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FINAL REPORT

DATA SYSTEM FOR PLANNING MAINTENANCE RESURFACING

by

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Highway Research Analyst

Virginia Highway Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways and the University of Virginia)

Charlottesville, Virginia

April 1973
VHRC 72-R36

SUMMARY

Planning for maintenance resurfacing in the Virginia Department of Highways is becoming an increasingly complex and important function. Increasing highway mileage and traffic volumes, as well as other requirements such as maintaining a minimum skid resistance, require that many variables be considered in order to most efficiently allocate the maintenance resurfacing dollar.

The purpose of this study was to develop an outline of a computer based data system for use in planning maintenance resurfacings on the interstate, arterial, and primary highways. The study deals with the determination of how planning for maintenance resurfacing is presently accomplished, the data that should be included in a new system, and how the data should be analyzed and presented; i.e., what outputs should be developed, who should receive them, and how they should be used. Also, to the extent possible, the costs and problems of making the new system operational are identified.

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INTRODUCTION

Planning for maintenance resurfacing in the Virginia Department of Highways is becoming an increasingly complex and important function. Increasing highway mileage and traffic volumes, as well as other requirements such as maintaining a minimum skid resistance, require that many variables be considered in order to most efficiently allocate the maintenance resurfacing dollar.

The large amount of data which should be analyzed in arriving at resurfacing decisions leads one to the conclusion that the computer may be an effective tool to aid in this analysis. This is particularly true since most data that resurfacing decisions are based on are generated within the Department, and, in fact, in many cases presently exist in computer data systems maintained by the Data Processing Division.

PURPOSE AND SCOPE

The purpose of this study was to develop an outline of a computer based data system for use in planning maintenance resurfacings. The system developed deals only with interstate and primary roads for the following reasons. First, as will be discussed later, the basic locational method to be used in the new system is mile-post, and at present there is no method to assign mileposts to the secondary system. Second, it seemed desirable to first include only the interstate and primary system, which contain far less mileage than the secondary system but on a per route basis carry much more traffic and account for the majority of the dollars expended for resurfacing.

While the ultimate goal of the project is to develop a computer based data system, this study did not include development of computer programs. The study did include the determination of how planning for maintenance resurfacing is presently accomplished, the data to include in a new system, and how the data should be analyzed and presented — that is, what outputs should be developed, who should receive them, and how they should be used.

As indicated above, much of the data required for a maintenance resurfacing planning data system may already exist in data systems presently maintained or being implemented by the Data Processing Division. Later in the paper, indications are given of what data needed for the new system are available in existing systems, how existing systems may have to be modified in order for them to generate the necessary data, and how data not in existing data systems can be obtained most efficiently.

To the extent possible, the costs and problems of making the new system operational are identified so that the Maintenance Division management can decide how much of the new system warrants implementation.

It is not planned that the system developed will deal with resurfacing overlays on bridges. It is hoped that a compatible maintenance planning system for bridges will be developed sometime in the near future.

PRESENT SYSTEM

It was felt that the first step in the development of a maintenance resurfacing planning data system should be an evaluation of how the planning for maintenance resurfacing on the primary and interstate systems is presently accomplished. The determination of how the present process works was made primarily through discussions with the state maintenance engineer, a state assistant maintenance engineer, and a resident engineer.

The present process can be broken down into long- and short-range planning as described below.

Short-Range Planning

Annually each resident engineer decides through visual inspection which roadway sections are in the greatest need of resurfacing, using the guidelines of an eight-year average life for bituminous plant mixes, and a five-year average life for slurry seals. These needs are summarized in the residency on form M-32D (Figure 1), which requires descriptive information about the sections to be resurfaced. The resident engineer uses his judgement to determine the type of resurfacing and rate of application to use, with the general criterion that a slurry seal surface is not resurfaced with slurry seal.

Form M-32D (Revised 7-1-66)

FIGURE 1

VIRGINIA DEPARTMENT OF HIGHWAYS - 19

FURNISHING, DELIVERING AND APPLYING PLANT MIXED BITUMINOUS MATERIAL

PAGE: ________
DISTRICT: ________
SCHEDULE NO. ________

TRAFFIC COUNT EST. COST YR. LAST TREAT. TYPE LAST TREAT.	COUNTY	ROUTE SECTION PROJECT	DESCRIPTION FROM	TO	WIDTH (FEET)	LENGTH (MILES)	LBS. PER SQ. YD.	TYPE	TOTAL TONNAGE

The requests of the resident engineer are reviewed by the district engineer and state maintenance engineer, or their representatives, by visually surveying the roadways with the resident engineer. The work approved is then summarized in Plant Mix ans Slurry Seal Schedules (Figures 2 and 3).

There is one additional criterion used for establishing resurfacing needs; this is skid resistance. At present, when the average skid number for a section of roadway is below 40 that section is resurfaced, even though the pavement may have useful structural life remaining. Skid testing is presently done on a request basis with the request generally arising because a section of roadway has a poor wet accident history. Thus, usually when a section is found to have a skid number below 40 it also has a poor wet accident history and, of course, should be resurfaced.

It was indicated by the Department engineers with whom the project was discussed that the below listed improvements could be made in the present short-range planning process.

1. Have the data of the type required on form M-32D (Figure 1) easily available.

2. Provide volume data, deflection data, and materials and construction data about the surface and subsurface layers, so that decisions regarding resurfacing needs could be based on more than visual inspection and age alone. This information could also provide aid in determining what type and rate of resurfacing may be required.

3. Provide skid data so that resurfacing required because of low skid resistance would be known.

Long-Range Planning

The primary purpose of long-range planning for maintenance resurfacing is to establish the amount of funds required for resurfacing in the coming years. The present planning is accomplished by determining the center line miles of primary and interstate highways, exclusive of those having portland cement concrete surfaces, and then adding the anticipated growth in lane miles. In determining the resurfacing requirements for non-portland cement concrete surfaces the following assumptions are made.

