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COST-EFFECTIVENESS PROGRAM FOR ROADSIDE SAFETY IMPROVEMENTS ON TEXAS HIGHWAYS--VOLUME ONE, PROCEDURES MANUAL

in cooperation with the
Department of Transportation
Federal Highway Administration

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STUDY 2-10-74-15
ROADSIDE SAFETY IMPROVEMENTS

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The cost-effectiveness analysis procedure for roadside safety improvement evaluation has been developed on an immediate implementation basis. This report documents the procedures to be applied in conducting the physical roadside hazard inventory and recommending safety improvement alternatives on Texas highways--both controlled and non-controlled access.

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COST-EFFECTIVENESS PROGRAM FOR ROADSIDE SAFETY IMPROVEMENTS ON TEXAS HIGHWAYS

VOLUME 1: PROCEDURES MANUAL

by
Graeme D. Weaver
Edward R. Post
Donald L. Woods
and
William R. Ratcliff

Research Report 15-1

Research Studies 2-8-72-11 and 2-10-74-15

Sponsored by
The Texas Highway Department
in Cooperation with the
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August, 1974
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TEXAS TRANSPORTATION INSTITUTE
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IMPLEMENTATION

The cost-effectiveness analysis procedure for roadside safety improvement evaluation has been developed on an immediate implementation basis. This report documents the procedures to be applied in conducting the physical roadside hazard inventory and recommending safety improvement alternatives on Texas highways--both controlled and non-controlled access. Immediate implementation of the material in this report is anticipated on a statewide basis.

DISCLAIMER

FOREWORD

This report represents the final report (Volume 1 of 3) of Research Study 2-10-74-15, entitled "Cost-Effectiveness Priority Program for Roadside Safety Improvements on Non-Controlled Access Roadways," a follow-on to Research Study 2-8-72-11, "Cost-Effectiveness Priority Program for Roadside Safety Improvements on Texas Freeways." This report presents a method to inventory hazards and recommend safety improvements alongside both types of rural highways--controlled and non-controlled access--using one procedure and a common computer program.

Special acknowledgment is given Messrs. Paul R. Tutt, Edwin M. Smith, and William R. Ratcliff of the Texas Highway Department and Mr. Ed Kristaponis (FHWA) for their cooperation and assistance through the developmental stages and field testing of the program. Their suggestions were invaluable in achieving an implementable research product.

The researchers are indebted to personnel of the Texas Highway Department, particularly from three Districts: Fort Worth, Houston, and Austin, where extensive field trials were conducted during the developmental phases. Special thanks are due Messrs. J. R. Stone, R. Burkett, C. E. McCarty, and Billie E. Davis (Fort Worth): Messrs. Dale D. Marvel, John M. Lipscomb, and James H. Doss (Houston); and Mr. Billy M. Schnerr (Austin) for assisting in field trials and offering numerous suggestions to improve the cost-effectiveness program. Appreciation is expressed to Messrs. Larry G. Walker, Frank F. Cooper,

Richard L. Jamison, and Jerry L. Dike (THD Automation, Austin) for their cooperation and assistance in adapting the cost-effectiveness model to the Texas Highway Department computer equipment.

SUMMARY

PROBLEM DEFINITION

Roadside safety improvement programs, like any phase of highway construction or maintenance, must compete for limited funds. As increasing emphasis is being directed toward roadside safety, it is apparent that a definite need exists for methods by which administrators may evaluate alternative safety improvements and program those to realize the greatest return within the budget constraints of their available roadside safety improvement funds.

The National Cooperative Highway Research Program (NCHRP) Project 20-7, Task Order 1 (3) presented a conceptual probabilistic model to be used as a management tool in establishing the priority for roadside safety improvements on freeways. The requirement that this research be applicable on a national scale resulted in a high degree of generalization in the model and, therefore, it was not implementable in its current form for specific needs. It was expected that each state would adapt the findings of this research to its own specific needs and administrative structure if the concept was to be implemented.

In this regard, the Texas Highway Department (THD) and the Texas Transportation Institute (TTI), through the cooperative research program, developed a formalized implementation procedure, compatible with Texas Highway Department policy, to program roadside safety improvements on freeways (4) based on the generalized NCHRP 20-7 research. In a follow-on study (5), the concept and procedure were adapted to include non-controlled access roadways as well. The resulting product of the two research studies is a procedure that is applicable for the two types of highways and utilizing a general computer program to accommodate both. This report describes the procedures used in conducting the physical roadside hazard inventory and recommending safety improvements. The procedures, in general, apply to all controlled access highways (both rural and urban), and to rural non-controlled access facilities. Those portions that apply specifically to only one type are so noted.

The research studies are documented in three volumes as follows:

Volume 1: Procedures Manual

Volume 2: Computer Program Documentation Manual

Volume 3: Cost-Effectiveness Analysis Manual

SCOPE OF ROADSIDE INVENTORY

Accepted practice in most existing roadside improvement programs has been to consider the primary and secondary recovery areas, which would benefit approximately 85 percent of drivers encroaching the roadside. The inventory procedure proposed in this study includes all applicable roadside hazards located within a median and a 30-ft lateral distance adjacent to the outer edge of the traveled lane.

Hazards have been categorized in three major classifications for purposes of inventorying: (1) point hazards, (2) longitudinal hazards, and (3) slopes. Classification codes have been assigned to all applicable hazards.

PROCEDURE FOR CONDUCTING SAFETY IMPROVEMENT PROGRAM

The procedure to evaluate safety improvements for roadside hazards comprises three related functions:

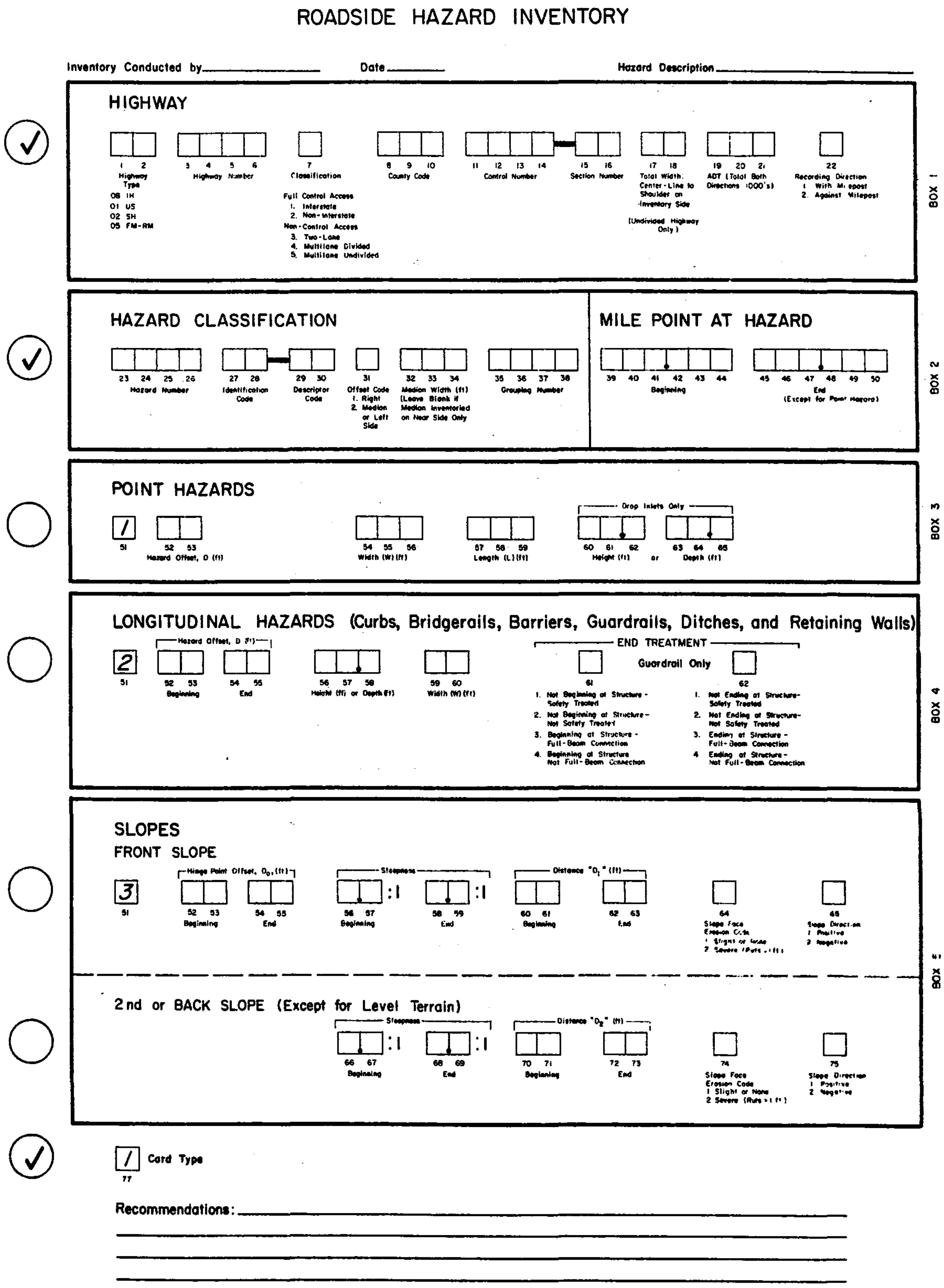
(1) conducting a detailed physical inventory of rural highways to identify and locate each roadside hazard,

(2) recommending feasible safety improvement alternatives for each hazard or for groups of hazards, and

(3) evaluating the recommended safety improvement alternatives using the cost-effectiveness model.

The extremely large number of hazards that must be inventoried and feasible safety improvement alternatives necessitates the use of a systematic coding procedure for eventual analysis by computer. Two forms were developed to accomplish this. The Roadside Hazard Inventory form is shown in Figure S-1. Figure S-2 illustrates the counterpart, the Roadside Hazard Improvement form.

This report includes detailed descriptions of the use of each of these forms. Also included is a discussion of the data input/output format and five case examples of selected hazards to illustrate the manner in which the forms must be completed.



ROADSIDE HAZARD INVENTORY

Inventory Conducted by____________ Date______ Hazard Description________________

✓ **HIGHWAY** BOX 1

1 2 Highway Type
- 08 IH
- 01 US
- 02 SH
- 05 FM-RM

3 4 5 6 Highway Number

7 Classification
- Full Control Access
  - 1. Interstate
  - 2. Non-interstate
- Non-Control Access
  - 3. Two-Lane
  - 4. Multilane Divided
  - 5. Multilane Undivided

8 9 10 County Code

11 12 13 14 Control Number

15 16 Section Number

17 18 Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)

19 20 21 ADT (Total Both Directions 1000's)

22 Recording Direction
1. With Milepost
2. Against Milepost

✓ **HAZARD CLASSIFICATION** BOX 2

23 24 25 26 Hazard Number

27 28 Identification Code

29 30 Descriptor Code

31 Offset Code
1. Right
2. Median or Left Side

32 33 34 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only

35 36 37 38 Grouping Number

MILE POINT AT HAZARD

39 40 41 42 43 44 Beginning

45 46 47 48 49 50 End (Except for Point Hazard)

○ **POINT HAZARDS** BOX 3

1
51

52 53 Hazard Offset, D (ft)

54 55 56 Width (W) (ft)

57 58 59 Length (L) (ft)

Drop Inlets Only: 60 61 62 Height (ft) or 63 64 65 Depth (ft)

○ **LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)** BOX 4

2
51

Hazard Offset, D (ft): 52 53 Beginning; 54 55 End

56 57 58 Height (ft) or Depth (ft)

59 60 Width (W) (ft)

END TREATMENT — Guardrail Only

61
1. Not Beginning at Structure - Safety Treated
2. Not Beginning at Structure - Not Safety Treated
3. Beginning at Structure - Full-Beam Connection
4. Beginning at Structure Not Full-Beam Connection

62
1. Not Ending at Structure - Safety Treated
2. Not Ending at Structure - Not Safety Treated
3. Ending at Structure - Full-Beam Connection
4. Ending at Structure - Not Full-Beam Connection

○ **SLOPES** BOX 5

FRONT SLOPE

3
51

Hinge Point Offset, D_0, (ft): 52 53 Beginning; 54 55 End

Steepness: 56 57 Beginning :1; 58 59 End :1

Distance "D_1" (ft): 60 61 Beginning; 62 63 End

64 Slope Face Erosion Code
1. Slight or None
2. Severe (Ruts > 1 ft)

65 Slope Direction
1. Positive
2. Negative

○ **2nd or BACK SLOPE (Except for Level Terrain)**

Steepness: 66 67 Beginning :1; 68 69 End :1

Distance "D_2" (ft): 70 71 Beginning; 72 73 End

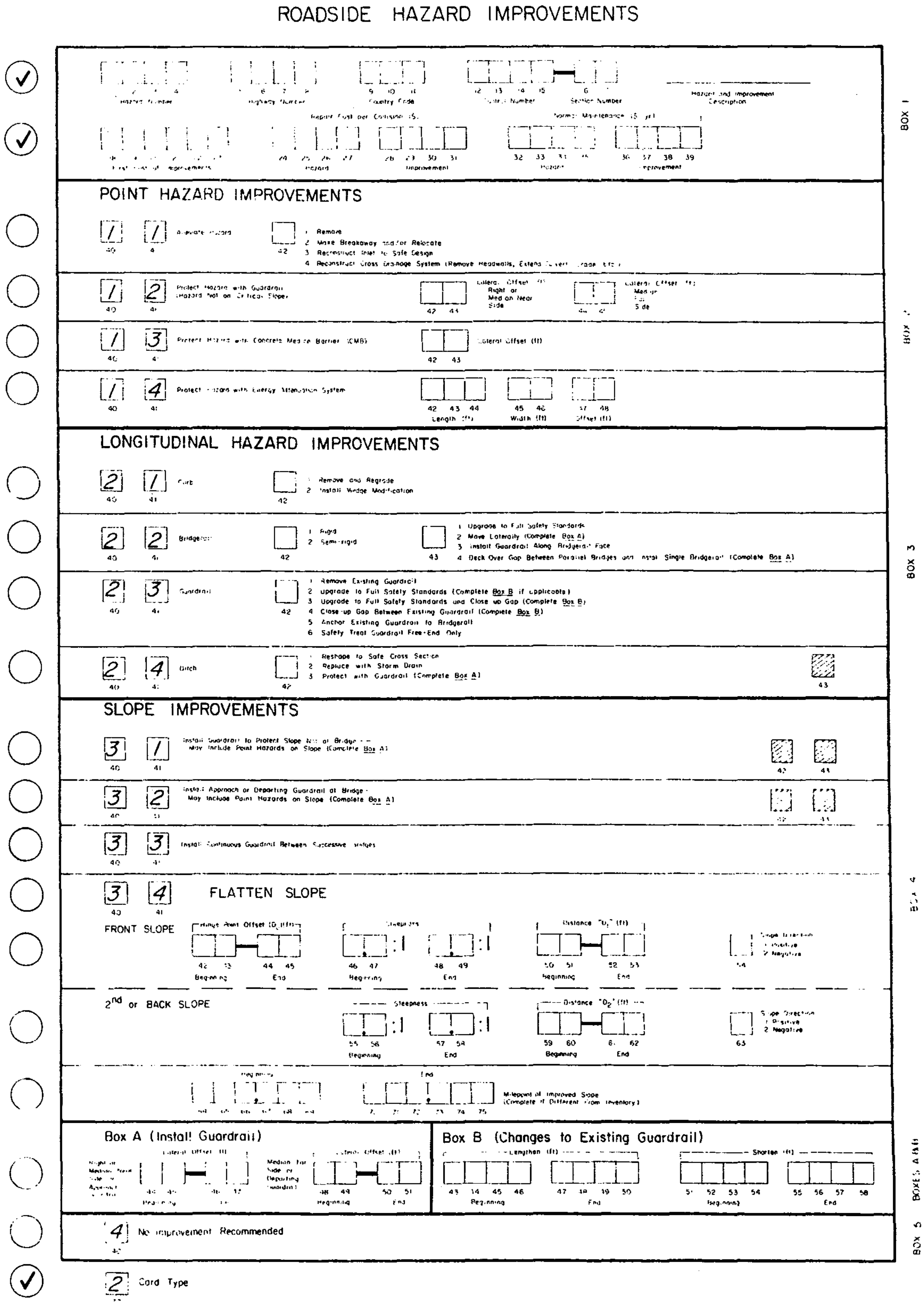
74 Slope Face Erosion Code
1. Slight or None
2. Severe (Ruts > 1 ft)

75 Slope Direction
1. Positive
2. Negative

✓ 1 Card Type
77

Recommendations:____________________________

Figure S-1. Hazard inventory form.



ROADSIDE HAZARD IMPROVEMENTS

☑ Hazard Number (1–4) · Highway Number (5–8) · Country Code (9–11) · District Number (12–15) – Section Number (16–17) · Hazard and Improvement Description

☑ First Cost of Improvements (18–23) · Repair Cost per Collision ($): Hazard (24–27), Improvement (28–31) · Normal Maintenance ($/yr): Hazard (32–35), Improvement (36–39)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard · 42:
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) · Lateral Offset (ft) Right or Median Near Side (42–43) · Lateral Offset (ft) Median Far Side (44–45)

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) · Lateral Offset (ft) (42–43)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System · Length (ft) (42–44) · Width (ft) (45–46) · Offset (ft) (47–48)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb · 42:
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail · 42:
1 Rigid
2 Semi-rigid

43:
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail · 42:
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch · 42:
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

▨ 43

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge – May Include Point Hazards on Slope (Complete Box A) · ▨ 42 ▨ 43

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge – May Include Point Hazards on Slope (Complete Box A) · 42 43

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE · Hinge Point Offset D_c (ft): Beginning (42–43) – End (44–45) · Steepness: Beginning (46–47) :1, End (48–49) :1 · Distance "D_1" (ft): Beginning (50–51) – End (52–53) · Slope Direction 1 Positive 2 Negative (54)

○ 2nd or BACK SLOPE · Steepness: Beginning (55–56) :1, End (57–58) :1 · Distance "D_2" (ft): Beginning (59–60) – End (61–62) · Slope Direction 1 Positive 2 Negative (63)

○ Milepoint of Improved Slope (Complete if Different from Inventory) · Beginning (64–69) · End (70–75)

BOX 4

○ Box A (Install Guardrail) · Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) Beginning (44–45) – End (46–47) · Median Far Side or Departing Guardrail: Lateral Offset (ft) Beginning (48–49) – End (50–51)

Box B (Changes to Existing Guardrail) · Lengthen (ft): Beginning (43–46), End (47–50) · Shorten (ft): Beginning (51–54), End (55–58)

BOXES A AND B

○ 4 (42) No Improvement Recommended

BOX 5

☑ 2 Card Type

Figure S-2. Hazard improvement form.

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1. INTRODUCTION

PROBLEM STATEMENT

Single vehicle accidents constitute a sizable portion of all highway accidents, particularly on freeways--accounting for about one half of the fatal accidents and 40 percent of all accidents on freeways (1). Texas accident statistics (2) revealed that 35 percent of statewide accidents involved single vehicles striking fixed objects or running off the roadway. The elements of roadside design that contribute heavily to single vehicle accident severity are obstacles such as bridge abutments and piers, bridge rails, utility poles, trees, drainage headwalls, steep side slopes and guardrails.

Considerable emphasis has been placed on roadside safety improvements to the extent that many highway departments maintain funded programs to reduce the roadside hazard on existing facilities. Notable examples of such programs are the breakaway sign and luminaire programs of the Texas Highway Department, the CURE program of the California Division of Highways, and similar programs in Utah and Colorado.

Programs of this type generally have followed the same roadside improvement strategy:

1. Remove roadside obstacles.
2. Relocate those obstacles that cannot be removed. This includes moving to a protected location and moving laterally.

3. Reduce the impact severity of those obstacles that cannot be moved. This includes improvements such as breakaway devices, turning down guardrail ends, and flattening roadside slopes.
4. Protect the driver from those obstacles that cannot be improved otherwise, using attenuation or deflection devices.

This strategy would be ideal if sufficient funds were available to accomplish all four steps throughout a particular highway. However, this is seldom realized because safety improvements, like any phase of highway construction or maintenance, must compete for limited funds. What is lacking is a method by which administrators may evaluate alternative safety improvements and program those to realize the greatest return within the budget constraints of their available roadside safety improvement funds.

The National Cooperative Highway Research Program (NCHRP) Project 20-7, Task Order 1 (3) presented a probabilistic model to be used as a management tool in establishing the priority for roadside safety improvements on controlled access highways. The requirement that this research be applicable on a national scale resulted in a high degree of generalization in the model and, therefore, it was not implementable in its current form for specific needs. It was expected that each state would adapt the findings of this research to its own specific needs and administrative structure.

In this regard, the Texas Highway Department (THD) and the Texas Transportation Institute (TTI), through the cooperative research program, developed a formalized implementation procedure, compatible with Texas Highway Department policy, to program roadside safety improvements on freeways (4) based on the generalized NCHRP 20-7 research. In a follow-on study (5), the concept and procedure were adapted to include non-controlled access roadways as well. The resulting product of the two research studies is a procedure that is applicable for the two types of highways and utilizing a general computer program to accommodate both. This report describes the procedures used in conducting the physical roadside hazard inventory and recommending safety improvements. The procedures, in general, apply to all controlled access highways (both rural and urban), and to rural non-controlled access facilities. Those portions that apply specifically to only one type are so noted.

OBJECTIVES

The overall goal of Studies 11 and 15 was to develop a formalized implementation procedure, compatible with Texas Highway Department policy, to program roadside safety improvements on controlled and non-controlled access highways based on the generalized NCHRP 20-7 research. The specific objectives within the study to achieve the overall goal are summarized:

1. Develop a procedure to systematically inventory roadside hazards existing along Texas highways.
2. Develop a procedure to identify appropriate measures that may be taken to alleviate or reduce existing hazards.

3. Incorporate the above procedures into a computer program based on the NCHRP 20-7 probabalistic cost-effectiveness model from which may be determined a priority ranking of improvement alternatives to assist administrators in preparing safety improvement programs.
4. Document the hazard inventory and improvement procedures, and the computer program.

The research studies are documented in three volumes as follows:

Volume 1: Procedures Manual
Volume 2: Computer Program Documentation Manual
Volume 3: Cost-Effectiveness Analysis Manual

2. PROGRAM CONCEPT DEVELOPMENT

BASIC CONCEPT

Every segment along a roadway has an associated degree of roadside hazard for vehicles traveling through that segment. The hazard may be relatively small for a flat slope free of fixed objects while on the other hand, the hazard may be very high for a steep side slope or a large rigid object near the edge of the roadway (3). From this, it is seen that the degree of potential hazard is influenced by proximity to the roadway and by the severity of resulting impact if the object is struck. The severity can be assumed to be independent of distance, that is, the severity associated with striking a rigid object located ten feet from the roadway is no different than if the same object was struck at fifty feet from the roadway. The probability of encroaching the latter distance, however, is much smaller. Also influencing the potential hazard is the probability that a vehicle will encroach on the roadside at a location such that the obstacle is in the vehicle path and will be impacted. This is a function of the traffic volume and expected encroachment rate, the latter being derived empirically from research. Obviously, a small rigid obstacle exhibits a smaller probability of being struck than does, for example, a continuous guardrail at the same offset distance. To strike the rigid obstacle, a vehicle must leave the roadway within a relatively small segment whereas it may collide with the guardrail after leaving the roadway anywhere along the rail length. The severity of striking the rigid obstacle may be extremely high as is the case for a bridge pier. On the other hand, the severity of striking the guardrail is substantially less. Therefore, trade-offs must be considered--probability of impact versus severity of impact--in many situations.

If quantitative measures can be assigned to these influencing parameters and costs associated with improvement alternatives can similarly be determined, cost-effectiveness techniques may be used to evaluate various recommended safety improvements. To accomplish this, objects (hazards) must be identified and assigned some relative degree of hazard (severity index). Encroachment distances and frequency must be defined. Feasible improvement alternatives must be defined for each hazard identified and costs must be determined for the hazard as it exists and after each improvement. These factors may be used in the cost-effectiveness program to evaluate the alternatives.

The cost-effectiveness methodology requires a rather comprehensive inventory of roadside obstacles (size of obstacle, lateral placement, severity of a collision with the obstacle, etc.). The inventory of existing roadside hazards is the underlying key to improvement cost-effectiveness because it forms the basis of comparison for alternative recommended improvements and, hence, influences directly the relative rating of the improvement. Since the inventory is so vital to the end product of the program, detailed procedures are required to insure that an accurate and comprehensive inventory is made in a uniform manner throughout all regions to which the improvement program is applicable (usually a District).

Since safety improvements for each hazard (or group of hazards) will be compared to the existing hazard in the computer model, it is equally important that detailed procedures for identifying improvements are established and used to provide the necessary information in the required format for computer input. These two procedures form the basis for the computer program developed. As with any computer program, input data must be furnished in a precise manner. Forms have been developed, field tested and refined to accommodate data collection for both the hazard inventory and safety improvement alternatives. These forms and a detailed procedure of their use are discussed in later sections of this report.

SCOPE OF ROADSIDE INVENTORY

The roadside obstacles to be included in the inventory and the lateral boundaries assumed for inventory purposes are administrative decisions. Accepted practice in most existing roadside improvement programs has been to consider the primary and secondary recovery areas (30-ft lateral clearance) as generally sufficient. From available information (6), safety improvements within this region would benefit approximately 85 percent of drivers encroaching the roadside. The inventory procedure proposed in this study includes all applicable roadside hazards located within the median and a 30-ft lateral distance adjacent to the outer edge of the traveled lane. In particular cases involving critical slopes, the 30-ft lateral distance must be exceeded. This is discussed later in this report.

Each roadside obstacle has associated with it some degree of hazard. However, certain obstacles such as sign posts and luminaire supports, through the advanced technology in breakaway concepts, have been designed such that the hazard of impact is virtually negligible. Also, the state of technology is such that very little can be done to reduce the impact severity below its current level. Therefore, by joint decision of project personnel of the Texas Highway Department and the research staff, breakaway sign supports and luminaire supports will not be included in the inventory.

Other roadside obstacles are placed along highways for operational control which, although their presence constitutes a hazard, if omitted, would allow operational maneuvers that would produce greater hazard. Post and cable installations placed between main lanes and frontage roads or in the median to prohibit intentional vehicle crossover are an example. Similarly, median barriers and fences fall within the same category. These obstacles are considered necessary for operational control and are not included as an inventoriable roadside hazard; therefore, no safety improvement alternatives are offered. They may be recorded for reasons other than safety improvement considerations and given an improvement code 4 (no improvement recommended), however, they should not be inventoried within a group of hazards (see Section 3).

Retaining walls constitute another "necessary" hazard, particularly on depressed urban facilities. Although provision is made to evaluate several alternatives, it is probable that certain retaining walls cannot be substantially changed because of geometric and right-of-way considerations and would not be inventoried.

Channelizing islands at grade intersections on non-controlled access highways will not be inventoried. These operational control elements are considered necessary to orderly traffic flow and, as such, will not be removed. Right-of-way fences similarly will not be inventoried.

Other roadside obstacles that will not be inventoried include buildings or other fixed objects adjacent to non-controlled access highways passing through urban areas, or control devices not within the jurisdiction of the Texas Highway Department.

IDENTIFICATION OF ROADSIDE HAZARDS

Uniformity in inventory procedure and content is essential to the operation of the cost-effectiveness computer program. Therefore, those roadside obstacles that will be included in the inventory have been identified and assigned an input coding system as shown in Table 2-1. Hazards are grouped by descriptive title under general identification code designation and, where necessary, each general classification is sub-divided into several categories with each being identified by a descriptor code designation. This classification system permits greater flexibility in recording hazards by allowing the addition of new general categories or, more often, additional descriptor codes when "special" or unusual hazards are encountered during the field inventory. Any code additions would necessitate computer program modification prior to implementation. Table 2-1 includes a comprehensive

TABLE 2-1

HAZARD CLASSIFICATION CODES

Note: Circled Codes denote Point Hazard

Identification Code		Descriptor Codes	
01.	Utility Poles	(00)	
02.	Trees	(00)	
03.	Rigid Signpost	(01)	single-pole-mounted
		(02)	double-pole-mounted
		(03)	triple-pole-mounted
		(04)	cantilever support
		(05)	overhead sign bridge
04.	Rigid Base Luminaire Support	(00)	
05.	Curbs	(01)	mountable design
		(02)	non-mountable design less than 10 inches high
		(03)	barrier design greater than 10 inches high
06.	Guardrail or Median Barrier	(01)	w-section with standard post spacing (6 ft-3 in.) (including departing guardrail at bridge)
		(02)	w-section with other than standard post spacing (including departing guardrail at bridge)
		(03)	approach guardrail to bridge--decreased post spacing (3 ft-1 in.) adjacent to bridge
		(04)	approach guardrail to bridge--post spacing not decreased adjacent to bridge
		(05)	post and cable
		(06)	Metal Beam Guard Fence (Barrier) (in median)
		(07)	median barrier (CMB design or equivalent
07.	Roadside Slope	(01)	sod positive slope
		(02)	sod negative slope
		(03)	concrete-faced positive slope

TABLE 2-1, CONTINUED

Identification Code		Descriptor Codes
07.	Roadside Slope, cont.	(04) concrete-faced negative slope (05) rubble rip-rap positive slope (06) rubble rip-rap negative slope
08.	Ditch (includes erosion, rip-rap runoff ditches, etc.--does <u>not</u> include ditches formed by intersection of front and back slopes	(00)
[✓ 09.]	Culverts	(01) headwall (or exposed end of pipe culvert) (02) gap between culverts on parallel roadways (03) sloped culvert with grate (04) sloped culvert without grate
[✓ 10.]	Inlets	(01) raised drop inlet (tabletop) (02) depressed drop inlet (03) sloped inlet
[✓ 11.]	Roadway under Bridge Structure	(01) bridge piers (02) bridge abutment, vertical face (03) bridge abutment, sloped face
12.	Roadway over Bridge Structure	[✓ 01] open gap between parallel bridges [✓ 02] closed gap between parallel bridges (03) rigid bridgerail--smooth and continuous construction (04) semi-rigid bridgerail--smooth and continuous construction (05) other bridgerail--probable penetration, snagging, pocketing or vaulting (06) elevated gore abutment
13.	Retaining Wall	(01) face [✓ 02] exposed end

list of hazards, but it is anticipated that additional descriptor codes will be needed to accommodate all hazards that can be found along the roadway, and provisions for including these are made in the computer cost-effectiveness program.

For purposes of inventorying, all hazards have been categorized in three major classifications:

(1) point hazards (codes circled in Table 2-1)
(2) longitudinal hazards
(3) slopes

The above general classification system was selected to facilitate recording inventory data and to organize the computer program logic. To maintain uniformity between hazard inventory and hazard improvement procedures, the same classification system was used for the improvement data input. Section 3 of this report presents details concerning the formal inventory procedure and Section 4 deals with the recommended improvement alternatives data input. The forms necessary for these input factors are described in their respective section.

PROCEDURE FOR CONDUCTING SAFETY IMPROVEMENT PROGRAM

The procedure to evaluate safety improvements for roadside hazards comprises three related functions: (1) conducting a detailed physical inventory of the highway system to identify and locate each roadside hazard, (2) recommending feasible safety improvement alternatives for each hazard or for groups of hazards, and (3) evaluating the recommended safety improvement alternatives using the cost-effectiveness model. The general procedure for the inventory and improvement recommendations phase is discussed below.

In the inventory phase, each applicable hazard is located longitudinally along the highway by milepoint using the data input forms discussed in Section 3 of this report. As each hazard is located and evaluated, recommendations for remedial action necessary for safety improvement are made and this information recorded on the data forms discussed in Section 4. These two data sources provide basic input information for evaluation by the cost effectiveness computer program. It is apparent that the quality of the results depends to a very large degree on the quality of the input data.

Since the recommendations for alternative safety improvements will govern to a great extent the cost-effectiveness results, the inventory team must include personnel having considerable experience in traffic operations, geometric design, maintenance, and cost-estimating. Field trials of the inventory procedure have indicated that a four-person team represents an efficient working force to include as a minimum, a driver, a data recorder, and two decision-makers to recommend safety improvements. The more experienced the team members, the more flexibility is afforded to rotate duties. The following was one procedure that was found to work very efficiently. The driver assumed the responsibility of identifying each hazard as he drove along the highway shoulder at low speed, and stopped adjacent to each hazard to read the odometer. All data were recorded by one member of the team who was familiar with the hazard inventory form. The driver called out the hazard milepoint and identified the hazard by name. These were recorded and necessary identification codes assigned. Offset distances and other applicable data (hazard number, grouping code number, etc.) were recorded while the two decision-makers were evaluating the hazard situation to select improvement alternatives.

Since all data were recorded by one person, considerable time was saved because the identification codes and necessary data for each type of hazard (in addition to the location on the form where these data must be recorded) became memorized. It was evident that considerably less recording errors (omissions, erroneous codes, etc.) were made when the data-recording operation was done by one person rather than rotating throughout the inventory team.

It is emphasized that the driver must be well aware of each type of hazard to be inventoried to avoid his bypassing hazards.

Two decision-makers are recommended to alleviate bias in improvement alternative recommendations. It proved advantageous in many cases because opposing views for improvement alternatives were presented or reinforcement added.

Odometer Measurements

Roadside hazards may be located in reference to existing milepost signs or to a known milepoint from the Road Inventory sheets (such as a bridge or other structure that will remain in a fixed position). Sufficient accuracy may be obtained using a vehicle equipped with an odometer capable of recording to one-thousandth of a mile (approximately 5 ft) and having data entry and bi-directional capabilities.

The vehicle is stopped adjacent to a milepoint and that mileage value is entered into the odometer. The odometer is set to record positively or negatively depending on the direction in which the inventory will progress (with or against roadway mileage markers). The vehicle is driven along the shoulder until a roadside hazard is encountered. The odometer reading is recorded as a point of reference on the vehicle (usually the front door of the vehicle) is adjacent to the beginning (upstream end) of the hazard. Figure 2-1 illustrates the method to locate a point hazard. If the hazard is a longitudinal hazard such as a guardrail, the beginning point is located as above and the odometer reading is again recorded when the vehicle reaches the downstream end. The length of the longitudinal hazard is computed by the program through subtraction. Figure 2-2 illustrates how a longitudinal hazard is located. The beginning and end points of a roadside slope are located in the same manner as those for a longitudinal hazard.

The odometer should be re-initialized frequently as points of known milepoint are passed; however, not within the extremities of a longitudinal hazard and never within the boundaries of a group of hazards. If a longitudinal hazard extends for an appreciable distance (such as a curb), it may be terminated at a point of odometer re-initialization and subsequently begun again at the same milepoint provided it is assigned a new hazard number. Techniques to accommodate these special cases are discussed in more detail in Section 3 and 4 of this document.

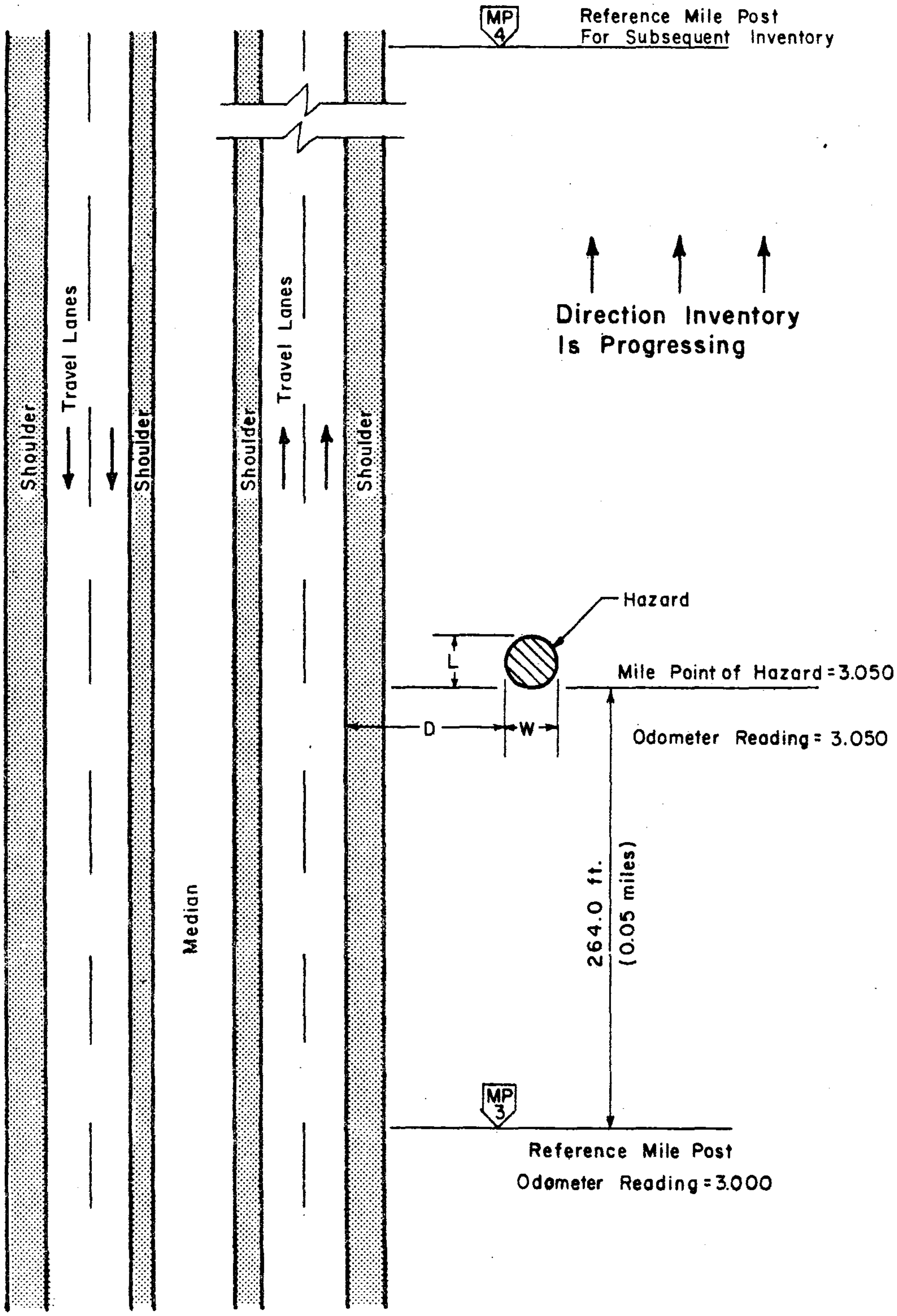


Figure 2-1. Point hazard location and dimensions.

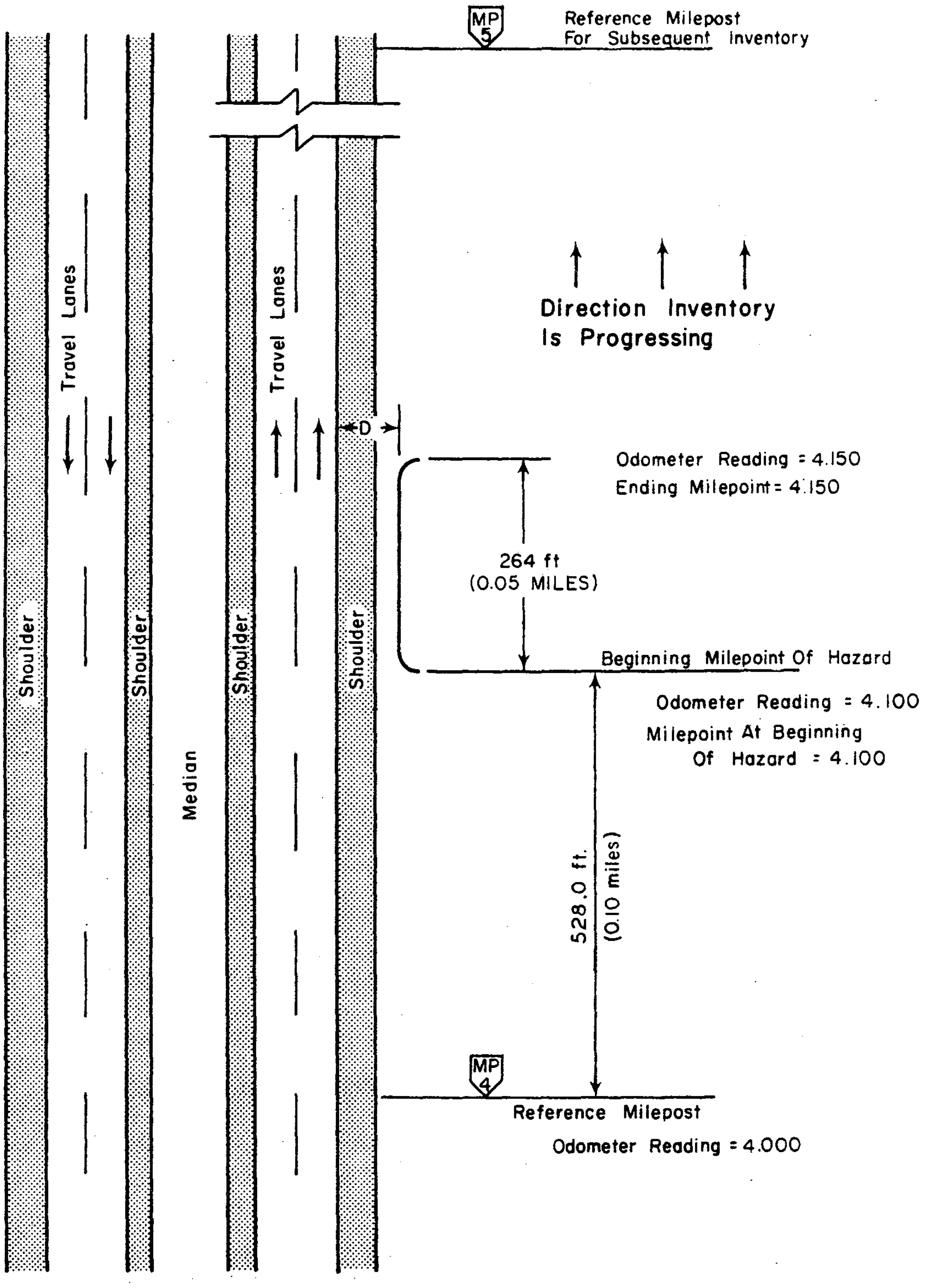


Figure 2-2. Longitudinal hazard location and dimensions.

Slope Measurements

Slopes of 4:1 or steeper are included in the inventory. Based on results of roadside slope studies (7), slopes flatter than 4:1 are not considered hazardous. The longitudinal length of a slope is the distance between the point where the slope becomes 4:1 and the point at the downstream end where it becomes flatter than 4:1, or terminates such as would be the case where the slope meets a cross-street under a structure. The end milepoint of a slope approaching an overcrossing structure may be considered to be the beginning point of the bridge rail. Figure 2-3 illustrates the method of determining the beginning and end milepoints of a roadside slope approaching or departing a bridge.

Particular care must be taken in determining the longitudinal boundaries of long slopes having variable steepness. The average slope steepness over the slope longitudinal length is used in the program. Therefore, to accurately define the slope geometry under severe steepness changes, the slope should be inventoried in sections, each being assigned a new hazard number. For example, a slope with a 4:1 beginning milepoint steepness, steepening to a 2:1 then flattening out again to a 4:1 should be inventoried as two individual slopes; the first ending at the 2:1 steepness and the second beginning at the same milepoint. Otherwise, the average slope steepness would be computed as 4:1 throughout the entire slope length.

The steepness of all slopes should be measured to avoid omitting slopes that appear to be flatter than 4:1 but are, in fact, steeper than 4:1. To alleviate the time-consuming operation of measuring

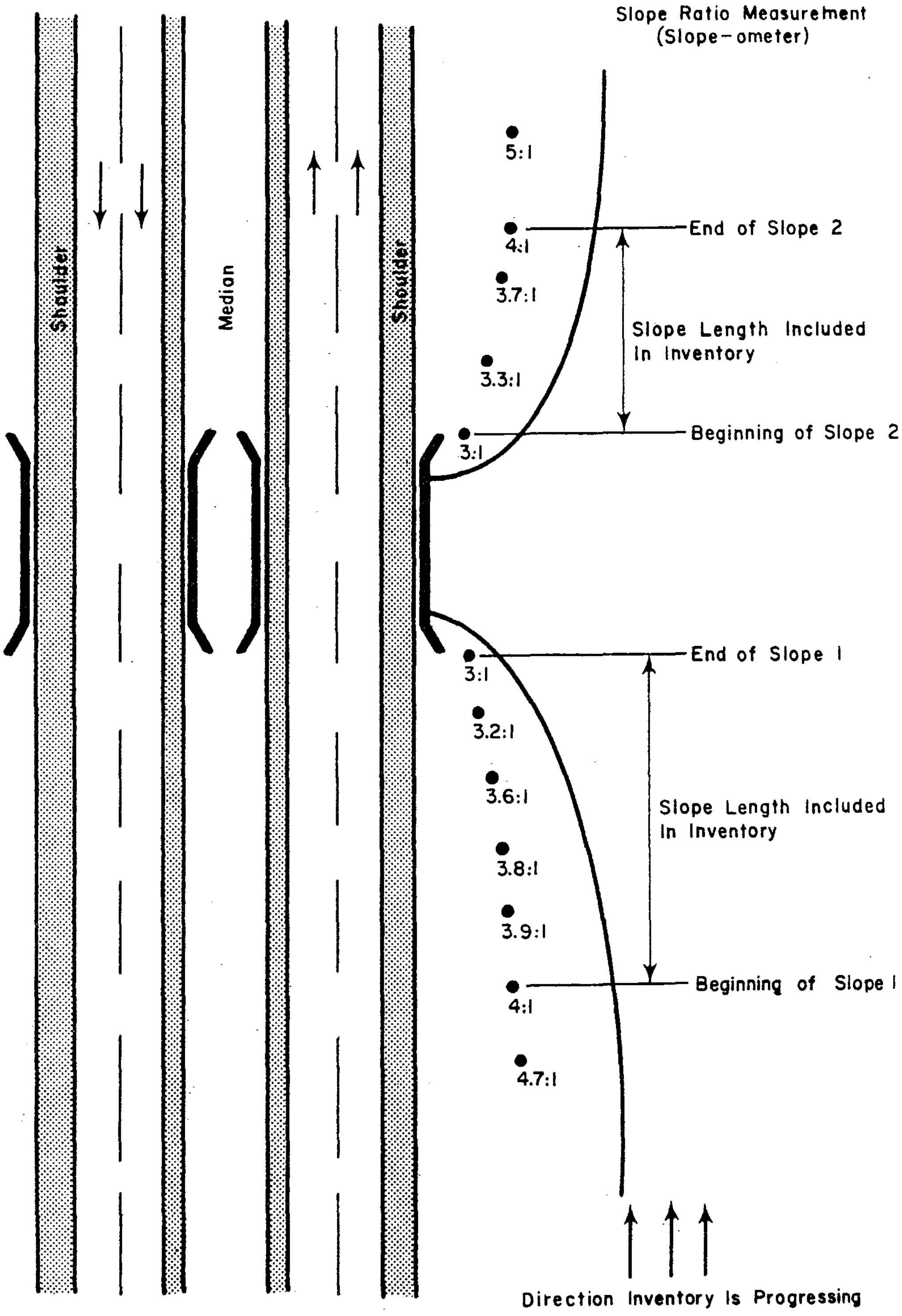


Figure 2-3. Determination of slope beginning and end points.

slope steepness by conventional surveying techniques, a device called a "slopeometer" was designed to permit rapid steepness measurement. This device consists of a steel ball that rolls within a 6-inch radius groove adjacent to a slope ratio scale. It is attached to a 3-ft rod which is placed on the slope face and the slope ratio is read directly below the position at which the ball comes to rest in the groove due to gravity.

