Development of Condition Surveys and Inventories for Guide Rail and Drainage Facilities

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ABSTRACT

In 1983 the Pennsylvania Department of Transportation implemented a systematic technique to analyze and manage Pennsylvania pavements (STAMPP), its first complete pavement management system. With STAMPP as the foundation, the department has embarked on the development of a total roadway management information system (RMIS), which to become functional requires the addition of guide rail and drainage conditions. A special task force, comprised of district, county, and central office personnel developed the techniques with which to inventory and collect the condition data for guide rail and drainage facilities, assigned treatment strategies and related costs to deficient conditions, and proposed methods for implementing identified survey results. The result is a more complete roadway management system, which allows department management to more effectively manage approximately 43,000 mi of highway pavements, shoulders, and appurtenances.

In 1983 the Pennsylvania Department of Transportation implemented its first complete pavement management system, a systematic technique to analyze and manage Pennsylvania pavements (STAMPP). This methodology provides department personnel with an objective, useful tool to more effectively manage approximately 43,000 mi of highway pavements and shoulders. STAMPP is now being used as the foundation of a roadway management information system (RMIS), currently under development by the department. In the development of the RMIS, the STAMPP task force identified a need for inclusion of data on guide rail, median barrier, and drainage facilities, along with the pavement and shoulder data being collected in STAMPP. This would result in a more complete roadway management system.

To identify the information required, and to develop a methodology to acquire that information, a special task force comprised of district, county, and central office personnel was formed. The task force members represented a variety of engineering and managerial disciplines: highway maintenance, design, pavement management, planning, and highway safety. These individuals were charged to evaluate and recommend techniques by which to systematically inventory and collect the condition data for guide rail and drainage, to assign appropriate treatment strategies to deficient conditions, and to implement these results as enhancements to STAMPP.

In their initial sessions, the task force adopted the following working objectives:

1. Develop a uniform 100 percent inventory and survey of statewide guide rail and drainage facility conditions;
2. Identify appropriate condition criteria, recommend treatments, and estimate associated costs; and
3. Develop factors relative to the inventoried guide rail and drainage items for use in allocating maintenance monies to the counties.

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The task force also adopted the following co-objectives from the STAMPP Pavement Condition Survey Field Manual (1):

1. To provide a uniform statewide condition evaluation that would improve decision making;
2. To provide management with the information and tools to monitor the condition of the network, assess future needs, establish county condition rankings, and optimize investments;
3. To provide condition information to fulfill the requirements of Pennsylvania Act 68 (1980), which requires the allocation of maintenance funds to the individual counties based on need;
4. To provide information for monitoring the performance of various pavement (guide rail and drainage) designs, materials, rehabilitation, and maintenance techniques; and
5. To provide information for identifying candidate projects for maintenance and betterment programs.

Over a period of several weeks, the task force developed the criteria and survey input forms to conduct the inventories of guide rail, median barrier, and drainage facilities on the state's highways. These criteria and forms underwent several stages of revision as a result of field surveys conducted by the task force members and meetings held with personnel in the more urban districts. The result is an inventory that satisfies the previously stated objectives and yields the following benefits to the department:

1. It provides condition information to fulfill the requirements of Act 68, enabling the department to modify the RPQI portion of the formula to allocate maintenance funds to individual counties. Overall needs will be better defined as a result of the information that will be gathered.
2. The information collected on the condition of barrier and drainage systems can be used to generate work plans for county maintenance operations.
3. In conjunction with the current STAMPP data, guide rail and drainage condition data can be used

in the development of the department's annual Highway Restoration Program.

4. Overall system management is enhanced. All managers, whether at the district, county, or central office level, will have the necessary information to better assess their future needs.

5. The survey forms that were developed will facilitate the collection of information that can be readily integrated into the roadway information data base (RIDB). Ultimately, this information will be available to develop automated straight line diagrams (SLDs), which indicate, among other things, the type and location of all traffic barriers and drainage facilities along each section of highway.

6. It improves the department's ability to address tort claims associated with guide rail or drainage conditions. The additional information that will be available to all managers will enable them to assess their needs and better establish logical priorities for improvements. This is true at the county level, in the development of annual maintenance work plans; at the district level, in the development of the annual Highway Restoration Program; and at the central office level, in the establishment of overall program guidelines.

