SHRP-H-358

Pavement Maintenance Effectiveness

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Abstract

Billions of dollars are spent annually in the United States on pavement maintenance by state, local, and federal agencies. The purpose of project H-101, Pavement Maintenance Effectiveness, is to develop a data base that will permit increased understanding of selected maintenance treatments in extending pavement service life or reducing the development of pavement distress, including an evaluation of the cost-effectiveness of the pavement maintenance treatments.

This study evaluated six specific preventive treatments. Four treatments are for asphalt concrete surfaced (flexible) pavements:

1. chip seals,
2. crack sealing,
3. slurry seals, and
4. thin overlays.

Two treatments are for portland cement concrete surfaced (rigid) pavements:

1. joint and crack sealing and
2. undersealing.

Performance of the pavement sections with the treatments compared to the performance of a similar pavement section without the treatment. Performance is measured in terms of pavement distress, roughness or profile, surface friction, and structural capacity.

All of the flexible pavement test sections flexible pavements and most of the rigid pavement test sections have been constructed. Performance data are being collected.

The report discusses the experimental design, project selection, construction, data collection, analysis, and future activities of the pavement maintenance effectiveness project.

Executive Summary

Billions of dollars are spent annually in the United States on pavement maintenance by state, local, and federal agencies. The purpose of Strategic Highway Research Program project H-101, Pavement Maintenance Effectiveness, is to develop a data base that will permit increased understanding of selected maintenance treatments in extending pavement service life or reducing the development of pavement distress. This includes an evaluation of the cost-effectiveness of the pavement maintenance treatments.

The study includes six specific preventive treatments. Four treatments are for asphalt concrete surfaced (flexible) pavements:

1. chip seals,
2. crack sealing,
3. slurry seals, and
4. thin overlays.

Two treatments are for portland cement concrete surfaced (rigid) pavements:

1. joint and crack sealing and
2. undersealing.

An experimental design was developed to help determine the impact of important variables on the performance of these treatments. Major factors considered include environment, traffic, subgrade type, structural capacity, and condition prior to treatment for the test sections applied to flexible pavements. For the test sections applied to rigid pavements, the major factors considered include environment, subgrade type, and subbase type.

The participating states and provinces were required to fund the construction of the treatments, and willingness to participate was a controlling factor in the number of sites actually available. Sites were selected adjacent to SHRP Long-Term Pavement Performance (LTPP) General Pavement Studies (GPS) test sections to minimize data collection expenses.

The chip seals, crack sealing, and slurry seals were applied by regional contractors under the direction of the Federal Lands Highway Division (FLHD) of the Federal Highway Administration (FHWA). The thin overlays, joint and crack sealing, and undersealing were constructed under the direction of the participating agencies. The SHRP Regional

Coordinating Office Contractors (RCOCs) collected a considerable amount of data during the construction, and a considerable amount of laboratory testing was conducted on the materials during the construction. These data were later entered into the SHRP national data base.

All of the test sections on flexible pavements and most of the test sections on rigid pavements have been constructed. Performance has been measured and continues to be measured on a periodic basis in terms of pavement distress, roughness or profile, surface friction, and structural capacity. Although the data were not available for analysis until just before this report was prepared, a data analysis plan was prepared and some preliminary analysis was completed. The report also discusses a plan for continuing data collection, storage, and analysis after the SHRP program ends.

1

Introduction

Background

Billions of dollars are spent annually in the United States on pavement maintenance by state, local, and federal agencies. As the networks of streets, roads, and highways mature, emphasis is changing from constructing new pavements to preserving existing pavements. Pavement management concepts are being applied at all levels to assist in allocating scarce funds to best fulfill the overall goals of providing a safe and efficient transportation network. Providing this safe and efficient pavement network is a vital element in maintaining the competitiveness of many components of the economic base of the United States. Any approach that improves allocation of funds in pavement maintenance can save millions of dollars while improving our world competitiveness by reducing user costs and funds spent on pavement maintenance; however, each approach also requires an analysis of the benefits of applying the treatment compared to some other maintenance or rehabilitation approach, including the "do nothing" approach. A literature survey of recent studies involved with maintenance verified that little information is available on the cost-effectiveness of maintenance treatments. Even those that address cost-effectiveness generally address the difference in cost of applying the treatments rather than the relationship of the treatment cost to the extension of effective pavement life or comparisons to other maintenance and rehabilitation options.

Objectives and Scope of Work

The purpose of Strategic Highway Research Program (SHRP) project H-101, Pavement Maintenance Effectiveness, is to develop a data base that will permit increased understanding of selected maintenance treatments in extending pavement service life or reducing the development of pavement distress. This includes an evaluation of the effectiveness of the pavement maintenance treatments and establishment of a study methodology that can be followed by highway agencies to evaluate other maintenance treatments. Specific objectives include:

1. design and coordination of the experimental design, implementation, and analysis plans for a controlled experiment to evaluate performance, effectiveness, and mechanisms by which pavement maintenance treatments preserve and extend pavement service life;
2. develop technology transfer materials for highway agencies to assist in implementing the study; and
3. identify and quantify the effectiveness of specific maintenance activities.

The study includes six specific preventive treatments. Four treatments are for asphalt concrete surfaced (flexible) pavements:

1. chip seals,
2. crack sealing,
3. slurry seals, and
4. thin overlays.

Two treatments are for portland cement concrete surfaced (rigid) pavements:

1. joint and crack sealing and
2. undersealing.

The study of these preventive maintenance treatments applied to flexible pavements was designated specific pavement study-3 (SPS-3), and the study of preventive maintenance treatments applied to rigid pavements was designated SPS-4. This designation made the treatments part of the Long-Term Pavement Performance (LTPP) study, which is scheduled to continue for fifteen years after the end of the original SHRP study.

The treatment effects of primary interest are those that are considered the main effects of the experiment design and are the dependent, or Y, variables considered in the experiment. The effect that will be measured is the change of the dependent variable that can be attributed to the application of the preventive maintenance treatment. In general, this means that the performance of the pavement with the preventive maintenance treatment will be compared to the performance of a similar pavement without the application of that treatment, which is called the control section. The dependent variables include measures of selected pavement distress types, measures of pavement roughness or profile, measures of pavement surface friction, and measures of pavement material properties.

Definitions

The American Association of State Highway and Transportation Officials (AASHTO) defines maintenance as (AASHTO 1987), "A program to preserve and repair a system of roadways with its elements to its designed or accepted configuration." The purpose of maintenance is described as (AASHTO 1987), "Highway maintenance programs are developed to offset the effects of weather, vegetation growth, deterioration, traffic wear, damage and vandalism. Deterioration would include effects of aging, material failures, and design and construction faults." The Organization for Economic Cooperation and Development (OECD) lists the primary objectives of maintenance as (OECD 1978):

1. restore skid resistance;
2. restore evenness; and
3. maintain or restore impermeability.

Definitions of maintenance in the pavement area do not appear to be consistent and have changed considerably over the last ten to twenty years. Much of the impetus behind the changes seems to be the "3R" and "4R" acts (Kelly 1981; Peterson 1981; Darter et al. 1984). Before enactment of the 1976 Federal Highway Act, federal matching funds were available for "construction" only; however, construction was defined for all classes of federal highway support except the interstate system to include reconstruction and overlays greater than 1 1/2-in (38-mm) thick. During the same time frame, AASHTO identified two major classes of work, each with two subgroups (AASHTO 1976):

1. maintenance,
    a. traffic services,
    b. physical maintenance;
2. construction,
    a. betterment,
    b. construction and reconstruction.

The overlays, and all work beyond maintenance but less than reconstruction, were generally included in the subclassification of betterment under the construction class.

The 1976 Federal Highway Act provided funds for three new activities other than construction. These were resurfacing, restoration, and rehabilitation. The definitions of each of these changed over time. However, resurfacing included overlays over 3/4-in (19-mm) thick, restoration included a planned set of activities developed to restore the pavement to a serviceable condition (most of these activities are generally considered maintenance alone but become restoration as part of an overall approach to address the damage the pavement develops), and rehabilitation included everything other than maintenance and reconstruction. This resulted in a definition of physical maintenance of the traveled way that includes (AASHTO 1987): "Scarifying, reshaping, applying dust pallatives, and restoring material losses; patching, mudjacking, joint filling, crack sealing, surface treating, etc. Resurfacing of hard surfaces with bit. materials less than 3/4" thick. Replacement of traveled way in kind for less than 500 continuous feet. Replacement of unsuitable base materials in patching operations." Reconstruction of interstate pavements was added as the fourth "R" by the 1981 Federal Highway Act.

Within system engineering and reliability engineering, definitions have been established for preventive and corrective maintenance as follows (Goldmand and Slattery 1964):

- "Preventive maintenance: maintenance which is carried out to retain equipment in an acceptable operating state by providing orderly detection and inspection in addition to prevention of incipient failures."

- "Corrective maintenance: maintenance which is carried out to restore failed equipment to an acceptable operable condition."

Pavement maintenance classifications have not been accepted by most affected groups, and maintenance is currently classified in several different ways. AASHTO divides roadway surface maintenance methods into preventive maintenance and repair but cautions that some methods may fit into more than one group (AASHTO 1987). OECD classifies maintenance based on purpose of treatment and organizational responsibility (OECD 1978).

When the purpose of the treatment is used in classification of maintenance, the classes are usually designated as corrective or preventive. These classifications are based on whether the basic intent of the treatment is to correct an existing problem or to prevent a problem from either occurring or developing further. However, the distinction between preventive and corrective is not always clear, and many treatments contain elements of both. Sealing cracks in flexible pavements is a treatment that some call corrective while others believe it is preventive. Our general conclusion is that crack sealing is corrective for the crack and preventive for the pavement. Crack sealing corrects the condition that allows water to enter the pavement structure through the crack, and it helps prevent more rapid deterioration by reducing the moisture content of the pavement layers.

We have chosen to define preventive maintenance based on the purpose of the treatment. Preventive maintenance includes treatments that are applied to a pavement primarily to prevent development of damage or to reduce the rate of damage development.

Report Organization

This report describes the effort completed in SHRP Study H-101 and the work that still needs to be completed. The remainder of this report is divided into the following chapters:

2. Experimental Design
3. Project Approval Process
4. Construction Guidelines
5. Field Sampling, Testing, and Data Collection
6. Laboratory Program
7. Status of SPS-3 and SPS-4 Test Sections
8. Data Analysis Plan
9. Data Analysis

10. Products
11. Future Activities
12. Conclusions and Recommendations

These chapters are followed by several appendices and the references.

2

Experimental Design

Introduction

The objectives of the SPS-3 and SPS-4 studies include determining the impact of the preventive maintenance treatments on preserving and extending pavement service life, and determining the mechanisms by which these treatments provide this benefit. The agencies that use these treatments are located in areas with a variety of environmental conditions and traffic volumes, so these and other important factors must be considered in the analysis. To determine the impact of these factors on the performance changes caused by the preventive maintenance treatments, an experimental design was developed.

Some factors were important to all similar pavement studies (e.g., flexible and rigid), and these were denoted as primary factors. Others were specific to the types of pavements and materials being studied. These were referred to as secondary factors. The designations of primary and secondary are for convenience in referencing and visualization, and should not be construed to indicate the importance of the variables so designated. Other studies to be performed by various subgroups (such as states) may consider a third level of factors specific to the treatments and materials in which they are most interested. Finally, there are other factors that could not be controlled through the experimental design but that are known to affect the treatment, such as age and thickness of the pavement. These were considered covariables. The analyses will try to consider them to adjust their potential confounding effect on treatments so that treatment comparisons can be made on similar levels.

Background

The experimental designs were coordinated with the Long-Term Pavement Performance (LTPP) General Pavement Studies (GPS) program. The treatment effects of primary interest were those that were considered the main effects of the experiment design and were the dependent, or Y, variables considered in the experiment. The effects being measured are the changes in the dependent variable that can be attributed to the presence of the preventive maintenance treatments. In other words, the performance of the pavements with the preventive maintenance treatments is being compared with the performance of similar pavements without the treatments in the control sections. The dependent variables include the following measures:

1. selected pavement distress types;
2. pavement roughness or profile;
3. pavement surface friction; and
4. pavement material properties.

In this effort, the goal is to determine the effect of the individual treatments in extending pavement life. The impact of individual materials or construction processes is not a part of the study. In addition, the overall goal is not to compare the performance of one treatment with another, but rather to compare the performance of the treated sections with the performance of the untreated sections. The impact of the preventive maintenance treatment is based on the process, for example, a slurry seal. Therefore, treatment materials, treatment designs, and treatment construction specifications that are known to work reasonably well in each individual climatic zone were selected.

Factors

The designation of factors as primary and secondary does not imply the level of importance of the factors. Rather, this differentiation was based on a division between the site-related and the pavement-related factors, which were the same for this study and the LTPP GPS studies. The primary factors included environmental, traffic, and subgrade data. These were considered main factors that were defined to determine their effect on pavement performance as well as preventive maintenance treatment effects. Two levels were defined for each of these factors, which match the LTPP GPS levels.

The primary (or site) factors in the experimental design for preventive maintenance for asphalt concrete and portland cement concrete pavements include the following:

1.	moisture:	wet dry
2.	temperature:	freeze no-freeze
3.	subgrade type:	fine grained coarse grained
4.	traffic loading:	low high

The levels for each of these factors are defined later along with the site selection requirements.

The secondary-tier factors for the SPS-3 and SPS-4 experiments generally were different from those of the GPS experiments. The individual treatments were included. For flexible pavements, there were four individual treatments (crack sealing, chip seal, slurry seal, and thin overlays). For rigid pavements there were two treatments (crack/joint sealing and undersealing). Each individual treatment was considered a single-level factor. There was no plan to explicitly evaluate the effectiveness of combinations of the treatments; each was considered a separate treatment and considered alone.

Design Considerations

Flexible Pavements

Two factors are believed to have the most influence on the performance of preventive maintenance treatments applied to flexible pavements: the condition of the pavement at the time the treatment is placed, and the structural capacity of the pavement compared to the traffic loads being applied to it. The structural capacity can be considered a two level factor. There was considerable discussion about the number of levels that should be considered for the condition of the pavement at the time the treatment is placed. Two, three, and some combination of levels were considered. The preventive maintenance treatments were to be applied to the pavement sections in the hope of preventing, or reducing the rate of, deterioration. This approach is most effective if the pavement is in good condition, and the treatment is applied to retain the pavement in that condition level. Depending on the traffic level, there is some intermediate level at which the treatments will reduce the rate of deterioration. Further, there is a condition level at or below which the preventive maintenance treatments will have little effect. Three levels were required to define all of these effects; however, the primary goal was to assess the effect of the treatments on pavements that were in a condition that would allow them to respond to the treatment. There was some concern about spending money to demonstrate something that presumably is already known. However, if the treatments were not applied to the pavements in all three condition levels, it is possible we would not be able to answer all the questions. It was important to apply the treatments to pavements at the poor condition level to anchor the analysis, but it was decided to try to use less than a full factorial of pavements in that condition. The condition and structural adequacy were defined as the second level of variables for the study. They are shown as follows:

1.	condition:	good fair poor
2.	structural adequacy:	high low

Although these variables were established during the initial selection of candidate sections, some test sections were moved to other cells when more complete data became available at later times in the study. Figure 1 shows the experimental design for treatments applied to flexible pavements.

Rigid Pavements

The original experimental design for preventive maintenance treatments included two second-level factors: condition at the time of treatment and type of subbase. The subbases considered were granular and stabilized. Pavement condition was to be divided into three levels, as were the flexible pavement studies. Again, fewer sections at the poor condition level were to be used. Basically, the subbase would replace the structural adequacy factor in the flexible pavement study design. All other factors are similar. However, the traffic level was considerably different. The selected factors were as follows:

1.	condition:	good fair poor
2.	subbase:	granular stabilized

However, few agencies were willing to provide sites for the rigid pavement preventive maintenance (SPS-4) study. A primary concern was the use of undersealing as a preventive maintenance treatment. The rigid pavement preventive maintenance study was modified to allow agencies to participate in installation of sections with joint/crack sealing and undersealing, with joint/crack sealing only, or with undersealing only. This modification increased participation, but not enough to sufficiently fill the experimental design. The rigid pavement preventive maintenance experimental design was reduced to the following factors:

1.	moisture:	wet dry
2.	temperature:	freeze no-freeze
3.	subgrade type:	fine grained coarse grained
4.	subbase:	granular stabilized

Only jointed concrete pavements were included in the study. Jointed reinforced pavements were restricted to the wet moisture region because they are seldom found in

Cell Number — 48 — 991001 — SHRP ID

CONDITION	SN RATIO	WET							
MOISTURE		WET							
TEMPERATURE		FREEZE				NO-FREEZE			
SUBGRADE		FINE		COARSE		FINE		COARSE	
TRAFFIC		LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
G	≤1	1 171003 211034 361644	7 171002 871620	13	19	25 483559	31 53071 481050	37 281802 14155	43 14125
G	>1	2 421597	8	14 211010 241634 261001	20 511023	26	32	38 473075 481169	44 11019
F	≤1	3 261010 291002	9 181028 196150	15 361643	21	27 401015 483579	33 471023	39	45
F	>1	4 261012	10 891021	16	22 261013	28	34	40	46 129054
P	≤1	5 291005	11	17 271016	23 871622	29 473101	35 404088 481069	41	47 123997 124154
P	>1	6 276251	12 421605	18 271019	24 271028	30	36	42 531801	48

Figure 1. Experimental design for treatments applied to flexible pavements

Cell Number — 48
991001 — SHRP ID

MOISTURE		DRY							
TEMPERATURE		FREEZE				NO-FREEZE			
SUBGRADE		FINE		COARSE		FINE		COARSE	
TRAFFIC		LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
CONDITION	SN RATIO								
G	≤1	49 201010 311030	55	61 491006	67	73 483749 489005	79 481122 482172	85	91
G	>1	50 161020 831801	56 81053	62 161010	68 531008	74 61253	80	86 483769 481094	92 41021
F	≤1	51 82008	57	63	69	75 404087	81 483865	87	93 483739
F	>1	52	58	64	70	76	82	88	94
P	≤1	53 321021 567775	59 322027 906405 901802	65 491004	71	77	83	89	95
P	>1	54 201005 301001	60	66 481017 531501 561007	72 161021 327000	78 41036	84	90 41017	96 41016 481183

Figure 1. Experimental design for treatments applied to flexible pavements (Cont.)

the dry regions of the country. Figure 2 shows the experimental design for treatments applied to rigid pavements.

Covariables

Covariables are measured independent variables that are not used in the basic design to select the treatment locations. They are variables that are suspected to have an impact on the performance of the preventive maintenance treatment, but that are not controlled in the experiment. The reasons for not controlling them can be many. Primary reasons include monetary constraints, lack of available candidate sections, and lack of prior knowledge during the site selection process.

Covariables that were identified for preventive maintenance applied to flexible pavement include age, thickness of layers, base thickness, base material properties, shoulder type, subdrainage, material composition of pavement layers, prior maintenance, quality of the treatment construction or application, treatment material properties, and environmental conditions at the time of treatment application. There are also unknown and uncontrolled variables, but their effects are not expected to be significant.

In addition to the covariables mentioned for the flexible pavement studies, the covariables for preventive maintenance applied to rigid pavements include traffic, pavement condition at the time of treatment, slab length, load transfer method, and load transfer efficiency.

Treatment of Missing Cells

Missing cells could pose a problem in the analysis depending on the question at hand and the location of the missing cells. The following example illustrates this situation. Suppose the question at hand is, "Do treatments perform well under wet conditions across all distress levels?" Also suppose that the true relationship between these variables is generically depicted in either figure 3 or 4. The term generic refers to the fact that the y axis represents some measure of treatment effectiveness, the exact measure not being relevant to this discussion. Suppose further that no sites were available under wet conditions for roads in poor condition. In figure 5 the observed data are connected with solid lines, which optimistically agree with the true values for the sites that we could observe. However, without observing the missing cell, denoted by x, we do not know if it is valid to draw the conclusion that the treatment is uniformly best under wet conditions, as figure 3 shows, or if it is actually worse for roads in poor condition, as figure 4 shows. That is, even though the data we observed are representative of the true conditions, the missing data could result in an erroneous conclusion. Therefore, it is imperative that we do the following:

Pavement	Moisture	Base Type	Freeze: Fine	Freeze: Coarse	No-Freeze: Fine	No-Freeze: Coarse
Plain	Wet	Dense	1 IA KY	3	5	7
Plain	Wet	Stab	2 IN OH	4 IA	6 OK TX	8
Plain	Dry	Dense	9 CO+ KS NE NE	11 NE SD	13 TX	15 AZ
Plain	Dry	Stab	10 UT+ KS	12 CO+ UT+ UT+ NV	14 CA	16 CA
Reinforced	Wet	Dense	17 PA+ PA+ MO MO	19	21 AR	23 AR+
Reinforced	Wet	Stab	18	20 OH	22 MS+ TX TX	24 AR+ TX

\+ Joint Seal Only

Figure 2. Experimental design for treatments applied to rigid pavements

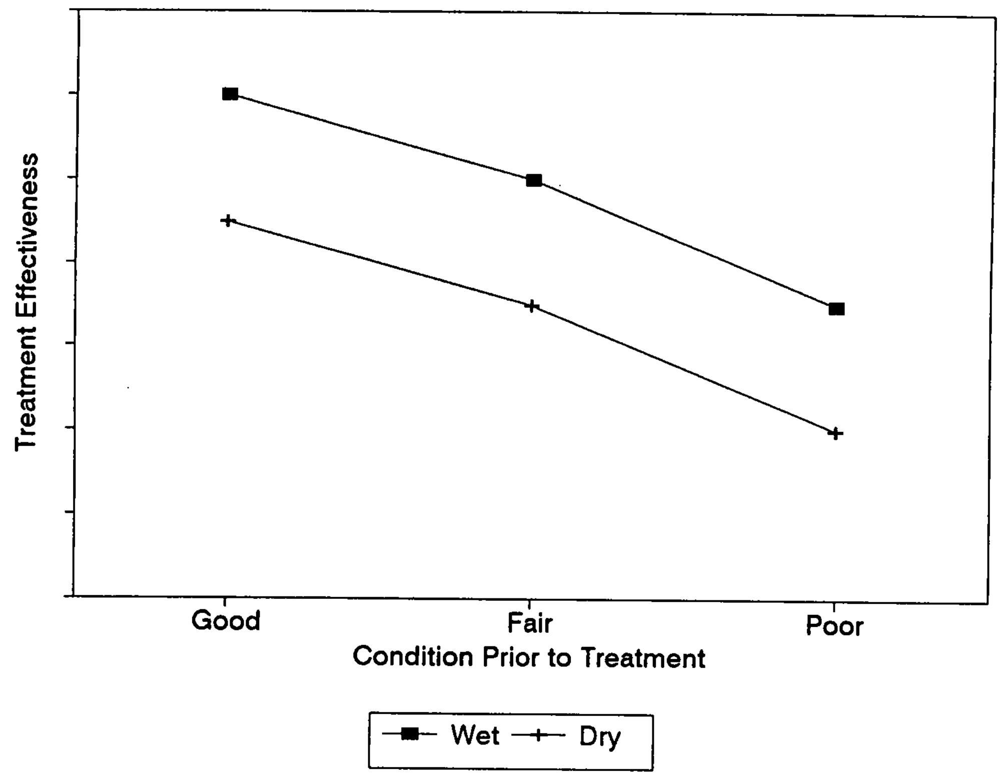

Figure 3. Illustration of treatment effectiveness with no interaction

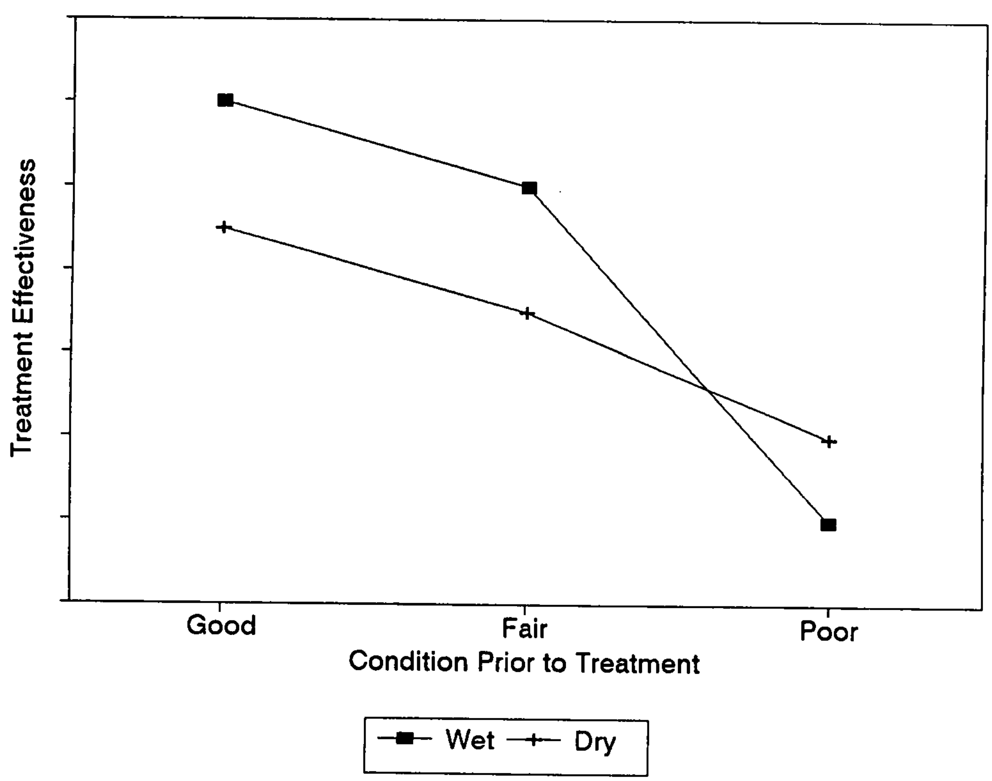

Figure 4. Illustration of treatment effectiveness with interaction

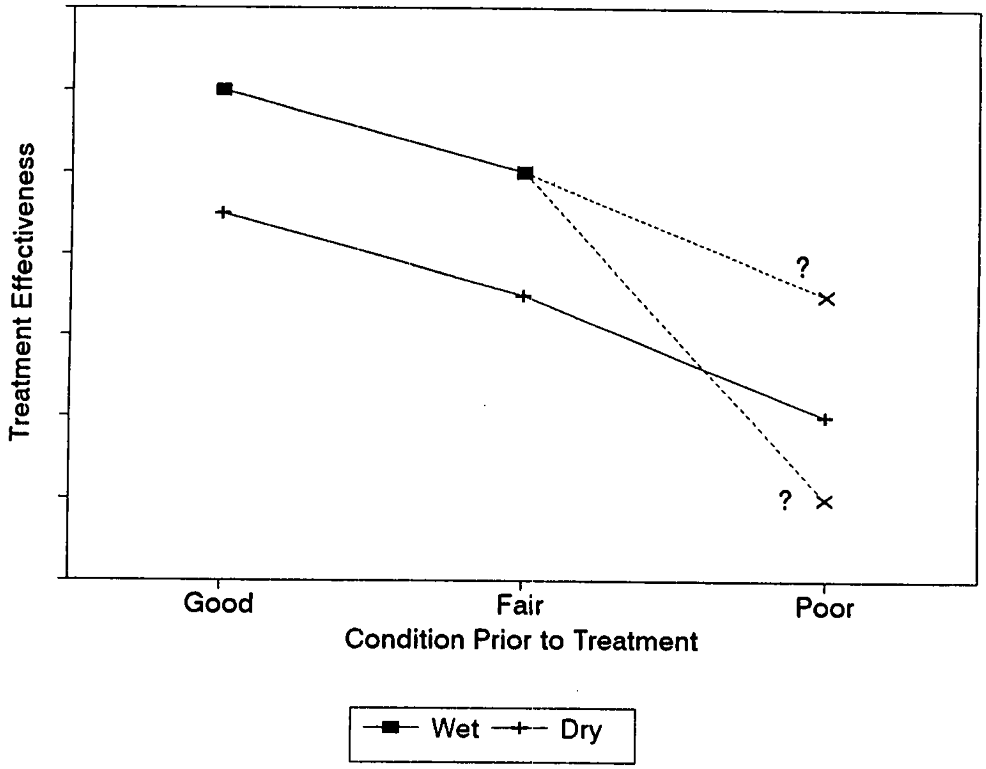

Figure 5. Illustration of impact of missing cell on treatment effectiveness analysis

1. design for missing cells and strategically place them where they will have minimal effect on the design before the study, and

2. consider measures for retrieving this information when an unanticipated missing cell does occur.

These goals can be achieved either through additional sampling or statistical methods. Because all sections available have been included in the study, statistical methods will be used in the analysis. The statistical methods for handling the problem of missing cells are not magic cure-alls and require certain assumptions. These assumptions need to be clearly stated and critically scrutinized in the analysis before drawing inferences.

3

Project Approval Process

Site Selection Criteria

The basic site selection criteria were defined by the experimental design and the participation criteria. However, other constraints were considered.

Experimental Design-Defined Criteria

The experimental design factors identical to Long-Term Pavement Performance (LTPP) General Pavement Studies (GPS) factors include climatic zone based on temperature and moisture, subgrade type, and traffic level. The experimental design factors that were not included in the LTPP GPS factors include condition at the time of treatment application, structural adequacy of the pavement or subbase type, and the maintenance treatments. The experimental design factor levels are defined below.