This instrument may be used to quickly determine if a slope is indeed 4:1 or steeper and, hence, should be inventoried. Also, the beginning and end milepoints of a slope may be quickly determined by a series of measurements along the slope face as shown in Figure 2-3.

Length of Inventory Section

Preliminary field implementation has indicated that about 30 to 50 hazards per mile of roadway can be expected in urban facilities. Based on the average number of hazards encountered during the field trials on Interstate highways, it appears that the control-section represents a convenient length of roadway to inventory as a unit. Also, based on an expected number of hazards, the amount of data collected in the average section length provides a workable unit from a computer operations standpoint. Therefore, hazard numbers should be unique within a control-section but can be re-used in another section.

It is strongly recommended that a computer run of the field data be made as early as possible--definitely before large amounts of data are collected (no more than one-half day). Initial computer runs will identify errors in data recording that can be corrected in subsequent inventorying and permit the inventory team to determine problems that can be avoided both in recording hazards and selecting improvement alternatives.

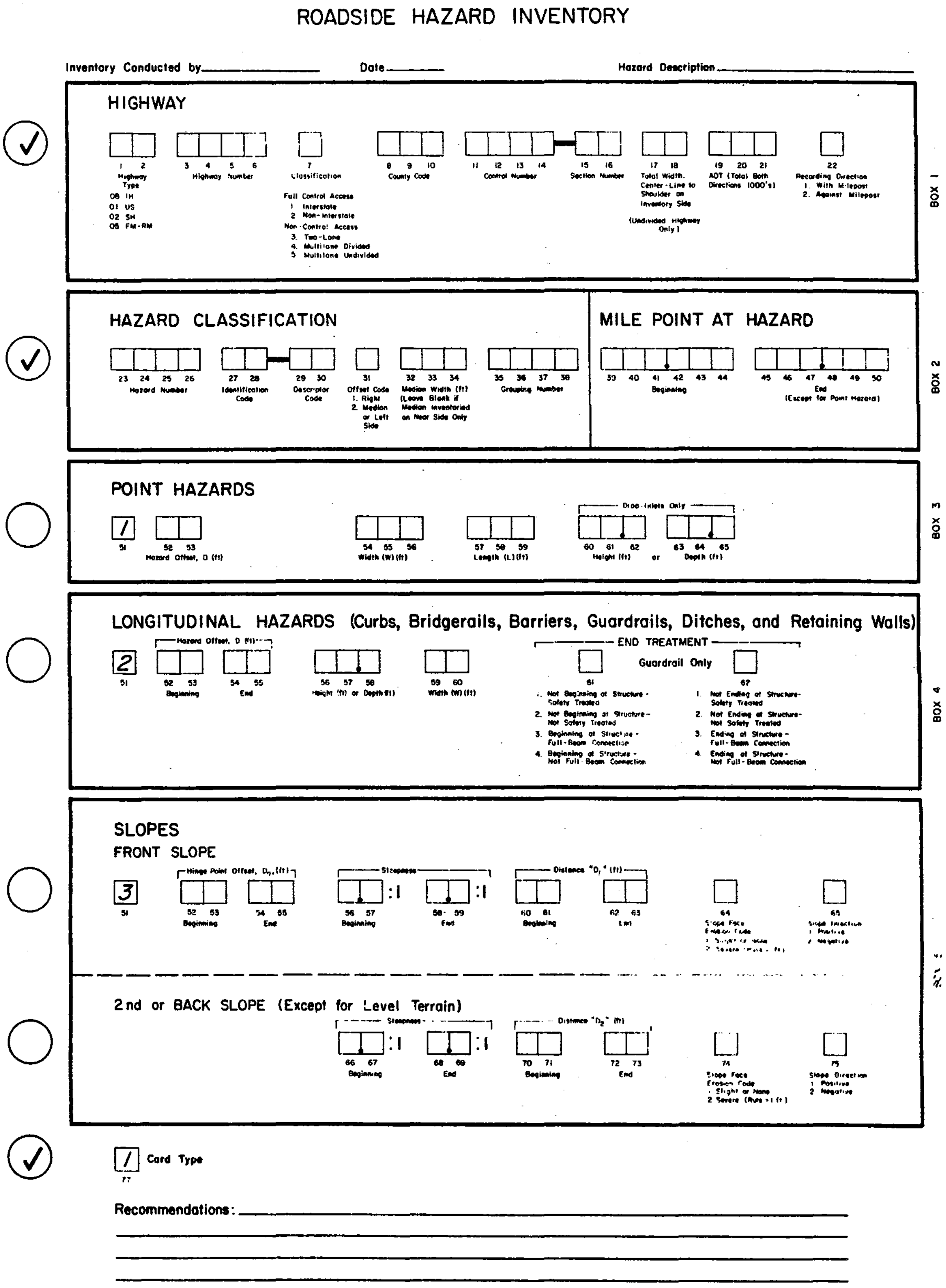
3. ROADSIDE HAZARD INVENTORY FORM

GENERAL

The extremely large number of hazards that must be inventoried along a section of roadway necessitates use of a systematic coding process for eventual analysis by computer. The roadside hazard inventory form shown in Figure 3-1 has been designed to accomplish this. The form is applicable for both controlled and non-controlled access roadways, the analysis procedures being accommodated internally within the computer program depending on the highway type and classification code entered on the form.

The inventory form was developed cooperatively by personnel of the Texas Highway Department, Federal Highway Administration, and the Texas Transportation Institute and represents the culmination of repeated field trials and modifications after field implementation on controlled access Interstate highways in several Districts. The format is particularly responsive to the thorough field implementation experience gained in the Fort Worth District.

The hazard inventory form has been designed to collect data under five categories, labeled Boxes 1 through 5. Box 1 contains highway and geographical information. Box 2 contains hazard classification information and specific hazard location information. The information in these two boxes is essential to the computer program operation. Space is also provided at the top of the form to identify the hazard by general name in words for manual review of the forms.



ROADSIDE HAZARD INVENTORY

Inventory Conducted by ____________ Date ________ Hazard Description ____________

HIGHWAY

BOX 1

1 2 Highway Type
- 08 IH
- 01 US
- 02 SH
- 05 FM-RM

3 4 5 6 Highway Number

7 Classification
- Full Control Access
  - 1 Interstate
  - 2 Non-Interstate
- Non-Control Access
  - 3. Two-Lane
  - 4. Multilane Divided
  - 5 Multilane Undivided

8 9 10 County Code

11 12 13 14 Control Number

15 16 Section Number

17 18 Total Width, Center-Line to Shoulder on Inventory Side (Undivided Highway Only)

19 20 21 ADT (Total Both Directions 1000's)

22 Recording Direction
- 1. With Milepost
- 2. Against Milepost

HAZARD CLASSIFICATION

BOX 2

23 24 25 26 Hazard Number

27 28 Identification Code

29 30 Descriptor Code

31 Offset Code
- 1. Right
- 2. Median or Left Side

32 33 34 Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)

35 36 37 38 Grouping Number

MILE POINT AT HAZARD

39 40 41 42 43 44 Beginning

45 46 47 48 49 50 End (Except for Point Hazard)

POINT HAZARDS

BOX 3

/ 51

52 53 Hazard Offset, D (ft)

54 55 56 Width (W) (ft)

57 58 59 Length (L) (ft)

Drop Inlets Only: 60 61 62 Height (ft) or 63 64 65 Depth (ft)

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

2 51

Hazard Offset, D (ft): 52 53 Beginning; 54 55 End

56 57 58 Height (ft) or Depth (ft)

59 60 Width (W) (ft)

END TREATMENT — Guardrail Only

61
- 1. Not Beginning at Structure - Safety Treated
- 2. Not Beginning at Structure - Not Safety Treated
- 3. Beginning at Structure - Full-Beam Connection
- 4. Beginning at Structure - Not Full-Beam Connection

62
- 1. Not Ending at Structure - Safety Treated
- 2. Not Ending at Structure - Not Safety Treated
- 3. Ending at Structure - Full-Beam Connection
- 4. Ending at Structure - Not Full-Beam Connection

SLOPES

FRONT SLOPE

3 51

Hinge Point Offset, D_H, (ft): 52 53 Beginning; 54 55 End

Steepness: 56 57 Beginning ☐☐:1; 58 59 End ☐☐:1

Distance "D_1" (ft): 60 61 Beginning; 62 63 End

64 Slope Face Erosion Code
- 1 Slight or None
- 2 Severe (Ruts > 1 ft)

65 Slope Direction
- 1 Positive
- 2 Negative

2nd or BACK SLOPE (Except for Level Terrain)

Steepness: 66 67 Beginning ☐☐:1; 68 69 End ☐☐:1

Distance "D_2" (ft): 70 71 Beginning; 72 73 End

74 Slope Face Erosion Code
- 1 Slight or None
- 2 Severe (Ruts > 1 ft)

75 Slope Direction
- 1 Positive
- 2 Negative

/ Card Type 77

Recommendations: ____________

Figure 3-1. Roadside hazard inventory form.

Boxes 1 and 2 must be completed on every form. Hazards have been classified into three categories--*point hazards*, Box 3; *longitudinal hazards*, Box 4; and *slopes*, Box 5. In addition to Boxes 1 and 2, only one of Boxes 3, 4, or 5 will be completed on each form. A separate form is used to inventory each roadside hazard.

Each inventory form constitutes a single computer card data input source and the form has been developed to permit direct transfer of inventory data to computer card for entry to the cost-effectiveness program. Only those data within the numbered spaces in each box will be entered on computer cards. The number below each space denotes the column number on the computer card.

The format has been simplified as much as possible to assist the key-punch operator in transferring the data to cards. Data spaces have been located in a straight line reading from left to right and all spaces between consecutively key-punched columns have been closed up. A circle appears in the left margin adjacent to each row of data spaces. Since only certain rows of spaces must be key-punched from each form, and these rows may differ between consecutive forms, a check mark (✓) must be placed in the circle adjacent to the appropriate completed row of spaces. The key-punch operator may use the check mark to quickly locate the data to be key-punched from that form. The circles adjacent to Boxes 1 and 2, and "Card Type (column 77)" contain pre-printed check marks because the data in these rows of spaces must be key-punched from every form.

It is emphasized that a check mark must be placed in a circle along the left margin adjacent to any row of data spaces in which entries are made. *If the check mark is omitted, the key-punch operator may overlook certain data.*

HIGHWAY -- BOX 1

Contained in this category are general information concerning the type and operating characteristics of the highway facility under consideration; general location by county, control and section, and inventory direction. These data are necessary for cross-reference and information retrieval, but, more importantly, provide basic decision-making information sources by which the computer program operates.

The highway type (columns 1 and 2) coding numbers agree with the codes used in the Road Inventory Log sheets (RI-1 sheets) to facilitate cross-reference at a later date. Space is provided for a four-digit highway number (columns 3 through 6) which must be right-justified. For example, Interstate Highway 10 would be recorded as 08-0010 in columns 1 through 6, the 08 being the prefix code for Interstate Highway.

Access control classification (column 7) is defined by five numerical codes. It is extremely important to the computer program operation that the proper codes be used for the particular highway being inventoried because the program branches internally on this code alone. Codes 1, 2, or 4 in Column 7 must be used when inventorying a median-divided highway. Codes 3 or 5 are applicable for non-median facilities. If codes 3 or 5 are used, the total width center-line to shoulder on inventory side (columns 17 and 18) must be specified to the nearest foot. For codes 1, 2, or 4, columns 17 and 18 may be left blank. The width specified in columns 17 and 18 is necessary within the program operation to calculate the additional hazard index of a roadside object to an opposing vehicle which can cross the undivided centerline and impact the obstacle from the opposite direction. If the width were not specified (resulting in a zero width), the additional increment would be in error.

The county codes (columns 8-10) are listed in Table 3-1 which agree with the standard Texas Highway Department alphabetical-numerical designation. The Houston Urban Office is coded as County 255.

The control and section number identification, used by the Texas Highway Department, generally is used more widely than the county or highway number. To facilitate cross-referencing hazard inventory forms to on-site location, space is supplied to record both control number (columns 11-14) and section number (columns 15 and 16). These data constitute a principal sorting key for computer analysis operations. Omission of these data or incompatibility between successive hazard coding (particularly within grouped hazards) can result in erroneous output.

TABLE 3-1

COUNTY CODES

Co. No.	*County Name*	*Dist. No.*	*Co. No.*	*County Name*	*Dist. No.*
1	Anderson	10	41	Coke	7
2	Andrews	6	42	Coleman	23
3	Angelina	11	43	Collin	18
4	Aransas	16	44	Collingsworth	24
5	Archer	3	45	Colorado	13
6	Armstrong	4	46	Comal	15
7	Atascosa	15	47	Comanche	23
8	Austin	12	48	Concho	7
9	Bailey	5	49	Cooke	3
10	Bandera	15	50	Coryell	9
11	Bastrop	14	51	Cottle	25
12	Baylor	3	52	Crane	6
13	Bee	16	53	Crockett	7
14	Bell	9	54	Crosby	5
15	Bexas	15	55	Culberson	24
16	Blanco	14	56	Dallam	4
17	Borden	8	57	Dallas	18
18	Bosque	9	58	Dawson	5
19	Bowie	19	59	Deaf Smith	4
20	Brazoria	12	60	Delta	1
21	Brazos	17	61	Denton	18
22	Brewster	24	62	DeWitt	13
23	Briscoe	25	63	Dickens	25
24	Brooks	21	64	Dimmit	22
25	Brown	23	65	Donley	25
26	Burleson	17	66	Kenedy	21
27	Burnet	14	67	Duval	21
28	Caldwell	14	68	Eastland	23
29	Calhoun	13	69	Ector	6
30	Callahan	8	70	Edwards	22
31	Cameron	21	71	Ellis	18
32	Camp	19	72	El Paso	24
33	Carson	4	73	Erath	2
34	Cass	19	74	Falls	9
35	Castro	5	75	Fannin	1
36	Chambers	20	76	Fayette	13
37	Cherokee	10	77	Fisher	8
38	Childress	25	78	Floyd	5
39	Clay	3	79	Foard	25
40	Cochran	5	80	Fort Bend	12

TABLE 3-1

CONTINUED

Co. No.	*County Name*	*Dist. No.*	*Co. No.*	*County Name*	*Dist. No.*
81	Franklin	1	121	Jackson	13
82	Freestone	17	122	Jasper	20
83	Frio	15	123	Jeff Davis	24
84	Gaines	5	124	Jefferson	20
85	Galveston	12	125	Jim Hogg	21
86	Garza	5	126	Jim Wells	16
87	Gillespie	14	127	Johnson	2
88	Glasscock	7	128	Jones	8
89	Goliad	16	129	Karnes	16
90	Gonzales	13	130	Kaufman	18
91	Gray	4	131	Kendall	15
92	Grayson	1	66	Kenedy	21
93	Gregg	10	132	Kent	8
94	Grimes	17	133	Kerr	15
95	Guadalupe	15	134	Kimble	7
96	Hale	5	135	King	25
97	Hall	25	136	Kinney	22
98	Hamilton	9	137	Kleberg	16
99	Hansford	4	138	Knox	25
100	Hardeman	25	139	Lamar	1
101	Hardin	20	140	Lamb	5
102	Harris	12	141	Lampsas	23
103	Harrison	19	142	LaSalle	15
104	Hartley	4	143	Lavaca	13
105	Haskell	8	144	Lee	14
106	Hays	14	145	Leon	17
107	Hemphill	4	146	Liberty	20
108	Henderson	10	147	Limestone	9
109	Hidalgo	21	148	Lipscomb	4
110	Hill	9	149	Live Oak	16
111	Hockley	5	150	Llano	14
112	Hood	2	151	Loving	6
113	Hopkins	1	152	Lubbock	5
114	Houston	11	153	Lynn	5
115	Howard	8	154	Madison	17
116	Hudspeth	24	155	Marion	19
117	Hunt	1	156	Martin	6
118	Hutchinson	4	157	Mason	14
119	Irion	7	158	Matagorda	12
120	Jack	2	159	Maverick	22

TABLE 3-1

CONTINUED

Co. No.	*County Name*	*Dist. No.*	*Co. No.*	*County Name*	*Dist. No.*
160	McCulloch	23	201	Rusk	10
161	McLennan	9	202	Sabine	11
162	McMullen	15	203	San Augustine	11
163	Medina	15	204	San Jacinto	11
164	Menard	7	205	San Patricio	16
165	Midland	6	206	San Saba	23
166	Milam	17	207	Schleicher	7
167	Mills	23	208	Scurry	8
168	Mitchell	8	209	Shackelford	8
169	Montague	3	210	Shelby	11
170	Montgomery	12	211	Sherman	4
171	Moore	4	212	Smith	10
172	Morris	19	213	Somervell	2
173	Motley	25	214	Starr	21
174	Nacogdoches	11	215	Stephens	23
175	Navarro	18	216	Sterling	7
176	Newton	20	217	Stonewall	8
177	Nolan	8	218	Sutton	7
178	Nueces	16	219	Swisher	5
179	Ochiltree	4	220	Tarrant	2
180	Oldham	4	221	Taylor	8
181	Orange	20	222	Terrell	6
182	Palo Pinto	2	223	Terry	5
183	Panola	19	224	Throckmorton	3
184	Parker	2	225	Titus	19
185	Parmer	5	226	Tom Green	7
186	Pecos	6	227	Travis	14
187	Polk	11	228	Trinity	11
188	Potter	4	229	Tyler	20
189	Presidio	24	230	Upshur	19
190	Rains	1	231	Upton	6
191	Randall	4	232	Uvalde	22
192	Reagan	7	233	Val Verde	22
193	Real	22	234	Van Zandt	10
194	Red River	1	235	Victoria	13
195	Reeves	6	236	Walker	17
196	Refugio	16	237	Waller	12
197	Roberts	4	238	Ward	6
198	Robertson	17	239	Washington	17
199	Rockwall	18	240	Webb	21
200	Runnels	7	241	Wharton	13

TABLE 3-1

CONTINUED

Co. No.	*County Name*	*Dist. No.*
242	Wheeler	25
243	Wichita	3
244	Wilbarger	3
245	Willacy	21
246	Williamson	14
247	Wilson	15
248	Winkler	6
249	Wise	2
250	Wood	10
251	Yoakum	5
252	Young	3
253	Zapata	21
254	Zavala	22
255	Houston Urban	26

Two other information sources necessary for program execution are included in Box 1: the total ADT on the facility (columns 19-21), and the recording direction (column 22). The ADT is used within the program in the probability of encroachment routine. Similarly, the direction in which the inventory is being conducted (with or against increasing milepost) must be specified to direct the program to the proper operating routines.

HAZARD CLASSIFICATION -- BOX 2

The information in columns 23 through 38 is vital to the computer program for several reasons. It provides hazard description information from which severity indices are designated, provides the key to direct the program to analysis of a rightside or median-located hazard, and is the information source to define a group of hazards rather than a single hazard.

Hazard Number

The hazard number (columns 23-26) generally is assigned consecutively throughout the inventory section, beginning with number 0001. No two hazards within the same inventory length may be assigned the same hazard number. If additional hazards are inventoried after the initial inventory (or, if one was omitted), a new number must be assigned to the omitted hazard. The form may be inserted at the appropriate place within a sequence of inventory forms (say, arranged according to increasing milepoint) even though the hazard numbering sequence is thus non-consecutive.

Identification and Descriptor Codes

The identification and descriptor codes (columns 27-28 and 29-30 respectively) identify the type of hazard from which the severity index is assigned. Codes are shown in Table 2-1.

Offset Code

The offset code (column 31) defines the position of the hazard with respect to the left or right side of the travel lane(s) in the inventory direction. A code 1 (right side) denotes that the hazard is located on the right side of the highway from inventory direction orientation. A code 2 (median or left side) is used when the hazard is located in the median on a divided highway facility (either controlled or non-controlled access) or if the hazard is located on the left side of a non-median-divided highway with respect to the inventory direction orientation.

Median Width

The median width (columns 32-34) must be specified in certain situations, and not in others, as discussed below. The median width should be left blank when an offset code 1 (right side) is used. If the hazard is located in the median and the median width is left blank, the hazard effect on opposing traffic is not included in the hazard index determination. Under certain conditions, this is satisfactory. For example, if the hazard were located in a wide median near the left edge of the inventory travel lanes and it was obvious to the person conducting the inventory that an opposing vehicle would not cross the median and impact the hazard, the additional increment of hazard index would be insignificant. Therefore, the hazard should be inventoried as a near side median offset (code 2, column 31) and the median width left blank (columns 32-34). The program would analyze the hazard from an inventory side impact only.

Also, on highways with wide medians (in excess of 60 ft), each set of travel lanes, in effect, operates as two independent roadways. Therefore, each set would probably be inventoried individually, thus the median width may be left blank.

There are, however, certain cases where the median width must be recorded. If the effects of opposing traffic are to be considered, the median width must be specified. Also, if the entire median is inventoried concurrently with one set of travel lanes, the width must be recorded. The median width is required if a hazard on the far side of the median (adjacent to the opposing traffic lanes) is inventoried from the inventory side or if an improvement is recommended for the far side of the median.

It is recommended that the median width be recorded unless the inventory personnel are certain that the hazard should be considered only as a "near side" hazard, the term "near side" referring to the portion of the median adjacent to the travel lanes in which the inventory is progressing. If the median width is recorded for a situation in which it is not needed, it will not be used in the program calculations. Also, if the distance from the opposing lanes to the hazard is greater than 30 ft yet the median width had been recorded, the hazard effect on opposing traffic would be determined by the program to be insignificant.

Grouping Number

Of particular importance to the operation of the program is the grouping number (columns 35-38). A "group" of hazards represents any two or more hazards in close proximity that are related to each other either by proximity or by interdependence in combined severity. For example, a guardrail protecting a point hazard on a slope constitutes a group of three hazards--the guardrail, the point hazard, and the slope. Each hazard within the 3-element group would be numbered individually, but the grouping number (columns 35-38) would be identical for all three.

The grouping number provides the only key to the program that more than a single hazard is to be considered. Therefore, if an improvement can affect any other hazard, that hazard must be included in the same group and assigned the same grouping number. It is emphasized that if the grouping number is omitted (or if a hazard is omitted from a group), the program does not consider the improvement effects on related hazards. Several basic premises apply to the use of grouping numbers as discussed below:

(1) A zero or blank group number is valid only for a single hazard.

(2) The offset code (column 31) must be the same for all hazards within one group. Hazards on both sides of a highway cannot be grouped together--they must be inventoried as being in two separate groups.

(3) If guardrail is included in a group, it is assumed that it protects the entire group. Therefore, any hazard that is not protected by the guardrail should not be included in that group; it must be inventoried separately.

(4) If guardrail is included in a group, and improvements are recommended to hazards behind the guardrail, error messages will be printed out to this effect. Therefore, unless the guardrail is to be removed, all hazards behind the guardrail must be designated a "No Improvement" code. (See Section 4 for improvement recommendations.)

(5) Generally, hazards within the median may be grouped together regardless of which set of travel lanes they are adjacent to. The primary exception to this occurs in inventorying the bridge-associated groups on both sides of a median. The bridge group on each side of the median must be assigned a separate grouping number.

The grouping code is used at most overcrossing structures where a typical group could include approach guardrail, the bridge rail, departing guardrail, and a slope at each end of the structure. These hazards normally exist both on the right side and on the median side. A separate grouping number is assigned to the group of hazards on each side (right side and median side) of the travel lanes.

Many times, several individual point hazards will be spaced close together. When clusters of point hazards of the same type are encountered, they may be inventoried as a single point hazard having dimensions of an imaginary box around their periphery. It is recommended that bridge piers and small clusters of trees be inventoried in this manner. Figure 3-2 illustrates a set of bridge piers considered as a single point hazard. In effect, the individual piers act as a rectangular point hazard because a vehicle cannot pass between adjacent piers. No grouping number would be assigned in this case. Judgment must be used in clustering point hazards as a single hazard, but a realistic criterion is that it may be assumed to act as a single point hazard if a vehicle cannot pass between any two hazards.

The series of hazards located in the median (Figure 3-3) represents a group consisting of five individual hazards: (1) the guardrail, (2) critical slope, (3) cluster of three trees considered to be a single point hazard with peripheral dimensions, (4) a raised drop inlet, and (5) a cluster of five trees again considered as a single point hazard. Each of these five hazards would be assigned an individual hazard number and all would be assigned the same grouping number.

MILEPOINT AT HAZARD--BOX 2

All hazards are located along the highway by milepoint using the thousandth-reading odometer discussed in Section 2. It should be noted that only the beginning hazard milepoint is required for point hazards. Both beginning and end hazard milepoint must be recorded for longitudinal and slope hazards, the length being computed by the computer program by subtraction of the two values.

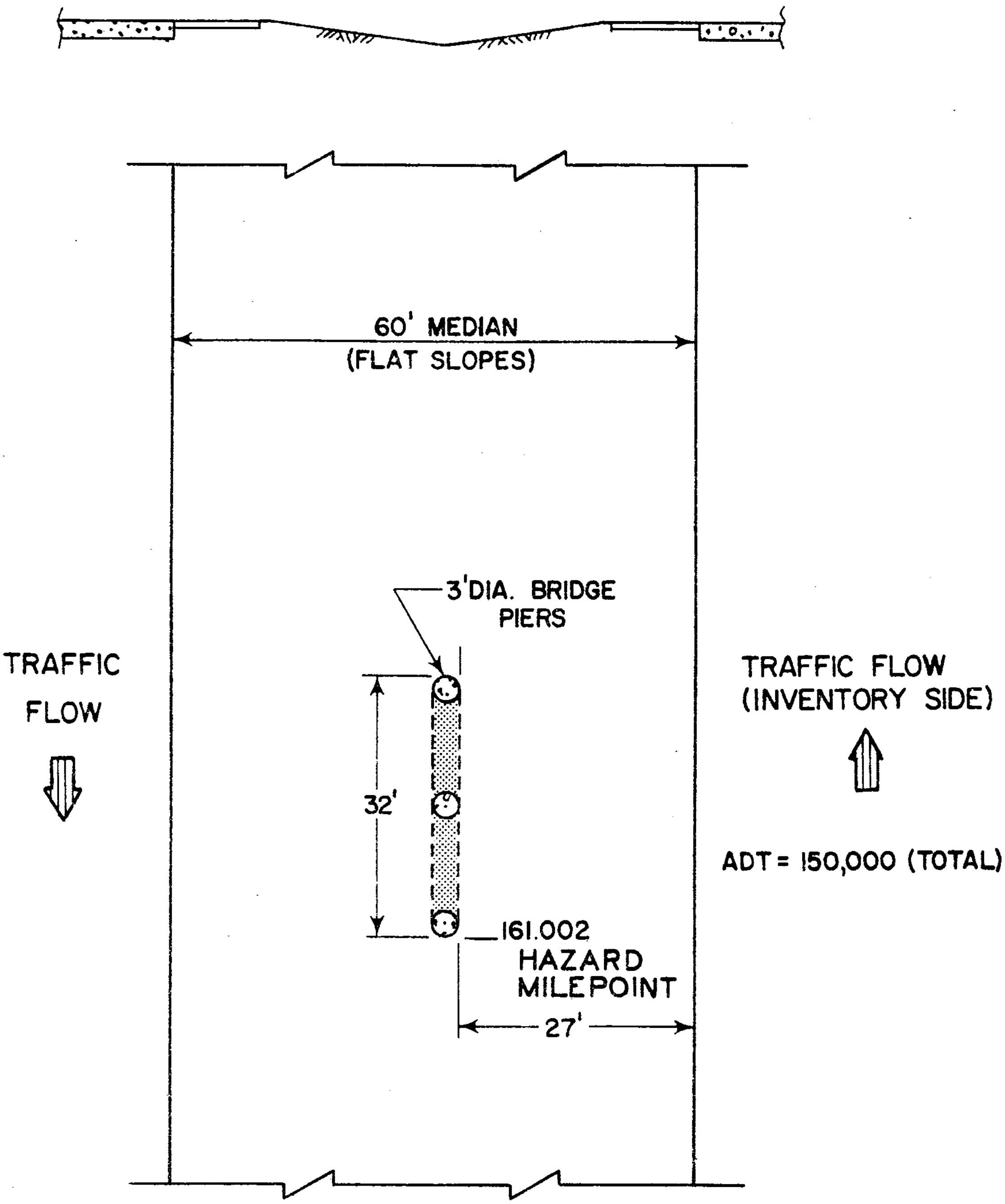


Figure 3-2. Closely-spaced hazards inventoried as a single point hazard.

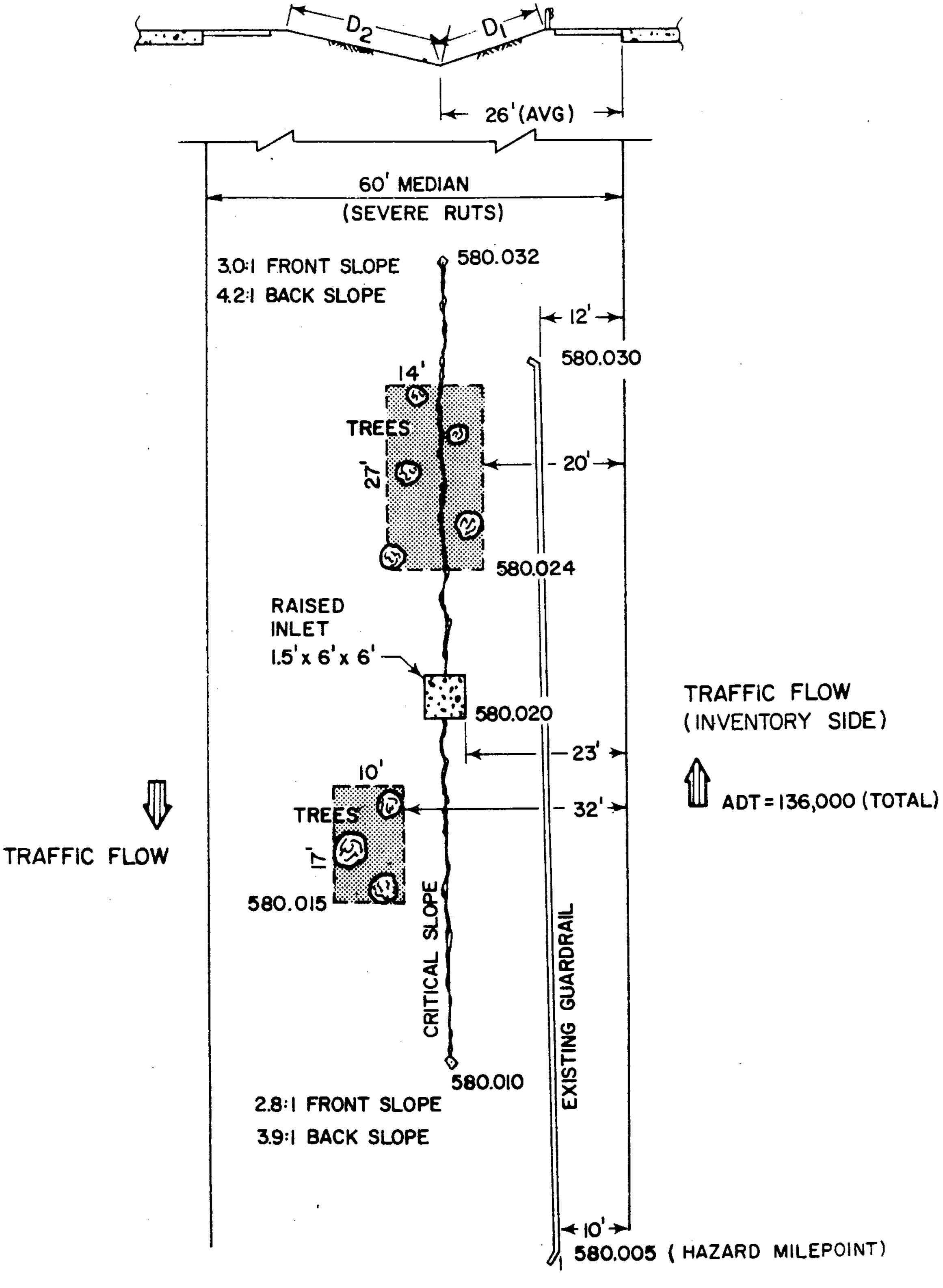


Figure 3-3. Hazard grouping in median.

It is again emphasized that <u>Box 2 must be completed on each inventory form</u> regardless of the category into which the hazard is assigned (Boxes 3, 4, or 5).

POINT HAZARDS--BOX 3

The code 1 in column 51 designates that the hazard is a point hazard. With the exception of drop inlets, only hazard offset (columns 52-53), width (columns 54-56), and length (columns 57-59) are required in Box 3. All dimensions are recorded to the nearest foot. In the case of a raised drop inlet (table top design), the height must be recorded (columns 60-62) to the nearest tenth foot. Similarly, for a depressed drop inlet, depth must be recorded in columns 63-65. These data are necessary to assign different severity indices for various heights or depths of inlets. For point hazards other than inlets, columns 60-65 are left blank. Point hazards are specifically identified in Table 2-1.

LONGITUDINAL HAZARDS--BOX 4

Hazards assigned to this category include curbs, bridge rails, median barriers, guardrails, ditches, and retaining walls, and are so identified by the code 2 in column 51. The length of a longitudinal hazard is computed within the program from the beginning and end milepoints recorded in Box 2. Offset distance at the beginning and end of the longitudinal hazard is recorded in columns 52-53 and 54-55 respectively. In many cases, both offset distances will be identical because the hazard is located parallel to the roadway; however, provision must be made for the exception, and both offsets must be recorded. All dimensions for offset and width (columns 59-60) are recorded to the nearest foot. Height of depth (columns 56-58) must be recorded to the nearest tenth foot for guardrail, curbs, and ditches.

Columns 61 and 62 pertain primarily to guardrail and identify end conditions and safety treatment. If median barriers are inventoried, end treatments must be specified also. Column 61 describes the beginning end; column 62 pertains to the downstream end. Four codes for each are provided, the sixteen combinations of which describe all possible guardrail installations. A guardrail may (1) be isolated (protecting a point hazard, a slope, or combination) and not connected at either end to a bridge or other sturcture, (2) be located at the approach to a structure, or (3) be located at the downstream end of a structure. Isolated guardrail may be safety treated including post spacing and end treatment in accordance with current accepted safety specifications, or it may not satisfy these specifications (not safety treated). Guardrail connections at a bridge or other structure are classified as "full-beam connection" or "not full-beam connection." A full-beam connection is defined as one transmitting continuous rail strength through the "eight-bolt" connection or other connection assumed by the Texas Highway Department equally acceptable. All one-bolt connections, unconnected guardrail (short gap between rail and structure) and other such connections are classified as "not full-beam." Thus, an isolated guardrail installation of at least 150 ft in length (plus end treatment) and having current post spacing specified for safety and turned down ends would be coded as a 1 (column 61), 1 (column 62). An approach guardrail with beginning point safety treated, but connecting to a bridge wingwall with a one-bolt connection would be a 1, 4 in columns 61 and 62 respectively.

Curbed exit or entrance ramps are classified as longitudinal hazards and are inventoried rather uniquely. The length of the gore curb at an exit ramp is measured parallel to the main lane beginning at the nose of the gore area. If the highway is curbed throughout the region being inventoried, the length of the gore curb should be arbitrarily defined as 150 ft and the subsequent curb inventoried as another hazard beginning at the arbitrary cutoff point. If only the exit region is curbed, the true length of the curb should be recorded. The width of the gore curb is defined as the average width of the gore at a point 25 ft downstream from the gore nose, but not to exceed a width of 10 ft.

Certain widths generally have been established for guardrail and curb parallel to the roadway. Both should be recorded as 1 ft (columns 59-60).

Guardrail height should be measured in all cases (columns 56-58). Also, each existing guardrail installation should be critically examined to determine if it is, in fact, protecting an object from impact for the 11-degree encroachment angle assumed in the model (see Reference 3). The guardrail installation may meet all safety requirements yet be located such that an encroaching vehicle could pass either end and impact the object which the guardrail was intended to protect. This problem is especially prevalent where short sections of guardrail are installed to protect a point hazard, or at bridge approaches where a vehicle could travel behind the guardrail ending up on a critical slope.

SLOPES--BOX 5

Slopes 4:1 or steeper in the median and alongside the outer travel lanes are included in the inventory and categorized as such by a code 3 in column 51. The hinge-point offset distance must be specified for both ends of the slope (columns 52-55). Slope steepness (columns 56-59) is recorded to the nearest tenth for both beginning and ending milepoints.

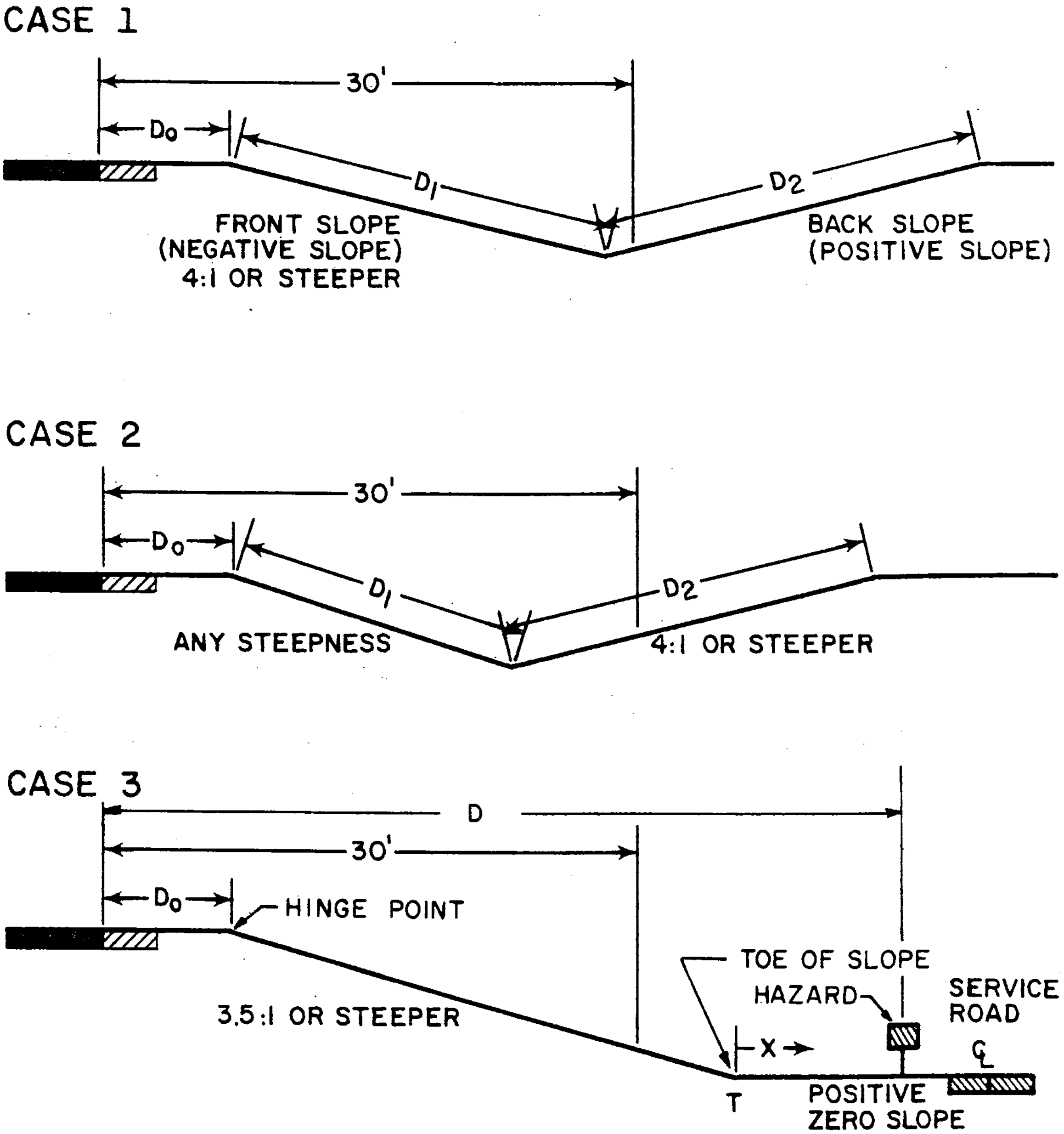
To facilitate measurement of slope distances without elaborate surveying equipment, the distance, D_1, (columns 60-63) is measured. This measurement is the length along the slope face from the hinge point to the toe of slope. Horizontal distance is computed within the program.

Space is provided (column 64) to record the degree of erosion on the slope face. In most cases, the code 1 (slight or no erosion) will be used, particularly if erosion cuts are present due to a recent rainfall, and normal maintenance would be expected to repair slopes. However, if erosion is severe (code 2), this fact should be noted. The program increases the severity index accordingly for badly eroded slopes.

The severity associated with slope traversal, other than vehicle rollover on a steep front slope, is actually dependent on the vehicle g-forces experienced as the vehicle travels through the region at the toe of slope. The combination of front and back slope, therefore, influence the severity. To quantify this, the steepness of both front and back slopes must be recorded. Space is provided in Box 5 to record similar data for both front and back slopes. The second slope may be either a back slope, or level terrain such as would be encountered at the toe of a fill section adjacent to a service road. If the second slope is level terrain, the steepness (columns 66-69) and the distance D_2 (columns 70-73) should be recorded by a digit "9" is each space which is interpreted by the program as a level slope. The distance, D_2, is the length of the second slope measured from the toe to the hinge-point along the slope face. If the second slope is level terrain, D_2 should be recorded as 99 ft at both end milepoints.

The slope direction (columns 65 and 75 for each slope respectively) is used to key the computer program to various subroutines for analysis purposes and must be recorded. The slope direction convention is that used in roadway alignment--downward slope is negative (code 2); upward is positive (code 1). All slope direction codes are referenced to the plane of the roadway being inventoried. Level terrain at the bottom of a fill section is coded as a positive slope.

Figure 3-4 illustrates direction coding for several slope situations and is used to describe several "special" inventorying procedures for slope configurations. Two assumptions are made within the program



ALL HAZARDS LOCATED WITHIN D_0+X UNTIL 30' TOTAL IS REACHED ARE INVENTORIED

OFFSET RECORDED FOR HAZARD = D.

Figure 3-4. Roadside slope configurations.

to compute the hazard index and the program keys on the value of slope steepness to select the appropriate subroutine. This feature can govern the lateral distance that must be inventoried for certain hazards included in groups containing slopes as discussed below.

If the steepness is less than 3.5:1, the program assumes that the errant vehicle will recover within a lateral travel distance of 30 ft. For slopes 3.5:1 or steeper, the assumption is made that the vehicle cannot be safely returned to the roadway and that it will travel to the toe of the slope. Therefore, hazards located beyond the toe of slope must be included if the sum of the hinge-point offset distance to the front slope, D_0 (columns 52-55), and the distance from the toe of front slope to the hazard is 30 ft or less (see Case 3, Figure 3-4). The hazard offset, D, recorded is the actual lateral offset from the edge of the travel lane to the hazard. The hazard may be located on the front or on the back slope.

Certain combinations of slopes can result in the necessity of inventorying a front slope flatter than 4:1. If, for example, the front slope steepness was 5:1 and the back slope steepness was 3:1, both slopes would require inventorying although the front slope is flatter than the basic criterion of 4:1. The severity index of the resulting ditch configuration is determined by the vector difference in slope gradient; therefore, both must be recorded to permit this calculation within the program. This situation, (see Case 2, Figure 3-4), would be expected to occur infrequently within the 30-ft lateral offset boundaries but becomes particularly important when full-width median inventorying procedures are used because of the increment of hazard associated with opposing traffic.

When a long slope exists prior to a bridge structure, the slope should be inventoried as two separate slopes--an isolated slope and an approach slope--with the ending milepoint of one being the beginning milepoint of the second. The arbitrary break-point should be at least 150 ft from the bridge structure. This procedure must be used in cases where guardrail is existing or proposed for either slope because, in the computer analysis model, approach guardrail at a bridge is assumed to protect the approach slope rather than the bridge end wall. This is discussed in detail in section 4 of the report.

CARD TYPE

Hazard inventory data are key-punched on a computer card designated by a code 1 in column 77. Each inventory card must contain this coded information for proper input information in the computer program.

RECOMMENDATIONS

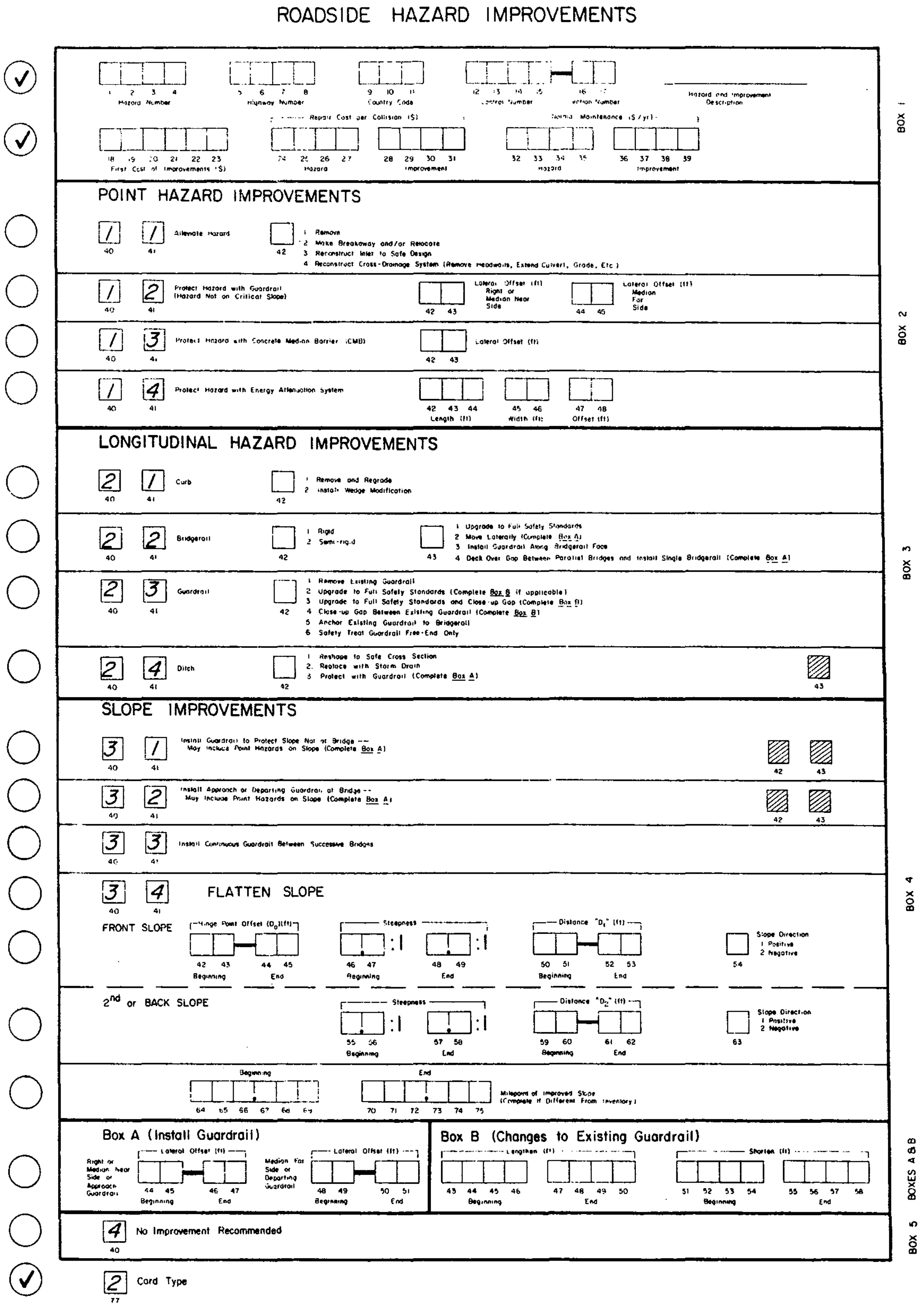
Space is provided at the bottom of the inventory form to specify the improvements to the hazard. This information is not key-punched, however, it is useful in manually checking coded information using the field-completed form. It is recommended that each improvement alternative be noted on each inventory form. This, in conjunction with the general hazard description in the upper right corner of the form, provides a concise explanation of the existing hazard and recommended improvements.

