cracking, deep failures, obvious instability. Very unsatisfactory riding surface.

3. Snow Problems - an evaluation based on the ability of roadside ditches and accessible portions of the right-of-way (R-O-W) to accommodate the quantity of snow that may have to be removed from the roadway and shoulders. Maximum score = 5.

Excellent 5. No significant drifting problems. Roadbed above the surrounding area, ditches deep and wide for storage.

Good 4. Occasional locations where drifting is a problem. Ditches still wide and deep enough to accommodate most of the snow.

Fair 3. Tolerable. Frequent locations where drifting is a problem, but not extremely long drifting areas or places where very deep drifts occur. Some problems on ditch width or depth. Roadbed elevation occasionally inadequate. Ditch may need some extensive maintenance to clear silt or vegetation.

Poor 0-2. Drifting and/or snow removal a recurring problem of significance. R-O-W width inadequate to allow for ditches to be wide or deep enough, or extensive grading needed to raise the roadbed and/or improve ditches.

4. Surface Type. Used to relate surface type on the road segment to the applicable design standard. Maximum score = 5.

Excellent 5. Surface type meets or exceeds design standard.

Fair 3. Surface type should be considered as 'tolerable', but fails to meet design standard. Road has a granular surface in place of the asphaltic or portland cement concrete surface stipulated by the design standard. Also applies if the road surface is earth instead of a granular surface - stipulated by the design standard.

Poor 1. Surface type should be considered as 'intolerable'. Surface is earth in lieu of the asphaltic or portland cement concrete surface stipulated by the design standard.

5. Shoulder Width. Shoulder width is measured from the edge of the pavement to the point where the shoulder line intersects the foreslope. Applicable to paved roads only. Maximum score = 5.

Excellent 5. Shoulder width meets or exceeds design standard.

Good 4. Shoulder width is less than design standard. Range of 6-8 feet (for 8 foot standard), 4-5 feet (for 6 foot standard), 2-3 feet (for 3 foot standard).

Fair 3. Less than design standard. Range of 4-6 feet (for 8 foot standard), 3-4 feet (for 6 foot standard), or 1-2 feet (for 3 foot standard). Tolerable.

Poor 0. Less than 4 feet (8 foot standard), or 3 feet (6 foot standard) or less than 1 foot (3 foot standard). Not tolerable.

3.6 TESTING THE MODEL

The next step in the development of the rating system was the preparation of a set of rating forms and a set of instructions to to aid in their use. The scaling factors discussed earlier were used as a basis for the forms, adjusted for variations in design standards.

A combination of functional class and ADT was used as a basis for selection of the appropriate design standard for the road to be evaluated. Directions for this selection have been provided in the GUIDE FOR PREPARATION OF WORKSHEETS. A sample copy of each of the worksheets and the Guide are provided in Appendix C.

A trial run of the use of the rating forms was made by completion of an actual rating of several secondary road segments in a central Iowa county (totalling slightly more than 25 miles), using the forms and the Guide. An evaluation was made of their ease of use and applicability to the rating and minor revisions made.

A second, more extensive test of the model was made in a second Iowa county. A random sample was selected of the county's secondary roads, which included about 20 percent of the 1100+ miles of its secondary system.

The sample included subsets by functional class, that is, separate samples randomly selected of trunk, trunk collector, and area service roads. The trunk and trunk collector roads chosen for rating were scattered throughout the county, in order to avoid bias which might be terrain related.[11] Area service roads were selected by township. Approximately 20 percent of each township's area service roads were in the sample, and included roads in each area service category.[12]

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[11] Terrain in the county ranged from very flat to rolling to somewhat hilly. The sample included roads over all three types of terrain.

[12] There were three (3) categories used, based on ADT. Divisions employed are the same as used in the suggested design guides, or >100, 26 to 100, and 0 to 25 vpd.

3.7 TEST RESULTS

Sufficiency ratings were completed for the roads in the sample. Revised forms and procedures from the first run were used for the ratings. Results have been tabulated and some tentative conclusions have been drawn. It should be noted, however, that these conclusions are based on somewhat limited experience in its use and some minor revisions are still likely to be made.

Some of these tentative conclusions are summarized below. Most of the problems noted can be easily solved, but some will require some additional rating experience and the involvement of more of the potential users of the proposed system.

1. About ten (10) percent of the roads in the sample county are designated as having a service B classification. Local interpretation of this classification means that any road so designated is not likely to be cleared of snow in the winter. It may receive infrequent maintenance during the rest of the year in the form of 'dragging' to provide a smoother riding surface. It is likely to be 'unsurfaced' and will probably never be improved, no matter how far the road may be below design standards.

   A 'sufficiency' rating of any of these roads would have no value, as it would have no impact on the road improvement program. Therefore, unless a county using the proposed sufficiency rating system interprets service B differently, these roads should not be rated.

2. Most of the rating can be done by someone familiar with the county road network, but the evaluation of maintenance economy should be done by someone familiar with the maintenance history of each road. Should more than one person be assigned to do this rating, it is important that the descriptors utilized with the rating scale be reviewed to assure uniform interpretation.
3. Completeness of local accident records may be a problem. However, fairly complete records are available from the Iowa DOT via its ALAS records. One important advantage to using ALAS is the inclusion of a 'Severity Index' in its data printout, making the Accident Rate evaluation easier.
4. Large scale use of the ALAS records for sufficiency ratings may require some adjustment in how they are keyed. The road identification numbers used in the Secondary Road County Engineers Listing are not the same as used by ALAS. Some time and effort are required to match the road segment with the data. Ultimately, it would be desirable to be able to request all the needed data from DOT records (accident <u>and</u> information from the County Engineer's Listing) and get it from a single source.

5. Stopping sight distance may be a difficult criterion to evaluate on roads without adequate records. However, an experienced evaluator can pinpoint potential trouble locations from a field analysis fairly quickly. Once this is done, records from previous evaluations can be reused until the road is regraded.
6. Passing sight distance poses a similar problem. The solution is the same as for stopping sight distance.
7. To a lesser extent, horizontal alignment causes a similar problem. However, this will not occur often, and can be solved by field observations as well.

A more significant problem remains in the scale calibration for five (5) rating criteria under the category of Safety. These include:

1. Accident Rate,
2. Hazards,
3. Stopping Sight Distance,
4. Traffic Controls, and
5. Horizontal Alignment.

What is lacking is a determination of what is 'tolerable' and what is considered to be 'intolerable' for these rating criteria. How many 'Hazards' per mile of road can there be before it should be considered intolerable? The calibration system proposed is flexible and could be modified to meet a variety of rating goals. What is needed is some level of consensus on what is appropriate from potential users of the proposed system.

Use of the rating system did yield what appeared to be reasonable results. For example, scores on the trunk roads in the sample ranged from 73 to 96. The 96 score was for a nearly new, straight road, in excellent condition. The road with the 73 score is much older, with narrow pavement and a number of curves. By most measures, it would be considered 'tolerable' and the score indicates that. However, it is the most heavily used road in the county's secondary system, and the accident rate would seem to reflect this combination of heavy use and road deficiencies.

Choice of design standard also affected the ratings. One trunk road received a score of 80, but it was scored this high only because its traffic count was under 200 vpd. Had it been more heavily used (over 400 vpd), it would have received a score of 71. It would seem that use of the design standard would help the county engineer to maximize the effect of tax funds spent, by meeting consumer needs better.

The trial runs do indicate that the proposed sufficiency rating system is feasible. However, the first time a sufficiency rating system is done for a given county, some extra effort will be required to gather data, especially as related to road geometrics. But, once done, much of the data gathered will be easily reusable, requiring only an evaluation of elements that change from year to year.

Chapter IV

SUMMARY AND CONCLUSIONS

The objective of this study was to produce a sufficiency rating system which could be used to evaluate the adequacy of secondary roads in Iowa. The system to be developed should be reasonably easy to use, yet yield results which are compatible with current processes used in priority programming.

Models currently being used for primary roads are empirical in nature, in that they are numerical ratings which relate well to 'experience based' adequacy ratings. It follows that the experience of local engineering practitioners should figure heavily in determining the form of the proposed model. To that end, a questionnaire was developed which could be used to survey local engineering practitioners - mostly county engineers. A statistical analysis of the responses provided the basis for the formation of the model proposed in this report.

The model that is proposed uses the same format used by the Arizona Highway Department for the first sufficiency rating system, developed in 1946. This format was adopted because it is well known, widely accepted, and comparatively easy to use. It also is considered to yield reasonable results, that are reproducible.

Rating criteria selection (and their relative weights) was based on the responses to the questionnaire. Scaling factors were based on the relative weights suggested by the responses and the model used by the Iowa DOT for primary roads. Maximum scores were established, using a set of design standards adopted for the model. Failure to meet the 'standard' represented a 'deficiency', the amount of deficiency dependent on how close the rated road segment came to meeting the standard. The concept of 'tolerability' figured heavily in forming the scales used with the criteria. This concept, discussed in detail in Volume 1 of this report, is predicated on the supposition that there exists (for each rating criterion) a 'tolerable' standard which is less desirable than the 'ideal', but still considered safe (or at least acceptable). A comparative level was selected for the 'tolerable' value (based on currently used models) and scales were graduated.

The worksheets and Guide in Appendix C were developed to aid users of the system in applying the model to roads in their jurisdiction. Revisions to the forms were made, using the experience gained in the testing of the model. Some of the revisions made as a result of the tests produced a more uniform model for all functional classes of roads to be evaluated. Variations in the resultant ratings are based on whether the rated road segment is paved or unpaved and on the variability in design standards, based on functional class and ADT.

Some additional effort is needed to more easily access available data and more input is needed from potential and actual users, to refine the model. The comparative results produced by the trial runs do suggest that the model is usable and should prove to be compatible with other processes used to form priority lists for project programming. It should provide results that are reproducible and defensible.

Appendix A

COUNTY ENGINEER'S QUESTIONNAIRE

ROAD SUFFICIENCY RATING CRITERIA QUESTIONNAIRE

Your opinions are solicited regarding the choice of suitable rating elements for use with a proposed sufficiency rating system for secondary roads. There are a set of common rating elements usually used as part of sufficiency rating systems in the United States. It would seem that not all of the elements used for primary roads are useful for use in evaluating secondary roads. This survey is being conducted to select the appropriate rating elements as part of the development of a sufficiency rating system for secondary roads for a contract with the Iowa Highway Research Board.

Secondary roads have been divided into two groups -- trunk - trunk collector roads and area service roads. Two identical lists of rating elements have been prepared, one for each functional class group. The rating elements have been segregated into three categories. The categories are CONDITION, SAFETY, and SERVICE.

The categories have from six (6) to nine (9) rating elements used for the actual rating by various state and/or local highway agencies using sufficiency rating systems for priority planning. A few rating elements appear in more than one category. Some of the overlap is intentional, using the rationale that the rating element is an important factor in both categories, while in some instances, it is a matter of disagreement as to where the rating element belongs.

CATEGORY RANK
For the rating elements in each category, please indicate your perception of the appropriate rank for each element -- <u>within each category</u>. Do this for each category separately, with one (1) being the most important. An example is shown in Table 1 shown below. A short description of the rating elements is enclosed with this mailing.

TABLE 1

Example -Ranked Rating Elements

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	2	5	80
Wearing surface	4	11	60
Shoulder	6	16	50
Drainage	5	12	57
Remaining life	3	7	74
Maintenance economy	1	2	92

OVERALL RANK

Next, determine your perception of the appropriate rank for all 23 elements, ignoring category. Rank one (1) to 23.

WEIGHTED RANK

Using this ranking as an aid, weight the 23 elements, using 100 for the most important rating element and lesser weights for less important elements. Duplicate weights may be used. Table 2 lists all the rating elements for trunk and trunk collector roads. A blank is included for insertion of additional rating elements.

TABLE 2

Rating Element Weights-Trunk & Trunk Collector Roads

	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
CONDITION			
Foundation	____	____	____
Wearing surface	____	____	____
Shoulder	____	____	____
Drainage	____	____	____
Remaining life	____	____	____
Maintenance economy	____	____	____
____________	____	____	____
SAFETY			
Pavement width (surface)	____	____	____
Shoulder width	____	____	____
Right-of-way width	____	____	____
Stopping sight distance	____	____	____
Passing sight distance	____	____	____
Hazards (safety)	____	____	____
Alignment consistency	____	____	____
Traffic control	____	____	____
Accident rate	____	____	____
____________	____	____	____
SERVICE			
Alignment (horizontal)	____	____	____
Alignment (vertical)	____	____	____
Pavement width (surface)	____	____	____
Improvement continuity	____	____	____
Ride quality	____	____	____
Surface type	____	____	____
Shoulder width	____	____	____
Snow problems	____	____	____
____________	____	____	____

AREA SERVICE ROADS

Please repeat the process for area service roads. Since most are built to different design standards and most carry lighter traffic volumes, it is quite possible that you may rank and weight differently. Again, for this part, begin by ranking the 23 elements, followed by the weighting. As before, weight the most important as 100, with lesser ranked elements receiving a weighted rank below 100. Table 3 has been provided for this purpose.

TABLE 3

Rating Element Weights - Area Service Roads

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	_____	_____	_____
Wearing surface	_____	_____	_____
Shoulder	_____	_____	_____
Drainage	_____	_____	_____
Remaining life	_____	_____	_____
Maintenance economy	_____	_____	_____
______________________	_____	_____	_____
SAFETY			
Pavement width (surface)	_____	_____	_____
Shoulder width	_____	_____	_____
Right-of-way width	_____	_____	_____
Stopping sight distance	_____	_____	_____
Passing sight distance	_____	_____	_____
Hazards (safety)	_____	_____	_____
Alignment consistency	_____	_____	_____
Traffic control	_____	_____	_____
Accident rate	_____	_____	_____
______________________	_____	_____	_____
SERVICE			
Alignment (horizontal)	_____	_____	_____
Alignment (vertical)	_____	_____	_____
Pavement width (surface)	_____	_____	_____
Passing opportunity	_____	_____	_____
Improvement continuity	_____	_____	_____
Ride quality	_____	_____	_____
Surface type	_____	_____	_____
Shoulder width	_____	_____	_____
Snow problems	_____	_____	_____
______________________	_____	_____	_____

CATEGORY RANKINGS

The last question pertains to the relative importance of the three rating categories. Please rank the three categories and indicate your perception of their comparative importance, using the following procedure:

1. Rank the three categories, using one (1) to indicate the most important.

2. Assign the score of ten (10) to the <u>most</u> important category.

3. Indicate your perception of the <u>relative</u> importance of the other two categories by scores ranging from nine (9) down to as low as one (1), and indicate the values in the blanks provided.

Table 4 below shows an example ranking and weighting.

TABLE 4

Example Category Weighting

CATEGORY	RANK	WEIGHTED RANK
Condition	1	10
Safety	2	8
Service	3	5

The example shown has assumed a fictional ranking of CONDITION (most important) to SERVICE (least important). Since CONDITION was considered to be most important, its weighted rank was ten (10). In the fictional response, SAFETY was considered to be 0.8X as important as CONDITION (for trunk and trunk collector secondary roads) and SERVICE deemed to be 0.5X as important as SAFETY.

TRUNK AND TRUNK COLLECTOR ROADS

Please indicate your perception of the relative importance of the three categories in evaluating trunk and trunk collector roads for sufficiency ratings. Table 5 below lists the categories.

TABLE 5

Category Weight - Trunk and Trunk Collector Roads

CATEGORY	RANK	WEIGHTED RANK
Condition	____	______
Safety	____	______
Service	____	______

AREA SERVICE ROADS

Please repeat the process for area service roads. Table 6 lists the categories.

TABLE 6

Category Weights - Area Service Roads

CATEGORY	RANK	WEIGHTED RANK
Condition	____	______
Safety	____	______
Service	____	______

Thank you for your time and effort. Your opinions will be analyzed, along with those expressed by peers. The goal will be to obtain a list of rating elements considered to be the most meaningful and useful for evaluating secondary roads for priority planning plus the most appropriate weights for each. If you have any questions, please call Clete Mercier at Iowa State University, telephone 515-294-8387.

DESCRIPTION OF RATING ELEMENTS

A brief description has been prepared of the rating elements listed in the accompanying questionnaire to assist you in its completion. They are listed below, in the same order as they appear on the questionnaire.

CONDITION

Foundation: An appraisal based on degree of plasticity and the number of foundation failures observed per unit length of road.

Wearing surface: An evaluation of the various types (and frequency of occurrence) of physical defects observed per unit length of road.

Shoulder: An evaluation of the physical defects - deviation from the ideal - of the surface of the shoulders.

Drainage: An analysis of the occurrence of ponding, ditch erosion, silting, and scouring plus adequacy and condition of the culverts.

Remaining life: A rating based on the expected remaining life of the wearing surface.

Maintenance economy: An appraisal of maintenance requirements, based on historical knowledge.

SAFETY

Pavement width (surface): An evaluation using a comparison of existing pavement width with a design standard.

Shoulder width: Same as pavement width, except using the design standard for shoulders.

Right-of-way width: An appraisal of the adequacy of the right-of-way width to accommodate the desirable roadway cross sections.

Stopping sight distance: An analysis of road alignment which enumerates the occurrences of less than desirable stopping sight distance, based on design speed.

Passing sight distance: An analysis of the frequency of occurrence of passing vision being restricted by alignment, based on design speed.

Hazards (safety): A rating based on a safety study tally of less than desirable horizontal clearances from roadside obstacles plus sharp horizontal curves.

Alignment consistency: Numerical rating as a function of the number of inconsistencies in horizontal alignment per unit length of road, recognizing area terrain characteristics.