Moisture	Wet	See figure 6
	Dry	See figure 6
Temperature	Freeze	See figure 6
	No-Freeze	See figure 6
Subgrade Type	Fine grained	See table 1
	Coarse grained	See table 1
Traffic Loading (flexible only)	Low	< 85 KESAL/yr
	High	≥ 85 KESAL/yr
Condition (flexible only)	Good	Defined later
	Fair	Defined later
	Poor	Defined later
Structural Adequacy (flexible only)	High	SN/SN required ≥ 1
	Low	SN/SN required < 1
Subbase (rigid only)	Dense granular	See table 2
	Stabilized	See table 2

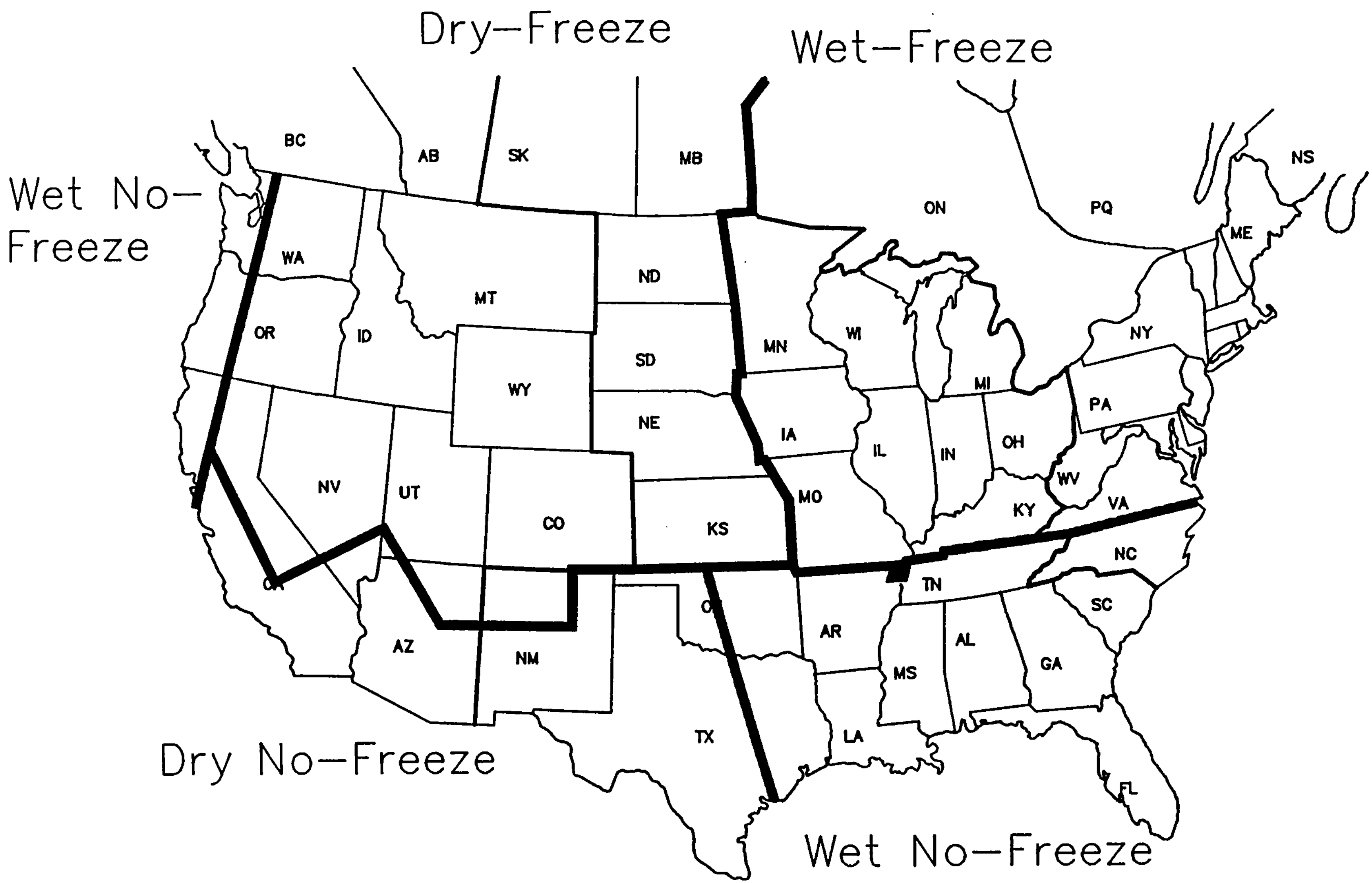

Figure 6. Environmental zones for SHRP LTPP studies

Table 1. Subgrade soil description codes

Soil Description	Code
Fine-Grained Subgrade Soils:	
Clay (Liquid Limit > 50)	51
Sandy Clay	52
Silty Clay	53
Silt	54
Sandy Silt	55
Clayey Silt	56
Coarse-Grained Subgrade Soils:	
Sand	57
Poorly Graded Sand	58
Silty Sand	59
Clayey Sand	60
Gravel	61
Poorly Graded Gravel	62
Clayey Gravel	63
Shale	64
Rock	65

Structural Adequacy

The structural adequacy of the pavement was defined as one of the selection criteria. The approach selected was to use the ratio of the in-place structural number to the required structural number as the method to determine structural adequacy. The required structural number was calculated using the current American Association of State Highway and Transportation Officials (AASHTO) design equation, and the in-place structural number was calculated using standard layer structural coefficients from the AASHTO "Guide for Design of Pavement Structures" (AASHTO 1986) and the layer information from the available inventory data.

Table 2. Base and subbase material type classification codes

Material	Code
Dense Granular	
Gravel (Uncrushed)	22
Crushed Stone, Gravel, or Slag	23
Sand	24
Soil-Aggregate Mixture (Predominantly Coarse-Grained Soil)	26
Limerock, Caliche (Soft Carbonate Rock)	41
Stabilized	
Soil Cement	27
Bituminous-Bound Base or Subbase Materials	
Dense Graded, Hot Laid, Central Plant Mix	28
Dense Graded, Cold Laid, Central Plant Mix	29
Dense Graded, Cold Laid, Mixed In-Place	30
Open Graded, Hot Laid, Central Plant Mix	31
Open Graded, Cold Laid, Central Plant Mix	32
Open Graded, Cold Laid, Mixed In-Place	33
Recycled Asphalt Concrete, Plant Mix, Hot Laid	34
Recycled Asphalt Concrete, Plant Mix, Cold Laid	35
Recycled Asphalt Concrete, Mixed In-Place	36
Sand Asphalt	46
Cement-Aggregate Mixture	37
Lean Concrete (< 3 sacks cement/cy)	38
Pozzolanic-Aggregate Mixture	44

The structural numbers are being recalculated as more complete information becomes available from the LTPP data base. This data base is supposed to contain more accurate layer thicknesses and more complete layer material characterization than were available during the project selection process.

Condition Prior to Treatment Application

Another criterion was the condition of the pavement as known when the section was selected, and at the time the treatment was placed. A set of definitions to define good, fair, and poor was developed and is discussed in the following paragraphs.

A section of pavement in good condition was permitted to exhibit low-severity raveling and weathering. Pavement designated in good condition also could contain longitudinal and transverse cracking, but very little of this cracking was allowed to be of medium severity and none could be high-severity cracking. No alligator cracking could develop in this pavement, and if rutting existed it should be less than 1/4-in (6-mm). Roughness to produce a serviceability level no lower than 3.0 was allowed, and surface friction was required to be acceptable to the state or provincial agency.

If a candidate section normally would fall in the good range based on low-severity cracking (< 60-ft or 18-m) but contained more than "only a few" medium-severity cracks, the section was classified as fair. The existence of alligator cracking would also cause the candidate section to be classified as fair. Sections classified as fair may have had low-severity raveling and weathering. Pavements with low-severity block cracking over more than 20 percent of the surface area were classified fair. Raveling and weathering of the existing surface in medium severity was acceptable. Moderate roughness that would produce a serviceability value of less than 3.0 but greater than 2.0 would cause the pavement to be considered fair. The surface friction could be less than desirable.

The existence of substantial amounts of any distress would cause the pavement to be considered poor. Pavements with medium-severity block cracking over more than 20 percent of the surface area were classified as poor. Pavements with surface roughness that would decrease the serviceability to less than 2.0 were considered poor.

Table 3 shows the allowable amounts of deterioration for certain key distress types for a 500-ft x 12-ft (152-m x 4-m) section.

A fourth condition of excellent also was defined. Sections in excellent condition were not selected as candidates for any treatment. These were defined as those less than five years of age since construction and that showed no evidence of distress.

Because all the treatments are preventive in nature and do not add significant structural improvements, any section that exhibited significant structural deterioration was not considered an applicable candidate and was also excluded from consideration. These sections were defined as follows:

Table 3. Definition of condition categories based on cracking amounts and severities

Condition Category	Longitudinal and Transverse Cracking Severities			Alligator Cracking	Rutting
	L	M	H		
Excellent	< 24-ft (7-m)	0	0	None	< 1/4-in (6-mm)
Good	0-60-ft (0-18-m)	< 24-ft (7-m)	0	None	< 1/4-in (6-mm)
Fair	0-120-ft (0-36-m)	12-60-ft (4-18-m)	< 24-ft (7-m)	Low Sev ≤ 5% Medium Sev ≤ 2%	1/4-1/2-in (6-13-mm)
Poor		≥ 60-ft (18-m)	≥ 24-ft (7-m)	Low Sev > 5% Medium Sev > 2%	> 1/2-in (13-mm)

1. No test section should contain extensive medium- or any appreciable high-severity structural (load associated) distresses (alligator cracking or rutting) or potholes of any severity. If structural distresses currently exist (at medium- or high-severity), their progression in severity and extent may overshadow the influence of the crack-sealing operation and cause premature failure of the other treatments. In addition, the occurrence of these distresses will skew the measurement of performance because the treatments should prolong life and slow the deterioration rate. Low- and medium-severity alligator cracking and rutting will be allowed if the affected area does not exceed 10 percent of the total area.

2. Sections with more than 5 percent of the area currently patched should not be considered as candidate test sections. Patching conceals the previously existing deterioration and reduces the ability to determine the cause of the deterioration.

In addition, certain other problems could not be adequately addressed with the treatments. Sections that exhibited the following problems also were excluded:

1. Sections exhibiting bleeding over more than 10 percent of the area. Bleeding will interfere with the ability of the treatments to bond with the existing asphalt concrete surface and obscure cracks.

2. Sections with rutting greater than 1-in (25-mm).

3. Sections with roughness that cannot be corrected with a thin overlay.

Other Site Selection Criteria for Preventive Maintenance Test Sections Applied to Flexible Pavements (SPS-3)

The following requirements were included in the site selection criteria for the flexible pavement study:

1. SPS-3 sections will be located adjacent to GPS sections unless no GPS sections fit the basic experimental design criteria.

2. SPS-3 sections will be located in a state or province that is willing to fund the construction of **all** the applicable treatments for each location as well as provide a control section.

3. The same data required for the GPS-1 candidate projects will be required.

4. Sections should be relatively straight in horizontal alignment and uniform in profile. Projects with high degrees of curvature, steep grades, deep cuts, or high fills are not considered acceptable; however, sections where the normal terrain consists of short, low hills requiring pavements to normally transition from a shallow cut to a low fill will be considered relatively uniform in profile.

5. Each section must be continuous between bridge abutments, large culverts, at-grade railroad crossings, and other discontinuities.

6. The construction project in which the GPS section is located must have sufficient lengths of pavement to meet the criteria described in 4 and 5 above to contain each of the four treatments and the control section, in addition to the area required for the GPS section. Each SPS-3 section will be 500-ft (152-m) long and have a transition area at each end. This transition area will be 200*-ft (61-m) on each end of the chip seal section and 100-ft (30-m) on each end of the other sections, including the control section. It is not required that all four treatments and the control section adjoin the GPS section. However, the entire length of a treatment or control section and its transition area must be within one unbroken length. As a general rule, an unbroken length of 1,000-ft (305-m) is required for a single section location, and any combination of lengths that will contain the total required length of 3,700-ft (1,128-m) will be acceptable.

7. The project should have relatively uniform traffic over the area containing the GPS and SPS sections.

8. Candidate sections should have been completed no earlier than 1970.

9. Original pavement surfaces that have been scarified by grinding, milling, or other means are not considered acceptable.

10. Projects that have received a seal coat are acceptable only if the seal coat was placed prior to May 1987.

11. Projects must fall in one of the good, fair, or poor condition categories listed above and have no other disqualifying conditions defined above.

* This length was later modified to 100-ft (30-m).

Other Site Selection Criteria for Preventive Maintenance Tests Sections Applied to Rigid Pavements (SPS-4)

The following requirements were included in the site selection criteria for the rigid pavement study:

1. SPS-4 sections will be located adjacent to GPS sections unless no GPS sections fit the basic experimental design criteria.

2. SPS-4 sections will be located in states and provinces that are willing to fund the construction of all the applicable treatments for each location as well as provide a control section.*

3. The same data required for the GPS candidate projects will be required.

4. Sections should be relatively straight in horizontal alignment and uniform in profile. Projects with significant curvature, steep grades, deep cuts, or high fills are not considered acceptable.

5. The project should have uniform traffic over the area throughout the length of the GPS and SPS sections.

6. Actual SPS-4 sections will total a minimum of 2,500-ft (762-m) in length when not located in conjunction with a GPS section. A GPS section may serve as the control section for the SPS-4 study; if it does, the section length requirement is reduced to 2,000-ft (610-m). As noted below, the total section length will be increased by a transition section between each treatment section. The sections need not be contiguous.

7. All 500-ft (152-m) treatment sections will be separated by a transition of at least two slabs in length.

* This requirement was later modified.

Project Verification

The information available for the GPS sections was used to identify sites that would potentially fit the experimental design. After the state or provincial agency agreed to be a potential participant, the condition of the sections were verified by the Regional Coordinating Office Contractors (RCOCs). At the same time, each section was located, marked, and cored. The participating agency provided the coring and drilling equipment to collect at least one 6-in (152-mm) diameter core adjacent to each section and to drill into the subgrade to identify the layer materials, layer thicknesses, and subgrade type for the test sections on flexible pavements. The RCOCs were responsible for submitting cores to the LTPP Regional Testing Laboratory. The participating state or province assisted the RCOC by providing the equipment, crew to extract the core, and traffic control.

The cores were taken in accordance with the directions for the A1 core for GPS-1 sections as described in the "SHRP Field Sampling Guide" (SHRP 1992a). Only the asphalt core was retained. The core hole was used as the auger site to visually classify the base type and subgrade type. The hole was filled in accordance with LTPP directions.

The cores were marked, wrapped, packaged, and shipped in accordance with the SHRP "LTPP Field Sampling Guide" requirements (SHRP 1992a). The information concerning the field sampling, cores recovered, and classification of base and subgrade material was recorded in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b).

The same process was followed for test sections on rigid pavements, except the core was taken in the shoulder. Construction records were reviewed to ensure that there was no change in surface thickness. At least one 6-in (152-mm) diameter core was taken from the paved shoulder adjacent to each test section. Drilling extended into the subgrade. Each layer material, layer thickness and subgrade type was identified. Information concerning the field sampling, core, and classification of base and subgrade material was recorded in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b). Figure 7 provided guidance on preventive maintenance test section location within a rigid pavement test site for various terrain conditions to minimize this influence. The invert of vertical curves was to be avoided if at all possible.

Project Approval

The regional task groups approved all sites. Any site that met the requirements was generally approved. Figures 8 and 9 show the distribution of the approved projects (test sites) in the United States and Canada for SPS-3 and SPS-4 studies, respectively.

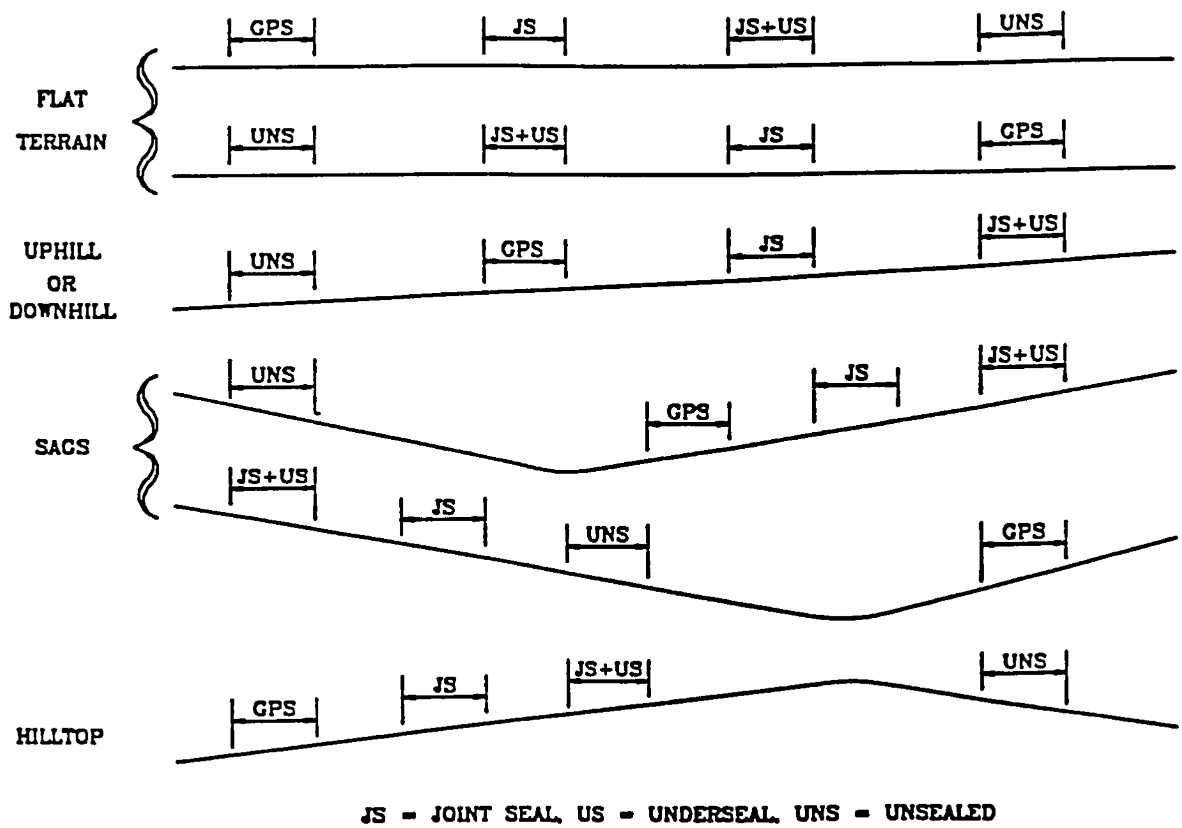

Figure 7. Location options for SPS-4 test sections with different topographic constraints

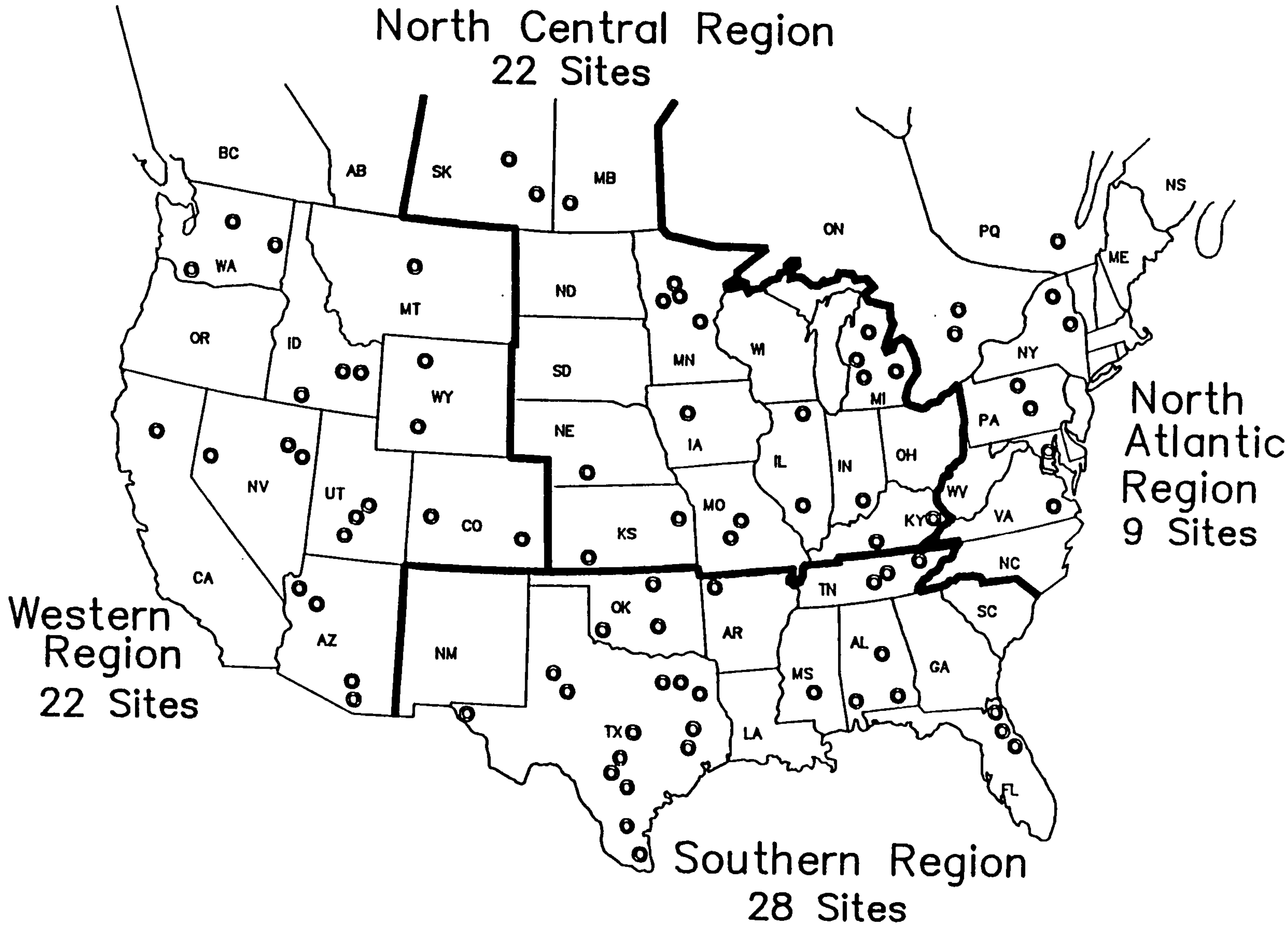

Figure 8. Distribution of approved SPS-3 test sites

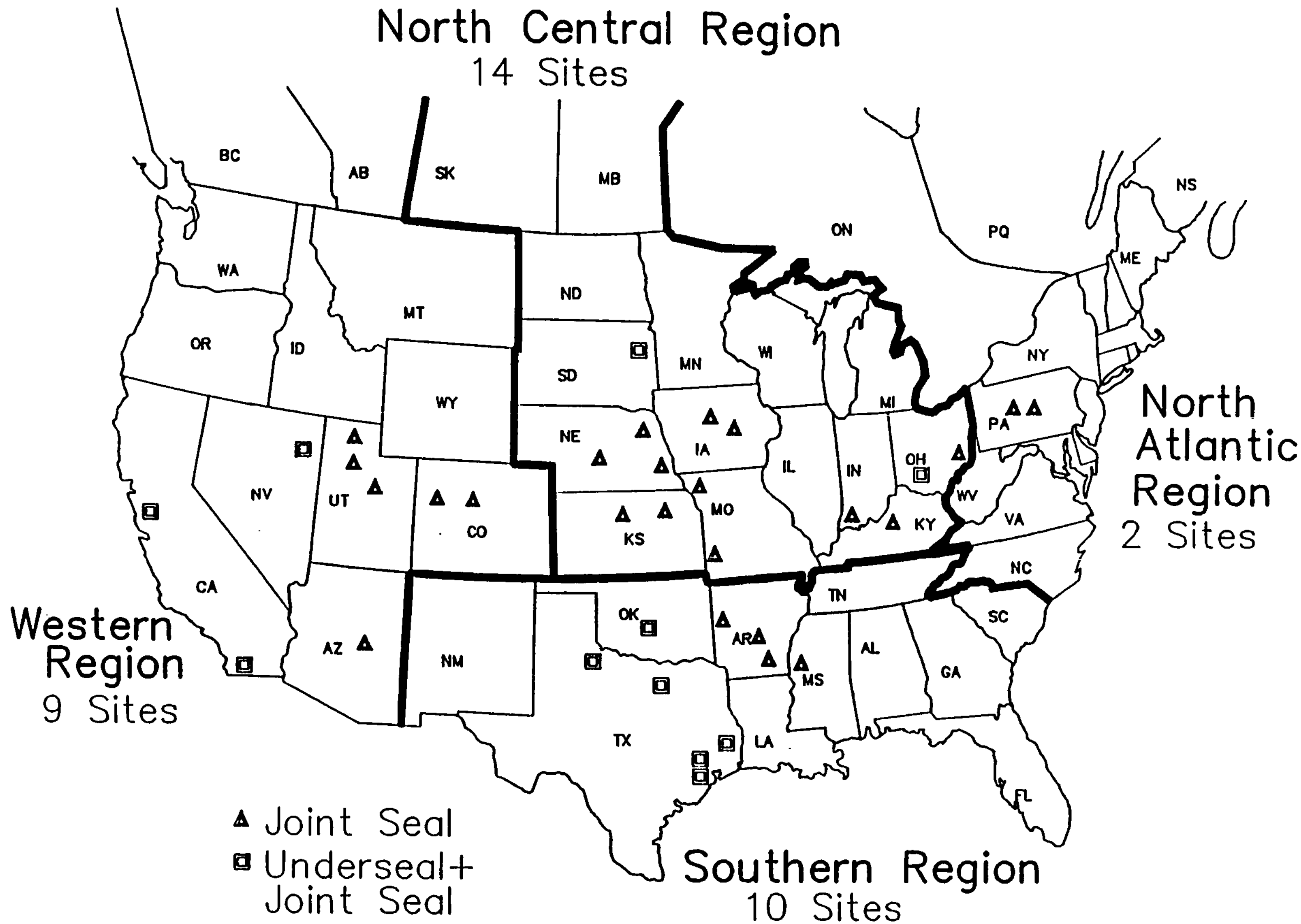

Figure 9. Distribution of approved SPS-4 test sites

4

Construction Guidelines

Construction Guidelines for Preventive Maintenance Test Sections Applied to Flexible Pavements (SPS-3)

The chip seal, crack seal, and slurry seal test sections were constructed by a single contractor within each Strategic Highway Research Program (SHRP) region. The Federal Lands Highway Divisions (FLHD) of the Federal Highway Administration (FHWA) acted as contracting officers for the application of the chip seal, crack seal, and slurry seal test sections in each SHRP region. Each participating agency was responsible for surface preparation and constructing the remaining treatments, including the thin overlay and any state experiment (supplemental) test sections in the preventive maintenance study for flexible pavements (SPS-3). The assistance of the FLHD, Regional Coordinating Office Contractors (RCOCs), SHRP Regional Engineers (REs), and participating agencies was paramount to the success of this study. Without their cooperation and assistance, this project could not have been completed. Figure 10 shows a typical layout of test sections at a test site for the SPS-3 study.

Surface Preparation, SPS-3

Surface preparation guidelines were developed and distributed to participating agencies. Each agency was responsible for performing the necessary surface preparation for all test sections, including completing the appropriate data collection sheets for recording quality assurance checks. These data collection sheets were to be taken from chapters 6 and 7 of the SHRP "Data Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988). No surface preparation or maintenance was to be applied to the control section. Surface preparation requirements for the agency-designed experiments were developed by the participating agency. The surface preparation for all treatments was to be performed at least sixty days in advance of construction. A description of the surface preparation and materials allowed was provided to participating agencies along with the data collection requirements and the appropriate data collection sheets.

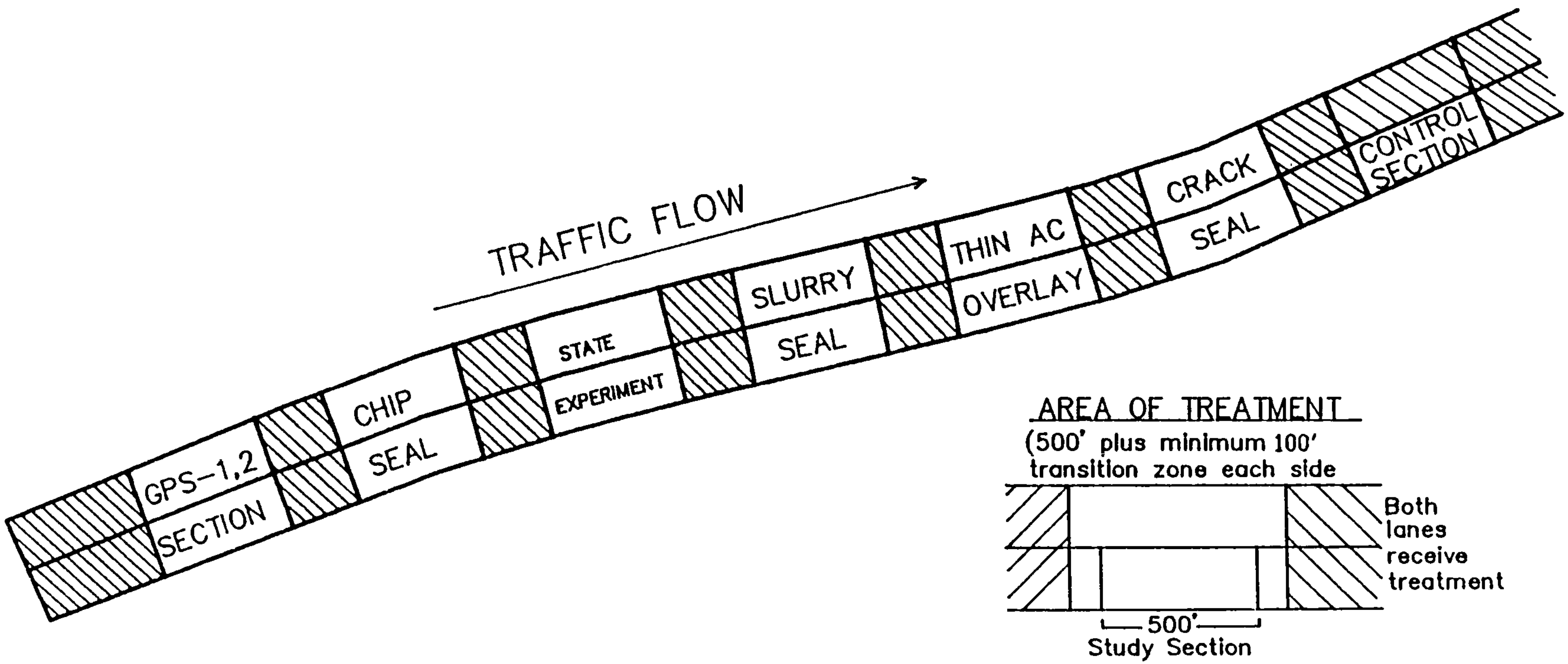

Figure 10. Typical layout for SPS-3 test sections

Traffic Control During Construction, SPS-3

The responsibility for traffic control during construction of the chip seal, crack seal, and slurry seal test sections of the H-101 study varied among the four SHRP regions as chosen by the regional task groups (RTGs). The participating agencies in the North Central and the Western regions were responsible for supplying traffic control at the treatment site, including flaggers, barricades, flashing lights, or other equipment or personnel required by the regulations and laws of the participating agency. The Canadian provinces in the North Atlantic region were also responsible for traffic control. This requirement was placed on the regional contractor in the North Atlantic and Southern regions. Each agency was responsible for traffic control during surface preparation and construction of the thin overlay and supplemental test sections. Traffic was restricted from the chip seal and slurry seal until they had adequately cured to prevent damage to the treatments.