4. ROADSIDE HAZARD IMPROVEMENT FORM

GENERAL

The manner in which improvement alternative information is input to the program is equally as important as the inventory data input. The roadside hazard improvement form (Figure 4-1) has been designed to provide a system whereby feasible safety improvements for each category of hazard can be coded and evaluated in the cost-effectiveness model. Also included are cost data associated with the improvement selected. The format of the form is similar to that of the hazard inventory form, and the general discussion of the left-margin circles for check marks, hazard dimensions and hazard classification within the three categories also applies to completion of the improvement form. The improvement form is applicable for all types of rural highways and has undergone extensive field trial on Interstate highways, particularly in the Fort Worth District.

The improvement form has been designed to collect data within five boxes in addition to Boxes A and B which provide a central location for guardrail information. Whereas the information on the inventory form pertained to the hazard as it existed at the time of inventory, all information (dimensions, offsets, etc.) on the improvement form pertain to the improved situation recommended. Each improvement form constitutes a single computer card data input source. Only the data within the numbered spaces in each box will be entered on computer cards.



ROADSIDE HAZARD IMPROVEMENTS

✓ ☐☐☐☐ 1 2 3 4 Hazard Number ☐☐☐☐ 5 6 7 8 Highway Number ☐☐☐ 9 10 11 County Code ☐☐☐☐ 12 13 14 15 Control Number – ☐☐ 16 17 Section Number ____ Hazard and Improvement Description

✓ ☐☐☐☐☐☐ 18 19 20 21 22 23 First Cost of Improvements ($)

Repair Cost per Collision ($): ☐☐☐☐ 24 25 26 27 Hazard ☐☐☐☐ 28 29 30 31 Improvement

Normal Maintenance ($/yr): ☐☐☐☐ 32 33 34 35 Hazard ☐☐☐☐ 36 37 38 39 Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ 42 43 Lateral Offset (ft) Right or Median Near Side ☐☐ 44 45 Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ 42 43 Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ 42 43 44 Length (ft) ☐☐ 45 46 Width (ft) ☐☐ 47 48 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2. Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ 42 43 Beginning – ☐☐ 44 45 End
Steepness: ☐☐ :1 46 47 Beginning ☐☐ :1 48 49 End
Distance "D_1" (ft): ☐☐ 50 51 Beginning – ☐☐ 52 53 End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ :1 55 56 Beginning ☐☐ :1 57 58 End
Distance "D_2" (ft): ☐☐ 59 60 Beginning – ☐☐ 61 62 End
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐☐☐☐ 64 65 66 67 68 69 End ☐☐☐☐☐☐ 70 71 72 73 74 75 Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ 44 45 Beginning – ☐☐ 46 47 End
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ 48 49 Beginning – ☐☐ 50 51 End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ 43 44 45 46 Beginning ☐☐☐☐ 47 48 49 50 End
Shorten (ft): ☐☐☐☐ 51 52 53 54 Beginning ☐☐☐☐ 55 56 57 58 End

BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure 4-1. Roadside hazard improvements form.

Box 1 and the card type (column 77) contain preprinted check marks in the left margin circles. The information in the rows of data adjacent to the check marks <u>must be completed on every form</u>. In addition to Box 1 and card type, only one of Boxes 2, 3, 4, or 5 will be completed on each form. Box A or B will be completed only when directed by certain improvement alternatives listed in Boxes 3 or 4.

The form is designed to permit only improvement alternatives for compatible hazard type. Therefore, point hazard improvements may be recommended only for point hazards, longitudinal hazard improvements only for longitudinal hazards, and slope hazard improvements only for slope hazards. The "No Improvement Recommended" alternative may be specified for any of the three primary classifications of hazard.

LOCATION AND COST INFORMATION--BOX 1

The hazard number (columns 1-4) entered on the improvement form must agree with the applicable hazard number on the inventory form. Similarly, the location information (columns 5-17) must be identical on the inventory and improvement forms. Incompatibility of these data will produce error messages in the output because the link between existing hazard and improvement is provided to a large degree by this row of data.

The cost-effectiveness model operates on the principle of severity-cost relationship of the existing hazard compared to the same relationship in its improved state. Therefore, costs must be assigned to both conditions. Costs are defined as those which will be borne by the Texas Highway Department. They do not include vehicle damage or personal injury costs incurred in a collision.

The "first cost of improvements" (columns 18-23) represents the initial lump-sum net cost associated with incorporating the improvement. It may represent a cost of removal if simple removal was the recommended safety improvement. Where installation of guardrail was the recommended improvement, it would represent the total cost associated with this installation.

Repair costs per collision (excluding vehicle repair costs and personal injury costs) must be estimated both for the existing hazard (columns 24-27) and the recommended improvement (columns 28-31). Either may be zero, depending on the particular hazard. For example, repair cost per collision incurred by a collision of a vehicle and a bridge pier would be zero unless the collision involved a large truck and the pier was severely damaged structurally. The repair cost for the improvement had protection by a barrel attenuation device been recommended, would be the expected replacement costs for the damaged barrel system after collision. Conversely, the hazard repair cost for a rigid sign post may be complete replacement cost of the sign, whereas a recommendation of "removal" would reduce the expected improvement repair cost to zero since future collisions would be impossible at that location.

Normal maintenance costs include those maintenance costs for the hazard in its existing state (columns 32-35) and those estimated for the improved state (columns 36-39). As in the case of repair costs, either could be zero. If the recommended improvement was removal, the "improvement normal maintenance costs" would be zero.

In all cost data spaces, zero should be entered where applicable rather than merely leaving the space blank. This also acts as a check system to avoid overlooking data spaces. All data spaces in Box 1 must be completed on each hazard improvement form to avoid rejection by the computer program. Each line of data checked should be completed in full unless otherwise noted.

POINT HAZARD IMPROVEMENTS--BOX 2

A code 1 in column 40 signifies that the improvement applies to a point hazard. Four improvement alternatives are available with the appropriate code entered in column 41.

(1) Alleviate Hazard (Code 1, Column 41) includes removal, making the hazard breakaway, reconstruction of the hazard to a traversable design. The particular subdivision is identified by a code 1, 2, 3, or 4 in column 42.

(2) Protect Hazard with Guardrail (Code 2, Column 41). This code may be used for any point hazard that is not located on a slope. The lateral offset must be specified in columns

42-43 if the guardrail is recommended for a hazard on the right side or median near side. If guardrail is specified on the median far side, (median must be inventoried across full width) the offset (measured from inventory side to front face of far side guardrail) must be entered in columns 44-45.

When guardrail is recommended to protect a point hazard, a minimum of 3 ft clearance must be provided between the object and the guardrail face. One exception to this is guardrail installation to protect bridge piers. Where clearance is not available, the guardrail may be tied into the bridge piers.

Clusters of hazards of the same type such as several signs or several trees may be protected by guardrail as a unit. The peripheral boundaries of the cluster are used to define the hazard dimensions. Bridge piers should be inventoried in this manner.

(3) Protect Hazard with Concrete Median Barrier (Code 3, Column 41).

A concrete median barrier may be recommended for either the median location or on the right side. If the barrier is placed in the median, no offset distance need be specified since the dimensions relative to the hazard are built into the computer program. If the barrier is recommended for right-side placement, the offset distance (columns 42-43) must be specified. The computer program assumes a 35-ft length of median barrier both upstream and downstream of the point hazard. Therefore, length need not be specified on the improvement form.

(4) Protect Hazard with Energy Attenuation System (Code 4, Column 41). When this improvement is recommended, length (columns 42-44), width (columns 45-46) and offset distance (columns 47-48) must be specified. If, for example, a barrel attenuation system is recommended to protect a median bridge pier, the length of only one barrel system is specified. Similarly, costs for only one system are entered. If the median was inventoried only for near side, the analysis of the improvement is based only on an impact from the inventory side. However, if the median width is specified, the analysis is based on an opposing impact also and the program determines if two attenuation systems are indeed required (one at each end of the piers) to protect the piers from both directions of traffic flow. If two systems are required, the cost-effectiveness index is computed on the double system and costs are doubled internally although dimensions and costs entered on the improvement form reflect only a single system. The data output will reflect the double costs.

LONGITUDINAL HAZARD IMPROVEMENTS--BOX 3

A code 2 in column 40 identifies the improvement as a longitudinal improvement. Improvement alternatives are provided for four types of longitudinal hazards:

1. curb (code 1, column 41)
2. bridge rail (code 2, column 41)
3. guardrail (code 3, column 41)
4. ditch (code 4, column 41)

each having several sub-categories as denoted by a code in column 42. The bridgerail category is further subdivided by codes in column 43.

In certain sub-categories, completion of Box A or Box B is required. These data spaces need to be completed only when the appropriate instruction appears adjacent to the selected improvement alternative on the improvement form. Box A pertains only to installation of a longitudinal improvement where none existed previously such as the installation of new guardrail or approach or departing guardrail at bridges, or lateral relocation of a bridge rail if the bridge is widened. When only minor modifications are made to existing longitudinal hazards (examples: lengthening, shortening, or closing up gaps between existing guardrail sections), Box B must be completed. It should be noted that a guardrail may be lengthened (Box B) in three ways: (1) adding guardrail to the beginning end (columns 43-46); (2) adding guardrail to the downstream end (column 47-50); or (3) adding length to both ends (columns 43-46 and 47-50). Similarly, guardrail may be shortened in the same ways (columns 51-58). Gaps between guardrail sections may be closed up by lengthening either the upstream or downstream section by the gap length.

Extreme care should be exercised when completing Box A to assure that entrees are properly located. Approach guardrail at a bridge _must_ be coded in columns 44-47 and departing guardrail _must_ be coded in columns 48-51. If, for example, approach guardrail were coded erroneously in columns 48-51, the information needed for program operation would not be provided to the computer program.

Curb--Two improvement alternatives are provided for curbs, each being identified by a code in column 42.

Bridge rail--Four improvement alternatives are provided (column 43) for each of two recommended bridge rail types (column 42). "Upgrade to full safety standards" (code 1, column 43) is interpreted to include all safety improvements necessary to bring the existing rail up to the highest current safety standards. This may include only minor anchorage modification or it may include complete replacement of the existing rail with a new rail system. The costs associated with the improvement will reflect the degree of construction necessary.

If the recommendation is made to move the rail laterally (code 2, column 43), bridge widening would be necessary. Again, costs will reflect the degree of construction necessary to accomplish this alternative. As noted on the improvement form, Box A must be completed to designate the offset distance for the proposed bridge rail.

Installation of guardrail across a bridge rail face (code 3, column 43) represents a safety improvement that is being incorporated on many bridges. This feature provides continued beam strength across the bridge in addition to reduced severity of collision with the concrete bridge rail face.

Although it constitutes rather major reconstruction, provision is made to evaluate the safety improvement of decking over the gap between parallel bridges (code 4, column 43). Box A must be completed if this alternative is selected.

Guardrail--Six safety improvement alternatives are provided for guardrail hazards, each identified by a code number in column 42 under the guardrail general codes 2 and 3 in columns 40 and 41 respectively. In most instances, guardrail will be inventoried as a part of a grouping because it invariably is installed to protect some other hazard. Therefore, care must be taken in the improvement recommendation to insure that all hazards within the group are accounted for in any recommendation involving guardrail removal. Indiscriminant removal of guardrail will expose hazards located behind it (and, therefore, previously inaccessible to vehicle impact) so that they now become potential hazards.

Guardrail installation procedures according to Texas Highway Design procedures are incorporated into the computer program. Therefore, when new guardrail is recommended, its placement and minimum length to protect a point hazard, or a group of point hazards will be in accordance with these specifications. The minimum length of guardrail installation is 150 ft not including safety treatment at the upstream end and required overlap at the downstream end of the hazard.

It is emphasized that approach and departing guardrail at bridges are not included as a "guardrail" improvement in the longitudinal hazard improvement category. Approach and departing guardrail at bridges are treated as slope improvements and are discussed in that category later in this section of the manual.

Removal of existing guardrail is accomplished by using a code 1 in column 42. Since the improvement form is keyed to the inventory form by hazard number and Texas Highway Department guardrail specifications are built in, no longitudinal dimensions are required on the improvement form. Removal is defined as complete removal of the total length of guardrail inventoried.

Full safety standards for guardrail include safety treatment of ends, current post spacing (6 ft-3 in.) and height in accordance with latest safety specifications, and full-beam connections at bridge ends if the rail attaches to a structure. If this recommendation is selected, a code 2 is placed in column 42. Where additional length must be added to provide the 150-ft minimum allowable length, Box B must be completed. This code is not used when only closure of short gaps is recommended; a separate code (code 4) is used for this purpose.

When gap closure is required in addition to upgrading (post-spacing, end treatment, etc.), a code 3 is placed in column 42 and Box B is completed. Cost entries would reflect the total improvement cost.

A code 5 in column 42 is used when only the anchorage connection of guardrail attaching to a bridge is recommended (no other upgrading of the guardrail is necessary, or recommended). A separate code is provided (code 6) to recommend safety treatment of only the free-end portion of guardrail located at either end of a structure. It is noted that this code applies only to the free-end of guardrail beginning or terminating at a structure, not to isolated guardrail protecting a hazard that is not associated with a structure. Use of the code 6 implies that only the end point of the rail furthest from the structure will be safety treated (turned down, buried, anchored, etc.) and that no changes will be made to existing post spacing other than perhaps at the treated section.

In all cases where installation of new guardrail is recommended, it is assumed that the new installation will comply with the highest current safety specifications and costs must reflect this.

Ditch--Three options are available for safety improvements recommended for ditches. Ditches under the "longitudinal hazard" category, include both longitudinally or laterally oriented ditches caused by erosion (washout) or designed ditches to carry runoff along or down fill slopes such as are often found near overpassing structures. Ditches formed by the intersection of roadside slopes are not included in this category and are not coded as an individual hazard. Instead, provision to evaluate the severity of this feature is incorporated in the front and back slope categories in Box 5 on the inventory form and Box 4 on the improvement form.

SLOPE IMPROVEMENTS--BOX 4

Three possible recommendations may be made with respect to slopes. First, the slope may be left in its existing state without guardrail protection. Guardrails may be recommended to protect the slope. Finally, a slope or combination of front and back slope may be regraded to a flatter cross-section such that an errant vehicle can safety traverse it. The latter recommendation, of course, constitutes rather major reconstruction. However, it is emphasized that slope flattening and drainage inlet changes may constitute a very cost-effective safety improvement and should not be overlooked as a feasible improvement alternative. Investigation of this alternative through the cost-effectiveness model alleviates personal bias toward this improvement alternative.

For purposes of differentiation on the improvement form, slopes are classified in two basic categories--isolated slopes not beginning or terminating at a bridge; and slopes adjacent to a bridge. Improvement alternatives include installation of guardrail or flattening the slope for the isolated slope; guardrail only for the slope adjacent to a bridge.

Slope improvements are denoted by a code 3 in column 40 with the four subcategories of improvement denoted by the appropriate code in column 41.

Guardrail protection for an isolated slope is specified by a code 1 in column 41. This option is applicable for slopes with or without point hazards. The guardrail offers protection for the entire group of hazards. Since new guardrail is recommended where none existed previously, Box A must be completed with this improvement alternative.

Installation of approach or departing guardrail at a bridge is coded as a slope improvement by a code 2 in column 41. Although it generally is accepted that approach guardrail offers protection from an exposed wingwall in addition to the steep slopes normally found adjacent to a bridge, the computer program logic is based on the slope protection rather than the point hazard protection of the bridge end. Therefore, a slope adjacent to the bridge must be inventoried as part of a hazard grouping for this improvement alternative. It is highly improbable that a slope would not exist near a bridge; however, if one does not, a "dummy" slope must be included in the group and should be inventoried as follows: 150 ft length; 10-ft hinge-point offset, D_0; 4:1 front slope steepness; 20 ft slope face length, D_1; and a level back slope.

It may be desirable to install continuous guardrail between closely spaced bridges, particularly on non-controlled access roadways. This improvement may be accommodated by a code 3 in column 41, with successive bridges and the slope between them being treated as a hazard grouping. Each side of the roadway must be treated as an individual group.

The hazard associated with traversing a slope is dependent primarily upon two factors: the steepness of the front slope, and the relative difference between steepness of front and back slopes. The cross-section of the ditch formed between front and back slopes also influences the vehicle g-forces; however, the severity indices incorporated in the computer program are based on a vee-ditch.

Therefore, in recommending a slope flattening, both front slope steepness (columns 46-49) and back slope steepness (columns 55-58) must be specified. If the back slope is level terrain, it is assigned a steepness of 9.9:1 in columns 55-58. The distance, D_1, (columns 50-53) which is the distance from the hinge-point to toe-of-slope along the slope face, must be estimated because until detailed cross-section data are prepared, the toe-of-slope for the newly proposed slope will not be known. The distance, D_2, for the second slope also must be estimated. If the hinge-point offset for the proposed front slope does not differ from the existing slope, the entry in columns 42-45 will be identical to the hinge-point offset of the inventoried slope. If the hinge point is expected to be moved laterally, the new offset must be estimated and entered in columns 42-45. The slope direction code must be entered for both front and back slopes in column 54 and 63 respectively.

If only a portion of a slope is to be flattened, provision is made to enter the beginning milepoint (columns 64-69) and ending milepoint (columns 70-75) for the boundaries of the improved (flattened) section of the slope. If the entire slope is to be flattened, these spaces are left blank.

NO IMPROVEMENT RECOMMENDED--BOX 5

The computer program is developed on a one-for-one relationship between hazard inventory and hazard improvement. That is, for each hazard inventoried, there must be a corresponding improvement recommendation even if the recommendation is one of "no improvement." Provision for this is made through a code 4 in column 40 on the improvement form. Some examples are used to illustrate the use of this code.

Many times a grouping of hazards is inventoried in which guardrail is protecting one or more hazards. Each individual hazard within the grouping must be inventoried. If the safety improvement recommendation for the whole grouping is that only the guardrail be upgraded to full safety standards and nothing be done to the hazards behind the guardrail, the improvement for each of the hazards behind the guardrail would be merely a code 4 in column 40. If guardrail exists in a grouping, it is assumed to protect all hazards behind it. Therefore, improvements to any hazard behind it must be a code 4 in column 40 unless guardrail removal is recommended as the improvement alternative for the guardrail. If guardrail removal is recommended, the hazards behind it then become open to vehicle impact. Also, guardrail must be inventoried as a hazard grouping--it cannot be inventoried as a single longitudinal hazard protecting no other hazard. Therefore, it is strongly recommended that every hazard be inventoried. If at a later date, the guardrail is removed, the grouping evaluation would be incomplete because no data would be available concerning objects located behind it. Also, reasons other than safety evaluation may require a detailed inventory of particular hazard types along a section of highway and retrieval programs could be adapted to locate the information from the inventory data.

The "no improvement" code is not intended to be used as a "catch-all" for these hazards which appear to have no feasible improvement possibility. It is provided to reduce the field time required in completing the forms while maintaining the computer program requirements that an improvement form be provided for each hazard form. If an improvement form is not provided, an error message will be printed out on the data output.

It is noted that the basic requirement is that an improvement form must be provided for each hazard inventory form. It should be noted also that <u>more than one</u> improvement form may be provided for each hazard inventory form. The program is capable of analyzing four improvements per hazard. The arrangement of data input and data output that can be expected is discussed in Section 5 of this report.

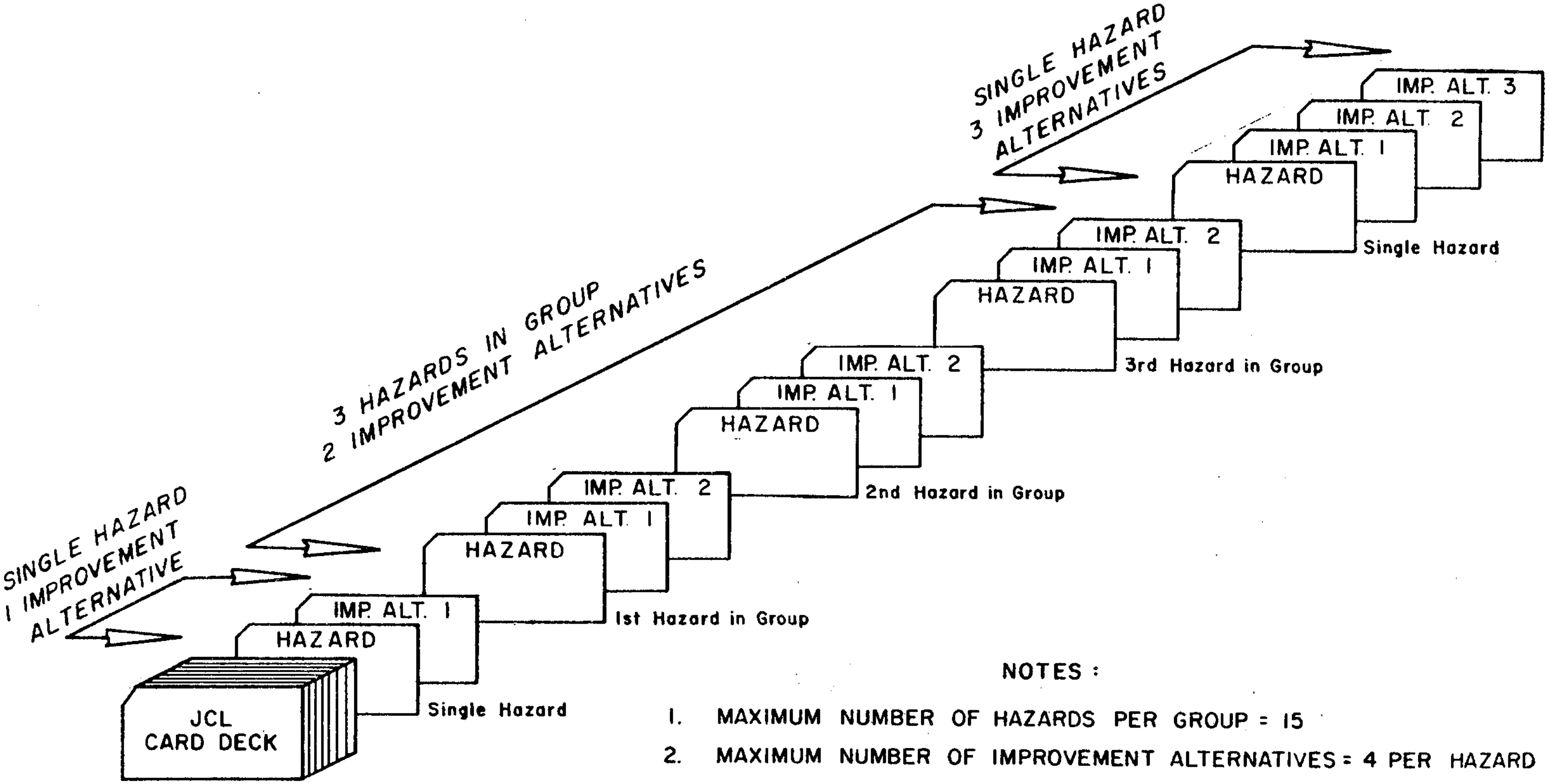
5. COMPUTER PROGRAM USAGE

DATA DECK ARRANGEMENT

Correct type, location, and amount of data on an inventory or improvement form are imperative to successful operation of the computer program. It is equally important that the data deck be correctly arranged so that an equal number of improvement alternatives are provided for each hazard within a hazard grouping.

The computer program is capable of evaluating a grouping containing a maximum of 15 hazards and 4 improvement alternatives per hazard. Four alternatives were ample in all cases during field testing; in only rare instances were more than two alternatives required.

In any hazard/improvement set, the improvement card (or cards) follows immediately behind the hazard card to which it applies. A maximum of four improvements is allowed per hazard. Particular care must be exercised in arranging the sequence of improvement cards within a grouping. The program evaluates the improvements in a prescribed sequence. For example, using Figure 5-1 to illustrate, in the grouping of 3 hazards with 2 improvement alternatives, the analysis procedure for the first improvement considers improvement alternative 1 with the first hazard, alternative 1 with the second hazard and alternative 1 with the third hazard as a single grouping evaluation. A grouping cost effectiveness is computed. The process is then repeated using improvement alternative 2 with each of the



NOTES :

1. MAXIMUM NUMBER OF HAZARDS PER GROUP = 15
2. MAXIMUM NUMBER OF IMPROVEMENT ALTERNATIVES = 4 PER HAZARD
3. NUMBER OF IMPROVEMENT ALTERNATIVES MUST BE EQUAL FOR EACH HAZARD IN GROUP

Figure 5-1. Arrangement of input data cards.

three hazards and a grouping cost effectiveness is again computed. Therefore, compatible alternatives must be in the proper sequence throughout the grouping deck arrangement.

Since a grouping cost-effectiveness is computed in the above described manner, it should be noted that within each grouping, the same number of improvement alternatives must be specified for each hazard, even if for one hazard in the grouping, a "No Improvement" alternative is recommended. For example, if in a three-hazard grouping, two improvement alternatives are recommended, two improvement alternative cards must be inserted behind each of the three hazard inventory cards. If two improvement alternative cards were inserted for the first two hazards and only one for the third hazard, the omission error would be detected during data reading, and no computer execution would occur on either of the two improvement alternatives even though the error applied only to the second improvement alternative. An error message, therefore, would be printed on the output data and no grouping cost-effectiveness would be computed for either improvement alternative.

REMOTE TERMINAL OPERATION

The computer program is accessed from the D-19 automation computer facilities by remote terminals in each District. Control cards for remote terminal operation will be supplied each District.

ERROR MESSAGES

Since computer program execution is highly dependent on precise data input both in type and location, error messages have been incorporated into the program to "flag" input errors. Due to the complexity of the program and extensive branching within subroutines from several key data sources, it is expected that errors will occur. To avoid program termination (which would normally occur for each data error), the program has been developed to bypass the erroneous data, print out an error message, and continue with the next data input.

Fifty-one error messages have been incorporated. They are listed in Table 5-1. In most cases, the message is self-explanatory. Each error message is identified on the data output by reference number. The list of messages is printed out for each computer run. Also printed out is the location within the program or subroutine in which the data error affected the program execution. The message indicates the type of error and provides direction to remedy the data error. The program will automatically terminate if 100 error messages are printed during any run.

A message, "Hazard Improvement Not Cost-Effective," may appear in the data output. This is not an error message, and is not included in the 100-maximum count for automatic program termination. It indicates that the recommended improvement produces, for all intents and purposes, no safety benefit over the hazard currently existing. Under certain circumstances it indicates that the recommended

TABLE 5-1

LIST OF ERROR OR FLAG MESSAGES

Message Number	Subroutine Calling Message	Description of Message
1	HAZARD	End milepoint at hazard not specified
2	PTHAZ	Unmatched point hazard and improvement codes
3	PTHAZ	Non-existing improvement classification specified in column 41 of improvement form
4	DITCH	Non-existing ditch improvement code classification
5	RAILNG	Guardrail installation not necessary--reexamine roadway group hazard
6	HAZARD	Non-existing hazard classification specified in column 51 of inventory form
7	PTHAZ	Non-existing point hazard improvement code (column 40)
8	PTHAZ	No improvement needed, flat slopes and/or offset greater than 30 ft (right side or median near side)
9	PTRAIL	Distance between guardrail and obstacle less than 3.0 ft
10	LGHAZ	No improvement needed, flat slopes and/or offset to longitudinal hazard > 30 ft (full median)
11	CURB	Non-existing curb improvement classification specified in column 42 of improvement form
12	BRIDGE	Non-existing bridgerail improvement classification specified in column 42 of improvement form
13	BRIDGE	Non-existing bridgerail improvement classification specified in column 43 of improvement form

TABLE 5-1, CONTINUED

Message Number	Subroutine Calling Message	Description of Message
14	RAIL	Non-existing guardrail improvement classification specified in column 42 of improvement form
15	RAIL6	Guardrail end-treatment adjacent to bridge incorrectly specified
16	LGHAZ	Longitudinal hazard offset on non-critical slopes greater than 30 ft (right or median near side)
17	SLOPE1	Non-existing slope direction classification specified on inventory form
18	LGHAZ	Curb improvement valid only for curb hazard
19	ZERO, DITCH	Logic breakdown--vehicle not permitted to penetrate guardrail
20	PTHAZ	No improvement needed, flat slopes and/or offset greater than 30 ft (median inventoried across)
21	ZERO	Logic breakdown in subroutine ZERO--refer to flow charts
22	PTHAZ	Point hazard offset greater than 30 ft on right or median near side (critical slopes)
23	MAIN PROGRAM	Stop computer program -- 100 or more errors
24	HAZARD	Unmatched identification information
25	LGHAZ	Bridgerail improvement valid only for bridgerail hazard
26	LGHAZ	Guardrail improvement valid only for guardrail hazard
27	INVTRY	End of data and program

TABLE 5-1, CONTINUED

Message Number	Subroutine Calling Message	Description of Message
28	HAZARD	Unequal number of improvement alternatives per hazard in group
29	RAIL1	Not permitted to remove 1 group on median side if other group on same side is not removed
30	MAIN PROGRAM	*Hazard improvement not cost-effective*
31	HAZARD	Hazards on right side and left side of roadway cannot be grouped together
32	HAZARD	Guardrail end treatment code not specified on inventory form
33	HAZARD	Guardrail end treatment code not defined--value greater than 4.
34	HAZARD	Improvement costs not specified
35	HAZARD	Guardrail hazard repair and/or maintenance costs not specified
36	HAZARD	Guardrail improvement repair and/or maintenance costs not specified
37	LGHAZ	Longitudinal hazard offset greater than 30 ft (critical slopes) on right or median near side
38	ZERO	Logic breakdown in group consisting of point hazards and group on both sides of median
39	ZERO	Improvement not needed for existing point hazard behind existing guardrail
40	----	Reserved for future use
41	BRIDGE	Median inventoried across width allowed only for improvement codes 2 or 4 in column 43

TABLE 5-1, CONTINUED

Message Number	Subroutine Calling Message	Description of Message
42	DITCH	Ditch improvement not needed behind existing guardrail
43	LGHAZ	Ditch improvement valid only for ditch hazard
44	BRGR	Approach and departing guardrail offsets not specified in columns 44 through 51
45	LGHAZ	Non-existing improvement classification specified in column 41 of improvement form
46	DTRAIL	Median inventoried across full width but no group specified to protect far side
47	SLHAZ	Slope improvement not specified in columns 40 or 41 on improvement form
48	SLRAIL	Inventory median full width only if group also needed on far side to protect slope
49	LGHAZ	Non-existing longitudinal hazard improvement code (column 40)
50	BRGR1	Logic breakdown in placing guardrail between successive bridges
51	BRGR	Bridge approach or departing guardrail lateral offset in wrong location in Box A

improvement in fact produces a more hazardous situation than the existing one. The message may be obtained under two circumstances as shown below.

The simplified cost-effectiveness ratio is determined by:

$$\text{Cost-Effectiveness} = \frac{\text{Cost}}{H_B - H_A}$$

where H_A = Hazard Index after Improvement

H_B = Hazard Index before Improvement (Existing)

If H_A is greater than H_B, the denominator becomes negative. This means that the recommended alternative, is in fact, more hazardous than the existing situation. Obviously, it is impractical to incur costs to produce a more critical situation than currently exists; therefore, the flag message "Hazard Improvement Not Cost-Effective" is printed out when this occurs and the cost-effectiveness ratio is not computed.

When H_A is only slightly less than H_B, the denominator becomes very small numerically, hence the cost-effectiveness ratio becomes very large. Based on statistical logic, a lower cut-off level has been incorporated into the model such that when the numerical value of $H_B - H_A$ is less than 0.02, the flag message is printed out and the cost-effectiveness ratio is not computed. The 0.02 level indicates a 55-percent probability of no hazard reduction.

The message, "No Improvements Recommended" merely indicates that for that particular hazard, the recommended safety improvement was "No Improvement Recommended" (code 4, column 40, improvement form). It is not counted as an error message for program termination.

If a data error occurs within a grouping, a group cost-effectiveness cannot be determined. Therefore, an error message will be printed out and the message, "End Group" will also appear where the grouping cost-effectiveness value would normally appear. The message "Group" denotes that the cost-effectiveness value represents a total grouping value.

SEVERITY INDICES

The severity index is the relative measure of an obstacle's ability to produce a given outcome on the vehicle and/or occupants when a collision occurs. The severity indices selected for the NCHRP 20-7 Project represented an "average" set of values based on limited data and were, to a large degree, determined subjectively. To adapt the NCHRP 20-7 results to the needs of the Texas Highway Department, a two-part questionnaire was developed to subjectively determine severity indices for common types of roadside hazards expected in the state. The first part of the questionnaire consisted of ninety-eight hazard comparison statements to which an "agree" or "disagree" response was requested. The second part consisted of an evaluation of fifty-two roadside hazards and conditions; the respondent was requested to numerically rate the potential hazard of each on a one-to-ten rating scale.

The questionnaire was administered to individuals employed by the

State of Texas in professions related to highway safety. These professions included the areas of design, operations, maintenance, law enforcement, and administration. The results were evaluated and a base severity index on the one-to-ten scale was determined.

The cost-effectiveness ratio is extremely sensitive to the severity index. A severity index reduction from 10 to 8 represents a much greater safety improvement than a reduction from 5 to 3 although the numerical reduction is the same. Therefore, to provide a relative weighting system, cost values supplied by the Texas Highway Department were used and the one-to-ten scale was expanded to a one-to-one-hundred scale according to the following relationship:

$$0 < SI_B < 4, \; SI_A = SI_B$$

$$4 < SI_B < 7, \; SI_A = 7SI_B - 24$$

$$7 < SI_B < 10, \; SI_A = 25SI_B - 150$$

where

SI_B = Base Severity Index (one-to-ten scale)

SI_A = Adjusted Severity Index (one-to-one-hundred scale)

The adjusted severity indices are used for calculation purposes in the computer program. Severity indices for all coded hazards are incorporated in the computer program. As the list of inventoried hazards is expanded, corresponding severity indices must be added to the computer program. The severity indices used and the adjustment methodology are presented in Volume 2, Computer Program Documentation Manual.

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2. Texas Department of Public Safety, Motor Vehicle Traffic Accidents, 1970.

3. Glennon, John C. "A Cost-Effectiveness Priority Approach for Roadside Safety Imrpovement Programs on Freeways," NCHRP Project 20-7, Task Order 1/1, Research Report 625-2F, Texas Transportation Institute, February, 1972 (also published as NCHRP Report 148).

4. Cost-Effectiveness Priority Program for Roadside Safety Improvements on Texas Freeways. Texas Transportation Institute/Texas Highway Department Research Study 2-8-72-11.

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6. Hutchinson, John W., and Kennedy, Thomas W. "Medians of Divided Highways--Frequency and Nature of Vehicle Encroachments," University of Illinois Engineering Experiment Station Bulletin 487, 1966.

7. Weaver, G. D., Marquis, E. L., and Olson, R. M. "The Relation of Side Slope Design to Highway Safety," NCHRP 20-7, Task 2 Final Report, Texas Transportation Institute Research Report 626F, September 1974.

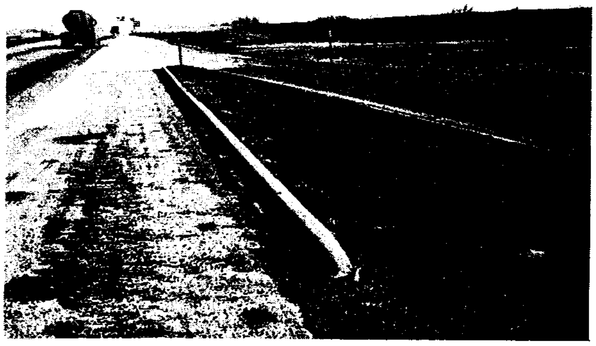
APPENDIX A

PHOTOGRAPHS OF ROADSIDE HAZARDS

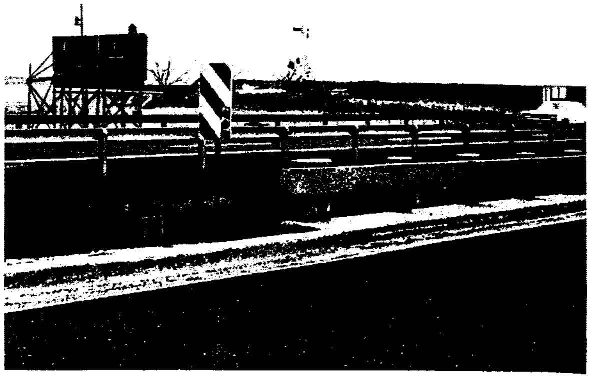
Included in this Appendix are photographs of roadside hazards depicting the identification and descriptor codes for hazard inventory purposes. The identification and descriptor codes for applicable hazards are listed in Table 2-1 (page 2-6).

It should be noted that all hazards having identification or descriptor codes enclosed in a circle in Table 2-1 are inventoried as point hazards. If the identification code is so designated, all descriptor codes within that major classification apply to point hazard codes. In some categories, only certain descriptor codes apply to point hazards (ex. bridge piers, and open gap between parallel bridges).

a. Mountable Curb Design
(Code 05-01)

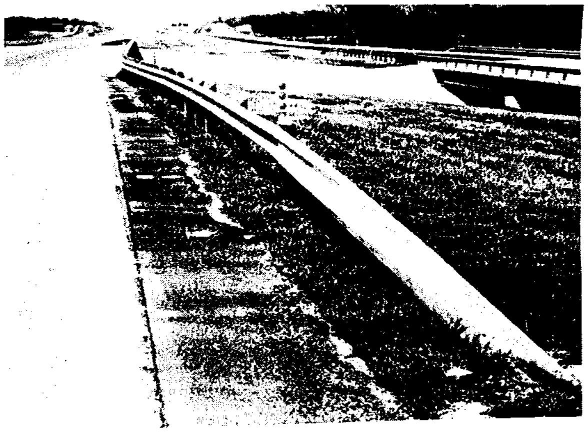


b. Non-mountable Curb Design
Less than 10 inches High
(Code 05-02)

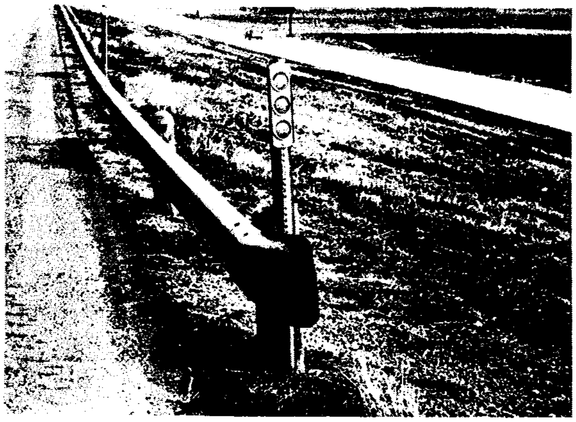


c. Barrier Curb Greater
than 10 inches High
(Code 05-03)

Figure A-1. Curb Hazards (Identification Code 05).

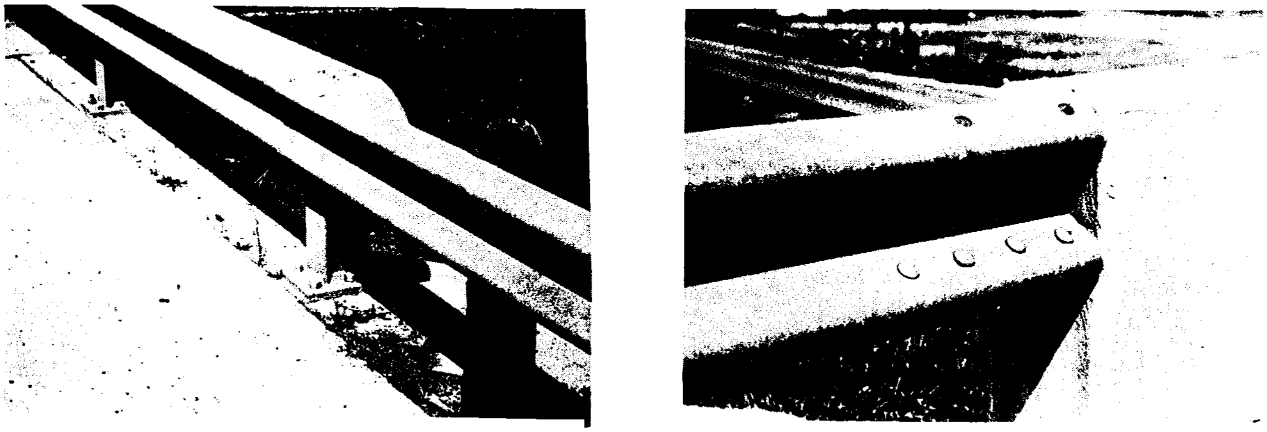


a. Safety-Treated Guardrail End (Turned Down)



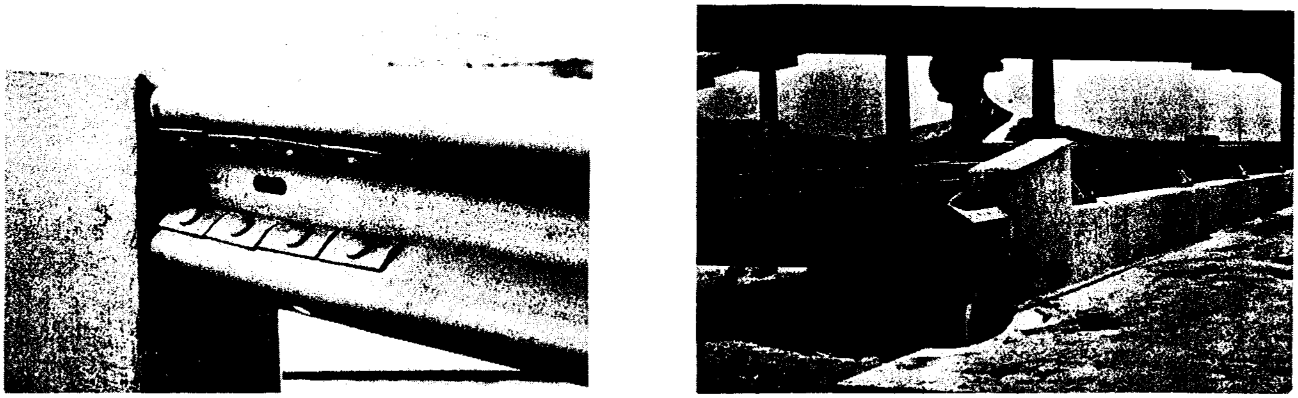
b. Blunt Guardrail End--Not Safety Treated

Figure A-2. Guardrail End Treatment.



a. Full Beam Strength Developed Because Rail is Carried Across Bridge

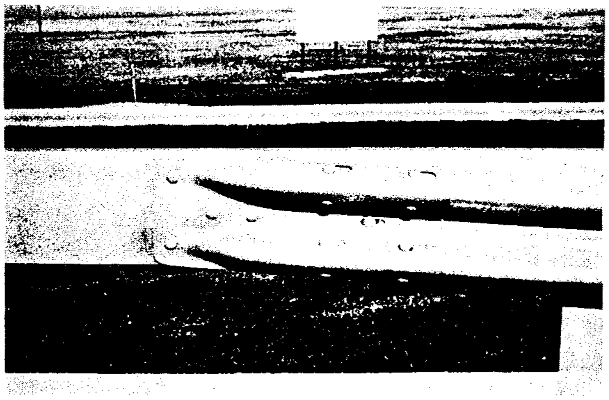
b. Full Beam Strength Developed Through 8-Bolt Connection



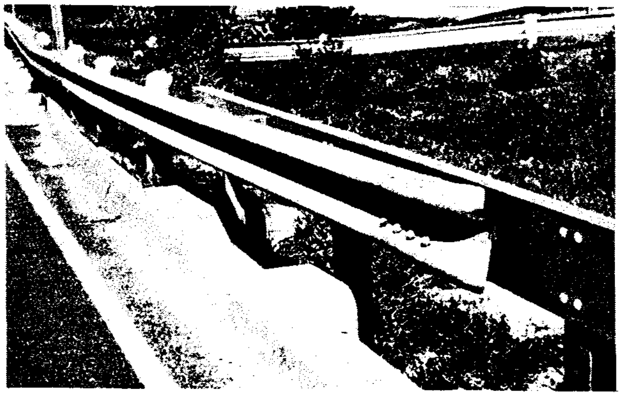
c. Full Beam Strength Developed Through 8-Bolt Connection With Washers

d. Construction of 8-Bolt Connection Anchor Bracket

Figure A-3. Approach Guardrail--Full Beam Strength Connection.

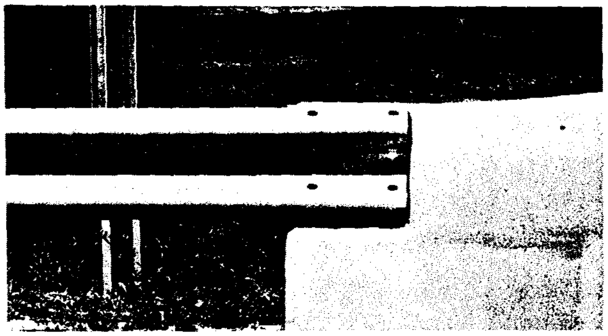


a. Michigan End Shoe--Develops Full Beam Strength

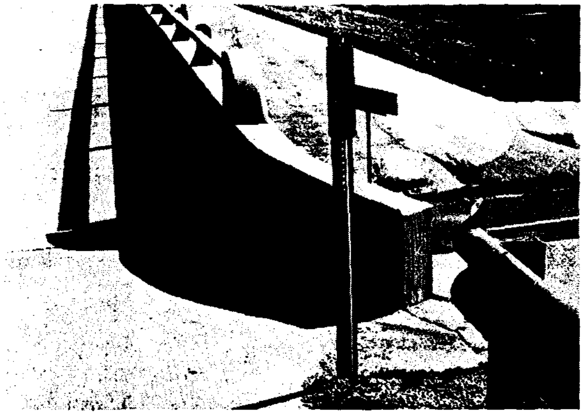


b. Shop Fabrication--Develops Full Beam Strength

Figure A-4. Approach Guardrail--Full Beam Strength Connection.