1. The average surface life is 8 years, and

2. slurry seal treatments will account for 10% of the resurfacing and bituminous concrete plant mix 90%.

FIGURE 2

VIRGINIA DEPARTMENT OF HIGHWAYS
FURNISHING, DELIVERING AND APPLYING PLANT MIX BITUMINOUS MATERIAL

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PAGE: 2

DISTRICT: Suffolk

CONTRACT ITEM	COUNTY	TRAFFIC GROUP	ROUTE SECTION PROJECT	FROM TO DESCRIPTION	WIDTH (FEET)	LENGTH (MILES)	LBS. PER SQ. YD.	TYPE	TOTAL TONNAGE
S-A-2	Accomack	I	0013 (Bus.) 0050	0.07 Mile East of Route 13 - 0.11 Mi. North N.C.L. of Accomac (Passing lanes only)	24	0.97	80	MS-7	550
		II	0013 0010	0.63 Mile South of Route 729 - 0.17 Mile North of Route 187 (Southbound Lane Only)	24	0.36	110	MS-5	280
		II	0175 0060	2.03 Miles East of Route 679 - Route 175Y	22	4.33	110	MS-5	3.080
		II	0175 0060	0.08 Mile East of Route 798 - 0.70 Mile West of Route 679	22	0.06	125	MS-5	60
			(Tonnage includes 10 tons for leveling course)						
		II	0176 0090	Route 13 - Route 316	22-40	2.58	110	MS-5	1,930
		I	0187 0210	Route 13 - Route 658	18	3.70	80	MS-7	1,560
		II	0316 0220	Route 176 - Route 187	20	3.68	110	MS-5	2,380

- Continued -

FIGURE 3

VIRGINIA DEPARTMENT OF HIGHWAYS
FURNISHING, DELIVERING, AND APPLYING EMULSIFIED ASPHALT SLURRY SEAL MATERIAL

Page: 3
District: Bristol
Schedule No. SS-1-72

1972

TRAFFIC GROUP	ROUTE	FROM	DESCRIPTION	TO	LENGTH (Miles)	WIDTH (Feet)	AREA (Square Yards)

COUNTY

APPROXIMATE CONTRACT QUANTITIES:

222,410 Sq. Yds. Slurry Seal Type B @ Average Price Per Sq. Yd. . . . . $_______ $_______

TOTAL $_______

The compulsory completion date for this schedule is October 1, 1972.

THIS SCHEDULE IS TO BE CONSIDERED AS ONE PROJECT

BIDDER: ____________________

ADDRESS: ____________________

NOTE: The Special Provisions on this contract require that the last page of this proposal be properly completed and signed. Signing this page does not waive this requirement.

Resurfacing requirements are not programmed for portland cement concrete surfaces since this type of resurfacing would normally be handled as a construction item. Also, surface treatments are not included since this type of surface is not normally used on the primary, arterial, or interstate systems.

Thus, annual resurfacing requirements are programmed by determining the total center line mileage for the year in question using the base year mileage and growth criteria, and dividing this mileage by eight, since the assumed average service life is eight years. This mileage to be resurfaced is then apportioned on the basis of 90% of bituminous plant mix and 10% slurry seal.

At present, there is no direct link between the short- and long-range planning processes.

In discussions of the current long-range planning procedure, Maintenance Division personnel stated that it had deficiencies and that additional data would be desirable so that predicted resurfacing requirements could be based on criteria other than age. This additional information included:

1. Lane mile totals rather than center line mileage totals, since center line miles do not distinguish between two-lane and other types, e.g., four-lane highways.

2. Summaries of lane mile totals for each mix type subdivided by age.

3. Summaries of lane mile totals having below minimum skid resistance, or above maximum 18 kip equivalent accumulated volume, broken down as described in No. 2 above.

4. A summary of miles of paved shoulders broken down by age. (At present, no planning is done for the resurfacing of paved shoulders.)

PROPOSED SYSTEM

As a result of many discussions with personnel from the Maintenance Division, Districts, Residencies, and the Research Council the system as outlined below is proposed. It should be understood that the system proposed is an ideal system, and that portions of it could be implemented without implementing the entire system.

The system has two basic characteristics. One, the basic unit in the new system is a surface mix section, which is defined as a section for which the surface mix type, age, materials data, and other descriptive data remain constant. Data on most outputs from the new system will be summarized in terms of surface mix sections. Two, the locational method used in the system is milepost as derived from the graphic logs maintained by the Traffic and Safety Division. The use of some locational method such as milepost is the only effective way of correlating data from several computer data systems and milepost is the most acceptable method used by the Virginia Department of Highways.

Table 1 shows the data desired for each surface mix section. As shown, the data can be broken down into eight basic categories as discussed below.

Discussion of Desired Data

Section Location and Descriptive Data

The desired location and descriptive data would define the exact location of each surface mix section, and also provide a general description of the section. In Table 1, highway system refers to the interstate, arterial and primary systems and will allow breakdowns of the resurfacing needed for each. District, residency, county/city/town, route, direction/lane, beginning milepost, and ending milepost define the location of the surface mix section, and, of course, allow outputs to be generated by district, residency, or county/city/town. Descriptive beginning and descriptive ending are included to aid field personnel in their use of the output from the new system. Maintenance section is the section used for the allocation of maintenance costs, and is included in this data system so that projected resurfacing needs can be shown. Highway type indicates if the highway is two-lane, three-lane, four-lane divided, etc., and can be useful in several ways, but particularly will be used to determine how many surface mix sections exist across the highway at any point. For instance, a north-south four-lane divided highway may require separate surface mix sections for the northbound and southbound lanes. Also, highway type permits data to be summarized by lane mile rather than center line mile. Length and width are necessary to determine the area to be resurfaced (length, of course, can be determined from the beginning and ending mileposts). Mix type will indicate if the present surface is portland cement concrete, surface treatment, slurry seal, mix-in-place, or bituminous concrete (for bituminous concrete the particular mix type such as S-5 is required). Special feature refers to particular characteristics about the surface such as grooved pavement and will be most useful in selecting data for future research studies. The last data item shown in this category is age, which is required so that output can be provided by age, age and mix type, etc.