Traffic control: An analysis of traffic controls - how closely they meet MUTCD regulations, in terms of color, symbols, and proper sign distances. Also, do they convey sufficient information to the driver? Are they clearly visible and well maintained?
Accident rate: An assessment of the road segment's relative safety, based on the the number of fatal, personal injury, and property damage accidents, using accident records.

SERVICE
Alignment (horizontal): Frequency of occurrence of horizontal curves which cannot be safely negotiated at design speed.
Alignment (vertical): An analysis of deficiencies in vertical alignment, such as gradient exceeding design standards, or at railroads or drainage structures.
Pavement width (surface): A service rating based on the relationship between width and average daily traffic volume.
Improvement continuity: A rating which stresses the continuity (or discontinuity) of the rated segment compared to total route of which it is a part.
Ride quality: A rating element which is an evaluation of surface quality -- waviness, irregular surface evaluation, corrugations, and/or channeling.
Surface type: Is the surface type adequate for the type and volume of traffic using the road segment?
Shoulder width: For the average daily traffic on the evaluated road segment, does the width and condition of the shoulder meet design standards for adequate capacity and refuge for emergency stops?
Snow problems: An evaluation based on the ability of roadside ditches and accessible portions of the right-of-way to accommodate the quantity of snow that may have to be removed from the roadway and shoulders.

Appendix B

STATE QUESTIONNAIRE

State Questionnaire State ____________________________

Name, title, telephone # of contact person

1. Does your state have a numerical evaluation system, a sufficiency rating or similar, used to prioritize secondary road projects for planning and/or budgetting purposes? Y N

2. If yes, by state or counties (circle one).

3. If state gathers data:

   a) Is there a written copy of the procedure? Y N

   b) Is it possible to get a copy? Y N (if yes, arrange for it)

   c) How are the results used?

   d) Does it vary from that used on primary roads? Y N

   e) If yes, how? (Try to gather details.)

   f) What do you use for data sources?

4. If local jurisdiction uses rating system, who do I contact to get information?

   a) Does state see the results? Y N

   b) If so, how is it used by the state?

   c) Does state do any disbursement of funds to local jurisdiction? Y N

   d) If so, describe briefly.

   e) Are the ratings used to prioritize any financial or other aid from state to local? Y N

   f) If so, how?

5. Are you aware of any attempt to evaluate surface condition of non-paved roads? (If so, try to get details.)

6. Who has responsibility for secondary roads in your state?

7. Do you know how the rating items and their weights were determined? If so, how?

8. What design standards are used for road design in your state? (If not a national standard, try to get a copy.)

Appendix C

SAMPLE EVALUATION FORMS AND GUIDE FOR PREPARATION

Pavement (roadbed) Width Rating

For paved roads, use 2X the lane width for the design standard. If unpaved, use 2X (sum of lane width standard + shoulder width standard). Use the roadway width (for non-paved roads) for roadbed width. Use the table provided below to rate the road segment.

TABLE 1

Pavement (roadbed) Width Ratings

Design Width (ft)	Actual	Rating Score
Paved		
24	=>24	9
24	23-24	7
24	22-23	6
24	20-22	5
24	18-20	4
24	<18	1-3
22	=>22	9
22	21-22	7
22	20-21	6
22	18-20	5
22	<18	1-4
Unpaved		
34	=>34	9
34	33-34	7
34	32-33	6
34	30-32	5
34	28-30	4
34	26-28	3
34	<26	0
30	=>30	9
30	29-30	7
30	28-29	6
30	26-28	5
30	24-26	4
30	<24	0
28	=>28	9
28	27-28	7
28	26-27	6
28	24-26	5
28	<24	1-4
22	=>22	9
22	21-22	7
22	20-21	6
22	18-20	5
22	<18	1-4

Shoulder Width Rating

Use Table 2 to select the ratings for the Shoulder Width criterion. Record <u>only</u> if the road is paved.

TABLE 2

Shoulder Width Ratings

Design Width (ft)	Actual	Rating Score
8	=>8	5
8	6-8	4
8	4-6	3
8	<4	0
6	=>6	5
6	4-5	4
6	3	3
6	<3	0
3	=>3	5
3	2	4
3	1	3
3	0	0

Surface Type Rating

Relate design standard to surface type (as noted in Iowa DOT records). To relate surface type code to design standard, refer to Table 3 provided below.

TABLE 3

Surface Type Codes

CODE	DESCRIPTION
7001, 7011	P. C. Concrete
6202, 6901, 6902, 6903	Asphaltic Concrete
3210, 4221, 5223	Surface Treatment
2010, 2015	Gravel (granular)
0010, 1014	Earth

Rate the road segment (non-paved roads) as shown below.

Design Standard	Actual	Rating Score
Paved	Granular	3
Paved	Earth	1
Granular	Earth	3

Passing Sight Distance Rating

Relate passing sight distance (at design speed) to alignment. Compute % of rated segment available by:

- -determining total length/segment with restricted passing, and
- -computing the percent available, via the equation shown below.

% Available = 100[Segment length-restricted length(sum)]/Length

Determine rating score by selecting from Table 4 below, using the appropriate design standard and computed % Segment Available. (See reprint of design standards, page 1.)

TABLE 4

Safe Passing Sight Distance Score

Design Std.	7	8,10,13,16	9,11,12,14,15,17	18,20,21,23,24
91-100	5	5	5	5
81-90	4	5	5	5
71-80	4	4	4	5
61-70	3	4	4	4
51-60	3	3	3	4
41-50	2	3	3	3
31-40	1	2	2	3
21-30	0	1	1	2
0-20	0	0	0	0

SAFETY EVALUATION WORKSHEET

All ratings on this worksheet are done on the basis of formulae, as noted on the worksheet. Scores are the result of subtracting 'deficiency' points from the maximum score for each rating element listed. Details and formulae are provided on the worksheet for all rating elements to be evaluated.

FIELD WORKSHEET

Complete Part I. Be sure that local identification (Local I.D.) correlates with the Secondary Road County Engineer's Listing. Group logically.

Complete the ratings for Part II. Use the Field Data Collection Guide from the next page of these instructions. Make a copy and attach to your clipboard.

Make notes on Hazards, Traffic Control Problems, and Others for the Safety Evaluation.

SAFETY EVALUATION WORKSHEET

This worksheet should be completed, using office records and notes from the Field Worksheet.

TABLE 5

FIELD DATA COLLECTION GUIDE

NOTE: Use in judging the average condition throughout the road segment.

Rating Criteria	General Descriptions Excellent	Good	Fair	Poor
Foundation	No base failure. Foreslopes in excellent condition.	Occasional base failure, fully correctable by spot repairs. No need for extensive rework.	Frequent base failure, requiring heavy maintenance. Causes reduction in speeds below design speed. Candidate for reconstruction. Tolerable.	Severe base failure over all. Extreme 'wash-board' condition. Speeds reduced significantly. Needs rebuild.
Wearing Surface	Satisfactory. Smooth surface. Routine grading for granular surface. No surface failure.	Occasional spots of surface failure, correctable by normal maint. Resurfacing not absolutely necessary.	Frequent spots of surface failure, correctable by heavy maintenance. Rough surfaces cause reduction in speed. Tolerable.	Severe surface failure over all/segment. Resurfacing or reconstruction necessary. Substantial speed reduct.
Drainage	Satisfactory. No silting, scouring, significant erosion or ponding. Culverts are adequate, in good condition.	Heavy rains cause occasional ponding - some silting or scouring of culverts, requiring maintenance. Some problems with slope of crown.	Substantial ponding during light rain. Traffic problems due to ponding, rough or softened surface or fnd. Excessive costs of maintenance of road and/or drainage. Costly corrections or improvements needed. Tolerable.	Excessive ponding, poor drainage. Problems not correctable through maintenance.
Mainten ance Economy	No expenditures except routine. Pavement patch rarely needed. Occasional need for add'n of gravel, but not lge. amounts. Earth road regularly needs blading, but no real problem.	Some expenses, not excessive. Some annual patching needed. Resurf/pvmt. desirable, not necessary. More gravel desired, not really necessary. Spot re-grading or extra dragging required.	Large expenditures of money, material. Much patching and crack filling. More gravel needed continuously, or annually. Road candidate for resurface/rebuild. Special attention needed on many locations. Tolerable.	Lge. expenses needed to keep serviceable. Great amt. of patching, more gravel needed regularly. Many spots need much regrading. Needs rebuilding.

Ride Quality	Smooth riding at design speed or above.	Minor roughness of surface causes little discomfort in riding. Occasional irregularities, corrugations, or channelling causes driver to slow to below design speed for short distances.	Noticeable discomfort in riding due to surface roughness. Occasional pvmt. cracking & failures require extensive patching. 'Wash-board' on gravel surface road requires frequent grading. Tolerable.	Heavy cracking, deep failures, obvious instability. Unsatisfactory riding surface.
Snow Problems	No significant drifting problems. Roadbed above surrounding area, ditches deep and wide for storage.	Occasional locations where drifting is a problem. Ditches still wide and deep enough to accommodate most of the snow.	Frequent locations where drifting a problem, but no extremely long drifting areas or places where very deep drifts occur. Some problems on ditch width or depth. Roadbed elevation occasionally inadequate. Ditch may need some extensive maintenance to clear silt or vegetation. Tolerable.	Drifting and/or snow removal a recurring problem of significance. R-O-W width inadequate to allow for ditches to be wide or deep enough, or extensive grading needed to raise the roadbed and/or improve ditches.

FIELD WORKSHEET - Sufficiency Rating System

County__________ Length ______miles Odometer-begin_______ end______

Local I.D. ____

Functional Class (circle) Trunk Trunk Collector Area Service

Record average condition over the rated road segment for each of the following rating criteria by circling the proper point score.

CRITERION	RATING SCORES								
	Excellent		Good		Fair	Poor			
Foundation	9	8	7	6	5	4	3	2	1
Wearing Surface	9	8	7	6	5	4	3	2	1
Drainage	8	7	6	5	4	3	2	1	
Maintenance Economy	9	8	7	6	5	4	3	2	1
Ride Quality	6		5	4	3	2	1		
Snow Problems	5		4		3	2	1		

Total (Worksheet) ____

Notes on other field observations. [Design Speed=___mph]

Hazards	Odometer Reading		
Narrow drainage structure	_____	_____	_____
R. R. X-ing @ grade w/o signals	_____	_____	_____
Poor Structure Approach (specify)	_____	_____	_____
Other Fixed Structure Encroachment	_____	_____	_____
Traffic Control Problems			
Poor pavement markings (readability)	_____	_____	_____
Warning sign distance	_____	_____	_____
Vision @ uncontrolled intersection	_____	_____	_____
Consistency/sign placement	_____	_____	_____
Other ____________________	_____	_____	_____

Other Notes: [Example - note any curves which must be driven @ less than design speed. Record probable maximum safe speed.]

OFFICE WORKSHEET - Sufficiency Rating System

County__________ Length ______miles Terrain type________________

Local I.D. ____Design Std.___

Road I.D. Nos. _______ _______ _______ _______ _______ _______

Functional Class (circle) Trunk Trunk Collector Area Service

BASIC DATA - Iowa DOT Records

Surface Type ____ Width/surface____' Width/rdy____' ADT_______Yr___

Number/R.R. X-ings____ Number/Structures______

OFFICE RATING

Record Design Standard (use functional class, ADT)____Des. Speed__
Compare rated road segment to design standards and score.

Pavement (roadbed) width: Design Std.___' Actual___' Rating___

Shoulder width (paved): Design Std.___' Actual___' Rating____

Surface type (non-paved): Design Std.____ Actual____ R ating____

Passing sight distance: Percent of road available___ Rating____

WORKSHEET TOTAL (include only three ratings) _______

COMPOSITE RATING

The composite rating of the road segment is equal to the sum of individual ratings from three (3) sheets. These are the:

Field Worksheet,
Safety Evaluation Worksheet, and
Office Worksheet (this sheet).

List the scores from each sheet below and record the composite score in the space provided.

Field Worksheet____ + Safety Evaluation____ + Office Worksheet___

COMPOSITE SCORE _____

Notes on rating (include any remarks on critical needs):

SAFETY EVALUATION WORKSHEET - Sufficiency Rating System

County__________ Length (L)______miles

Local I.D. ____ ____Design Std.___

Road I.D. Nos. _______ _______ _______ _______ _______ _______

Functional Class (circle) Trunk Trunk Collector Area Service

Accidents (use data from past five years):
Property damage (Y,N). If yes, how many? ___X 1 point =____
Personal injury (Y,N). If yes, how many? ___X 4 points=____
Fatality (Y,N). If yes, how many? ___X 12 points=____
Total Deficiency Points (n)____
Rating Score = 6 - (n/L) = 6 - (___/___) Accident Rate Score____

Hazards (see field worksheet and County Engineer's Listing) Number
Structure (bridge or culv) restricts rdy. width (<20') __
Poor structure approach alignment __
R. R. X-ing @ grade without automatic signals __
Other fixed structure extending onto roadbed __
(10' from edge/pavement or onto roadbed)
Abrupt or severe grade changes __
Combination of above conditions __
Other conditions (describe)_____________________________ __
Total (N) ____
Rating Score = 9 - 2(N/L) = 9 - 2(___/___) Hazard Score ____

Stopping Sight Distance Design Std.=___ SSSD=____@ Design Speed___
Occurrences less than Design Standard (N) ____
Rating Score = 8 - (N/L) = 8 - (___/___) SSD Score___

Traffic Controls (see field worksheet) - record occurrences/segment
Poor pavement markings (readability) _____
Warning sign distance _____
Vision @ uncontrolled intersection (non-crop) _____
Consistency of sign placement _____
Other ____________________________ _____
Total (N) _____
Rating Score = 6 - 2(N/L) = 6 - 2(___/___) Traffic Control Score___

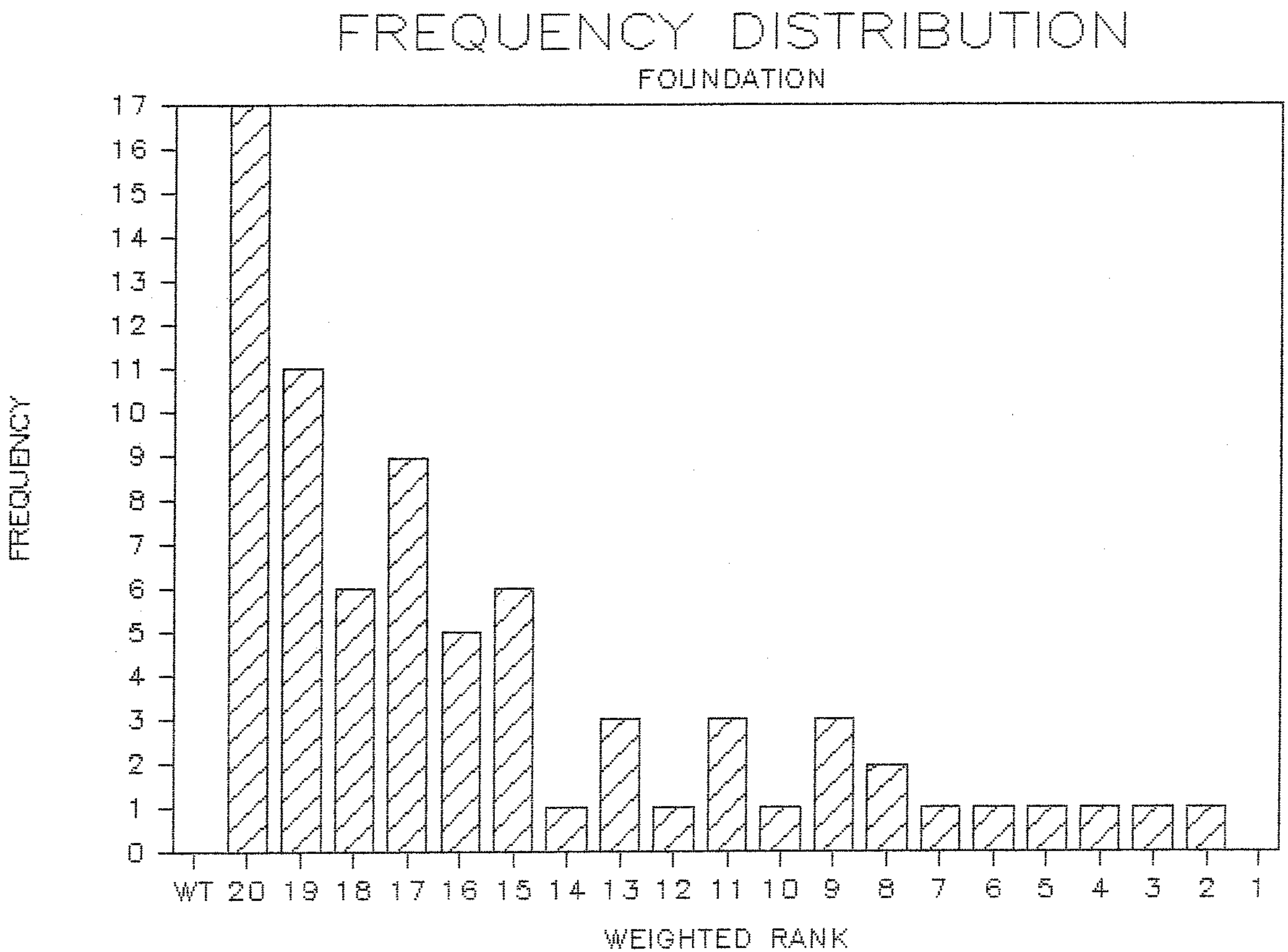
Horizontal Alignment [Design Speed=____mph] [30 mph for Area Service]
Compute point deductions based on the number of curves on the rated road segment where speed reduction of @ least 5 mph less than the road design speed is required for safe operation.
___ curves @ 5 mph < speed reduction < 10 mph X 1 = ___
___ curves @ 10 mph < speed reduction < 15 mph X 2 = ___
___ curves @ 15 mph < speed reduction < 20 mph X 3 = ___
Total Deficiency Points (n)____
Rating Score = 6 - (n/L) = 6 - (___/___) Horizontal Alignment Score___