GENERAL INFORMATION AND SURVEY DEVELOPMENT

Both the guide rail and the drainage surveys were developed to be compatible with STAMPP methodology for conducting visual condition surveys. The existing STAMPP segments and offset distances are used to locate barriers and drainage items.

The initial surveys for both guide rail and drainage will be inventories as well as condition surveys. The guide rail survey will be done on 100 percent of the highway network system on an annual basis. In the case of drainage, the complete survey of the system will be phased in over a period of 4 years, by doing 25 percent of each of the Primary Commercial Network (PCN) and the Off-PCN roadways each year. It is recognized that periodic updates will be required to quantify the condition of the drainage or barrier elements; however, this will not necessarily have to be done on an annual basis. To keep the inventory data current for both barriers and drainage, a means will be established to automatically update the information whenever work is accomplished by department forces or under contract. This will require some software development and an interface with other department recordation systems. The result will be an up-to-date inventory that will require less resurveying and will therefore be less expensive to maintain.

GUIDE RAIL SURVEY

The task force considered existing department design criteria and maintenance techniques when developing the guide rail inventory and condition survey format. Some of those considerations included the Standard Roadway and Bridge Construction Drawings, the Highway Design Manual, Part 2, Chapter 12, on Guide Rail and Median Barrier, the Maintenance Manual criteria on guide rail maintenance and replacement, the Highway Features Inventory-System, and other existing planning criteria used for I-4R, 3R, and betterment project development.

After discussions with district personnel, primarily in the commonwealth's two major urban areas, it was decided that the end treatments and actual systems currently found on roadways would be specified on the survey forms and used in the inventory, as opposed to a previous plan to merely include systems broken down by cable or panel, and strong or weak posts. The additional time required to do a more detailed inventory was considered a good tradeoff for getting a more complete inventory and accurate cost estimate of needs for maintenance and repairs.

Guide rail and median barrier system conditions are observed for extent and severity of post deflection, cable sag, system deterioration, hardware condition, and system height. Treatments and associated costs were identified for the various conditions or combinations of conditions. These are used in estimating the total needs relative to barrier condition and also in the development of STAMPP project cost estimates and are based on actual repair and construction costs currently being quoted on Pennsylvania contracts.

The condition of the system end treatments is identified as functional or nonfunctional on the basis of the ability of the treatment to perform its intended function. For bridge connections, only a current strong-post W-beam rail system with appropriate connection hardware and reduced post spacing in the vicinity of the structure is considered functional.

An important aspect of the survey is the identification of potentially unneeded guide rail and median barrier. The task force recommended that removal of existing nonfunctional systems be stressed, with update only where truly needed. The task force's sentiments were strongly reinforced by district personnel, and a reassessment of warrants and standards has been mandated by department management. It was also recognized that the department did not fully use the cost-effectiveness approach outlined in the 1977 AASHTO "Guide for Selecting, Locating, and Designing Traffic Barriers" and subsequent publications.

A reevaluation of placement options for typical existing conditions was recommended in accordance with the AASHTO cost-effectiveness analysis. This will include guide rail along cut-and-fill slopes, along tree-lined rural roadways, in areas where speeds have been reduced, and so forth.

Subsequent to development of the survey format, a second task group was convened to consider existing national and Pennsylvania warrants for barrier use and to evaluate revisions to design criteria in accordance with the AASHTO barrier guide Chapter 7 cost-effectiveness approach. Easy-to-use criteria were developed for use as a guideline for checking the "candidate for removal" block and revised standard criteria were recommended for consideration. These criteria are more liberal than previous criteria in that they recognize motorists' ability to safely negotiate certain slopes and fill heights. Moreover, they take into account the probability of a motorist losing control and encountering the slope. If these criteria are adopted, significant cost savings can be realized through reduced maintenance needs where barrier is removed and lesser construction costs on 3R projects. Removal of old and unwarranted barriers and a program to update warranted barriers will provide the motoring public with the most cost-effective and safe system practicable. Moreover, by reassessing barrier warrants, the department will be able to upgrade the truly needed barrier systems without spending limited funds on questionable or unneeded installations.

The guide rail survey form is shown in Figure 1, and treatment strategies and costs are given in Tables 1-4.