TABLE 1

DATA DESIRED FOR SYSTEM FOR PLANNING MAINTENANCE RESURFACING

SECTION LOCATION & DESCRIPTIVE DATA	SURFACE MIX MATERIALS & CONSTRUCTION DATA	SUBSURFACE LAYERS & 18k EQUIV. DESIGN VOL.	DYNAFLECT DATA	SKID DATA	ACCIDENT DATA	VOLUME DATA	RESIDENT ENGINEERS' COMMENTS
Highway System	Application Rate	Mix Type(1)	Spreadability Mean(2)	Mean PSDN(2)	Total Accidents	Average Vehicles Daily	Date of Review
District	Aggregate Size	Depth(1)	Standard Deviation(2)	Standard Deviation(2)	Tot. Fatal Accidents	Trucks: 2 axle-4 wheels	Estimated Remaining Life
Residency	Aggregate Type	Percent Cement/	Sample Size(2)	Sample Size(2)	Wet Accidents	2 axle-6 wheels	Reason for Resurfacing
County	Aggregate Source	Lime/	Date of Test(2)	Date of Test(2)	Wet Fatal Accidents	3 axle	
City/Town	Aggregate Percent	Asphalt(1)		Test Vehicle(2)	% Wet Accidents	Trailer Trucks	
Route		18 kip Equivalent Design Volume			Accident Rate	Buses	
Maintenance Section							
Highway Type							
Direction/Lane							
Beginning Milepost							
Descriptive Beginning							
Ending Milepost							
Descriptive Ending							
Length							
Width							
Surface Mix Type							
Special Feature							
Age							

(1) For each layer

(2) For each lane

With the exception of maintenance section and width, all the section location and descriptive data are available in the Pavement Information Data System now being implemented by the Research Council and the Data Processing Division. However, while this system is complete on the interstate and arterial systems, it is complete on the remainder of the primary system only for the areas resurfaced during 1972. In this manner the file for the rest fo the primary will not be completed until resurfacing occurs over the entire system. Thus, before implementing a maintenance resurfacing planning data system it will be necessary to develop some limited pavement information for that portion of the primary system for which it is not yet available. It is estimated that the development of these data would require 24 man-months.

With regard to maintenance section and width, these items could easily be assigned to each surface mix section using the graphic log as the source of information. Of course, the Pavement Information Data System should be altered to automatically include this information in the future.

Surface Mix Materials and Construction Data

The materials and construction data are desired so that estimations can be made about the useful life remaining for surface mix sections, and to faciliate research work on the performance of materials. For instance, surfaces containing limestone aggregates likely will become slippery sooner than those containing other aggregate types and therefore require resurfacing sooner. Also, these data may show that aggregates from certain sources do not perform well from a structural standpoint. Application rate refers to the pounds of mix placed and is required for bituminous plant mixes only. Aggregate size, geologic type, source, and percent are required for all mix types, and are required for each aggregate used in the mix.

These data also are available from the pavement descriptive information system, but, of course, are available only where that system is complete. It is not felt, however, that it is necessary to obtain all materials and construction data on the primary system prior to implementing a maintenance resurfacing planning system.

Subsurface Layers and 18 kip Equivalent Design Volume Data

Where possible it is desirable to know mix type, depth and percent cement, lime, or asphalt for each layer under the surface, as well as the 18 kip equivalent design volume. These data are desirable for several reasons, but principally to indicate the maximum 18 kip equivalent volume the pavement was designed to carry, to aid in the evaluation of the performance of pavement designs, and to aid in deciding what type and rate of resurfacing to apply.

Data on the subsurface layers are also being collected for all new projects as part of the pavement information data system. It is felt that initially it would be desirable to obtain subsurface layer data only for projects not yet resurfaced, which would require approximately 12 man-months of effort. It is not necessary that this information be collected in full prior to the implementation of the maintenance resurfacing planning system.

The 18 kip equivalent volume data are required for each new project. These data could be obtained for existing projects and automatically recorded for new projects with very little effort.

Dynaflect Data

Dynaflect data are desired when the maximum 18 kip equivalent voluem design is not available as described above, and to aid in determining what type and rate of resurfacing to apply. The value used to determine the maximum 18 kip equivalent traffic load is called "spreadability" and is computed as:

$$s = \frac{d_0 + d_1 + d_2 + d_3 + d_4}{d_0} \times 100$$

where

d_0 = maximum deflection directly under the dynaflect load, and

d_1, d_2, d_3, and d_4 = the deflections at 1 foot, 2 feet, 3 feet, and 4 feet from the load.

A spreadability mean value and standard deviation would be required for each lane in the surface mix section.

Each time a section is resurfaced it would be desirable to obtain new dynaflect data before establishing a new maximum 18 kip equivalent volume figure.

At present, only a very limited amount of dynaflect data exist. These data have come as the result of research projects conducted by the Research Council. Full-scale collection of dynaflect data would require one or more full-time crews working on a full-time basis, and would be a costly endeavor. However, as mentioned for other data above, it is not necessary that dynaflect data be obtained prior to implementation of the maintenance resurfacing planning system. In fact, implementation of the proposed data system with only limited dynaflect data would be an appropriate way of testing the effectiveness of a wide-scale program for the collection of dynaflect data.