Construct Thin Overlay

The participating agency was responsible for constructing the thin overlay including completing the appropriate data collection sheets for recording quality assurance checks. These were to be taken from Chapter 7 of the SHRP "Data Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988). The appropriate data collection sheets were provided. A set of guide specifications for use in designing and constructing the overlay was also provided. To reduce variation among agency constructed overlay treatments, each agency was requested to select and use their hot mix asphalt concrete materials and construction specifications that most closely matched those found in the guide specifications.

Participating Agency Supplemental Test Sections, SPS-3

Participating agencies constructing their own test sections adjacent to the SHRP-designated test sections were responsible for constructing these test sections and for completing the appropriate quality assurance and construction monitoring checklists. The data collection sheets for recording quality assurance checks were to be taken from the SHRP "Data Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988).

Construction Guidelines for Preventive Maintenance Test Sections Applied to Rigid Pavements (SPS-4)

The agencies were responsible for preparing surfaces, constructing all sections or contracting for their construction, and preparing the control section for all preventive maintenance test sections applied to rigid pavements (SPS-4). Figure 11 provides a typical layout of test sections at an SPS-4 test site.

Surface Preparation, SPS-4

Surface preparation was to be performed at least fifteen days in advance of treatment application. The participating agency was responsible for performing the necessary surface preparation for all test sections. This included completing the appropriate data collection sheets for recording quality assurance checks. These sheets were to be taken from the SHRP "Data Collection-Guide for Long-Term Pavement Performance Studies" (SHRP 1988).

Traffic Control During Construction, SPS-4

Each agency was responsible, either directly or through contract, for traffic control during surface preparation, testing and installation of joint and crack seal and underseal test sections.

Preparation of Control Section, SPS-4

The control section for joint sealing is a section with no joint sealing or filler, or the joint sealer with a filler rendered ineffective. If the section was new construction, the joint sealer was not to be installed. The control section of an existing pavement was to have existing joint sealer or filler removed or rendered ineffective.

Installation of Joint and Crack Seal and Underseal, SPS-4

Each participating agency was responsible for treatment installation. A set of guide specifications was provided for undersealing, sealing of cracks and joints, and patching as surface preparation. Undersealing was to be applied to both approach and leave sides of joints/cracks that exceed 0.020-in (0.5-mm) deflection when measured by the Benkelman Beam. The undersealing was to be applied to both sides of the joint even though only one side of the joint/crack exceeds the 0.020-in (0.5-mm) deflection criterion. The undersealing was normally also applied to the joint or crack in the adjacent lane when the joint or crack was undersealed in the H-101 test section.

The participating agency was responsible for installation of the joint/crack seal and underseal test sections, including completing the quality assurance and construction monitoring checklist. The appropriate data collection sheets were provided. General items to be monitored included initial deflection tests, stability tests, equipment calibration, material volumes, locations, temperatures, and other similar tasks.

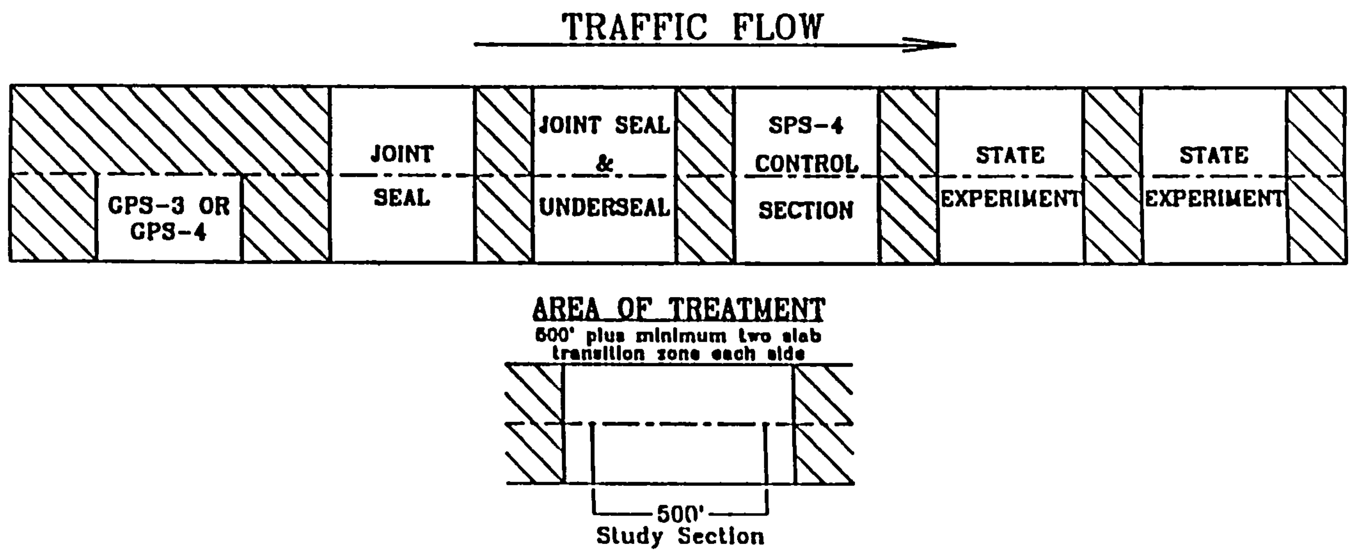

Figure 11. Typical layout for SPS-4 test sections

Specific data were required for joint and crack sealing activities on air temperature, relative humidity, temperature of the sealant, width of joint and cracks, depth of sealant below pavement surface, depth of backer rod, application pressure, and thickness of sealant. Relative humidity was based on local weather information. Temperature of the ASTM D 3405 sealant was based on the calibrated temperature gauge on the sealant heating equipment.

Undersealing data required to be collected included deflection measurements, air temperature, relative humidity, fluidity of the grout (Field Protocol H35F), volume of the grout pumped per hole, hole pattern distances, depth of holes, amount of materials, and pumping pressure.

Participating Agency Supplemental Test Sections, SPS-4

Participating agencies interested in installing their own test sections adjacent to the SHRP-designated test sections were responsible for constructing these test sections and for completing the appropriate quality assurance and construction monitoring checklists. Appropriate background data was to be collected for these additional sections. Data collection sheets could be utilized from the SPS-4 field sheets or the SHRP "Data Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988).

Guide Specifications

Guide specifications were developed for each of the six treatments. These were reviewed and modified by the regional task groups. The guide specifications for the treatments applied by regional contractors were previously published by SHRP (Bullard 1992). The remainder of the guide specifications are included in the appendixes of this report.

Numbering of Test Sections in the Field

A numbering system was developed for SPS-3 and SPS-4 test sections that would assist in identifying the type of treatment. All SPS-3 and SPS-4 sites are adjacent to an LTPP test section, and the data base has an identified data set that allows the SPS-3 and SPS-4 sites to be matched to the corresponding LTPP test section. The LTPP numbering system used six digits with a state or province code as the first two digits. This concept was retained in the SPS-3 and SPS-4 numbering system. The third digit used a letter sequence of A for the first SPS-3 and for the first SPS-4 site in a state or province. Additional sites in a state or province continued sequentially through the alphabet, except that no site would be given an O. A 3 is used in the fourth digit for SPS-3 sites, and a 4 is used in the fourth digit for SPS-4 sites. The fifth digit indicates the type of treatment based on the following:

SPS-3

Thin overlay	1
Slurry seal	2
Crack seal	3
Control section	4
Chip seal	5

SPS-4

Joint/crack seal	1
Joint seal and underseal	2
Control section	3

Numbers greater than those in the fifth digit would be used for participating agency test sections that had no corresponding SPS-3 or SPS-4 treatment. They would be increased sequentially for the treatments used in that agency. They would not necessarily be the same for different agencies.

The sixth digit is 0 for all SHRP-designed test sections. The sixth digit is sequentially increased for state or province experiments. If a participating agency applied its own agency-designed chip seal, the last three numbers would be 351. If it applied a second agency-designed chip seal, the last three numbers would be 352, and so on.

Table 4 illustrates the numbering system used. The xx represents the state or province code number. An agency might not have the same number of additional agency-designed test sections at each site, which is illustrated by the cell with the asterisk.

Table 4. Illustration of SPS-3 and SPS-4 numbering system

Type of Section	First Site in a State	Second Site in a State	Third Site in a State
Thin Overlay	xxA310	xxB310	xxC310
Slurry Seal	xxA320	xxB320	xxC320
Crack Seal	xxA330	xxB330	xxC330
SPS-3 Control Section	xxA340	xxB340	xxC340
Chip Seal	xxA350	xxB350	xxC350
State Slurry Seal	xxA321	xxB321	xxC321
State Crack Seal	xxA331	xxB331	xxC321
Second State Crack Seal	xxA332	*	xxC332
State Section with No Corresponding SPS-3 Treatment	xxA360	xxB360	xxC360
Joint Seal	xxA410	xxB410	xxC410
Joint Seal and Underseal	xxA420	xxB420	xxC420
SPS-4 Control Section	xxA430	xxB430	xxC430
State Joint Seal	xxA411	xxB411	xxC411

5

Field Sampling, Testing, and Data Collection

General

There are four phases of field testing, sampling, and data collection in addition to the standard condition monitoring. In the first phase, the initial conditions prior to treatment application were defined as part of the site verification process. In the second phase, the materials to be used in the treatments were sampled. In the third phase, information was collected during the treatment application to determine the quality of the treatment process, including the materials being used at each site. In the fourth phase, tests were performed to determine how the pavements change over time after treatment application.

Preventive Maintenance Test Sections on Flexible Pavements (SPS-3)

Site Verification

The first materials sampling occurred during the site verification process. During that period, the participating agency provided the coring and drilling equipment to collect at least one 6-in (152-m) diameter core adjacent to each section and to drill into the subgrade to identify the layer materials, layer thicknesses, and subgrade type. The Regional Coordinating Office Contractors (RCOC's) were responsible for submitting cores to the Long-Term Pavement Performance (LTPP) Regional Testing Laboratory. The participating state or province assisted the RCOC by providing the equipment and crew to extract the core.

The core was taken in accordance with the directions for the A1 core for GPS-1 sections in accordance with the "SHRP Field Testing Guide" (SHRP 1992a). Only the asphalt core was retained. The core hole was then used as the auger site to visually classify the base type and subgrade type. The hole was then filled in accordance with LTPP directions.

The cores were marked, wrapped, packaged, and shipped in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. The information concerning the field sampling, cores recovered, and classification of base and subgrade material was recorded in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. The SHRP section ID number was the section ID number. The first core for each section was numbered CA01. If additional cores were taken, they were numbered CA02, and so on. The field set was H to designate it as an H-101 core. The following sheets were required:

1. Field Material Sampling and Field Testing, Log of Bore Hole, Form S02, (to record base, subbase, and subgrade classification) and

2. Field Material Sampling and Field Testing, Log of Pavement Core (only for use at bore hole locations), Form S01 (to record coring information).

The data from Forms S01 and S02 were entered into the Regional Information Management System (RIMS). A copy of S01 was forwarded with the cores to the SHRP designated laboratory. The SHRP section testing number system for H-101 was provided to all RCOCs and regional engineers, as well as to SHRP. Each sample was identified with the appropriate section identification number.

It was requested that a distress survey be completed within ninety days of treatment construction. Falling weight deflectometer (FWD) deflection and roughness testing were also to be conducted on the test sections before treatment construction.

Acceptance Sampling

In each region, the RCOC traveled to the location of the materials sources and sampled, packaged, and submitted the materials to the regional testing labs for appropriate testing for the treatments placed by regional contractors. For other treatments the participating agency was responsible for carrying out these tasks.

All samples were marked, packaged, and shipped in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. They were accompanied by Form S06, Material Samples Inventory for Shipment to Laboratory. The sample location was designated SO01 when taken at the source of the materials production. The crack sealant sample numbers were designated HC01 for crack sealing material. The aggregate sample numbers were designated HA01 for aggregate. The emulsified asphalt cement sample numbers were designated HE01 for emulsified asphalt cement. The sample material was designated AESL for emulsified asphalts for slurry seals and AECS for asphalt emulsions for the chip seal. The sample material was designated AGSL for aggregate for the slurry seal and AGCS for the aggregate for the chip seal. All acceptance samples identified with the section identification number of the first planned test section in the region when section identification numbers were required.

Table 5 provides the requirements for sampling materials for treatments applied by the regional contractors. SHRP test methods are presented in the appendixes of this report.

Construction Monitoring Sampling and Field Tests

The RCOC collected the check samples of the materials during the construction. These were then marked, packaged, and shipped to the regional testing lab in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. They were accompanied by Form S06, Material Samples Inventory for Shipment to Laboratory. The sample location was AD01 when taken from a distributor or slurry seal applicator. The sample location was TR01 when taken from a delivery truck. The crack sealant sample numbers were designated HC01 for crack sealing material. The aggregate sample numbers were designated HA01 for aggregate. The emulsified asphalt cement sample numbers were designated HE01 for emulsified asphalt cement. The sample material was designated AESL for emulsified asphalts for slurry seals and AECS for asphalt emulsions for the chip seal. The sample material was designated AGSL for the aggregate for the slurry seal and AGCS for the aggregate for the chip seal. Slurry seal samples were defined as slurry seal. Samples were identified with the section identification number from which they were taken. When samples were taken other than in a section, they were identified with the section number of the next section to which they were to be applied. For the check samples, which are taken only once per state or province, the samples were taken at the first location in the state or province where the treatments were placed and were identified with that section identification number. Sampling was completed in accordance with the same requirements shown in table 5.

Table 5. Sampling procedures for SPS-3 materials

Material	Test Method		
	SHRP	ASTM	AASHTO
Crack Sealant	HF01	D 3405	
Emulsion	HF02		T 40
Aggregate	HF03		T 2

To address the problem of changes in the crack sealing material over time, a second set of material tests was conducted after approximately one-half of the sections in a region were completed. Field check samples of the slurry seal aggregate and emulsion were taken at each site. The total slurry seal mix was sampled once in each state or province in accordance with SHRP procedure HF08. Field check samples of both the aggregate and emulsion were taken at each chip seal site.

Field Tests During Construction

The RCOC was responsible for monitoring the application process. A checklist was prepared by the H-101 research team. The checks involved equipment calibration, temperature, distance measurements, area measurements, and other similar tasks.

Crack Sealing

The only physical measurements completed were of the temperature of the air and sealant, and the width of cracks and sealant. Relative humidity was based on local weather information. Temperature of the sealant was based on the temperature gauge on the sealant heating equipment.

Slurry Seals

The physical measurements made included moisture content of the aggregate, ambient temperature, and relative humidity. Relative humidity was based on local weather information. The application rate measurement was based on the equipment readings, which varied with the type of machine. Table 6 gives the requirements for the sampling of slurry seals.

Table 6. Requirements for sampling slurry seal materials during construction

Process	Test Method	
	SHRP	AASHTO
Application Rate	HF04	
Aggregate Moisture	HF27	T 217

Chip Seals

The physical measurements taken included moisture content of the aggregate, ambient temperature, and relative humidity. Relative humidity was based on local weather information. The emulsion application rate was based on measurements of the emulsified asphalt quantity in the distributor. Table 7 gives the requirements for the sampling of chip seal materials.

Materials Sampling After Construction

Final materials sampling will occur approximately three years after construction and will be repeated biennially or triennially until the section is removed from the study. The participating agency will provide the coring and drilling equipment to collect at least one 6-in (152-mm) diameter core adjacent to each section. The RCOCs are responsible for submitting cores to the LTPP Regional Testing Laboratory. The participating state or province assists the RCOC by providing the equipment and crew to extract the cores.

The cores will be taken in accordance with the directions for the A1 core for GPS-1 sections in accordance with the "SHRP Field Testing Guide" (SHRP 1992a), except that the core will be moved 2-ft (0.6-m) toward the test section location. Only the asphalt core will be retained. The hole will then be filled in accordance with LTPP directions.

The information concerning the field sampling and core is recorded in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. The Field Material Sampling and Field Testing, Log of Pavement Core (Only for Use at Bore Hole Locations), Form S01, will be required to record coring information. The cores are marked, wrapped, packaged, and shipped in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements.

Table 7. Requirements for sampling chip seal materials during construction

Process	Test Method	
	SHRP	AASHTO
Emulsion Application Rate	HF05	
Aggregate Application Rate	HF06	
Aggregate Moisture	HF27	T 217

Preventive Maintenance Test Sections on Rigid Pavements (SPS-4)

Site Verification

Assurance coring was part of the site verification process. The participating agency was to perform the coring in coordination with the SHRP RCOCs. Testing at the General Pavement Studies (GPS) site provided general confirmation of the pavement section. However, construction records were also reviewed to ensure that there was no change in surface thickness. The participating agency provided the personnel and the coring and drilling equipment to take at least one 6-in (152-mm) diameter core from the paved shoulder adjacent to most test sections; it was waived on some sections. Drilling was to extend into the subgrade. Each layer of material, layer thickness, and subgrade type were identified. Information concerning the field sampling, coring, and classification of base and subgrade material was recorded in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. The SHRP section ID number became the section ID number. The following sheets were required:

1. Project Site Reports, Form S07, and

2. Field Material Sampling and Field Testing, Log of Bore Hole, Form S05.

No laboratory testing of cores or materials obtained during verification sampling was conducted.

Distress surveys were to be completed within ninety days of applying the treatments. This and subsequent distress surveys were to include a measurement of faulting and edge drop-off. Deflection and roughness testing were also to be conducted on the test sections before treatment application. The deflection testing was used to determine which joints and cracks to underseal.

Acceptance Sampling

The RCOC was able to help with material sampling when enough advance coordination was provided. Either the participating agency or RCOC sampled, packaged, and submitted the joint and crack sealant material samples to SHRP regional testing laboratory for testing. Sampling was required for each lot of joint and crack sealant purchased. Sampling requirements for ASTM D 3405 liquid sealant and silicone sealant are given in SHRP protocols H33F and H34F, respectively.

All joint and crack sealant samples were marked, packaged, and shipped in accordance with the "SHRP Laboratory Testing Guide" (SHRP 1992b) requirements. The samples were accompanied by Form S06, Material Samples Inventory for Shipment to Laboratory. Sample locations were designated SO01 when they were taken at the source of materials production. Joint and crack sealant sample numbers were designated HC01 for joint and crack sealing material. The joint and crack sealant materials were designated CKSL for the ASTM D 3405 material and CKSS for the silicone sealant. Sample material was identified with the section identification number where section identification numbers were required.

Construction Monitoring Sampling and Field Tests

The participating agency was responsible for completing the quality assurance and construction monitoring checklist; however, the RCOCs completed many of them. The appropriate data collection sheets were provided. General items to be monitored included initial deflection tests, stability tests, equipment calibration, material volumes, locations, temperatures, and other similar tasks.

Specific data were required for joint and crack sealing activities on air temperature, relative humidity, temperature of the sealant, width of joint and cracks, depth of sealant below pavement surface, depth of backer rod, application pressure, and thickness of sealant. Relative humidity was based on local weather information. Temperature of the ASTM D3405 sealant was to be based on the calibrated temperature gauge on the sealant heating equipment.

Required undersealing data included deflection measurements, air temperature, relative humidity, fluidity of the grout (Field Protocol H35F), volume of the grout pumped per hole, hole pattern distances, depth of holes, amount of materials, and pumping pressure. Relative humidity was based on local weather information.

Special Testing After Construction

It has been requested that deflection testing be conducted on the rigid test sections biennially. Deflection testing of the underseal section should include Benkelman Beam testing (Field Protocol H32F) in addition to FWD testing (Field Protocol H30F) using the field testing plan for these devices.

Postconstruction Monitoring of SPS-3 and SPS-4 Sites

A distress survey was to be completed approximately six months after treatment construction, approximately one year after construction, and on an annual basis thereafter. The "Distress Identification Manual for the Long-term Pavement Performance Studies" (SHRP 1993) is used to collect information for distress surveys. Some of the surveys are being completed manually, and some are being completed with the PASCO photographic equipment. No change in procedure or reporting requirements will be required for SPS-3 or SPS-4 test sections based on the current guidelines. However, it is recommended for SPS-3 sections that all transverse cracks, including those that do not extend across at least half of the lane, be shown on the crack maps. These cracks currently are not recorded, and will not be recorded as part of the distress survey. However, we believe the presence of the cracks should be recorded on crack maps so that we can more accurately determine the effect of maintenance treatments on reducing the occurrence and propagation of transverse cracks. All distress surveys of SPS-4 test sections should include measurements of faulting and edge drop-off.

Skid testing should be completed in accordance with current SHRP LTPP guidelines. No change in the procedure or reporting requirements is required on SPS-3 or SPS-4 test sections, based on the current (May 1989) guidelines. The current plan of obtaining two tests, one in the first 300-ft (91-m) of the test section with the first pass and the second reading in the last 200-ft (61-m) with a second pass, will meet the needs of the SPS-3 and SPS-4 program. This testing is to be conducted at least biennially.

The longitudinal profile, or roughness, testing should be completed in accordance with current SHRP LTPP guidelines. No change in the procedure or reporting requirements will be required on SPS-3 or SPS-4 test sections, based on the current (July 1989) guidelines. The current plan of five passes per section will meet the needs of the SPS-3 and SPS-4 program. This testing is to be conducted at least biennially.

Special testing requirements for deflection testing were developed for the SPS-3 and SPS-4 sites to reduce the amount of time that should be required at each site to a single day. These procedures were prepared as additions to the SHRP falling weight deflectometer (FWD) testing plans, and they are included in appendix A. The testing is to be completed biennially after construction. Standard loss of support testing for underseal sections was to be conducted using the Benkelman Beam (Field Protocol H32F).

Table 8 contains a summary of surveys planned for the SPS-3 and SPS-4 test sections.

Field Protocols

Protocols were developed for all field sampling and testing required in the study by the research team. The protocols were developed to correspond with the protocol formats used by SHRP LTPP staff. The protocols developed for the SPS-3 and SPS-4 study are listed in table 9 and are presented in appendix B.

Recording Data

All data were recorded on data collection sheets and were entered into the SHRP Regional Information Management System (RIMS) data base by RCOC personnel. Data that were not recorded on the standard SHRP LTPP data collection sheets or using standard SHRP LTPP data collection procedures were collected on special data collection sheets developed by the research team, if at all possible. These sheets are for data collection during construction and for some survey procedures. They are presented in appendix C. In some cases, RCOC personnel monitoring the construction of the treatments kept field notes that could not be entered into a standard data base. If they exist for a project, the data construction data sheets identify the location of those notes.

Table 8. Survey schedule for SPS-3 and SPS-4 test sections

Type of Survey	Time of Survey					
	Prior to Treatment	Within 90 Days Prior to Treatment	About 6 Months After Treatment	About 1 Year After Treatment	Once a Year	Once Every Other year
Distress		X	X	X	X	
Roughness	X					X
Surface Friction	X					X
Deflection	X					X

Table 9. List of field protocols

SHRP TEST NUMBER	PROTOCOL NUMBER	NAME
HF01	H21F	Standard Practice for Sampling of ASTM D3405 Crack and Joint Sealant
HF02	H22F	Standard Practice for Sampling Bituminous Materials
HF03	H23F	Standard practice for Sampling Aggregates
HF04	H24F	Standard Practice for Measuring Slurry Seal Application Rate
HF05	H25F	Standard Practice for Measuring Emulsified Asphalt Application Rate
HF06	H26F	Standard Practice for Measuring Aggregate Application Rate
HF07	H27F	Standard Practice for Determining Moisture in Slurry Seal and Chip Seal Aggregates
HF08	H28F	Standard Practice for Sampling Slurry Seal During Construction
HF09	H29F	Dynaflect Deflection Testing
HF10	H30F	Falling Weight Deflectometer Deflection testing
HF11	H31F	Transient Dynamic Response System Testing
HF12	H32F	Benkelman Beam Deflection Testing
HF13	H33F	Sampling ASTM D3405 Crack and Joint Sealant Material
HF14	H34F	Sampling Silicone Joint Sealant Material
HF15	H35F	Flow of Grout Mixtures
HF16	H36F	Epoxy-Core Test for Void Detection

6

Laboratory Program

General

The SHRP Materials Testing Laboratory in the Western Region, Western Technology, Inc., Phoenix, Arizona, conducted most of the tests for the H-101 study. These included all standard materials testing, acceptance tests, quality control tests, and evaluation tests over time associated with the asphalt study. Some acceptance testing was completed by the Federal Lands Highway Divisions (FLHD) of the Federal Highway Administration (FHWA). The mixture designs (except for the thin overlay mixture design) were confirmed by the regional testing contractor. On receipt of samples, tests were completed as quickly as possible.

The participating agencies were responsible for tests of materials applied to supplemental test sections. Laboratory tests were conducted in accordance with laboratory test procedures defined by H-101 protocols. The results were recorded on laboratory test sheets prepared for this testing. The results will be entered into the LTPP data base.

Laboratory Protocol List

Laboratory protocols were developed for each test to be completed as a part of the SPS-3 and SPS-4 study. As much as possible the protocols used standard test procedures of the American Association of State Highway and Transportation Officials (AASHTO) and the American Society for Testing and Materials (ASTM). Table 10 provides a list of laboratory protocols developed and used. The protocols are included in appendix D.

Laboratory Data Sheets

The results of the laboratory tests were entered onto data sheets developed by the research team and entered into the data base by Regional Coordinating Office Contractor (RCOC) personnel. The laboratory data collection sheets are included in appendix E.

Contractor (RCOC) personnel. The laboratory data collection sheets are included in appendix E.

Table 10. Laboratory protocols used in SPS-3 and SPS-4 testing

SHRP TEST NUMBER	PROTOCOL NUMBER	NAME
AC08	H01L	Preparation of Asphalt Cores for Aging Tests
AE01	H02L	Recovery of Asphalt from Solution by Abson Method
AE02	H03L	Penetration of Bituminous Materials
AE06	H04L	Viscosity of Asphalts
SC01	H05L	Standard Methods of Testing Emulsified Asphalts
SC02	H06L	Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test
SC03	H07L	Testing Crushed Stone, Crushed Slag, and Gravel for Single or Multiple Bituminous Surface Treatments
SC04	H08L	Determination of Flakiness Index of Aggregates
SC05	H09L	Design, Testing, and Construction of Slurry Seal
SC06	H10L	Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded-Wheel Tester and Sand Cohesion
SC07	H11L	Wet Stripping for Cured Slurry Seal Mixes
SC08	H12L	Determination of Slurry System Compatibility
SC09	H13L	Mixing, Setting, and Water Resistance Test to Identify "Quick Set" Emulsified Asphalts
SC10	H14L	Sieve Analysis of Seal Coat Aggregates
SC11	H15L	Chip Seal Mix Design
SC12	H19L	Determination of Asphalt Content from Slurry Seal Sample
SC13	H20L	Accelerated Polishing of Aggregate Using the British Wheel
CS01	H16L	Joint Sealants, Hot-Poured, for Cement and Asphalt Pavements
CS02	H17L	Joint Sealants, Silicone
US01	H18L	Compressive Strength of Hydraulic Cement Mortar

7

Status of SPS-3 and SPS-4 Test Sections

General

All preventive maintenance test sections on flexible pavements (SPS-3) are in place. Most preventive maintenance test sections on rigid pavements (SPS-4) are in place; however, a few are scheduled to be placed during the 1993 construction season. Figures 12, 13, 14, and 15 show the location of each test site by region.

Table 11 gives a breakdown of test section sites by SHRP region with a list of problems. Individual sites are identified by site number in appendix F. The supplemental or participating agency-designed test sections constructed at each site are identified along with other general information on the status of individual sites by SHRP region. Each site contains all standard SPS-3 or SPS-4 test sections and a control section unless otherwise noted.

Problems

Several chip seal sites lost some to nearly all cover aggregate shortly after construction. A number of factors contributed to this situation.

In Arizona, two sites lost practically all cover aggregate, even though a second application was tried. At these sites, the asphalt concrete surface was covered with an open graded friction course. The research team believed the surface was flushed enough that the binder could be placed in accordance with study requirements. However, it appears that the surface texture was coarse and open enough that the binder could not be placed in a single course. It is possible that the chip seal would have worked if a fog seal had been placed to fill the surface pores before applying the chip seal. Although not to the same extent, the presence of open graded friction courses apparently also contributed to initial aggregate loss on some other sites.