DRAINAGE SURVEY

Development of a drainage survey form, as in the case of guide rail, started with identification of appropriate inventory items. It was recognized that

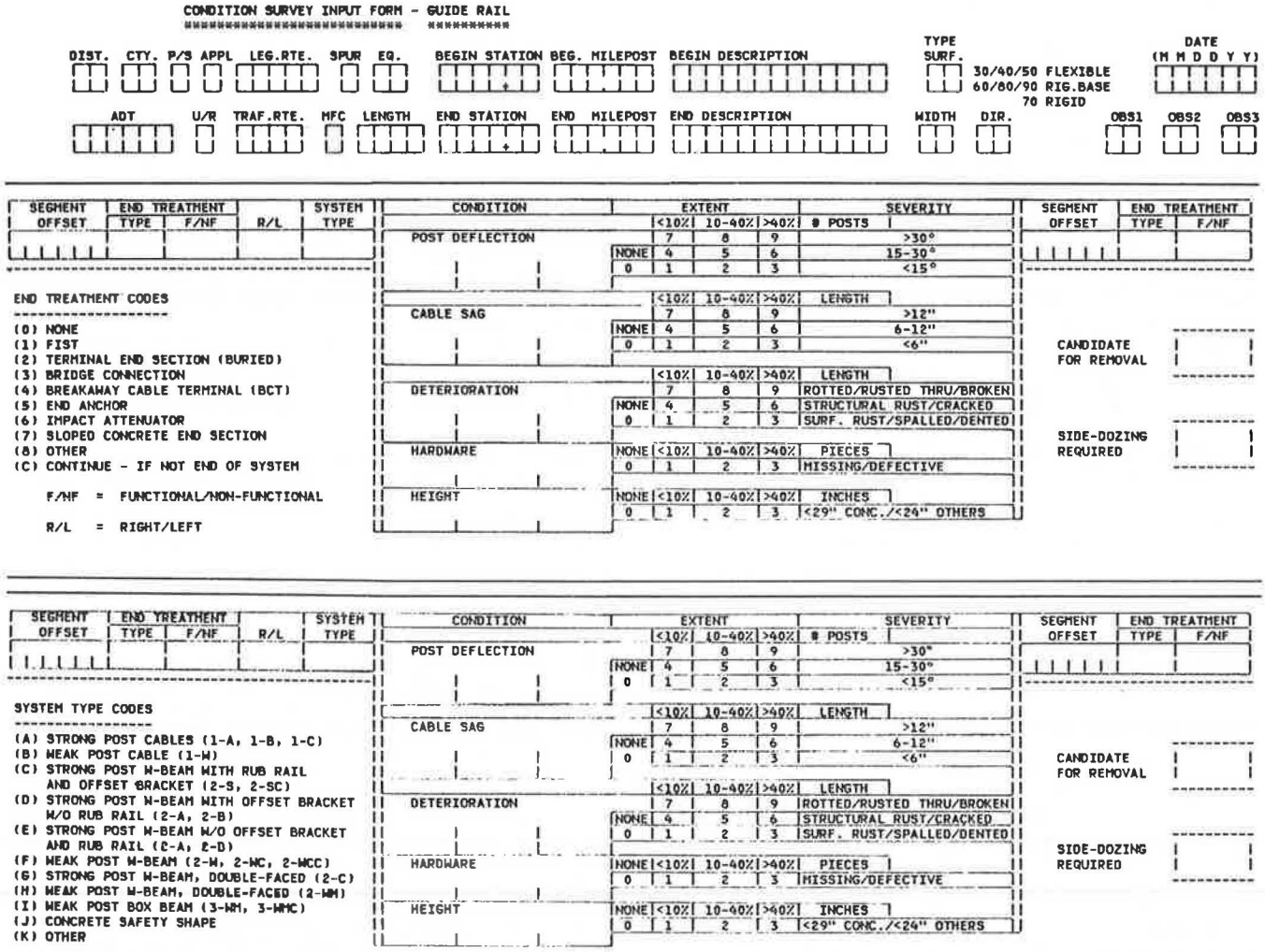

FIGURE 1 Guide rail survey form.

the drainage inventory needs would be much different in urban, curbed areas than on the rural roadway system. After much discussion within the task force and comments from the urban districts, inventory items were agreed on that included pipe and other structures less than 8 ft in width measured along the roadway centerline (structures 8 ft or greater are included in the structures inventory), inlet control, outlet control, outlet ditches, and parallel ditches. Treatments and related costs are based on normal maintenance treatments wherever possible and action is indicated based on flow conditions, structural conditions, and physical condition of the pipe, structure, inlet or outlet, ditch, and any apparent roadway distress caused by structure failure.