Skid Data

Skid data are required to determine when resurfacing is necessary because of low skid resistance. The skid data desired for each surface mix section are the average predicted stopping distance skid number (PSDN), the sample size the average is based on, the standard deviation, the date the tests were run, and the test vehicle. Of course, it will be necessary to collect and present data by lanes within the surface mix section.

The data are presented in terms of predicted stopping distance numbers for two reasons. One, it is felt that this value, as obtained by locking the brakes on an automobile and measuring the stopping distance to compute the skid number, is the most realistic skid value that can be used. Two, since several skid testing vehicles may be obtaining data in Virginia it is necessary to relate all methods to a particular machine so that the data values presented will be meaningful.

Inclusion of skid data in the data system for planning maintenance resurfacing would not result in any additional costs, since plans have already been made to collect skid data and to provide an automated system to handle the data.

Accident Data

Accident data are desired in order to make sound judgements about when sections should be resurfaced because of low skid resistance. As indicated earlier when discussing the present short-range planning system, skid testing is presently done primarily on a request basis, with the request usually originating because a section has a high wet accident experience. For the near future it is envisioned that the Virginia Department of Highways will begin collecting skid data on a survey basis on the interstate, arterial and primary systems. When this occurs, several sections of roadway may be found with relatively low skid resistance and it would be impractical to resurface these sections without first considering the wet accident experience on them.

The accident data desired for each surface mix section are total accident, total fatal accidents, wet accidents, wet fatal accidents, percent wet accidents, and accident rate (computed as accidents per 100,000,000 vehicle miles). While it would be desirable to have the accident data broken down by lane within the surface mix section, the present method of collecting accident data does not permit this.

An automated system for the collection and storage of accident data exists and programs presently exist which would provide the accident data desired for each section. Thus, at times the same accident data may be summarized for two sections, as, for instance, on a four-lane road having different sections for each direction. Thus, as with skid data, inclusion of accident data in the proposed data system for planning maintenance resurfacing would not result in any significant cost.

Traffic Volume Data

Traffic volume data are needed for each section for several reasons. First, volume data will permit the computation of an accumulated 18 kip equivalent volume which can be used to determine if the design maximum 18 kip equivalent volume has been exceeded, and thus to evaluate the performance of designs and to project resurfacing needs. Second, the availability of accumulated volumes together with skid data and materials data will permit evaluation of various materials with regard to retention of skid resistant properties, and thus will increase the ability to predict when surfaces will need resurfacing due to low skid resistance. Third, knowledge of the current traffic volume is important in determining what type and rate of resurfacing to use.

As was shown in Table 1, the traffic volume data required are average vehicles daily, 2-axle 4-wheel trucks, 2-axle 6-wheel trucks, 3-axle trucks, trailer trucks, and buses. These data are required for each year since the completion of the surface mix section, and must be broken down by lane. The accumulated volumes can be computed using the annual volume figures.

Traffic volume data are presently collected and summarized by traffic sections. Traffic volume data for each surface mix section could be determined annually by assigning beginning and ending mileposts to the traffic sections and automating the assignment of volume data to surface mix sections. Some similar work has been done in relating volume data to accident data and it is felt that the additional work required to assign volume data to surface mix sections would not exceed two-man months of programming time. Present accumulated volumes for surface mix sections would have to be manually assigned, but this task should not require more than four-man months of time.

Resident Engineers' Previous Comments

Each year the resident engineers review many more sections than are finally chosen for resurfacing. It was agreed that some method of including in the proposed data system their comments concerning their visual reviews of each section would be beneficial. It was decided that a form could be developed which could be submitted for each section reviewed showing the estimated remaining life for the surface of the section, the date of review, and the reason for resurfacing.

The cost of implementing this portion of the proposed data system would be very small. It is not proposed that this information be developed initially for any more sections than would normally be reviewed.

Basic System Design

Prior to discussing specifically what output would be provided by the data system for planning maintenance resurfacing, it is felt that some comments should be made about what the probable basic design characteristics of the system will be, even though, as stated earlier, it is not the purpose of this project to perform the computer systems design and programming work necessary to implement the proposed system.

Figure 4 shows in very general terms how the proposed system will work. It is planned that each year data for all resurfacing and new construction for the previous calendar year will be submitted to the Data Processing Division by February 1. These data will be checked for errors and the master file updated, and new listings provided to operating personnel by April 1. The pavement information master file will then be updated from five sources between July 1 and August 15. Four of these sources — skid data, dynaflect data, accident data, and volume data — will be separate computer files, which means detailed listings of these data will be available. For instance, the pavement information data file will contain only average skid numbers by lane, but each latest individual skid test result can be obtained from the skid data file if required. Finally, by September 1 of each year the outputs for planning maintenance resurfacing, as described below, will be provided.

It is obvious in looking at Figure 4 that the Pavement Information Data System will be used and expanded as necessary to become the master file for the Maintenance Resurfacing Planning Data System.

Outputs of Proposed System

Several outputs would be possible from the proposed data system for planning maintenance resurfacing. Initially, it is planned to provide the outputs discussed below.

Detailed Output

A detailed computer output will be available for each surface mix section as shown in Figure 5. In the output example shown the x's represent the longest possible