SAFETY EVALUATION TOTAL (total scores as noted below)
[Accident + Hazards + SSD + Traffic Controls + Horizontal Alignment]

[____ + ____ + ____ + ____ + ____] = _____ points

Appendix D

FREQUENCIES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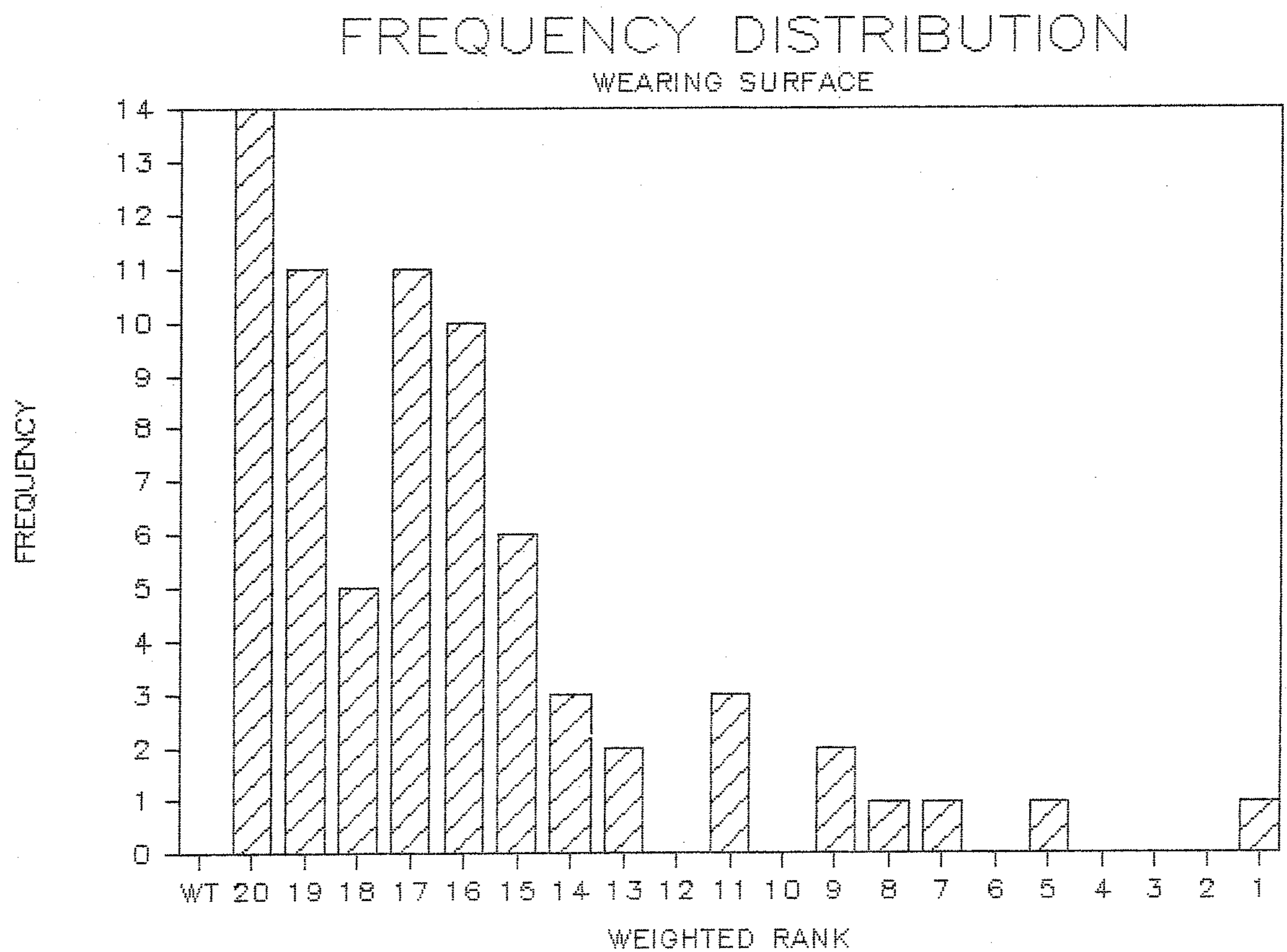
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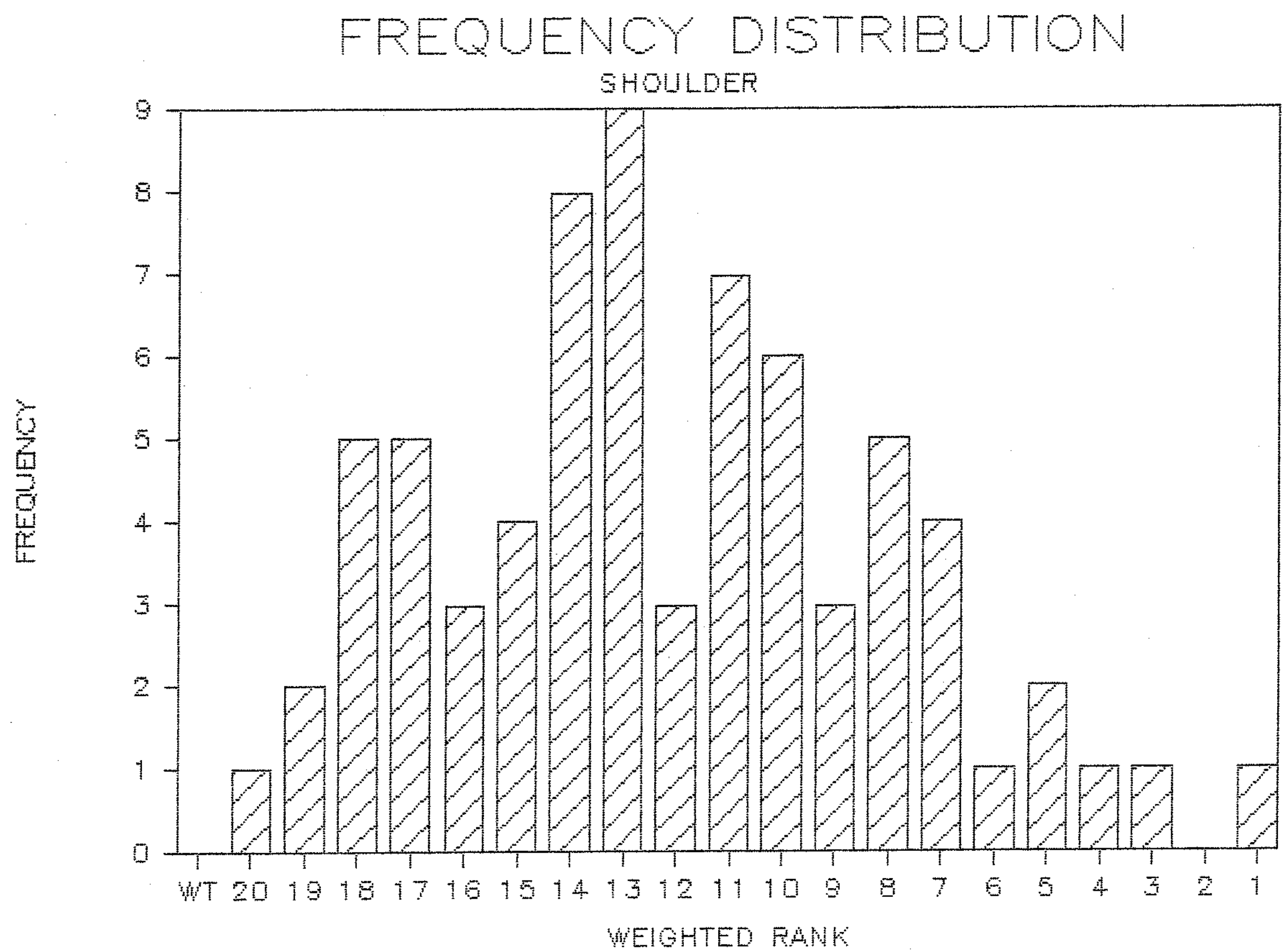
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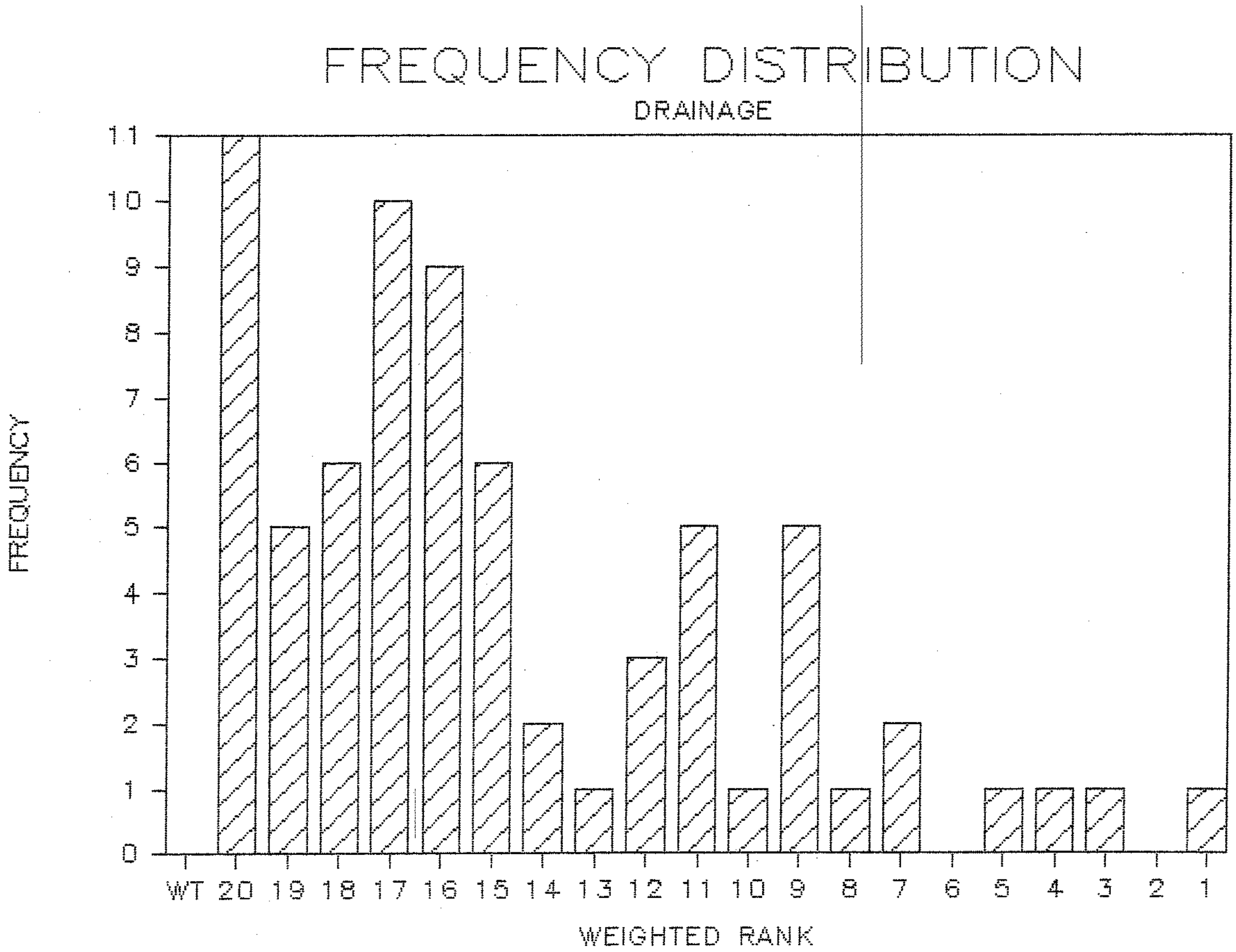
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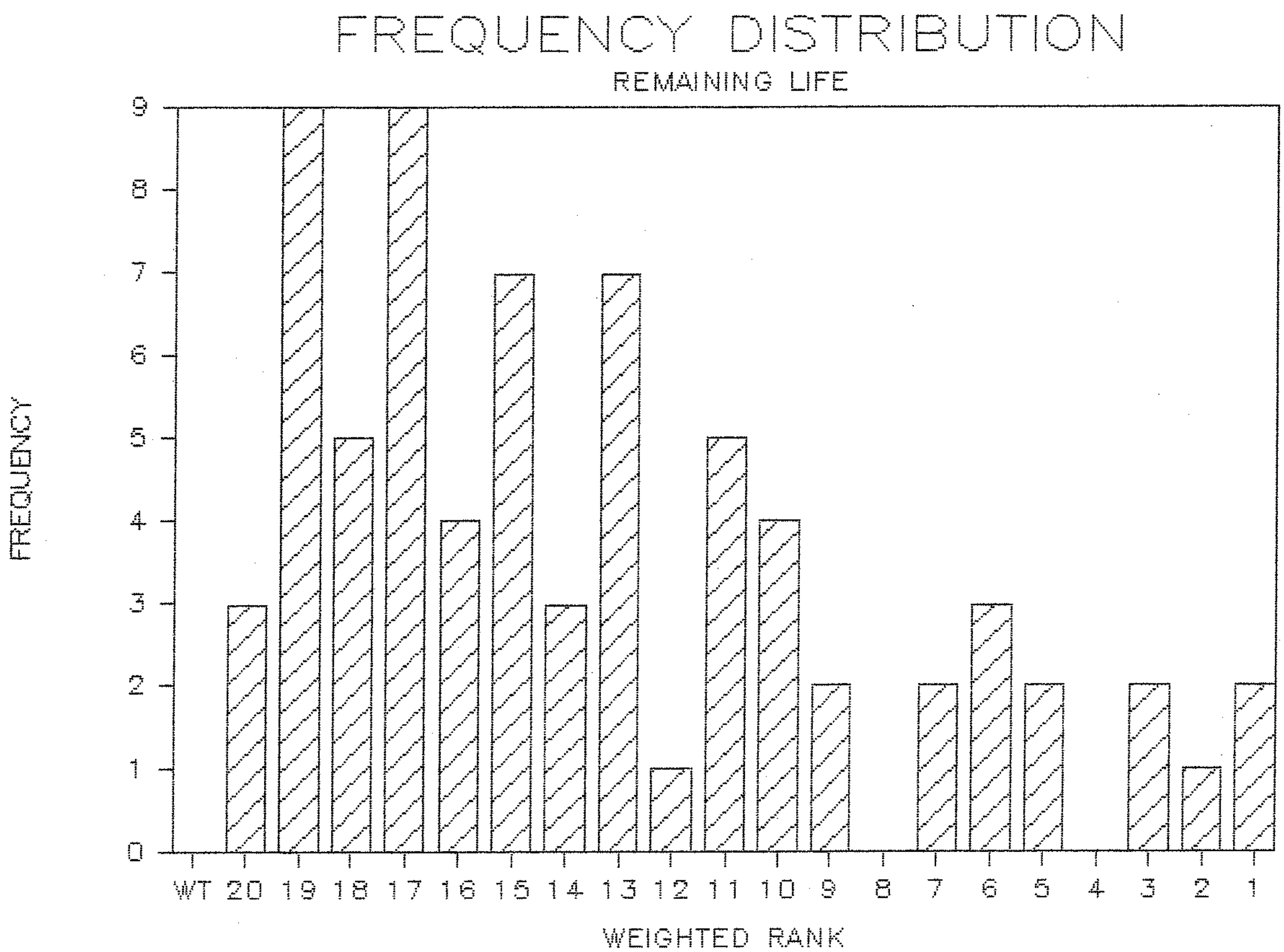
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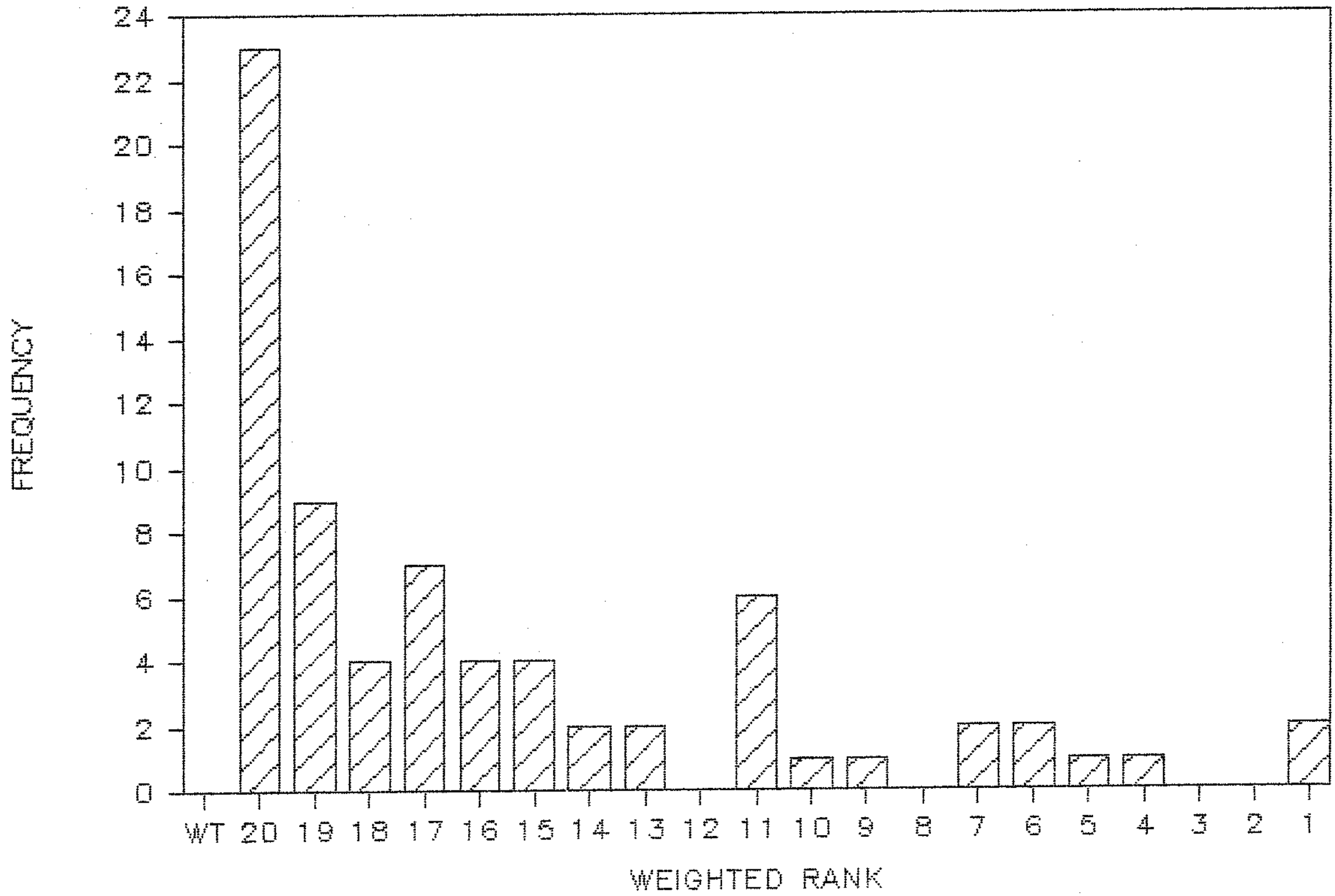
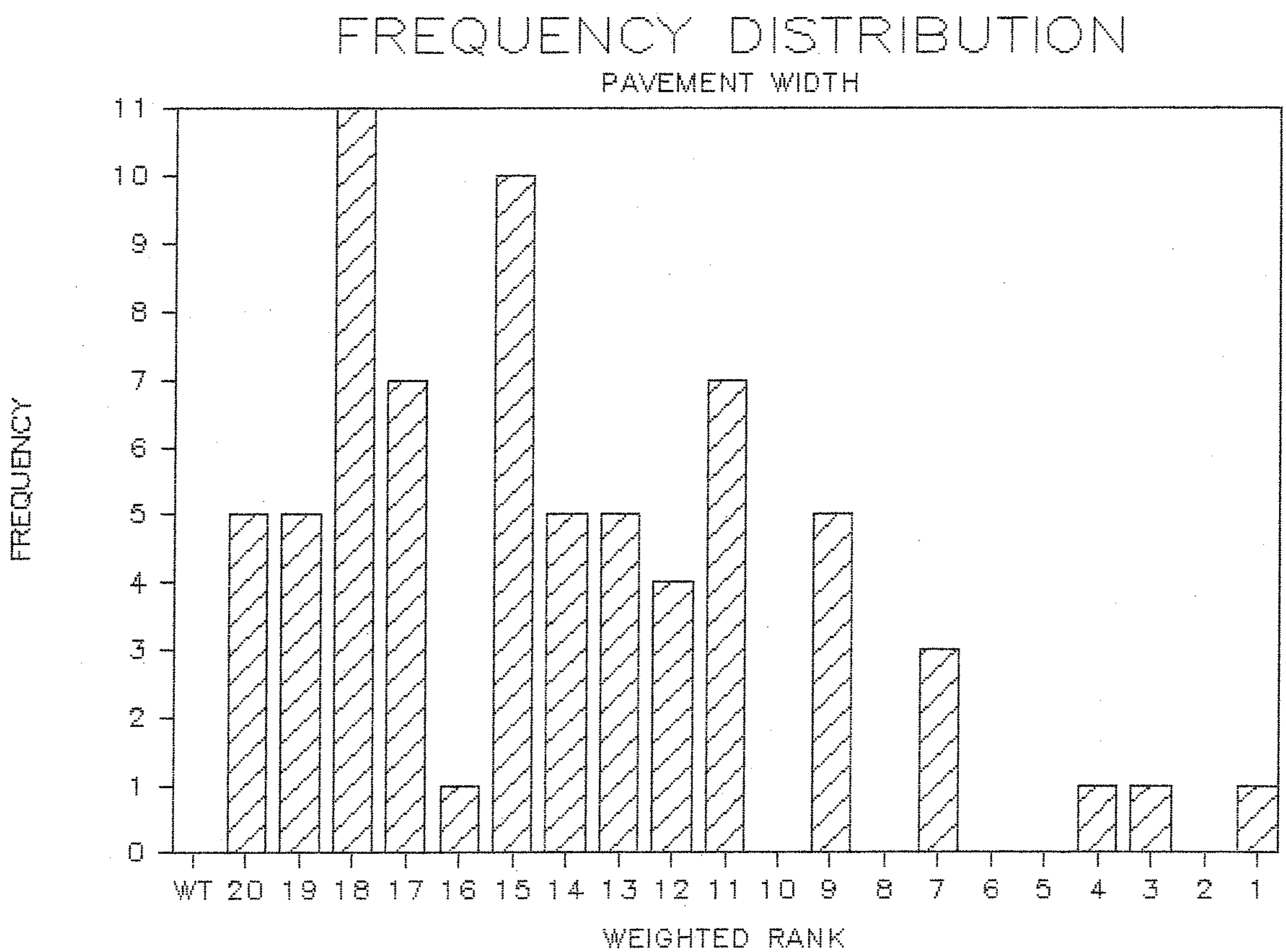
MAINTENANCE ECONOMY