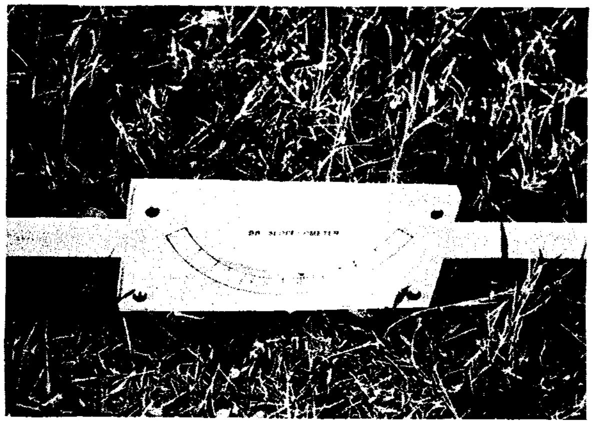


a. One-Bolt Guardrail/Bridge Connection.
Does Not Develop Beam Strength.



b. Approach Guardrail Not Connected to
Bridge Leaving Open Gap and Exposed
Wingwall.

Figure A-5. Approach Guardrail--Not Full Beam Strength Connection.



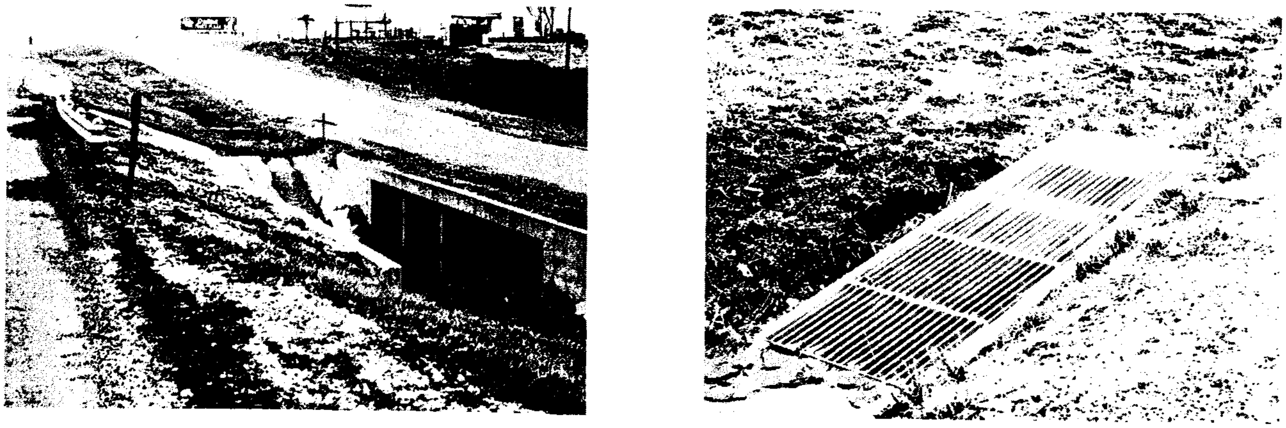
a. Slopeometer

b. Use of Slopeometer to Measure Roadside Slope Ratio

Figure A-6. Roadside Slope Measurement.

a. Culvert Headwall
(Code 09-01)

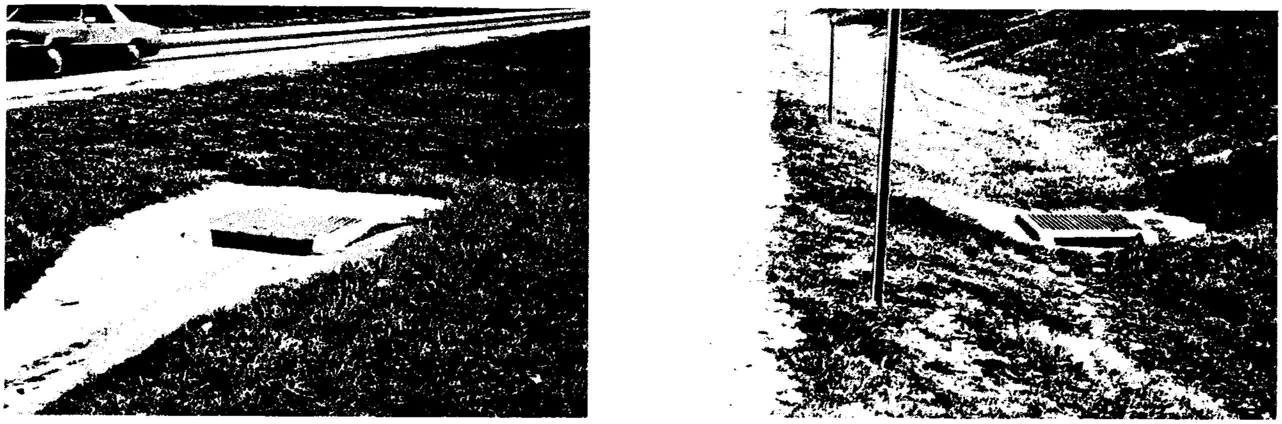
b. Culvert Headwall
(Code 09-01)



c. Gap between Culvert Headwalls on Parallel Roads
(Code 09-02)

d. Culvert with Sloped Grate
(Code 09-03)

Figure A-7. Culvert Hazards (Identification Code 09).

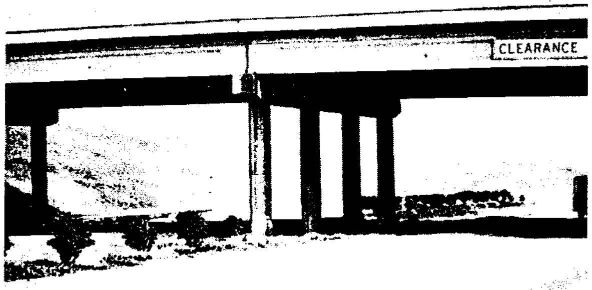


a. Raised Drop Inlet (Table-top) in Median
(Code 10-01)

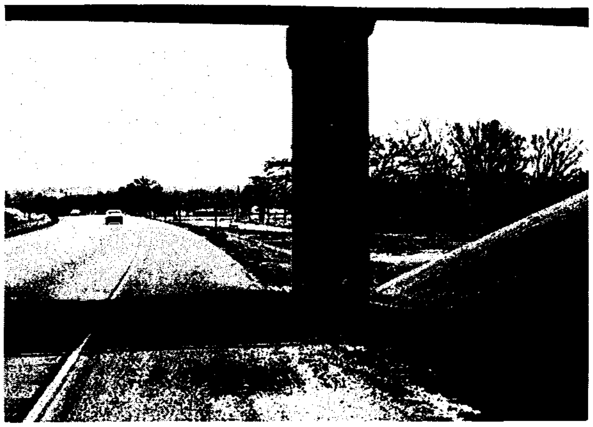
b. Raised Drop Inlet (Table-top) Alongside Outer Travel Lane
(Code 10-01)

c. Curb Inlet
(Inventoried as Non-Mountable Curb Less than 10 Inches High)
(Code 05-02)

Figure A-8. Inlet Hazards (Identification Code 10).

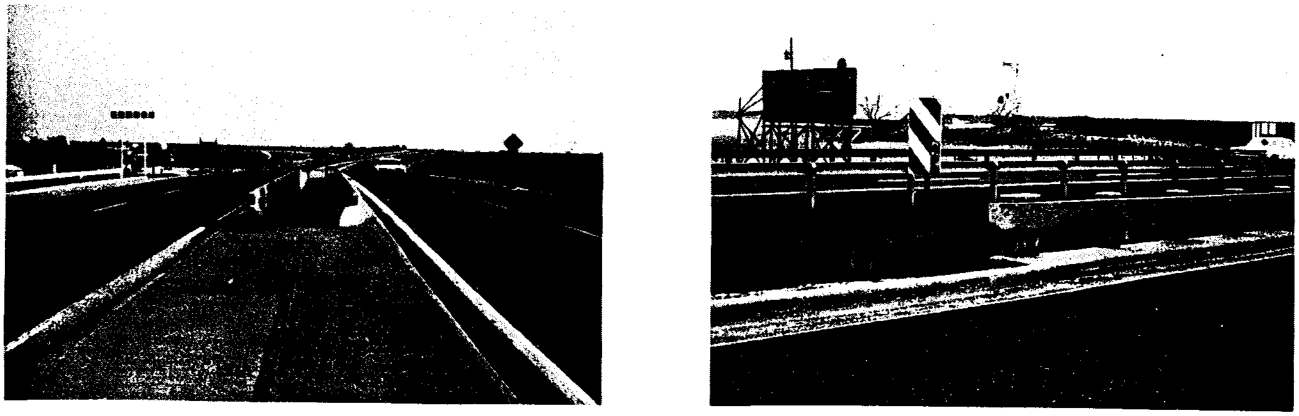


a. Bridge Piers Without Guardrail Protection
(Code 11-01)



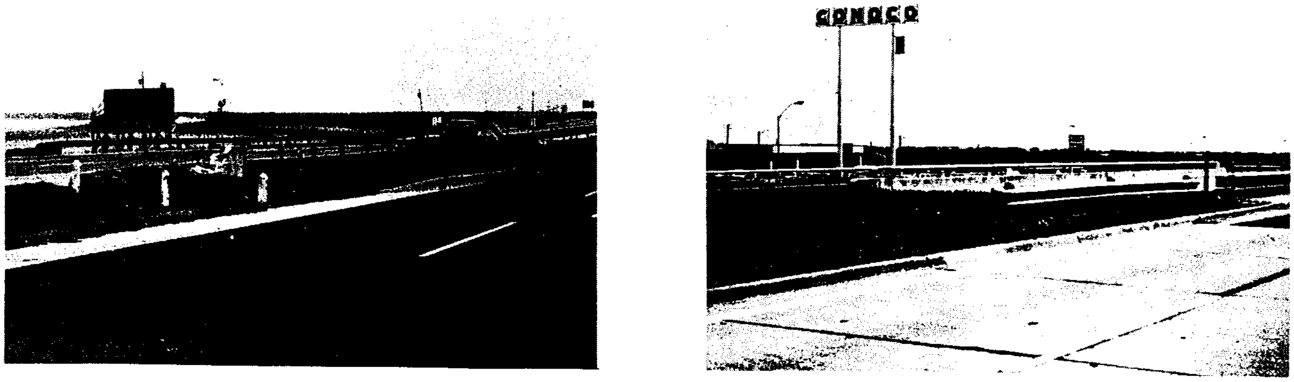
b. Slope Faced Bridge Abutment Behind Unprotected Piers
(Code 11-03)

Figure A-9. Hazards Associated with Roadway Under Bridge Structure (Identification Code 11).



a. Unprotected Open Gap Between Parallel Bridges
(Code 12-01)

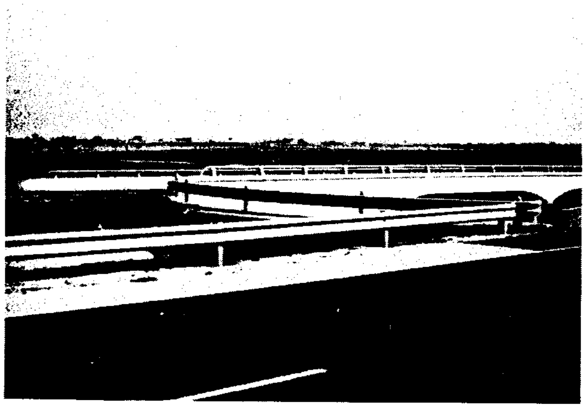
b. Open Gap Between Parallel Bridges
(Code 12-01)



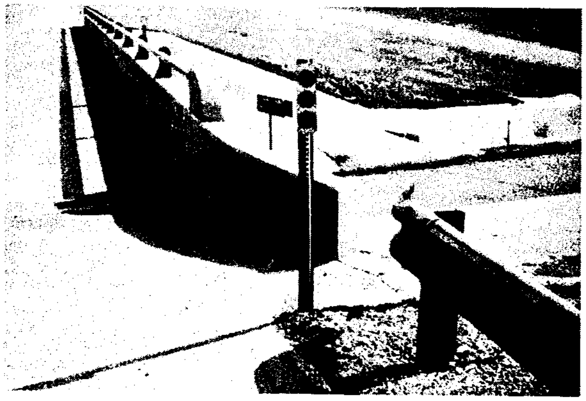
c. Semi-protected Open Gap Between Parallel Bridges. Vehicle can Easily Enter Gap
(Code 12-01)

d. Open Gap Semi-protected by Short Guardrail Section. Vehicle can Easily Enter Gap
(Code 12-01)

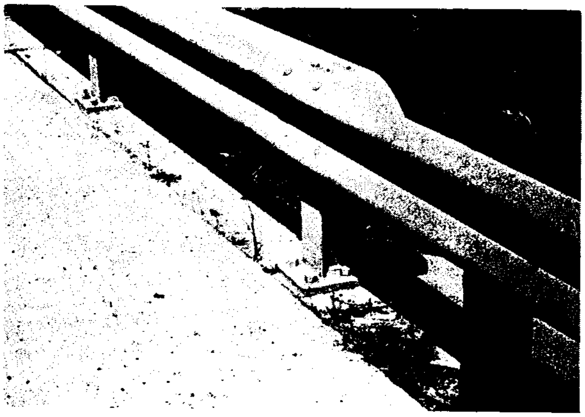
Figure A-10. Hazards Associated with Roadway Over Bridge Structure (Identification Code 12).



a. Closed Gap Between
Parallel Bridges
(Code 12-02)



b. Rigid Bridgerail--Smooth
and Continuous Construction
(Code 12-03)



c. Semi-Rigid Bridgerail--Smooth
and Continuous Construction
(Code 12-04)

Figure A-11. Hazards Associated with Roadway Over Bridge Structure (Identification Code 12).

APPENDIX B
CASE EXAMPLES OF DATA INPUT/OUTPUT

Five hypothetical sets of inventory and improvement data input are presented in this Appendix to illustrate the procedure for use of the two data forms. Typical output data are shown for each example.

CASE 1--POINT HAZARD IN MEDIAN (CONTROLLED ACCESS HIGHWAY)

The location and geometry of the set of three bridge piers assumed to be a rectangular point hazard (3 ft x 32 ft) are shown in Figure B-1. Typical hazard inventory data for this point hazard are shown in Figure B-2 with four possible improvement recommendations listed in the "Recommendations" section at the bottom of the form. Figures B-3 through B-6 illustrate the manner in which improvement forms would be completed to evaluate each of the four improvement recommendations. Figure B-7 presents the cost effectiveness data output obtained from the program for these four recommendations.

CASE 2--HAZARD GROUPING IN MEDIAN (CONTROLLED ACCESS HIGHWAY)

Figure B-8 illustrates the location of five hazards in a grouping. Each cluster of trees is considered to be a point hazard within the group. The group also includes a guardrail, a critical slope, and a raised drop inlet. Each hazard within the group is inventoried individually. Although several alternatives exist, only two are discussed for illustrative purposes. Figures B-9 through B-23 illustrate the data input to determine the group cost-effectiveness value for the two selected improvement alternatives. Figure B-24 presents cost-effectiveness data output for Case 2.

CASE 3--HAZARD GROUPING ON RIGHT SIDE (CONTROLLED ACCESS HIGHWAY)

Figure B-25 illustrates a typical group of hazards that may be encountered at an overcrossing structure. The group considered includes an approach guardrail, a sidewalk curb, a bridge rail, and a slope at each end of the bridge. These hazards along the right side of the travel lane constitute a group. Similar hazards along the median side of the same travel lanes would be coded as a different group. It should be noted that the subject group contains all hazards associated with the structure both upstream from, on, and downstream from the bridge. To illustrate, only one improvement alternative is specified for each hazard in the group and a total group cost-effectiveness value is determined. The process would be duplicated for other selected improvement alternatives. Figures B-26 through B-35 illustrate the input data. Figure B-36 presents cost-effectiveness data output.

CASE 4--CONTINUOUS GUARDRAIL BETWEEN BRIDGES (FM HIGHWAY)

Figure B-37 illustrates a group of hazards adjacent to and between two closely spaced overcrossing structures on a Farm-to-Market highway. The hazard group includes approach and departing slopes and bridge railings at each bridge. A clump of trees (considered as a point hazard) is located on the critical slope between the bridges.

Neither bridge contains approach or departing guardrail. For illustration purposes, only the right side hazard group is coded. The single improvement involves installation of approach guardrail at the upstream bridge, departing guardrail at the downstream bridge, upgrading of both bridgerails, and installation of continuous guardrail between the two bridges. Figures B-38 through B-49 illustrate the input data. Output is shown in Figure B-50.

CASE 5--POINT HAZARD ON RIGHT SIDE (NON-CONTROLLED ACCESS HIGHWAY)

Figure B-51 illustrates a rigid sign (point hazard) located alongside a Farm-to-Market two lane highway. Three improvement recommendations are recommended: removal, protection with guardrail, and installation of an impact-attenuation system. Hazard inventory data are shown in Figure B-52, improvement data in Figures B-53 through B-55, and data output in Figure B-56.

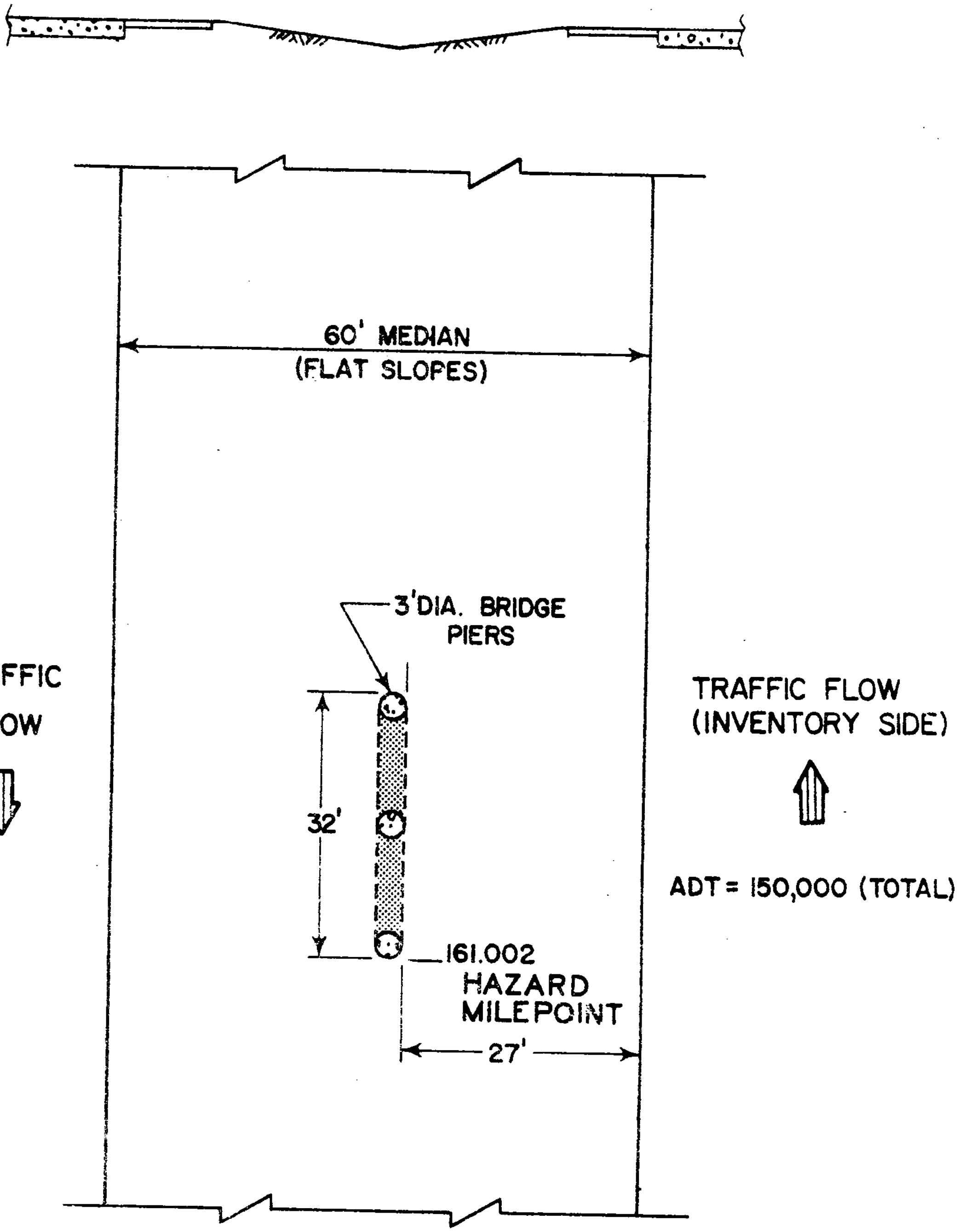
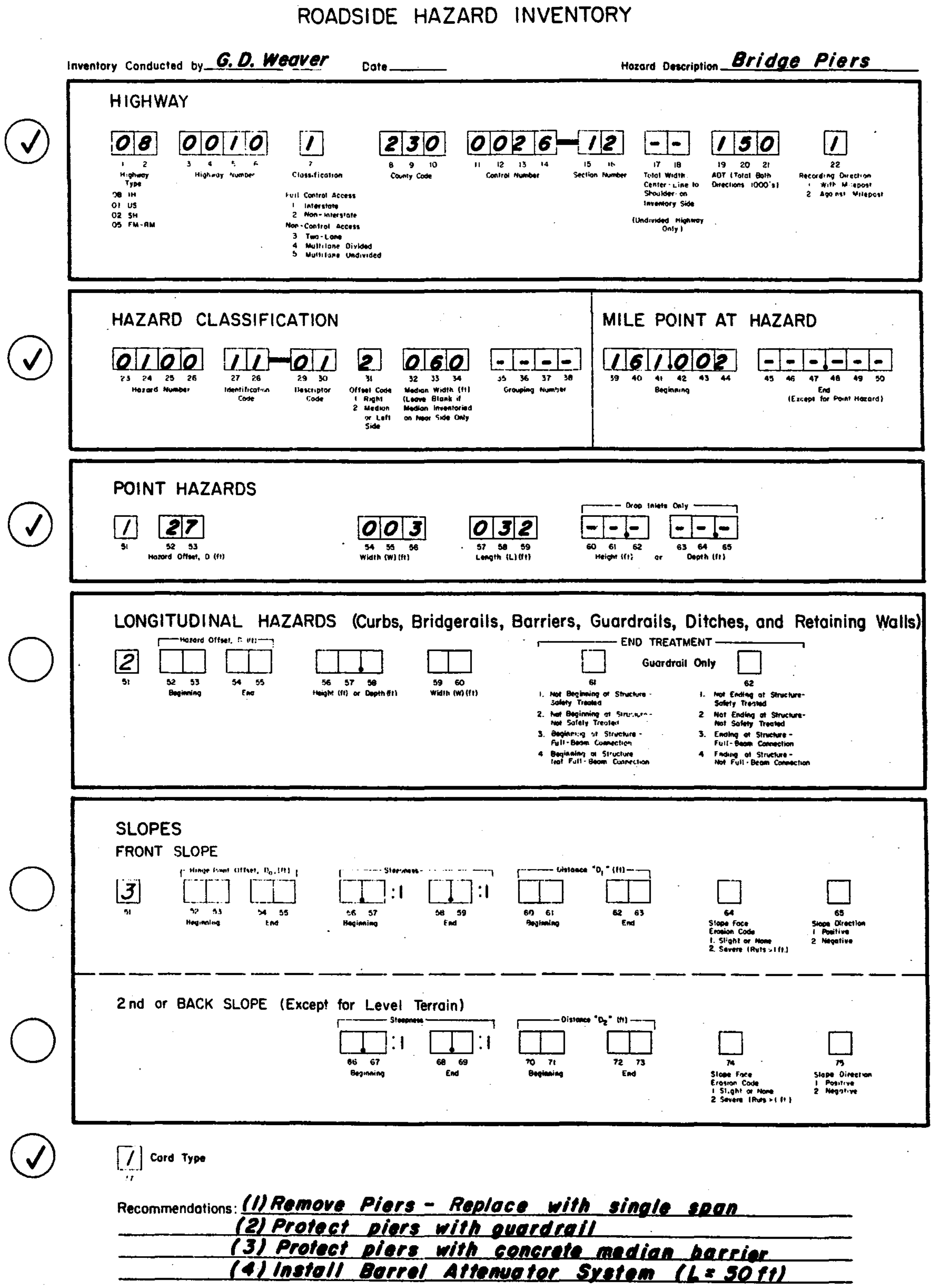


Figure B-1. Hazard description--Case 1.



ROADSIDE HAZARD INVENTORY

Inventory Conducted by G. D. Weaver Date ______ Hazard Description Bridge Piers

○ ✓

HIGHWAY

08	0010	1	230	0026	12	- -	150	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1 Interstate 2 Non-Interstate Non-Control Access 3 Two-Lane 4 Multilane Divided 5 Multilane Undivided	County Code	Control Number	Section Number	Total Width Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

BOX 1

○ ✓

HAZARD CLASSIFICATION

0100	11	01	2	060	- - - -
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1 Right 2 Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

161.002	- - - . - - -
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

BOX 2

○ ✓

POINT HAZARDS

1	27	003	032	- - . -	- - . -
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Drop Inlets Only Height (ft)	or Depth (ft)

BOX 3

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

2	☐☐	☐☐	☐☐.☐	☐☐	☐	Guardrail Only ☐
51	52 53	54 55	56 57 58	59 60	61	62
	Hazard Offset, D (ft) Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	END TREATMENT 1. Not Beginning of Structure - Safety Treated 2. Not Beginning at Structure - Not Safely Treated 3. Beginning at Structure - Full-Beam Connection 4 Beginning at Structure Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2 Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4 Ending at Structure - Not Full-Beam Connection

BOX 4

○

SLOPES

FRONT SLOPE

3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Hinge Point Offset, D_0, (ft) Beginning	End	Steepness Beginning	End	Distance "D_1" (ft) Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft.)	Slope Direction 1 Positive 2 Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Steepness Beginning	End	Distance "D_2" (ft) Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)	Slope Direction 1 Positive 2 Negative

BOX 5

○ ✓

1 Card Type

77

Recommendations: (1) Remove Piers - Replace with single span
(2) Protect piers with guardrail
(3) Protect piers with concrete median barrier
(4) Install Barrel Attenuator System (L = 50 ft)

Figure B-2. Hazard inventory--Case 1.

ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0100 (1 2 3 4 Hazard Number) — 0010 (5 6 7 8 Highway Number) · 230 (9 10 11 Country Code) — 0026 (12 13 14 15 Control Number) — 12 (16 17 Section Number) — **Piers -Remove** (Hazard and Improvement Description)

✓ 225000 (18 19 20 21 22 23 First Cost of Improvements ($))

Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0000 (28 29 30 31 Improvement)

Normal Maintenance ($/yr): 0000 (32 33 34 35 Hazard) 0000 (36 37 38 39 Improvement)

POINT HAZARD IMPROVEMENTS

BOX 2

✓ 1 (40) 1 (41) Alleviate Hazard — 1 (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb — ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42) — ▨ (43)
1 Reshape to Safe Cross Section
2. Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)
Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction 1. Positive 2. Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)
Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction 1. Positive 2. Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOXES A & B

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-3. Improvement alternative 1--Case 1 (Remove piers, replace with single span bridge).

ROADSIDE HAZARD IMPROVEMENTS

✓ 0100 — Hazard Number (1 2 3 4) | 0010 — Highway Number (5 6 7 8) | 230 — County Code (9 10 11) | 0026 — Control Number (12 13 14 15) – 12 — Section Number (16 17) | Piers - Install G.R. — Hazard and Improvement Description

✓ 003600 — First Cost of Improvements ($) (18 19 20 21 22 23) | Repair Cost per Collision ($): 0000 — Hazard (24 25 26 27); 0050 — Improvement (28 29 30 31) | Normal Maintenance ($/yr): 0000 — Hazard (32 33 34 35); 0150 — Improvement (36 37 38 39)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

✓ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) 23 (42 43) Lateral Offset (ft) Right or Median Near Side; 34 (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft); ☐☐ (45 46) Width (ft); ☐☐ (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_o)(ft): ☐☐ (42 43) Beginning – ☐☐ (44 45) End
Steepness: ☐.☐ :1 (46 47) Beginning; ☐.☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning – ☐☐ (52 53) End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56) Beginning; ☐.☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning – ☐☐ (61 62) End
☐ (63) Slope Direction
1 Positive
2. Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69); End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning – ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning – ☐☐ (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning; ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning; ☐☐☐☐ (55 56 57 58) End

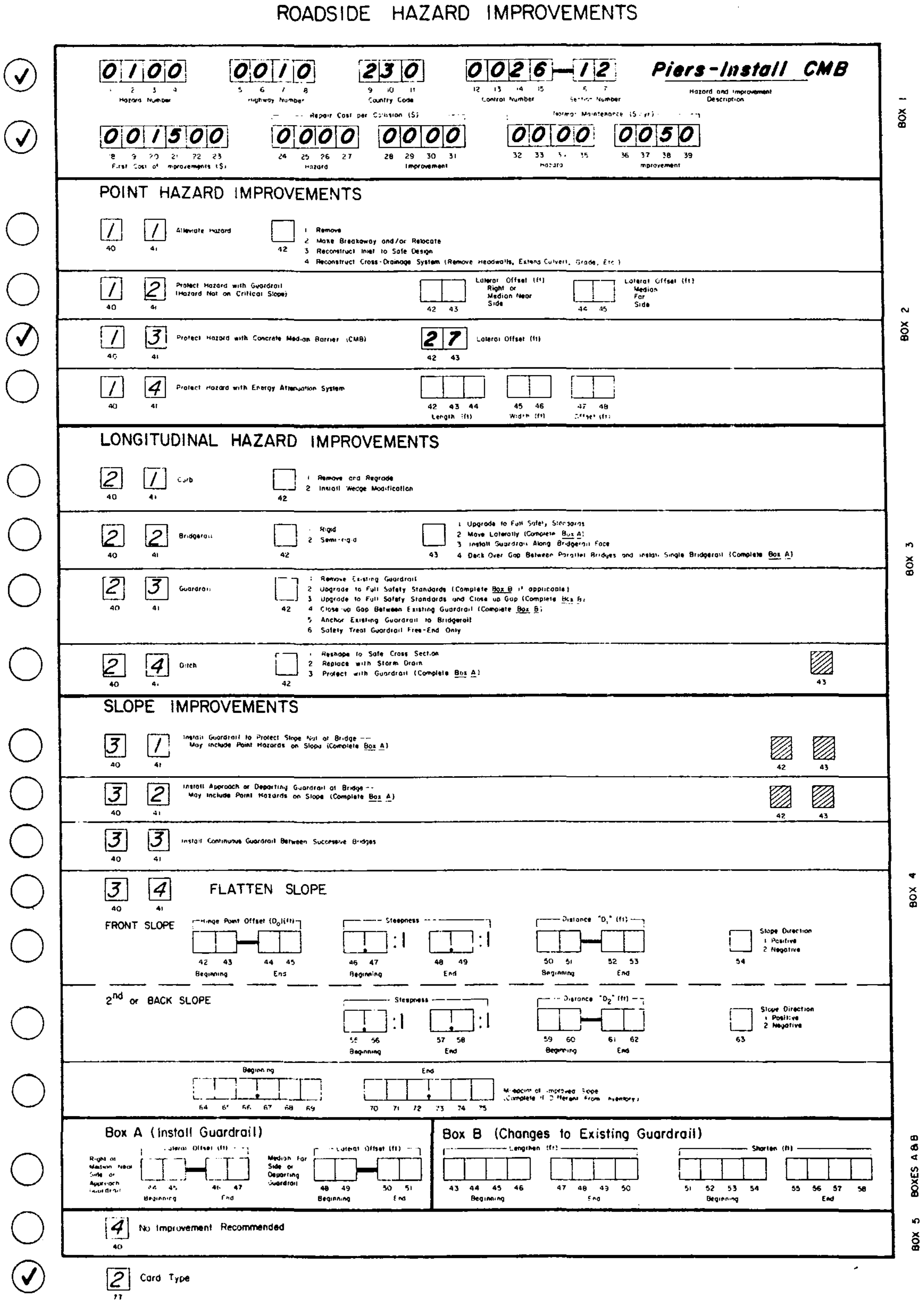
BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-4. Improvement alternative 2--Case 1 (Protect piers with guardrail).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0100 (1 2 3 4 Hazard Number) 0010 (5 6 7 8 Highway Number) 230 (9 10 11 Country Code) 0026—12 (12 13 14 15 Control Number; 16 17 Section Number) **Piers-Install CMB** (Hazard and Improvement Description)

✓ 001500 (18 19 20 21 22 23 First Cost of Improvements ($)) Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0000 (28 29 30 31 Improvement) Normal Maintenance ($/yr): 0000 (32 33 34 35 Hazard) 0050 (36 37 38 39 Improvement)

POINT HAZARD IMPROVEMENTS

BOX 2

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

✓ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) 27 (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐—☐☐ (42 43 Beginning; 44 45 End)
Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)
Distance "D_1" (ft): ☐☐—☐☐ (50 51 Beginning; 52 53 End)
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)
Distance "D_2" (ft): ☐☐—☐☐ (59 60 Beginning; 61 62 End)
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Mileposts of Improved Slope (Complete if Different From Inventory)

BOXES A & B

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐—☐☐ (44 45 Beginning; 46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐—☐☐ (48 49 Beginning; 50 51 End)

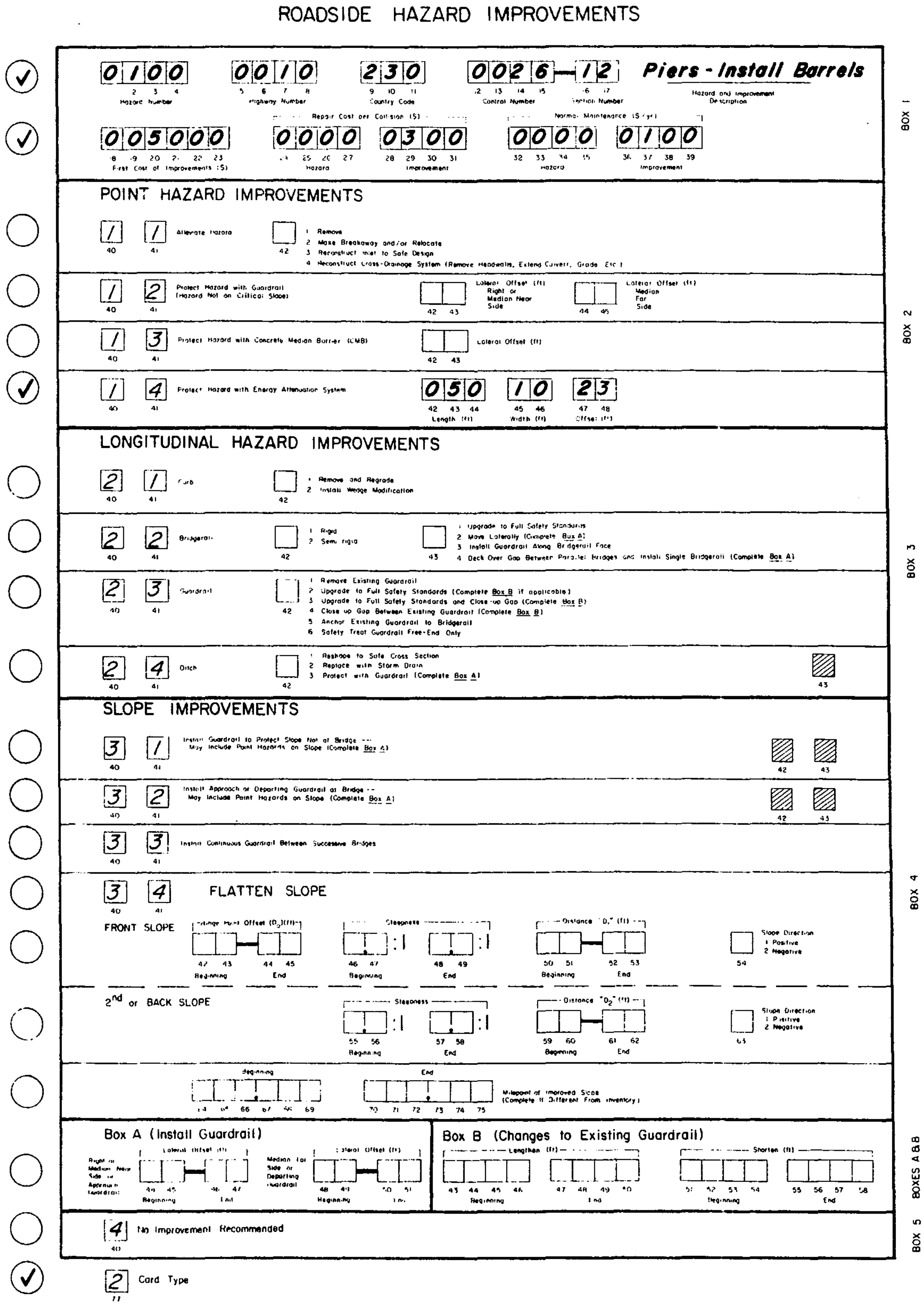
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-5. Improvement alternative 3--Case 1 (Protect piers with concrete median barrier).



ROADSIDE HAZARD IMPROVEMENTS

☑ 0100 — 2 3 4 Hazard Number; 0010 — 5 6 7 8 Highway Number; 230 — 9 10 11 County Code; 0026—12 — 12 13 14 15 Control Number, 16 17 Section Number; **Piers - Install Barrels** — Hazard and Improvement Description

☑ 005000 — 18 19 20 21 22 23 First Cost of Improvements ($)

Repair Cost per Collision ($): 0000 — 24 25 26 27 Hazard; 0300 — 28 29 30 31 Improvement

Normal Maintenance ($/yr): 0000 — 32 33 34 35 Hazard; 0100 — 36 37 38 39 Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ 42
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ 42 43 Lateral Offset (ft) Right or Median Near Side ☐☐ 44 45 Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ 42 43 Lateral Offset (ft)

☑ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System 050 — 42 43 44 Length (ft); 10 — 45 46 Width (ft); 23 — 47 48 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ 42
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ 42
1 Rigid
2 Semi rigid

☐ 43
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ 42
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ 42
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ 43

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ 42 ▨ 43

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ 42 ▨ 43

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐—☐☐ 42 43 Beginning, 44 45 End
Steepness: ☐.☐:1 46 47 Beginning; ☐.☐:1 48 49 End
Distance "D_1" (ft): ☐☐—☐☐ 50 51 Beginning, 52 53 End
☐ 54 Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐:1 55 56 Beginning; ☐.☐:1 57 58 End
Distance "D_2" (ft): ☐☐—☐☐ 59 60 Beginning, 61 62 End
☐ 63 Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐.☐☐☐ 64 65 66 67 68 69; End ☐☐☐.☐☐☐ 70 71 72 73 74 75 Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐—☐☐ 44 45 Beginning, 46 47 End
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐—☐☐ 48 49 Beginning, 50 51 End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ 43 44 45 46 Beginning; ☐☐☐☐ 47 48 49 50 End
Shorten (ft): ☐☐☐☐ 51 52 53 54 Beginning; ☐☐☐☐ 55 56 57 58 End

BOXES A&B

○ 4 (40) No Improvement Recommended

BOX 5

☑ 2 (77) Card Type

Figure B-6. Improvement alternative 4--Case 1 (Install barrel attenuation system).

```
                                                C O S T   E F F E C T I V E N E S S   P R O G R A M

                                                               TYPE HIGHWAY = INTERSTATE (CODE 08)
                                                     HIGHWAY CLASSIFICATION = CONTROLLED ACCESS -- INTERSTATE

                                                                HIGHWAY NO  =    10
                                                                 COUNTY NO  =   230
                                                               DISTRICT NO  =    19
                                                                CONTROL NO  =    26
                                                                SECTION NO  =    12

                                                      RECORDING DIRECTION  =     1
                                                                ADT (1000)  =   150
                                                                      LIFE  =    20(YRS)
                                                                  INTEREST  =   8.0(PERCENT)
                                                                      DATE  = 10-74

                        H   A   Z   A   R   D                                    I   M   P   R   O   V   E   M   E   N   T

HAZARD  IDENT  DESC     END    SEVERITY  OFFSET  GROUP     MILE-POST          IMPR  IMPR  SEVERITY  FIRST  PRESENT  ANNUAL    COST
  NO     CODE  CODE  TREATMENT  INDEX     CODE    NO     BEG      END          ALT  CODE   INDEX     COST   WORTH    COST   EFFECTIVE
                     BEG   END                                                                                                VALUE
                                                                                                     ($)     ($)    ($/YR)

  100    11       1    0     0     82.5     2         0  161.002 161.008         1  1-1-1-0    0.0   225000   224999   22916      10114

  100    11       1    0     0     82.5     2         0  161.002 161.008         2  1-2-0-0   *HAZARD IMPROVEMENT NOT COST-EFFECTIVE*

  100    11       1    0     0     82.5     2         0  161.002 161.008         3  1-3-0-0    2.6     1500     1990     202         96
  100    11       1    0     0     82.5     2         0  161.002 161.008         4  1-4-0-0    1.0    10000    12181    1240        576
```

Figure B-7. Cost-effectiveness program output--Case 1.

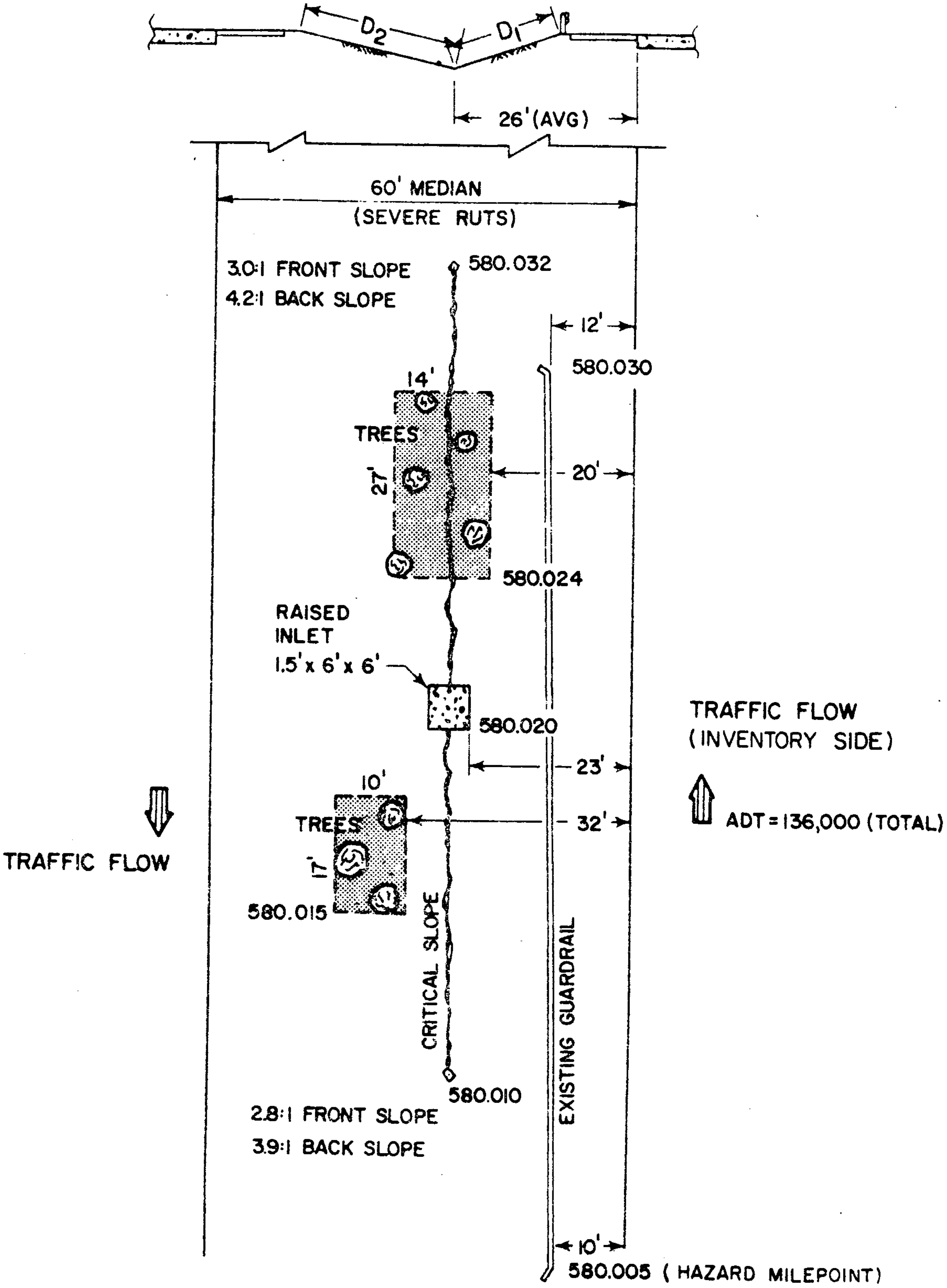


Figure B-8. Hazard description--Case 2.