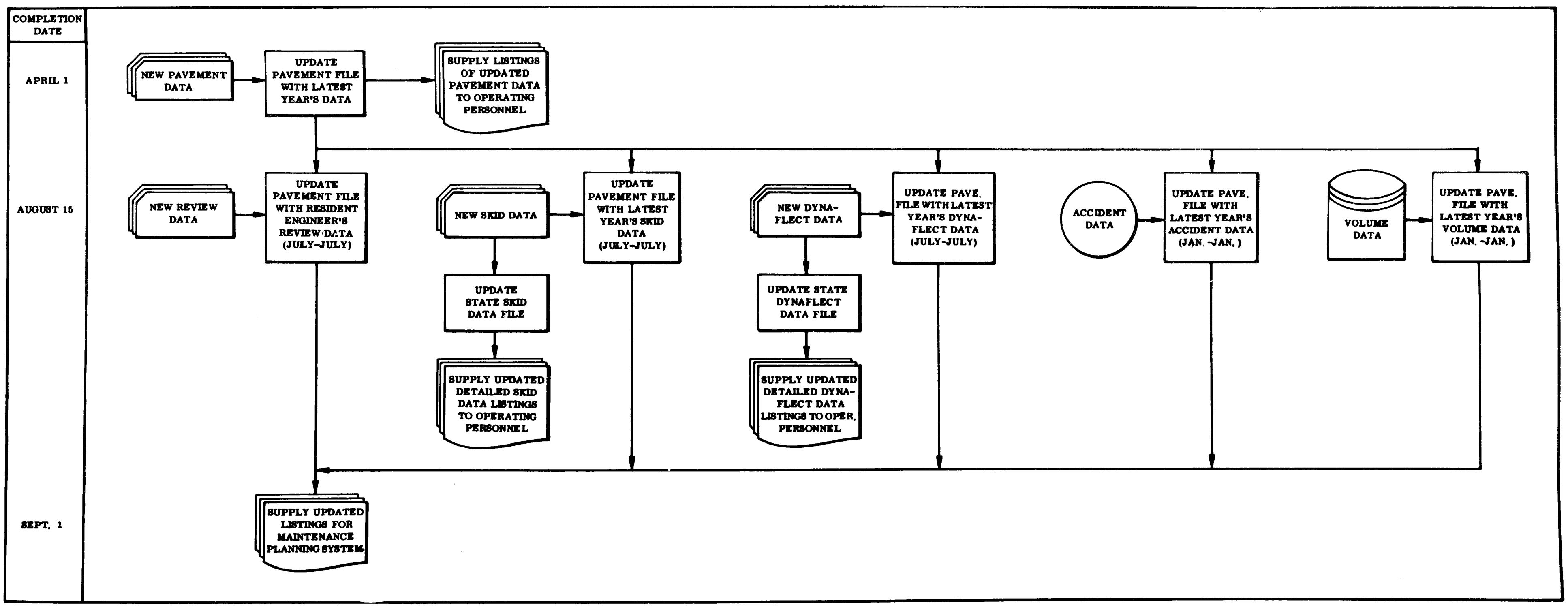

Figure 4. Basic system design for Maintenance Resurfacing Planning Data System.

response to each item of data. The output is broken down into eight basic categories as was discussed above. Under section location and descriptive data and surface mix materials and construction data, some output data is shown in Figure 5 which is not listed in Table 1, particularly for portland cement concrete mixes. As was discussed above, most of the data in these two categories are available from the Pavement Descriptive Information Data System, which also contains the additional information shown in Figure 5. It was felt that this additional data may be of value although this possibility was not mentioned in the many discussions about maintenance resurfacing planning.

The detailed listing would be provided by September 1, on an annual basis, to each residency and district for the counties they include, and to the Maintenance Division for the entire state. The primary use of this output will be as reference data. It could also be used as a planning tool, but a much more useful output could be produced for planning purposes, which would not require the engineer's time in evaluating each section shown in the detailed listing. This output would involve the selection of criteria which, when met would indicate that resurfacing may be necessary. An example of how this may work is discussed below.

Output by Exception

As indicated above, output by exception requires that criteria be established which indicate when resurfacing may be required. Surface mix sections could then be listed as requiring resurfacing when one or more of the critera are met. A priority list for resurfacing of surface mix sections could be established based on the number of criteria exceeded.

Below is listed the set of variables to which it is felt criteria should be applied to determine when resurfacing is necessary.

1. Age of surface.
2. 18 kip equivalent maximum volume (design, or as calculated based on spreadability).
3. Skid resistance.
4. Wet accidents.
5. Resident engineers' comments.

The criteria for each variable will change depending on the situation. Table 2 shows tenative criteria which may be changed prior to implementing the proposed data system. In fact, the system developed should be flexible enough to allow changing the criteria as seems appropriate.