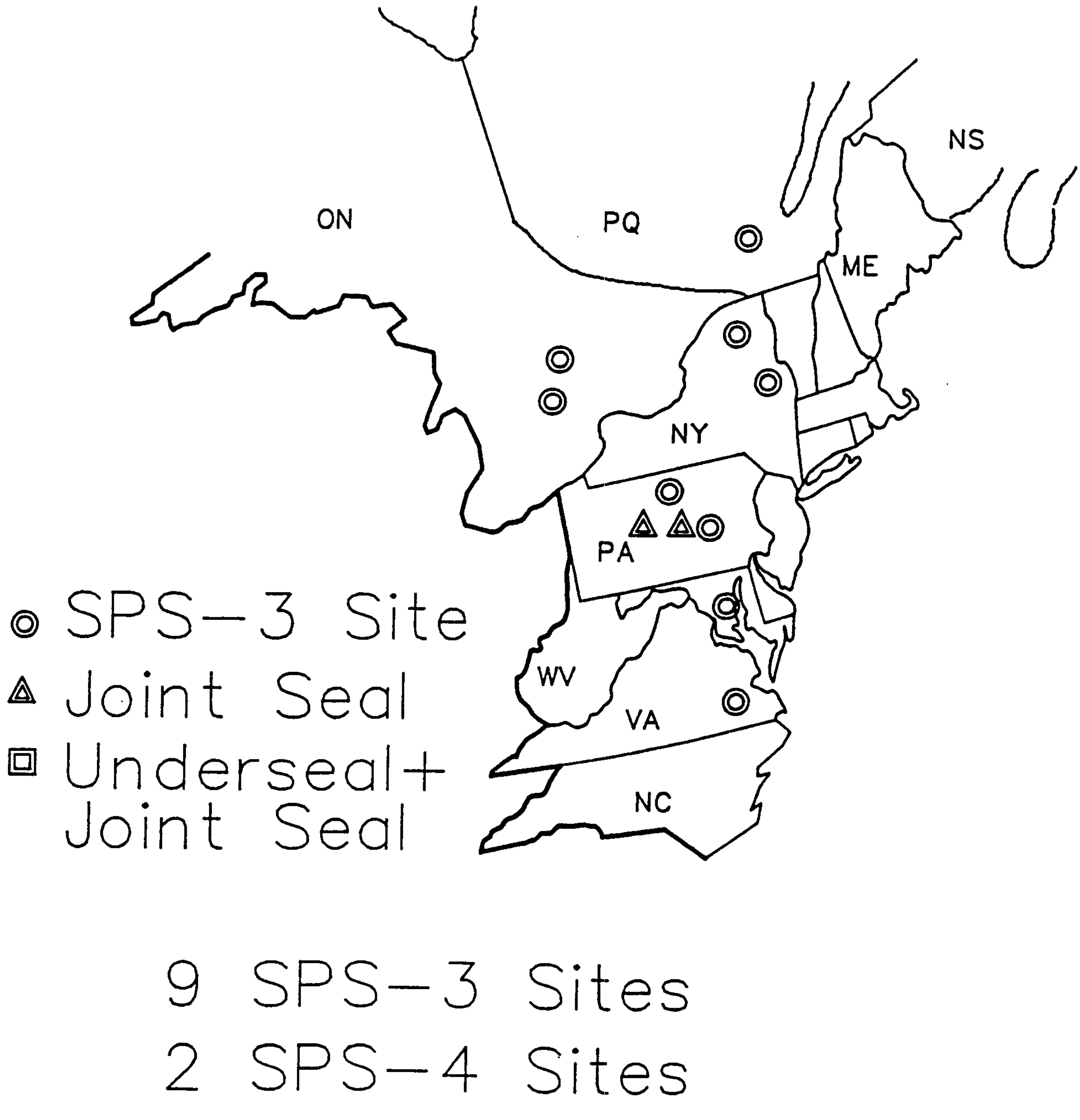

Figure 12. Location of SPS-3 and SPS-4 test sections in the North Atlantic region

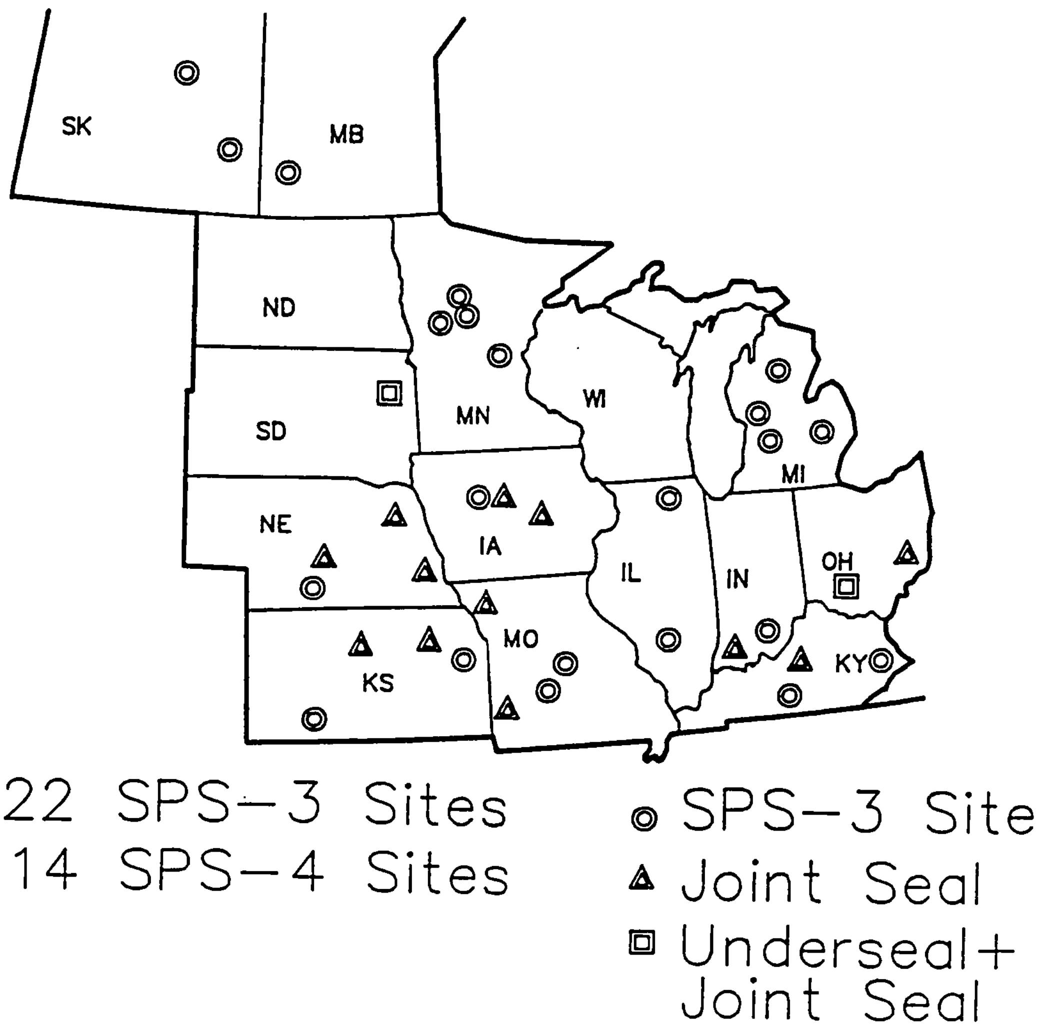

Figure 13. Location of SPS-3 and SPS-4 test sections in the North Central region

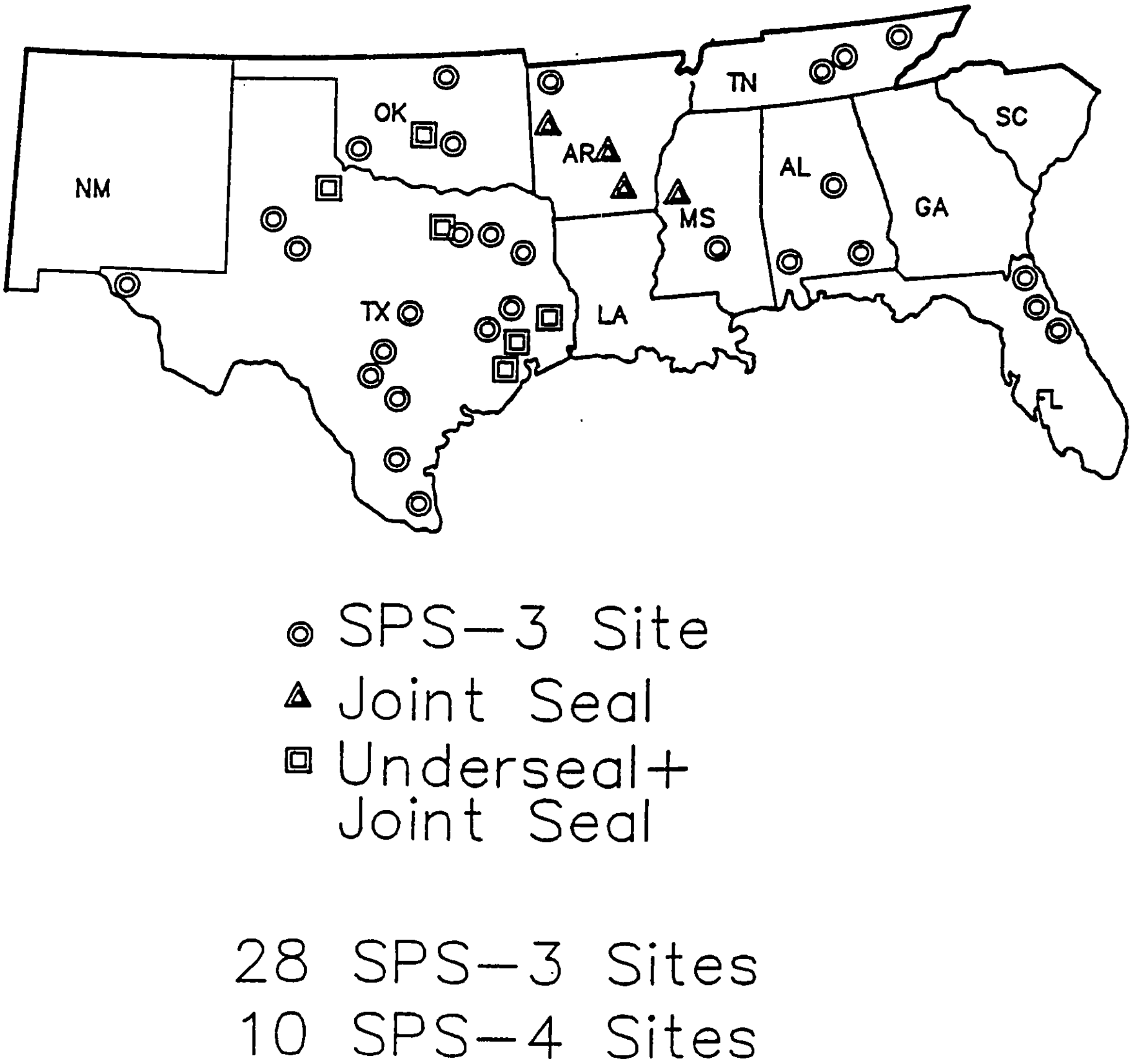

Figure 14. Location of SPS-3 and SPS-4 test sections in the Southern region

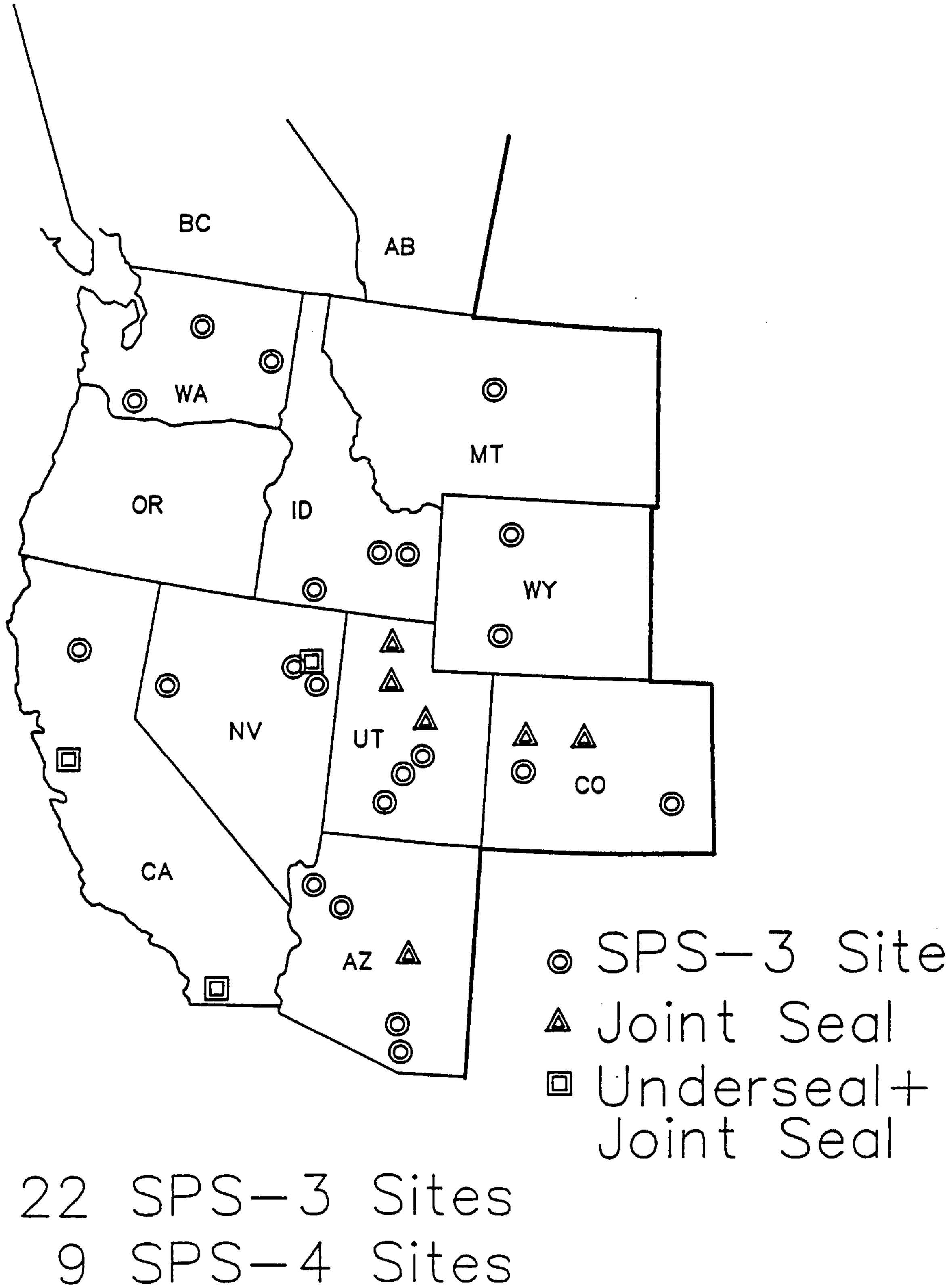

Figure 15. Location of SPS-3 and SPS-4 test sections in the Western region

Table 11. Number of SPS-3 and SPS-4 test sections by SHRP region

Section Status	SHRP Region				Total
	North Atlantic	Southern	North Central	Western	
SPS-3 Sites	9	28	22	22	81
SPS-4 Sites	2	10	14	9	35
Thin Overlays not Placed	0	1	0	0	1
SPS-4 Sites not Constructed	0	0	2	2	4
Chips Seals with Immediate Cover Aggregate Loss	6	3	0	9	18
Other Chip Seal Construction Problems	2	0	0	0	2
Slurry Seal Construction Problems	0	1	1	0	2

In some instances, it was observed that when there was an initial loss of cover aggregate on an SPS-3 test section, an adjacent state-designed chip seal did not lose cover aggregate; however, in several cases, these participating agency-designed chip seals are starting to show a flushed surface. In general, the SPS-3 chip seal used a lower binder rate than the participating agency-designed chip seal in these situations. It appears that on several pavements, if adequate binder is placed to prevent initial aggregate loss, the chip seal will be subject to flushing, probably partly due to embedment of the cover aggregate into the existing pavement caused by subsequent traffic in warmer periods of the year.

In one instance in Texas, there was an initial loss of aggregate when the application conditions were within minimal acceptable conditions according to the specifications, but were marginal. It was cool and rainy for a couple of days before application of the treatment. The afternoon and evening after the treatment were also cool, and the cover aggregate was lost during that period. When the weather improved the following day, no additional aggregate loss occurred. This situation is probably due to low initial embedment of the cover aggregate into the existing surface during construction and in the first few hours after construction. It indicates that the temperature before and after construction needs to be above a certain level as well as during construction. In warmer weather, the surface of the existing pavement is warm enough that some embedment will occur during construction and during the first few hours after construction. That is why reduced traffic speed following construction is helpful in reducing aggregate loss.

At one site in Texas, the slurry seal application truck ran out of emulsion near the end of the treatment, which allowed the aggregate to spread across the surface. The truck was recharged, the aggregate removed, and the slurry replaced in that area. However, a slippage crack developed in this area. It is believed that the dry aggregate left enough fine material on the pavement surface to prevent a good bond from developing between the slurry and the existing pavement at that location.

8

Data Analysis Plan

Introduction

The objectives of the data analysis plan are to specify the types of data to be collected in the field and develop procedures for determining relevant performance parameters. The data analysis strategy is closely related to the experimental design and consists of two stages. First, pavement performance parameters will be estimated within each experimental design cell through regression techniques. Second, variations in the estimated parameters between different levels of the experimental design factors will be investigated. The first stage consists almost exclusively of statistical regression analysis of observed pavement data based on a general pavement damage functional form--a sigmoidal (S-shaped) model. The second stage aims at characterizing each (categorical) cell in the experimental design with a set of quantitative variables (i.e., average annual temperature for "freeze" and "no-freeze" cells, Thornthwaite index for "wet" and "dry" cells, number of 18-kip equivalent single-axle loads [ESALs], etc.) and relating the performance parameter variations to these variables. The resulting relationships will provide a means to predict performance on pavements not directly covered in the original experimental design. The following text describes each of these stages in greater detail.

Performance Assessment

This section addresses model building for pavement performance parameter estimation within each experimental design cell. The discussion begins with desired model properties, follows with the statement and description of the proposed general regression model including its interpretation, and ends with the specific proposed models for each pavement performance measure under consideration.

Model Properties and Modeling Techniques

The analysis model must meet the following requirements:

1. reflect a reasonable assumption about the error distribution in observed performance;

2. provide the means to analyze pavement performance in the presence of such statistical "disturbance" as the application of a maintenance treatment to a test section at a certain time during its life;

3. be able to deal effectively with multiple severity levels on some distresses; and

4. provide for the analysis of distresses that are initiated after the beginning of the pavement life cycle.

The model selected for use in this project provides the appropriate mechanisms to meet all of these requirements.

The S-shaped curve is the basic functional form on which the statistical model is based. In general, each type of pavement deterioration may be expressed as a damage index that takes on values between zero and one, where zero indicates no damage and one indicates maximal damage. The S-shaped curve describes damage as follows:

$$g = e^{-\left(\frac{\rho}{W}\right)^{\beta}} \tag{1}$$

where:

g	=	the damage index
W	=	total 18-kip ESALs, total number of vehicles, or pavement age, depending upon the distress type under consideration
ρ	=	a "scale" parameter
β	=	a "shape" parameter

Observed performance data are expected to follow this relationship on the average. Individual observations will deviate from these expected values randomly, but none will be under zero or over one and their dispersion will approach zero at the extremes, as indicated in figure 16. The random error structure incorporated in the statistical model must not violate this condition. A statistical model with an additive random error can be expressed by

$$g = e^{-\left(\frac{\rho}{W}\right)^{\beta}} + \epsilon \qquad (2)$$

where:

ϵ = a random error term

This model is not acceptable since it is likely to produce negative observations, particularly at the beginning of the pavement life cycle, and observations greater than one, principally near the end of the pavement life. If ϵ in this additive model is forced to behave as illustrated in figure 16, its distribution will be dependent on W, which diminishes the model's power and presents difficulties for statistical treatment. An exponential error structure, on the other hand, will produce performance observations with the desired properties. This error structure is expressed as

$$g = e^{-\left(\frac{\rho}{W}\right)^{\beta} e^{\epsilon}} \qquad (3)$$

where:

ϵ = an independent random error exponent

The "exponential" statistical model lends itself to convenient regression analysis since it can be transformed into a linear model with an additive, independent error term. Taking the natural logarithm on both sides of Equation (3) yields

$$\ln[-\ln(g)] = \beta \ln(\rho) - \beta \ln(W) + \epsilon \qquad (4)$$

This equation can be fit easily to data using common linear regression analysis.

A principal objective of the study is to assess the effectiveness of specific preventive maintenance treatments. These treatments are four flexible pavement maintenance treatments - chip seals, thin overlays, slurry seals, and crack sealing; and two concrete pavement treatments - joint/crack sealing and undersealing. To determine the effect of these maintenance treatments, each has been applied to a section of pavement, and the performance of each will be monitored over time and will be compared to that of a control section to which no maintenance treatment is applied.

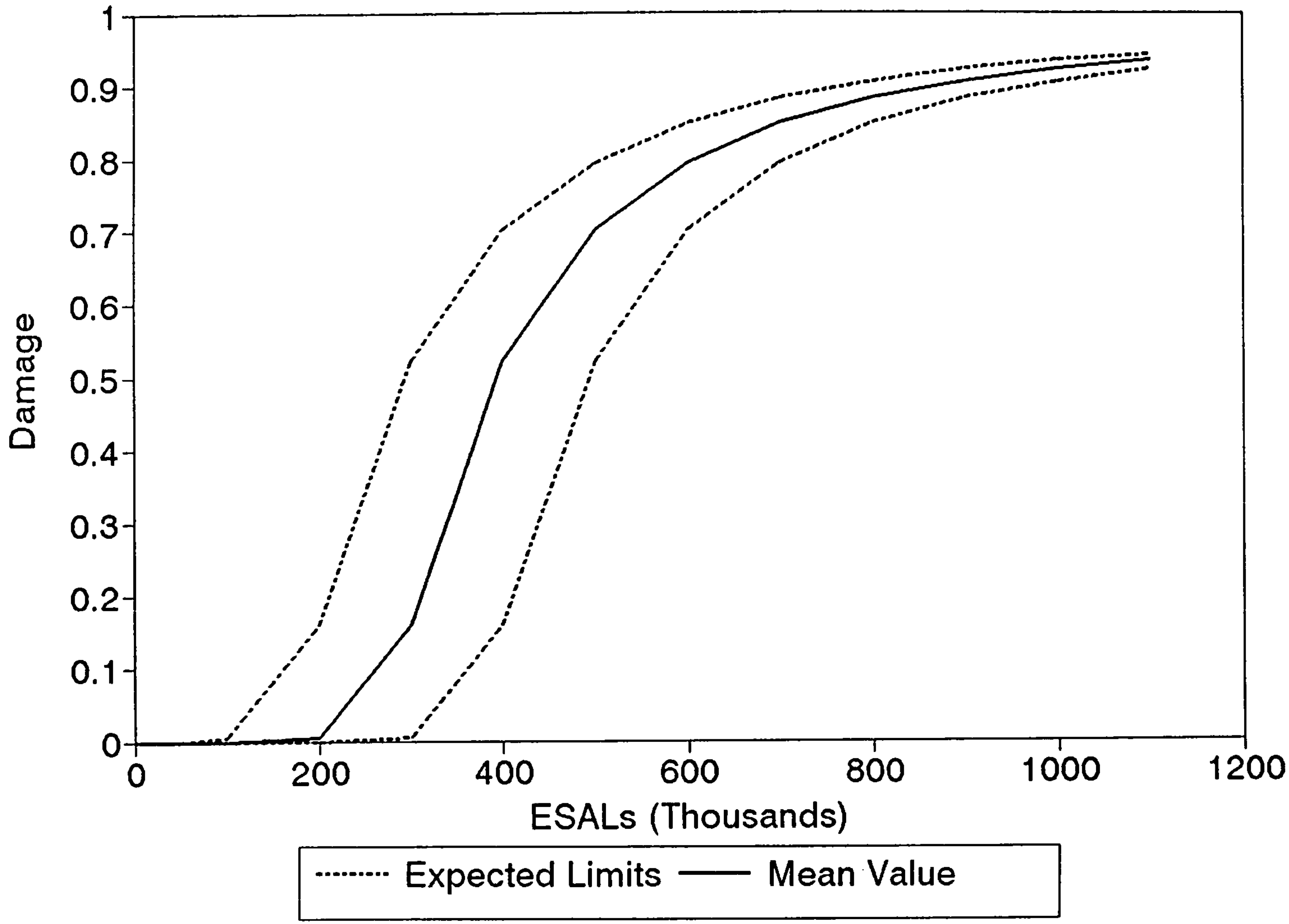

Figure 16. Expected range of performance data

The data records contain monitored data on increase in roughness, loss of skid resistance, increase in extent and severity of cracking, rutting, and others. The corresponding independent variable values for the various deterioration models will be obtained from observation dates that, in conjunction with road inventory and traffic information, may be used to calculate age, accumulated vehicle passes, or accumulated ESALs.

At the beginning of the pavement life cycle, before the application of any maintenance treatment, the basic model of equation (3) applies to all modeled pavements sections as there is no difference among them. When a maintenance treatment is applied, a change in performance parameters will generally occur that affects the deterioration process thereafter. A maintenance treatment can improve the condition of the pavement immediately or can slow down the deterioration process. These conditions can be modeled by introducing parameter factors that come into effect after the application of the maintenance treatment. An immediate condition improvement is represented by

$$g = e^{-\left(\frac{\rho\,\rho_t^{X_t}}{W}\right)^{\beta} e^{\epsilon}} \tag{5}$$

where:

ρ_t	=	a factor that affects the "scale" parameter
X_t	=	an indicator variable that takes on a value of one when the performance observation is made after the maintenance treatment application and a value of zero when it is made before the application

Before the maintenance treatment is applied, the scale parameter is ρ; after the treatment, it is $\rho \cdot \rho_t$.

A change in deterioration rate is expressed by

$$g = e^{-\left[\frac{\rho}{W\left(\frac{W}{W_t}\right)^{\beta_t X_t}}\right]^{\beta} e^{\epsilon}} \tag{6}$$

where:

W_t = the known value of the independent variable (age, ESALs, or number of vehicle passes) at which the treatment is applied

β_t = a factor that modifies the shape parameter after the maintenance treatment application

Before the maintenance treatment, equation (5) reduces to equation (3); after the treatment, the shape parameter is $\beta(1+\beta_t)$ and the scale parameter is $\rho\ W_t^{\beta_t}$.

Another important feature that the model must include is the ability to model different distress levels, such as for cracking, raveling, and rutting. In an initial attempt, the amount of pavement with no damage and with low, medium, and high severity distress was modeled directly under the restriction that the sum of these extensions equals 100 percent. This proved extremely difficult, not only for the assumptions that had to be made but also for the enormous computational complexity involved in estimating each distribution. The problem was simplified, however, when it was approached from another angle. The percent distribution of distress severity on a pavement section throughout its service life may be graphically represented as in figure 17. For a given value of W, the g_H ordinate is interpreted as the percent area exhibiting high-severity distress, the g_M ordinate as the percent area exhibiting medium- and high-severity distress, and the g_L ordinate as the percent area with low-, medium-, and high-severity distresses. If g_H, g_M, and g_L are known, the pavement area free of distress is calculated as $1-g_L$, the low-severity area is the difference between g_L and g_M, the medium-severity area is the difference between g_M and g_H, and the high-severity area is given by g_H.

Curves g_H, g_M, and g_L can be simultaneously fitted to an S-shaped model by using factors and indicator variables as:

$$g = e^{-\left(\frac{\rho\ \rho_M^{X_M}\ \rho_L^{X_L}}{W}\right)^{\beta}} e^{\epsilon} \tag{7}$$

where:

X_M, X_L = indicator variables

When the observation corresponds to the high severity (curve g_H), both X_M and X_L are equal to zero; when it corresponds to the medium or higher severity (curve g_M), then $X_M=1$ and $X_L=0$; and when it corresponds to the low or higher severity (curve g_L),

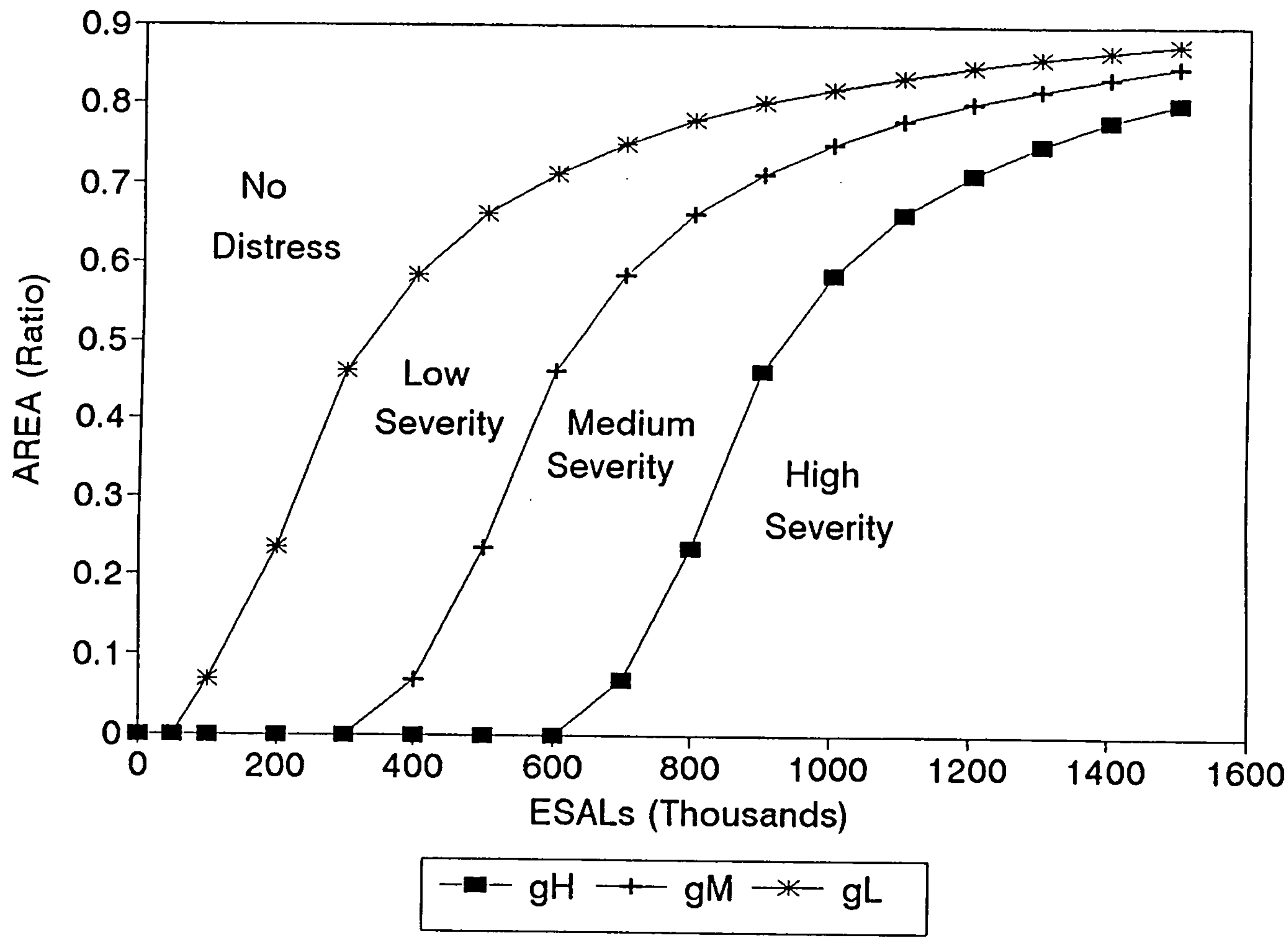

Figure 17. Percent distribution of distress severity

$X_M = 0$ and $X_L = 1$. Thus, the scale parameter is ρ for g_H, $\rho \cdot \rho_M$ for g_M, and $\rho \cdot \rho_L$ for g_L. The shape parameter β does not change at different severity levels because $g_H \leq g_M \leq g_L$ over the domain. A change in β could violate this condition.