Figure 2 is the sample drainage survey form; Tables 5 and 6 give treatment strategies based on drainage conditions and associated treatment costs.

CONDUCTING SURVEYS

It is the intent of the task force that the initial guide rail and drainage surveys be inventories as well as condition surveys. To properly indicate present and future needs, a 100 percent survey of

TABLE 1 Guide Rail Treatment Strategies

	Extent and Severity								
	Low			Medium			High		
Condition	1 (<10%)	2 (10-40%)	3 (>40%)	4 (<10%)	5 (10-40%)	6 (>40%)	7 (<10%)	8 (10-40%)	9 (>40%)
Post deflection	X	X	X	2	2	2	3	3	4
Cable sag	X	X	1	1	2	2	3	3	3
Deterioration	X	X	X	1	1	3	3	3	4
Hardware	1	3	3						
Height	2	2	2						

Note: 1 = routine maintenance, 2 = reset (repair in place), 3 = replace in kind, and 4 = update only if system does not meet current standards. Combinations for update if system does not meet current standards: A6 + B9, B9 + C8, and A8 + B9.

TABLE 2 Treatment Strategies—Nonfunctional End Treatments

Type	Cable System	Panel System	Concrete Barrier
0	3,4	3	3
1		3,4	
2		3	
3	4	3,4	
4		3	
5	3,4	3	
6	3	3	3
7			3
8	4	4	4
C			

Note: 1 = routine maintenance, 2 = reset (repair in place), 3 = replace in kind, and 4 = update only if system does not meet current standards.

TABLE 3 Treatment Costs for Guide Rail Systems

System	1. Routine Maintenance	2. Reset/Repair in Place	3. Replace in Kind	4. Update
A	1.50	4.38	6.20	11.50
B	1.50	4.38	6.20	6.20
C	1.50	5.75	16.50	16.50
D	1.50	5.75	11.50	11.50
E	1.50	5.75	10.00	11.50
F	1.50	5.75	10.00	10.00
G	1.50	8.00	19.00	19.00
H	1.50	5.75	16.80	16.80
I	1.50	12.78	33.00	33.00
J	1.50	3.50	23.50	23.50
K				11.50

Note: costs in dollars per linear foot.

the identified inventory items is essential. Proper updating of the system, to include newly constructed features, repair or replacement of existing features, and elimination of features, is necessary in order to make the system functional.

The task force assessed various options for conducting each survey and assigned relative costs to the various options. For the guide rail survey, four options were presented for consideration:

- Option 1: Conduct the survey annually in conjunction with the present STAMPP survey by the addition of a third person in the STAMPP vehicle. It was anticipated that the third person would be able to do the guide rail survey and the STAMPP shoulder condition survey. This method would eliminate the need for additional survey vehicles and other associated equipment. One drawback to this option is the anticipated initial reduction of approximately 2 mi per day in the STAMPP survey production. This is expected to happen only the first time the survey is made, because this will be both a condition survey and an inventory. Long-term production should actually increase. Estimated annual cost is $363,000 compared with $215,000 for the STAMPP condition survey alone.
- Option 2: Use of separate survey crews to conduct each of the guide rail and STAMPP condition surveys. The advantage is that the efficiency of each survey will not be affected; however, additional personnel, vehicles, and equipment are required. The cost of two separate sets of survey crews is estimated at $356,000.
- Option 3: Have the two-man STAMPP survey crew perform a second pass on each roadway segment to pick up the guide rail survey. This would significantly reduce survey efficiency and may be prohibitive in terms of time required; however, advantages include reduced personnel and equipment needs. Estimated cost is the same as Option 2.
- Option 4: Conducting the survey by engineering consultant contract was discussed at length and judged to be cost prohibitive, although no actual cost estimate was derived. Advantages are reduced department personnel and equipment needs and noninterference with the STAMPP survey.