FIGURE 5

DETAILED OUTPUT OF PROPOSED SYSTEM

```
SECTION LOCATION AND DESCRIPTIVE INFORMATION:
------------------------------------------------------------------------------------------------------------------------

SYSTEM          XXXXXXXXXX        BEGINNING MILE    XX.XX XXXXXXXXXXXXXXXXXX   PROJECT NUMBER  XXXX-XXX-XXX,XXXX,XXXX,XXXX,XXXX
DISTRICT        XXXXXXXXXXXXX     ENDING MILE       XX.XX XXXXXXXXXXXXXXXXXX                            XXX,XXXX,XXXX,XXXX,XXXX
RESIDENCY       XXXXXXXXXXXXXXX   LENGTH            XX.XX                                               XXX,XXXX,XXXX,XXXX,XXXX
COUNTY/CITY     XXXXXXXXXXXXXX    WIDTH             XX                                                  XXX,XXXX,XXXX,XXXX,XXXX
ROUTE           XXXX              SURFACE MIX TYPE  XXXXXXXX XXXXXX XXXXXXXX                            XXX,XXXX,XXXX,XXXX,XXXX
MAINT. SEC.     XX                SPECIAL FEATURE   XXXXXXXXXX XXXXXXXX                                 XXX,XXXX,XXXX,XXXX,XXXX
HIGHWAY TYPE    XX                COMPLETION DATE   XXXXXXXXX-XX               SCHEDULE NUMBER XXX-XX
DIRECTION/LANE  XXXXX XXXXX XXXXX AGE               XX.X                       SPEC. YEAR      XX

REVIEW DATA:
------------------------------------------------------------------------------------------------------------------------

DATE LAST REVIEW    XXXXXXXXX-XX        ESTIMATED REMAINING LIFE AT REVIEW:PAVEMENT  XX
                                        PRESENT REMAINING LIFE            :PAVEMENT  XX

SURFACE MIX MATERIALS AND CONSTRUCTION DATA:
------------------------------------------------------------------------------------------------------------------------

    BITUMINUOUS MIXES            PORTLAND CEMENT CONCRETE MIXES                              AGGREGATE INFORMATION
    -----------------            ------------------------------                              ---------------------
ASPHALT TYPE        XX-XX     CURING METHOD      XXXXXX XXXXXXXX                  SIZE        GEOLOGIC TYPE   SOURCE  PERCENT
                                                                              ------------   -------------   ------  -------
APPLICATION,PSY     XXX       TEXTURING METHOD   XXXXXXXX XXXXXX XXXX         XXX XXXX XXX   XXXXXXXX XXXXX   XXX     XXX
AVERAGE DESIGN AC   XX.XX     BAGS/CUBIC YARD    X.XX                         XX X           XXXXXXX          XXX      XX
CHANGE IN AC        XXX       CEMENT SOURCE      XX                           XX X           XXXXXXXXX        XXX      XX
ASPHALT,GSY         .XX       CONST. METHOD      XXXXXXXXXXX XXXXXXXXXX       XX XX          XXXX             XXX       X
STONE,PSY           XX        THICKNESS          XX.X
                              JOINT SPACING      XX
                              JOINT MATERIAL     X

SUBSURFACE LAYERS DATA BEGINNING WITH LAYER IMMEDIATELY UNDER THE SURFACE:
------------------------------------------------------------------------------------------------------------------------

                 MIX TYPE                                DEPTH         PERCENT CEMENT/LIME/ASPHALT
-----------------------------------------                -----         ---------------------------
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                     XX.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                      X.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                 X.X                      X.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                     XX.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                     XX.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                     XX.XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX                XX.X                     XX.XX
```

FIGURE 5(CONT)

DETAILED OUTPUT OF PROPOSED SYSTEM

TRAFFIC VOLUME DATA:

	TOTAL	ONE DIRECTION	LANE 1(TRAFFIC)	LANE 2	LANE 3
AVERAGE VEHICLES DAILY	XXXXXX	XXXXX	XXXXX	XXXXX	XXXXX
2 AXLE -4 TIRES	XXXXX	XXXXX	XXXX	XXXX	XXXXX
2 AXLE -6 TIRES	XXXXX	XXXXX	XXXX	XXXX	XXXXX
3 AXLE	XXXXX	XXXXX	XXXX	XXXX	XXXXX
TRAILER TRUCKS	XXXXX	XXXXX	XXXX	XXXX	XXXXX
BUSES	XXXXX	XXXXX	XXXX	XXXX	XXXXX
ACCUMULATED VEHICLE PASSES	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
2 AXLE -4 TIRES	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
2 AXLE -6 TIRES	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
3 AXLE	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
TRAILER TRUCKS	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
BUSES	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
EQUIVALENT PASSES	XXXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXXX
DESIGN 18 KIP VOLUME	XXXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXXX
18K EQUIVALENT VOLUME	XXXXXXXXX	XXXXXXXXX	XXXXXXXX	XXXXXXXXX	XXXXXXXXX

DYNAFLECT DATA						SKID DATA				ACCIDENT DATA		
DIRECTION/ LANE	DATE	SPREADABILITY AVE.	S.D.	N	MAXIMUM 18 KIP VOLUME	DATE	AVE.	S.D.	N		19XX	19XX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	TOTAL	XXX	XXX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	TOTAL FATALS	XX	XX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	WET	XXX	XXX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	WET FATALS	XX	XX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	PERCENT WET	XXX	XXX
XX XXXX X	XX-XX	.XX	.XX	XXX	XXXXXX	XX-XX	XX	XX	XX	ACCIDENT RATE	XXXX	XXXX

TABLE 2

TENTATIVE CRITERIA FOR SELECTING SECTIONS NEEDING RESURFACING

Variables	Criteria
Age	1. Select sections having bituminous concrete surfaces when the age exceeds 10 years. 2. Select sections having slurry seal surfaces, or surface treated surfaces when the age exceeds 7 years.
18 kip Equivalent Volume	1. Select sections when the 18 kip equivalent maximum volume based on design or spreadability measurements is exceeded by the greatest accumulated 18 kip equivalent lane volume computed from traffic volume data.
Skid Resistance	1. Select sections when the latest average skid number for any lane is less than 42.
Wet Accidents	1. Select sections when the total number of wet accidents is greater than 3 and the percent wet accidents is greater than 20 percent of total accidents.
Resident Engineers' Comments	1. Select sections when the present remaining life is equal to or less than one year based on latest review.

The present age of a surface mix can be determined on the basis of the date it was placed. It was decided the criteria for age should be greater than 10 years for bituminous concrete, and greater than 7 years for slurry seals and bituminous surface treatments.

The criteria for maximum accumulated 18 kip equivalent volume is variable, being either the design 18 kip equivalent maximum volume, or, where test data have been obtained, the maximum 18 kip equivalent volume based on the spreadability value computed from dynaflect test results. A section will be selected when the criterion is exceeded by the actual accumulated 18 kip equivalent volume as determined from traffic volume data. Obviously, it will be necessary to break traffic volumes down by lane and test the accumulated 18 kip equivalent volume for the lane having the greatest volume.

The criterion selected for skid resistance is a predicted stopping distance skid number of less than 42. A stopping distance skid number of 40 has long been used by the Virginia Department of Highways as a guideline for resurfacing, and research by the author and D. C. Mahone has indicated that skid numbers below 42 in general are associated with a high percentage of wet accidents. A section will be selected when the skid number averages below 42 for any lane within the section, regardless of the total number of lanes, or the average skid numbers in the other lanes.