The variations of the basic model introduced so far may be transformed into linear models by taking natural logarithms twice on both sides of the corresponding equations. This capability provides a means to explore the significance of each factor affecting pavement performance.

For some distress types, particularly cracking, the deterioration process of the visible distress does not start right at the beginning of the pavement cycle, but some time afterward. The time (or ESALs) until distress initiation may be estimated with yet another variation of the basic S-shaped model. Let initiation time be denoted by W_0; the statistical damage model becomes

$$g = e^{-\left(\frac{\rho}{W - W_0}\right)^{\beta} e^{\epsilon}} \tag{8}$$

This model shows that the basic model of equation (3) applies only after the deterioration process is initiated. In the basic model, the initiation time is assumed to be zero. A double log transformation on this model yields

$$\ln[-\ln(g)] = \beta \ln(\rho) - \beta \ln(W - W_0) + \epsilon \tag{9}$$

a nonlinear model, since W_0 is a parameter to be estimated. The model, Equation (8), may nevertheless be solved through nonlinear regression or by successive approximations using a combination of optimal search methods and linear regression techniques.

The Proposed General Model

The variations of the basic model described in the previous section may be combined into a comprehensive statistical model that allows the concurrent analysis of distress initiation, distress propagation for different severity levels, and the effects of each of the maintenance treatments on distress propagation for a given distress type. The chief advantage of the comprehensive model is the efficient utilization of observed data, since all the data collected on a project site--on all sections--about a particular distress type can be used to estimate all parameters of interest about that distress type simultaneously. For example, this model provides for the fit of the no-treatment case using all the observations on the control sections and the observations on the treatment sections **before** the treatment is applied.

The general model is expressed as:

$$g = e^{-\left[\frac{\rho\,\rho_M^{X_M}\,\rho_L^{X_L}}{W-W_0}\prod_{i=1}^{N}\left(\frac{\rho_i^{X_i}}{\frac{(W-W_0)^{\beta_i X_i}}{W_t-W_0}}\right)\right]^{\beta} e^{\epsilon}} \tag{10}$$

when $W > W_0$ and $g = 0$ otherwise, where:

g	=	a damage index with value between zero and one
ρ	=	the basic S-shaped model's "scale" parameter
β	=	the basic S-shaped model's "shape" parameter
W	=	the number of ESALs, age, or vehicle passes, depending on the performance measure under analysis
W_0	=	the number of ESALs, age, or vehicle passes at which the deterioration process starts ($W_0 = 0$ in the basic model)
W_t	=	the number of ESALs, age, or vehicle passes at which a maintenance treatment is applied
ρ_M, ρ_L	=	scale parameter factors that adjust the model for the distress severity level under consideration
X_M, X_L	=	indicator zero-one variables that jointly specify the distress severity level under consideration
ρ_i	=	a scale parameter factor that adjusts the model for the "immediate condition improvement" effect of maintenance treatment i
β_i	=	a shape parameter factor that adjusts the model for the "deterioration rate reduction" effect of maintenance treatment i
X_i	=	an indicator zero-one variable that signals whether maintenance treatment i has been applied

Not all factors included in the general model must be used when analyzing a particular distress type. In certain cases, experience dictates which factors are relevant. The proposed model provides sufficient modeling flexibility by allowing the analyst to select only the relevant factors. For example, it is expected that the application of a slurry seal will slow the development of roughness, but will not significantly reduce it. At the same time, analysis of different severity levels can be not relevant to roughness. In this case, ρ_M, ρ_L, and the ρ_i associated with slurry seal will be left out and the model will fit with the rest of the factors. When analysts are not sure whether a factor is relevant, they may run the analysis with the factor and statistically test its significance later.

Two considerations must be kept in mind as this general model is used: (1) it describes the development of pavement damage, a measure that, undisturbed, is expected to be monotonically nondecreasing; and (2) the pavement damage measure must be scaled to an index that fluctuates in value between zero and one. Thus, it will not directly model serviceability and skid resistance, for instance, but it will model loss of serviceability and loss of skid resistance. This situation does not pose any significant difficulty, since observed data on the distress types of interest in this study can be easily transformed into the index required for analysis without loss of information, and the results may be "back-transformed" into the measures and scales commonly used in the field.

Estimation of PSI Parameters When Final (Asymptotic) PSI is Unknown

The model presented above is able to analyze serviceability (present serviceability index or PSI) when its final value is assumed asymptotic to zero. In cases where this assumption is not valid, the method discussed in the following section will be used.

Deterioration in Terms of PSI

When the pavement performance function predicts deterioration in terms of PSI, the critical level of performance can also be expressed as the ratio of the loss in serviceability after W 18-kip ESALs to a specified maximum design loss, namely

$$g = \frac{P_0 - P_t}{P_0 - P_f} \tag{11}$$

where:

P_0 = initial PSI of the pavement (at W = 0)

P_t = PSI after W 18-kip ESALs

P_f = lower bound on the PSI

From equation (11) it is possible to express P_t as a function of g(w) as

$$P_t = P_0 - (P_0 - P_f)\ g \tag{12}$$

or:

$$P_t = P_0 - (P_0 - P_f)\ e^{-\left(\frac{\rho}{W}\right)^{\beta}} \tag{13}$$

Procedure for Determining Performance Parameters

For deterioration in terms of PSI, the performance function, equation (13) can be expressed as

$$P_0 - P_t = \alpha\ e^{-\left(\frac{\rho}{W}\right)^{\beta}} \tag{14}$$

where:

$\alpha = P_0 - P_f$

Taking the natural logarithm of equation (14) yields

$$\ln(P_0 - P_t) = \ln\alpha - \left(\frac{\rho}{W}\right)^{\beta} \tag{15}$$

or:

$$\ln(P_0 - P_t) = \ln\alpha - \rho^{\beta}\left(\frac{1}{W}\right)^{\beta} \tag{16}$$

Using the transformation $e^{\zeta} = 1/W$, equation (16) becomes

$$\ln(P_0 - P_t) = \ln\alpha - \rho^{\beta} \left(e^{\beta}\right)^{\tau} \tag{17}$$

which is equivalent to

$$z = a - bc^{\tau} \tag{18}$$

where:

$z = \ln(P_o - P_t)$

$a = \ln(\alpha)$

$b = \rho^{\beta}$

$c = e^{\beta}$

Parameters a, b, and c in equation (18) can be estimated by the least squares method. The corresponding statistical model is defined as

$$z_i = a - bc^{\tau} + \epsilon_i \tag{19}$$

where ϵ_i is the random error corresponding to the value of z_i associated with τ_i.

The normal equations for the statistical model formulated in equation (19) are shown below

$$\sum_{i=1}^{m} \left(z_i - a + bc^{\tau_i}\right) = 0 \tag{20}$$

$$\sum_{i=1}^{m} \left(z_i - a + bc^{\tau_i}\right) c^{\tau_i} = 0 \tag{21}$$

$$\sum_{i=1}^{m} \left(z_i - a + bc^{\tau_i}\right) \tau_i c^{(\tau_i - 1)} = 0 \tag{22}$$

It is noted that equations (20) and (21) are linear in a and b; therefore, both parameters can be obtained in terms of z_i, τ_i, and c. The corresponding results are

$$a = \frac{\left[\sum_{i=1}^{m} c^{2\tau_i}\right]\left[\sum_{i=1}^{m} z_i\right] - \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} z_i c^{\tau_i}\right]}{m\left[\sum_{i=1}^{m} c^{2\tau_i}\right] - \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} c^{\tau_i}\right]} \tag{23}$$

$$b = \frac{-m\left[\sum_{i=1}^{m} z_i c^{\tau_i}\right] + \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} z_i\right]}{m\left[\sum_{i=1}^{m} c^{2\tau_i}\right] - \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} c^{\tau_i}\right]} \tag{24}$$

The values of a and b given by equations (23) and (24) can be substituted into equation (22) to obtain the following final result:

$$\sum_{i=1}^{m} z_i \tau_i c^{\tau_i} = \frac{\left[\sum_{i=1}^{m} c^{2\tau_i}\right]\left[\sum_{i=1}^{m} z_i\right] - \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} z_i c^{\tau_i}\right]}{m\left[\sum_{i=1}^{m} c^{2\tau_i}\right] - \left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} c^{\tau_i}\right]} \left[\sum_{i=1}^{m} \tau_i c^{\tau_i}\right] \tag{25}$$

$$+\frac{-m\left[\sum_{i=1}^{m} z_i c^{\tau_i}\right]+\left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} z_i\right]}{m\left[\sum_{i=1}^{m} c^{2\tau_i}\right]-\left[\sum_{i=1}^{m} c^{\tau_i}\right]\left[\sum_{i=1}^{m} c^{\tau_i}\right]}\left[\sum_{i=1}^{m} \tau_i c^{2\tau_i}\right] = 0$$

Equation (25) can be solved for c using a numerical method.

Assuming a collection of m data points (P_i, w_i) where P_i is the serviceability index corresponding to a traffic load level W_i, and i = 1, 2,..., m, the data for solving the regression model can be computed as

(a) $z_i = \ln(P_o - P_t)$ for i = 1, 2,..., m (P_o is known)
(b) $\zeta_i = \ln(1/W_i)$ for i = 1, 2,..., m

With these data and the model of equation (18), it is possible to estimate the values of a, b, and c, which subsequently can be used to estimate α (and thus P_f), ρ, and β from equations (12), (13), and (14).

Performance Prediction

If the first stage of a data analysis plan is to determine by regression analysis the constants ρ and β that fit the observed trends on each site, the second stage is to find, by further regression analysis, the principal reasons why these ρ and β values differ from site to site and from section to section within each site. The major distinction will be between those control pavement sections that have not been maintained and the test sections that have. Having a good model of the performance of the pavement sections that have not been maintained provides a datum, a bench mark, against which to compare the performance of all other pavement sections. Differences between performance of bench mark sections will be due to differences in the structural design, materials in the layers, subgrade soils, climatic variables, and level of traffic that characteristics of each site. Without the bench mark, it would be impossible to determine the effectiveness of the maintenance treatments that are applied. The next major distinction is between performance of the sections with the different types of maintenance treatment and the control section. The individual treatments will be applied to pavements in different conditions, and the treatments themselves will differ in the quality of their application. The analysis of the data must be able to distinguish among the effects of these treatments, the condition of the pavement on which they were applied, and their quality on the subsequent performance of pavements.

Because the basic tool for analyzing maintenance effectiveness is regression analysis, numerical scales for each of the distinguishing factors noted above need to be developed and used consistently in evaluating all pavement sections.

The discussion presented below is divided into two parts: the first is concerned with the factors that will be used to predict the performance of unmaintained pavements, and the second considers means of constructing numerical scales for the maintenance type, quality, extent, and pavement condition when the treatment was applied.

Prediction of the Performance of Unmaintained Pavement

With each control section, there will be one β value and three ρ values for each type of pavement distress. The three ρ values are for the percentage of the surface area of the pavement covered by high severity, ρ_H; the sum of high- and medium-severity areas, ρ_M; and the sum of the high-, medium-, and low-severity areas, ρ_L. Regression equations must be developed for each of the four values and for each type of distress that is observed. The independent variables that will be used to explain the differences in the ρ and β values will be taken from the SHRP LTPP data base of inventory data, which includes numerous measured values. The measured properties of each pavement that will be used as independent variables will come from the following five categories:

1. **Design (D)** - includes layer thicknesses, shoulder width, and other geometric features of the pavement cross section.

2. **Materials (M)** - includes the resilient modulus, gradation, water content, asphalt content, and other such variables in each layer.

3. **Subgrade Soils (S)** - includes the resilient modulus, Atterberg limits, water content, estimates of the permeability, gradation, and other such variables in the subgrade.

4. **Climatic Variables (C)** - includes the annual rainfall, freeze-thaw cycles, freeze index, Thornthwaite index, solar radiation, and other numerical indicators of the local climate, all of which will be available in the SHRP LTPP data base.

5. **Traffic Rate (T)** - includes the number of vehicles per day, the number of trucks per day, the annual number of 18-kip equivalent single-axle loads, and other indicators of the level of traffic on the section.

The regression equations that are developed will be of the form

$$\rho_j = \rho_j(D,M,S,C,T),\ j = H,M,L \tag{26}$$

$$\beta - \beta(D,M,S,C,T) \quad (27)$$

where the letter subscripts (H, M, L) stand for high-, medium-, and low-severity levels of distress. The form and the coefficients of these equations will be found by either linear or nonlinear regression, whichever appears to fit the data better. It is to these values of ρ_j and β that corrections will be applied to represent the effect of maintenance.

Prediction of Maintenance Performance

Correction terms ρ_i and β_i will be used to predict the effects of the different types and quality of maintenance and of the pavement condition and traffic level when the maintenance is applied. Each treatment type will be considered separately. The purpose of the study is to determine the cost-effectiveness of each treatment. This determination will be accomplished by comparing the effect of each treatment on performance to the performance of the untreated control section. A method to numerically rate the quality of the maintenance treatment application was presented in another report.

Pavement condition can be measured in a number of ways, including an overall pavement condition index, and measures of the area and severity covered by the individual types of distress. The area and severity of each type of distress will be measured as specified in the "Distress Identification Manual for the Long-term Pavement Performance Studies" (SHRP 1993). This same area and severity of distress are predicted with the ρ_i and β values that are developed from data on the unmaintained pavement sections.

By using the multiplicative correction terms, ρ_i and β_i, it is possible to describe mathematically all of the expected types of changes in performance that will be affected by applying maintenance treatments. The regression equations that will be developed are of the form

$$\rho_i - \rho_i\ (Q,MD,PC,TL) \quad (28)$$

$$\beta_i - \beta_i\ (Q,MD,PC,TL) \quad (29)$$

where:

the index i	stands for the i^{th} type of maintenance treatment
Q	stands for the measures of end product and process quality

MD stands for the maintenance density

PC stands for the condition of the pavement at the time that maintenance is applied

TL stands for the traffic level when the maintenance is applied

The regression equation will be developed by either linear or nonlinear regression, whichever fits the data better.

Example Analysis

This section illustrates the use of the proposed regression model for pavement performance parameter estimation, including the different cases of maintenance treatment effects that are expected to be observed in this study. These cases are as follows:

1. a basic model describing the development of a distress type from the beginning of the life cycle in an unmaintained control section;
2. a model describing the initiation of a distress type some time after the beginning of the life cycle;
3. an improvement in pavement condition as a result of the application of a maintenance treatment without change in rate of distress development;
4. a change (most likely a decline) in the rate of distress development derived from the maintenance treatment application without improvement in pavement condition;
5. an improvement in both pavement condition and rate of distress development resulting from the maintenance treatment; and
6. a model for analyzing the progress of different levels of severity for a distress type.

The following equation shows the basic model form and hypothetical data used for estimating performance parameters ρ and β

$$g = e^{-\left(\frac{\rho}{W}\right)^{\beta}} \tag{30}$$

The number of equivalent single axle loads (ESALs) is denoted by W and the observed damage by g throughout this discussion. The transformed basic model is

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln W, \tag{31}$$

which is fitted as a linear regression model of the form $y = b_0 + bX$ using the transformed variables $y = \ln(-\ln g)$ and $X = \ln W$. The transformed parameters b_0 and b are related to the original parameters ρ and β as follows

$$b_0 = \beta \ln \rho$$
$$b = -\beta$$

Table 12 shows sample data points and the estimated parameters resulting from this procedure used with those data points. Figure 18 graphically portrays the fitted model and the corresponding observation points.

A model that better describes the propagation of distress such as cracking, where deterioration starts some time after the beginning of the life cycle, is the Delayed Initiation Model which is presented as

$$g = e^{-\left(\frac{\rho}{W-W_0}\right)^{\beta}} \tag{32}$$

The associated transformed model is expressed as

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln (W - W_0) \tag{33}$$

where ρ, β, and W_0 are the performance parameters to be estimated. The presence of W_0, the number of load application at which the distress starts developing, prevents this model from being linear; therefore, it is fitted as a nonlinear model of the form

$$y = b_0 - b \ln (W - W_0) \tag{34}$$

using the transformed variable $y = \ln(-\ln g)$. Parameters ρ and β are obtained from the resulting b_0 and b by solving the following equations

Table 12. Sample data and resulting parameters

Example Data	
ESALs (x 1000)	Observed Damage
20	0.005
40	0.693
60	0.852
75	0.901
80	0.952
Estimated Parameters	
ρ	32.548
ß	3.122

$$b_0 = \beta \ln \rho$$
$$b = \beta.$$

The illustration data and corresponding parameter estimates are also presented in table 13. Figure 19 shows the graphic representation of the statistical fit. The application of a maintenance treatment may reduce a given distress on a pavement without significantly affecting the rate at which such distress develops. This condition is analyzed and evaluated by the Immediate Improvement Model which is stated as

$$g = e^{-\left(\frac{\rho\ \rho_i^{X_i}}{W}\right)^{\beta}} \tag{35}$$

This model introduces a new variable, X_i, that indicates whether maintenance treatment i has been applied. The value of X_i is zero when the observation is made before the application of the maintenance treatment and one when it is made after the application of the treatment. The model also introduces a new parameter, ρ_i, a multiplier that affects the *scale* parameter after treatment application. These additions cause a "jump" in the function at the time the maintenance treatment is applied. The corresponding transformed model is written as

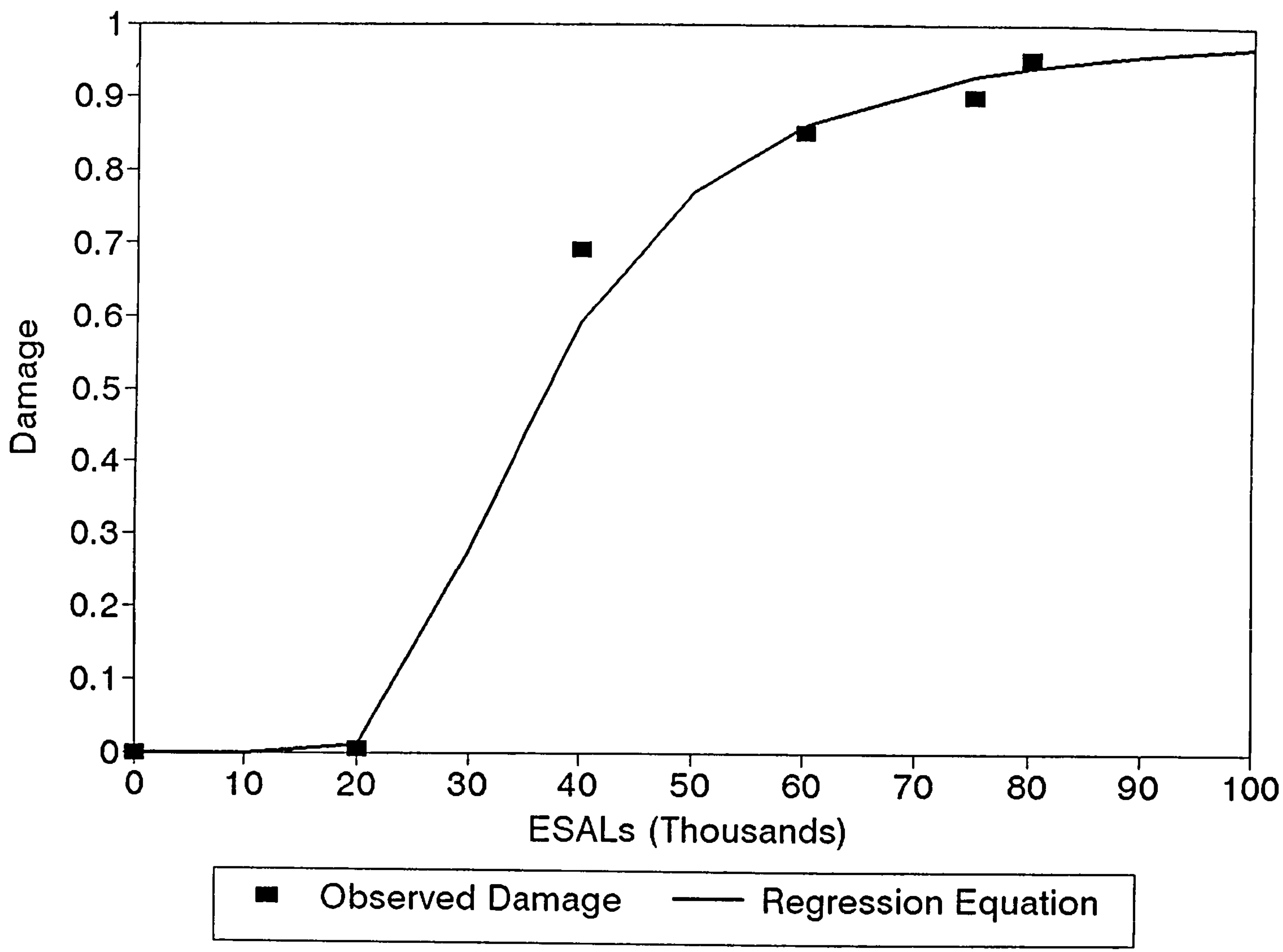

Figure 18. Example analysis using the basic model and normal performance data

Table 13. **Sample data and resulting parameters using the delayed initiation model**

Example Data	
ESALs (x1000)	Observed Damage
30	0.000
40	0.007
60	0.528
75	0.767
80	0.678
Estimated Parameters	
ρ	38.410
W_0	17.643
ß	2.654

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln W + \beta (\ln \rho_i) X_i \qquad (36)$$

This model is linear of the form

$$y = b_0 + bX + b_i X_i \qquad (37)$$

where y = ln(-ln g) and X = lnW. Regression parameters b_0, b, and b_i are related to performance parameters ρ, ρ_i, and β according to the equations

$$b_0 = \beta \ln \rho$$
$$b = -\beta$$
$$b_i = \beta \, ln \, \rho_i$$

Test data to illustrate this model and resulting parameter estimates are given in table 14. In figure 20, the solid line represents the fitted Immediate Improvement Model; the dotted line represents the estimated basic model had the maintenance treatment not been applied.

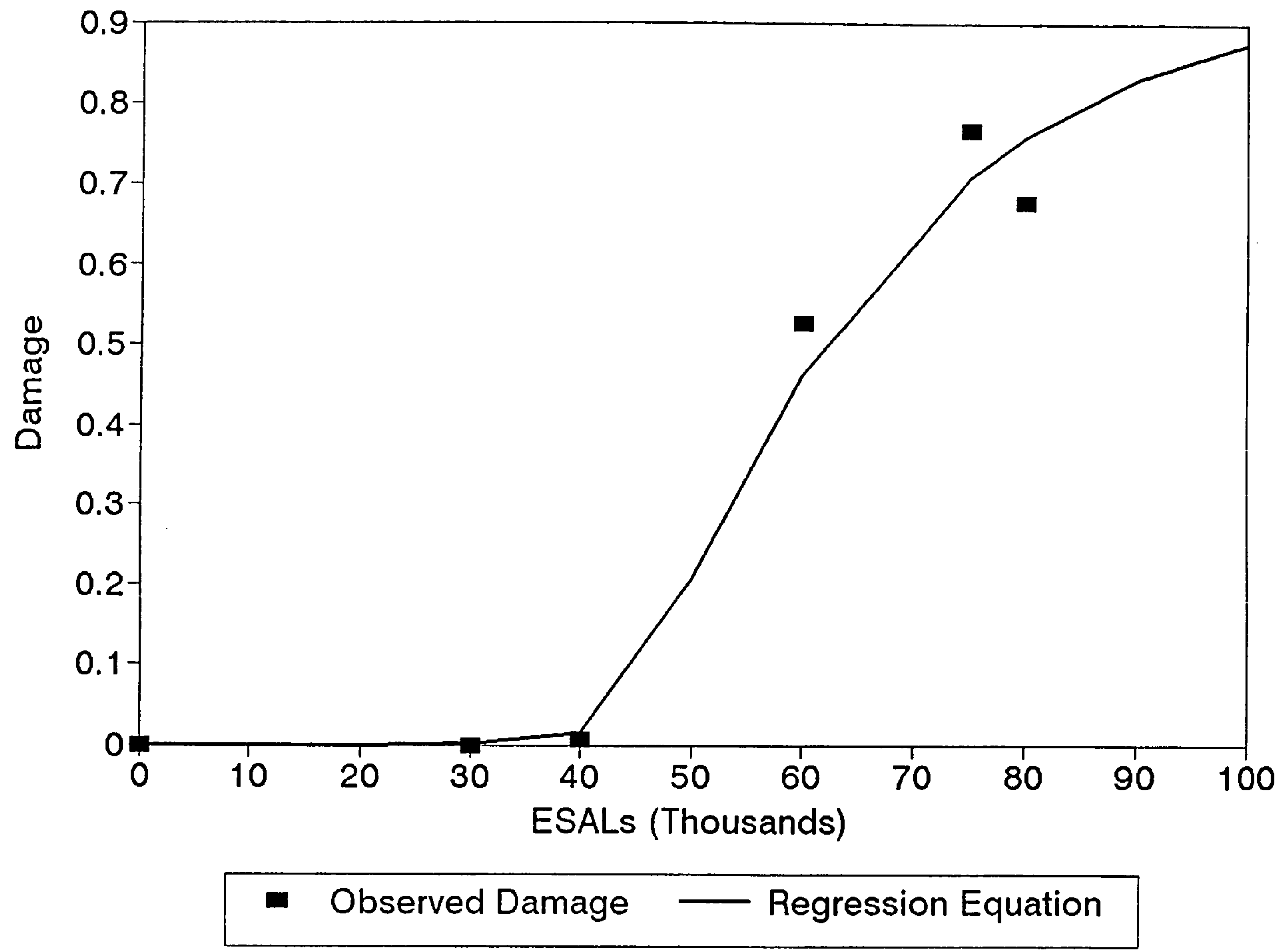

Figure 19. Example analysis using the delayed initiation model and performance data with delayed initiation of damage

Table 14. Sample data and resulting parameters using the immediate improvement model

Example Data	
ESALs (x1000)	Observed Damage
10	0.000
24	0.028
26	0.000
40	0.005
55	0.021
70	0.349
Estimated Parameters	
ρ	38.827
β	2.649
ρ_i	2.023

Maintenance treatments such as crack sealing do not significantly reduce the distress on a pavement but are expected to slow its development. The Deterioration Rate Variation Model, shown as

$$g = e^{-\left[\frac{\rho}{W\left(\frac{W}{W_t}\right)^{\beta_t X_t}}\right]^{\beta}}, \tag{38}$$

provides a means of analyzing this condition. As in the previous case, the variable X_i indicates whether the maintenance treatment has been applied (X_i = 0 before the treatment and X_i = 1 after the treatment). The parameter β_i modifies the *shape* parameter after treatment application. These modifications cause a "break" in the performance function at the time of the treatment application, which is denoted by W_t and is a known constant. The transformed Deterioration Rate Variation Model is

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln W + \beta\, \beta_i (\ln W_t - \ln W) X_i, \tag{39}$$

which is linear of the form:

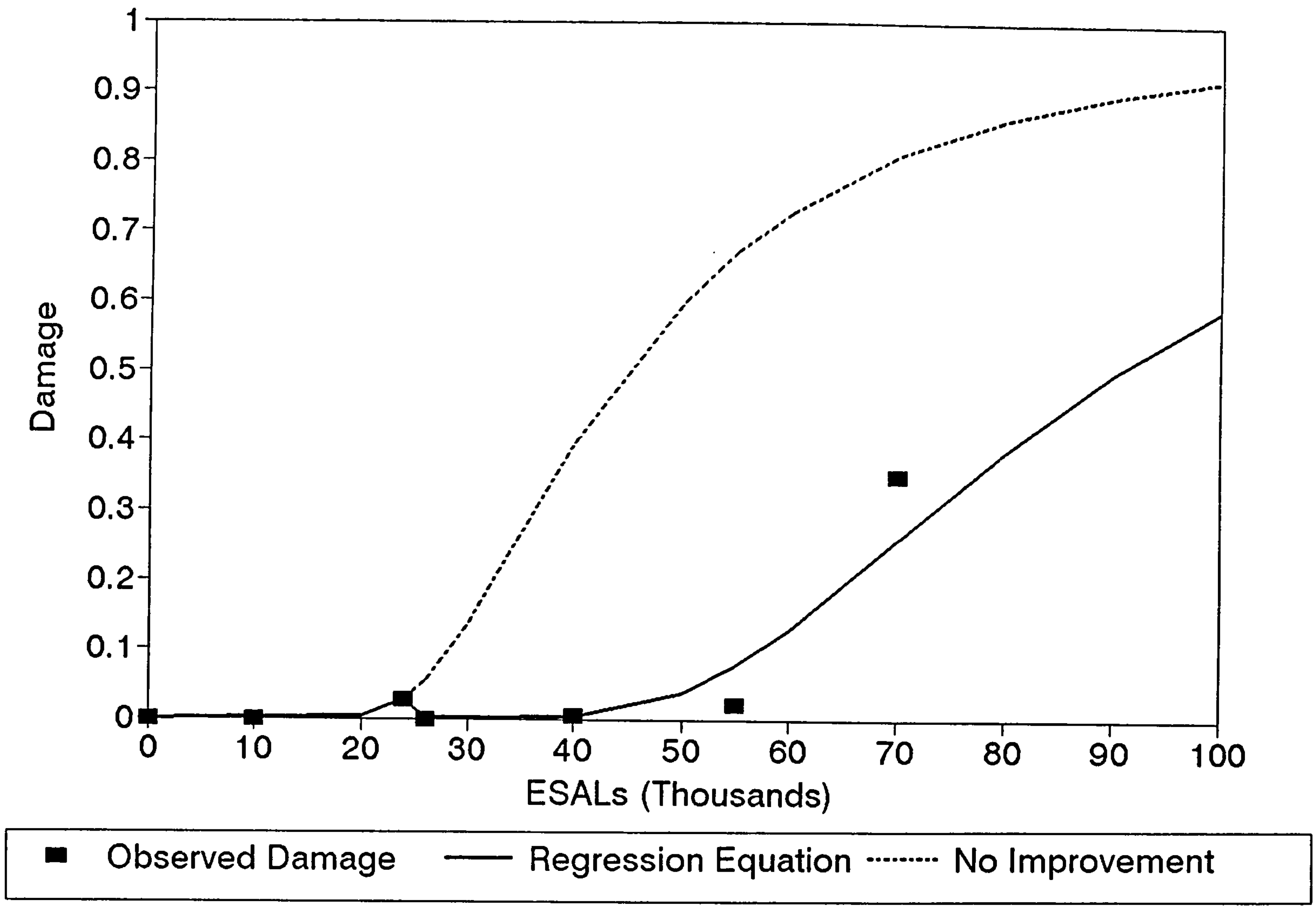

Figure 20. Example analysis using the immediate improvement model and sample data with maintenance applied at 25,000 ESALs

$$y = b_0 + bX + b_i' X_i' \tag{40}$$

A least-squares fit can be performed through linear regression using the transformed variables $y = \ln(-\ln g)$, $X = \ln W$, and $X'_i = (\ln W_t - \ln W)X_i$. Regression parameters b_0, b, and b'_i, and performance parameters, ρ, β, and β_i are related by

$$\begin{aligned} b_0 &= \beta \ln \rho \\ b &= -\beta \\ b_i' &= \beta \beta_i \end{aligned}$$

Example data for this model and resulting parameter estimates are given in table 15. Figure 21 graphically represents the fitted model. The solid line corresponds to the Deterioration Rate Variation Model and the dotted line the corresponding basic model if no treatment is applied.