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PAVEMENT WIDTH
FREQUENCY
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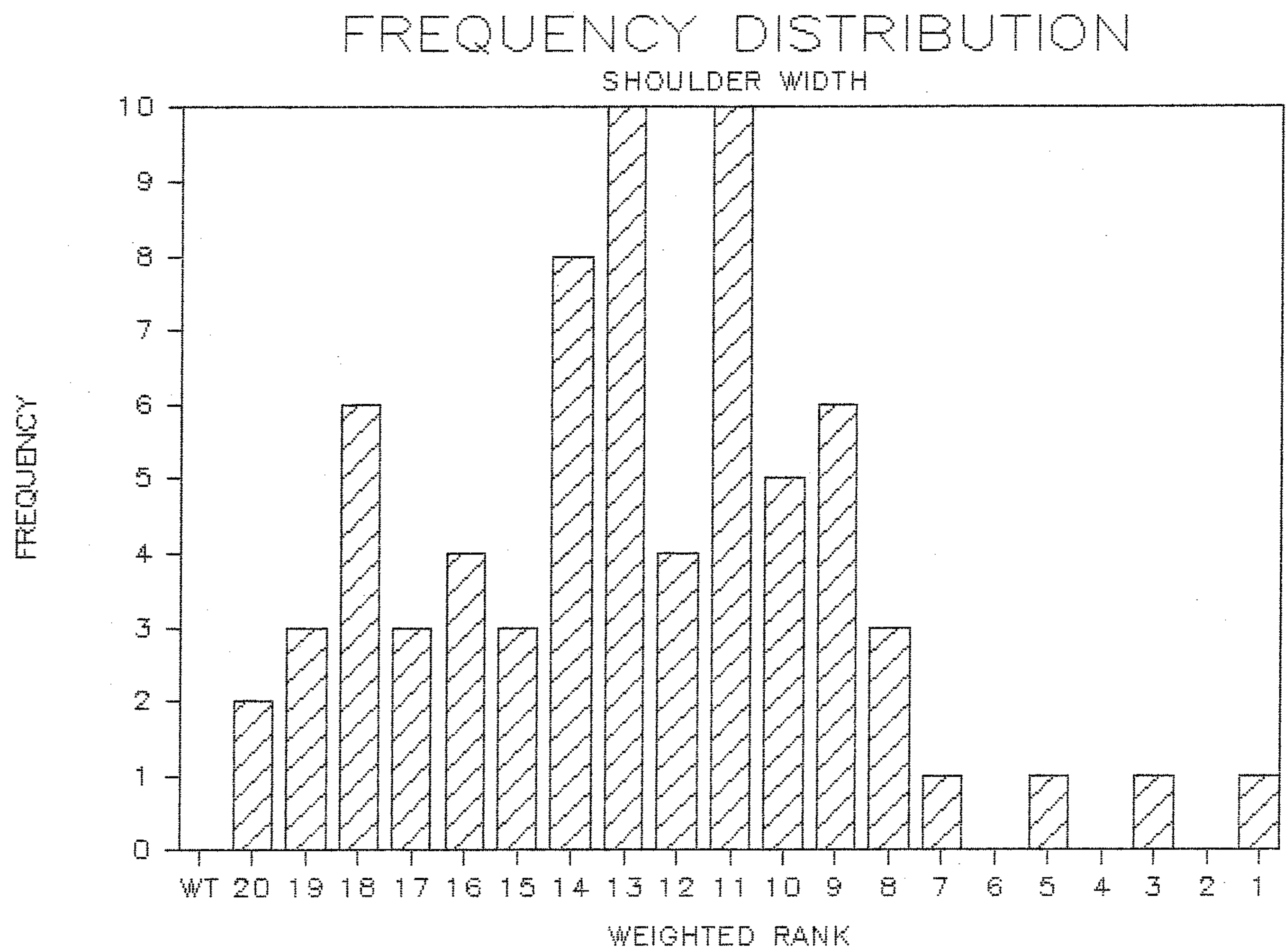
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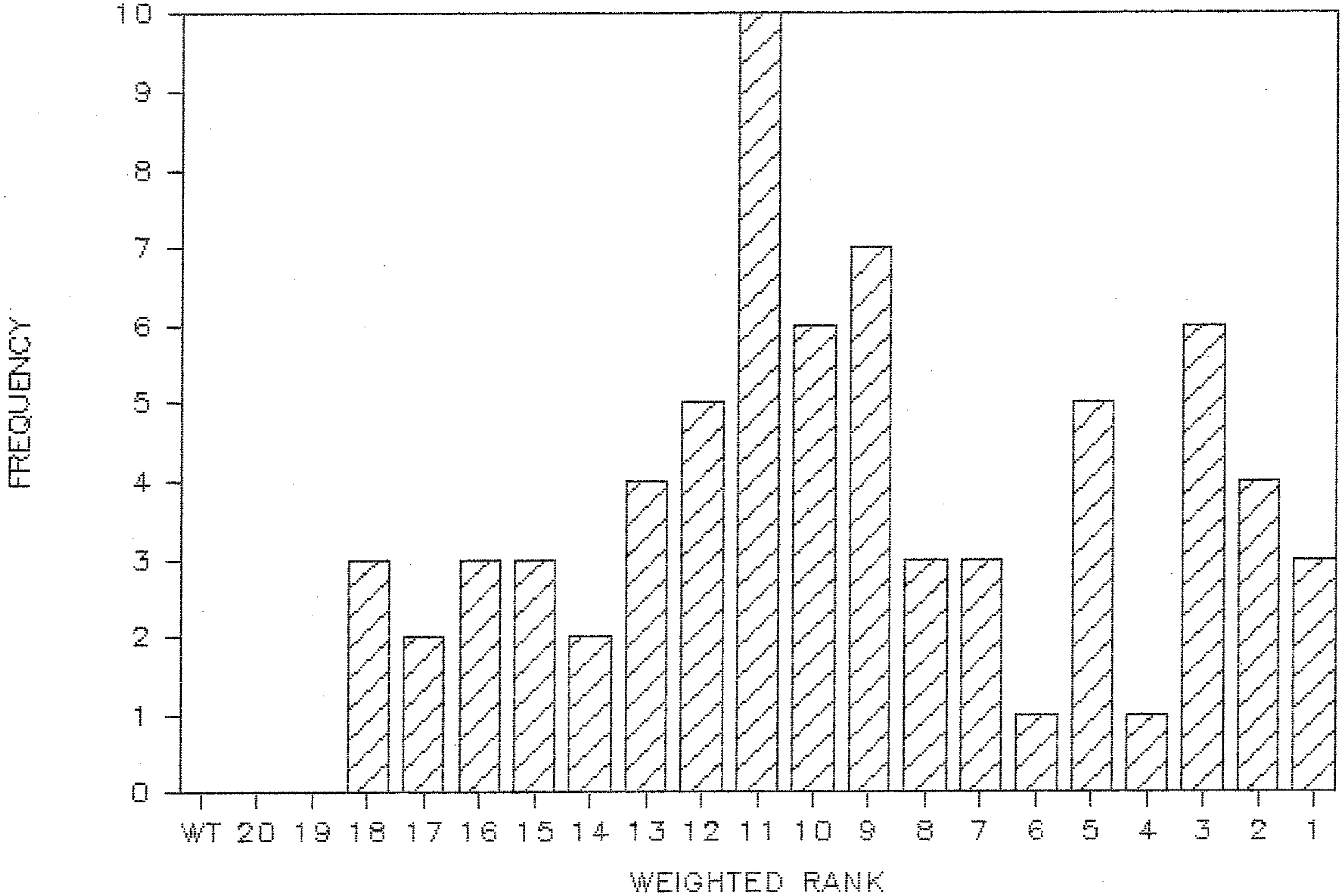
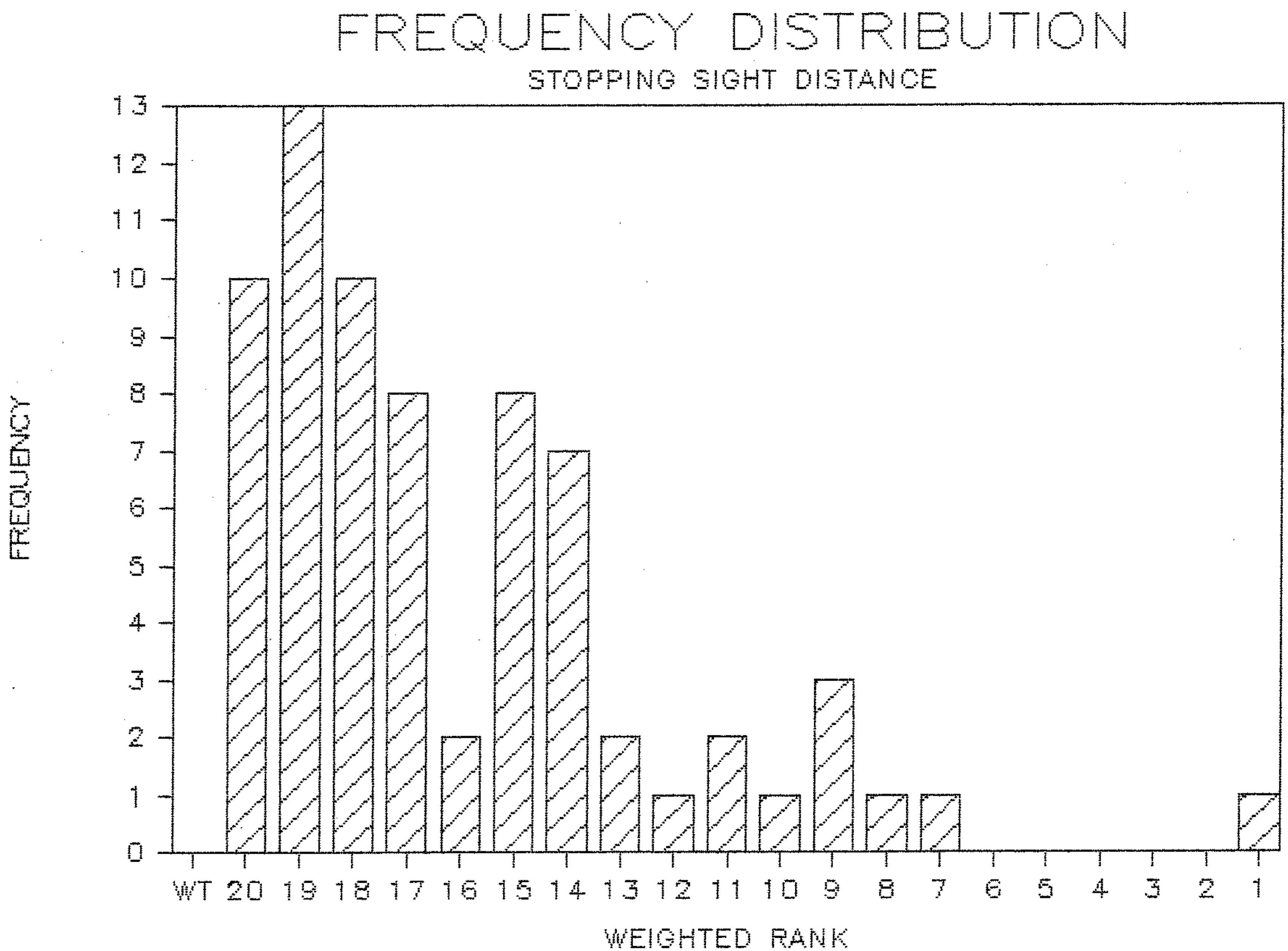
FREQUENCY DISTRIBUTION