As discussed previously, accident data are included in the system so that sound judgements can be made regarding the need for resurfacing due to low skid resistance. Thus, when the average skid number is less than 42, but there are few occurrences of wet accidents, it may not be necessary to resurface. However, it is also true that a high occurrence of wet accidents may occur when the average skid number equals or exceeds 42 for all lanes in a section, perhaps because of poor geometric characteristics. A section such as this may have a need for a relatively high skid resistance and should be selected for possible resurfacing. The criteria for selecting such sections are: (1) the total number of wet accidents for the previous calendar year must be greater than three, and (2) the percent wet accidents must exceed 20 percent of total accidents.

The final criteria chosen was to select sections having a present remaining life equal to or less than one year, based on the resident engineer's latest review comments.

It should be obvious that the selection of sections as described above is based on average conditions. This selection process may not, nor is it intended to, select small areas within sections. For instance, this system is not designed to select high accident locations within narrow bounds. This task, instead, should be the function of an accident data system designed to pinpoint high accident locations. The function of the data system for planning maintenance resurfacing is to provide personnel responsible for resurfacing general information about sections needing attention.

An example of how output by exception would work is illustrated by the data shown in Table 3, and the output shown in Figure 6. In this example there are five surface mix sections shown, all on Route 29 in Albemarle County.

TABLE 3

FICTITIOUS DATA TO ILLUSTRATE OUTPUT BY EXCEPTION
ROUTE 29, ALBEMARLE COUNTY, SEPTEMBER 1972

Information		Section 1	Section 2	Section 3	Section 4	Section 5
Direction/Lane		All Lanes	All Lanes	NB Lanes	SB Lanes	NB Lanes
Beginning Milepost		21.00	23.60	26.45	26.45	28.95
Ending Milepost		23.60	26.45	28.95	31.52	31.52
Surface Mix Type		S-5	MS-5	S-5	S-5	S-5
Completion Date		8/67	7/71	2/61	7/65	7/65
Age		5 years	1 year	11 years	7 years	7 years
Date Last Reviewed		10/71		10/71	10/71	10/71
Remaining Life:	At Review	3-4 years		1 year	2 years	3-4 years
	Present	2-3 years		0 year	1 year	2-3 years
18 kip Equivalent Volume: (millions)						
	Design			0.6		0.6
	By Dynaflect				0.52	
	Actual	TL 0.38 PL 0.10	TL 0.08 PL 0.02	TL 0.68 PL 0.18	TL 0.58 PL 0.15	TL 0.58 PL 0.15
Skid Numbers:	NBTL	41	52	41	48	46
	NBPL	45	58	46	52	49
	SBTL	40	51	43	46	47
	SBPL	45	59	48	51	51
Accidents:	Total	6	5	8	12	4
	Wet	2	1	4	5	1
	% Wet	33%	20%	50%	42%	25%

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FIGURE 6

EXAMPLE OF OUTPUT BY EXCEPTION:

DISTRICT CULPEPER

RESIDENCY CHARLOTTESVILLE

SECTION IDENTIFICATION								ATTENTION NEEDED BECAUSE OF				
COUNTY	ROUTE	HIGHWAY TYPE	DIRECTION AND LANE	BEGINNING MILEPOST	ENDING MILEPOST	LENGTH	MIX TYPE	AGE	PRESENT LIFE	18 KIP VOLUME	LOW SKID RESISTANCE	WET ACCIDENTS
ALBEMARLE	29	41	ALL LANES	21.00	23.60	2.60	S-5				*	
ALBEMARLE	29	41	NB LANES	26.45	28.45	2.50	S-5	*	*	*	*	*
ALBEMARLE	29	41	SB LANES	26.45	31.32	5.07	S-5		*	*		*

Figure 6 shows that three of the five sections were chosen as possibly needing attention because one or more criteria were met. Section 1 was chosen because of average skid numbers less than 42 in the traffic lanes. Section 2 was not chosen since no criterion was exceeded. Section 3 was chosen because all criteria were exceeded. Section 4 was chosen because the present remaining life was one year, the 18 kip equivalent maximum volume as determined by dynaflect data was exceeded, and the number of wet accidents was greater than three and the percent wet accidents exceeded 30%. Section 5 was not selected since no criterion was exceeded.

It was mentioned above that output by exception was designed to provide general information about sections needing attention. Once the sections are identified it will be necessary to use more detailed information to decide what action to take. In this example it seems obvious that Section 3 is most in need of attention since all five criteria were exceeded. Section 4 is next in need of attention, having three criteria exceeded, and Section 1 seems least in need of attention since only the criteria for skid number is exceeded. By referring to the detailed output one may determine better whether resurfacing is necessary in the coming year. For instance, for Section 1, where there is relatively low skid resistance, but few wet accidents and good structural conditions, it may be decided to delay resurfacing, or, at least, to provide only a light resurfacing solely for the purpose of increasing skid resistance. Prior to taking any action on Section 1 it would be important to refer to even more detailed accident and skid data than that provided in the proposed detailed listing in order to pinpoint exactly where resurfacing may be necessary. As explained earlier, these detailed data would be available from the computer files from which the maintenance resurfacing planning data system is built, as was shown in Figure 4. Section 3 probably requires a rather heavy resurfacing to improve the structural condition as well as providing good skid resistance. Section 4 would also require close examination of the detailed accident data since the skid numbers are fairly high. Since accident data included in the proposed system cannot be broken down by direction, a close analysis may show that most of the accidents occurred in the northbound lanes, and thus Section 4 actually may not have a high percentage of wet accidents. This is particularly true since Section 3 is within the mileposts of Section 4, and has low skid numbers. Also, visual examination by the resident engineer may reveal that from a structural standpoint resurfacing of Section 4 could be postponed for another season.

It will be necessary to establish criteria such that a relatively small number of sections will be selected, or output by exception will not be extremely useful. Again, this output only suggests what section probably needs some attention, and further information about the sections will have to be obtained from other, more detailed, output.