The task force recommendation was to use Option 1 because the estimated survey costs were in line with the other options presented and would make available a yearly update of guide rail needs for development of the counties' annual work plans and allocation of maintenance monies.

The drainage survey will have to be conducted separate from the STAMPP and guide rail surveys because it will entail considerable "walking" of each segment to assess conditions of drainage items and measure extents of some conditions. Regardless of how the survey is conducted, it is imperative that as many drainage locations as possible be identified before going into the field by checking as-built plans, when available. This will increase efficiency of the field survey as well as provide a check to assure that as many of the drainage items as possible are located and inventoried.

To replace the current trained observer survey (TOS) cycles in the maintenance allocation formula it was recommended that the drainage survey initially be conducted on the Off-PCN roads, with emphasis on those roads scheduled for surface improvement or on the 4-year plan because these are considered to generally have more urgent drainage needs. One option for conducting the survey was to have the assistant county maintenance managers responsible for inventorying and evaluating drainage conditions over approximately an 8-year period in advance of

TABLE 4 Treatment Costs for Nonfunctional End Treatments

	3. Replace in Kind			4. Update		
Type	Cable System	Panel System	Concrete	Cable System	Panel System	Concrete
0	240	750	140	750	750	
1		750			750	
2		750				
3		144		550	550	
4		1,200			1,200	
5	240	500		750		
6	1,000	1,000	1,000			
7			140			
8				240	750	140
C						

Note: cost in dollars each.

CONDITION SURVEY FORM — PENNSYLVANIA DEPARTMENT OF TRANSPORTATION — DRAINAGE

DIST. CTY. P/S APPL. LEG. RTE. SPUR EQ. BEGIN STATION BEG. MILEPOST BEGIN DESCRIPTION TYPE SURF. 30/40/50 FLEXIBLE 70/80/90 RIG. BASE 70 RIGID DATE (M M D D Y Y)

ADT U/R TRAF. RTE. MFC LENGTH END STATION END MILEPOST END DESCRIPTION WIDTH DIR. OBS1 OBS2 OBS3

INLET END SEGMENT OFFSET	R/L	PIPE/STRUCTURE: STYLE (A)	POSITION (B)	TYPE (C)	DIMENSION: HEIGHT	DIMENSION: WIDTH	LENGTH	INVERT DEPTH	COATING (D)	PHYSICAL CONDITION (E)	STRUCTURAL CONDITION (F)	FLOW CONDITION (G)	ROADWAY DEFLECTION (H)	INLET: TYPE (I)	INLET: STRUCTURE CONDITION (F)	INLET: FLOW CONDITION (G)	OUTLET: TYPE (I)	OUTLET: STRUCTURE CONDITION (F)	OUTLET: FLOW CONDITION (G)	OUTLET DITCH: LENGTH	OUTLET DITCH: FLOW CONDITION (G)	PARAL DITCH: FLOW CONDITION (G)	DITCH EROSION: SEVERITY (J)	DITCH EROSION: ERODED LENGTH	OUTLET END SEGMENT OFFSET

A STYLE	B POSITION	C TYPE	D COATING/PAVING	E PHYSICAL CONDITION	F STRUCTURAL CONDITION	G FLOW CONDITION	H ROADWAY DEFLECTION	I INLET/OUTLET TYPE	J DITCH EROSION
0 ○	0 CROSS	0 CONCRETE	0 NONE	0 LIKE NEW, NO DEFECTS	0 GOOD	0 OPEN	0 NONE	0 DROP INLET W/OUT GRATE	0 NONE
1 ⌓	1 PARALLEL	1 METAL	1 ASPHALT	1 CRACKED, SPALLED, LIGHT RUST	1 DISPLACEMENT <20° SAG	1 <1/2 CLOGGED	1 >1" SURFACE DISTRESS	1 DROP INLET WITH GRATE	1 <12"
2 □	2 SLOPE	2 CAST IRON	2 EPOXY	2 BROKEN, RUST PITTED, WEATHERED JOINTS	DISPLACEMENT >20° SAG	2 1/2 OR MORE CLOGGED		2 ENDWALL	2 >12"
3 ○○○		3 ALUMINUM	3 POLYMER	3 DETERIORATED, ROTTED, BOTTOM OUT	2 JOINT SEPRATN, SCOURING			3 FLARED END SECTION	
4 ⌒		4 PLASTIC		4 UNKNOWN	3 COLLAPSED			4 DITCH ONLY	
5 ⌒		5 OTHER			4 UNKNOWN			5 CONTINUOUS	
								6 UNDETERMINED	

FIGURE 2 Condition survey input form—drainage.