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Guardrail*

✓

HIGHWAY

BOX 1

08	0020	1	163	0123 —	02	- -	136	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5 Multilane Undivided	County Code	Control Number	Section Number	Total Width, Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

✓

HAZARD CLASSIFICATION

0101	06 —	02	2	060	0333
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2 Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

BOX 2

580.005	580.030
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○

POINT HAZARDS

BOX 3

1				┌—— Drop Inlets Only ——┐	
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W)(ft)	Length (L)(ft)	Height (ft) or	Depth (ft)

✓

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

	┌— Hazard Offset, D (ft)	—┐			┌—— END TREATMENT	——┐
2	10	12	02.3	01	2	Guardrail Only 2
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W)(ft)	1 Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure Full-Beam Connection 4. Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

SLOPES

BOX 5

○

FRONT SLOPE

	┌ Hinge Point Offset, D_0, (ft)	┐	┌—— Steepness	——┐	┌—— Distance "D_1" (ft)	——┐		
3			. :1	. :1				
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts > 1 ft)	Slope Direction 1. Positive 2. Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

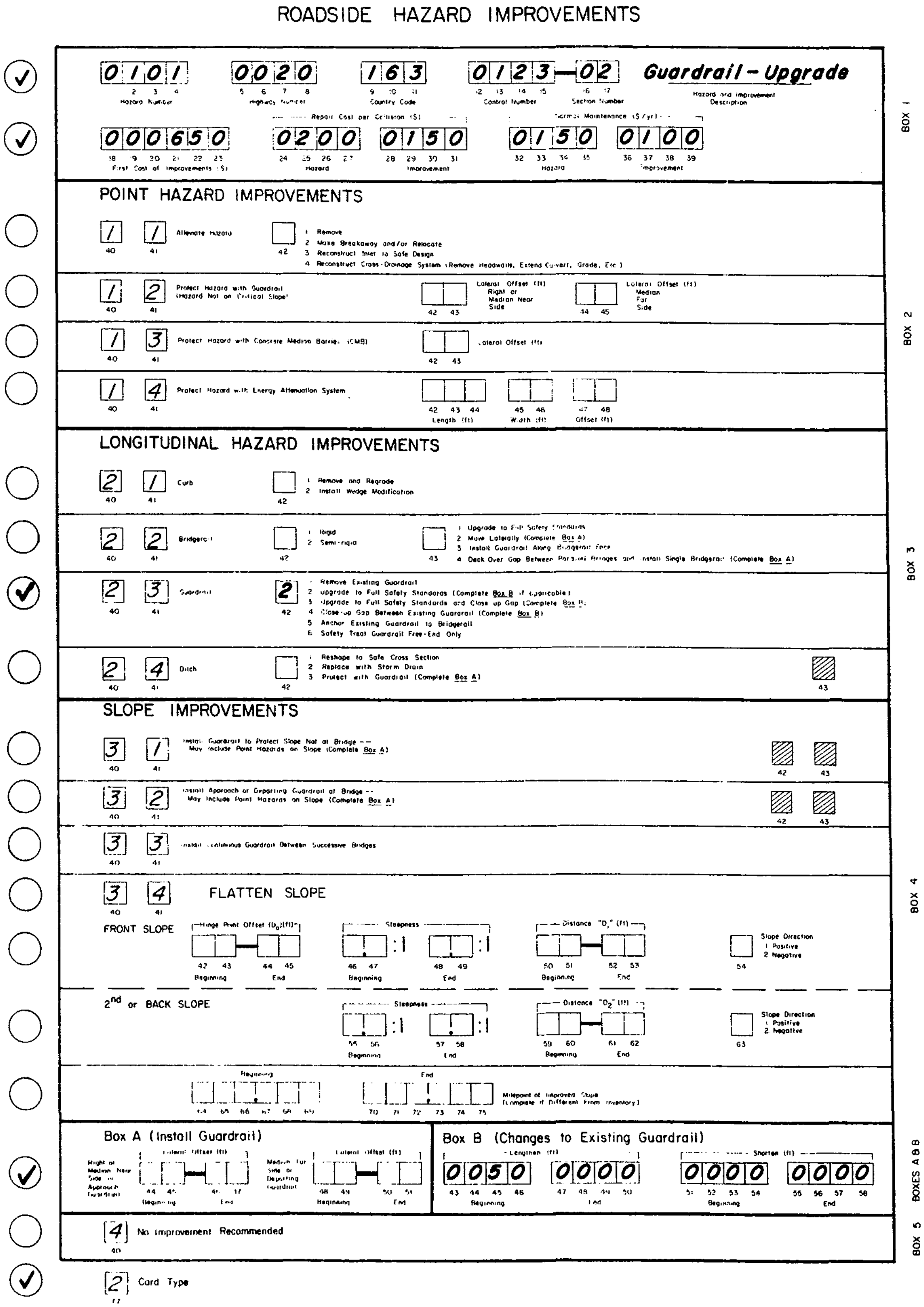
┌—— Steepness	——┐	┌—— Distance "D_2" (ft)	——┐		
. :1	. :1				
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)	Slope Direction 1 Positive 2. Negative

✓

1 Card Type
77

Recommendations: *(1) Upgrade to Full Safety Standards*
(2) Remove Existing Guardrail.

Figure B-9. Inventory of hazard 1 in grouping (Guardrail)--Case 2.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0101 Hazard Number (2 3 4) · 0020 Highway Number (5 6 7 8) · 163 County Code (9 10 11) · 0123—02 Control Number (12 13 14 15) — Section Number (16 17) · *Guardrail - Upgrade* Hazard and Improvement Description

✓ 000650 First Cost of Improvements ($) (18 19 20 21 22 23)

Repair Cost per Collision ($): 0200 Hazard (24 25 26 27) · 0150 Improvement (28 29 30 31)

Normal Maintenance ($/yr): 0150 Hazard (32 33 34 35) · 0100 Improvement (36 37 38 39)

BOX 2

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side · ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) · ☐☐ (45 46) Width (ft) · ☐☐ (47 48) Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

✓ 2 (40) 3 (41) Guardrail 2 (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐—☐☐ (42 43 Beginning, 44 45 End)
Steepness: ☐.☐:1 (46 47 Beginning) ☐.☐:1 (48 49 End)
Distance "D_1" (ft): ☐☐—☐☐ (50 51 Beginning, 52 53 End)
☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐:1 (55 56 Beginning) ☐.☐:1 (57 58 End)
Distance "D_2" (ft): ☐☐—☐☐ (59 60 Beginning, 61 62 End)
☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) · End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOXES A & B

✓ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐—☐☐ (44 45 Beginning, 46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐—☐☐ (48 49 Beginning, 50 51 End)

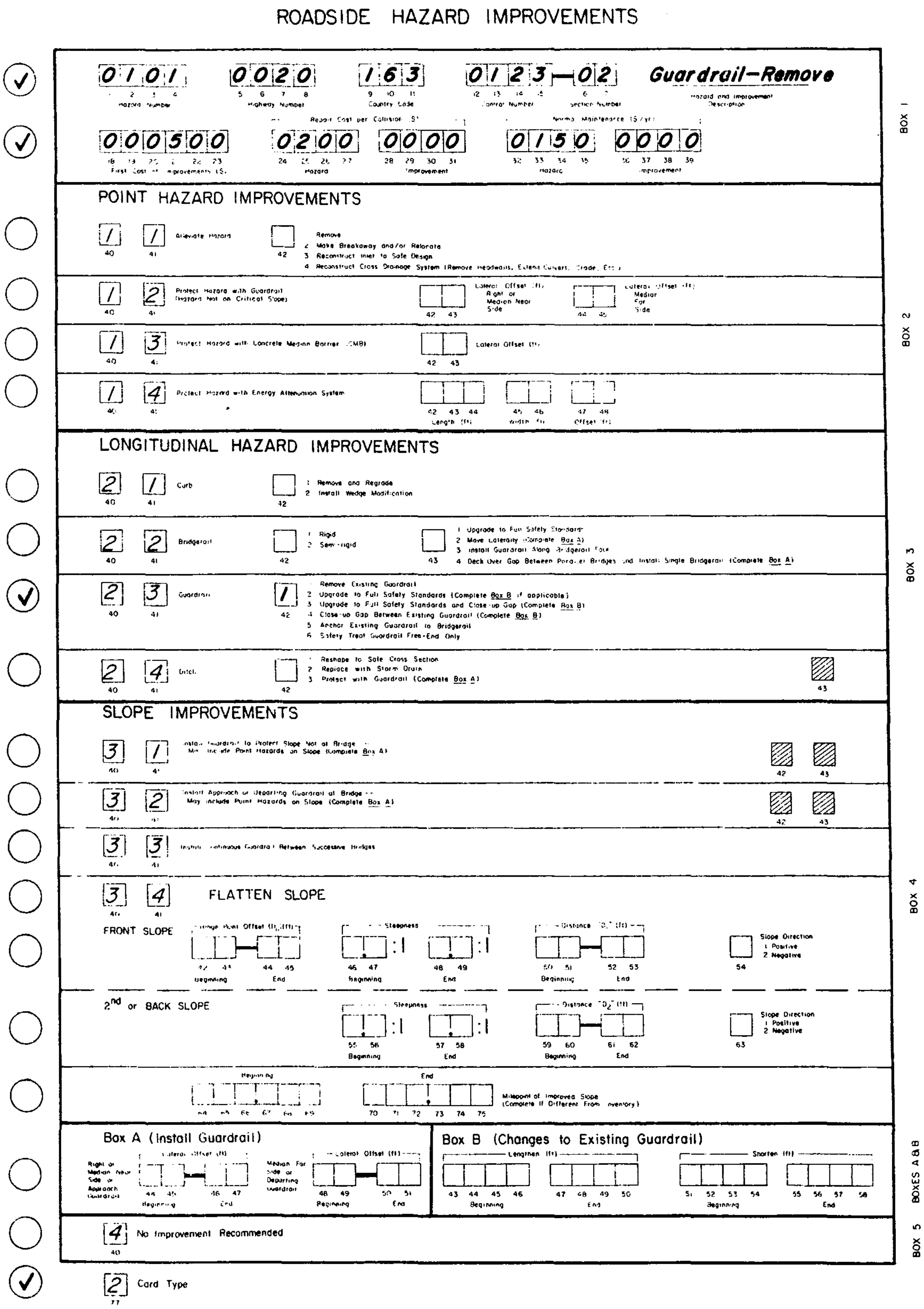
Box B (Changes to Existing Guardrail)
Lengthen (ft): 0050 (43 44 45 46 Beginning) · 0000 (47 48 49 50 End)
Shorten (ft): 0000 (51 52 53 54 Beginning) · 0000 (55 56 57 58 End)

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-10. Improvement alternative 1, hazard 1--Case 2 (Upgrade guardrail to full safety standards).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

☑ 0101 (1–4 Hazard Number) 0020 (5–8 Highway Number) 163 (9–11 Country Code) 0123 (12–15 Control Number) — 02 (16–17 Section Number) ***Guardrail—Remove*** (Hazard and Improvement Description)

☑ 000500 (18–23 First Cost of Improvements ($)) Repair Cost per Collision ($): 0200 (24–27 Hazard) 0000 (28–31 Improvement) Normal Maintenance ($/yr): 0150 (32–35 Hazard) 0000 (36–39 Improvement)

POINT HAZARD IMPROVEMENTS

BOX 2

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standard
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

☑ 2 (40) 3 (41) Guardrail 1 (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE Hinge Point Offset (D_1)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End) Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End) Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End) ☐ (54) Slope Direction 1 Positive 2 Negative

○ 2^{nd} or BACK SLOPE Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End) Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End) ☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

○ 4 (40) No Improvement Recommended

☑ 2 (77) Card Type

Figure B-11. Improvement alternative 2, hazard 1--Case 2 (Remove existing guardrail).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ________ Hazard Description *Slope*

✓

HIGHWAY

BOX 1

08	0020	1	163	0123 —	02	--	136	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type	Highway Number	Classification	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

Highway Type:
- 08 IH
- 01 US
- 02 SH
- 05 FM-RM

Classification:
- Full Control Access
  - 1 Interstate
  - 2. Non-Interstate
- Non-Control Access
  - 3 Two-Lane
  - 4. Multilane Divided
  - 5 Multilane Undivided

✓

HAZARD CLASSIFICATION

BOX 2

0102	07 —	02	2	060	0333
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Medion or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number

MILE POINT AT HAZARD

580.010	580.032
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○

POINT HAZARDS

BOX 3

				Drop Inlets Only		
1	☐☐	☐☐☐	☐☐☐	☐☐.☐	or	☐☐.☐
51	52 53	54 55 56	57 58 59	60 61 62		63 64 65
	Hazard Offset, 0 (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft)		Depth (ft)

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

	Hazard Offset, 0 (ft)				END TREATMENT	Guardrail Only	
2	☐☐	☐☐	☐☐.☐	☐☐	☐		☐
51	52 53	54 55	56 57 58	59 60	61		62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)			

61
1. Not Beginning at Structure - Safety Treated
2. Not Beginning at Structure - Not Safety Treated
3. Beginning at Structure - Full-Beam Connection
4. Beginning at Structure - Not Full-Beam Connection

62
1. Not Ending at Structure- Safety Treated
2. Not Ending at Structure- Not Safety Treated
3. Ending at Structure - Full Beam Connection
4. Ending at Structure - Not Full-Beam Connection

SLOPES

BOX 5

✓

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	11	12	2.8 :1	3.0 :1	16	17	2	2
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts >1 ft.)	Slope Direction 1. Positive 2. Negative

✓

2nd or BACK SLOPE (Except for Level Terrain)

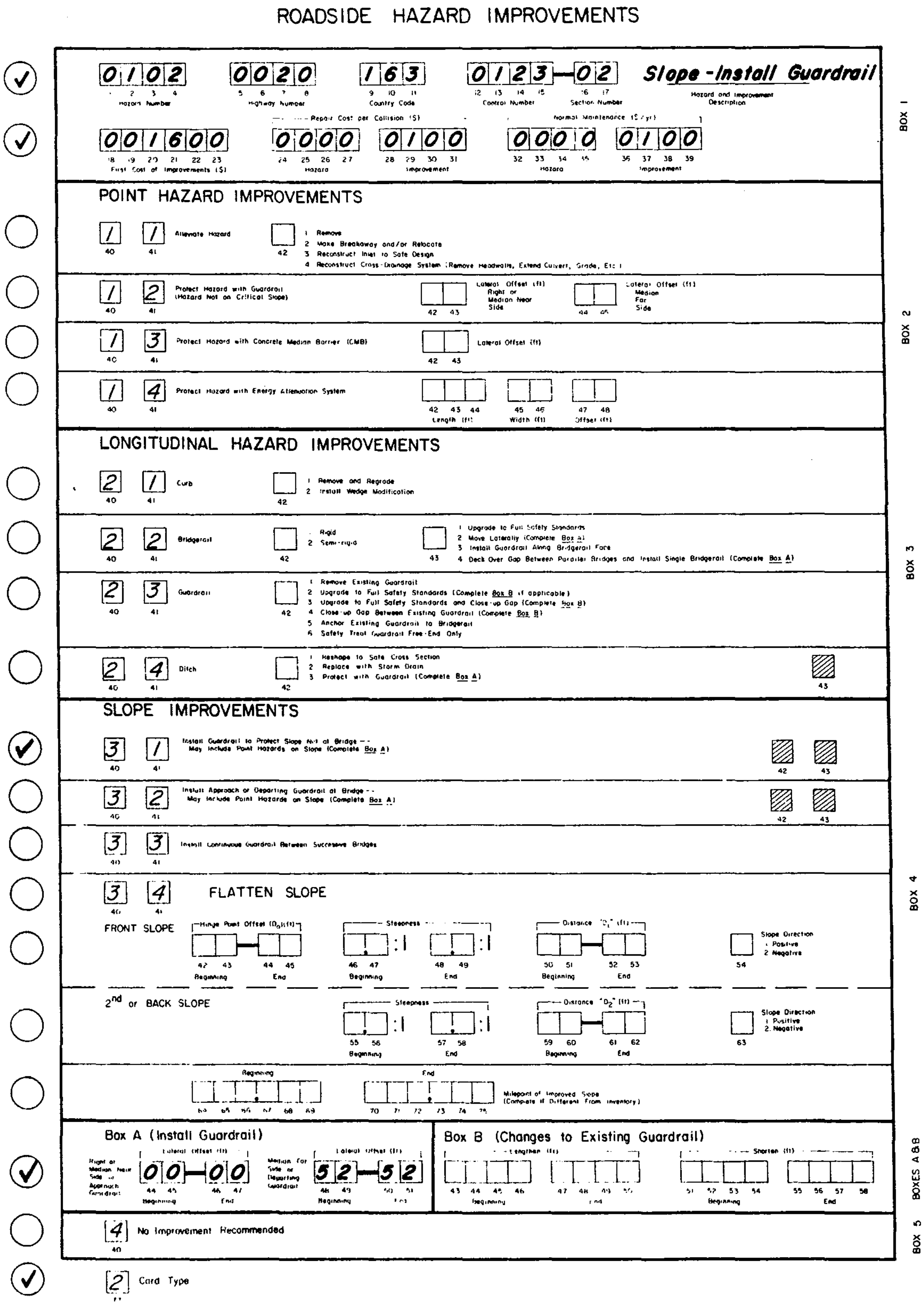
Steepness		Distance "D_2" (ft)			
3.9 :1	4.2 :1	23	24	2	1
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts >1 ft.)	Slope Direction 1 Positive 2. Negative

✓

1 Card Type
77

Recommendations: *(1) Install Guardrail (Far Side of Median)*
(2) No Improvement Recommended

Figure B-12. Inventory of hazard 2 in grouping (Slope)—Case 2.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0102 (1 2 3 4 Hazard Number) 0020 (5 6 7 8 Highway Number) 163 (9 10 11 Country Code) 0123 (12 13 14 15 Control Number) — 02 (16 17 Section Number) *Slope - Install Guardrail* (Hazard and Improvement Description)

✓ 001600 (18 19 20 21 22 23 First Cost of Improvements ($)); Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0100 (28 29 30 31 Improvement); Normal Maintenance ($/yr): 0000 (32 33 34 35 Hazard) 0100 (36 37 38 39 Improvement)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 3

SLOPE IMPROVEMENTS

✓ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (O_o)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐.☐ : 1 (46 47 Beginning) ☐.☐ : 1 (48 49 End)
Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ : 1 (55 56 Beginning) ☐.☐ : 1 (57 58 End)
Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

✓ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) 00 (44 45 Beginning) — 00 (46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) 52 (48 49 Beginning) — 52 (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

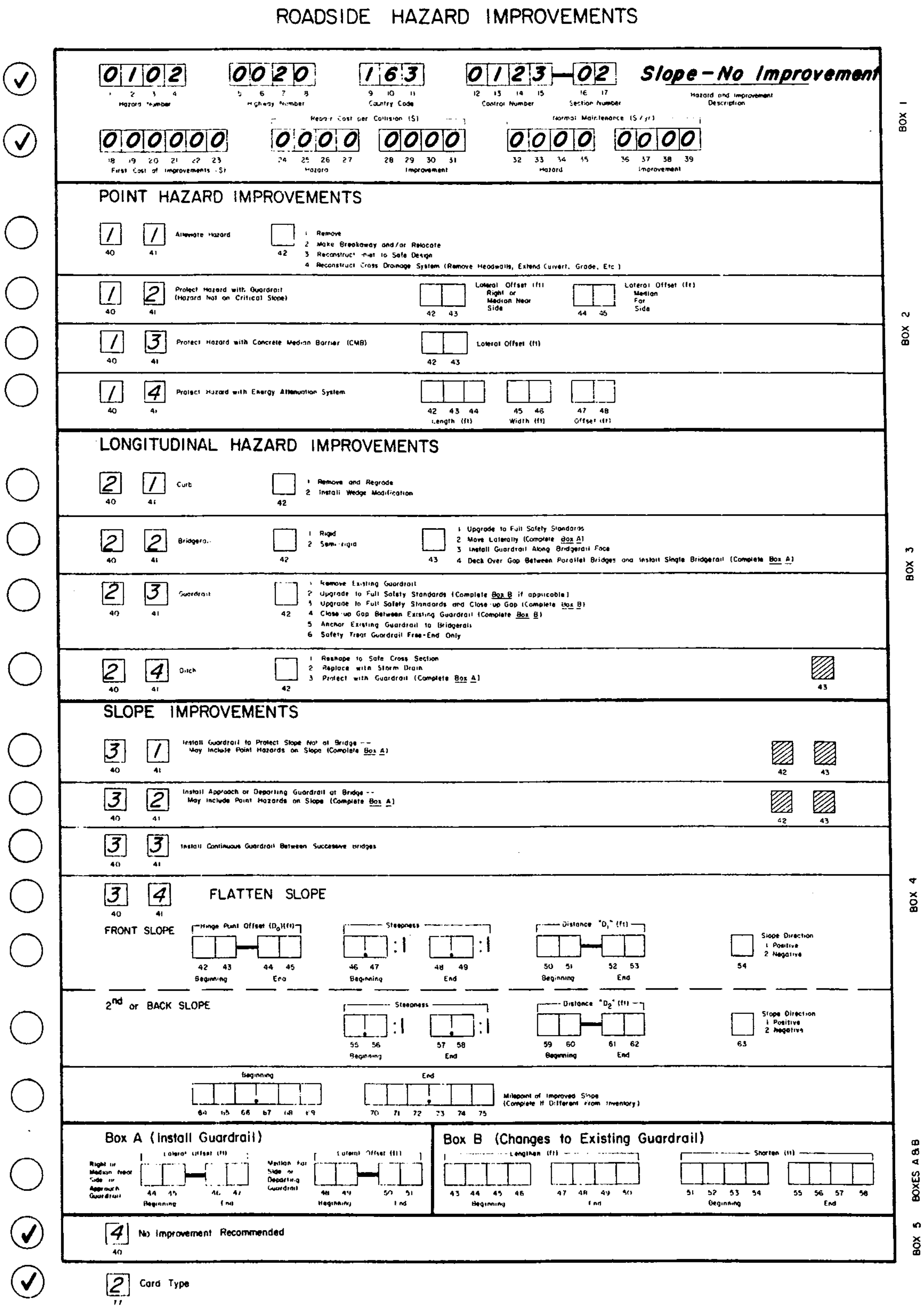
BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-13. Improvement alternative 1, hazard 2--Case 2 (Install guardrail to protect slope).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

☑ 0102 Hazard Number (1 2 3 4) — 0020 Highway Number (5 6 7 8) — 163 County Code (9 10 11) — 0123–02 Control Number (12 13 14 15) – Section Number (16 17) — *Slope–No Improvement* Hazard and Improvement Description

☑ 000000 First Cost of Improvements ($) (18 19 20 21 22 23) — Repair Cost per Collision ($): 0000 Hazard (24 25 26 27), 0000 Improvement (28 29 30 31) — Normal Maintenance ($/yr): 0000 Hazard (32 33 34 35), 0000 Improvement (36 37 38 39)

BOX 2

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42) 1 Rigid 2 Semi-rigid ☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerails
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_0)(ft): ☐☐–☐☐ (42 43 Beginning, 44 45 End) — Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End) — Distance "D_1" (ft): ☐☐–☐☐ (50 51 Beginning, 52 53 End) — ☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End) — Distance "D_2" (ft): ☐☐–☐☐ (59 60 Beginning, 61 62 End) — ☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different from Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐–☐☐ (44 45 Beginning, 46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐–☐☐ (48 49 Beginning, 50 51 End)

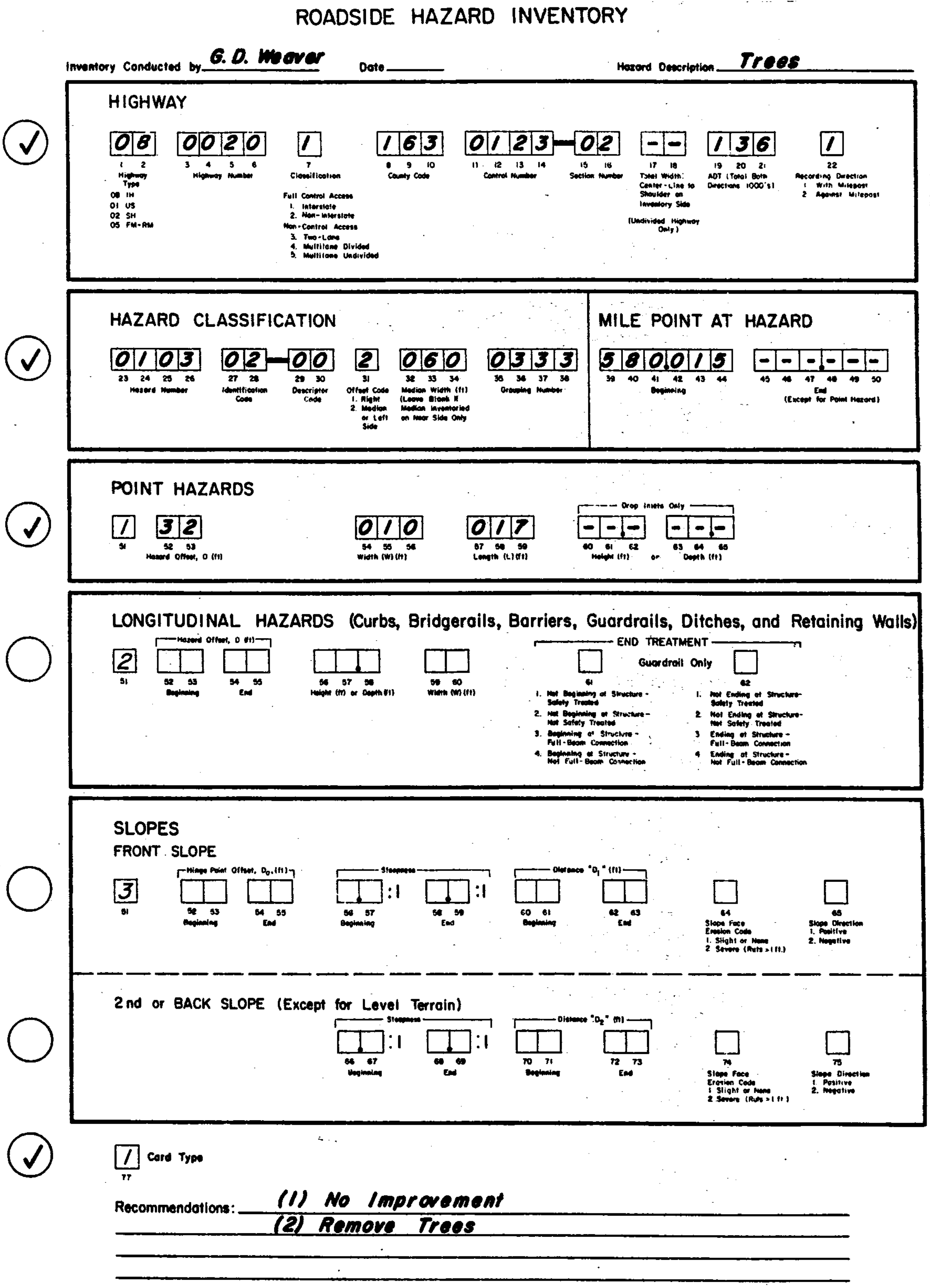
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

☑ 4 (40) No Improvement Recommended

☑ 2 (77) Card Type

Figure B-14. Improvement alternative 2, hazard 2--Case 2 (No improvement recommended).



ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Trees*

✓ **HIGHWAY** (BOX 1)

08	0020	1	163	0123 —	02	--	136	1
1 2 Highway Type 08 IH 01 US 02 SH 05 FM-RM	3 4 5 6 Highway Number	7 Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5. Multilane Undivided	8 9 10 County Code	11 12 13 14 Control Number	15 16 Section Number	17 18 Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	19 20 21 ADT (Total Both Directions 1000's)	22 Recording Direction 1 With Milepost 2 Against Milepost

✓ **HAZARD CLASSIFICATION** (BOX 2)

0103	02 —	00	2	060	0333
23 24 25 26 Hazard Number	27 28 Identification Code	29 30 Descriptor Code	31 Offset Code 1. Right 2. Median or Left Side	32 33 34 Median Width (ft) (Leave Blank If Median Inventoried on Near Side Only)	35 36 37 38 Grouping Number

MILE POINT AT HAZARD

580.015	---.---
39 40 41 42 43 44 Beginning	45 46 47 48 49 50 End (Except for Point Hazard)

✓ **POINT HAZARDS** (BOX 3)

1	32	010	017	--.-	--.-
				Drop Inlets Only	
51	52 53 Hazard Offset, O (ft)	54 55 56 Width (W) (ft)	57 58 59 Length (L) (ft)	60 61 62 Height (ft) or	63 64 65 Depth (ft)

○ **LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)** (BOX 4)

2	☐☐	☐☐	☐☐.☐	☐☐	☐	☐
	Hazard Offset, O (ft)				END TREATMENT Guardrail Only	
51	52 53 Beginning	54 55 End	56 57 58 Height (ft) or Depth (ft)	59 60 Width (W) (ft)	61 1. Not Beginning of Structure - Safety Treated 2. Not Beginning of Structure - Not Safety Treated 3. Beginning of Structure - Full-Beam Connection 4. Beginning of Structure - Not Full-Beam Connection	62 1. Not Ending of Structure - Safety Treated 2 Not Ending of Structure - Not Safety Treated 3 Ending of Structure - Full-Beam Connection 4 Ending of Structure - Not Full-Beam Connection

SLOPES (BOX 5)

○ FRONT SLOPE

3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
51	52 53 Beginning	54 55 End	56 57 Beginning	58 59 End	60 61 Beginning	62 63 End	64 Slope Face Erosion Code 1. Slight or None 2 Severe (Ruts > 1 ft.)	65 Slope Direction 1. Positive 2. Negative

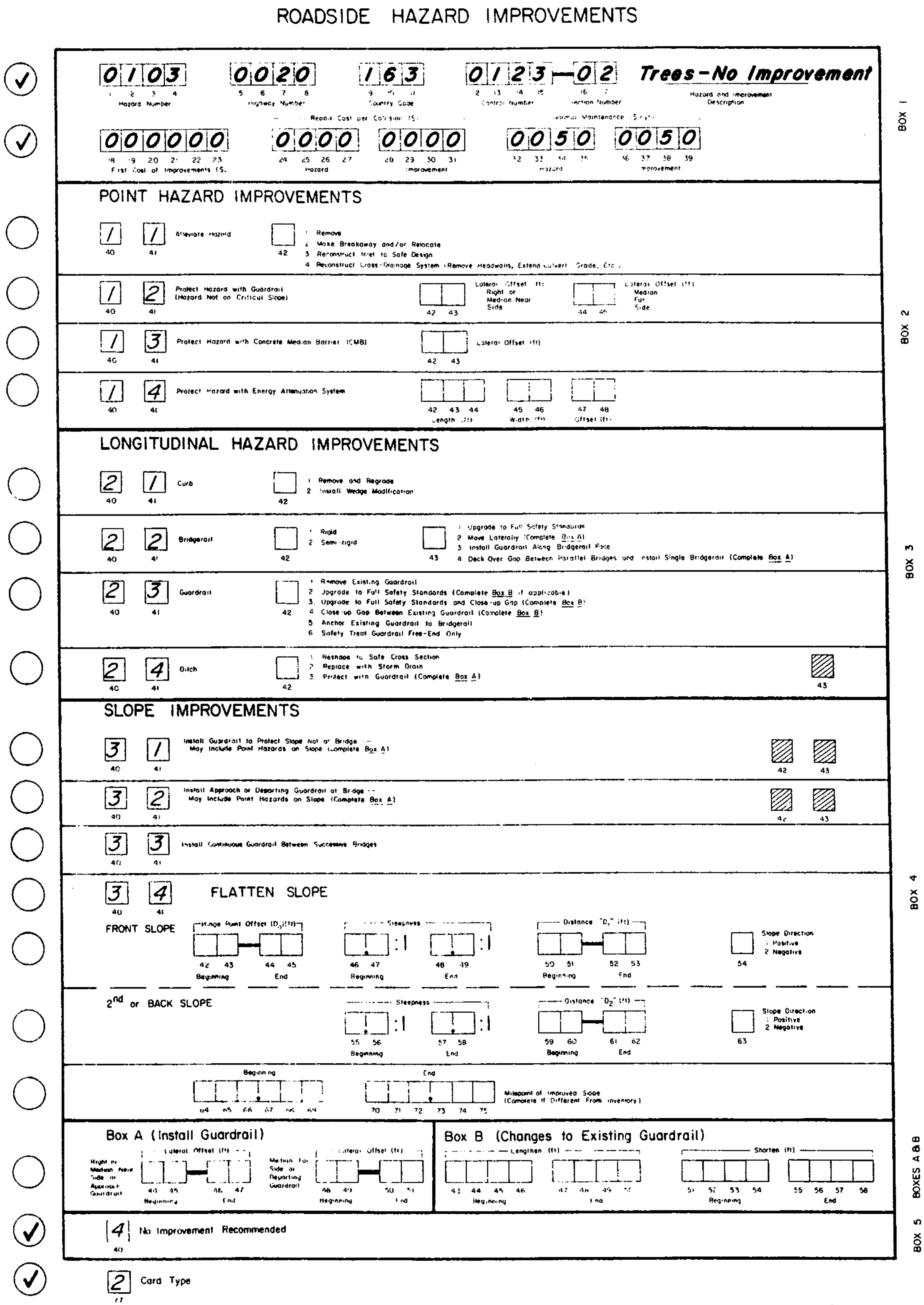
○ 2nd or BACK SLOPE (Except for Level Terrain)

☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
Steepness		Distance "D_2" (ft)			
66 67 Beginning	68 69 End	70 71 Beginning	72 73 End	74 Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)	75 Slope Direction 1. Positive 2. Negative

✓ 1 Card Type
77

Recommendations: *(1) No Improvement*
(2) Remove Trees

Figure B-15. Inventory of hazard 3 in grouping (Trees)—Case 2.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0103 (1 2 3 4) Hazard Number — 0020 (5 6 7 8) Highway Number — 163 (9 10 11) County Code — 0123 (12 13 14 15) Control Number — 02 (16 17) Section Number — **Trees-No Improvement** Hazard and Improvement Description

✓ 000000 (18 19 20 21 22 23) First Cost of Improvements ($) — Repair Cost per Collision ($): 0000 (24 25 26 27) Hazard, 0000 (28 29 30 31) Improvement — Annual Maintenance ($/yr): 0050 (32 33 34 35) Hazard, 0050 (36 37 38 39) Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3. Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3. Protect with Guardrail (Complete Box A)

▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_3)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End; Steepness: ☐.☐ :1 (46 47) Beginning, ☐.☐ :1 (48 49) End; Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End; ☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐.☐ :1 (55 56) Beginning, ☐.☐ :1 (57 58) End; Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End; ☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning — ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning — ☐☐ (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning, ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning, ☐☐☐☐ (55 56 57 58) End

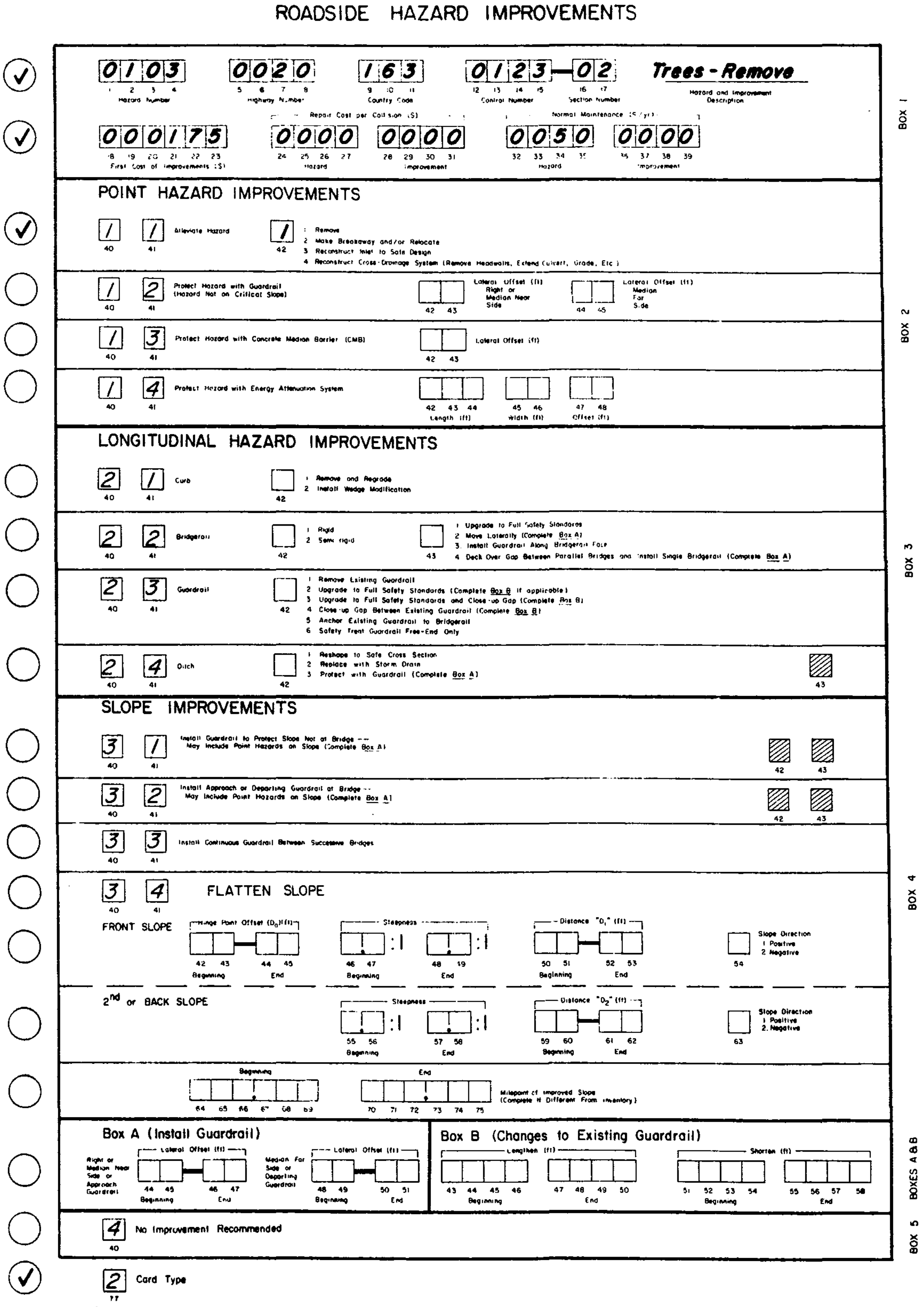
BOXES A & B

✓ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-16. Improvement alternative 1, hazard 3--Case 2 (No improvement recommended).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0103 (1 2 3 4 Hazard Number) 0020 (5 6 7 8 Highway Number) 163 (9 10 11 County Code) 0123 (12 13 14 15 Control Number) — 02 (16 17 Section Number) Trees - Remove (Hazard and Improvement Description)

✓ 000175 (18 19 20 21 22 23 First Cost of Improvements ($))
Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0000 (28 29 30 31 Improvement)
Normal Maintenance ($/yr): 0050 (32 33 34 35 Hazard) 0000 (36 37 38 39 Improvement)

BOX 2

POINT HAZARD IMPROVEMENTS

✓ 1 (40) 1 (41) Alleviate Hazard 1 (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)
Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)
Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction 1 Positive 2. Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOXES A&B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-17. Improvement alternative 2, hazard 3--Case 2 (Remove trees).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Raised Drop Inlet*

✓

HIGHWAY

08	0020	1	163	0123	02	--	136	1
1 2	3 4 5 5	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5 Multilane Undivided	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2. Against Milepost

BOX 1

✓

HAZARD CLASSIFICATION

0104	10	01	2	060	0333
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

580.020	---.---
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

BOX 2

✓

POINT HAZARDS

				Drop Inlets Only	
1	23	006	006	01.5	00.0
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft) or	Depth (ft)

BOX 3

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

	Hazard Offset, D (ft)				END TREATMENT	Guardrail Only
2	☐☐	☐☐	☐☐.☐	☐☐	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3 Beginning at Structure - Full-Beam Connection 4 Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

BOX 4

○

SLOPES

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft.)	Slope Direction 1. Positive 2. Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

Steepness		Distance "D_2" (ft)			
☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts > 1 ft)	Slope Direction 1. Positive 2. Negative

BOX 5

✓

[1] Card Type
77

Recommendations: *(1) No Improvement*
(2) Reconstruct Inlet to Safe Design

Figure B-18. Inventory of hazard 4 in grouping (Raised inlet)--Case 2.

ROADSIDE HAZARD IMPROVEMENTS

☑ 0104 — 1 2 3 4 Hazard Number | 0020 — 5 6 7 8 Highway Number | 163 — 9 10 11 Country Code | 0123 — 12 13 14 15 Control Number — 02 — 16 17 Section Number | *Inlet - No Improvement* — Hazard and Improvement Description

☑ 000000 — 18 19 20 21 22 23 First Cost of Improvements ($)

Repair Cost per Collision ($): 0000 — 24 25 26 27 Hazard | 0000 — 28 29 30 31 Improvement

Normal Maintenance ($/yr): 0050 — 32 33 34 35 Hazard | 0050 — 36 37 38 39 Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2. Make Breakaway and/or Relocate
3. Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_3)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐☐ :1 (46 47) Beginning ☐☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction 1 Positive 2. Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ :1 (55 56) Beginning ☐☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning — ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning — ☐☐ (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning ☐☐☐☐ (55 56 57 58) End

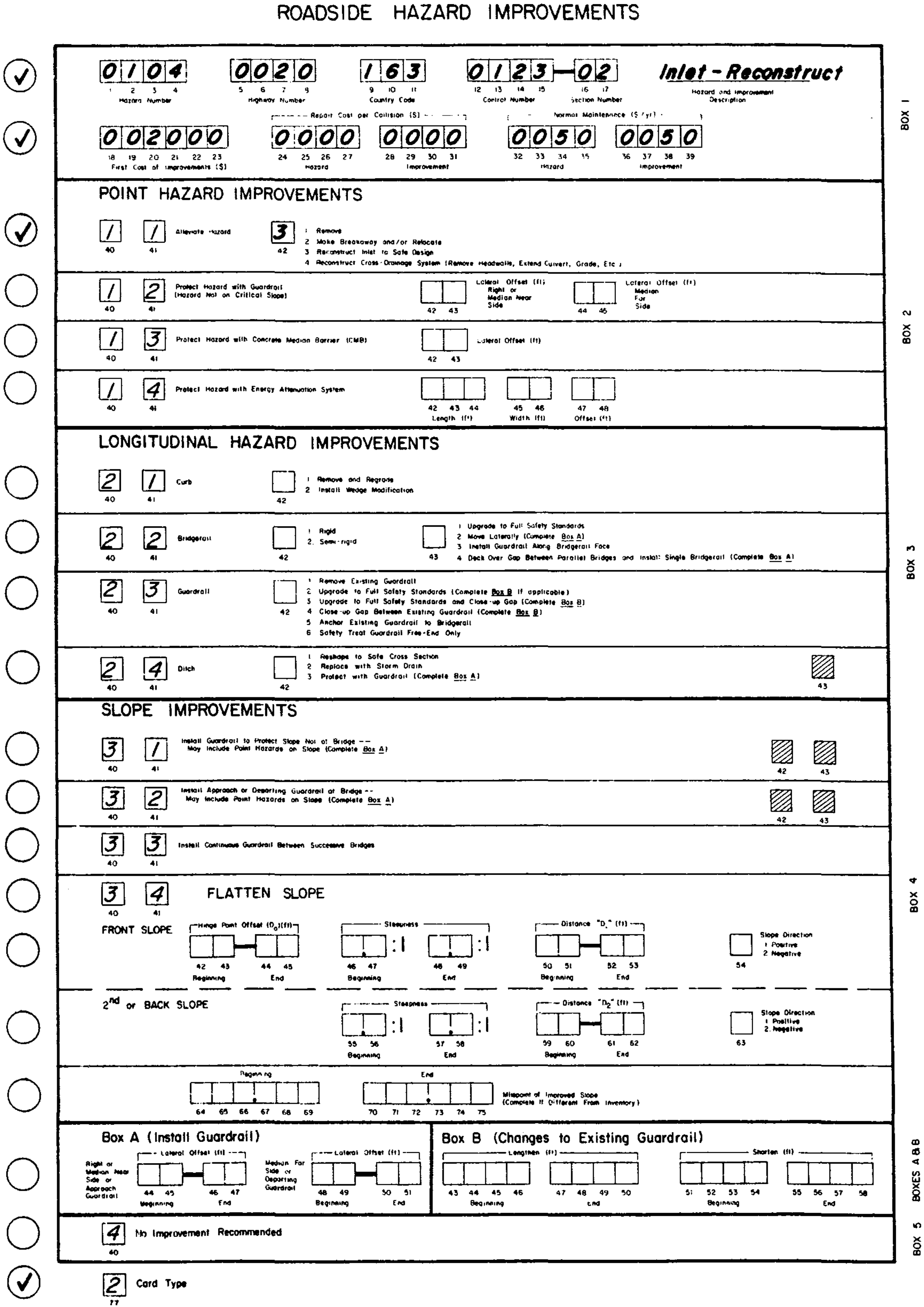
BOXES A & B

☑ 4 (40) No Improvement Recommended

BOX 5

☑ 2 (77) Card Type

Figure B-19. Improvement alternative 1, hazard 4--Case 2 (No improvement recommended).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

☑ 0104 Hazard Number (1 2 3 4) — 0020 Highway Number (5 6 7 8) — 163 Country Code (9 10 11) — 0123 Control Number (12 13 14 15) — 02 Section Number (16 17) — *Inlet - Reconstruct* Hazard and Improvement Description

☑ 002000 First Cost of Improvements ($) (18 19 20 21 22 23)
Repair Cost per Collision ($): 0000 Hazard (24 25 26 27) — 0000 Improvement (28 29 30 31)
Normal Maintenance ($/yr): 0050 Hazard (32 33 34 35) — 0050 Improvement (36 37 38 39)

POINT HAZARD IMPROVEMENTS

BOX 2

☑ 1 (40) 1 (41) Alleviate Hazard — 3 (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42 43 44) Length (ft) — ☐☐ (45 46) Width (ft) — ☐☐ (47 48) Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb — ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42)
1 Rigid
2. Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42) — ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐.☐ :1 (46 47) Beginning — ☐.☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56) Beginning — ☐.☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction
1 Positive
2. Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) — End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Midpoint of Improved Slope (Complete If Different From Inventory)

BOXES A & B

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning — ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning — ☐☐ (50 51) End

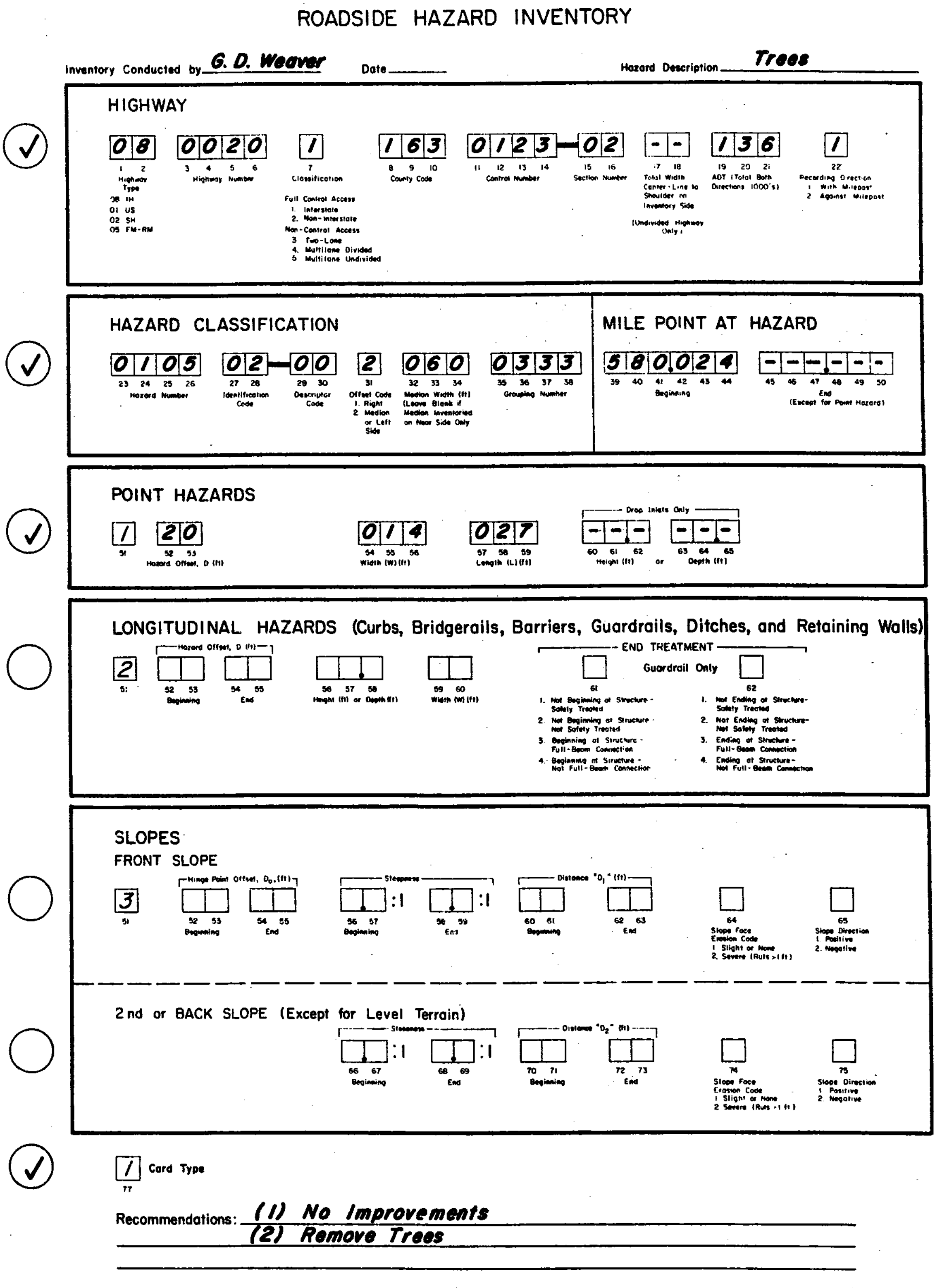
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning — ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning — ☐☐☐☐ (55 56 57 58) End

BOX 5

○ 4 (40) No Improvement Recommended

☑ 2 (77) Card Type

Figure B-20. Improvement alternative 2, hazard 4--Case 2 (Reconstruct inlet to safe design).



ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Trees*

✓

BOX 1

HIGHWAY

0 8	0 0 2 0	1	1 6 3	0 1 2 3 —	0 2	- -	1 3 6	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5 Multilane Undivided	County Code	Control Number	Section Number	Total Width Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

✓

BOX 2

HAZARD CLASSIFICATION

0 1 0 5	0 2 —	0 0	2	0 6 0	0 3 3 3
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2 Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

5 8 0 . 0 2 4	- - - . - - -
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

✓

BOX 3

POINT HAZARDS

				Drop Inlets Only	
1	2 0	0 1 4	0 2 7	- - . -	- - . -
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft) or	Depth (ft)

○

BOX 4

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

	Hazard Offset, D (ft)				END TREATMENT	Guardrail Only
2	☐☐	☐☐	☐☐.☐	☐☐	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure - Full-Beam Connection 4. Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

BOX 5

SLOPES

○

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts >1 ft)	Slope Direction 1. Positive 2. Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

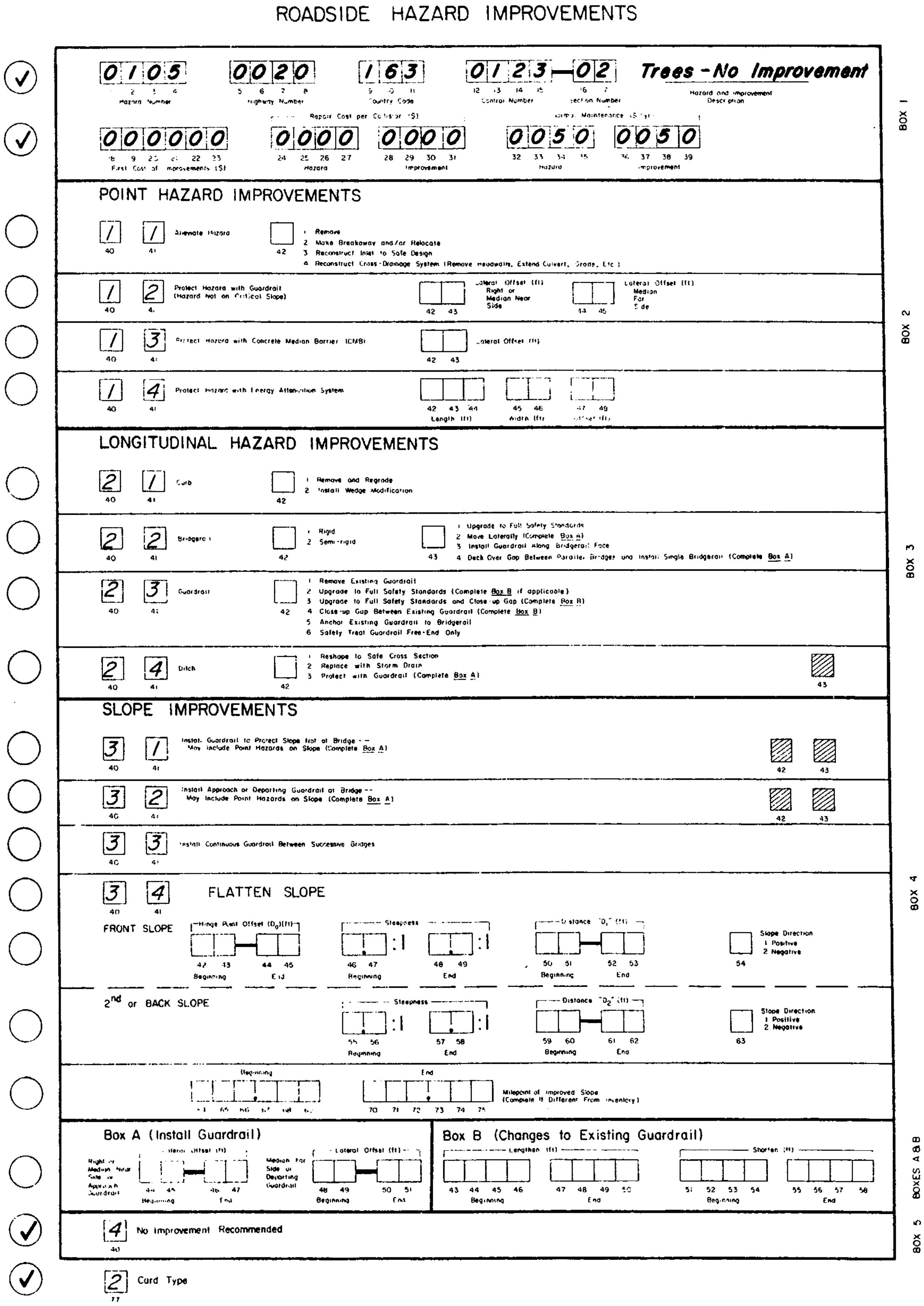
Steepness		Distance "D_2" (ft)			
☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts >1 ft)	Slope Direction 1 Positive 2 Negative

✓

1 Card Type
77

Recommendations: *(1) No Improvements*
(2) Remove Trees

Figure B-21. Inventory of hazard 5 in grouping (Trees)—Case 2.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0105 Hazard Number (1 2 3 4) — 0020 Highway Number (5 6 7 8) — 163 County Code (9 10 11) — 0123—02 Control Number (12 13 14 15) Section Number (16 17) — **Trees - No Improvement** Hazard and Improvement Description

✓ 000000 First Cost of Improvements ($) (18 19 20 21 22 23) — Repair Cost per Collision ($): 0000 Hazard (24 25 26 27), 0000 Improvement (28 29 30 31) — Normal Maintenance ($/yr): 0050 Hazard (32 33 34 35), 0050 Improvement (36 37 38 39)

POINT HAZARD IMPROVEMENTS

BOX 2

○ 1 (40) 1 (41) Alternate Hazard — ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42 43 44) Length (ft) — ☐☐ (45 46) Width (ft) — ☐☐ (47 48) Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb — ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safely Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

▨ (43)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_0)(ft): ☐☐—☐☐ (42 43 Beginning, 44 45 End) — Steepness: ☐.☐:1 (46 47 Beginning) ☐.☐:1 (48 49 End) — Distance "D_1" (ft): ☐☐—☐☐ (50 51 Beginning, 52 53 End) — ☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐.☐:1 (55 56 Beginning) ☐.☐:1 (57 58 End) — Distance "D_2" (ft): ☐☐—☐☐ (59 60 Beginning, 61 62 End) — ☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) — End ☐☐☐.☐☐☐ (70 71 72 73 74 75) — Milepoint of Improved Slope (Complete If Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail) — Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐—☐☐ (44 45 Beginning, 46 47 End) — Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐—☐☐ (48 49 Beginning, 50 51 End)

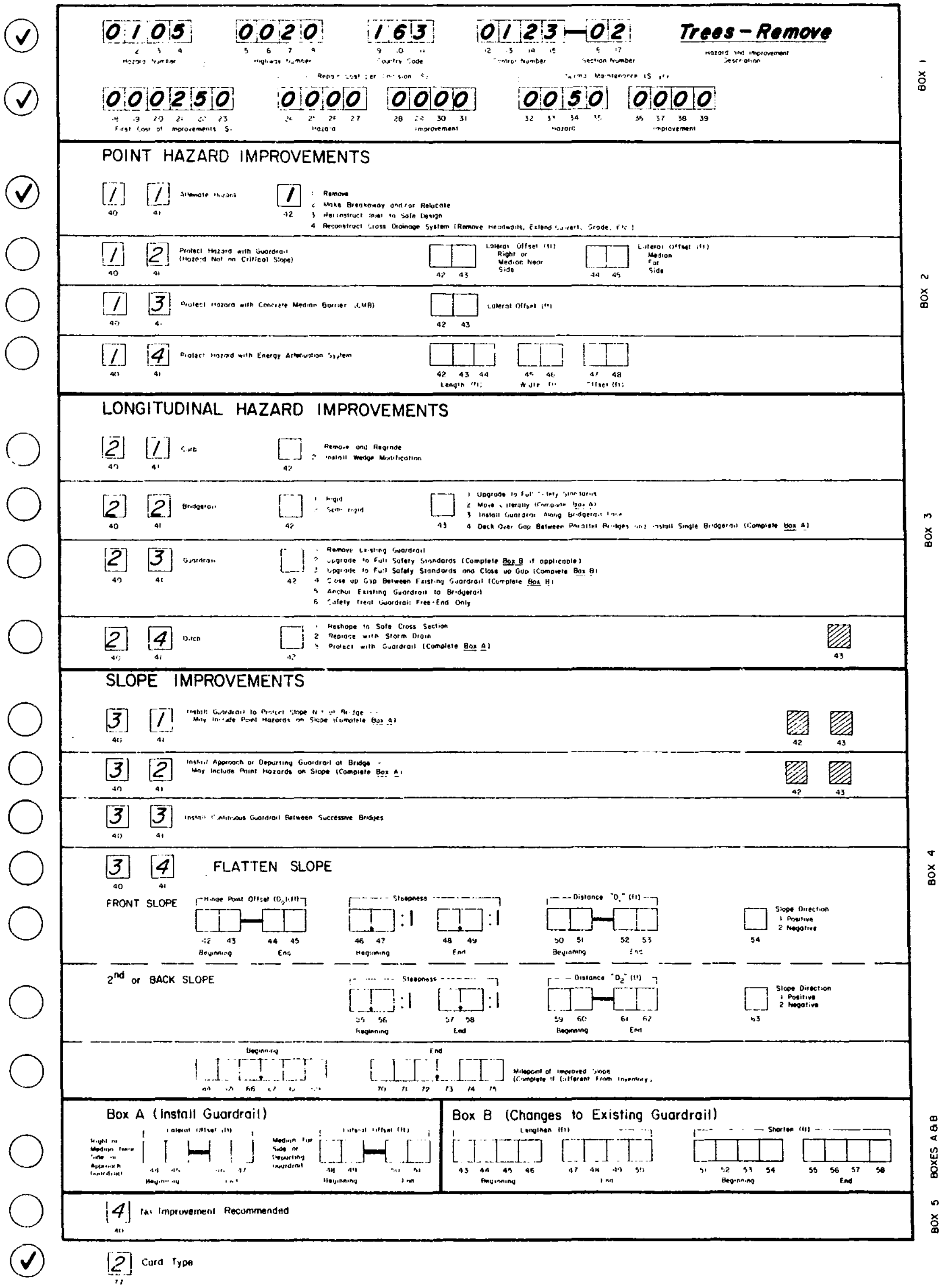
Box B (Changes to Existing Guardrail) — Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End) — Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

✓ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-22. Improvement alternative 1, hazard 5--Case 2. (No improvement recommended).



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

☑ 0105 Hazard Number (1–4) | 0020 Highway Number (5–8) | 163 County Code (9–11) | 0123–02 Control Number (12–15), Section Number (16–17) | **Trees – Remove** Hazard and Improvement Description

☑ 000250 First Cost of Improvements ($) (18–23) | Repair Cost per Collision ($): 0000 Hazard (24–27), 0000 Improvement (28–31) | Normal Maintenance ($/yr): 0050 Hazard (32–35), 0000 Improvement (36–39)

BOX 2

POINT HAZARD IMPROVEMENTS

☑ 1 (40) 1 (41) Alternate Hazard — 1 (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42–43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44–45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42–43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42–44) Length (ft) — ☐☐ (45–46) Width (ft) — ☐☐ (47–48) Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb — ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge - May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_3) (ft): ☐☐ (42–43) Beginning – ☐☐ (44–45) End — Steepness: ☐☐ :1 (46–47) Beginning, ☐☐ :1 (48–49) End — Distance "D_1" (ft): ☐☐ (50–51) Beginning – ☐☐ (52–53) End — ☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐☐ :1 (55–56) Beginning, ☐☐ :1 (57–58) End — Distance "D_2" (ft): ☐☐ (59–60) Beginning – ☐☐ (61–62) End — ☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐☐☐☐ (64–69) — End ☐☐☐☐☐☐ (70–75) — Milepoint of Improved Slope (Complete if Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail) — Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ (44–45) Beginning – ☐☐ (46–47) End — Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ (48–49) Beginning – ☐☐ (50–51) End

Box B (Changes to Existing Guardrail) — Lengthen (ft): ☐☐☐☐ (43–46) Beginning, ☐☐☐☐ (47–50) End — Shorten (ft): ☐☐☐☐ (51–54) Beginning, ☐☐☐☐ (55–58) End

BOX 5

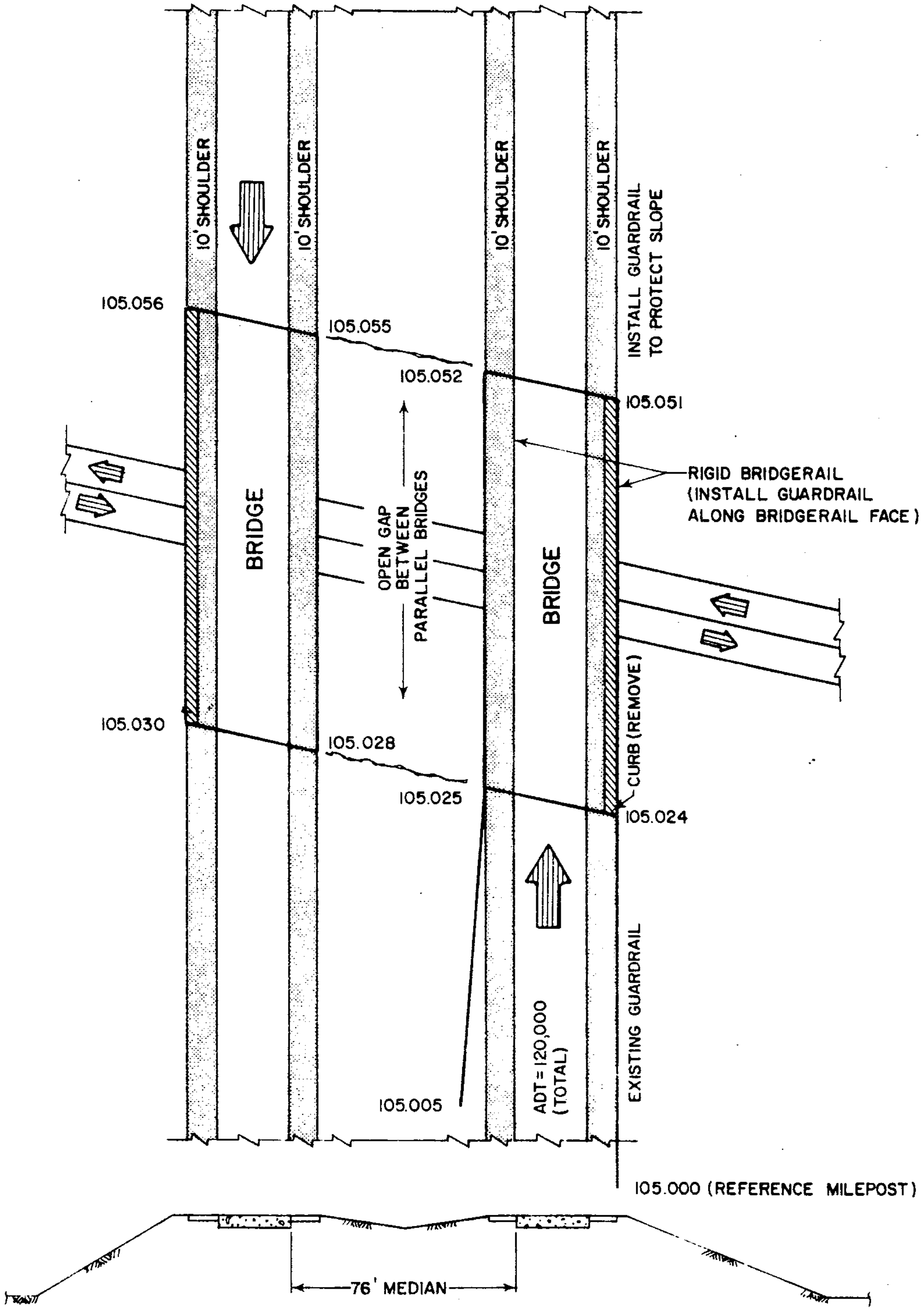
○ 4 (40) No Improvement Recommended

☑ 2 (77) Card Type

Figure B-23. Improvement alternative 2, hazard 5--Case 2 (Remove trees).

```
                                                       C O S T   E F F E C T I V E N E S S   P R O G R A M

                                                                 TYPE HIGHWAY = INTERSTATE (CODE 08)
                                                         HIGHWAY CLASSIFICATION = CONTROLLED ACCESS -- INTERSTATE


                                                                   HIGHWAY NO  =   20
                                                                    COUNTY NO  =  163
                                                                  DISTRICT NO  =   15
                                                                   CONTROL NO  =  123
                                                                   SECTION NO  =    2

                                                           RECORDING DIRECTION  =    1
                                                                   ADT (1000)  =  136
                                                                         LIFE  =   20(YRS)
                                                                     INTEREST  =  8.0(PERCENT)
                                                                         DATE  = 10-74

                         H   A   Z   A   R   D                                          I   M   P   R   O   V   E   M   E   N   T

HAZARD  IDENT  DESC     END     SEVERITY  OFFSET  GROUP    MILE-POST             IMPR  IMPR   SEVERITY  FIRST  PRESENT  ANNUAL    COST
  NO    CODE   CODE  TREATMENT  INDEX     CODE     NO     BEG       END          ALT   CODE    INDEX    COST    WORTH    COST   EFFECTIVE
                      BEG  END                                                                                                  VALUE
                                                                                                        ($)      ($)    ($/YR)

  101     6     2     2    2     17.3      2      333  580.005 580.030           1  2-3-2-0    3.7     650      157      15     GROUP
  105     2     0     0    0     50.0      2      333  580.024 580.029           1  4-0-0-0   50.0       0      157      15     GROUP
  104    10     1     0    0     82.5      2      333  580.020 580.021           1  4-0-0-0   82.5       0      157      15     GROUP
  102     7     2     0    0     60.0      2      333  580.010 580.032           1  3-1-0-0    3.7    1600     2990     304     GROUP
  103     2     0     0    0     50.0      2      333  580.015 580.018           1  4-0-0-0   50.0       0     2990     304        121

  101     6     2     2    2     17.3      2      333  580.005 580.030           2  2-3-1-0    0.0     500    -1127    -114     GROUP
  105     2     0     0    0     50.0      2      333  580.024 580.029           2  1-1-1-0    0.0     250    -1368    -139     GROUP
  104    10     1     0    0     82.5      2      333  580.020 580.021           2  1-1-3-0    0.0    2000      631      64     GROUP
  102     7     2     0    0     60.0      2      333  580.010 580.032           2  4-0-0-0   60.0       0      631      64     GROUP
  103     2     0     0    0     50.0      2      333  580.015 580.018           2  1-1-1-0    0.0     175      315      32          8
```

Figure B-24. Cost-effectiveness program output--Case 2.



MEDIAN CROSS-SECTION
ADJACENT TO BRIDGE

Figure B-25. Hazard description--Case 3.

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver*   Date ______   Hazard Description *Guardrail*

✓

HIGHWAY

BOX 1

0 8	0 0 3 5	1	0 9 7	2 5 6 1 —	0 8	- -	1 2 0	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5. Multilane Undivided	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

✓

HAZARD CLASSIFICATION

0 2 5 0	0 6 —	0 4	1	- - -	0 1 1 1
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

BOX 2

1 0 5 . 0 0 0	1 0 5 . 0 2 4
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○

POINT HAZARDS

BOX 3

				Drop Inlets Only		
1	☐☐	☐☐☐	☐☐☐	☐☐.☐		☐☐.☐
51	52 53	54 55 56	57 58 59	60 61 62		63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft)	or	Depth (ft).

✓

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

	Hazard Offset, D (ft)				END TREATMENT		
2	1 1	1 0	0 2 . 3	0 1	1	Guardrail Only	4
51	52 53	54 55	56 57 58	59 60	61		62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1 Not Beginning at Structure - Safety Treated 2 Not Beginning at Structure Not Safety Treated 3 Beginning at Structure - Full-Beam Connection 4 Beginning at Structure - Not Full-Beam Connection		1. Not Ending at Structure- Safety Treated 2. Not Ending at Structure- Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4 Ending at Structure - Not Full-Beam Connection

○

SLOPES

FRONT SLOPE

BOX 5

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts >1 ft)	Slope Direction 1 Positive 2 Negative

○

2nd. or BACK SLOPE (Except for Level Terrain)

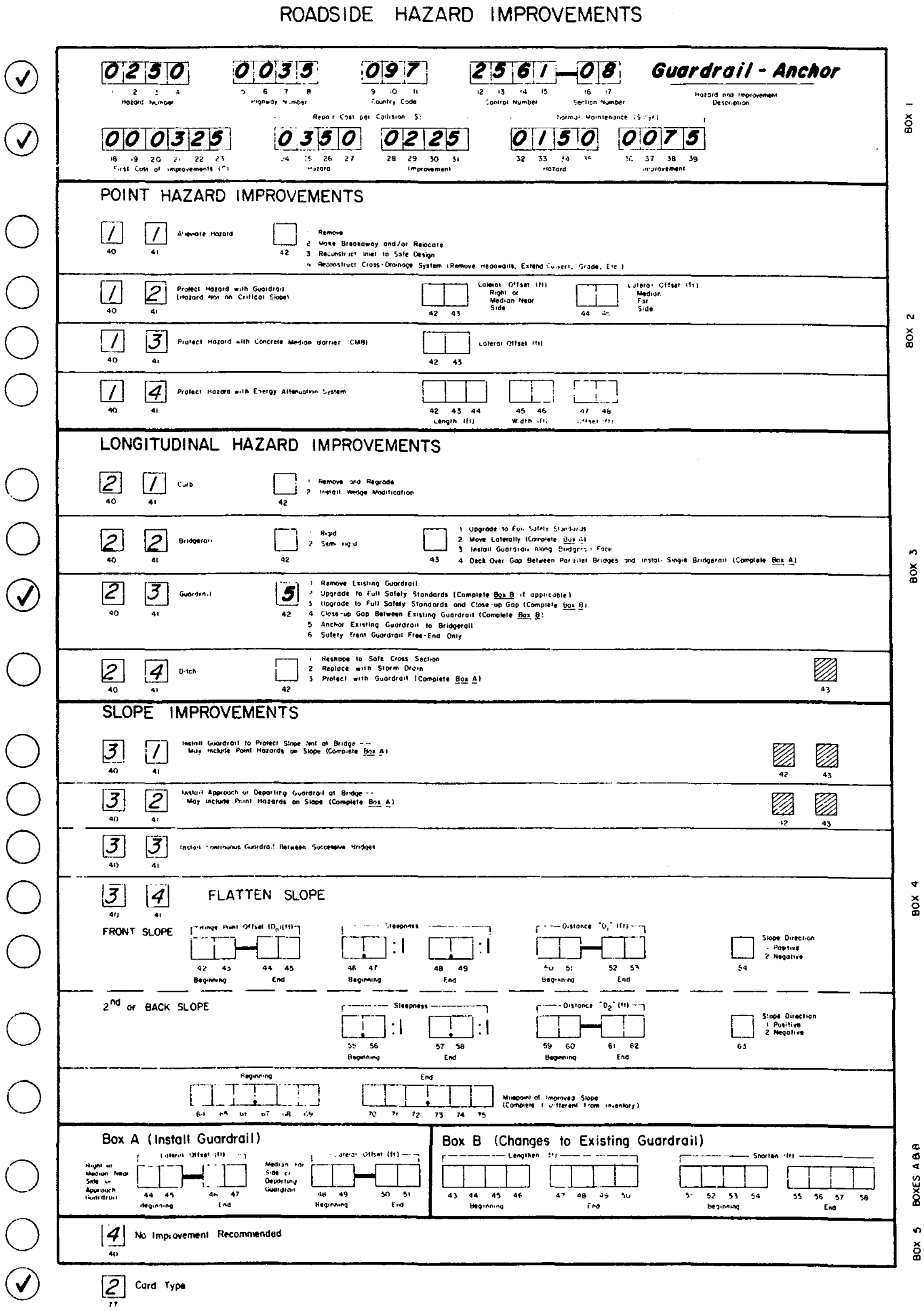
Steepness		Distance "D_2" (ft)			
☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts >1 ft)	Slope Direction 1 Positive 2 Negative

✓

| 1 | Card Type

Recommendations: *(1) Anchor Existing Guardrail to Bridgerail (only)*
(No other improvements to guardrail)

Figure B-26. Inventory of hazard 1 in grouping (Guardrail)—Case 3.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0250 Hazard Number (1 2 3 4) | 0035 Highway Number (5 6 7 8) | 097 County Code (9 10 11) | 2561 Control Number (12 13 14 15) — 08 Section Number (16 17) | **Guardrail - Anchor** Hazard and Improvement Description

✓ 000325 First Cost of Improvements ($) (18 19 20 21 22 23) | Repair Cost per Collision ($): 0350 Hazard (24 25 26 27), 0225 Improvement (28 29 30 31) | Normal Maintenance ($/yr): 0150 Hazard (32 33 34 35), 0075 Improvement (36 37 38 39)

BOX 2

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

✓ 2 (40) 3 (41) Guardrail 5 (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE: Hinge Point Offset (D_0)(ft) ☐☐ (42 43) Beginning — ☐☐ (44 45) End | Steepness ☐☐ :1 (46 47) Beginning, ☐☐ :1 (48 49) End | Distance "D_1" (ft) ☐☐ (50 51) Beginning — ☐☐ (52 53) End | ☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE: Steepness ☐☐ :1 (55 56) Beginning, ☐☐ :1 (57 58) End | Distance "D_2" (ft) ☐☐ (59 60) Beginning — ☐☐ (61 62) End | ☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐☐☐☐ (64 65 66 67 68 69) End ☐☐☐☐☐☐ (70 71 72 73 74 75) Midpoint of Improved Slope (Complete if different from inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ (44 45) Beginning — ☐☐ (46 47) End
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ (48 49) Beginning — ☐☐ (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft) ☐☐☐☐ (43 44 45 46) Beginning ☐☐☐☐ (47 48 49 50) End
Shorten (ft) ☐☐☐☐ (51 52 53 54) Beginning ☐☐☐☐ (55 56 57 58) End

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-27. Improvement alternative 1, hazard 1--Case 3 (Anchor guardrail to bridge).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ________ Hazard Description *Sidewalk Curb*

✓

HIGHWAY

BOX 1

08	0035	1	097	2561	08	- -	120	1
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1 Interstate 2. Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5 Multilane Undivided	County Code	Control Number	Section Number	Total Width, Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2. Against Milepost

✓

HAZARD CLASSIFICATION

BOX 2

0251	05	03	1	- - -	0111
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number

MILE POINT AT HAZARD

105.024	105.051
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○

POINT HAZARDS

BOX 3

1				Drop Inlets Only	
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft) or	Depth (ft)

✓

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

	Hazard Offset, D (ft)				END TREATMENT	Guardrail Only
2	06	06	01.0	04		
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure - Full-Beam Connection 4. Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full Beam Connection

SLOPES

BOX 5

○

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3			. :1	. :1				
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft.)	Slope Direction 1 Positive 2 Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

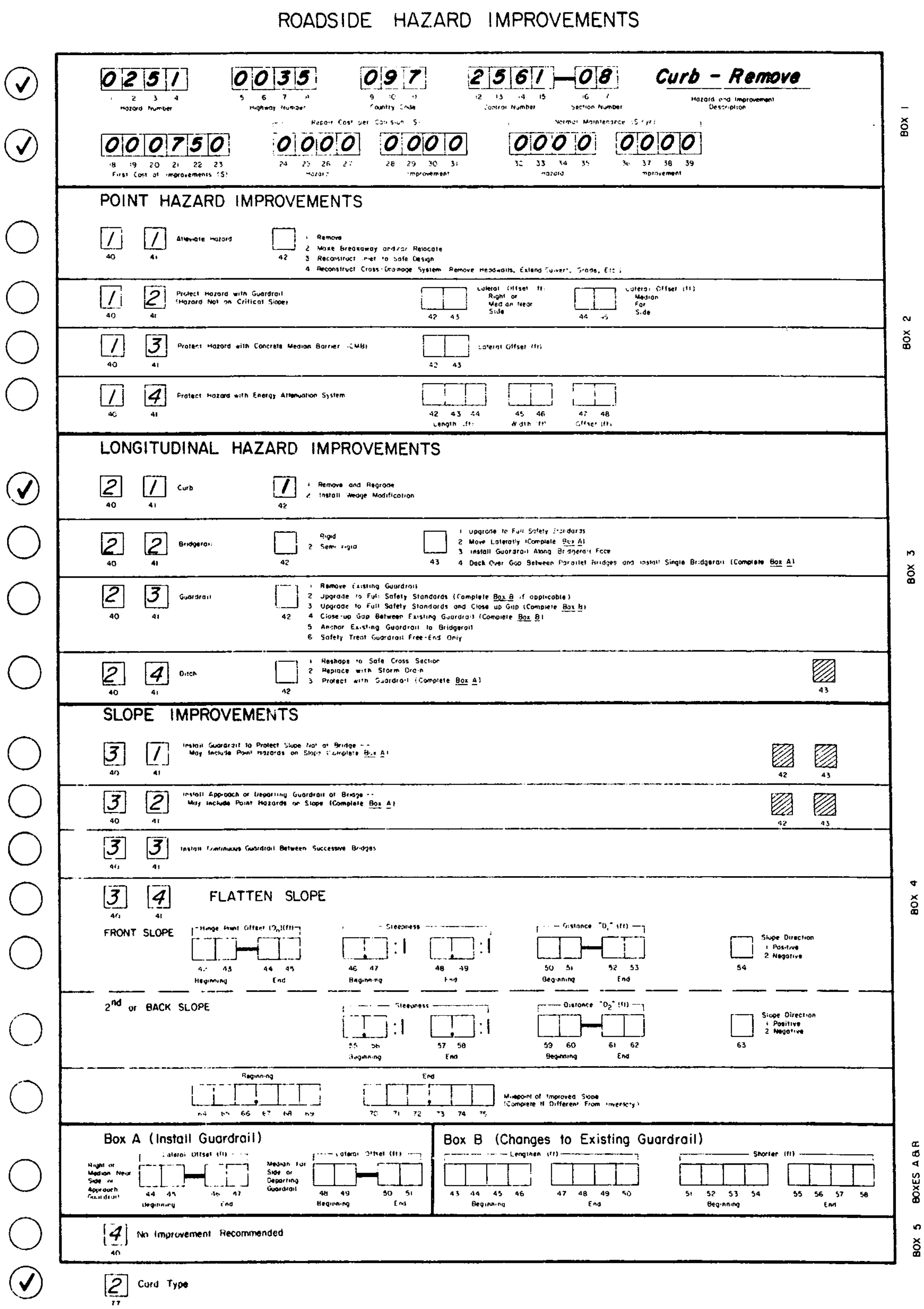
Steepness		Distance "D_2" (ft)			
. :1	. :1				
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)	Slope Direction 1 Positive 2 Negative

✓

1 Card Type
77

Recommendations: *(1) Remove Curb & Regrade*

Figure B-28. Inventory of hazard 2 in grouping (Curb)—Case 3.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0 2 5 1 (1 2 3 4 Hazard Number) — 0 0 3 5 (5 6 7 8 Highway Number) — 0 9 7 (9 10 11 County Code) — 2 5 6 1 (12 13 14 15 Control Number) — 0 8 (16 17 Section Number) — Curb - Remove (Hazard and Improvement Description)

✓ 0 0 0 7 5 0 (18 19 20 21 22 23 First Cost of Improvements ($))

Repair Cost per Collision ($): 0 0 0 0 (24 25 26 27 Hazard) — 0 0 0 0 (28 29 30 31 Improvement)

Normal Maintenance ($/yr): 0 0 0 0 (32 33 34 35 Hazard) — 0 0 0 0 (36 37 38 39 Improvement)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard — ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

✓ 2 (40) 1 (41) Curb — 1 (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42) 1 Rigid 2 Semi-rigid — ☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) — ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (O_0)(ft): ☐☐ (42 43 Beginning) ☐☐ (44 45 End) — Steepness: ☐☐ :1 (46 47 Beginning) ☐☐ :1 (48 49 End) — Distance "O_1" (ft): ☐☐ (50 51 Beginning) ☐☐ (52 53 End) — ☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐☐ :1 (55 56 Beginning) ☐☐ :1 (57 58 End) — Distance "O_2" (ft): ☐☐ (59 60 Beginning) ☐☐ (61 62 End) — ☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐☐☐☐ (64 65 66 67 68 69) — End ☐☐☐☐☐☐ (70 71 72 73 74 75) — Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ Box A (Install Guardrail) — Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ (44 45 Beginning) ☐☐ (46 47 End) — Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ (48 49 Beginning) ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail) — Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End) — Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-29. Improvement alternative 1, hazard 2--Case 3 (Remove curb and regrade).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Bridgerail*

HIGHWAY

✓ BOX 1

08	1 2	Highway Type 08 IH 01 US 02 SH 05 FM-RM
0035	3 4 5 6	Highway Number
1	7	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5 Multilane Undivided
097	8 9 10	County Code
2561	11 12 13 14	Control Number
08	15 16	Section Number
- -	17 18	Total Width, Center Line to Shoulder on Inventory Side (Undivided Highway Only)
120	19 20 21	ADT (Total Both Directions (000's)
1	22	Recording Direction 1 With Milepost 2 Against Milepost

HAZARD CLASSIFICATION

✓ BOX 2

0252	23 24 25 26	Hazard Number
12	27 28	Identification Code
05	29 30	Descriptor Code
1	31	Offset Code 1. Right 2. Median or Left Side
- - -	32 33 34	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only
0111	35 36 37 38	Grouping Number

MILE POINT AT HAZARD

105.024	39 40 41 42 43 44	Beginning
105.051	45 46 47 48 49 50	End (Except for Point Hazard)

POINT HAZARDS

○ BOX 3

1	51	
☐☐	52 53	Hazard Offset, D (ft)
☐☐☐	54 55 56	Width (W) (ft)
☐☐☐	57 58 59	Length (L) (ft)
☐☐.☐	60 61 62	Drop Inlets Only: Height (ft) or
☐☐.☐	63 64 65	Drop Inlets Only: Depth (ft)

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

✓ BOX 4

2	51	
10	52 53	Hazard Offset, D (ft): Beginning
10	54 55	Hazard Offset, D (ft): End
02.3	56 57 58	Height (ft) or Depth (ft)
01	59 60	Width (W) (ft)

END TREATMENT

☐ 61
1. Not Beginning at Structure - Safety Treated
2. Not Beginning at Structure - Not Safety Treated
3. Beginning at Structure - Full-Beam Connection
4. Beginning at Structure - Not Full-Beam Connection

Guardrail Only ☐ 62
1. Not Ending at Structure - Safety Treated
2. Not Ending at Structure - Not Safety Treated
3. Ending at Structure - Full-Beam Connection
4. Ending at Structure - Not Full-Beam Connection

SLOPES

BOX 5

FRONT SLOPE

○

3	51	
☐☐	52 53	Hinge Point Offset, D_0, (ft): Beginning
☐☐	54 55	Hinge Point Offset, D_0, (ft): End
☐.☐ :1	56 57	Steepness: Beginning
☐.☐ :1	58 59	Steepness: End
☐☐	60 61	Distance "D_1" (ft): Beginning
☐☐	62 63	Distance "D_1" (ft): End
☐	64	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft.)
☐	65	Slope Direction 1. Positive 2. Negative

2nd or BACK SLOPE (Except for Level Terrain)

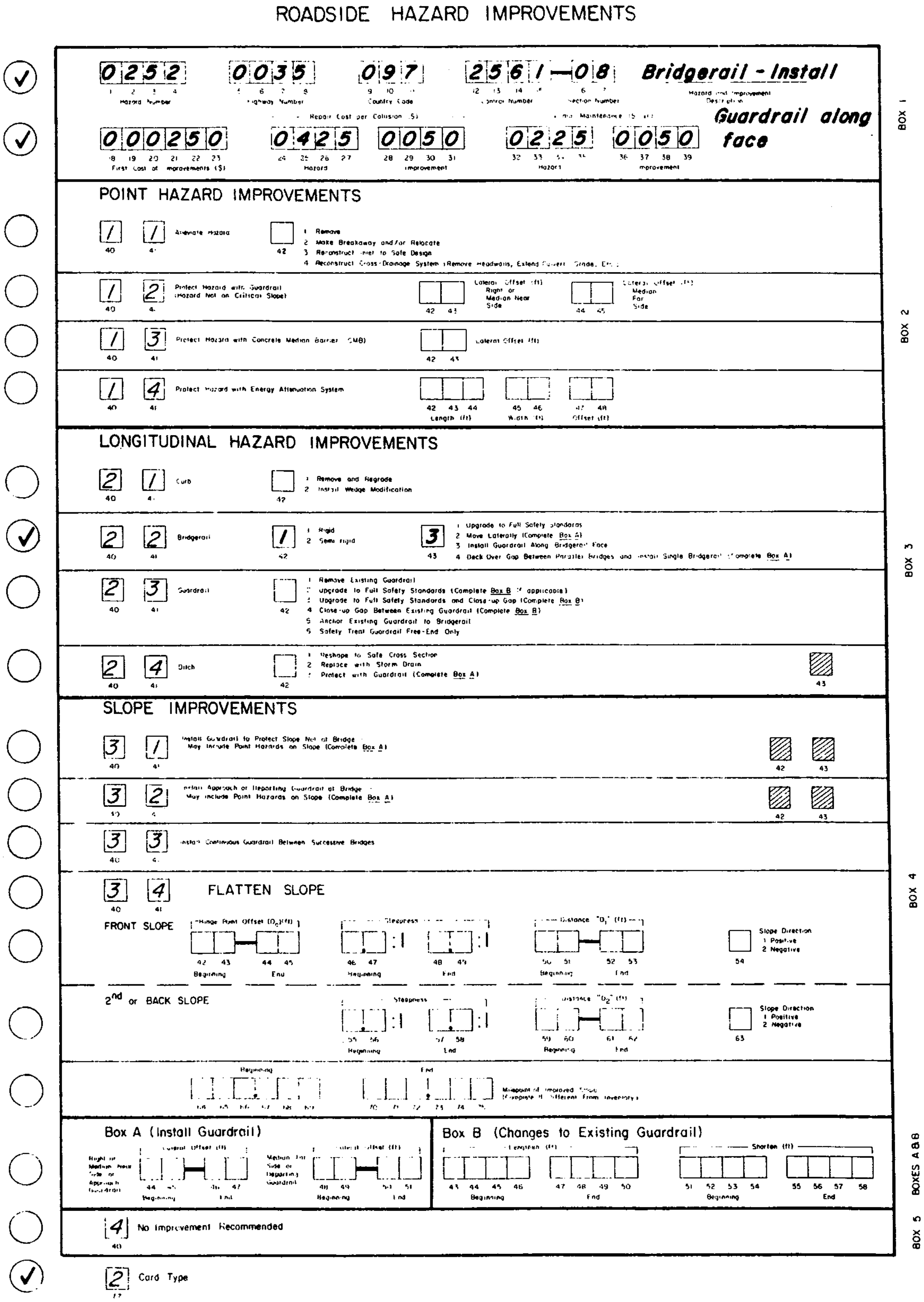
○

☐.☐ :1	66 67	Steepness: Beginning
☐.☐ :1	68 69	Steepness: End
☐☐	70 71	Distance "D_2" (ft): Beginning
☐☐	72 73	Distance "D_2" (ft): End
☐	74	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)
☐	75	Slope Direction 1 Positive 2. Negative

✓ 1 Card Type (77)

Recommendations: *(1) Install Guardrail along Bridgerail face*

Figure B-30. Inventory of hazard 3 in grouping (Bridgerail)—Case 3.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0252 | 0035 | 097 | 2561—08 | Bridgerail - Install

1 2 3 4 Hazard Number; 5 6 7 8 Highway Number; 9 10 11 Country Code; 12 13 14 15 Control Number; 16 17 Section Number; Hazard and Improvement Description

Repair Cost per Collision ($) — Annual Maintenance ($/yr)

✓ 000250 | 0425 | 0050 | 0225 | 0050 | Guardrail along face

18 19 20 21 22 23 First Cost of Improvements ($); 24 25 26 27 Hazard; 28 29 30 31 Improvement; 32 33 34 35 Hazard; 36 37 38 39 Improvement

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

✓ 2 (40) 2 (41) Bridgerail 1 (42)
1 Rigid
2 Semi-rigid

3 (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
5 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge - May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge - May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (O_c)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐☐ :1 (46 47) Beginning; ☐☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ :1 (55 56) Beginning; ☐☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐☐☐☐ (64 65 66 67 68 69) End ☐☐☐☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

Box A (Install Guardrail)

○ Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning — ☐☐ (46 47) End

Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning — ☐☐ (50 51) End

Box B (Changes to Existing Guardrail)

Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning; ☐☐☐☐ (47 48 49 50) End

Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning; ☐☐☐☐ (55 56 57 58) End

BOXES A&B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (17) Card Type

Figure B-31. Improvement alternative 1, hazard 3--Case 3 (Install guardrail along bridgerail face).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by **G.D. Weaver** Date ______ Hazard Description **Slope**

✓

HIGHWAY

BOX 1

Field	Columns	Entry	Codes
Highway Type	1 2	08	08 IH 01 US 02 SH 05 FM-RM
Highway Number	3 4 5 6	0035	
Classification	7	1	Full Control Access 1 Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5 Multilane Undivided
County Code	8 9 10	097	
Control Number	11 12 13 14	2561	
Section Number	15 16	08	
Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	17 18	- -	
ADT (Total Both Directions (000's)	19 20 21	120	
Recording Direction	22	1	1. With Milepost 2. Against Milepost

✓

HAZARD CLASSIFICATION

Field	Columns	Entry	Codes
Hazard Number	23 24 25 26	0253	
Identification Code	27 28	07	
Descriptor Code	29 30	02	
Offset Code	31	1	1. Right 2. Median or Left Side
Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	32 33 34	- - -	
Grouping Number	35 36 37 38	0111	

MILE POINT AT HAZARD

BOX 2

Field	Columns	Entry
Beginning	39 40 41 42 43 44	105.005
End (Except for Point Hazard)	45 46 47 48 49 50	105.024

○

POINT HAZARDS

BOX 3

Field	Columns	Entry
	51	1
Hazard Offset, D (ft)	52 53	
Width (W) (ft)	54 55 56	
Length (L) (ft)	57 58 59	
Drop Inlets Only: Height (ft)	60 61 62	
or Depth (ft)	63 64 65	

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

Field	Columns	Entry	Codes
	51	2	
Hazard Offset, D (ft) Beginning	52 53		
Hazard Offset, D (ft) End	54 55		
Height (ft) or Depth (ft)	56 57 58		
Width (W) (ft)	59 60		
END TREATMENT Guardrail Only	61		1. Not Beginning of Structure - Safety Treated 2. Not Beginning of Structure - Not Safety Treated 3. Beginning of Structure - Full-Beam Connection 4. Beginning of Structure - Not Full-Beam Connection
END TREATMENT Guardrail Only	62		1. Not Ending of Structure - Safety Treated 2. Not Ending of Structure - Not Safety Treated 3. Ending of Structure - Full-Beam Connection 4 Ending of Structure - Not Full Beam Connection

✓

SLOPES

FRONT SLOPE

BOX 5

Field	Columns	Entry	Codes
	51	3	
Hinge Point Offset, D_0, (ft) Beginning	52 53	14	
Hinge Point Offset, D_0, (ft) End	54 55	12	
Steepness Beginning	56 57	3.1 :1	
Steepness End	58 59	2.6 :1	
Distance "D_1" (ft) Beginning	60 61	72	
Distance "D_1" (ft) End	62 63	61	
Slope Face Erosion Code	64	2	1. Slight or None 2. Severe (Ruts > 1 ft)
Slope Direction	65	2	1. Positive 2. Negative

✓

2nd or BACK SLOPE (Except for Level Terrain)