The outputs discussed thus far deal primarily with short-range planning. Of course, from these outputs it would be possible for the users to establish a longer than one-year plan for resurfacing. It is hoped that once the system has been implemented for one to two years, it will be possible to begin to include some projected data which will be beneficial in long-range planning. The first attempts at projecting data probably will be as follows.

1. Using the historical volume data and design 18 kip maximum accumulated volume, it may be possible to project the number of years before the 18 kip maximum accumulated volume will be exceeded.

2. Using the historical volume data, aggregate data, and skid data for a section, it may be possible to project the numbers of years before a skid number below 42 will be reached.

In addition to the outputs described above, a summary output as discussed below will be provided annually for long-range planning.

Summary Output for Long-Range Planning

The summary output will deal basically with the same criteria as discussed above, with the exception of those for wet accidents. An example of the proposed output is shown in Figure 7. There will be an output for bituminous concrete, surface treatments, slurry seals, and portland cement concrete. Each output will be broken down by age, with data being expressed in terms of lane miles or percentages. For example, as illustrated in Figure 7 it will be possible to determine the number of lane miles of bituminous concrete that is five years old, and what percent this is of the total. It is also possible to determine the number of lane miles five years old that exceed the criteria for skid number, 18 kip equivalent maximum volume, and present remaining life. Since it is possible that some miles will exceed several criteria, the output is summarized as shown at the bottom of Figure 7, where the lane miles exceeding two or all criteria are shown.

This summary output will be provided to the Maintenance Division for the entire state, to each district for the mileage in the district, and to each residency for the mileage in the residency.

SUMMARY

At present, short-range planning for resurfacing is accomplished by having the resident engineer submit a list of sections requiring resurfacing based on his visual examination. This list is reviewed in the field by District and Maintenance

FIGURE 7

SUMMARY OUTPUT IN LONG RANGE PLANNING:

MIX TYPE XXXXXXXX XXXXXX XXXXXXXX

	AGE															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	'15	TOTAL
TOTAL MILAGE	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
PERCENT OF TOTAL MILAGE	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	100
MILES TESTED FOR SKID NUMBER	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES WITH SKID NUMBER < 42	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
PERCENT OF MILES TESTED < 42	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	100
MILES ASSIGNED 18 KIP MAX.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES EXCEEDING 18 KIP MAX.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
PERCENT EXCEEDING 18 KIP MAX.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	100
MILES REVIEWED	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES PRESENT LIFE <1 YR.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
PERCENT PRESENT LIFE <1 YR.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	100
MILES SN<42 EXCEEDING 18 KIP MAX.	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES SN<42 PRESENT LIFE < 1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES EXCEED 18 KIP LIFE < 1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
MILES EXCEEDING ALL CRITERIA	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

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Division representatives and a final list established. In addition, sections are resurfaced when the average stopping distance skid number is found to be below 40. Long-range planning is accomplished by determining the system mileage, applying an annual growth factor, and then using an average surface life of 8 years.

It was indicated that additional information would be helpful for both short- and long-range planning. These additional data can be broken down into several categories as was shown in Table 1. Several outputs could then be made available, notably a detailed output (Figure 5), output by exception (Figure 6), and a summary output (Figure 7), which would be helpful in both short- and long-range planning for maintenance resurfacing, and better planning hopefully would allow better utilization of maintenance funds. Side benefits of the system would allow better research regarding skid resistance retention qualities of various aggregates, and better evaluations of pavement designs, which again, hopefully, would lead to reduced maintenance costs.

The costs of obtaining the proposed data are as follows. Most data shown in the first three categories — section location and descriptive data, surface mix materials and construction data, and subsurface layers and 18 kip equivalent maximum design volume — are being collected in the recently developed Pavement Information Data System. However, since this system is not complete for the primary system it will be necessary to complete it in a skeleton form prior to implementing a maintenance resurfacing planning data system. It is estimated that 36 man-months would be required to complete the Pavement Information Data System for the entire state. Inclusion of skid data, dynaflect data, and accident data would not result in any cost other than the cost required to develop a system to handle the data, since it is not suggested that any increase in the amount of data collection be made over what is already done or planned. The same is true for volume data, except that 2 man-months may be necessary to provide present accumulated volume data for each surface mix section. The cost of collecting the resident engineers' comments would also be limited essentially to systems development costs since data will be submitted only for the sections normally reviewed. Thus, assembling the data required to implement the proposed system on a statewide basis would require about 38 man-months of effort, or, translated to dollars, probably about $40,000. However, it may be incorrect to assume that all $40,000 would be an out-of-pocket expense to the Department, since much of the data probably could be assembled in the residencies as time permits.

In addition to the costs of data collection there would be a cost of developing the system to handle the data and provide the proposed outputs.

RECOMMENDATION

It is recommended that the development of the proposed system be handled as a continuation of the work reported here. It is proposed that this new project involve the development of the system and implementation in one district. The total cost of the project would be no more than $34,575.00 as outlined below.

System Outline and Development:	
Research Analyst C (2/5 time for 15 months)	$10,375.00
Research Analyst A (4/5 time for 15 months)	12,700.00
Data Collection:	
Technician B (full time for 6 months)	5,000.00
Data Preparation and Computer Charges	5,000.00
Travel Charges	1,000.00
Miscellaneous Charges	500.00
Total	$34,575.00

The estimates stated are maximum figures, and it is hoped the project could be completed for less.

It is proposed that a skeleton system be developed by September 1, 1973, and that output from this system be used for resurfacing planning for 1974 in the chosen district. The system would be revised and evaluated in the year September 1973 to September 1974, with the final report coming October 1, 1974.

Providing the system proves useful for the district chosen, the maximum cost of then implementing the system statewide should not exceed $40,000, and most likely could be done for less.

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