A combination of the two previous cases is analyzed with the model

$$g = e^{-\left[\frac{\rho \rho_i^{x_i}}{W\left(\frac{W}{W_t}\right)^{\beta_i X_i}}\right]^{\beta}}, \tag{41}$$

which simultaneously incorporates the modifications of the Immediate Improvement Model and the Deterioration Rate Variation Model. The corresponding transformed model is expressed as

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln W + \beta(\ln \rho_i)X_i + \beta \beta_i(\ln W_t - \ln W)X_i \tag{42}$$

which is linear of the form

$$y = b_0 + bX + b_i X_i + b_i' X_i', \tag{43}$$

Table 15. Sample data and resulting parameters using the deterioration rate variation model

Example Data	
ESALs (x1000)	Observed Damage
20	0.004
24	0.028
26	0.090
40	0.264
55	0.207
70	0.540
Estimated Parameters	
ρ	34.869
ß	3.111
$ß_i$	-0.599

and can be fitted as such using the transformed variables y = ln(-ln g), X = lnW, and X'_i = $(\ln W_t - \ln W)X_i$. The relationship between regression and performance parameters is established by the parametric equations

$$\begin{aligned} b_0 &= \beta \ln \rho \\ b &= -\beta \\ b_i &= \beta \ln \rho_i \\ b_i' &= \beta \beta_i \end{aligned}$$

When using this model, the analyst must ensure that there is adequate data observations for a reasonable fit. At a minimum, five usable data points are needed to provide enough degrees of freedom for a statistical fit. The data used for this illustration and the estimated parameters are presented in table 16. Figure 22 shows the fitted model graphically (solid line). In this example, the maintenance treatment was applied at W_t = 25,000. As in the two preceding cases, the dotted line corresponds to the basic model assuming no maintenance treatment is applied to the pavement section.

The development of various severity levels of a distress is analyzed by means of the model presented in the equation

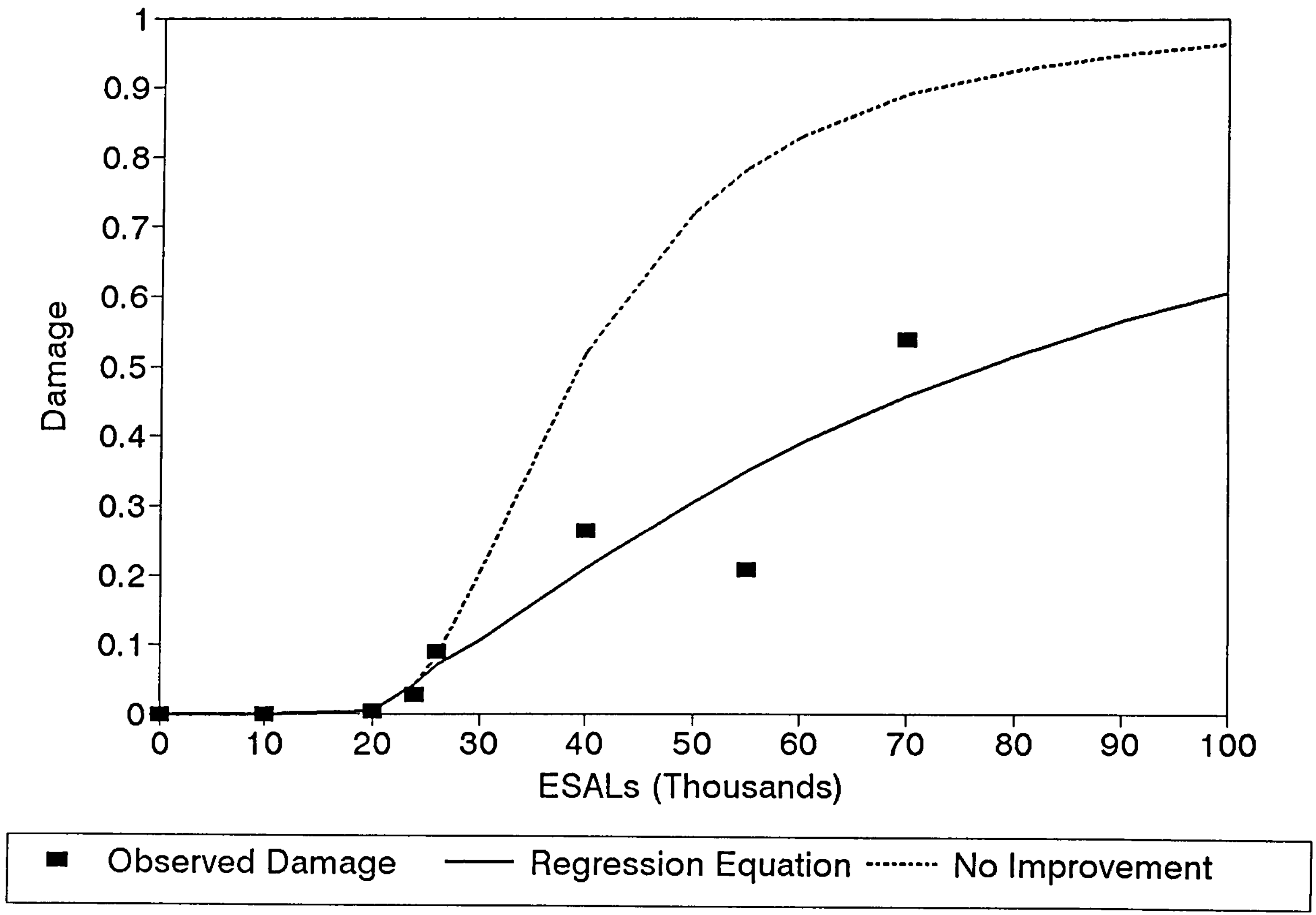

Figure 21. Example analysis using the deterioration rate variation model and data with maintenance applied at 25,000 ESALs

Table 16. Sample data and resulting parameters using the combination model

Example Data	
ESALs (x1000)	Observed Damage
15	0.000
24	0.155
26	0.000
40	0.001
55	0.150
70	0.092
Estimated Parameters	
ρ	28.7
β	3.485
ρ_i	1.891
β_i	-0.412

$$g = e^{-\left(\frac{\rho\,\rho_M^{X_M}\,\rho_L^{X_L}}{W}\right)^{\beta}} \tag{44}$$

The combined values of indicator variables X_L and X_M designate the critical distress level under consideration: $X_L = 0$ and $X_M = 0$ refer to high severity, $X_L = 0$ and $X_M = 1$ define medium severity, and $X_L = 1$ and $X_M = 0$ indicate low severity. Parameters ρ_L and ρ_M are multipliers of the basic scale parameter ρ. The associated transformed model is

$$\ln(-\ln g) = \beta \ln \rho - \beta \ln W + \beta(\ln \rho_L)X_L + \beta(\ln \rho_M)X_M \tag{45}$$

which is linear of the form

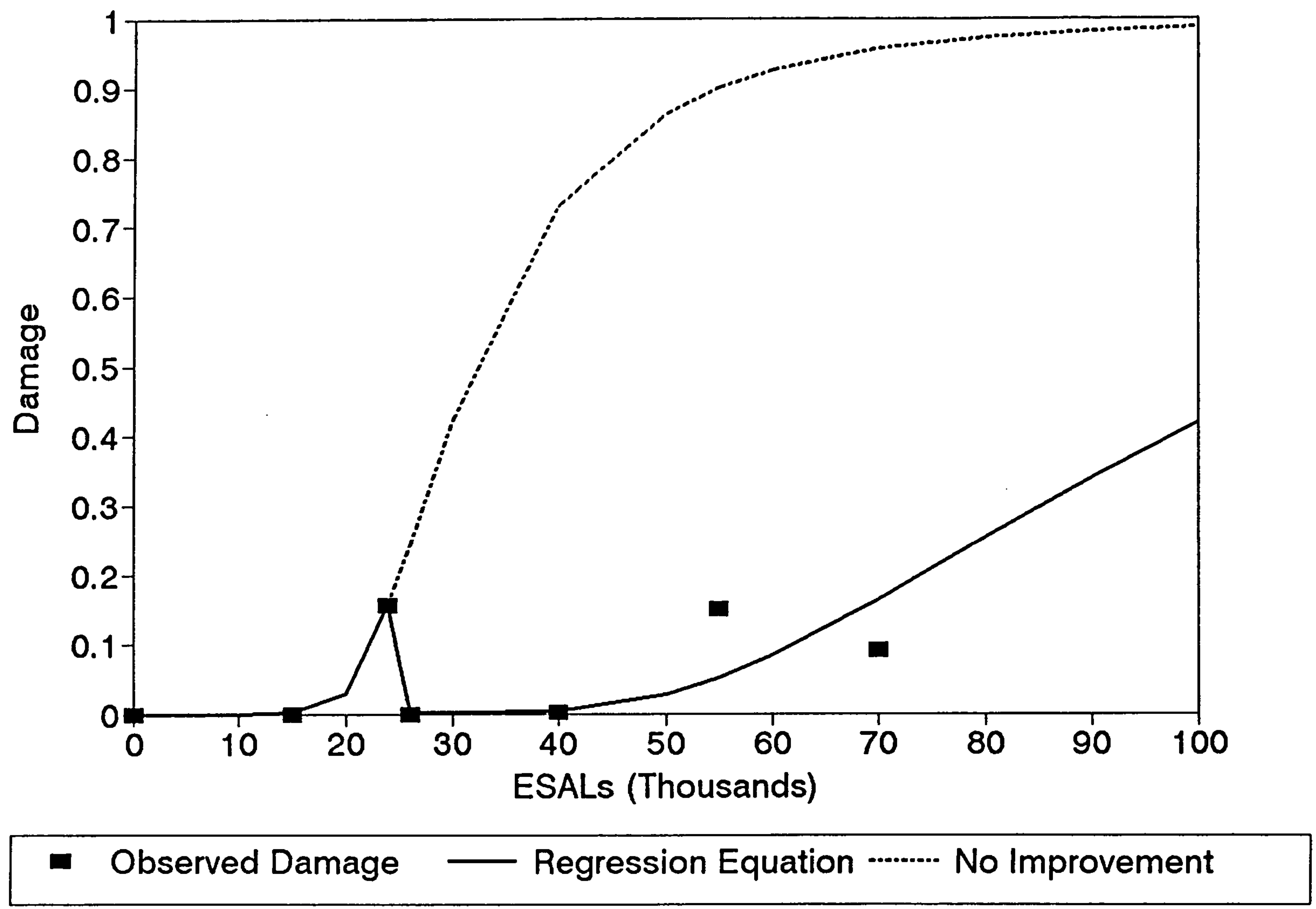

Figure 22. Example analysis using the deterioration rate variation and immediate improvement model and data with maintenance applied at 25,000 ESALs

$$y = b_0 + bX + b_L X_L + b_M X_M \tag{46}$$

where $y = \ln(-\ln g)$ and $X = \ln W$. The regression parameters b_0, b, b_L, and b_M are related to the performance parameters ρ, ρ_L, ρ_M, and β according to the equations

$$\begin{aligned} b_0 &= \beta \ln \rho \\ b &= -\beta \\ b_L &= \beta \ln \rho_L \\ b_M &= \beta \ln \rho_M \end{aligned}$$

The data used for the illustration and the estimated parameters are shown in table 17. The graph of the fitted model is displayed in figure 23. The development of each individual distress level throughout the pavement life cycle, derived from this model, is graphed in figure 24.

Determining Cost-Effectiveness of Treatments

Cost-effectiveness requires information about costs and the effectiveness of the treatment being analyzed. Cost information varies dramatically among agencies, and the costs for the treatments constructed in this study are not representative of normal preventive maintenance treatment costs. This study primarily defines the effectiveness of the treatments.

Defining Treatment Effectiveness

Pavement maintenance treatment "effectiveness" has been defined differently in several pavement management systems (Peterson 1987). This study is collecting enough information so that nearly any rational definition of effectiveness can be found. All SHRP distress measures, longitudinal profile (roughness), surface friction (skid), and deflection (structural capacity) are being measured on each treated section. The same information is being collected on a control (untreated) section at each site to allow direct comparison of the performance of treated sections with the performance of the untreated control sections.

One of the most common measures of effectiveness used in this type of analysis is the impact of the treatment on pavement life (Joseph 1992). Of course, pavement life is not well defined, and that is why there are differing definitions of effectiveness. Pavement

Table 17. Sample data and resulting parameters using multiple distress levels

Example Data		
ESALs	Observed Damage	Lowest Severity
15	0.0001	High
30	0.1159	High
45	0.5766	High
60	0.6283	High
75	0.9642	High
15	0.0034	Medium
30	0.1173	Medium
45	0.8931	Medium
60	0.9040	Medium
75	0.9802	Medium
15	0.2072	Low
30	0.3884	Low
45	0.8931	Low
60	0.9370	Low
75	0.9812	Low
Estimated Parameters		
β	3.1140	
ρ	35.0522	
ρ_M	0.76357	
ρ_L	0.64357	

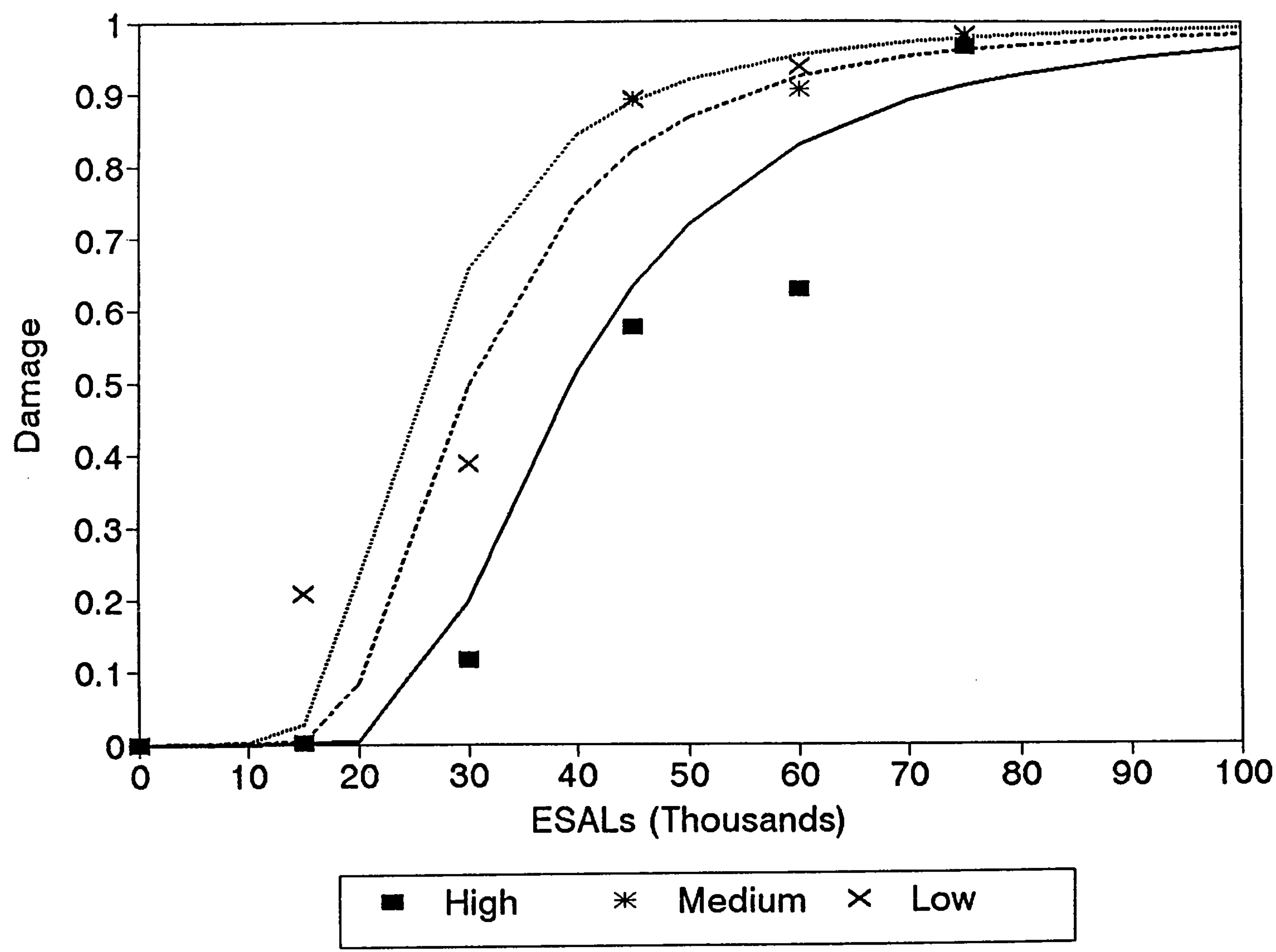

Figure 23. Example analysis using the model fit to multiple distress levels

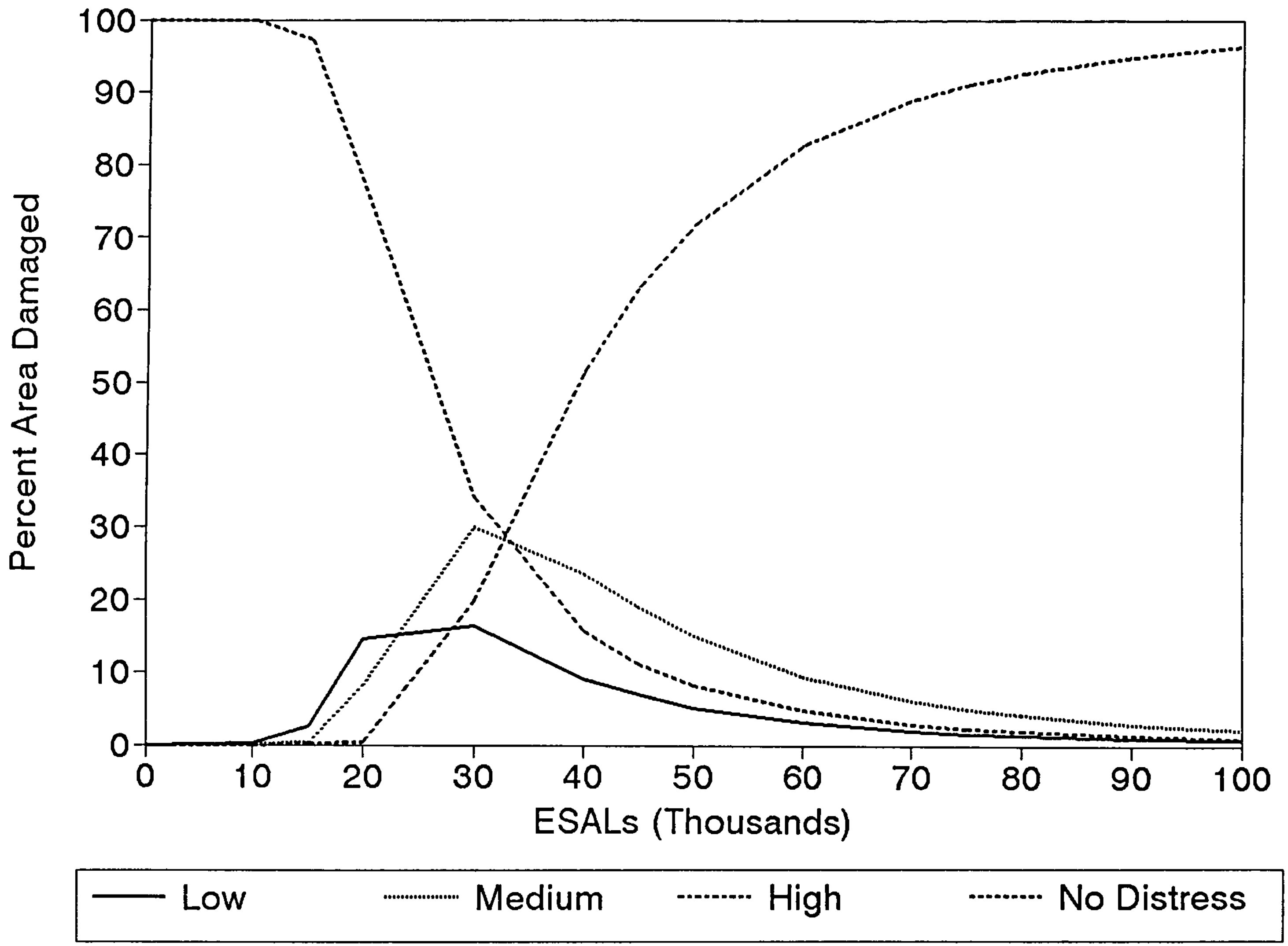

Figure 24. Illustration of development of three levels of severity throughout the life of a pavement

life is often defined in terms of serviceability (PSI); however, low surface friction can also lead to the end of a safe and serviceable pavement life. In general, all measures that can define the end of life to a safe and serviceable pavement should be included.

No matter what the measure, a minimum acceptable condition must be defined. When the condition of the pavement reaches that level, the pavement is considered to have reached the end of its serviceable (useful) life. This minimum acceptable level can vary among agencies and among classes of roads within an agency. Effectiveness of the preventive maintenance treatment can then be determined based on how long it took a treated section to reach the minimum acceptable level compared with how long it took the untreated control section to reach that same level when they both started from some common level. The increase in life of the treated section compared with the untreated section can be considered the effectiveness in years of serviceable pavement life.

All sections at a given test site were selected to be as similar as possible in all regards; however, there were some differences. When the sections being compared start at different levels, the analysis must adjust by matching common starting points in condition and comparing both time and traffic loadings. It is important that each test section be allowed to reach the minimum acceptable condition at each test site rather than discontinuing the test when any single section reaches minimum acceptable condition at a site because of this.

Calculating Cost-Effectiveness

The difference in life in years is one measure of effectiveness that will be available for the test sections in this study. This information can then be used with life-cycle cost analysis concepts and local agency costs for the treatments to determine cost-effectiveness (Joseph 1992; Peterson 1985). Each agency will have to use its own costs and discount (interest and inflation) rates to determine cost-effectiveness. The agencies should select an analysis period that covers the period of time from construction through rehabilitation after the section reaches the minimum acceptable condition. The costs of the untreated section must be compared to the costs of the treated sections which will require that construction costs and any maintenance costs be determined or estimated. The discount rate can be used to calculate present worth costs of the untreated (control) section. The costs of each treatment are added to the costs for the treated sections, and the present worth of each treated section can be calculated. However, since the lives of the sections will vary in length and the results will be used to compare the cost-effectiveness to other treatments, such as more-expensive and longer-life rehabilitation treatments, the equivalent uniform annual costs should also be calculated to determine the annualized costs. This calculation will give the information in dollars per year of life. The difference in the costs per year of the treated sections compared to the costs per year of the untreated sections or rehabilitation treatments can then be used to compare the cost-effectiveness.

9

Data Analysis

Data Availability

The construction data were collected by the Regional Coordinating Office Contractors (RCOCs) and the participating agencies. The RCOCs were responsible for entering the data into the National Information Management System (NIMS), the data base for all Long-Term Pavement Performance (LTPP) study data. The distress, roughness, surface friction, and deflection data were collected by Strategic Highway Research Program (SHRP) contractors and were to be entered into NIMS by the RCOCs. In addition, the research team needed information on the adjacent General Pavement Studies (GPS) test sections collected as part of the LTPP studies to characterize the traffic, materials, and structural capacity of each SPS-3 and SPS-4 section. Because some of the data were not in the correct form for entering into the data base, and because the data base was not in a condition to receive the data, data were not available to the research team for analysis until January 1993. When it became apparent that data problems would prevent access to the data until late in the study period, the H-101 contract was extended to allow more time for getting the data in appropriate form for analysis. It was also decided to concentrate the data analysis on the SPS-3 study because the SPS-4 study sections generally were built later than the SPS-3 study sections and because it will take more time for the impact of the SPS-4 treatments to show up in the performance of the pavements.

Obtaining Data

The original plan for obtaining data for the H-101 analysis was to directly query the NIMS national LTPP data base to retrieve data on SPS-3 and SPS-4 sites. This approach was not possible because the national LTPP data base was still under development when this study ended. In fact, until late summer 1992, there were no data entry screens for the H-101 data. Also, no data on H-101 sections could be entered because the sites had not been approved for entry and the regions had not been directed to enter the data. Although the solutions to these problems were implemented, it became clear that the data would not be uploaded into the national LTPP data base in time to complete any analysis of the SPS-3 and SPS-4 data. The research team had to obtain available data directly from each of the regions and was not able to develop a set of standardized data retrieval procedures. As a result, much of the data had not been through the complete NIMS data-checking process, so there could be problems with the data that the research team did not know about.

The research team and the Southern region RCOC staff developed a set of procedures to obtain the data from the Regional Information Management System (RIMS) using the extraction procedures provided in RIMS. These procedures produced the desired output for the Southern region except that none of the PASCO Distress Analysis System (PADIAS) data (distresses taken from PASCO films) could be retrieved. The procedures were sent to each of the regions in early November 1992. For a variety of reasons, including a crashed hard disk in one region, software upgrades to the RIMS system, uploads to NIMS, and LTPP constraints, data from the other regions did not arrive until January, February, and early March 1993, which was too late for analysis for this report. In some cases the information received was not complete. Much of the GPS data that were available came from the Southern region through its efforts in the P-020 data analysis contract. This included traffic for all sites, first-round PASCO distress data, and rutting data. Without the help of the Southern region RCOC staff, the research team would not have been able to analyze any data. The data arrived in separate files on diskettes. Selected data from each file were extracted into analysis files.

During analysis of the distress data, it was found that only the first-round PASCO distress data were currently available. Because many of the SPS-3 sites were identified after the first-round PASCO survey, the precondition distress survey was part of the second-or third-round PASCO distress survey. Through the efforts of the Federal Highway Administration (FHWA) and SHRP Contractor, PCS-Law, most of the second- and third-round data needed were finally provided. Although these distress data had not yet been checked as closely as much of the other data, they were needed for the analysis. These data were provided in report form, and each survey had to be printed out, the appropriate numbers recorded, and the data entered into the distress data base being analyzed by the research team. Once the distress data base was created, additional problems were identified. Initial distress surveys recorded only the number of transverse cracks and not the total length. Therefore, a distress survey was listed as having ten transverse cracks and a total length of transverse cracks of zero (0). Because the total length of cracks was needed, the Southern region RCOC staff was asked to provide this information, which was not originally collected. The Southern region RCOC staff reviewed the crack maps drawn during the survey and determined the appropriate lengths.

This omission indicates a serious problem with some of the data. The length of transverse cracks should have been recorded as a missing value because it was not collected. A missing value is treated far differently, in a statistical sense, than a zero value. Fortunately, it was possible to identify this discrepancy because the number of cracks indicated a problem. However, there may be other instances where a zero reflects no measurement rather than no distress (or temperature). For example, if all of the zero value alligator cracking are actually missing values, the average preconstruction alligator cracking is 1190-ft^2 (100-m^2). If the zeroes are actually zero, the average is 207-

ft^2 (19-m^2). The concept of a missing value, not a zero, should be reintroduced into the LTPP data base, and missing values that are currently zeroes should be corrected.

The distress summaries typically were different for the PASCO surveys than for the manual distress surveys. While some differences are expected, one method of reducing these differences would be to have the region RCOCs review their recent manual surveys while reviewing the PASCO films and resulting distress surveys. Currently, the regions only review the films and resulting surveys. Their purpose is to judge the survey based only on what can be seen on the film. Occasionally, the manual survey will classify a distress as a different distress, different severity, or will identify distresses that the film did not identify. Since the analysis depends on accurate data, any procedure that improves this accuracy should be embraced. This study is not one to identify which type of survey is best, but a study that needs accurate performance data. Every effort must be made to ensure that accurate performance data are recorded and properly stored in the data base.

Data Processing

The analysis of the damage data at this time attempted to answer the following questions:

1. On average, did damage grow as a function of time, and did damage in the treated sections grow significantly different from the growth in the control sections?

2. Did posttreatment damage growth relate to pretreatment damage?

3. Was distress growth significantly related to the independent variables such as traffic, climate, subgrade, and structure?

Information on life extension and the difference in the life provided by a treated section versus an untreated section will not be available until adequate deterioration occurs.

When data analysis began, variability problems in the condition of data were observed. This prompted the following questions:

1. What were the sources of survey data variability?
2. Was variability introduced as a function of the season a survey was taken?
3. Did the survey method (PASCO or manual) play a part in variability?

Data Summary

The data used in the analysis consisted of information on 28 SPS-3 locations from the SHRP southern region. The performance information was collected in surveys that spanned a period of slightly more than three years (August 14, 1989 through November 6, 1992). After reviewing the data and considering that only a couple of months was available for the analysis, the longitudinal and transverse cracking data, alligator cracking data, and surface friction (skid) data were selected for the preliminary analysis. Block cracking distress was excluded because all but two of the locations (12A and 47A) had data consisting entirely of zeros. There simply was not enough information in the block cracking data to perform an analysis at this time. Roughness was originally included for analysis, but it was excluded because there was an inadequate number of data points on any sections other than the GPS to warrant analysis.