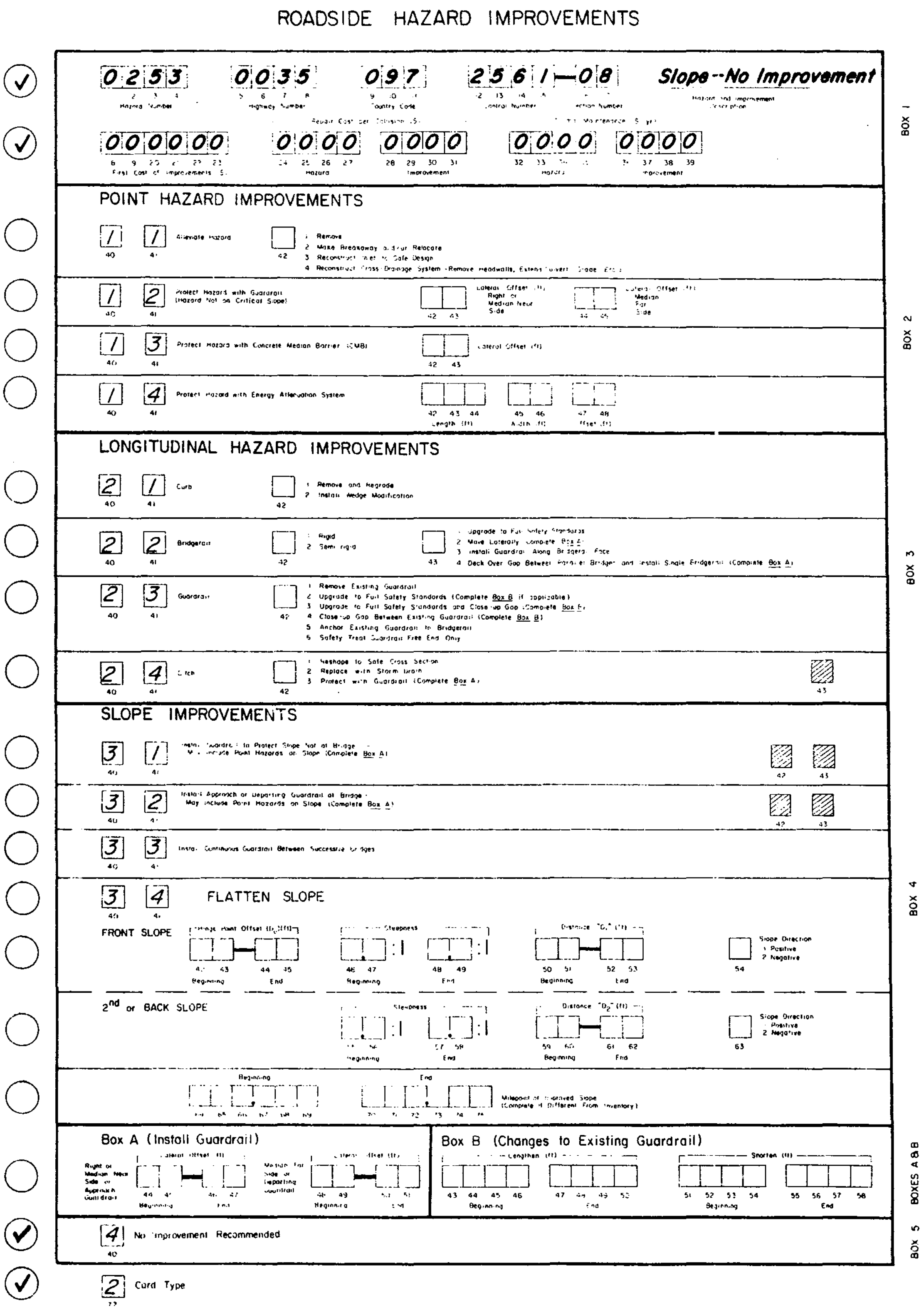
Field	Columns	Entry	Codes
Steepness Beginning	66 67	9.9 :1	
Steepness End	68 69	9.9 :1	
Distance "D_2" (ft) Beginning	70 71	99	
Distance "D_2" (ft) End	72 73	99	
Slope Face Erosion Code	74	1	1 Slight or None 2 Severe (Ruts > 1 ft)
Slope Direction	75	1	1 Positive 2. Negative

✓

1 Card Type (77)

Recommendations: **(1) No Improvement**

Figure B-32. Inventory of hazard 4 in grouping (Slope)—Case 3.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0253 Hazard Number (2 3 4) | 0035 Highway Number (5 6 7 8) | 097 Country Code (9 10 11) | 2561 Control Number (12 13 14 15) — 08 Section Number | Slope--No Improvement Hazard and Improvement Description

Repair Cost per Collision ($) | Annual Maintenance ($/yr)

✓ 000000 First Cost of Improvements ($) (18 19 20 21 22 23) | 0000 Hazard (24 25 26 27) | 0000 Improvement (28 29 30 31) | 0000 Hazard (32 33 34 35) | 0000 Improvement (36 37 38 39)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 1 Alleviate Hazard ☐ 42
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 2 Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ 42 43 Lateral Offset (ft) Right or Median Near Side ☐☐ 44 45 Lateral Offset (ft) Median Far Side

○ 1 3 Protect Hazard with Concrete Median Barrier (CMB) ☐☐ 42 43 Lateral Offset (ft)

○ 1 4 Protect Hazard with Energy Attenuation System ☐☐☐ 42 43 44 Length (ft) ☐☐ 45 46 Width (ft) ☐☐ 47 48 Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 1 Curb ☐ 42
1 Remove and Regrade
2 Install Wedge Modification

○ 2 2 Bridgerail ☐ 42
1 Rigid
2 Semi-rigid

☐ 43
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 3 Guardrail ☐ 42
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free End Only

○ 2 4 Ditch ☐ 42 ▨ 43
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 3

SLOPE IMPROVEMENTS

○ 3 1 Install Guardrail to Protect Slope Not at Bridge - May Include Point Hazards on Slope (Complete Box A) ▨ 42 ▨ 43

○ 3 2 Install Approach or Departing Guardrail at Bridge - May Include Point Hazards on Slope (Complete Box A) ▨ 42 ▨ 43

○ 3 3 Install Continuous Guardrail Between Successive Bridges

○ 3 4 FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ 42 43 Beginning — ☐☐ 44 45 End
Steepness: ☐.☐ :1 46 47 Beginning | ☐.☐ :1 48 49 End
Distance "D_1" (ft): ☐☐ 50 51 Beginning — ☐☐ 52 53 End
☐ 54 Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 55 56 Beginning | ☐.☐ :1 57 58 End
Distance "D_2" (ft): ☐☐ 59 60 Beginning — ☐☐ 61 62 End
☐ 63 Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐☐.☐☐ 64 65 66 67 68 69 | End ☐☐☐.☐☐☐ 70 71 72 73 74 75 Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ 44 45 Beginning — ☐☐ 46 47 End
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ 48 49 Beginning — ☐☐ 50 51 End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ 43 44 45 46 Beginning | ☐☐☐☐ 47 48 49 50 End
Shorten (ft): ☐☐☐☐ 51 52 53 54 Beginning | ☐☐☐☐ 55 56 57 58 End

BOXES A&B

✓ 4 No Improvement Recommended (40)

BOX 5

✓ 2 Card Type (77)

Figure B-33. Improvement alternative 1, hazard 4--Case 3 (No improvement recommended).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Slope*

✓

HIGHWAY

BOX 1

1 2	Highway Type 08 IH 01 US 02 SH 05 FM-RM	08
3 4 5 6	Highway Number	0035
7	Classification Full Control Access 1. Interstate 2 Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5. Multilane Undivided	1
8 9 10	County Code	097
11 12 13 14	Control Number	2561
15 16	Section Number	08
17 18	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	- -
19 20 21	ADT (Total Both Directions 1000's)	120
22	Recording Direction 1. With Milepost 2. Against Milepost	1

✓

HAZARD CLASSIFICATION

BOX 2

23 24 25 26	Hazard Number	0254
27 28	Identification Code	07
29 30	Descriptor Code	02
31	Offset Code 1. Right 2. Median or Left Side	1
32 33 34	Median Width (ft) (Leave Blank if Median inventoried on Near Side Only	- - -
35 36 37 38	Grouping Number	0111

MILE POINT AT HAZARD

39 40 41 42 43 44	Beginning	105.051
45 46 47 48 49 50	End (Except for Point Hazard)	105.086

○

POINT HAZARDS

BOX 3

51		1
52 53	Hazard Offset, O (ft)	
54 55 56	Width (W) (ft)	
57 58 59	Length (L) (ft)	
60 61 62	Drop Inlets Only — Height (ft) or	
63 64 65	Drop Inlets Only — Depth (ft)	

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

51		2
52 53	Hazard Offset, O Ft) — Beginning	
54 55	Hazard Offset, O Ft) — End	
56 57 58	Height (ft) or Depth (ft)	
59 60	Width (W) (ft)	
61	END TREATMENT 1. Not Beginning of Structure - Safety Treated 2. Not Beginning of Structure - Not Safety Treated 3. Beginning of Structure - Full-Beam Connection 4 Beginning of Structure - Not Full-Beam Connection	
62	END TREATMENT — Guardrail Only 1. Not Ending of Structure- Safety Treated 2. Not Ending of Structure- Not Safety Treated 3. Ending of Structure - Full-Beam Connection 4 Ending of Structure - Not Full-Beam Connection	

SLOPES

BOX 5

✓

FRONT SLOPE

51		3
52 53	Hinge Point Offset, D_o, (ft) — Beginning	12
54 55	Hinge Point Offset, D_o, (ft) — End	15
56 57	Steepness — Beginning	2.5 :1
58 59	Steepness — End	3.2 :1
60 61	Distance "D_1" (ft) — Beginning	59
62 63	Distance "D_1" (ft) — End	68
64	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts >1 ft)	2
65	Slope Direction 1. Positive 2. Negative	2

✓

2nd or BACK SLOPE (Except for Level Terrain)

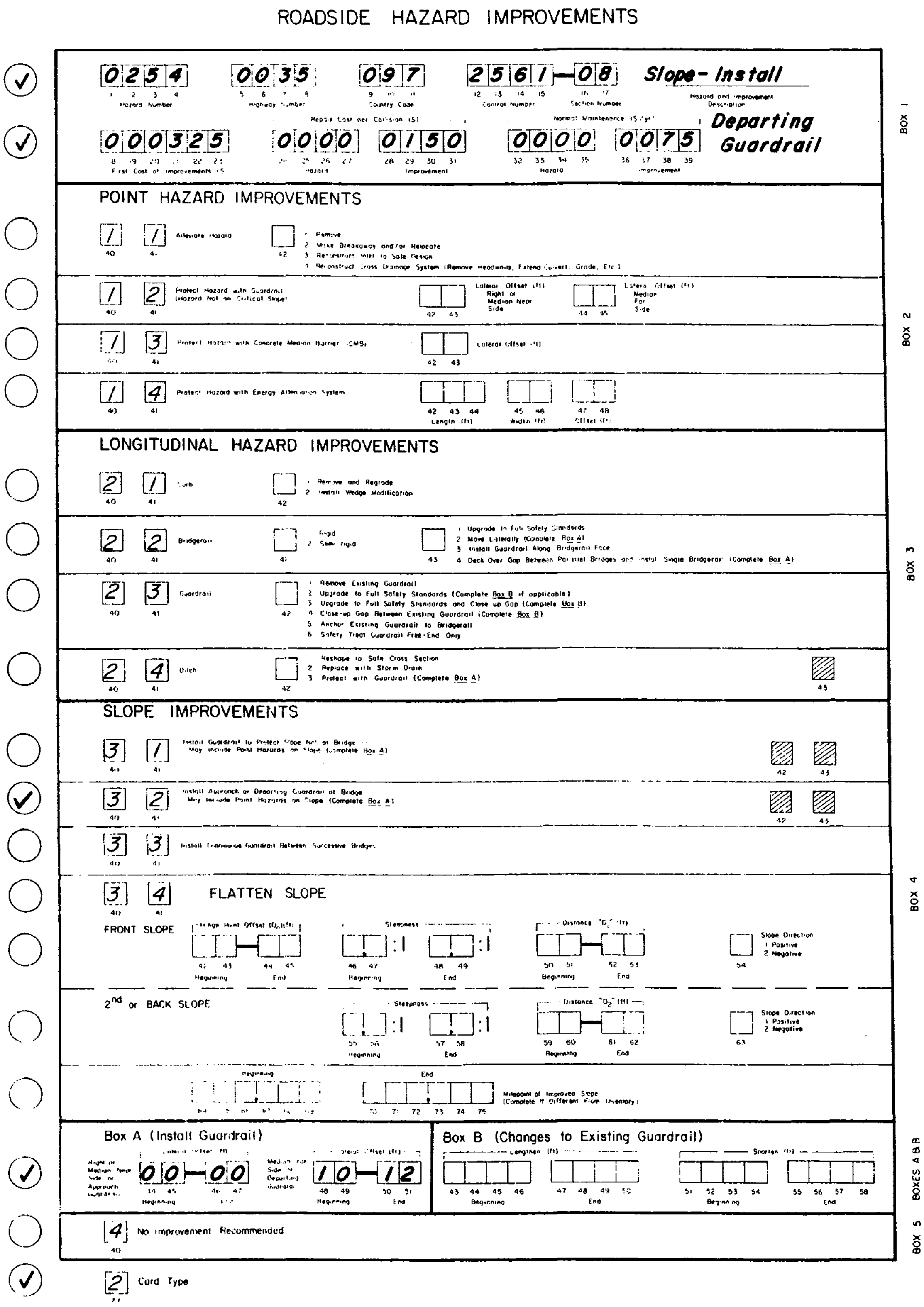
66 67	Steepness — Beginning	9.9 :1
68 69	Steepness — End	9.9 :1
70 71	Distance "D_2" (ft) — Beginning	99
72 73	Distance "D_2" (ft) — End	99
74	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts >1 ft)	1
75	Slope Direction 1 Positive 2. Negative	1

✓

1 Card Type
77

Recommendations: *(1) Install Guardrail Departing Bridge*

Figure B-34. Inventory of hazard 5 in grouping (Slope)--Case 3.



ROADSIDE HAZARD IMPROVEMENTS

✓ 0254 (1 2 3 4 Hazard Number) 0035 (5 6 7 8 Highway Number) 097 (9 10 11 County Code) 2561—08 (12 13 14 15 Control Number; 16 17 Section Number) *Slope- Install Departing Guardrail* (Hazard and Improvement Description)

✓ 000325 (18 19 20 21 22 23 First Cost of Improvements ($)) Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0150 (28 29 30 31 Improvement) Normal Maintenance ($/yr): 0000 (32 33 34 35 Hazard) 0075 (36 37 38 39 Improvement)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42) 1 Rigid 2 Semi Rigid ☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42) ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

✓ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_h)(ft): ☐☐—☐☐ (42 43 Beginning; 44 45 End)
Steepness: ☐.☐:1 (46 47 Beginning) ☐.☐:1 (48 49 End)
Distance "D_1" (ft): ☐☐—☐☐ (50 51 Beginning; 52 53 End)
☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐:1 (55 56 Beginning) ☐.☐:1 (57 58 End)
Distance "D_2" (ft): ☐☐—☐☐ (59 60 Beginning; 61 62 End)
☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

✓ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) 00—00 (44 45 Beginning; 46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) 10—12 (48 49 Beginning; 50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-35. Improvement alternative 1, hazard 4--Case 3 (Install guardrail departing bridge).

```
                                          C O S T   E F F E C T I V E N E S S   P R O G R A M

                                                 TYPE HIGHWAY = INTERSTATE (CODE 08)
                                       HIGHWAY CLASSIFICATION = CONTROLLED ACCESS -- INTERSTATE


                                                   HIGHWAY NO  =   35
                                                    COUNTY NO  =   97
                                                  DISTRICT NO  =   25
                                                   CONTROL NO  = 2561
                                                   SECTION NO  =    8

                                          RECORDING DIRECTION  =    1
                                                   ADT (1000)  =  120
                                                         LIFE  =   20(YRS)
                                                     INTEREST  =  8.0(PERCENT)
                                                         DATE  = 10-74

                        H   A   Z   A   R   D                                            I   M   P   R   O   V   E   M   E   N   T

 HAZARD  IDENT  DESC     END      SEVERITY  OFFSET  GROUP      MILE-POST         IMPR  IMPR   SEVERITY  FIRST  PRESENT  ANNUAL    COST
   NO    CODE   CODE  TREATMENT    INDEX     CODE    NO     BEG        END        ALT  CODE    INDEX    COST    WORTH    COST  EFFECTIVE
                      BEG   END                                                                                                 VALUE
                                                                                                         ($)     ($)    ($/YR)

  251     5      3     0     0      3.7       1      111  105.024 105.051         1  2-1-1-0   0.0     750      749      76    GROUP
  252    12      5     0     0     82.5       1      111  105.024 105.051         1  2-2-1-3   3.3     250     -998    -101    GROUP
  250     6      4     1     4      7.5       1      111  105.000 105.024         1  2-3-5-0   3.6     325    -1491    -151    GROUP
  254     7      2     0     0     60.0       1      111  105.051 105.086         1  3-2-0-0   3.3     325     -299     -30    GROUP
  253     7      2     0     0     60.0       1      111  105.005 105.024         1  4-0-0-0  60.0       0     -299     -30          0
```

Figure B-36. Cost-effectiveness program output--Case 3.

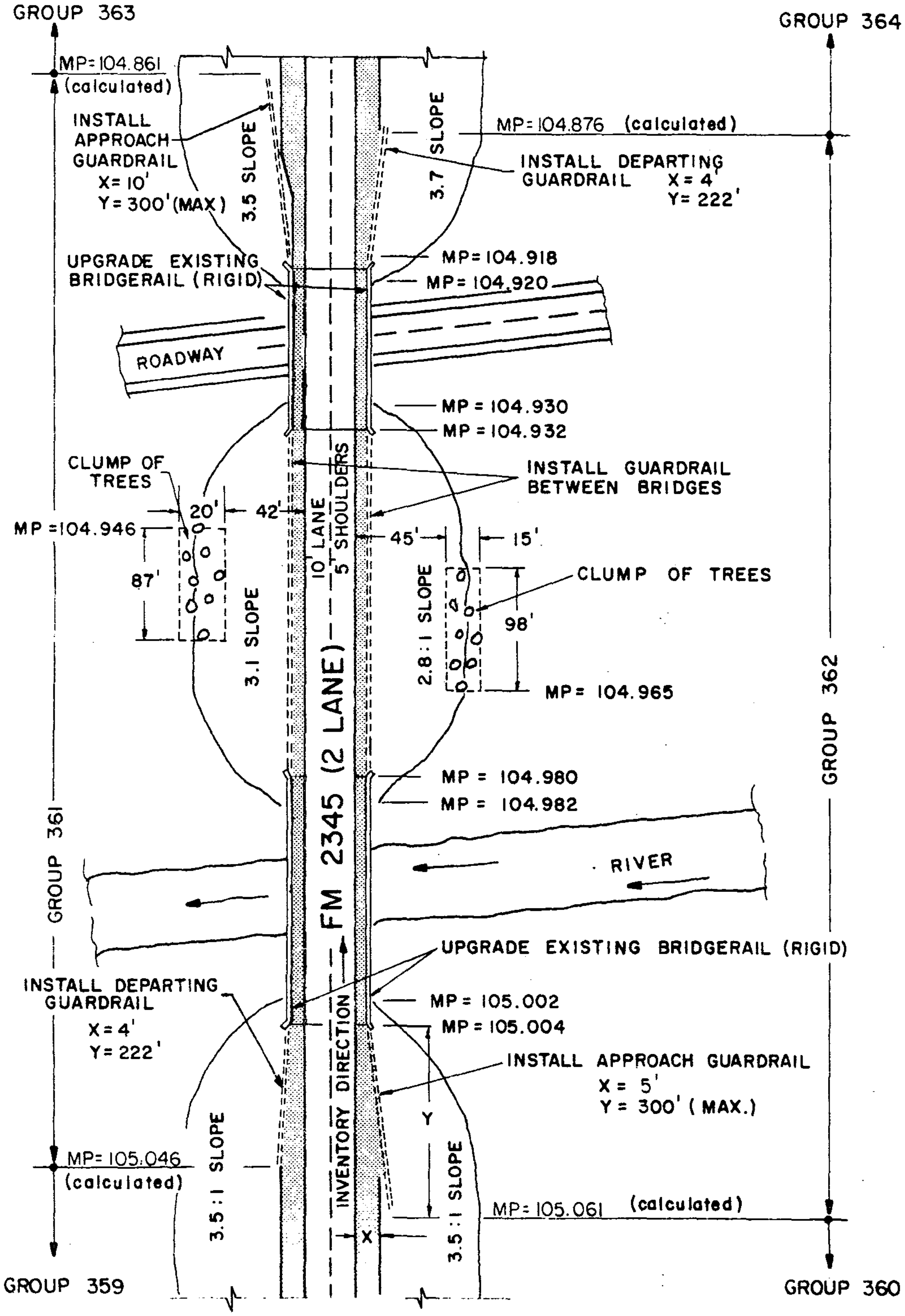


Figure B-37. Hazard description--Case 4.

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G.D. Weaver* Date ________ Hazard Description *Slope (approach)*

✓

HIGHWAY

05	2345	3	160	4321—08	10	003	2
1 2	3 4 5 6	7	8 9 10	11 12 13 14 — 15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5. Multilane Undivided	County Code	Control Number — Section Number	Total Width Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

BOX 1

✓

HAZARD CLASSIFICATION

2000	07—02	1	- - -	0362
23 24 25 26	27 28 — 29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code — Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

105.061	105.004
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

BOX 2

○

POINT HAZARDS

				Drop inlets Only	
1	☐☐	☐☐☐	☐☐☐	☐☐.☐	☐☐.☐
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft) or	Depth (ft)

BOX 3

○

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

	Hazard Offset, D (ft)				END TREATMENT	Guardrail Only
2	☐☐	☐☐	☐☐.☐	☐☐	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure - Full-Beam Connection 4 Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

BOX 4

✓

SLOPES

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	12	08	3.5 :1	2.0 :1	50	40	2	2
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts >1 ft.)	Slope Direction 1. Positive 2. Negative

✓

2nd or BACK SLOPE (Except for Level Terrain)

Steepness		Distance "D_2" (ft)			
9.9 :1	9.9 :1	99	99	2	1
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts >1 ft)	Slope Direction 1. Positive 2. Negative

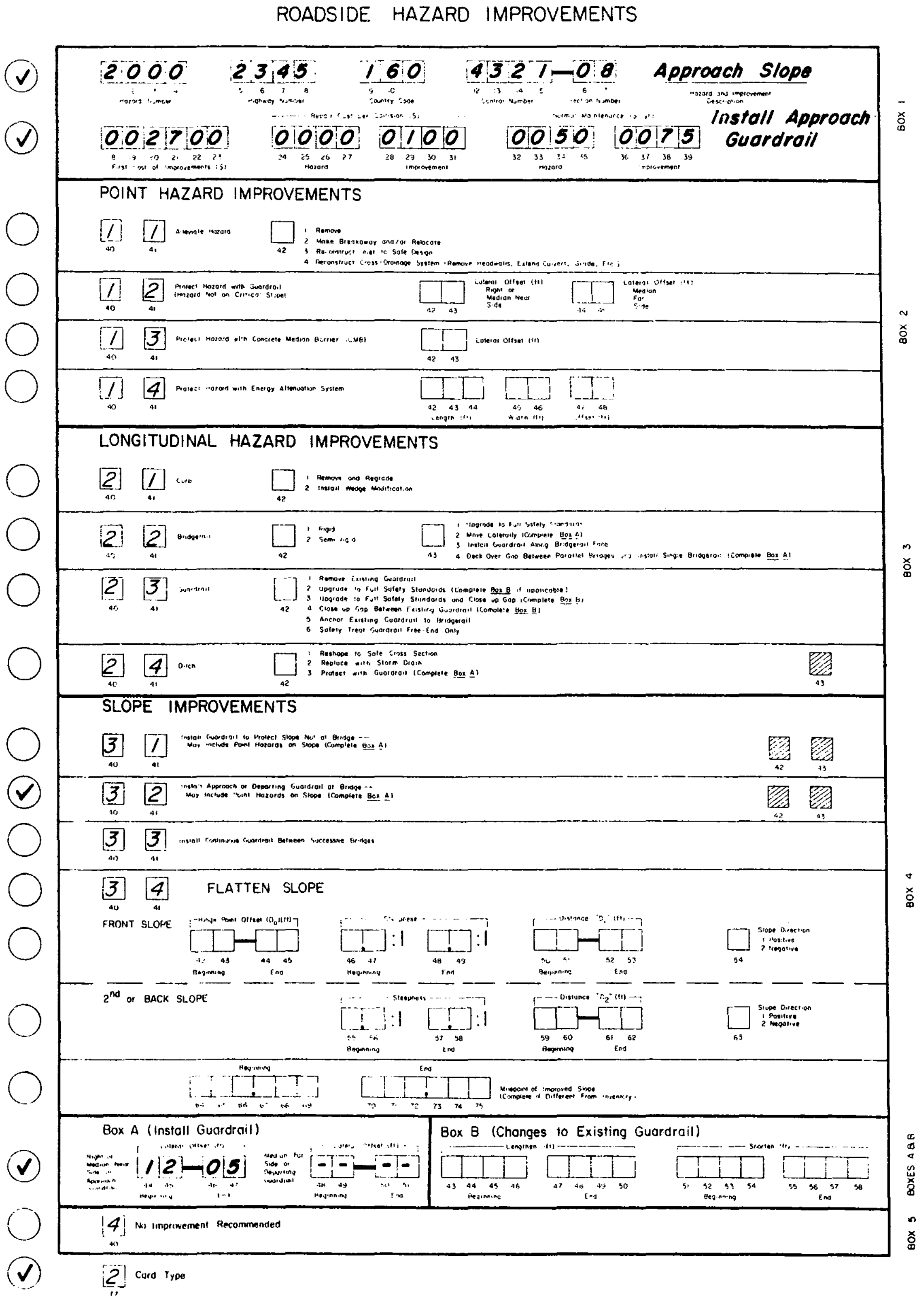
BOX 5

✓

1 Card Type
77

Recommendations: *Install Approach Guardrail*

Figure B-38. Inventory of hazard 1 in grouping (Slope)—Case 4.



ROADSIDE HAZARD IMPROVEMENTS

☑ 2000 (Hazard Number, 2 3 4) — 2345 (Highway Number, 5 6 7 8) — 160 (County Code, 9 10) — 4321 (Control Number, 12 13 14 15) — 08 (Section Number, 16 17) — ***Approach Slope*** (Hazard and Improvement Description)

☑ 002700 (First Cost of Improvements ($), 18 19 20 21 22 23) — Repair Cost per Collision ($): 0000 (Hazard, 24 25 26 27), 0100 (Improvement, 28 29 30 31) — Normal Maintenance ($/yr): 0050 (Hazard, 32 33 34 35), 0075 (Improvement, 36 37 38 39) — ***Install Approach Guardrail***

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alternate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

☑ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_o)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐☐ (46 47) :1 Beginning ☐☐ (48 49) :1 End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ (55 56) :1 Beginning ☐☐ (57 58) :1 End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐☐☐☐ (64 65 66 67 68 69) End ☐☐☐☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete if Different From Inventory)

BOX 4

☑ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): 12 (44 45) Beginning — 05 (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): - - (48 49) Beginning — - - (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning ☐☐☐☐ (55 56 57 58) End

BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

☑ 2 (77) Card Type

Figure B-39. Improvement alternative 1, hazard 1--Case 4 (Install approach guardrail).

ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Bridgerail*

✓

HIGHWAY

BOX 1

05	2345	3	160	4321	08	10	003	2
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type	Highway Number	Classification	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction

Highway Type:
- 08 IH
- 01 US
- 02 SH
- 05 FM-RM

Classification:
- Full Control Access
  - 1. Interstate
  - 2. Non-Interstate
- Non-Control Access
  - 3 Two-Lane
  - 4. Multilane Divided
  - 5. Multilane Undivided

Recording Direction:
- 1. With Milepost
- 2. Against Milepost

✓

HAZARD CLASSIFICATION

2001	12	05	1	- - -	0362
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number

MILE POINT AT HAZARD

BOX 2

105.004	104.980
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○

POINT HAZARDS

BOX 3

				Drop Inlets Only		
1	☐☐	☐☐☐	☐☐☐	☐☐☐	or	☐☐☐
51	52 53	54 55 56	57 58 59	60 61 62		63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft)		Depth (ft)

✓

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

BOX 4

	Hazard Offset, D (ft)				END TREATMENT	Guardrail Only
2	05	05	02.5	01	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning of Structure - Safety Treated 2. Not Beginning of Structure - Not Safety Treated 3. Beginning of Structure - Full-Beam Connection 4 Beginning of Structure - Not Full-Beam Connection	1. Not Ending of Structure - Safety Treated 2. Not Ending of Structure - Not Safety Treated 3. Ending of Structure - Full-Beam Connection 4. Ending of Structure - Not Full-Beam Connection

○

SLOPES

BOX 5

FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	☐☐	☐☐	☐☐ :1	☐☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts >1 ft.)	Slope Direction 1. Positive 2. Negative

○

2nd or BACK SLOPE (Except for Level Terrain)

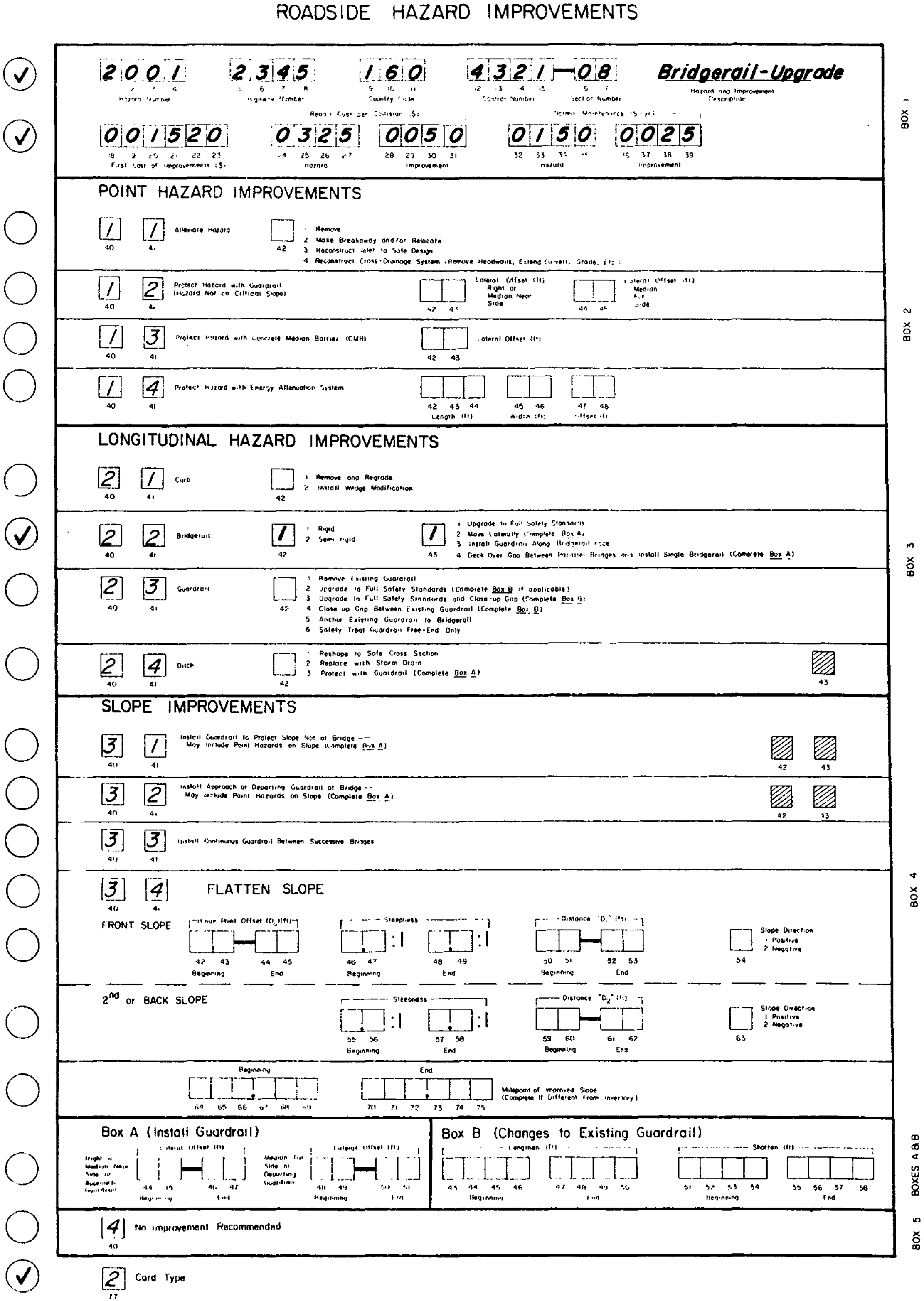
Steepness		Distance "D_2" (ft)			
☐☐ :1	☐☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2. Severe (Ruts >1 ft)	Slope Direction 1. Positive 2. Negative

✓

1 Card Type
77

Recommendations: *Upgrade Bridgerail*

Figure B-40. Inventory of hazard 2 (1st bridgerail)—Case 4.



ROADSIDE HAZARD IMPROVEMENTS

✓ 2 0 0 1 (2 3 4) Hazard Number | 2 3 4 5 (5 6 7 8) Highway Number | 1 6 0 (9 10 11) County Code | 4 3 2 1 (12 13 14 15) Control Number – 0 8 (16 17) Section Number | **Bridgerail-Upgrade** Hazard and Improvement Description

BOX 1

✓ 0 0 1 5 2 0 (18 19 20 21 22 23) First Cost of Improvements ($)

Repair Cost per Collision ($): 0 3 2 5 (24 25 26 27) Hazard | 0 0 5 0 (28 29 30 31) Improvement

Normal Maintenance ($/yr): 0 1 5 0 (32 33 34 35) Hazard | 0 0 2 5 (36 37 38 39) Improvement

POINT HAZARD IMPROVEMENTS

BOX 2

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44) Length (ft) ☐☐ (45 46) Width (ft) ☐☐ (47 48) Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

✓ 2 (40) 2 (41) Bridgerail 1 (42)
1 Rigid
2 Semi-rigid

1 (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

▨ (43)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_3)(ft): ☐☐ (42 43) Beginning – ☐☐ (44 45) End
Steepness: ☐.☐ :1 (46 47) Beginning ☐.☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning – ☐☐ (52 53) End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56) Beginning ☐.☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning – ☐☐ (61 62) End
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning – ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning – ☐☐ (50 51) End

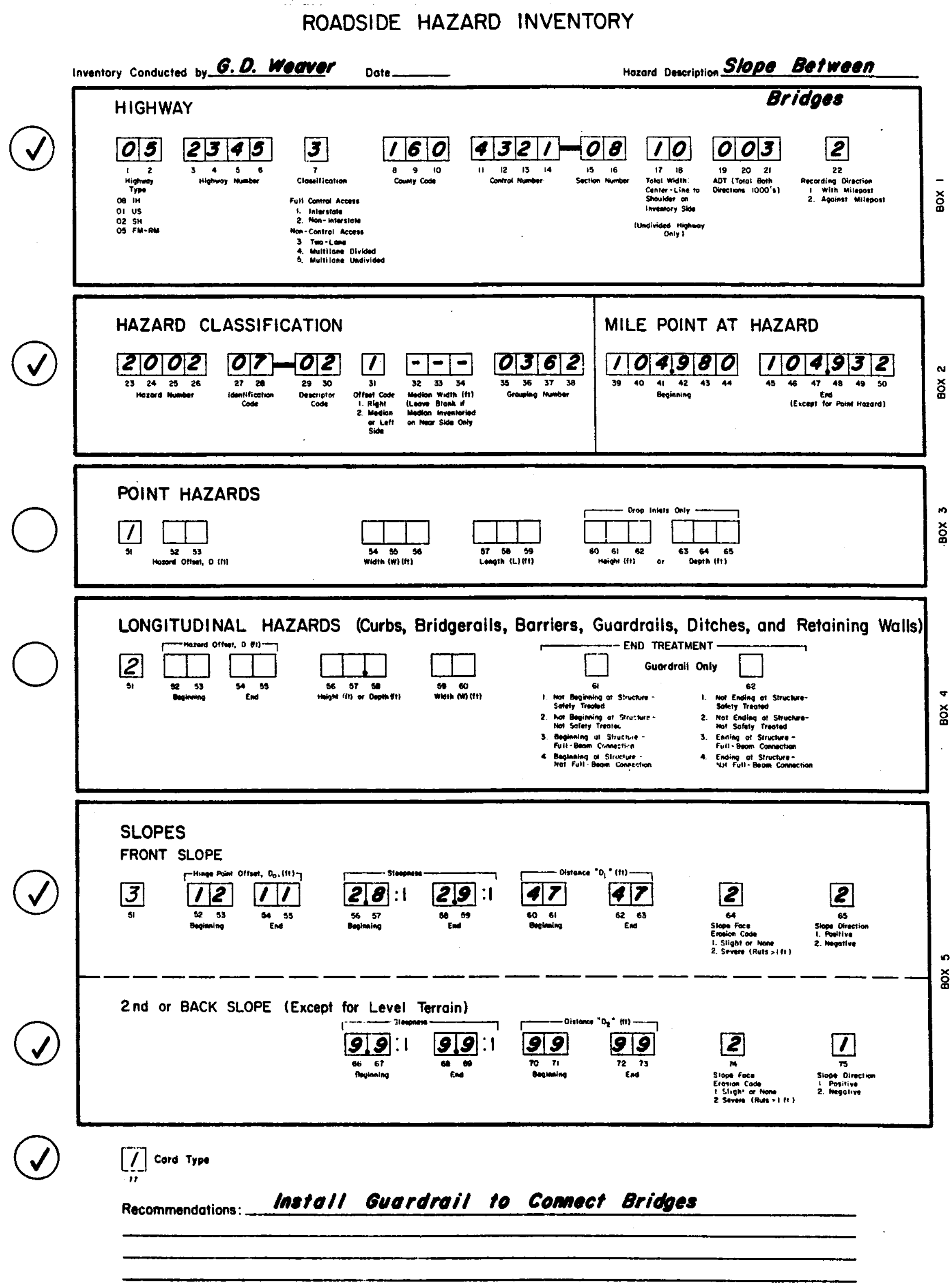
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning ☐☐☐☐ (55 56 57 58) End

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-41. Improvement alternative 1, hazard 2--Case 4 (Upgrade to full safety standards).



ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Slope Between Bridges*

✓ **BOX 1**

HIGHWAY

0 5	2 3 4 5	3	1 6 0	4 3 2 1	— 0 8	1 0	0 0 3	2
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5. Multilane Undivided	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2. Against Milepost

✓ **BOX 2**

HAZARD CLASSIFICATION

2 0 0 2	0 7	— 0 2	1	- - -	0 3 6 2
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only	Grouping Number

MILE POINT AT HAZARD

1 0 4.9 8 0	1 0 4.9 3 2
39 40 41 42 43 44	45 46 47 48 49 50
Beginning	End (Except for Point Hazard)

○ **BOX 3**

POINT HAZARDS

				Drop Inlets Only		
1						
51	52 53	54 55 56	57 58 59	60 61 62		63 64 65
	Hazard Offset, O (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft)	or	Depth (ft)

○ **BOX 4**

LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)

	Hazard Offset, O (ft)				END TREATMENT	Guardrail Only
2			.			
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure - Full-Beam Connection 4 Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

BOX 5

SLOPES

✓ FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	1 2	1 1	2.8 :1	2.9 :1	4 7	4 7	2	2
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft)	Slope Direction 1. Positive 2. Negative

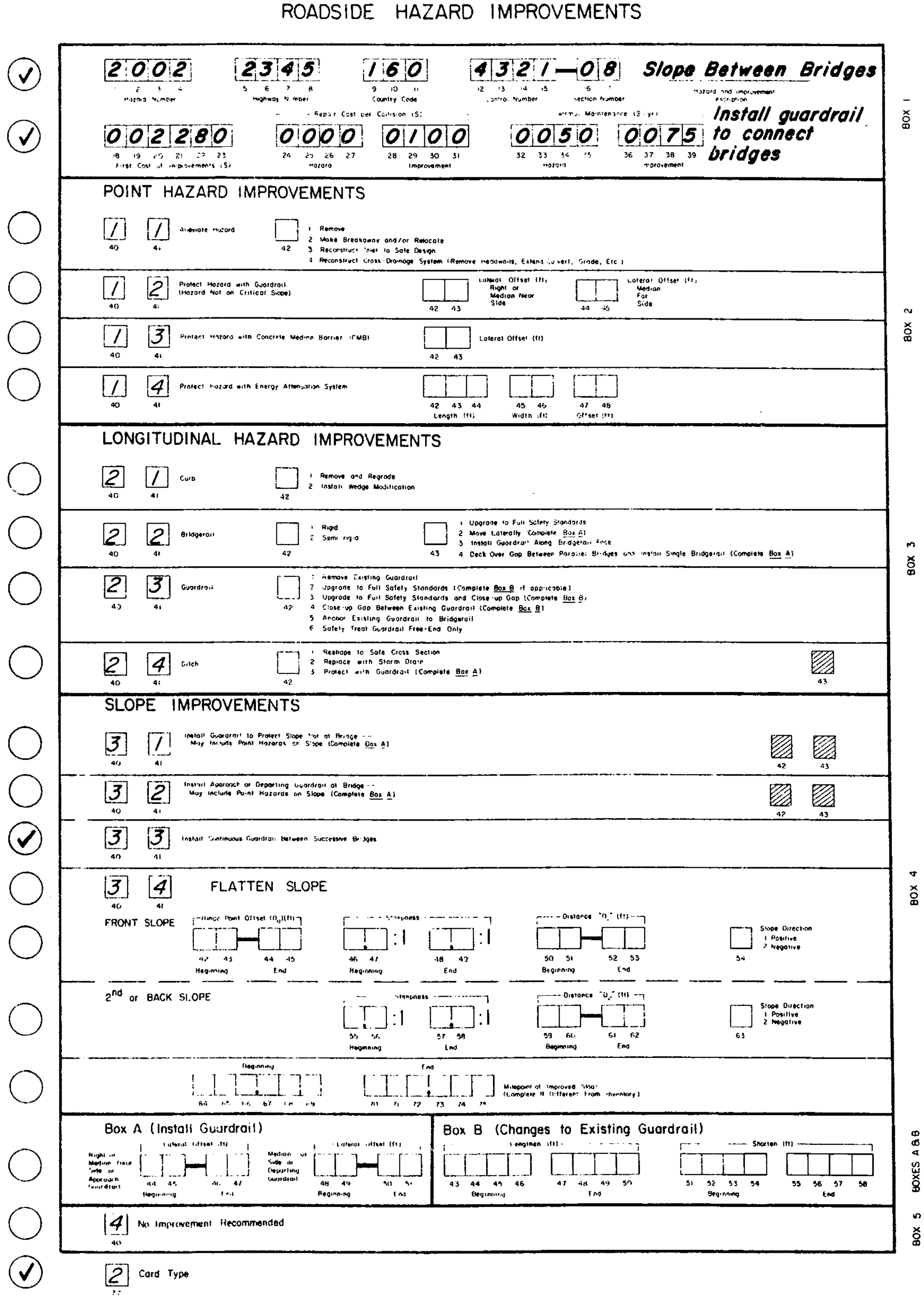
✓ 2nd or BACK SLOPE (Except for Level Terrain)

Steepness		Distance "D_2" (ft)			
9.9 :1	9.9 :1	9 9	9 9	2	1
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft)	Slope Direction 1 Positive 2. Negative

✓ 1 Card Type
77

Recommendations: *Install Guardrail to Connect Bridges*

Figure B-42. Inventory of hazard 3 in grouping (Slope)—Case 4.



ROADSIDE HAZARD IMPROVEMENTS

☑ 2 0 0 2 (1 2 3 4 Hazard Number) 2 3 4 5 (5 6 7 8 Highway Number) 1 6 0 (9 10 11 County Code) 4 3 2 1 — 0 8 (12 13 14 15 Control Number; 16 17 Section Number) **Slope Between Bridges** (Hazard and Improvement Description)

☑ 0 0 2 2 8 0 (18 19 20 21 22 23 First Cost of Improvements ($)) Repair Cost per Collision ($): 0 0 0 0 (24 25 26 27 Hazard) 0 1 0 0 (28 29 30 31 Improvement) Annual Maintenance ($/yr): 0 0 5 0 (32 33 34 35 Hazard) 0 0 7 5 (36 37 38 39 Improvement) **Install guardrail to connect bridges**

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

☑ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (O_H)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐☐ (46 47 Beginning) :1 ☐☐ (48 49 End) :1
Distance "O_s" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ (55 56 Beginning) :1 ☐☐ (57 58 End) :1
Distance "O_s" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

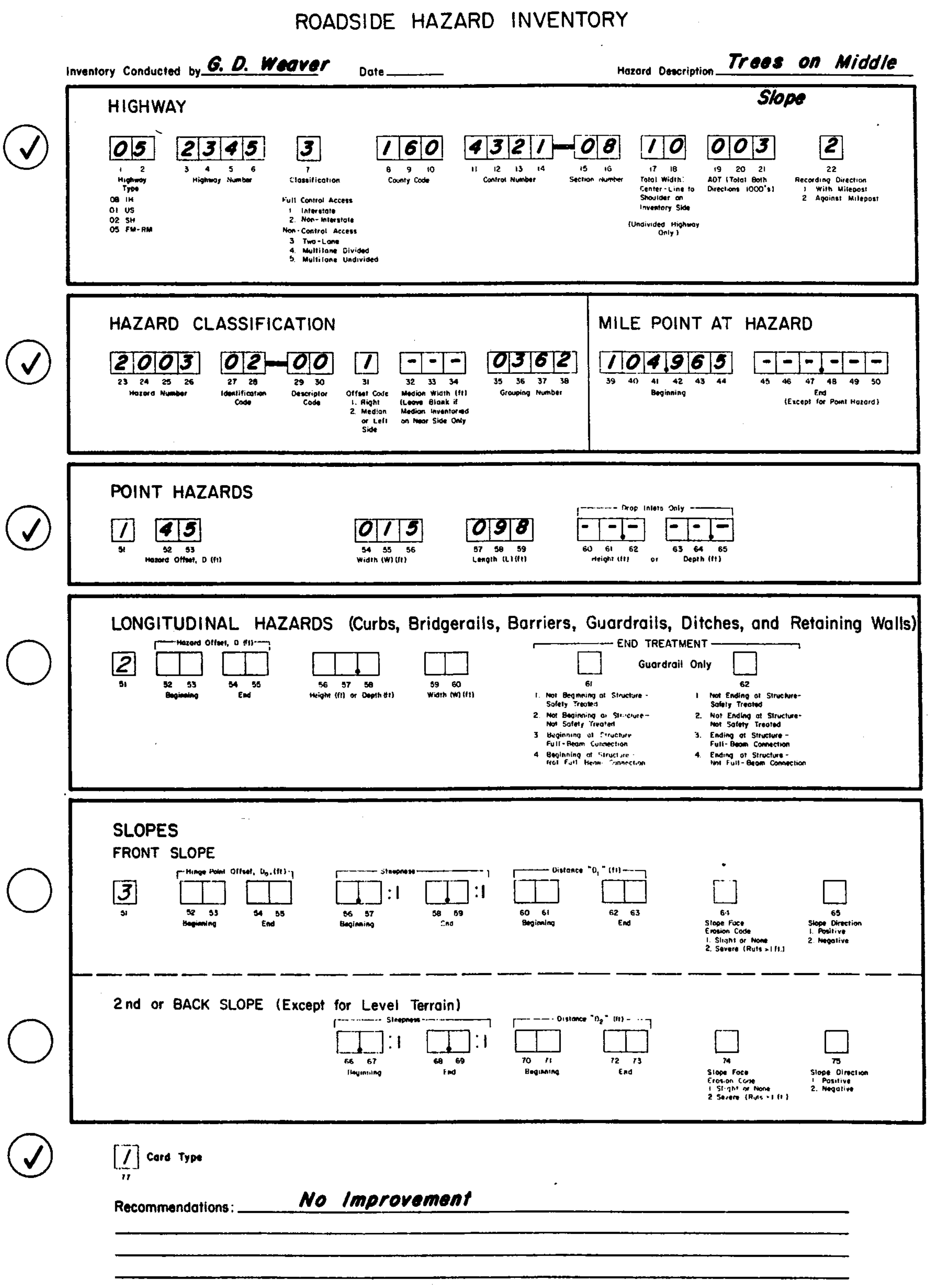
BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

☑ 2 (77) Card Type

Figure B-43. Improvement alternative 1, hazard 3--Case 4 (Install continuous guardrail between bridges).