TABLE 5 Drainage Treatment Strategies

Condition	Extent	Pipe Style (0-3)	Structure Style (4&5)
Physical, E	0	1	1
	1	1	1
	2	2	7
	3	4	7
	4	1 or 2	1 or 2
Structural, F	0	1	
	1	1	
	2	3	
	3	4	
	4	1 or 2	
Flow, G	0	1	
	1	2	
	2	5	
Ditch erosion, J	0	1	
	1	3	
	2	6	

Note: 1 = do nothing, reinspect in 5 years; 2 = do nothing, reinspect in 2 years; 3 = repair/reset; 4 = replace; 5 = flush/clean and inspect; 6 = reline; and 7 = requires inspection by bridge inspection personnel (SIRS). Combination for replacement (4): Flow condition G = 2 + roadway deflection H = 1.

their yearly surface improvement program or 4-year plan.

Another option was creation of a maintenance technician position as an assistant to each assistant county manager. This technician would be responsible for coordination of the survey with county forces over a 2-year period. A general option was to mandate conduct of the survey, starting with the Off-PCN roads, to be completed over a 2-year period, allowing the district engineer to decide who will conduct the survey. Some available personnel options included consultant contract, coordination by district staff, county staff, temporary or part-time personnel, and workfare people. It is estimated that at 5 mi per day for a two-man survey team, 17,600 man-days will be required to conduct the drainage survey.

The task force could not agree on a single, most favorable option. Thus no specific recommendation was made about who should conduct the drainage survey. The option of allowing the district engineers the choice of personnel appeared to make the most

TABLE 6 Treatment Costs—Drainage Items

Treatment	Pipe and Pipe-Arch ⓪ ①	Box Culvert ②	Multiple Pipes ③	Small Structures ④ ⑤	Inlets and Outlets	End Walls	Pipe and Culvert End Sections	Parallel and Outlet Ditches	Erosion Control
1									
2									
3	≤36 in., $23.00/LF >36 in., $46.00/LF	$100.00/LF	$75.00/LF	$35.00/ft^2	$400.00 each $1,200.00 each	$100.00 each	$100.00 each ≤36 in., $500.00 each		
4	≤36 in.,$62.00/LF								
	>36 in., $122.00/LF	$125.00/ft^2	$105.00/ft^2	$135.00/ft^2	$1,500 each with grate	$250.00 each	>36 in., $1,000.00 each		
5	$2.50/LF	$36.00/LF	$7.50/LF	$36.00/LF	$25.00 each	$25.00 each	$25.00 each	$1.00/LF	
6									$15.00/LF
7				$300.00 each					

Note: LF = linear foot. Circled numbers represent style (see Figure 2).

sense because they would be better aware of their district and county personnel commitments and needs and any budgetary constraints.

The drainage survey has built-in cycles of reinspection based on existing condition, inability to assess conditions because of present survey limitations, and the degree of inspection expertise required on small structures. However, it was generally recommended that, after the initial inventory and condition survey, reinspection should be performed at 5-year intervals unless a shorter period is deemed more suitable.

STAMPP ENHANCEMENTS

It was recommended that side-dozing and swale grading be included in the STAMPP survey; however, only side-dozing was considered appropriate because swale grading is generally included in the shoulder cutting treatment for a buildup condition in the shoulder portion of the STAMPP survey. Several other RMIS system enhancements were also recommended:

1. Add an assistant county manager designation to each STAMPP segment to expedite county data acquisition for development of annual work plans. This can be built into the RMIS currently under development by the department.
2. In developing project cost estimates (2), drainage costs, based on the condition survey, should be added to the normal project assessment software programming. Guide rail costs, again based on the condition survey, should be provided as an option for project cost estimate development in a manner similar to that in which maintenance and protection of traffic, mobilization, and engineering are currently handled.
3. Include the guide rail and drainage inventory items in the development of the automated straight line diagrams.