RIGHT-OF-WAY

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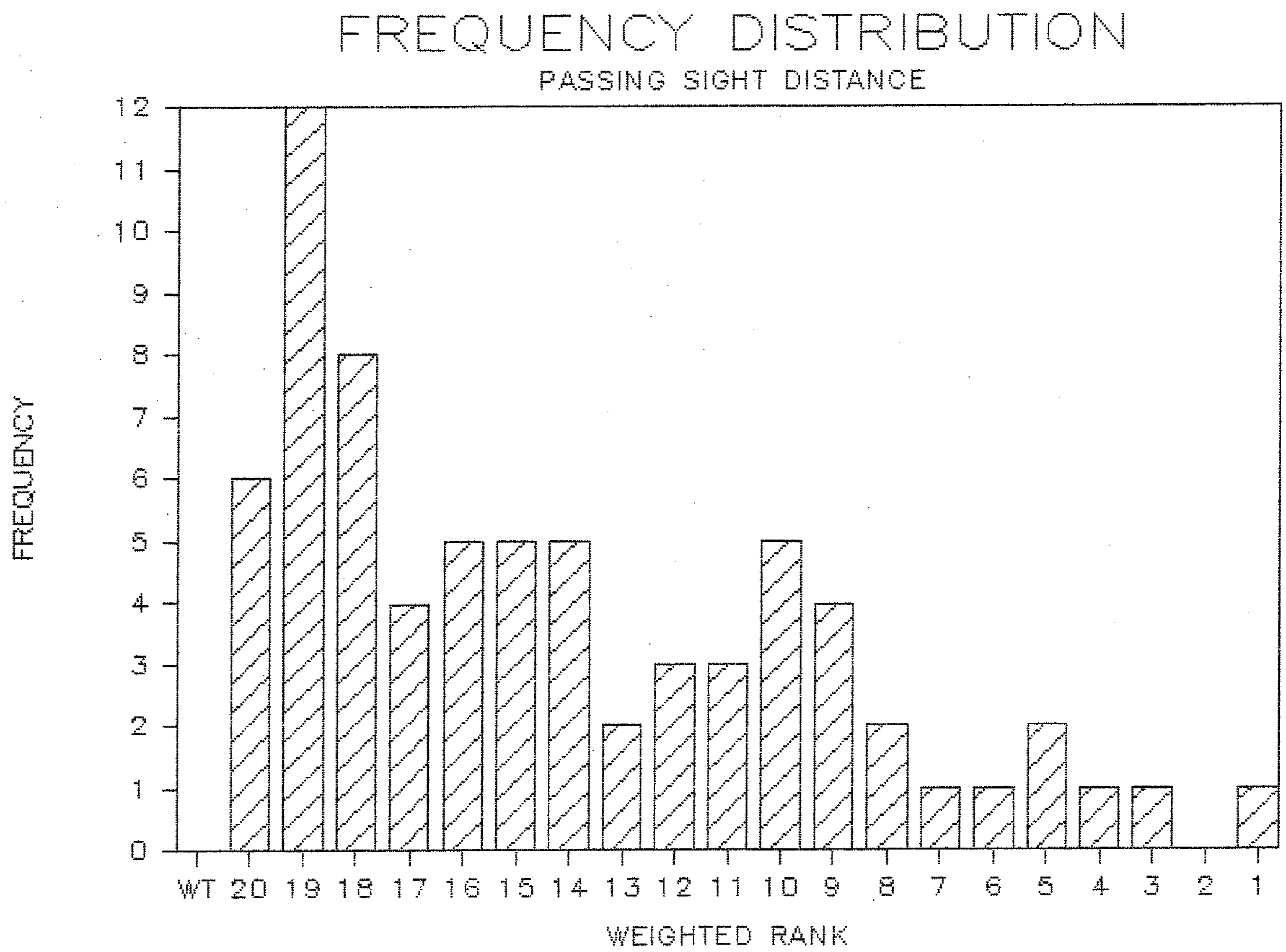

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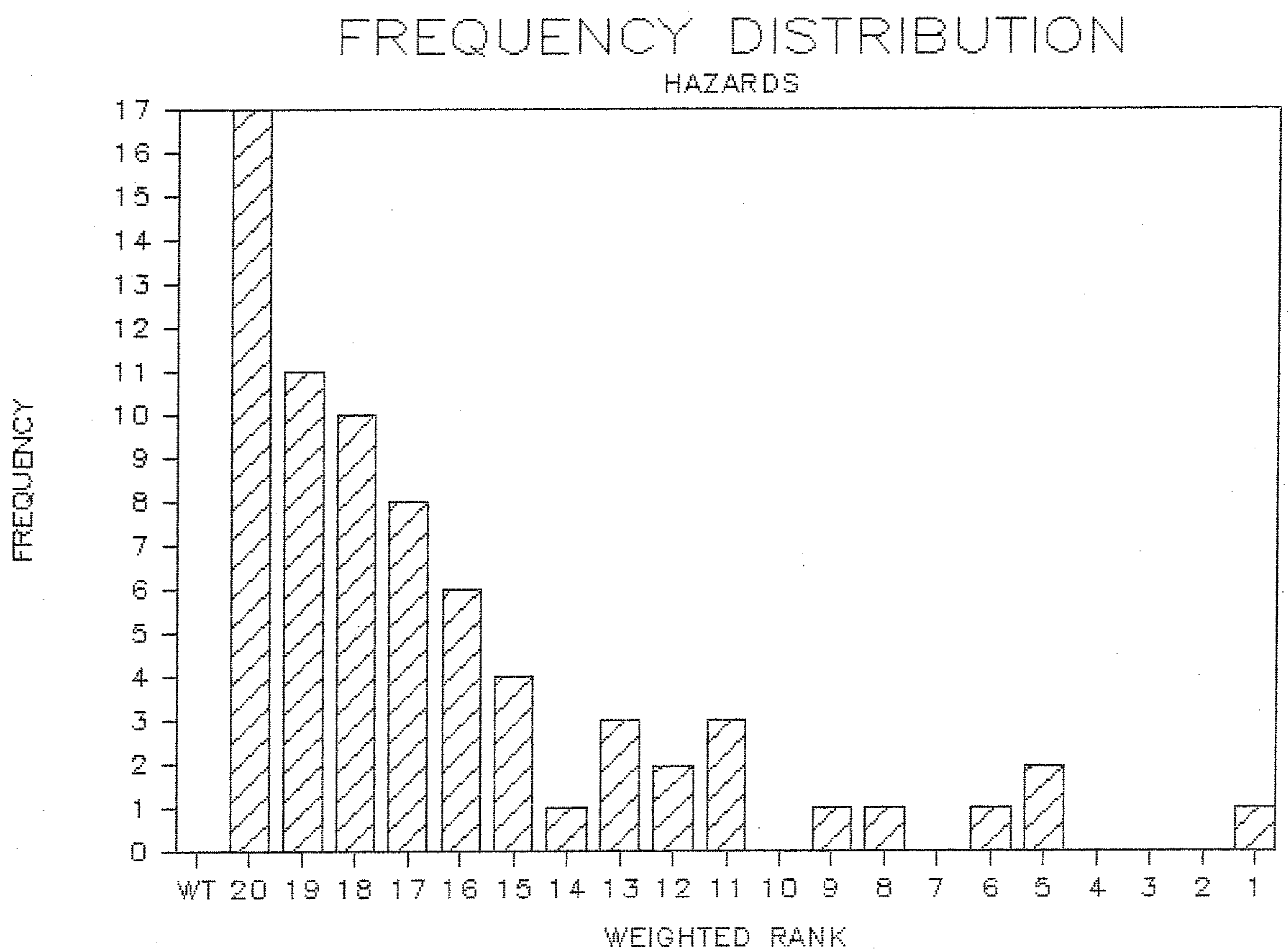