ROADSIDE HAZARD INVENTORY

Inventory Conducted by *G. D. Weaver* Date ______ Hazard Description *Trees on Middle Slope*

✓ **HIGHWAY** — BOX 1

0 5	2 3 4 5	3	1 6 0	4 3 2 1	0 8	1 0	0 0 3	2
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1 Interstate 2. Non-Interstate Non-Control Access 3 Two-Lane 4. Multilane Divided 5. Multilane Undivided	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1 With Milepost 2 Against Milepost

✓ **HAZARD CLASSIFICATION** / **MILE POINT AT HAZARD** — BOX 2

2 0 0 3	0 2	0 0	1	- - -	0 3 6 2	1 0 4 . 9 6 5	- - - . - - -
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38	39 40 41 42 43 44	45 46 47 48 49 50
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median Inventoried on Near Side Only)	Grouping Number	Beginning	End (Except for Point Hazard)

✓ **POINT HAZARDS** — BOX 3

1	4 5	0 1 5	0 9 8	- - . -	- - . -
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Drop Inlets Only Height (ft)	or Depth (ft)

○ **LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls)** — BOX 4

2	☐☐	☐☐	☐☐.☐	☐☐	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Hazard Offset, D (ft) Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	END TREATMENT 1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3 Beginning at Structure Full-Beam Connection 4 Beginning at Structure - Not Full Beam Connection	Guardrail Only 1 Not Ending at Structure - Safety Treated 2. Not Ending at Structure - Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

SLOPES — BOX 5

○ **FRONT SLOPE**

3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Hinge Point Offset, D_0, (ft) Beginning	End	Steepness Beginning	End	Distance "D_1" (ft) Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts >1 ft.)	Slope Direction 1. Positive 2. Negative

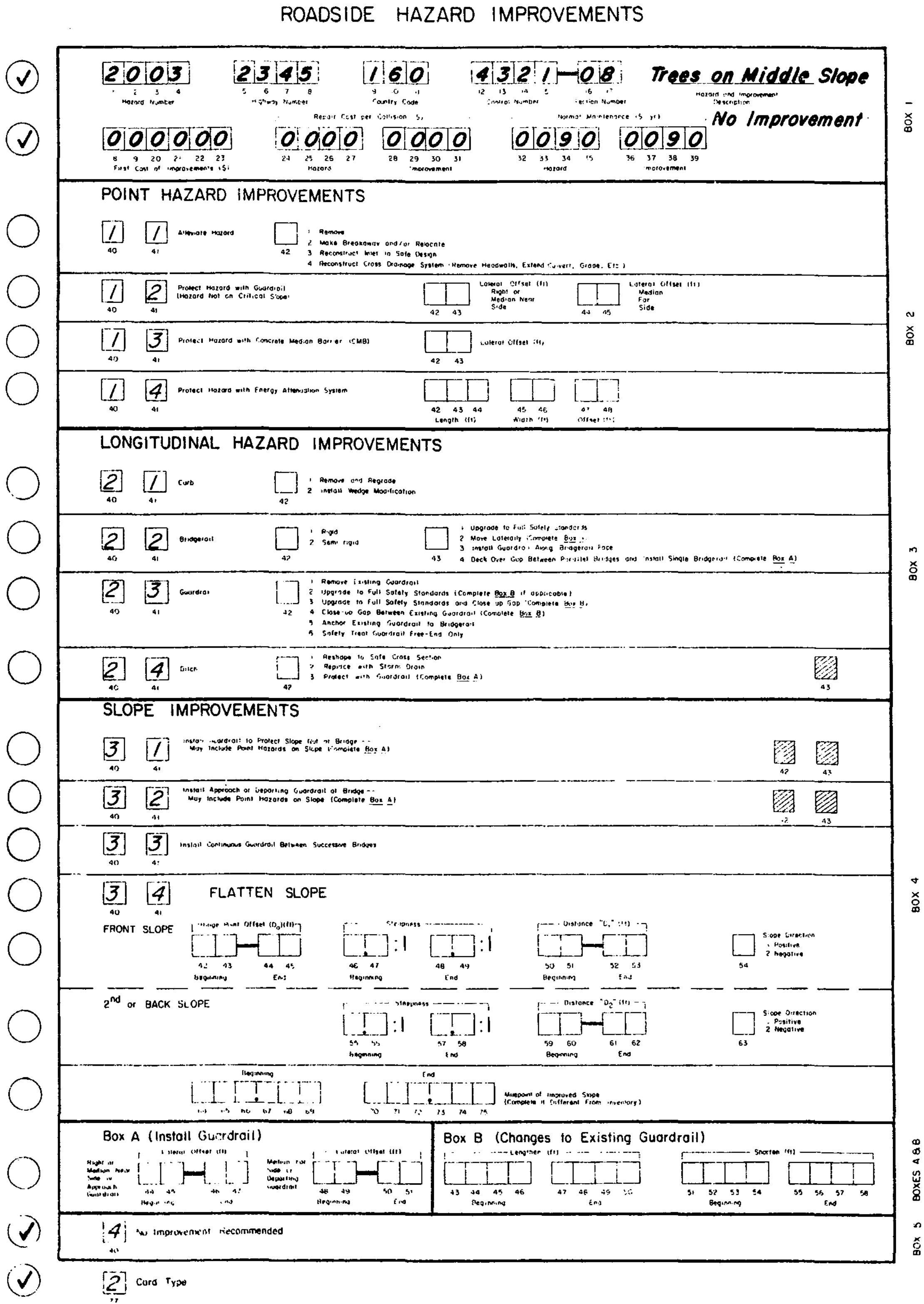
○ **2nd or BACK SLOPE (Except for Level Terrain)**

☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Steepness Beginning	End	Distance "D_2" (ft) Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts >1 ft)	Slope Direction 1 Positive 2. Negative

✓ 1 Card Type
77

Recommendations: *No Improvement*

Figure B-44. Inventory of hazard 4 in grouping (Trees)—Case 4.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 2003 (1 2 3 4 Hazard Number) 2345 (5 6 7 8 Highway Number) 160 (9 10 11 County Code) 4321 (12 13 14 15 Control Number) — 08 (16 17 Section Number) *Trees on Middle Slope* (Hazard and Improvement Description)

✓ 000000 (18 19 20 21 22 23 First Cost of Improvements ($)) Repair Cost per Collision ($): 0000 (24 25 26 27 Hazard) 0000 (28 29 30 31 Improvement) Normal Maintenance ($/yr): 0090 (32 33 34 35 Hazard) 0090 (36 37 38 39 Improvement) *No Improvement*

BOX 2

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 4

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope (Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)
Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)
Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Midpoint of Improved Slope (Complete if Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail: Lateral Offset (ft) ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail: Lateral Offset (ft) ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

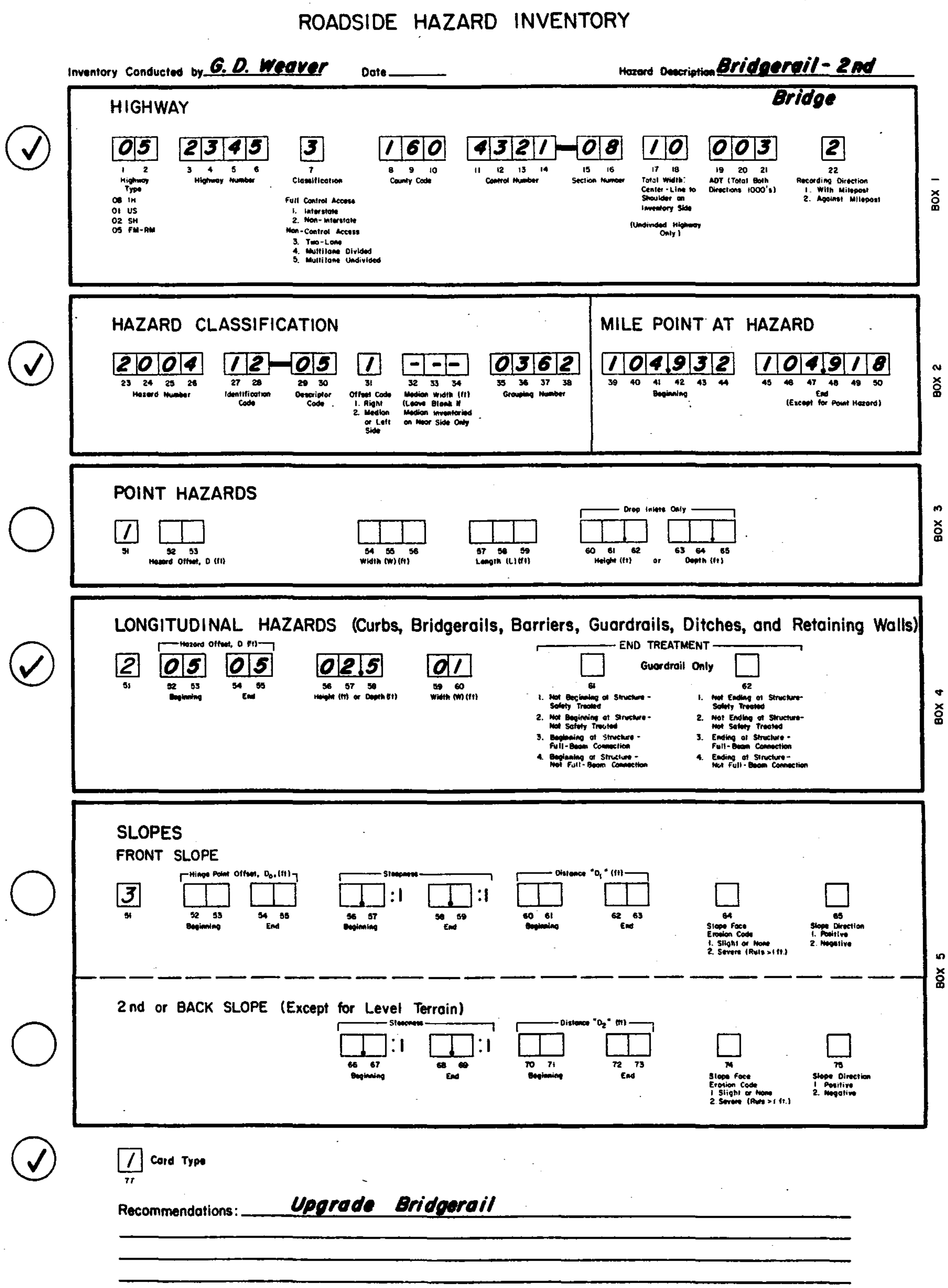
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOX 5

✓ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-45. Improvement alternative 1, hazard 4--Case 4 (No improvement recommended).



ROADSIDE HAZARD INVENTORY

Inventory Conducted by G. D. Weaver Date ______ Hazard Description Bridgerail - 2nd Bridge

✓ HIGHWAY — BOX 1

05	2345	3	160	4321	08	10	003	2
1 2	3 4 5 6	7	8 9 10	11 12 13 14	15 16	17 18	19 20 21	22
Highway Type 08 IH 01 US 02 SH 05 FM-RM	Highway Number	Classification Full Control Access 1. Interstate 2. Non-Interstate Non-Control Access 3. Two-Lane 4. Multilane Divided 5. Multilane Undivided	County Code	Control Number	Section Number	Total Width: Center-Line to Shoulder on Inventory Side (Undivided Highway Only)	ADT (Total Both Directions 1000's)	Recording Direction 1. With Milepost 2. Against Milepost

✓ HAZARD CLASSIFICATION — MILE POINT AT HAZARD — BOX 2

2004	12	05	1	- - -	0362	104.932	104.918
23 24 25 26	27 28	29 30	31	32 33 34	35 36 37 38	39 40 41 42 43 44	45 46 47 48 49 50
Hazard Number	Identification Code	Descriptor Code	Offset Code 1. Right 2. Median or Left Side	Median Width (ft) (Leave Blank if Median inventoried on Near Side Only	Grouping Number	Beginning	End (Except for Point Hazard)

○ POINT HAZARDS — BOX 3

1	☐☐	☐☐☐	☐☐☐	Drop Inlets Only ☐☐.☐	or ☐☐.☐
51	52 53	54 55 56	57 58 59	60 61 62	63 64 65
	Hazard Offset, D (ft)	Width (W) (ft)	Length (L) (ft)	Height (ft)	Depth (ft)

✓ LONGITUDINAL HAZARDS (Curbs, Bridgerails, Barriers, Guardrails, Ditches, and Retaining Walls) — BOX 4

	Hazard Offset, D Ft)				END TREATMENT	Guardrail Only
2	05	05	02.5	01	☐	☐
51	52 53	54 55	56 57 58	59 60	61	62
	Beginning	End	Height (ft) or Depth (ft)	Width (W) (ft)	1. Not Beginning at Structure - Safety Treated 2. Not Beginning at Structure - Not Safety Treated 3. Beginning at Structure - Full-Beam Connection 4. Beginning at Structure - Not Full-Beam Connection	1. Not Ending at Structure- Safety Treated 2. Not Ending at Structure- Not Safety Treated 3. Ending at Structure - Full-Beam Connection 4. Ending at Structure - Not Full-Beam Connection

SLOPES — BOX 5

○ FRONT SLOPE

	Hinge Point Offset, D_0, (ft)		Steepness		Distance "D_1" (ft)			
3	☐☐	☐☐	☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
51	52 53	54 55	56 57	58 59	60 61	62 63	64	65
	Beginning	End	Beginning	End	Beginning	End	Slope Face Erosion Code 1. Slight or None 2. Severe (Ruts > 1 ft.)	Slope Direction 1. Positive 2. Negative

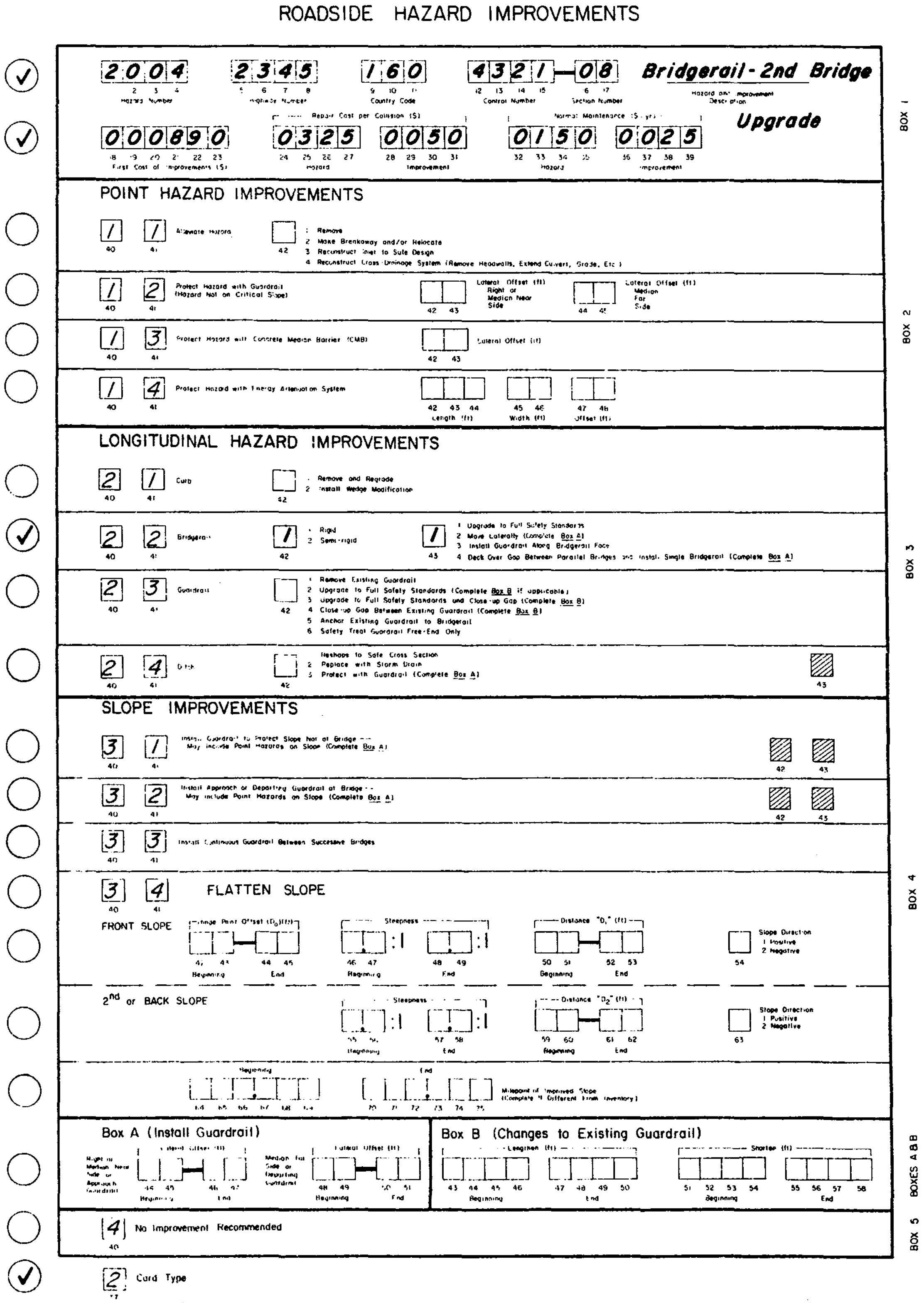
○ 2nd or BACK SLOPE (Except for Level Terrain)

Steepness		Distance "D_2" (ft)			
☐.☐ :1	☐.☐ :1	☐☐	☐☐	☐	☐
66 67	68 69	70 71	72 73	74	75
Beginning	End	Beginning	End	Slope Face Erosion Code 1 Slight or None 2 Severe (Ruts > 1 ft.)	Slope Direction 1 Positive 2. Negative

✓ 1 Card Type
77

Recommendations: Upgrade Bridgerail

Figure B-46. Inventory of hazard 5 (2nd bridgerail)--Case 4.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 2004 (1 2 3 4 Hazard Number) | 2345 (5 6 7 8 Highway Number) | 160 (9 10 11 Country Code) | 4321 (12 13 14 15 Control Number) — 08 (16 17 Section Number) | Bridgerail - 2nd Bridge Upgrade (Hazard and Improvement Description)

✓ 000890 (18 19 20 21 22 23 First Cost of Improvements ($)) | Repair Cost per Collision ($): 0325 (24 25 26 27 Hazard), 0050 (28 29 30 31 Improvement) | Normal Maintenance ($/yr): 0150 (32 33 34 35 Hazard), 0025 (36 37 38 39 Improvement)

BOX 2

POINT HAZARD IMPROVEMENTS

○ [1] 40 [1] 41 Alleviate Hazard — ☐ 42
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ [1] 40 [2] 41 Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ 42 43 Lateral Offset (ft) Right or Median Near Side — ☐☐ 44 45 Lateral Offset (ft) Median Far Side

○ [1] 40 [3] 41 Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ 42 43 Lateral Offset (ft)

○ [1] 40 [4] 41 Protect Hazard with Energy Attenuation System — ☐☐☐ 42 43 44 Length (ft) — ☐☐ 45 46 Width (ft) — ☐☐ 47 48 Offset (ft)

BOX 3

LONGITUDINAL HAZARD IMPROVEMENTS

○ [2] 40 [1] 41 Curb — ☐ 42
1 Remove and Regrade
2 Install Wedge Modification

✓ [2] 40 [2] 41 Bridgerail — [1] 42
1 Rigid
2 Semi-rigid

— [1] 45
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ [2] 40 [3] 41 Guardrail — ☐ 42
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ [2] 40 [4] 41 Ditch — ☐ 42 ▨ 43
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

BOX 4

SLOPE IMPROVEMENTS

○ [3] 40 [1] 41 Install Guardrail to Protect Slope Not at Bridge -- May include Point Hazards on Slope (Complete Box A) — ▨ 42 ▨ 43

○ [3] 40 [2] 41 Install Approach or Departing Guardrail at Bridge -- May include Point Hazards on Slope (Complete Box A) — ▨ 42 ▨ 43

○ [3] 40 [3] 41 Install Continuous Guardrail Between Successive Bridges

[3] 40 [4] 41 FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_0) (ft): ☐☐—☐☐ 42 43 Beginning, 44 45 End — Steepness: ☐.☐ : 1 46 47 Beginning, ☐.☐ : 1 48 49 End — Distance "D_1" (ft): ☐☐—☐☐ 50 51 Beginning, 52 53 End — ☐ 54 Slope Direction 1 Positive 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐.☐ : 1 55 56 Beginning, ☐.☐ : 1 57 58 End — Distance "D_2" (ft): ☐☐—☐☐ 59 60 Beginning, 61 62 End — ☐ 63 Slope Direction 1 Positive 2 Negative

○ Beginning ☐☐☐.☐☐☐ 64 65 66 67 68 69 — End ☐☐☐.☐☐☐ 70 71 72 73 74 75 — Milepoint of Improved Slope (Complete If Different from Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐—☐☐ 44 45 Beginning, 46 47 End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐—☐☐ 48 49 Beginning, 50 51 End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ 43 44 45 46 Beginning, ☐☐☐☐ 47 48 49 50 End
Shorten (ft): ☐☐☐☐ 51 52 53 54 Beginning, ☐☐☐☐ 55 56 57 58 End

BOX 5

○ [4] 40 No Improvement Recommended

✓ [2] 77 Card Type

Figure B-47. Improvement alternative 1, hazard 5--Case 4 (Upgrade to full safety standards).

ROADSIDE HAZARD IMPROVEMENTS

BOX 1

☑ Hazard Number (1–4): 2005 · Highway Number (5–8): 2345 · Country Code (9–11): 160 · Control Number (12–15): 4321 — Section Number (16–17): 08 · Hazard and Improvement Description: *Departing Slope*

☑ First Cost of Improvements ($) (18–23): 002000 · Repair Cost per Collision ($): Hazard (24–27): 0000, Improvement (28–31): 0100 · Normal Maintenance ($/yr): Hazard (32–35): 0050, Improvement (36–39): 0075 · *Install Departing Rail*

POINT HAZARD IMPROVEMENTS

BOX 2

○ 1 (40) 1 (41) Alleviate Hazard · ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) · ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side · ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) · ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System · ☐☐☐ (42 43 44) Length (ft) · ☐☐ (45 46) Width (ft) · ☐☐ (47 48) Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb · ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail · ☐ (42)
1 Rigid
2 Semi rigid

☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail · ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch · ☐ (42) · ▨ (43)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) · ▨ (42) ▨ (43)

☑ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) · ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_3)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐.☐ :1 (46 47) Beginning · ☐.☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56) Beginning · ☐.☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction: 1 Positive, 2 Negative

○ Milepoint of Improved Slope (Complete if different from Inventory)
Beginning: ☐☐☐.☐☐☐ (64 65 66 67 68 69) · End: ☐☐☐.☐☐☐ (70 71 72 73 74 75)

BOXES A & B

☑ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): – – (44 45) Beginning — – – (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): 05 (48 49) Beginning — 12 (50 51) End

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning · ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning · ☐☐☐☐ (55 56 57 58) End

BOX 5

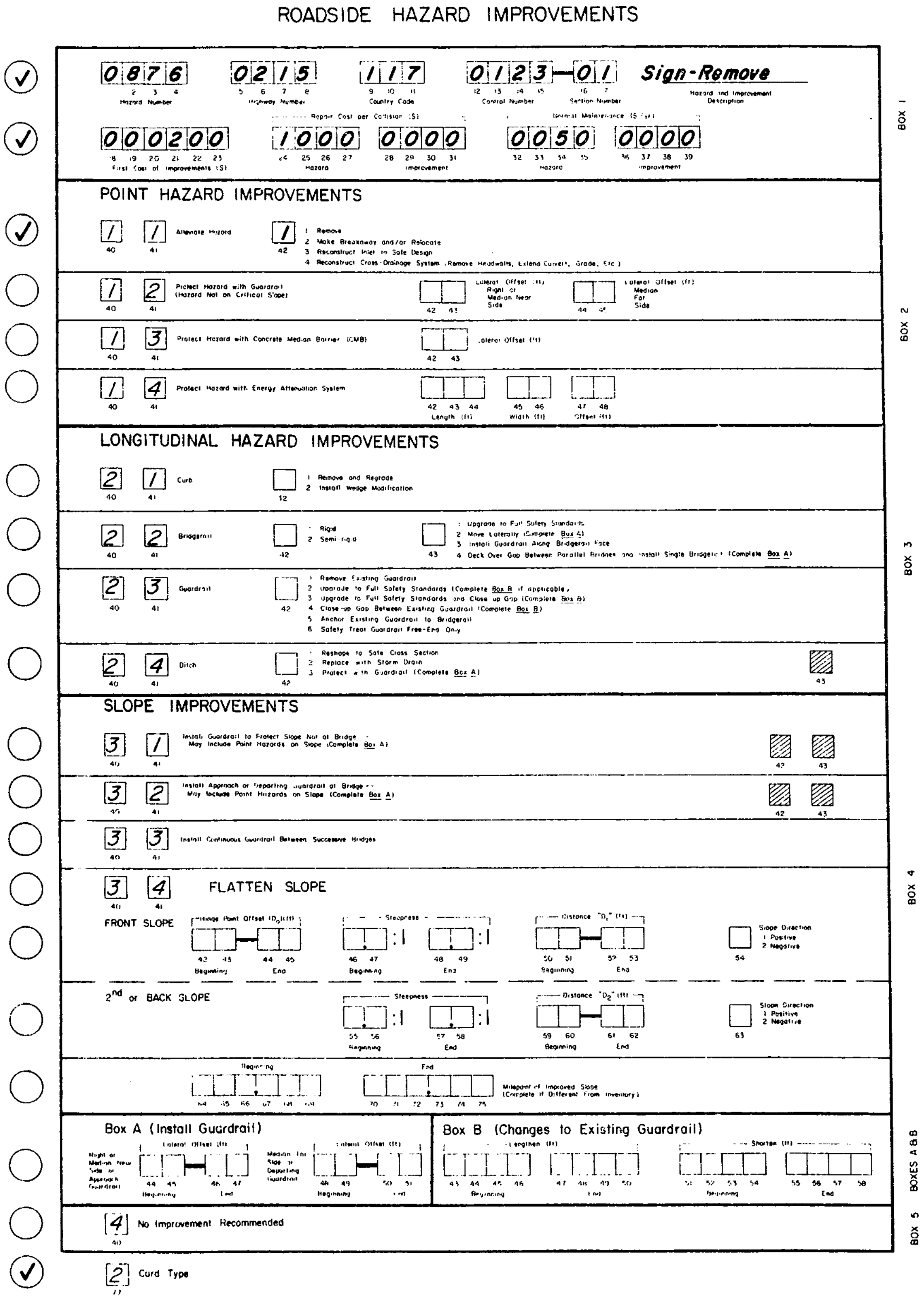
○ 4 (40) No Improvement Recommended

☑ 2 (77) Card Type

Figure B-49. Improvement alternative 1, hazard 6--Case 4. (Install departing guardrail).

```
                                      C O S T   E F F E C T I V E N E S S   P R O G R A M

                                                  TYPE HIGHWAY = FARM-TO-MARKET, RANCH-TO-MARKET
                                        HIGHWAY CLASSIFICATION = NON-CONTROLLED ACCESS -- TWO LANE


                                                   HIGHWAY NO  = 2345
                                                    COUNTY NO  =  160
                                                  DISTRICT NO  =   23
                                                   CONTROL NO  = 4321
                                                   SECTION NO  =    8

                                          RECORDING DIRECTION  =    2
                                                   ADT (1000)  =    3
                                                         LIFE  =   20(YRS)
                                                     INTEREST  =  8.0(PERCENT)
                                                         DATE  = 10-74

                         H    A    Z    A    R    D                                           I    M    P    R    O    V    E    M    E    N    T

HAZARD  IDENT  DESC      END      SEVERITY  OFFSET  GROUP     MILE-POST            IMPR  IMPR   SEVERITY  FIRST  PRESENT  ANNUAL   C
  NO    CODE   CODE   TREATMENT    INDEX     CODE    NO     BEG       END          ALT   CODE    INDEX    COST    WORTH    COST   EFFE
                      BEG   END                                                                                                  NE
                                                                                                         ($)      ($)    ($/YR)

 2001    12     5      0     0     82.5       1     362  105.004 104.980            1  2-2-1-1    3.3    1520      272      27    GR
 2004    12     5      0     0     82.5       1     362  104.932 104.918            1  2-2-1-1    3.3     890      -79      -8    GR
 2003     2     0      0     0     50.0       1     362  104.965 104.946            1  4-0-0-0   50.0       0      -79      -8    GR
 2000     7     2      0     0     60.0       1     362  105.061 105.004            1  3-2-0-0    3.3    2700     2881     293    GR
 2005     7     2      0     0     60.0       1     362  104.918 104.876            1  3-2-0-0    3.3    2000     5141     523    GR
 2002     7     2      0     0     60.0       1     362  104.980 104.932            1  3-3-0-0    3.3    2280    10709  [illegible]
```

Figure B-50. Cost-effectiveness program output--Case 4.



ROADSIDE HAZARD IMPROVEMENTS

BOX 1

✓ 0876 (Hazard Number, 2 3 4) 0215 (Highway Number, 5 6 7 8) 117 (Country Code, 9 10 11) 0123 (Control Number, 12 13 14 15)—01 (Section Number, 16 17) *Sign-Remove* (Hazard and Improvement Description)

Repair Cost per Collision ($) — Normal Maintenance ($/yr)

✓ 000200 (First Cost of Improvements ($), 18 19 20 21 22 23) 1000 (Hazard, 24 25 26 27) 0000 (Improvement, 28 29 30 31) 0050 (Hazard, 32 33 34 35) 0000 (Improvement, 36 37 38 39)

POINT HAZARD IMPROVEMENTS

BOX 2

✓ 1 (40) 1 (41) Alleviate Hazard — 1 (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) — ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side — ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) — ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System — ☐☐☐ (42 43 44) Length (ft) — ☐☐ (45 46) Width (ft) — ☐☐ (47 48) Offset (ft)

LONGITUDINAL HAZARD IMPROVEMENTS

BOX 3

○ 2 (40) 1 (41) Curb — ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail — ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail — ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch — ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

SLOPE IMPROVEMENTS

BOX 4

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge — May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge — May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_0)(ft): ☐☐ (42 43) Beginning — ☐☐ (44 45) End
Steepness: ☐☐ :1 (46 47) Beginning — ☐☐ :1 (48 49) End
Distance "D_1" (ft): ☐☐ (50 51) Beginning — ☐☐ (52 53) End
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐☐ :1 (55 56) Beginning — ☐☐ :1 (57 58) End
Distance "D_2" (ft): ☐☐ (59 60) Beginning — ☐☐ (61 62) End
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) — End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOXES A & B

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45) Beginning — ☐☐ (46 47) End
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49) Beginning — ☐☐ (50 51) End

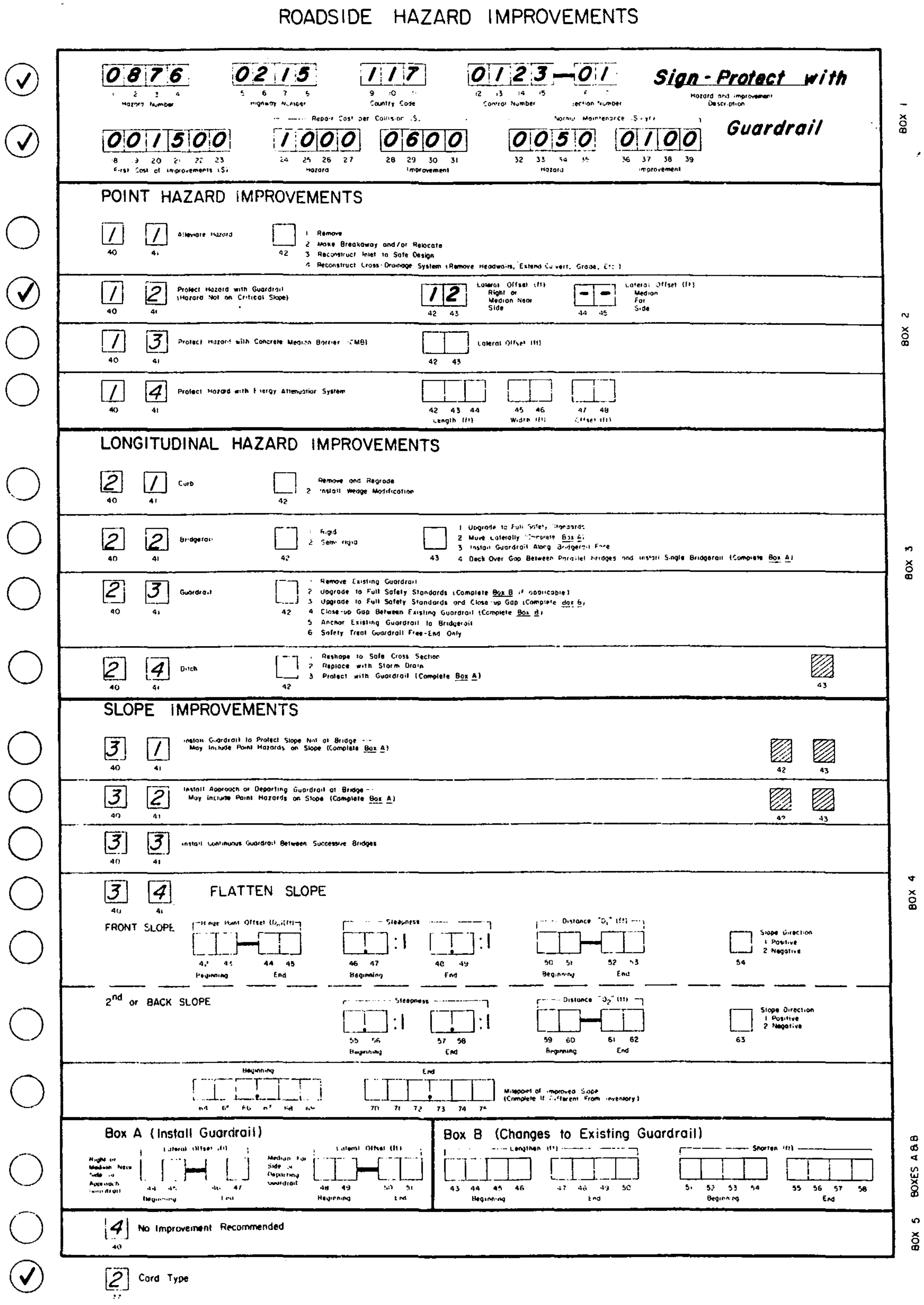
Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46) Beginning — ☐☐☐☐ (47 48 49 50) End
Shorten (ft): ☐☐☐☐ (51 52 53 54) Beginning — ☐☐☐☐ (55 56 57 58) End

BOX 5

○ 4 (40) No Improvement Recommended

✓ 2 (77) Card Type

Figure B-53. Improvement alternative 1--Case 5 (Remove sign).



ROADSIDE HAZARD IMPROVEMENTS

✓ 0876 (1 2 3 4 Hazard Number) 0215 (5 6 7 8 Highway Number) 117 (9 10 11 County Code) 0123 (12 13 14 15 Control Number) — 01 (16 17 Section Number) **Sign-Protect with** (Hazard and Improvement Description)

✓ 001500 (18 19 20 21 22 23 First Cost of Improvements ($)) Repair Cost per Collision ($): 1000 (24 25 26 27 Hazard) 0600 (28 29 30 31 Improvement) Normal Maintenance ($/yr): 0050 (32 33 34 35 Hazard) 0100 (36 37 38 39 Improvement) **Guardrail**

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alleviate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

✓ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) 12 (42 43) Lateral Offset (ft) Right or Median Near Side; — — (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

○ 1 (40) 4 (41) Protect Hazard with Energy Attenuator System ☐☐☐ (42 43 44 Length (ft)) ☐☐ (45 46 Width (ft)) ☐☐ (47 48 Offset (ft))

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi-rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE
Hinge Point Offset (D_h)(ft): ☐☐ (42 43 Beginning) — ☐☐ (44 45 End)
Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End)
Distance "D_1" (ft): ☐☐ (50 51 Beginning) — ☐☐ (52 53 End)
☐ (54) Slope Direction
1 Positive
2 Negative

○ 2nd or BACK SLOPE
Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End)
Distance "D_2" (ft): ☐☐ (59 60 Beginning) — ☐☐ (61 62 End)
☐ (63) Slope Direction
1 Positive
2 Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ Box A (Install Guardrail)
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐ (44 45 Beginning) — ☐☐ (46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐ (48 49 Beginning) — ☐☐ (50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

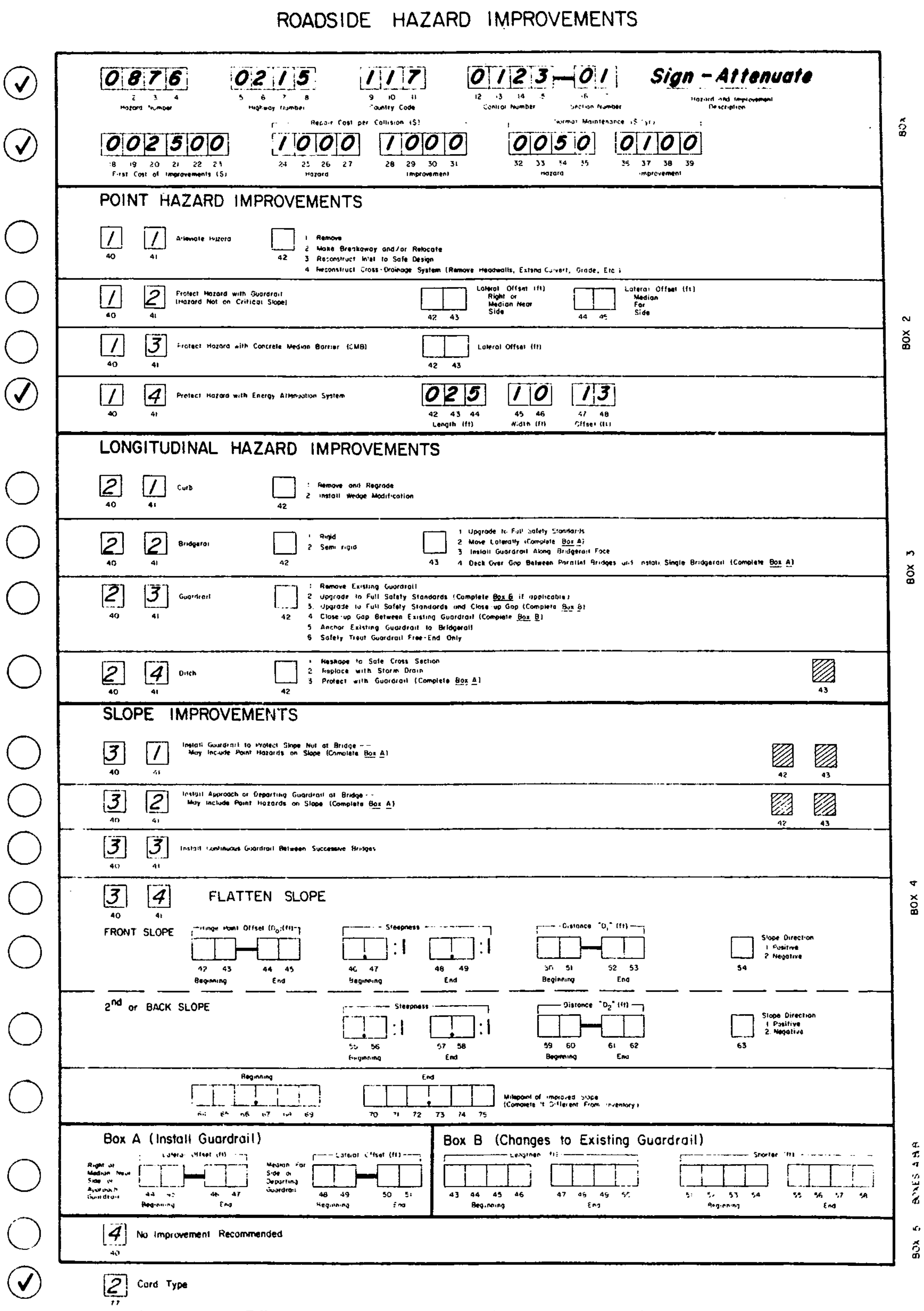
BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-54. Improvement alternative 2--Case 5 (Install guardrail).



ROADSIDE HAZARD IMPROVEMENTS

✓ 0876 — Hazard Number (2 3 4) | 0215 — Highway Number (5 6 7 8) | 117 — County Code (9 10 11) | 0123—01 — Control Number (12 13 14 15), Section Number (16 17) | **Sign - Attenuate** — Hazard and Improvement Description

✓ 002500 — First Cost of Improvements ($) (18 19 20 21 22 23) | Repair Cost per Collision ($): 1000 — Hazard (24 25 26 27); 1000 — Improvement (28 29 30 31) | Normal Maintenance ($/yr): 0050 — Hazard (32 33 34 35); 0100 — Improvement (36 37 38 39)

BOX 1

POINT HAZARD IMPROVEMENTS

○ 1 (40) 1 (41) Alternate Hazard ☐ (42)
1 Remove
2 Make Breakaway and/or Relocate
3 Reconstruct Inlet to Safe Design
4 Reconstruct Cross-Drainage System (Remove Headwalls, Extend Culvert, Grade, Etc.)

○ 1 (40) 2 (41) Protect Hazard with Guardrail (Hazard Not on Critical Slope) ☐☐ (42 43) Lateral Offset (ft) Right or Median Near Side ☐☐ (44 45) Lateral Offset (ft) Median Far Side

○ 1 (40) 3 (41) Protect Hazard with Concrete Median Barrier (CMB) ☐☐ (42 43) Lateral Offset (ft)

✓ 1 (40) 4 (41) Protect Hazard with Energy Attenuation System 025 (42 43 44) Length (ft) 10 (45 46) Width (ft) 13 (47 48) Offset (ft)

BOX 2

LONGITUDINAL HAZARD IMPROVEMENTS

○ 2 (40) 1 (41) Curb ☐ (42)
1 Remove and Regrade
2 Install Wedge Modification

○ 2 (40) 2 (41) Bridgerail ☐ (42)
1 Rigid
2 Semi rigid
☐ (43)
1 Upgrade to Full Safety Standards
2 Move Laterally (Complete Box A)
3 Install Guardrail Along Bridgerail Face
4 Deck Over Gap Between Parallel Bridges and Install Single Bridgerail (Complete Box A)

○ 2 (40) 3 (41) Guardrail ☐ (42)
1 Remove Existing Guardrail
2 Upgrade to Full Safety Standards (Complete Box B if applicable)
3 Upgrade to Full Safety Standards and Close-up Gap (Complete Box B)
4 Close-up Gap Between Existing Guardrail (Complete Box B)
5 Anchor Existing Guardrail to Bridgerail
6 Safety Treat Guardrail Free-End Only

○ 2 (40) 4 (41) Ditch ☐ (42)
1 Reshape to Safe Cross Section
2 Replace with Storm Drain
3 Protect with Guardrail (Complete Box A)
▨ (43)

BOX 3

SLOPE IMPROVEMENTS

○ 3 (40) 1 (41) Install Guardrail to Protect Slope Not at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 2 (41) Install Approach or Departing Guardrail at Bridge -- May Include Point Hazards on Slope (Complete Box A) ▨ (42) ▨ (43)

○ 3 (40) 3 (41) Install Continuous Guardrail Between Successive Bridges

○ 3 (40) 4 (41) FLATTEN SLOPE

○ FRONT SLOPE — Hinge Point Offset (D_0) (ft): ☐☐—☐☐ (42 43 Beginning, 44 45 End) | Steepness: ☐.☐ :1 (46 47 Beginning) ☐.☐ :1 (48 49 End) | Distance "D_1" (ft): ☐☐—☐☐ (50 51 Beginning, 52 53 End) | ☐ (54) Slope Direction: 1 Positive, 2 Negative

○ 2nd or BACK SLOPE — Steepness: ☐.☐ :1 (55 56 Beginning) ☐.☐ :1 (57 58 End) | Distance "D_2" (ft): ☐☐—☐☐ (59 60 Beginning, 61 62 End) | ☐ (63) Slope Direction: 1 Positive, 2. Negative

○ Beginning ☐☐☐.☐☐☐ (64 65 66 67 68 69) End ☐☐☐.☐☐☐ (70 71 72 73 74 75) Milepoint of Improved Slope (Complete If Different From Inventory)

BOX 4

○ **Box A (Install Guardrail)**
Right or Median Near Side or Approach Guardrail — Lateral Offset (ft): ☐☐—☐☐ (44 45 Beginning, 46 47 End)
Median Far Side or Departing Guardrail — Lateral Offset (ft): ☐☐—☐☐ (48 49 Beginning, 50 51 End)

Box B (Changes to Existing Guardrail)
Lengthen (ft): ☐☐☐☐ (43 44 45 46 Beginning) ☐☐☐☐ (47 48 49 50 End)
Shorten (ft): ☐☐☐☐ (51 52 53 54 Beginning) ☐☐☐☐ (55 56 57 58 End)

BOXES A & B

○ 4 (40) No Improvement Recommended

BOX 5

✓ 2 (77) Card Type

Figure B-55. Improvement alternative 3--Case 5 (Install impact attenuation system).

```
                                        C O S T   E F F E C T I V E N E S S   P R O G R A M

                                                    TYPE HIGHWAY = FARM-TO-MARKET, RANCH-TO-MARKET (CODE 05)
                                          HIGHWAY CLASSIFICATION = NON-CONTPOLLED ACCESS -- TWO LANE

                                                     HIGHWAY NO  =  215
                                                      COUNTY NO  =  117
                                                    DISTRICT NO  =    1
                                                     CONTROL NO  =  123
                                                     SECTION NO  =    1

                                              RECORDING DIRECTION  =    1
                                                       ADT (1000)  =    4
                                                             LIFE  =   20(YRS)
                                                         INTEREST  =   8.0(PERCENT)
                                                             DATE  = 10-74
                          H   A   Z   A   R   D                                          I   M   P   R   O   V   E   M   E   N   T

 HAZARD  IDENT  DESC       END      SEVERITY  OFFSET  GROUP     MILE-POST         IMPR  IMPR   SEVERITY  FIRST  PRESENT  ANNUAL    COST
   NO    CODE   CODE    TREATMENT    INDEX     CODE    NO     BEG       END        ALT  CODE    INDEX    COST    WORTH    COST   EFFECTIVE
                        BEG   END                                                                                                VALUE
                                                                                                          ($)     ($)    ($/YR)

  876     3      2      0     0      30.0       1       0  100.000 100.001         1  1-1-1-0   0.0      200     -305     -31       -345
  876     3      2      0     0      30.0       1       0  100.000 100.001         2  1-2-0-0  *HAZARD IMPROVEMENT NOT COST-EFFECTIVE*

  876     3      2      0     0      30.0       1       0  100.000 100.001         3  1-4-0-0   1.0     2500     3003     305       3550
```

Figure B-56. Cost-effectiveness program output--Case 5.