OUTPUT AND SOFTWARE NEEDS

The formats used for each of the guide rail and drainage survey forms require some specific software programming to assure that output needs are properly addressed.

For the guide rail form, programming will be required to account for a continuous string of guide rail that extends onto an adjacent STAMPP segment, continues onto a ramp, or continues onto an intersecting road (centerline route or local). The system must be able to output an indication of need for an update to end treatments and systems identified as "other" or "none." Bridge connections identified as "nonfunctional" should also have an automatic update treatment indicated. The cost of this update should include the standard bridge terminal section and 25 ft of 2-SC guide rail, for estimation of needs or development of a project cost estimate.

On the drainage form, multiple pipes will require programming to determine the number of pipes at the location. Inlets and outlets identified as "undetermined" for programming purposes should be included with drop inlets without grates, although no costs for treatment are to be specified. Similarly, the physical or structural condition "unknown" must automatically be programmed to indicate the need for a more detailed reinspection.

Continuous parallel ditches and storm sewers with drop inlets acting as junction boxes (identified as "continuous") require programming to connect ditches and storm sewer systems from one STAMPP segment to the other. As in the case of continuous guide rail systems, this will be more important when implemented on the automated straight line diagrams.

The input of data from both surveys will need some program edits to control faulty information. Summary treatment screens as well as condition summaries by segment and other information generally output in the existing STAMPP data analysis programming (2) should be made available. The ability to have preprinted forms for subsequent surveys must be built into the program because this will significantly increase survey efficiency and thereby reduce survey costs.

It was recognized that the counties will generally want to use the data available from the surveys in developing their annual work plans and preparing guide rail and pipe repair or replacement contracts. Computer program formatting for generation of these reports should also be made available.

The districts, counties, and central office will be able to obtain the following typical information from each survey:

Drainage

1. Number of feet of pipe by size and condition per county,
2. Number of feet of pipe by size and condition per Legislative Route (LR),
3. Inlets needing repairs by LR,
4. Inlets needing reconstruction or replacement by LR or county,
5. Ditch cleaning needs (footage),
6. Pipe footage requiring flushing,
7. Inlets needing cleaning by LR and county,
8. Outlet ditches needing cleaning (footage) by LR and county,
9. Ditches needing repairs or material placement, and

10. Pipe survey needs per year by assistant manager section.

Guide Rail

1. Total amount of guide rail not within current standard (location);
2. Amount of guide rail requiring repair (location);
3. Amount of guide rail requiring replacement or updating (location);
4. Amount of guide rail for suggested removal (location);
5. End treatments needing repair;
6. End treatments needing replacement or updating;
7. Costs for treatments, replacements, and updating;
8. Percentage of "candidate for removal" in the system; and
9. Inventory of needs by guide rail type.

SURVEY IMPLEMENTATION

To effectively implement the proposed guide rail and drainage inventories and condition surveys, several steps were considered important:

1. Review by the existing STAMPP task force and upper department management for concurrence on proposed inventory and condition surveys. This was done in December 1984.
2. Development of condition survey manuals for each survey. Draft condition survey manuals were developed in early 1985 for immediate use and preliminary evaluation of survey techniques.
3. Pilot surveys to assess adequacy of survey forms and developed condition survey manuals were conducted in April and May 1985 on a sample of all state roadway classifications in York County, Pennsylvania, and changes were subsequently made to the condition survey manuals (3,4). The pilot survey consisted of preliminary condition surveys of guide rail and drainage conditions on approximately 60 mi of Legislative Routes, conducted by an in-house survey team, whose results were compared with those obtained independently on the same roadway sections by a separate quality assurance survey team. For both surveys, a one-to-one agreement was obtained for the condition items being evaluated within ±1 deviation in excess of 90 percent of the time (Figures 3 and 4).
4. Develop a training program for survey personnel. Training was given to department personnel coordinating conduct of the surveys and to all survey personnel in May 1985 for the guide rail condition survey. Training for the drainage condition survey has been developed and is to be given in August and September 1985.
5. Development of a quality assurance (QA) plan to monitor survey effectiveness and accuracy. This plan will be developed by the Roadway Management Division of the department's Bureau of Bridge and Roadway Technology, whose responsibility it will be to conduct survey QA.
6. Develop appropriate systems needs for use directly on the mainframe computer, with modifications to the STAMPP programs made as appropriate.
7. Conduct surveys and perform required QA.
8. Interface the guide rail and drainage surveys with STAMPP and include in the RIDB.