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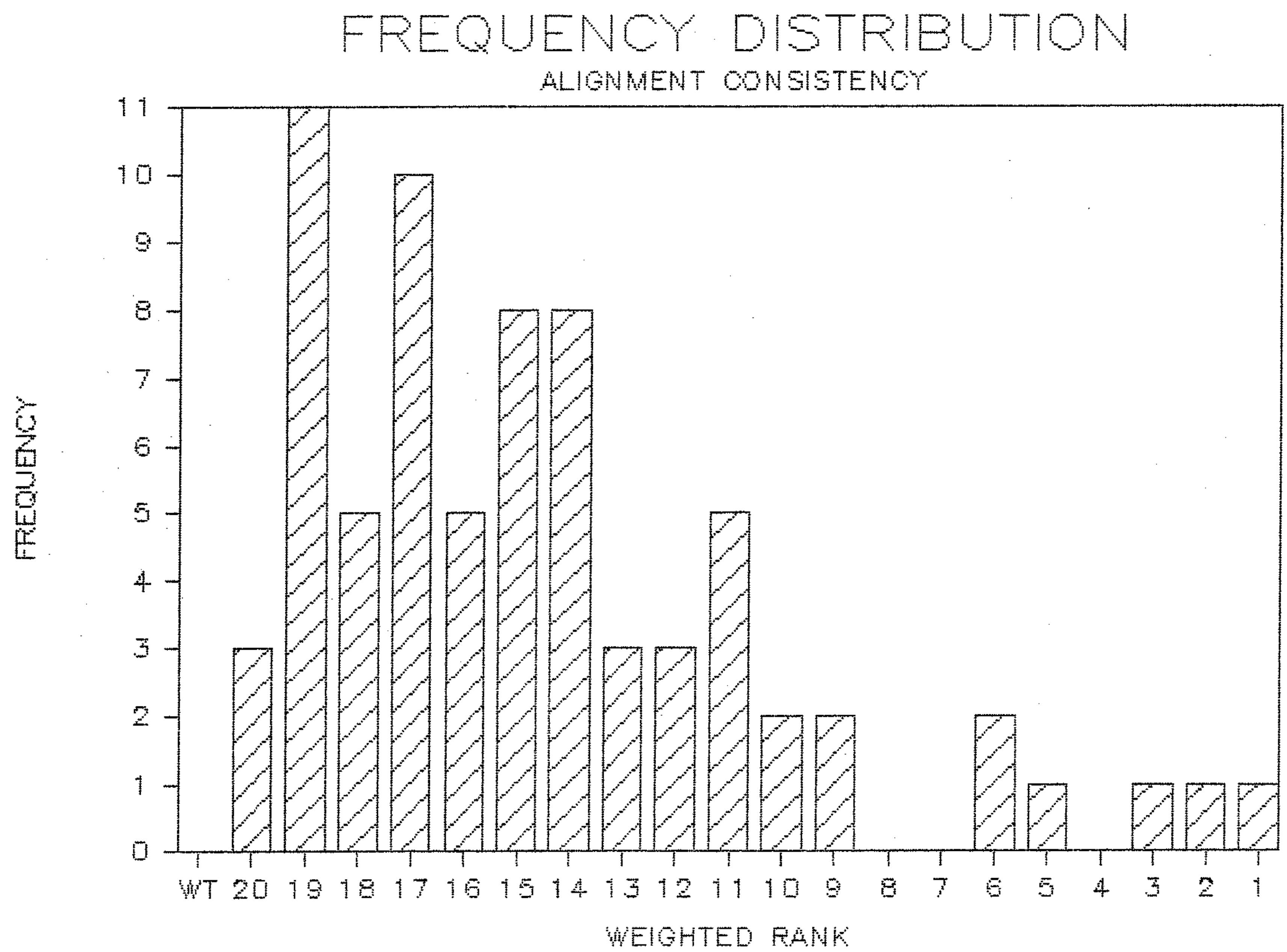
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WT
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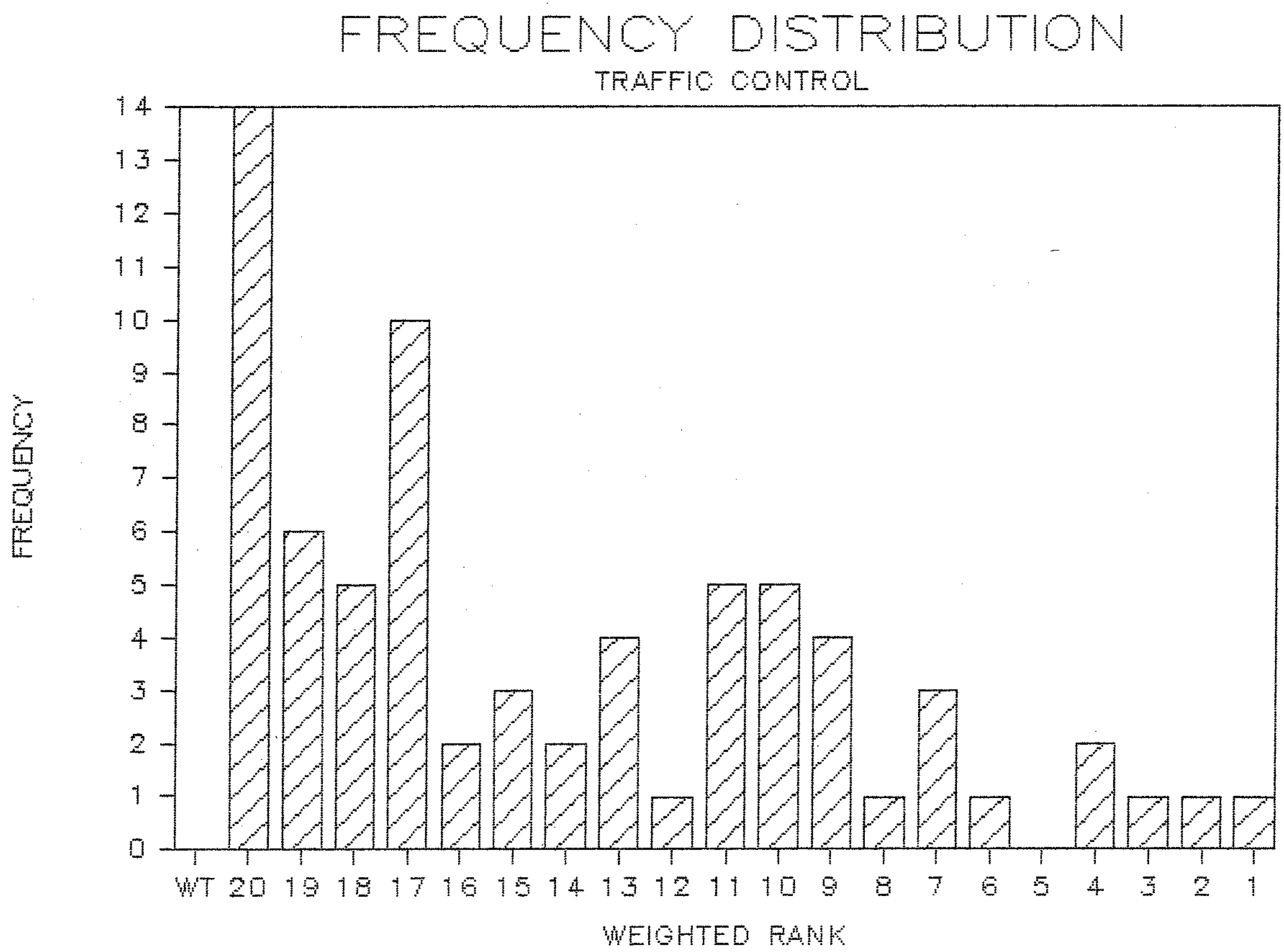
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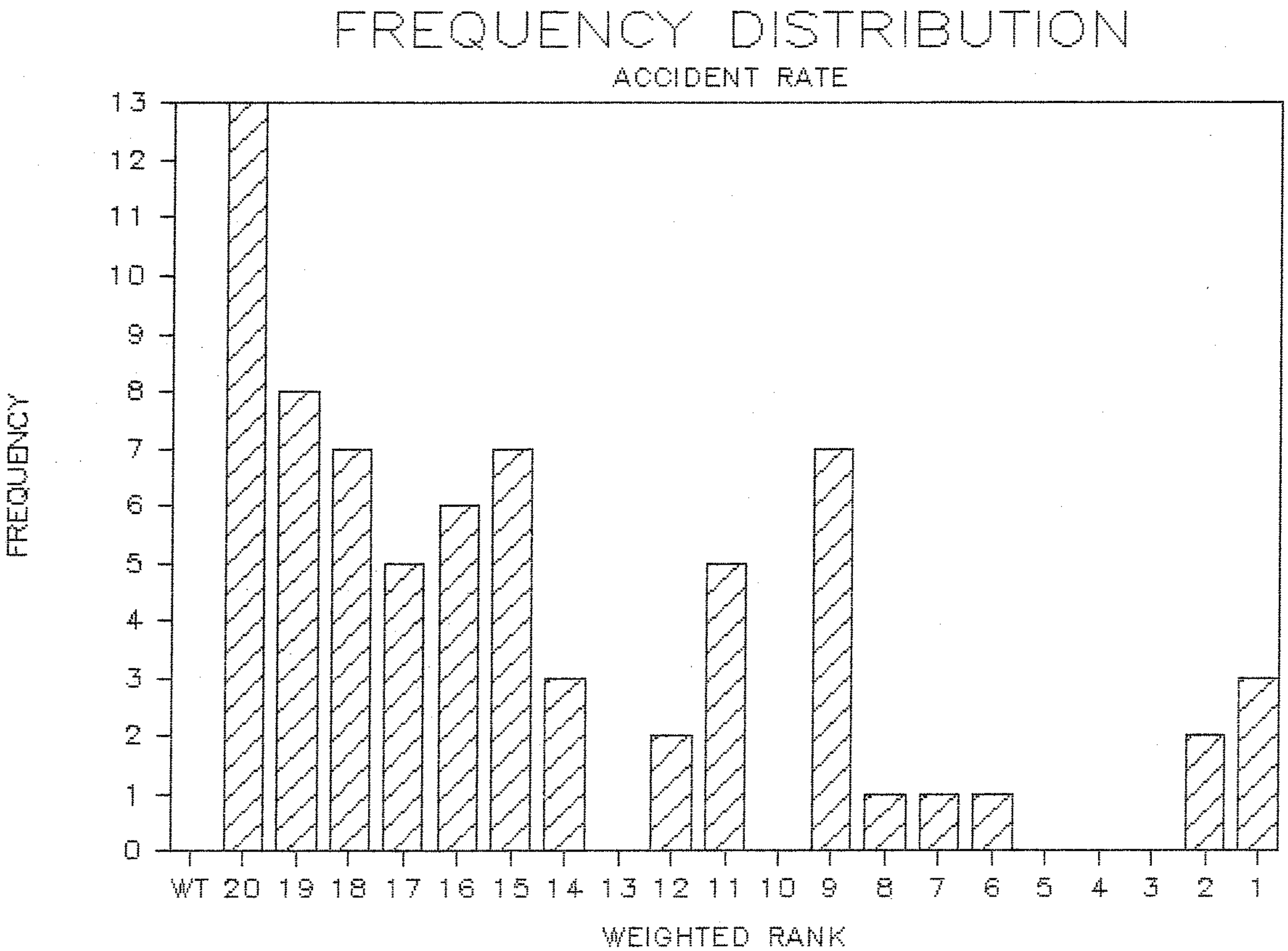
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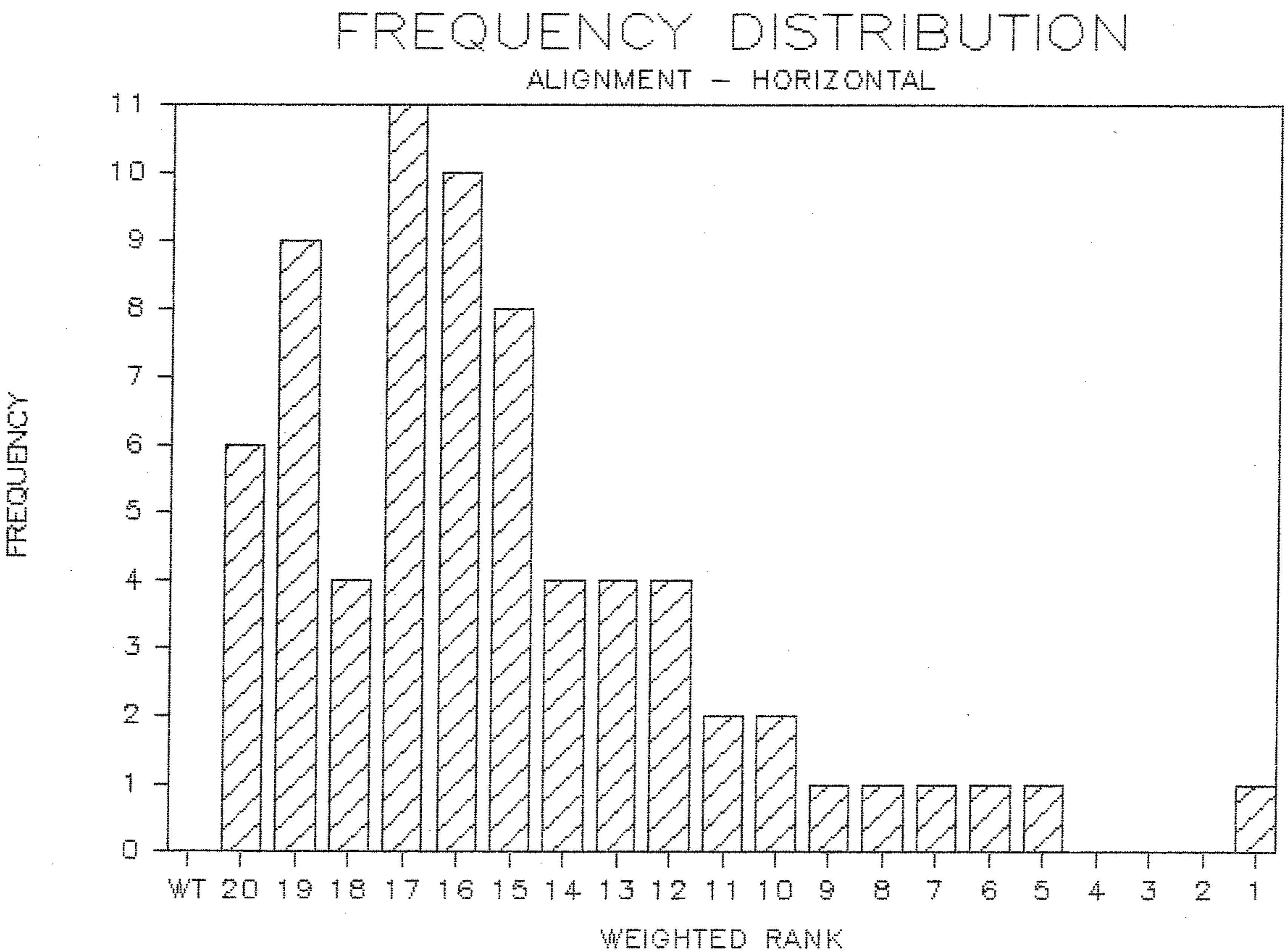
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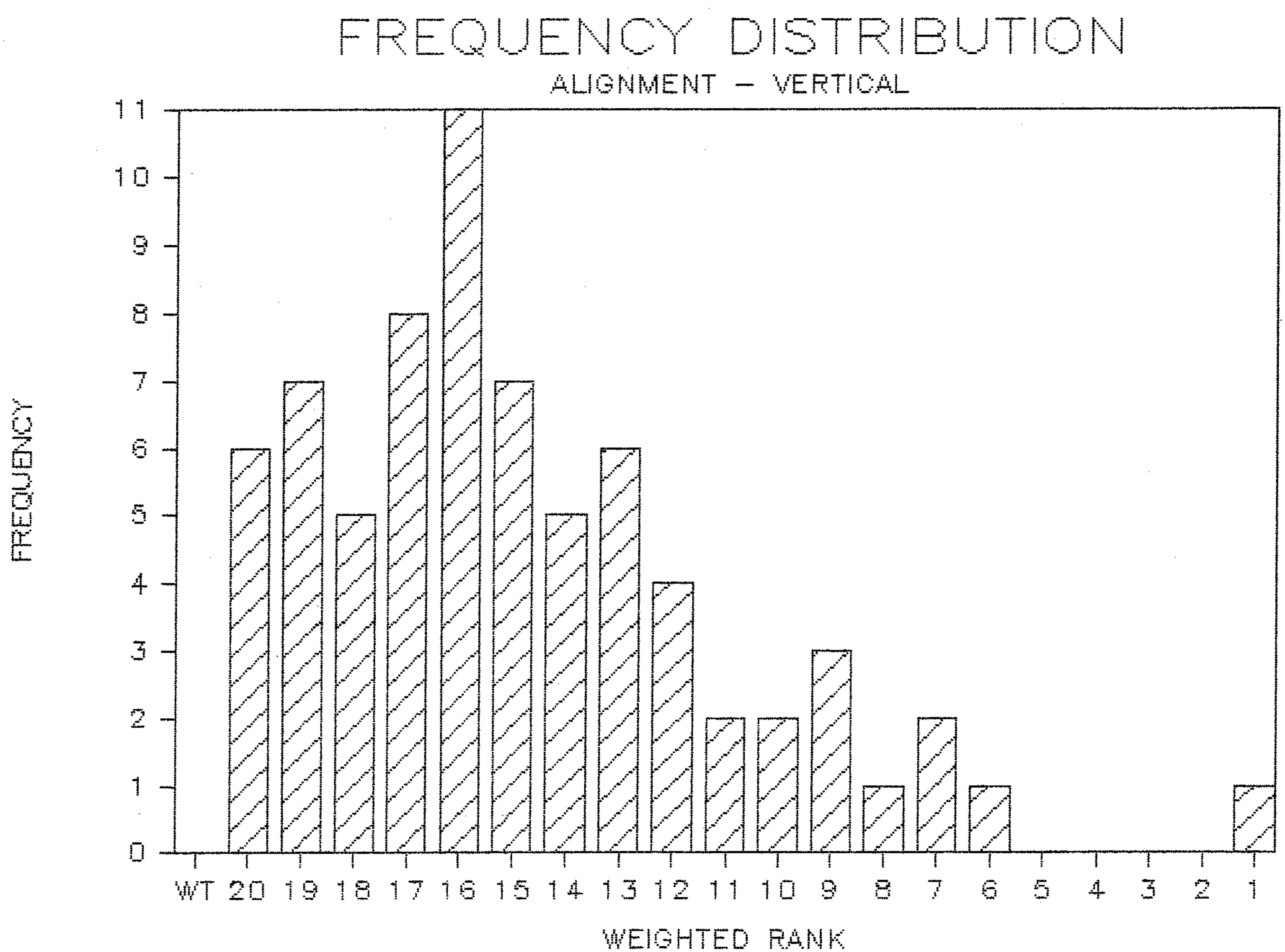
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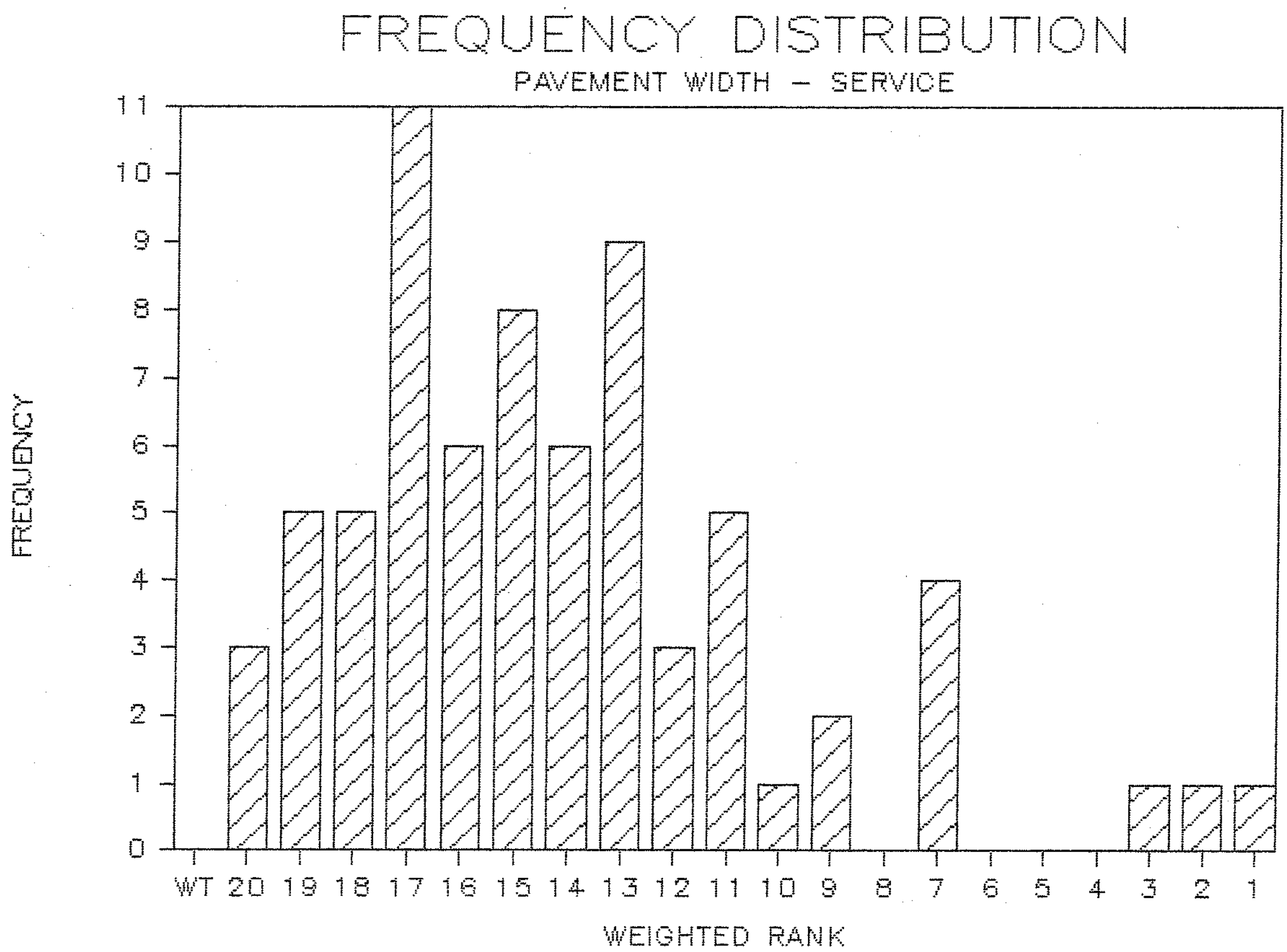