Because the information contains relatively few observations of performance over time, simplified data analysis concepts were used to try to model the performance and determine the impact of the treatments and important experimental variables. At this point, there is not adequate data to develop the full S-shaped curves discussed in the previous section. In general, the condition after treatment was analyzed either as posttreatment condition or slope of posttreatment condition compared to pretreatment condition rather than the S-shaped curve parameters that should be used when adequate data becomes available.

Initial manipulation of the data was completed to more easily define pre- and posttreatment survey information. For the GPS and control sections, there were no treatments; thus, for those data, "pre" and "post" were defined as any survey that was taken before or after the earliest treatment date of any of the other four test sections. Displays of this information were produced and treatment sections were designated for acceptance or rejection based on an analysis of the data trends in each section. These displays are shown in appendix G for alligator cracking and longitudinal and transverse cracking. All distress data have been converted to damage by dividing the total quantity of distress by 6,000, the area of the test section in square feet. This measurement gives the ratio of area of square feet of alligator cracked pavement to total pavement area for alligator cracking and linear feet of cracked pavement to total square feet of pavement area which gives a damage range from 0 to 1. The displays use a damage range from 0 to 0.20 unless the site had damage levels greater than that. The displays for all sections at a site have the same damage level scale so that they can be compared directly. The displays are separated into groups that were accepted and groups that were rejected for analysis.

Rejection for further analysis was based on the variation between inspections and trends that show reduction in distress over time when no treatments have been placed. The longitudinal and transverse cracking data had forty treatment sections rejected from twenty locations. Table 18 lists those accepted for and table 19 lists those rejected for analysis of longitudinal and transverse cracking. The alligator-cracking data had sixteen treatment sections rejected from ten locations. Table 20 lists those sections accepted for, and table 21 lists those rejected for analysis of alligator cracking. Table 22 lists the sites for which the GPS section also serves as the control section.

Table 18. SPS-3 test sections accepted for analysis of longitudinal and transverse cracking data

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
01A	Chip Seal	24	.	.	.	.	0	12	15	13	.	.
	Control	22	.	.	.	.	25	36	.	.	.	.
	Overlay	20	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	27	.	.	.	.	0	0	0	0	0	.
01B	Chip Seal	0	.	.	.	.	0	0	0	0	0	.
	Control	0	.	.	.	.	15	22	34	34	.	.
	Crack Seal	5	.	.	.	.	0	65	71	71	.	.
	Overlay	0	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	0	.	.	.	.	0	8	12	4	4	.
01C	Crack Seal	520	.	.	.	.	925	962	1026	.	.	.
	Overlay	110	.	.	.	.	0	0	0	1	.	.
05A	Chip Seal	9	.	.	.	.	0	0	1	0	.	.
	Crack Seal	0	.	.	.	.	0	17	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	20	.	.	.	.	0	0	8	0	.	.
	Slurry Seal	0	.	.	.	.	0	0	24	0	.	.
12A	Chip Seal	542	275	.	.	.	0	0	0	.	.	.
	Crack Seal	334	.	.	.	.	240	62	18	201	.	.
	Overlay	79	272	22	42	.	0	0	.	.	.	.
	Slurry Seal	270	588	.	.	.	0	0	2	159	.	.
12B	Chip Seal	479	0	.	.	.	0	0	0	.	.	.
	Overlay	512	214	407	0	.	0	.	.	.	.	.
	Slurry Seal	696	0	.	.	.	0	0	31	.	.	.
12C	Chip Seal	747	297	.	.	.	0	0	0	0	.	.
	Crack Seal	499	.	.	.	.	220	76	566	256	.	.
	Overlay	356	310	57	.	.	0	0	0	.	.	.
	Slurry Seal	840	425	.	.	.	0	0	0	0	.	.

Table 18. SPS-3 test sections accepted for analysis of longitudinal and transverse cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
28A	Crack Seal	78	.	.	.	.	105	120	.	.	.	.
	Overlay	87	.	.	.	.	0	61	67	.	.	.
	Slurry Seal	147	.	.	.	.	0	0	295	.	.	.
40A	Chip Seal	0	.	.	.	.	0	0	0	.	.	.
	Control	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	.	.	0	0	.	.	.	.
	GPS	.	.	.	.	.	0	0	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	.	.	.
40B	GPS	116	.	.	.	.	164	151	165	64	.	.
	Overlay	238	.	.	.	.	0	29	26	.	.	.
40C	Chip Seal	126	.	.	.	.	0	50	54	86	.	.
	Crack Seal	196	.	.	.	.	241	163	1734	.	.	.
	GPS	208	.	.	.	.	208	136	.	.	.	.
	Overlay	459	.	.	.	.	0	0	52	100	.	.
	Slurry Seal	134	.	.	.	.	0	95	242	214	.	.
47A	Chip Seal	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	34	.	.	.	.	.	.	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	.	.	.	.	0	0	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	.	.	.	.
47B	Chip Seal	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	.	.	10	.	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	.	.	.	.	0	0	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	.	.	.	.

Table 18. SPS-3 test sections accepted for analysis of longitudinal and transverse cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
47C	Chip Seal	574	355	.	.	.	0	0	0	.	.	.
	Crack Seal	488	200	.	.	.	635	592	.	.	.	.
	Overlay	441	280	.	.	.	0	0	0	.	.	.
	Slurry Seal	280	89	.	.	.	0	0	0	.	.	.
48A	Chip Seal	48	.	.	.	.	0	14	.	.	.	.
	Control	14	.	.	.	.	60	67	55	69	.	.
	Crack Seal	0	.	.	.	.	65	0	0	0	.	.
	GPS	86	.	.	.	.	54	.	.	.	.	.
	Overlay	42	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	63	.	.	.	.	0	8	8	22	52	.
48B	Chip Seal	1559	1339	849	.	.	0	0	59	45	.	.
	Control	1247	1447	.	.	.	1228	1429	1531	.	.	.
	Crack Seal	1212	1347	422	.	.	1390	1378	1402	.	.	.
	GPS	1480	.	.	.	.	1551	1835	.	.	.	.
	Overlay	1485	2035	785	.	.	0	0	4	267	.	.
	Slurry Seal	1379	1519	994	.	.	0	0	91	185	.	.
48D	Crack Seal	556	375	.	.	.	530	873	660	.	.	.
	GPS	790	.	.	.	.	621	694	694	.	.	.
	Overlay	585	491	.	.	.	0	0	25	22	.	.
	Slurry Seal	523	612	.	.	.	0	0	33	30	.	.
48E	Chip Seal	91	.	.	.	.	0	0	137	90	96	.
	Control	113	.	.	.	.	36	134	191	276	.	.
	Crack Seal	90	.	.	.	.	62	170	238	154	215	.
	GPS	.	.	.	.	.	92	115	164	124	.	.
	Slurry Seal	123	.	.	.	.	0	7	243	232	300	.

Table 18. SPS-3 test sections accepted for analysis of longitudinal and transverse cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
48F	Chip Seal	116	63	.	.	.	0	42	81	41	.	.
	GPS	126	60	.	.	.	134	93	.	.	.	.
	Overlay	146	128	.	.	.	0	92	81	87	.	.
48G	Chip Seal	54	121	.	.	.	0	0	0	0	.	.
	Crack Seal	0	0	.	.	.	0	2	0	.	.	.
	Slurry Seal	2	0	.	.	.	0	0	22	0	.	.
48H	Chip Seal	5	35	.	.	.	0	0	18	0	.	.
	Control	27	24	.	.	.	45	115	217	.	.	.
	Overlay	71	60	.	.	.	0	0	4	7	.	.
	Slurry Seal	73	75	.	.	.	0	0	22	118	.	.
48I	Chip Seal	0	22	.	.	.	0	0	0	.	.	.
	GPS	9	.	.	.	.	0	0	.	.	.	.
48J	Crack Seal	48	.	.	.	.	0	0	0	0	0	.
	GPS	6	.	.	.	.	0	15	0	0	.	.
	Overlay	67	13	.	.	.	0	0	0	0	0	.
48K	Control	482	495	.	.	.	482	473	397	507	.	.
	GPS	169	.	.	.	.	229	233	.	.	.	.
	Overlay	79	262	.	.	.	0	0	0	0	0	.
	Slurry Seal	79	104	.	.	.	0	0	0	0	0	.
48L	Chip Seal	713	226	.	.	.	0	65	129	.	.	.
	Control	592	77	.	.	.	666	462	.	.	.	.
	Crack Seal	708	373	.	.	.	784	827	651	.	.	.
	GPS	122	.	.	.	.	238	224	223	.	.	.
	Overlay	40	258	266	454	0	0	.	.	.	.	.
	Slurry Seal	197	296	.	.	.	0	81	148	.	.	.

Table 18. SPS-3 test sections accepted for analysis of longitudinal and transverse cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
48M	Chip Seal	0	7	.	.	.	0	0	0	0	0	.
	Crack Seal	0	5	.	.	.	0	5	0	0	.	.
	Slurry Seal	0	1	.	.	.	0	0	3	0	0	.
48N	Control	0	.	.	.	.	0	0	0	0	35	.
	Crack Seal	3	.	.	.	. .	0	0	0	0	9	.
	GPS	5	.	.	.	.	10	19	83	.	.	.
	Overlay	6	.	.	.	.	0	0	0	0	0	8
	Slurry Seal	10	.	.	.	.	0	49	0	0	0	1
												0
48Q	Chip Seal	0	0	.	.	.	0	0	3	0	.	.
	Control	1	.	.	.	.	0	0	11	9	.	.
	Crack Seal	0	.	.	.	.	0	0	12	44	.	.
	GPS	2	.	.	.	.	0	0	0	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	4	0	.	.

Table 19. Sections rejected for analysis of longitudinal and transverse cracking data

Location	Treatment	Pretreatment Survey			Posttreatment Survey					
		1	2	3	1	2	3	4	5	6
01A	Crack Seal	0	.	.	209	0	191	.	.	.
	GPS	10	.	.	540	29	103	.	.	.
01B	GPS	0	.	.	43	5	.	.	.	.
01C	Chip Seal	367	.	.	0	0	15	0	.	.
	Control	84	.	.	249	163	124	.	.	.
	GPS	128	.	.	306	53	.	.	.	.
	Slurry Seal	286	.	.	0	211	0	0	.	.
12A	GPS	12	.	.	250	0	14	0	.	.
12B	Crack Seal	658	0	.	1277	40	.	.	.	.
	GPS	183	0		150	0	.	.	.	.
12C	GPS	599	.	.	271	441	396	221	.	.
28A	Chip Seal	.	.	.	0	2	.	.	.	.
	GPS	122	239		0	272	156	.	.	.
40A	Overlay	0	0	0	.	.	.	.	.	.
40B	Chip Seal	283	.	.	0	58	491	241	.	.
	Crack Seal	336	.	.	479	481	480	167	.	.
	Slurry Seal	72	.	.	0	27	107	67	41	.
47C	GPS	619	383	.	72	197	.	.	.	.
48D	Chip Seal	368	601	.	0	0	22	0	.	.
48E	Overlay	244	3	0	0	148	115	121	.	.
48F	Control	30	67	.	10	85	0	.	.	.
	Crack Seal	75	90	.	34	163	30	.	.	.
	Slurry Seal	36	38	.	0	43	105	21	.	.

Table 19. Sections rejected for analysis of longitudinal and transverse cracking data (Cont.)

Location	Treatment	Pretreatment Survey			Posttreatment Survey					
		1	2	3	1	2	3	4	5	6
48G	GPS	12	1741	0	106	0	1783	0	.	.
	Overlay	0	0	.	0	0	235	0	.	.
48H	Crack Seal	4	14	.	17	114	47	.	.	.
	GPS	43	57	.	0	0	207	.	.	.
48I	Control	3	42	.	0	0	.	.	.	.
	Crack Seal	0	108	.	0	52	0	.	.	.
	Overlay	0	3	.	0	110	0	.	.	.
	Slurry Seal	0	33	.	0	0	646	0	.	.
48J	Chip Seal	3	53	.	0	0	24	0	0	.
	Control	36	.	.	0	2	29	0	2	.
	Slurry Seal	40	0	.	0	0	138	0	0	.
48K	Chip Seal	139	322	.	0	0	16	0	0	.
	Crack Seal	4	55	.	4	84	0	0	.	.
48M	Control	.	.	.	0	0	16	0	0	.
	GPS	.	.	.	0	22	0	0	.	.
	Overlay	.	.	.	0	0	0	0	0	0
48N	Chip Seal	0	.	.	0	0	16	0	0	0

Table 20. Sections accepted for analysis of alligator cracking data

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
01A	Chip Seal	0	.	.	.	.	0	0	0	0	.	.
	Control	0	.	.	.	.	37	30	.	.	.	.
	Crack Seal	0	.	.	.	.	0	0	0	.	.	.
	GPS	0	.	.	.	.	0	12	282	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	0	.	.	.	.	0	0	0	0	.	.
01B	Chip Seal	0	.	.	.	.	0	0	0	0	0	.
	Control	0	.	.	.	.	0	0	0	0	.	.
	Crack Seal	0	.	.	.	.	82	93	178	178	.	.
	GPS	0	.	.	.	.	0	800	.	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	0	.	.	.	.	0	0	0	0	0	.
01C	Chip Seal	427	.	.	.	.	0	0	0	0	.	.
	GPS	0	.	.	.	.	12	736	.	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	0	.	.
05A	Chip Seal	0	.	.	.	.	0	0	0	0	.	.
	Crack Seal	0	.	.	.	.	0	0	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	0	.	.
12A	Chip Seal	0	0	.	.	.	0	.	0	.	.	.
	GPS	0	.	.	.	.	0	0	0	0	.	.
	Overlay	0	0	0	0	.	0	0	.	.	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.

Table 20. Sections accepted for analysis of alligator cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
12B	Chip Seal	424	2000	.	.	.	0	0	0	.	.	.
	GPS	1862	2000	.	.	.	1358	3000	.	.	.	.
	Overlay	704	850	561	0	.	0	.	.	.	.	.
	Slurry Seal	328	2000	.	.	.	0	0	152	.	.	.
12C	Chip Seal	199	306	.	.	.	0	0	0	0	.	.
	Crack Seal	1148	.	.	.	.	1108	1108	1273	1337	.	.
	GPS	2540	.	.	.	.	2358	2358	3058	2743	.	.
	Overlay	2743	2761	2742	.	.	0	0	0	.	.	.
	Slurry Seal	1111	608	.	.	.	0	0	0	0	.	.
28A	Overlay	0	.	.	.	.	0	0	0	.	.	.
40A	Chip Seal	0	.	.	.	.	0	0	0	.	.	.
	Control	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	.	.	0	0	.	.	.	.
	GPS	.	.	.	.	.	0	31	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	.	.	.
40B	Chip Seal	339	.	.	.	.	0	0	0	270	.	.
	Crack Seal	25	.	.	.	.	0	0	0	299	.	.
	GPS	0	.	.	.	.	0	0	0	108	.	.
	Overlay	162	.	.	.	.	0	0	0	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	0	74	.
40C	Chip Seal	28	.	.	.	.	0	0	0	55	.	.
	Crack Seal	0	.	.	.	.	0	2	129	.	.	.
	GPS	164	.	.	.	.	269	695	.	.	.	.
	Overlay	551	.	.	.	.	0	0	0	21	.	.
	Slurry Seal	249	.	.	.	.	0	0	47	162	.	.

Table 20. Sections accepted for analysis of alligator cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
47A	Chip Seal	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	.	.	.	.	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	.	.	.	.	0	0	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	.	.	.	.
47B	Chip Seal	0	.	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	.	.	0	.	.	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	.	.	.	.	0	0	.	.	.	.
	Slurry Seal	0	.	.	.	.	0	0	.	.	.	.
47C	Chip Seal	50	53	.	.	.	0	0	0	.	.	.
	Crack Seal	0	0	.	.	.	0	90	.	.	.	.
	GPS	0	0	.	.	.	1245	1136	.	.	.	.
	Overlay	0	25	.	.	.	0	0	0	.	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	.	.	.
48A	Chip Seal	0	.	.	.	.	0	0	.	.	.	.
	Control	64	.	.	.	.	0	0	64	64	.	.
	Crack Seal	0	.	.	.	.	0	0	0	0	.	.
	GPS	0	.	.	.	.	0	.	.	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	0	.
	Slurry Seal	44	.	.	.	.	0	0	0	0	0	.
48B	Chip Seal	0	0	0	.	.	0	0	0	0	.	.
	Control	0	0	.	.	.	0	0	0	.	.	.
	Crack Seal	0	0	0	.	.	0	0	0	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	0	0	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	0	.	.	0	0	0	0	.	.

Table 20. Sections accepted for analysis of alligator cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
48D	Chip Seal	0	0	.	.	.	0	0	0	0	.	.
	Crack Seal	0	0	.	.	.	0	0	0	.	.	.
	GPS	0	.	.	.	.	0	0	0	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.
48E	Chip Seal	28	.	.	.	.	0	0	12	34	0	.
	GPS	.	.	.	.	.	0	0	0	79	.	.
	Overlay	14	0	0	.	.	0	0	0	0	.	.
	Slurry Seal	0	.	.	.	.	0	0	0	15	0	.
48F	Chip Seal	0	0	.	.	.	0	0	0	0	.	.
	Control	0	0	.	.	.	0	0	0	.	.	.
	Crack Seal	0	0	.	.	.	0	0	0	.	.	.
	GPS	0	0	.	.	.	0	10	.	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.
48G	Chip Seal	0	0	.	.	.	0	0	0	0	.	.
	Crack Seal	0	0	.	.	.	0	0	0	.	.	.
	GPS	0	0	0	.	.	0	0	0	0	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.
48H	Chip Seal	0	4	.	.	.	0	0	2	0	.	.
	Crack Seal	0	0	.	.	.	0	0	0	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.

Table 20. Sections accepted for analysis of alligator cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
48I	Chip Seal	0	0	.	.	.	0	0	0	.	.	.
	Control	0	0	.	.	.	0	0	.	.	.	.
	Crack Seal	0	0	.	.	.	0	0	0	.	.	.
	GPS	0	.	.	.	.	0	0	.	.	.	.
	Overlay	0	0	.	.	.	0	0	0	.	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.
48J	Chip Seal	0	0	.	.	.	0	0	0	0	0	.
	Control	0	.	.	.	.	0	0	0	0	0	.
	Crack Seal	0	.	.	.	.	0	0	0	0	0	.
	GPS	0	.	.	.	.	0	0	0	0	.	.
	Overlay	0	0	.	.	.	0	0	0	0	0	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	0	.
48K	Chip Seal	17	0	.	.	.	0	0	0	0	0	.
	Crack Seal	0	0	.	.	.	0	0	0	0	.	.
	GPS	126	.	.	.	.	19	75	.	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	0	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	0	.
48L	Chip Seal	0	0	.	.	.	0	0	0	.	.	.
	Control	0	0	.	.	.	0	0	.	.	.	.
	GPS	0	.	.	.	.	0	0	0	.	.	.
	Overlay	0	0	0	0	0	0	.	.	.	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	.	.	.
48M	Chip Seal	0	0	.	.	.	0	0	0	0	0	.
	Control	.	.	.	.	.	0	0	0	6	35	.
	Crack Seal	0	0	.	.	.	0	0	0	0	.	.
	GPS	.	.	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	0	.

Table 20. Sections accepted for analysis of alligator cracking data (Cont.)

Location	Treatment	Pretreatment Survey					Posttreatment Survey					
		1	2	3	4	5	1	2	3	4	5	6
48N	Chip Seal	0	.	.	.	.	0	0	0	0	0	0
	Control	0	.	.	.	.	0	0	0	0	59	.
	Crack Seal	0	.	.	.	.	28	0	0	40	118	.
	GPS	0	.	.	.	.	0	8	45	.	.	.
	Overlay	0	.	.	.	.	0	0	0	0	0	0
	Slurry Seal	0	.	.	.	.	0	0	0	0	0	0
48Q	Chip Seal	0	0	.	.	.	0	0	0	0	.	.
	Control	0	.	.	.	.	0	0	0	0	.	.
	Crack Seal	0	.	.	.	.	0	0	0	0	.	.
	GPS	0	.	.	.	.	0	0	0	.	.	.
	Overlay	0	0	.	.	.	0	0	0	0	.	.
	Slurry Seal	0	0	.	.	.	0	0	0	0	.	.

Table 21. Sections rejected for analysis of alligator cracking data

Location	Treatment	Pretreatment Survey			Posttreatment Survey					
		1	2	3	1	2	3	4	5	6
O1C	Control	37	.	.	0	157	0	.	.	.
	Crack Seal	566	.	.	0	0	56	.	.	.
12A	Crack Seal	0	.	.	10	22	0	91	.	.
12b	Crack Seal	154	2000	.	349	2773	.	.	.	.
28A	Chip Seal	.	.	.	0	0	.	.	.	.
	Crack Seal	0	.	.	1108	0	.	.	.	.
	GPS	0	0	.	494	0	.	.	.	.
	Slurry Seal	0	.	.	0	162	0	.	.	.
40A	Overlay	0	0	0	.	.	.	.	.	.
48E	Control	24	.	.	0	0	324	102	.	.
	Crack Seal	0	.	.	0	0	188	453	159	.
48H	Control	0	0	.	35	0	0	.	.	.
	GPS	62	9	.	200	15	28	.	.	.
48K	Control	348	0	.	354	0	285	158	.	.
48L	Crack Seal	0	0	.	0	125	0	.	.	.
48M	Overlay	.	.	.	0	0	0	0	0	0

Table 22. List of sites where the GPS section also serves as the control section

Location	05A	12A	12B	12C	28A	40B	40C	47A	47B	47C	48D	48

In an attempt to see the impact of the treatments on performance and the impact of the condition before treatment, scatter plots were produced, by treatment, for both distress types, of mean pretreatment damage by last observed posttreatment damage. These are provided in appendix H. They show that there is very little development of alligator cracking in the sections treated with chip seals, slurry seals, and thin overlays since the treatments were applied, and no general trends can be identified. The crack seal, control, and GPS sections show that those with greater initial alligator cracking continue to have greater quantities of alligator cracking, as we would expect. The figures for the longitudinal and transverse cracking shown in appendix H show a trend similar to that of the alligator cracking, although there is more longitudinal and transverse cracking than alligator cracking in the treated sections. The chip seal, slurry seal, and thin overlay treatments have reduced the amount of longitudinal and transverse cracking in the pavement sections compared to that originally present. The crack seal, control, and GPS sections show that those with greater initial cracking continue to have greater quantities of cracking, as we would expect.

Several sections in a location had no pretreatment surface friction (skid) values. When available, the pretreatment skid data from the GPS section were substituted for the adjacent-treated sections, pretreatment data. Table 23 lists the sections for which the GPS pretreatment skid value was substituted. A total of 54 sections are listed in table 24 that could not be analyzed because there were no posttreatment skid surveys.

Initial analysis of skid data consisted of comparing the single pretreatment skid value of a section to the average of the posttreatment skid values. Scatter plots were produced for these two values by treatment and are included in appendix I. The chip seal, slurry seal, and thin overlay treatments have reasonable skid numbers with no relation to the skid numbers that were present before the treatment. This situation would be expected since the skid number should be a function of the treatment surface and not related to the underlying surface. The crack seal, control, and GPS sections show that the skid numbers after treatment are similar to those before treatment, as we would expect.

Data Concerns

Visual inspection of the data initially led to a suspicion that PASCO and manual survey methods were producing data that were systematically different. Since surveys in all sections were performed using a mix of the two methods, it was thought that a preponderance of any single survey method might have an impact on the acceptance/rejection ratio across sections. Chi-square analysis showed no significant deviation from expected cell frequencies in the acceptance/rejection, PASCO/manual matrix. However, this does not mean that there is not a significant difference in the way the data are interpreted. Based on visual inspection, it appears that there was less variation within surveys completed with the same method than when there is a mix of survey methods.

Table 23. Sections with no posttreatment skid data

Location	Treatment	Location	Treatment
05A	GPS	40B	Crack Seal
28A	GPS	40C	Crack Seal
40A	GPS	47A	Crack Seal
40B	GPS	47B	Crack Seal
40C	GPS	47C	Crack Seal
47A	GPS	05A	Control
47B	GPS	12A	Control
47C	GPS	12B	Control
05A	Overlay	12C	Control
28A	Overlay	28A	Control
40A	Overlay	40A	Control
40B	Overlay	40B	Control
40C	Overlay	40C	Control
47A	Overlay	47A	Control
47B	Overlay	47B	Control
47C	Overlay	47C	Control
05A	Slurry Seal	48D	Control
28A	Slurry Seal	48G	Control
40A	Slurry Seal	05A	Chip Seal
40B	Slurry Seal	28A	Chip Seal
40C	Slurry Seal	40A	Chip Seal
47A	Slurry Seal	40B	Chip Seal
47B	Slurry Seal	40C	Chip Seal
47C	Slurry Seal	47A	Chip Seal
05A	Crack Seal	47B	Chip Seal
28A	Crack Seal	47C	Chip Seal
40A	Crack Seal		

At this point it is necessary to question the basic integrity of the data. Rejection of about 24 percent of the sections for analysis of longitudinal and transverse cracking data is not acceptable and would support the question of data integrity. Questions that need to be addressed include the repeatability of distress surveys, both within the same method of collection and between the two types of data collection. Among the longitudinal and transverse cracking data, there were at least four cases where survey data collected on the same section within days of each other were substantially different. For example, section 47C-Chip Seal was surveyed twice on the same day. One survey showed 574 linear ft (175-m) of longitudinal and transverse cracking, the other showed 355 linear ft (108-m). Both were surveyed using PASCO. Section 48B-Crack Seal was surveyed twice within two days, showing 1,347 linear ft (411-m) of longitudinal and transverse cracking on one survey and only 422 linear ft (129-m) on the next. The first was surveyed using PASCO; the smaller value was surveyed manually.

Table 24. Sections with posttreatment skid data

Location	Treatment
12A	Overlay Slurry Seal Crack Seal Chip Seal
12B	Slurry Seal Crack Seal Chip Seal
12C	Overlay Slurry Seal Crack Seal Chip Seal
48M	Overlay
48N	Overlay

In addition to the problem of survey nonrepeatability, it was recently determined that there was confusion within the data as to how missing data points were represented. In some cases they were left truly missing, while in other cases missing values were represented by zeros. Needless to say, such confusion has a tremendous impact on the outcome of statistical tests.

Statistical Analysis for Longitudinal and Transverse Cracking

Although the distress data set for longitudinal and transverse cracking was better than most with regard to the quantity and quality of the data set, it was by no means adequate for any sophisticated modeling of distress over time with any reasonable statistical significance or reliability. However, by grouping the data and deleting obviously erroneous or questionable data elements, some trends seemed to be measurable, although it was difficult to attach any statistical significance to these trends given the degree of "noise" in this data set. The analysis was completed with the goal of establishing some guidelines and suggestions for future analyses of the LTPP data as more complete and, hopefully, more consistent data are obtained over longer time periods.

One of the most serious problems in establishing any time trends was the amount of variability both among and within the sections. The data were not complete enough to allow good estimation of the within-site variances. After removing the obviously erroneous data elements, there were very few sites that had sufficient information over time, in order words, good measurements for at least three time periods. Similarly, there was not sufficient information to incorporate the control information in evaluating the time trend for a given site. This was because often, if the control or GPS section at a site was available, the treatment data were not available, and vice versa. Table 25 shows the number of control and GPS sections that had data for corresponding treatment sections, grouped by three time periods:

1. distress measurements made between 1 and 90 days from the treatment date;
2. measurements made between 90 and 180 days from the treatment date; and
3. measurements made 180 days or more from the treatment date.

Table 26 shows the average distress for the treatment sections and their corresponding GPS sections. Note that whereas there appears to be an expected increase in distress over time for overlay and slurry treatment sections, their corresponding GPS sections show no pattern over time. This variability and lack of consistency in the GPS sections make it impossible to use the GPS sections as any kind of control condition for the treatment sections. The same was found for the control sections as reflected in table 27. These problems are indicative of the same problems discussed earlier and can be corrected by better controlling interpretation of distress data.

To provide some type of analysis at this point, the data were grouped. The grouping of the data by the designated time periods was motivated by the following two factors:

1. The data measurements were made at very different time periods, and the sparsity of the data made it impossible to identify any trends over time when time was specified in daily units.
2. Units were chosen to reflect a fairly uniform amount of information for each treatment. That is, it appeared that roughly the same numbers of sections that had measurements made during these time intervals. Since there were relatively few sections that had distress data for more than a year after treatment, the information for these sections was pooled with information from those sections with data more than 180 days since treatment.

This grouping of the time units revealed certain trends not previously evident when time was analyzed as daily units.

Tables 25 through 27 are based only on sections that had corresponding control or GPS information. The analysis presented in the following tables contains all sections that reported a distress measurement during the corresponding time periods.

Table 25. Control and GPS data completeness

	GPS			Control		
	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Overlay	2	7	15	3	8	13
Slurry	4	6	10	3	8	16
Crack	4	7	10	4	6	9
Chip	3	5	6	3	6	11

Table 26. Average cracking for GPS/treatment pairs

	Treatment			GPS		
	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Overlay	0.0	20.2	38.7	429.5	406.7	258.3
Slurry	14.7	77.1	109.1	266.5	497.7	349.5
Crack	419.4	371.1	376.9	266.5	396.0	326.2
Chip	21.7	76.5	66.4	148.3	439.4	424.8

Table 27. Average cracking for control/treatment pairs

	Treatment			Control		
	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Overlay	0.0	1.0	21.1	397.7	459.9	195.8
Slurry	16.2	14.8	45.8	397.7	459.9	195.8
Crack	481.2	332.8	225.8	278.7	480.8	201.8
Chip	16.2	45.1	34.7	220.3	500.0	238.9

Distress vs. No Distress

The most abundant information in this data set is zero distress; in other words, the majority of pavements showed no distress over the time period available for this study. This information alone is meaningful over time. The question is: What is the rate at which pavements show some initial distress over time for a given treatment? Table 28 depicts the proportion of pavements with zero distress at each of the grouped time periods.

Note that for all treatments except crack seal, there is a decreasing proportion of pavements that have showed no distress over time. In fact, for most crack seal sections, there was more distress measured in the first 90 days from treatment than there was pretreatment. The average distress for all sections before treatment was 241.4 and after the first 90 days increased to 326.2. The GPS and control sections are listed in this table primarily to reflect the degree of inconsistency in these sections. These sections, even though they have not been treated, actually have more sections with no distress over time than they started with. This is likely due to the fact that a certain amount of reporting of zero distress is actually missing data. These cases should be further investigated to ensure that zero distress is an actual measurement, not a gap in the data.