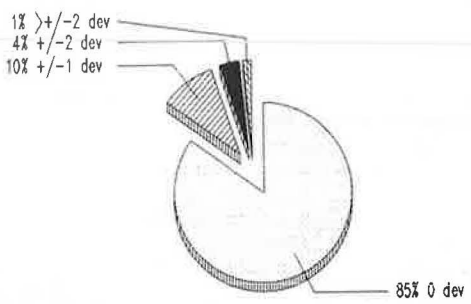

FIGURE 3 Guide rail survey—total deviation from quality assurance.

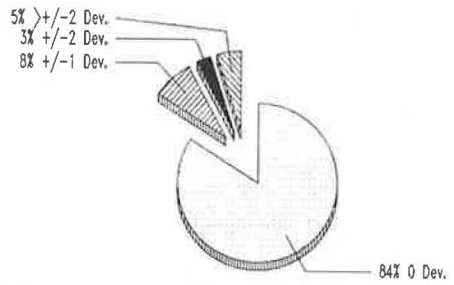

FIGURE 4 Drainage survey—total deviation from quality assurance.

The Pennsylvania Department of Transportation is committed to the use and implementation of the surveys discussed in this paper and described more completely in the condition survey manuals. By properly using the information obtained from conducting these surveys, the department will be in a better position to cost-effectively manage state tax revenues for the construction, maintenance, and general operation of the 43,000-mi state roadway system.

The department stands ready to share its survey systems with other interested governmental agencies that wish to adopt similar management tools for their roadway systems, but cautions that conditions, extents and severities, and treatments and associated costs contained herein have been selected specifically for Pennsylvania. Other systems may have to be modified accordingly.

By the end of this year, the department will have more experience with the operation of the guide rail and drainage condition surveys because the initial surveys will have been performed. Again, the department is most willing to share the results of these initial surveys with interested parties.

ACKNOWLEDGMENTS

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This paper was prepared for internal use by the Pennsylvania Department of Transportation. The contents of this paper reflect the views of the Guide Rail and Drainage Task Force, which is solely responsible for the facts and the data presented herein. The contents do not necessarily reflect the official views or policies of the Pennsylvania Department of Transportation, nor does this paper constitute a standard, specification, or regulation.

Real-World Impact Conditions for Run-Off-the-Road Accidents

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ABSTRACT

Information is presented on real-world impact conditions for accidents involving roadside objects and features based on in-depth accident data. Of particular interest are the distributions of impact speed and angle for various functional classes. Other considerations relating to impact conditions, such as vehicle orientation at impact, are also discussed. The potential applications of the information presented in this paper are illustrated with two examples, one involving the full-scale crash test matrix and the other involving benefit-cost procedures.

In the design of roadside safety appurtenances and features, it is desirable to have information on the real-world impact conditions to ensure that the appurtenances and features will be effective in serving the intended purpose of mitigating the consequences of impacts by errant vehicles. The impact conditions refer primarily to impact speed and angle, but there are also other considerations, such as the orientation of the vehicle at impact and the area of impact on the vehicle.

To obtain such detailed information, in-depth investigation and reconstruction of accidents are required. Police-level accident data do not provide sufficient detail for this purpose. Also, the accidents have to be either a census or a statistically representative sample in order to establish the distributions of impact conditions. Unfortunately, the costs associated with in-depth accident investigation and reconstruction are high and few programs of this nature have been undertaken.

Two such data sources (1,2) were identified and analyzed as part of a study conducted for the FHWA on severity measures for roadside objects and features (3). The first source provides data on a statistically representative sample of pole accidents collected over a 20-month period from two study areas: Bexar County (including the city of San Antonio), Texas, and a nine-county area around Lexington, Kentucky. The second source includes a census of accidents involving bridge rails, bridge or parapet ends, and approach guardrails in a 15-county area around San Antonio, Texas, over a 21-month period.

After screening for nonapplicable cases, 472 pole accident cases and 124 bridge accident cases were merged for use in the study. Note that the actual sample size available for analysis is slightly less than 596 because some of the cases have unknown impact speed or angle. Also, the pole accident cases

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