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PAVEMENT WIDTH – SERVICE
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11
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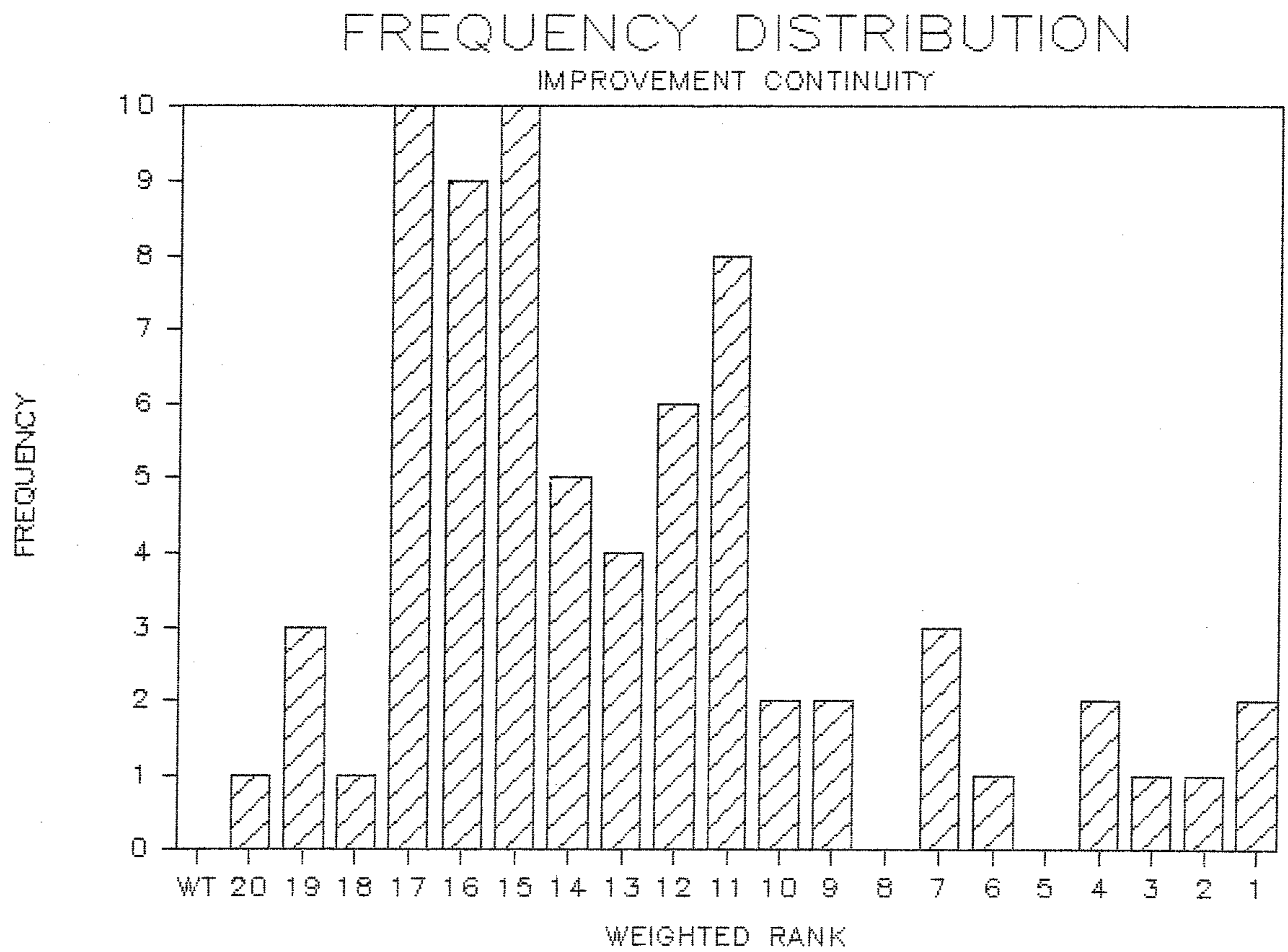
WEIGHTED RANK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IMPROVEMENT CONTINUITY
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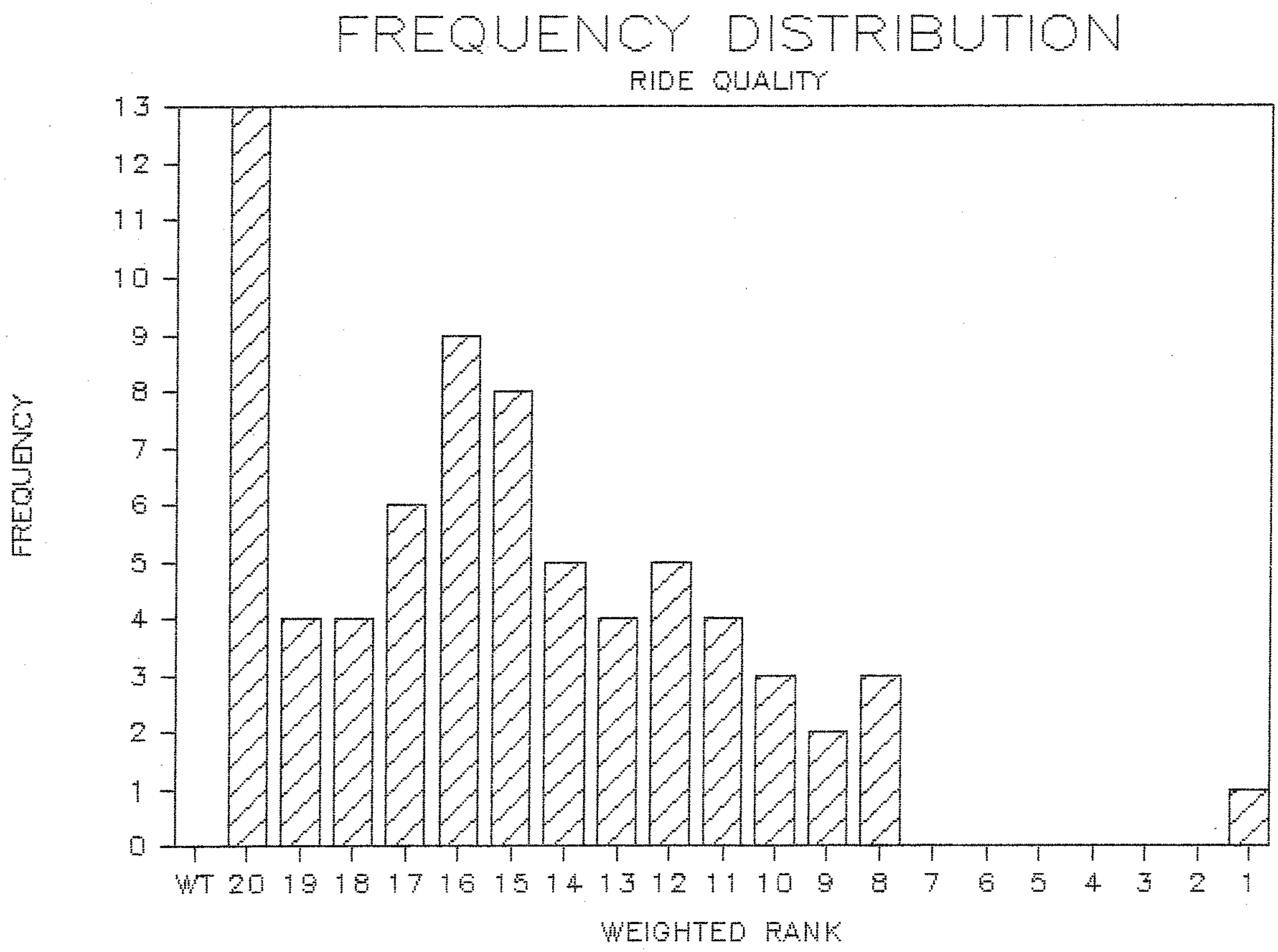
WT 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
WEIGHTED RANK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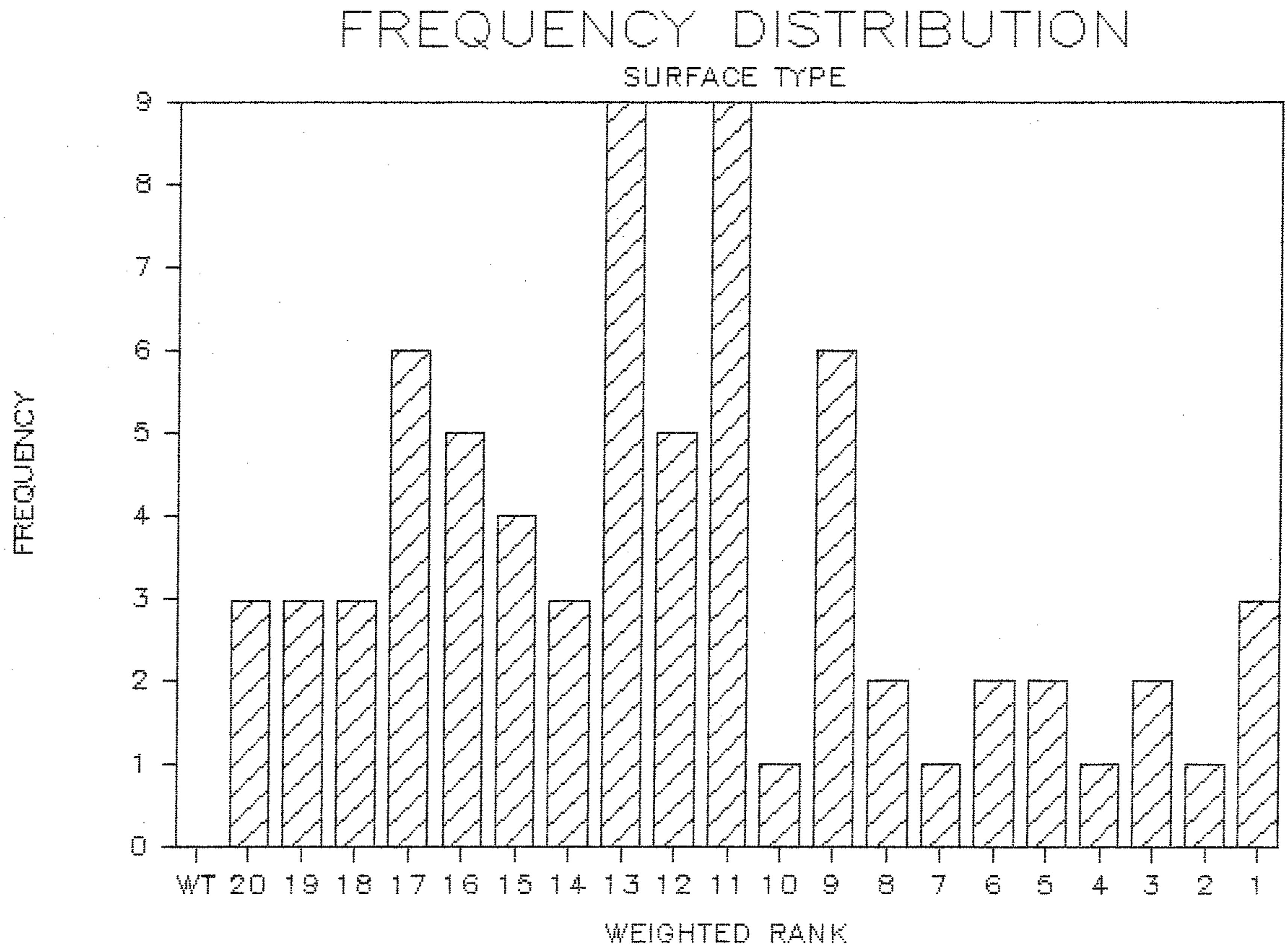
RIDE QUALITY
FREQUENCY
13
12
11
10
9
8
7
6
5
4
3
2
1
0
WT 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
WEIGHTED RANK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SURFACE TYPE
FREQUENCY
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2
3
4
5
6
7
8
9
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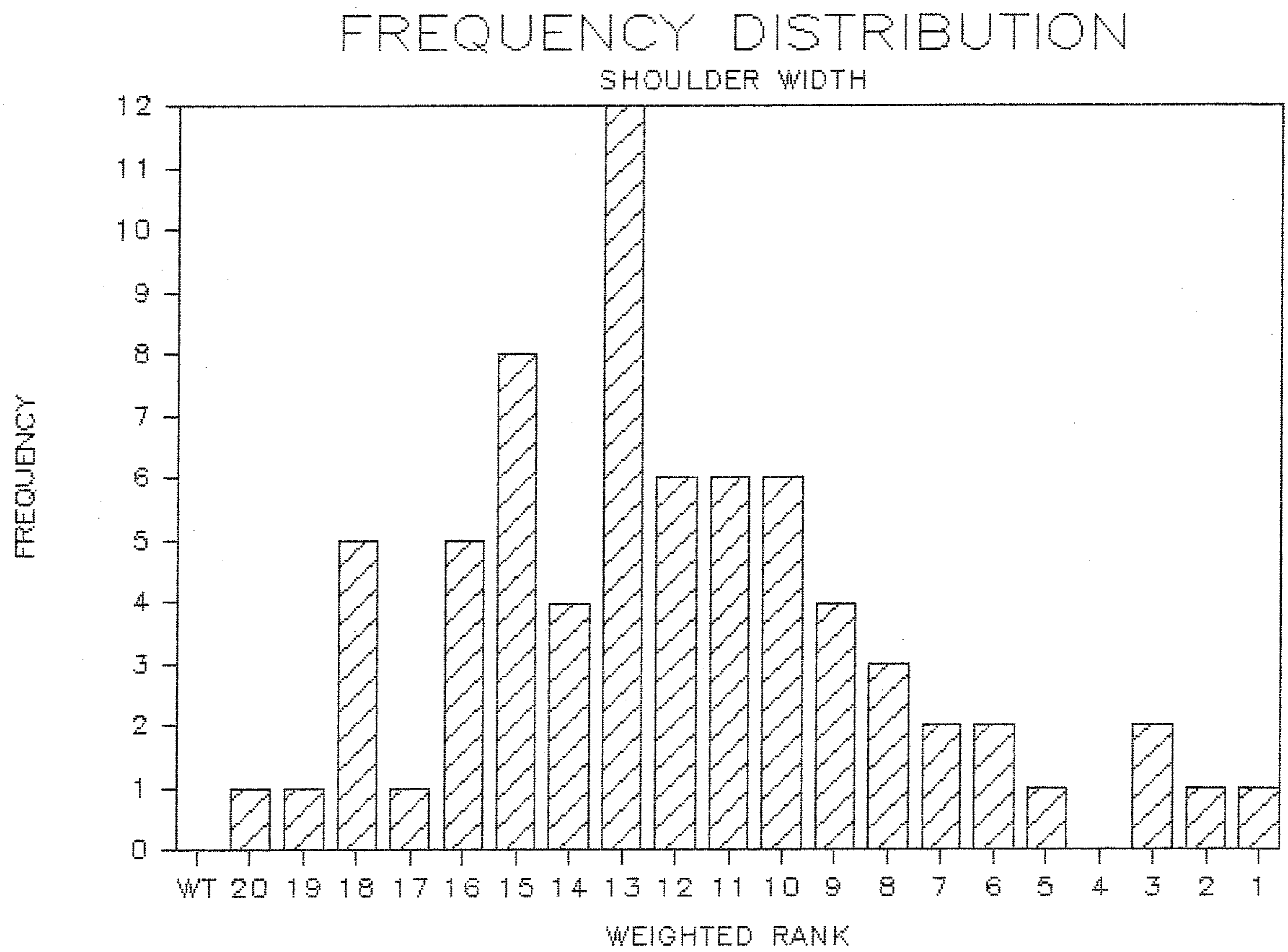
WEIGHTED RANK



FREQUENCY DISTRIBUTION
SHOULDER WIDTH
FREQUENCY
WEIGHTED RANK
0
1
2
3
4
5
6
7
8
9
10
11
12
WT
20
19
18
17
16
15
14
13
12
11
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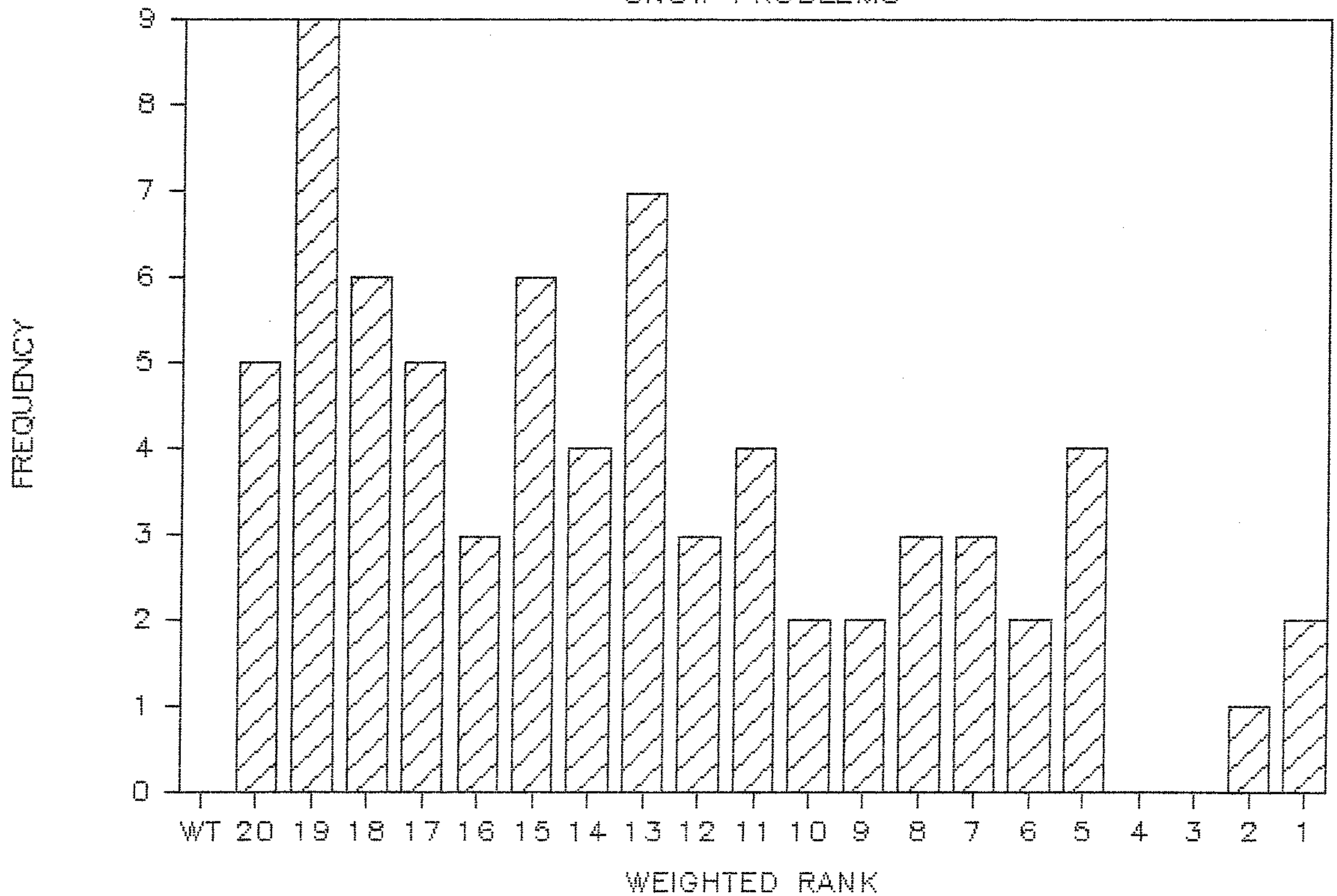
9
8
7
6
5
4
3
2
1

FREQUENCY DISTRIBUTION

SNOW PROBLEMS



Appendix E

DESIGN STANDARDS

Del Norte County Rural Highway Design Standards

Average Daily Traffic	under 25			25 to 100			100 to 400		
Surface Type	graveled, graded and drained			gravel or crushed stone			bit. surface treatment		
Terrain	flat	roll.	mtn.	flat	roll.	mtn.	flat	roll.	mtn.
Design Speed	35	30	25	45	35	25	55	45	35
Curvature, Max. Deg.	18	25	36	11	18	36	7	11	18
Gradient, Max. %	6	12	15	5	7	12	5	7	9
Stopping Sight Dist.	240	200	165	315	240	165	415	315	240
Surface Width	20	20	(a)	20	20	20	22	22	22
Shoulder Width	2	2	(a)	4	3	2	5	4	3
R/W Width	50	50	50	50	50	50	60	60	60

Average Daily Traffic	400 to 1,000			1,000 to 2,000			2,000 and up		
Surface Type	mix bit., 1½-in. minimum			mixed bit., 2-in. minimum			plant-mix bit., 3-in. minimum		
Terrain	flat	roll.	mtn.	flat	roll.	mtn.	flat	roll.	mtn.
Design Speed	60	50	40	60	50	40	60	60	50
Curvature, Max. Deg.	6	9	14	6	9	14	6	6	9
Gradient, Max. %	5	6	7	5	6	7	4	5	6
Stopping Sight Dist.	475	350	275	475	350	275	475	475	350
Surface Width	24	24	24	24	24	24	24	24	24
Shoulder Width	6	6	4	8	8	6	8	8	6
R/W Width	60	60	60	60	80	100	80	80	100

(a) Graded width of 14 ft. and turnouts.

Design Standards for Five Traffic Groups

Design Feature	Terrain	Average Daily Traffic 50	50 to 100	100 to 400	400 to 1000	1000 to 4000
DESIGN STANDARDS FOR ROADS						
Right of Way Width		40	50	60	80	80
Roadbed Width (feet)	Flat	24	28	30	34	40
	Rolling	24	26	28	30	38
	Mountainous	24	24	26	28	34
Surface Width (feet)		16	20	22	24	24
Radii (feet)	Flat	400	400	650	800	1000
	Rolling	250	250	450	525	750
	Mountainous	100	100	250	325	525
Grade (percent)	Flat	7	6	6	5	3
	Rolling	12	8	8	7	5
	Mountainous	15	12	10	9	6
Stopping Sight Distance (feet)	Flat	275	350	375	400	550
	Rolling	250	275	300	325	425
	Mountainous	125	200	225	250	300
Design Speed (mph)	Flat	40	45	50	55	65
	Rolling	30	35	40	45	55
	Mountainous	20	25	30	35	45
DESIGN STANDARDS FOR BRIDGES						
Width (feet)		18	24	26	26	28
Design Loading		H-10	H-12½	H-15	H-20	H-20

Pavement Section Standards

Average Daily Traffic	*Section*
1000 - 4000	40-ft. compacted subgrade; 6-in. by 31-ft. Class C CTB or equivalent rock base; 2½-in. by 24-ft. PMS; 2½-in. by 3-ft. PMS tapered shoulders.
400 - 1000	34-ft. compacted subgrade; 4-in. Class C CTB base; 2-in. by 24-ft. RMS; 2-ft. BST shoulders.
100 - 400	30-ft. compacted subgrade; stabilized base where required; 2-in. by 20-ft. BST.
50 - 100	28-ft. compacted subgrade; 2-in. by 20 ft. BST.
Less than 50	24-ft. compacted subgrade; 2-in. by 16-ft. BST.

County Engineer's Association of California

DESIGN POLICIES FOR RURAL COUNTY ROADS IN INDIANA THE JOINT HIGHWAY RESEARCH PROJECT PURDUE UNIVERSITY—1954

Road classification	Local service		County secondary		County primary	
Hourly traffic volume (vehic./30th highest hr.)	1–15		16–62		63–159	
Average daily traffic volume (veh./day)	1–99		100–399		400–999	
	Minimum	Desirable	Minimum	Desirable	Minimum	Desirable
Design speed (miles/hour)						
Level	35	50	40	60	50	65
Rolling	30	45	35	50	45	55
Hilly	25	35	30	40	40	45
Pavement type	Min. 5″ crushed stone or gravel	Min. 8″ crushed stone or gravel	Min. 8″ crushed stone or gravel	Min. 12″ cr. st. or gr. (stabilized where over 200 VPD)	Pavement on stabilized base	Pavement on stabilized base
Minium width (feet)						
Rt. of way	40	60	50	80	60	100
Shoulder	4	5	5	6	6	8
Surface	16	18	18	20	22	24
Min. sight distance (ft.)						
Stopping						
Level	240	350	275	475	350	540
Rolling	200	315	240	350	315	415
Hilly	165	240	200	275	275	315
Passing						
Level	700	1400	900	2100	1400	2500
Rolling	500	1150	700	1400	1150	1750
Hilly	300	700	500	900	900	1150
Degree and radius of sharpest curve (ft.)						
Level	18° (318)	9° (637)	14° (409)	6° (955)	9° (637)	5° (1146)
Rolling	25° (229)	11° (521)	18° (318)	9° (637)	11° (521)	7° (819)
Hilly	36° (159)	18° (318)	25° (229)	14° (409)	14° (409)	11° (521)
Maximum gradient (percent)						
Level	10	7	8	6	7	6
Rolling	10	8	10	7	8	7
Hilly	12	10	10	8	8	8
Struct.						
Width (feet)	18	22	20	24	24	28
Loading	10 T	15 T	10 T	15 T	15 T	20 T

IOWA STATE HIGHWAY COMMISSION

FARM-TO-MARKET ROAD DESIGN STANDARDS,[1] JANUARY 1, 1960

Design Control	Annual Average Daily Traffic					
	Under 100[2]		100 - 400		400 - 1,000	
	Min. Stand.	Recom. Stand.	Min. Stand.	Recom. Stand.	Min. Stand.	Recom. Stand.
Design speed (mph):						
Flat topography	40	50	50	55	50	60
Rolling topography	30	40	40	45	40	50
Mountainous topography	20	30	30	35	30	40
Sharpest curve (deg):						
Flat topography	14	9	9	7	9	6
Rolling topography	25	14	14	11	14	9
Mountainous topography	25	25	25	18	25	14
Maximum gradient (%):						
Flat topography	8	5	7	5	7	5
Rolling topography	12	7	8	7	8	6
Mountainous topography	15	10	10	9	10	7
Non-passing sight distance (ft):						
Flat topography[3]	350	350	350	415	350	475
Rolling topography[3]	275	275	275	315	275	350
Mountainous topography[3]	200	200	200	240	200	275
Dimensions of road (ft):						
Width of roadbed	22	28	24	34	30	36
Width of roadway surfacing	20	20	—	—	—	—
Width of pavement, A. C. conc.[4]	22	22	22	24	22	24
Width of pavement, P. C. conc.[4]	20	20	20	22	22	24
Roadway top, shoulder-to-shoulder[5]	22	28	22	30	28[6]	32
Thickness of pavement (in.)						
P. C. conc. pavement	6	6	6	6	6	8
Flexible base pavement[7]	8	8	8	8	8	8
Depth of ditch (ft):	3	3	3	3	3	3
Width of ditch bottom (ft):	6	6	6	6	6	6
Slope of foreslopes:						
In cuts:						
Not steeper than	2:1	2:1	2:1	2:1	2:1	2:1
Not flatter than	3:1	3:	3:1	3:1	3:1	3:1
In fills, over 5 ft (not steeper than):						
Traffic less than 100 vpd	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
Traffic more than 100 vpd	2:1	2:1	2:1	2:1	2:1	2:1
Slope of backslopes						
In cuts	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
Width of right-of-way (ft)	66	80	66	80-120	66	80-120

[1] Bridge design data omitted.

[2] When pavements are anticipated to be constructed on roads having less than 100 vpd, use the standards for traffic 100-400 except that the roadbed width shall be not less than 28 ft.

[3] In no case shall the passing sight distance be less than 250 ft.

[4] Bridge width minimum of 24 ft or 4 ft more than approach pavement width.

[5] When pavement is constructed in stages, widths will be increased so that when pavement is completed the finished shoulder-to-shoulder width will comply to these standards.

[6] For traffic volumes exceeding 750 vpd, minimum 4-ft shoulders will be required each side of the finished pavement; shoulders shall be let at the same time as the paving project.

[7] General note.---Grading or base projects let prior to Jan. 1, 1960, and meeting the requirements of the ISHC, Feb. 1, 1954, Farm-to-Market Standards, will be considered for a higher type surfacing improvement without full compliance with these standards.

KENTUCKY DEPARTMENT OF HIGHWAYS
BASIC GEOMETRIC DESIGN CRITERIA

THESE BASIC GEOMETRIC DESIGN CRITERIA ARE BASED ON THE LEVEL OF SERVICE CONCEPT. THE DESIRED LEVEL OF SERVICE RECOMMENDED BY THE DEPARTMENT WILL BE USED WITH THE APPROPRIATE ATTACHED TABLES IN SELECTION OF DESIGN CRITERIA ANY DEVIATION FROM THESE CRITERIA MUST BE APPROVED BY THE CENTRAL OFFICE.

HIGHWAY CLASS	6	5	4	3	2	1
TRAFFIC VOLUME (1)	CURRENT A.D.T. 0 - 100	CURRENT A.D.T. 100 - 250	CURRENT A.D.T. UNDER 400 (2)	CURRENT A.D.T. 400 - 749	D.H.V. 200 - 910 (A.D.T. 1500-7000) (3)	D.H.V. 650 - UP (A.D.T. 5000-UP) (3)
DESIGN SPEED (M.P.H.)	DESIGN SPEED WILL BE CONTROLLED BY THE HORIZONTAL & VERTICAL ALIGNMENTS		30 40 50 60	40 50 60 70	40 50 60 70	40 50 60 70
PAVEMENT (4) WIDTH 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	16'	18'	20' 20' 20' 22' –	– 22' 22' 22' 24'	– 24' 24' 24' 24'	24' PAVEMENT INITIAL 2-LANES WITH 4-LANES ULTIMATE OR 4 OR MORE LANES INITIAL DEPENDING ON D.H.V.
MINIMUM SHOULDER WIDTH	2'	3'	4'	6'	12'	SPECIAL DESIGN
MINIMUM ROADBED WIDTH 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	20'	24'	28' 28' 28' 30' –	– 34' 34' 34' 36'	– 48' 48' 48' 48'	SPECIAL DESIGN
DITCH WIDTH & SLOPE	3' @ 3:1	3' @ 3:1	6' @ 4:1	8' @ 4:1	8' @ 4:1 40 M.P.H. 18' @ 6:1 50-70 M.P.H.	8' @ 4:1 40 M.P.H. 18' @ 6:1 50-70 M.P.H.
EARTH CUT SLOPE RATIO UNDER 4' / OVER 4'	1:1 1:1	1:1 1:1	4:1 2:1	4:1 2:1	4:1 2:1	4:1 2:1
FILL SLOPE RATIO (5) UNDER 10' / 10' TO 20' / OVER 20'	1½ : 1 1½ : 1 1½ : 1	2 : 1 2 : 1 2 : 1	4 : 1 2 : 1 2 : 1	4 : 1 2 : 1 2 : 1	6:1 & 4:1 2:1 OR 4:1 2:1	6:1 & 4:1 2:1 OR 4:1 2:1
RIGHT OF WAY	The necessary width needed for construction and proper maintenance of entire roadway section.					
MAXIMUM CURVATURE (IN DEGREES) (Based on Superelevation rate of 0.10) 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	56	36	25.0 13.5 8.5 5.5 –	– 13.5 8.5 5.5 4.0	– 13.5 8.5 5.5 4.0	– 13.5 8.5 5.5 4.0
MAXIMUM GRADE (6) (IN PERCENT) TERRAIN: LEVEL / ROLLING / MOUNTAIN	14	12	M.P.H. 30 40 50 60 6 5 4 3 7 6 5 4 9 8 7 6	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –
MINIMUM STOPPING (7) SIGHT DISTANCE 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH			200' 275' 350' 475' –	– 275' 350' 475' 600'	– 275' 350' 475' 600'	– 275' 350' 475' 600'
MINIMUM PASSING (8) SIGHT DISTANCE 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH			1100' 1500' 1800' 2100' –	– 1500' 1800' 2100' 2500'	– 1500' 1800' 2100' 2500'	IF 2-LANES INITIAL THEN SAME AS CLASS 2. IF 4-LANES INITIAL THEN NOT NECESSARY
MAXIMUM DISTANCE			2.5 MILES	2.0 MILES	1.0 MILES	1.0 MILE IF 2-LANE

FARM TO MARKET DESIGN GUIDES

ACCEPTABLE VALUES FOR NEW OR RECONSTRUCTED RURAL SECONDARY ROADS

THESE FARM TO MARKET DESIGN GUIDES ARE PRESENTED FOR THE DESIGN OF ROADS ON THE TRUNK AND TRUNK COLLECTOR SYSTEMS, COUNTIES MAY ALSO USE THESE FOR ROADS ON THE AREA SERVICE SYSTEM EACH DESIGN ELEMENT OF EACH PROJECT SHOULD BE MEASURED AGAINST THE HIGHEST STANDARD PRACTICABLE AND ECONOMICALLY JUSTIFIED. VALUES BELOW THOSE SHOWN ON THIS TABLE WILL BE CONSIDERED ON A PROJECT BY PROJECT BASIS, PROVIDED THAT EACH EXCEPTION IS JUSTIFIED TO THE DISTRICT ENGINEER. IN NO CASE SHALL THE DESIGN CRITERIA BE LESS THAN THOSE SET OUT IN THE "GEOMETRIC DESIGN GUIDES FOR LOCAL ROADS AND STREETS, PART 1-RURAL, AASHTO", CURRENT EDITION.

DESIGN ELEMENTS		FUNCTIONAL CLASSIFICATION														
VALUES SHOWN ARE SUGGESTED GUIDES ONLY. EACH PROJECT IMPROVEMENT MUST BE ANALYZED ON ITS OWN MERITS AND FEATURES.		TRUNK OR TRUNK COLLECTOR (OR AREA SERVICE)														
		PAVED ROADWAY									NON-PAVED ROADWAY					
ADT-Design Year (In 20 yrs) -Current Yr. (After Completion)	(1)	2000 to 1000 Over 750			1000 to 400 750 to 250			400 to 100 250 to 50			400 to 100 250 to 50			Less than 100 Less than 50		
Terrain	(2)	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY
Design Speed	MPH	60	55	50	55	50	45	50	45	40	50	45	40	45	40	35
Stopping Sight Distance	ft	475	425	350	425	350	325	350	325	275	350	325	275	325	275	238
Maximum Curvature (3)	Degrees	5	6	7	6	7	9	7	9	12	7	9	12	9	12	17
Maximum Gradient (4)	%	5	6	7	6	6	8	6	7	9	6	7	9	6	8	10
Pavement Width	ft	24	24	24	22	22	22	22	22	22	NA	NA	NA	NA	NA	NA
Surfacing Width-Granular	ft	NA	NA	NA	NA	NA	NA	NA	NA	NA	20	20	20	20	20	20
Shoulder Width	ft	8	8	8	6	6	6	4	4	4	4	4	4	3	3	3
Roadway Top Width	ft	40	40	40	34	34	34	30	30	30	28	28	28	26	26	26
Bridge Width-New (5)	ft	40	40	40	30	30	30	30	30	30	24	24	24	24	24	24
Design Loading		HS-20	HS-20	HS-20	*H-20	*H-20	*H-20	H-20	H-20	H-20	H-15	H-15	H-15	H-15	H-15	H-15
Foreslope		4:1	4:1	4:1	3:1	3:1	3:1	3:1	3:1	3:1	2:1	2:1	2:1	2:1	2:1	2:1
Normal Minimum Ditch		5x10	5x10	5x10	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6
Special Ditch at Construction		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
Bridge Width-Existing	ft	24	24	24	24	24	24	24	24	24	20	20	20	20	20	20
Acceptable Loading		H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15
Clearance to Obstructions From edge of Surfacing	ft	30	30	30	16	16	16	14	14	14	10	10	10	10	10	10

IN CASE OF CONFLICT BETWEEN DESIGN YEAR ADT AND CURRENT YEAR ADT, USE THE HIGHER VALUES

GENERAL NOTES:

1. Over 2,000 ADT (Design Year), Use Arterial Connector Values
2. Use "Hilly Terrain" designation only upon concurrence by the District Engineer
3. Horizontal Curves shall have a minimum length of 500 feet
4. Maximum Gradient may be steepened by 1% for short distances
5. If over 100 ft long, may be pavement width plus 6 feet
6. *Over 400 ADT (Current Year), Use HS-20 Loading

LATEST REVISION DATE: February 1979

GUIDE FOR PREPARATION OF WORKSHEETS
Sufficiency Rating System for Secondary Roads

This is a set of instructions for completion of a set of worksheets. Completion of the worksheets will provide sufficient data for the assignment of a sufficiency rating to a designated segment of the county road system.

OFFICE WORKSHEET

Complete Part I from the field worksheet or office records. Combine road segments as appropriate to provide for logical continuity. List the I.D. numbers for each road segment from the Secondary Road Engineer's Listing.

Complete Part II from the Secondary Road County Engineer's Listing.

The Iowa DOT Alternate Design Guide (copy provided below) will be used as the basis for completion of Part III. Begin by determining the appropriate design class. Use ADT and the functional classification as a guide. Considering the type of terrain, determine the design standard and record the standard number. Then complete the ratings, using the information from Parts I and II and the guidelines provided in this document.

ALTERNATE DESIGN GUIDES
RURAL PRIMARY AND SECONDARY HIGHWAYS
1982-2001 NEEDS STUDY

	Arterial Connector/Trunk/Trunk Collector									Area Service								
Highway Group	3			4			5			6			7			8		
ADT (Design Year)	Over 1,500			400-1,500			Under 400			Over 100			26-100			0-25		
Design Standard #	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Terrain[1]	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Design Speed	50	50	40	50	40	40	40	30	30	40	30	30	40	30	30	30	25	25
Max. Degree Curve	7	7	10	7	10	14	10	19	19	10	19	19	10	19	19	19	19	19
Max. Grade (%)	6	8	9	6	7	9	7	10	12	7	10	12	7	10	12	7	11	12
Stopping Sight	375	375	275	275	275	275	275	200	200	275	200	200	275	200	200	200	150	150
Lane Width[2]	12	12	12	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Shoulder Width (Rt.)[3]	8	8	8	6	6	6	3	3	3	2	2	2	2	2	2	0	0	0
(Lft.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Median Width[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Type[5]	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	4	4	4
Pavement Sec.[6]	1	1	1	1	1	1	4	4	4	4	4	4	0	0	0	0	0	0
Shoulder Type[7]	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
Access Control[8]	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1 - Terrain, 1=Flat, 2=Rolling, 3=Hilly.
2 - Actual number of lanes is computed based on the 1965 Highway Capacity Manual methods.
3 - Left shoulder applies only to divided highways. Left shoulder equals right shoulder width on two-lane highways.
4 - Median applied only when number of lanes required equals or exceeds four and divided highway justified.
5 - 1=Asphaltic or portland cement concrete, 2=Surface treatment, 3=Gravel, 4=Earth.
6 - 0=No pavement, 1=Asphaltic or portland Cement concrete, 2=Cold mix or road mix, 3=Seal coat, 4=Dust treatment.
7 - 1=Paved, 2=Stabilized, 3=Earth, 4=No shoulder.
8 - 1=Full control, 2=Partial control, 3=No control or local zoning.