Another interesting statistic is the average time to some distress for each treatment. This time is somewhat imprecise in that we do not know the exact day of the distress.

However, we do know that cracking occurred at some point between the previous measurement, when no distress was recorded, and the time the distress was measured. Assuming this progression to cracking occurred in some sort of uniform fashion for all treatments, the average time to distress could be meaningful.

There was not sufficient data to allow a sophisticated modeling of this process. However, as data become more plentiful, the method of Cox regression modeling should be considered. This methodology models the time to distress as a function of other covariates, such as traffic load, and climatic zone. Table 29 reports the average time to distress for each treatment.

Table 29 shows the average number of days to the "first" sign of longitudinal and transverse cracking for each treatment. According to this data, crack seal and overlay tend to show signs of cracking earliest, followed by chip seal and slurry seal. Slurry seal, on the average, does not begin to show cracking until 224 days after treatment, whereas crack seal begins at 135 days after treatment. Again, these numbers will become more meaningful as more data are obtained.

Table 28. Proportion of no cracking sites for different time periods

Treatment	Proportion / Number	Age in Days		
		0-90	90-180	t 180
Overlay	Prop	90.0	66.7	66.7
	n	10	21	27
Slurry	Prop	77.7	55.2	40.7
	n	9	29	27
Crack	Prop	44.4	28.6	36.0
	n	9	28	25
Chip	Prop	85.7	62.5	56.5
	n	7	24	23
GPS	Prop	20.0	38.5	34.8
	n	5	13	23
Control	Prop	16.7	10.0	25.0
	n	6	10	20

Table 29. Average time to distress

Treatment	Number of Observations	Average Time to Distress
Overlay	10	137.4
Slurry	15	224.3
Crack	16	135.1
Chip	9	153.9

Initial Distress

The initial distress among the pavements in this sample is described in table 30 by treatment type. Although the average initial condition of the pavements was fairly uniform among the treatment sections, ranging from 240 for sections to be overlaid to 293 for the control sections, the variability of initial condition was extremely high. The coefficient of variation (standard deviation divided by the mean) exceeded 1.0 in all cases and approached 2.0 in some cases. This measurement indicates a serious need to control for initial condition in some way in the analysis. However, as already indicated, the GPS sections and control sections are not adequately represented in this data set to enable such an adjustment. The analysis of distress over time discussed in the following paragraphs attempts a rather crude adjustment for initial condition for the GPS and control sections by grouping the time intervals. Growth rate (or rate of increase in distress) for the treatments is evaluated assuming a base of zero distress at the time of treatment.

Degree of Distress over Time

Table 31 depicts the mean distress for each time interval by the treatment (and GPS and control) sections expressed the following three ways:

1. average distress computed as the mean of the distress measured on all pavements during the first 90 days, 90-180 days, and after more than 180 days;

2. the average of the ratios of the measured distress in the respective time period divided by (relative to) that pavement's initial distress; and

3. the average of the differences between the measured distress at that time period and the initial distress of that pavement.

The second and third measure are relative and attempt to adjust each pavement by its initial condition.

Although all three methods are presented in the table for all treatments and GPS and control sections, some methods are not as meaningful for pavements that have not been treated. The average method examines the average distress for all pavements within a given time period and can be interpreted as an unadjusted measure of the change (increase) in distress over time. This measure is not adjusted in any way by the initial condition of the pavement. Hence, if a pavement's initial condition is "good," then the amount of distress in the first 90 days can be expected to be low. Conversely, if the pavement had a high degree of distress in the initial observation period, distress after the first 90 days still is expected to be high. The average method averages these numbers

Table 30. Initial quantity of longitudinal and transverse cracking

Treatment	Initial Quantity		
	Number	Mean	Standard Deviation
Chip Seal	16.00	241.41	326.99
Control	8.00	293.19	461.58
Crack Seal	15.00	276.88	286.82
GPS	12.00	257.17	440.79
Overlay	19.00	240.01	326.43
Slurry Seal	17.00	257.43	330.89

Table 31. Cracking over time in days

Method	Time	GPS	Control	Overlay	Crack	Slurry	Chip
Average	0-90	213.2	227.2	**6.1**	326.2	**9.8**	**9.3**
	90-180	241.1	388.1	**13.4**	259.8	**36.6**	**20.5**
	gt 180	179.7	170.9	**21.9**	287.1	**57.4**	**21.5**
Ratio	0-90	**1.31**	0.66	0.70	**1.31**	0.19	0.14
	90-180	**1.51**	3.76	0.36	**2.07**	3.50	0.71
	gt 180	**2.38**	2.79	0.17	**4.02**	0.78	0.45
Difference	0-90	**-20.7**	47.9	-154.0	78.1	**-258.0**	**-254.1**
	90-180	**16.3**	7.1	-215.8	56.3	**-153.1**	**-168.5**
	gt 180	**22.9**	50.4	-161.3	117.3	**-111.9**	**-135.6**

Note: Bold numbers indicate trends over time

without regard to initial condition and therefore has a high degree of variability among the GPS and control conditions which, as we already know, have a high degree of variability among the sections with respect to initial condition. For the treatment sections, because distress at the time of treatment was basically zero for all sections, the degree of distress in the first 90 days is less variable; in other words the "numbers" we are averaging are much more consistent than for the GPS and control sections. For this reason, the average method is more meaningful for the treatment sections than the GPS and control sections. "Growth" in distress for the GPS and control sections must be measured in a way that controls for the initial condition of the pavement. This adjustment for initial condition appears to be less important for the treatment sections (with the exception of crack seal) as will be noted in the following discussion.

For the GPS sections, measuring the amount of cracking relative to the amount of initial cracking over time appears to reveal an increasing trend. (Bold numbers indicate trends over time). Both the ratio method (method 2) and the difference method (method 3) show that the amount of cracking increased over the three time periods for the GPS sections. The ratio method shows that the amount of cracking in the first 90 days is 1.37 times greater than the initial amount of cracking, and 1.51 and 2.38 times greater in days 90-180 and the period greater than 180 days, respectively. That is, cracking on the GPS sections more than doubles in six months, based on this data set. The difference measure also shows a trend over time; however, it is a bit perplexing that in the initial 90 days, there is actually **less** distress (-20.7) than there was initially. Whether this represents the normal degree of variability in the precision of the measurement of cracking or whether this is due to poor data quality is yet to be established.

The control sections in this data set were extremely variable and showed no trends in the growth of distress over time for any of the three methods. These data were extremely variable. For example, after the first 90 days there was a range in the amount of distress in 90 days (the measure for 0-90 days minus the initial distress), from -77 for one pavement to +331.5 for another. Clearly, if these are realistic measurements, there must be some other factor, such as traffic or patching, that has not been accounted for that is causing these variations. Adjusting for initial distress, for the control sections, did not appear to have any effect on establishing a trend.

For the overlay, slurry seal, and chip seal sections, there was an increase in the amount of average distress over time. The slurry seal method appeared to have the greatest increase in distress, going from 9.8 in the initial 90-day period to 57.4 after six months. Adjusting for the initial distress (methods 2 and 3) did not seem to be a factor, and no trends could be seen if this adjustment were made. In other words, the treatment seems to bring all pavements back to the same base initial condition and growth relative to this same base (zero distress) is the relevant measure. The degree of variability in initial condition wipes out any trend in growth that may be occurring. Again, if it were possible to adjust for other factors that are contributing to the degree of variability in initial condition, it might be possible to establish a trend.

Crack seal behaved differently from the other treatments in this data set. To begin with, nearly all pavements receiving crack seal treatment showed some sign of distress in the first 90 days, as table 28 showed. Also, most sections revealed a greater degree of distress **after** treatment in the first 90 days than was initially measured. This situation would imply that if the treatment were effective in reducing the amount of cracking, the effect wore off somewhere within the first 90 days. The average initial distress for the crack seal pavements was 276.9 (table 30). Yet, in the first 90 days after treatment, the amount of cracking already exceeded the initial degree of cracking and increased to 326.2 (table 31). The degree of cracking actually appeared to be constant from before and after crack seal treatment, implying that the treatment did nothing more than stabilize the degree of distress that was initially present; in other words the distress was not "reset" to zero as with the other treatments. Method 2, however, measuring relative distress to the initial pavement condition, did appear to show a trend over time. Based on this measure, the degree of cracking can be expected to double between three and six months after the treatment and quadruple in the period between six months of treatment and two years after treatment. The relative differences from initial distress did not show a pattern over time because of the variability of these differences and the fact that the average difference measure is more sensitive to extremes in the data than the ratio measurement.

Statistical Tests of Significance

Several statistical tests were performed on these data, but the degree of variability precluded establishing much significance. Analysis of variance was performed comparing the average distress among the three time periods over all sites, but the among-site variability exceeded the variability due to time and no significance could be found. If the among-site variability could be controlled by incorporating additional variables, the differences might be significant. In an attempt to "control" for the among-site variability, a nested Analysis of Variance (ANOVA) model was used. The model was

$$Y = TIME\ SITE(TIME)$$

where Y represented any of the three distress measurement methods, TIME was the three time periods, and SITE was the individual site. Because most sites were measured at different times, SITE was considered nested within time. Tables 32 through 34 depict the results of these analyses.

The first thing to note is that in all cases, the among-site variability is statistically significant. The table values are the p-values; in other words, the value at which the differences would not be statistically significant. P-values of less than .05 are generally declared as statistically significant. The p-values for TIME essentially test that the distress statistics listed in table 31 are equal among the three time periods (this, in itself, is not a test of time trends). For GPS, for example, we noted that both the ratio method and the difference method revealed a trend over time, but the average distress did not. The tables indicate that, though there appeared to be a trend for the ratio and difference measurements, these means were not significantly different from one another. The

Table 32. Average distress ANOVA results

Section	TIME	SITE (TIME)
Overlay	0.0004*	0.0001*
Slurry Seal	0.0727	0.0106*
Crack Seal	0.8129	0.0048*
Chip Seal	0.1617	0.0002*
GPS	0.0026*	0.0001*
Control	0.0001*	0.0001*

Table 33. Ratio ANOVA results

Section	TIME	SITE (TIME)
Overlay	0.0041*	0.0095*
Slurry Seal	0.0001*	0.0001*
Crack Seal	0.0463*	0.0248*
Chip Seal	0.1248	0.1976*
GPS	0.9859	0.9556*
Control	0.0001*	0.0001*

Table 34. Difference ANOVA results

Section	TIME	SITE (TIME)
Overlay	0.0001*	0.0001*
Slurry Seal	0.0001*	0.0001*
Crack Seal	0.9229	0.6887*
Chip Seal	0.0001*	0.0001*
GPS	0.2834	0.0213*
Control	0.0491*	0.0046*

* Statistically significant

average distress (AvG) for GPS, however, was different for the three time periods. That is, the average distress values of 213.2, 241.1, and 179.7 (table 31) were significantly different. This result is rather uninteresting since distress over time for these pavements is only meaningful when adjusted for initial distress. Similarly, for the treatment measurements that did not show a trend over time, the relevance of testing that they are different is questionable. To interpret these analyses, we must focus first on the measures that are showing a trend time over and then determine whether those means differ.

Thus, for GPS, the ratio and difference methods show a trend over time, but the means are not significantly different. For the control sections, no measures showed a significant trend, so none of the ANOVAs is relevant.

For crack seal, only the ratio measurement showed a significant trend and the means were significantly different (.0463 p value). Thus, there appears to be a significant increase in cracking for the crack seal treatment over time. Given the previous observations about crack seal, we can conclude that crack seal treatment:

1. Results in a significant increase in longitudinal and transverse cracking over a six-month period;

2. Does not improve the pavement performance (as reflected by degree of cracking) in the first 90 days but rather maintains the same level of performance as its initial level before any treatment.

For the other three treatments--overlay, slurry seal and chip seal--only the average distress measure over time showed trends (i.e., unadjusted for the pavement's initial condition). Of these, only the overlay treatment showed a statistically significant change in amount of cracking over time. A Duncan's test of these means, namely 6.1, 13.4, and 21.9, reveals that all three are statistically different from each other. What is interesting is that these means are lower than the average amount of cracking for either slurry or chip seal. The fact that the overlay means are significantly different over time when the others were not probably points more to a smaller variability among the overlay distress measurements than anything else. If so, it would mean that the overlay treatments yield a "better" data set for finding statistical significance because of the greater consistency in the distress measurements.

10

Products

Primary Products

Highway agencies will be able to use the performance data from this H-101 study to show the impact of the treatments studied on extending pavement life. Agencies that participate with their supplementary studies, which parallel the SHRP studies but address problems specific to the agency, will be able to evaluate the impact of localized conditions as well. When these are combined with their cost and life data, information about the cost-effectiveness of the treatments will be available.

The cost-effectiveness data will allow pavement management systems and managers to more accurately project needed preventive maintenance and its effects, which will lead to more efficient allocation of scarce maintenance dollars. In addition, it will improve the credibility of those who develop and present maintenance budget requests.

Knowledge about how treatments extend the life of the treated pavements will allow new and improved treatments to be developed. The construction rating system and construction control tables will help agencies better evaluate the quality of treatment application and determine its impact on performance of other treatments.

Other Products

A method to rate the effectiveness of pavement maintenance was prepared in the SPS-3 project. This methodology will allow development of a quantitative rating of the quality of a maintenance treatment application and is described in "Development of a Procedure to Rate the Application of Maintenance Treatments" (Bullard 1992). However, the methodology could be expanded to rate the materials and appropriateness of the road for that treatment.

The epoxy core test was developed in the SPS-4 study. This test establishes "ground truth" about the presence of voids under portland cement concrete pavements. It can be used to verify nondestructive test procedures used to identify voids under portland cement concrete pavements and to determine how well the undersealing was placed. The procedure is described with the field protocols in appendix B of this report.

Sets of treatment specifications were developed in the study that should provide state-of-the-practice information on the treatments to maintenance agencies. They are included in "Development of a Procedure to Rate the Application of Maintenance Treatments" (Bullard 1992).

Sets of lab and field test protocols were developed in the study that should provide maintenance agencies with guidance on testing related to the maintenance treatments studied. They are presented in the appendixes of this report.

Sets of lab and field data collection sheets were developed in the study that should help maintenance agencies with data collection and with establishing data bases related to the maintenance treatments studied. They are also presented in the appendixes of this report.

Lessons learned during construction are presented in "Development of a Procedure to Rate the Application of Maintenance Treatments" (Bullard 1992).

11

Future Activities

Preventive Maintenance Test Sections on Flexible Pavements (SPS-3)

The maintenance treatments placed in this study should have an impact on the life of the treated pavements for several years. It is expected that it will take five to ten years for the impact of some of the treatments applied to the flexible pavements to be determined. For this reason, it is important that the study be continued for several years after the completion of the Strategic Highway Research Program (SHRP) program. The test sections constructed for SHRP project H-101 were designated as a part of the Specific Pavement Studies (SPS) of the Long-Term Pavement Performance (LTPP) study that is to continue for fifteen years after the end of the SHRP program. This has established the vehicle for continued data collection. The following information is provided to describe a program for future activities to ensure that full the benefit is gained from the efforts begun in SHRP project H-101.

Resealing Cracks in Crack Sealing Test Sections

The purpose of the crack sealing test is to determine the impact on pavement performance of keeping the cracks sealed compared to the performance of the untreated control section. Each participating agency should periodically reseal the cracks in the crack sealing test section; however, cracks should not be sealed in any of the other SPS-3 test or control sections. Each participating agency should check the condition of the crack seal sections following the initial installation and reseal them when needed. It is requested that the reinspection and resealing be conducted semiannually before the wet or freeze periods at the particular site.

Controlling Maintenance on the SPS-3 Test Sections

The test sections must be protected from inappropriate maintenance and rehabilitation that would damage their usefulness in the study. The full value of the test sections can only be gained if each individual test section is allowed to deteriorate to a relatively poor condition. This will allow information on the impact of each treatment on pavement life to be determined.

The participating agencies must continue to control maintenance and rehabilitation at the H-101 test sites. Safety-related localized maintenance may be performed according to the governing highway authority standards at any time; however, information concerning the application of that maintenance must be recorded on applicable data sheets from the "Data Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988) and provided to the Regional Coordinating Office Contractor (RCOC). Safety-related items include spot patching of potholes or other surface defects that would be a hazard to the traveling public.

When the pavement section reaches a condition that is unacceptable to the responsible highway authority and cannot be repaired with the spot maintenance described above, the agency should contact the regional SHRP RCOC and Regional Engineer to arrange for a mutually agreeable date after which the agency can apply its desired rehabilitation treatment. This procedure will allow the SHRP staff to collect a final set of data before removing the section from the study. Some lead time will be required to arrange for the required testing and data collection. Each test section should be allowed to deteriorate to a reasonably low level of condition to adequately define the impact of applying preventive maintenance treatments; however, that level should not be so low that it becomes a safety hazard. An unacceptable condition includes anyone of the following:

1. a PSI of 2.0;

2. an unsafe skid level as defined by the agency within which the section is located; or

3. criteria normally used by the responsible highway authority.

After the last inspection is made by the SHRP staff, the section will no longer be considered an SPS-3 test section. The control sections probably will be the first to reach the terminal condition. The procedures apply to sections with treatments as well. Each test section at a test site should be allowed to reach the reduced level of condition and removed from the test individually.

Check Coring

After constructing the treatments, the material properties of the existing flexible pavements must be checked to determine how they change with time. The participating agency will perform the coring and associated traffic control in coordination with the SHRP RCOC. This procedure is scheduled to occur every two to three years until the SPS-3 pavement test sections are removed from the test program.

Postconstruction Condition Monitoring

Distress surveys were to be conducted within six months after application, one year after application, and on an annual basis thereafter. Deflection testing is to be conducted on the SPS-3 test sections biennially. Longitudinal profile and surface friction testing are to be conducted at the same time they are conducted on the adjacent GPS test sections.

Preventive Maintenance Test Sections on Rigid Pavements (SPS-4)

The maintenance treatments placed on rigid pavements in this study should have an impact on the life of the treated pavements for several years. It may take fifteen to twenty years for the impact of some of the treatments applied to the rigid pavements to be observed. For this reason, it is important that the study be continued for several years after the completion of the Strategic Highway Research Program (SHRP) program. The following information is provided to describe a program for future activities to ensure that full benefit is gained from the efforts begun in SHRP project H-101.

Construction

No additional SPS-4 sites are being solicited. However, some sites have been committed to the study on which the treatments have not been applied. A few may be delayed until the 1993 construction season because of unforeseen circumstances.

Resealing Cracks and Joints

Each participating agency should check the condition of the joint and crack sealant in the SPS-4 joint and crack seal test sections following the initial installation and reseal them when needed. It is requested that the reinspection and resealing be conducted semiannually before the wet or freeze periods at the particular site. The goal is to keep the cracks and joints sealed so the performance of the sealed section can be compared to the performance of the unsealed control section over a reasonable time period.

Controlling Maintenance on the SPS-4 Test Sections

The participating agency must control and document the maintenance and rehabilitation applied to the test sites including the sections to which a treatment has been applied as well as the control sections.

Safety-related, localized maintenance may be performed according to the governing highway authority standards at any time; however, information concerning the application of that maintenance should be recorded on applicable data sheets found in the "Data

Collection Guide for Long-Term Pavement Performance Studies" (SHRP 1988) and provided to the Regional Coordinating Office Contractor (RCOC). These data sheets can be provided by the SHRP RCOC. Safety-related items include patching of deteriorated areas or other surface defects that would be a hazard to the traveling public.

At some point the test sections will reach a condition level that is unacceptable to the responsible highway authority and that cannot be kept at an acceptable level with the spot maintenance allowed. Before the application of any intense maintenance or rehabilitation, the agency should contact the SHRP Regional Coordination Office to arrange for a mutually agreeable date after which the agency can apply its desired rehabilitation treatment. This procedure will allow SHRP staff to collect a final set of data before removing any specific section from the study. Some lead time will be required to arrange for the required testing and data collection. Each test section should be allowed to deteriorate to a reasonably low level of condition to adequately define the impact of applying preventive maintenance. However, that condition level should not create a safety hazard. General guidance on the minimum condition for SPS-4 sections is as follows:

1. a PSI of 2.5; and

2. criteria normally used by the responsible highway authority.

Each test section at an SPS-4 site should be allowed to reach the reduced level of condition and be removed from the test one at a time. The control sections probably will be the first to reach the terminal condition. After the last test section reaches the terminal condition and it is inspected by SHRP staff, the location will no longer be considered a test site.

Postconstruction Condition Monitoring

Distress surveys are to be conducted within six months after application, one year after application, and on an annual basis thereafter. Condition surveys should include measurements of faulting and edge drop-off. Deflection testing is to be conducted on the SPS-4 test sections biennially. Deflection testing of the underseal sections should include Benkelman Beam testing in addition to Falling weight deflectometer (FWD) testing, using the SPS-4 testing plan for these devices. Longitudinal profile and surface friction testing are to be conducted at the same time they are conducted on the adjacent GPS test sections.

Proposed Plan for Evaluating the SPS-3 and SPS-4 Test Sections

For each year data are collected, those responsible for evaluating the data should be available to answer questions and maintain contact with the regional offices responsible for collecting the data.

For the SPS-3 study, the data should be retrieved from the National Information Management System (NIMS) data base once every two years, and the impact of each treatment on performance by regions should be developed or updated. Five to six years after treatment application, there should be a full evaluation to determine which construction, structural, traffic, material, environmental, and other data can be shown to affect the performance. Ten to twelve years after treatment application, a final evaluation should be completed to include assessment of the impact of each treatment on performance, the impact of treatment time on performance, important performance indicators, and basic mechanisms of life extension.

For the SPS-4 study, the data should be retrieved from the NIMS data base once every four years, and the impact of each treatment on performance by regions should be developed or evaluated. Ten to twelve years after treatment application, a full evaluation should be performed to determine which construction, structural, traffic, material, environmental, and other data can be shown to affect the performance. Twenty to twenty-two years after treatment application, a final evaluation should be completed that includes assessment of the impact of each treatment on performance, the impact of treatment time on performance, important performance indicators, and basic mechanisms of life extension.

Every two years, meetings with the regional task groups and site visits to some of the treatment sites in each region will be needed to maintain continued interest and support of state and province highway agency personnel.

Failure Analysis

As each section fails, the cause of failure should be determined. At two SPS-3 sites in Arizona, it appears that some of the treated sections are failing more quickly than untreated sections because they have accelerated stripping in the underlying pavements. This type of problem needs to be thoroughly investigated and documented. Otherwise, it could be concluded that the treatments are not effective in a certain climatic region rather than that the treatments will not be effective in treating an asphalt concrete pavement that is experiencing stripping. The resulting incorrect conclusion could lead to an incorrect use of the treatments in certain circumstances.

12

Conclusions and Recommendations

Many agencies believe that preventive maintenance is cost-effective and make it an important part of their maintenance program. These agencies were willing to work together to support this project through a partnership of states, provinces, the Federal Highway Administration (FHWA), the Strategic Highway Research Program (SHRP) staff, and the research team. This type of cooperative effort can be used to address other common transportation problems.

Complex problems, such as the impact of preventive maintenance treatments on pavement life, require more time to solve than was available in the SHRP study period.

A thorough project-level evaluation should be conducted on a pavement section prior to application of a preventive maintenance treatment. If the treatment is placed on a pavement that is not in an appropriate condition for preventive maintenance, the treatment may provide little benefit, or in rare cases be detrimental to the pavement.

If the surface texture of the pavement is too coarse or open, the pavement could be unsuitable for application of some treatments without preparing the surface by either milling off the existing surface or applying a fog seal.

Potential embedment of the cover aggregate into the existing pavement surface should be included in the design of chip seals.

Some agencies do not check the calibration of the equipment used for preventive maintenance treatments. Equipment calibration ensures that the design material quantities are applied during construction and that the material is evenly applied. Equipment calibration should be required for all aggregate distributors, asphalt distributors, and slurry seal equipment.

Data availability problems prevented a thorough analysis of the impact of the treatments. In most cases however, the treatments have not been in place long enough to determine their full impact. For roughness and surface friction, no appreciable deterioration over time since treatment application could be differentiated from the normal variation in the measurements.

The distress surveys showed considerable variation over time, often with no discernible pattern. Longitudinal and transverse cracking are especially variable. In some cases the variation may be caused by differences in information determined from manual and PASCO measurements. This variation required that we discard several pavement test sections from the group being analyzed.

The distress data need to be carefully analyzed by an impartial party, and a plan developed on how to ensure continuity in this data. A cursory analysis indicated that in some cases, those interpreting the PASCO films are calling distress alligator cracking when those performing the manual surveys are calling the same distress longitudinal cracking. The PASCO film should still be available, and the distress from those surveys can be reviewed by the individuals completing the manual surveys to ensure that interpretation is consistent.

This problem will only get worse with time. It should be addressed immediately for all pavement distress data, not just the SPS-3 and SPS-4.

Data analysis and failure analysis for SPS-3 and SPS-4 test sections should be included in continuing efforts of SHRP LTPP studies.

Appendix A

Additions to the SHRP LTPP Manual for Field Testing

The material in this appendix was prepared as additions to the directions for falling weight deflectometer (FWD) testing included in the SHRP LTPP Manual for Field Testing. It provides guidance on how to complete the FWD testing and record the results for SPS-3 and SPS-4 test sections.

SPS-3 Additions to the SHRP LTPP Manual for Field Testing, Operational Field Guidelines, Version 1.0, 1989

The procedure for evaluating the SPS-3 test sections using the falling weight deflectometer (FWD) is very similar to the procedures outlined in the other chapters of the basic manual. Changes to the procedure used to collect FWD data on GPS test sections are outlined below.

The drop sequence for SPS sections shall be as follows:

II. FWD FIELD TESTING (GPS SECTIONS)

DROP (REPETITION) SEQUENCE

SPS-3

Sequence No.	No. of Drops	Drop Height	Remarks
1	3	h_3	See Note #1
2	3	h_1	See Note #2
3	3	h_2	See Note #2
4	3	h_3	See Note #2
5	3	h_4	See Note #2

Note #1: Drops used for seating only; no data recorded.

Note #2: Store only deflection peaks for first two drops at each drop height; for last drop at each drop height a complete deflection-time history will be stored.

FWD TEST PLANS

Please note that all testing must use station 0+00 of each of the test sections as the reference point for the distance measuring indicator on the FWD unit.

Detailed Test Plan (FLEX) - The distance between tests should be 100′ ft. (30 m) instead of 25′ ft. (8 m). Testing will only be completed at mid-lane and in the outer wheel path. Table 1 from the guide still applies except that the number of test points shall be 12 (6@ P_1 + 6@ P_3).

OTHER FWD OPERATOR FIELD MEASUREMENTS

Temperature Gradient Measurements - Temperature measurements will be conducted in accordance with the latest version of the SHRP LTPP Manual for FWD Testing. However, temperature measurements need only be made at the GPS locations and at two additional locations within the treatment layout. The readings should be continued throughout the duration of the testing on the SPS sections.

III. DATA ACQUISITION AND HANDLING

Test Sequence Setups (Main Menu Choice 1, Same as Testing) - See Below.

"FLEX" BASIN TEST

11. Deflector distances: 8 12 18 24 36 60
12. Drop Numbers 1-11
13. Heights CCC111222333444 (note: 3 drops at 4 heights)
14. Test Plots .....*..*..*..*
15. Save Peaks ...************
16. Load His none stored
17. Whole His .....*..*..*..*

USING THE SOFTWARE IN THE FIELD

Field Data Collection Program - No Change. Note that the SHRP ID will be different for each test section at a, SPS site, including any additional state sections.

SPS-4 Additions to the SHRP LTPP Manual for Field Testing Operational Field Guidelines, Version 1.0, 1989

The procedure for evaluating the SPS-4 test sections using the falling weight deflectometer (FWD) is similar to the procedures outlined in the other chapters of this manual. Changes to the procedure used to collect FWD data on GPS test sections are outlined below.

The drop sequence for SPS sections shall be as follows:

II. FWD FIELD TESTING (GPS SECTIONS)

DROP (REPETITION) SEQUENCE FOR STANDARD TESTING

SPS-4

Sequence No.	No. of Drops	Drop Height	Remarks
1	3	h_3	See Note #1
2	4	h_2	See Note #2
3	4	h_3	See Note #2
4	4	h_4	See Note #2

Note #1: Drops used for seating only; no data recorded.
Note #2: Store only deflection peaks for first three drops at each drop height; for last drop at each drop height a complete deflection-time history will be stored.

DROP (REPETITION) SEQUENCE FOR LOSS OF SUPPORT TESTING

SPS-4

Sequence No.	No. of Drops	Drop Height	Remarks
1	3	h_3	See Note #1
2	3	h_1	See Note #3
3	3	h_2	See Note #3
4	3	h_3	See Note #3

Note #1: Drops used for seating only; no data recorded.
Note #3: Store only deflection peaks.

FWD TEST PLANS

Please note that all testing must use station 0+00 of each of the test sections as the reference point for the distance-measuring indicator on the FWD unit.

Detailed Test Plan (RIGID) - The deflection testing for SPS-4 sites will consist of a single pass in the outer wheel path (OWP). Tests will be conducted on each side of the joint/crack and at the midslab using the load transfer test sensor configuration. The standard test procedure for joint/crack-sealing test sections, control sections, and state test sections will be to test the first joint and the center of the first slab. Every third joint and slab will be tested thereafter. Any cracks within the slabs tested will also be tested. For the **underseal** test sections, **all slabs/panels** in the section will be tested.

OTHER FWD OPERATOR FIELD MEASUREMENTS

Temperature Gradient Measurements - Temperature measurements will be conducted in accordance with the latest version of the SHRP LTPP Manual for FWD Testing. However, temperature measurements need only be made at GPS locations and at two additional locations within the treatment layout. The readings should be continued throughout the duration of the testing on the SPS sections.

Joint and Crack Widths "RIGID" Category - The degree and severity of pavement cracking is an important factor influencing the deflection response of any pavement. Likewise, joint openings in rigid pavement systems also affect deflection and load transfer. While a wide variety of differing crack types, severity (width of opening), and frequency will be encountered in all GPS sections, it will be physically impossible, because of time constraints, to measure crack/joint openings at each FWD test point within a given section. Because of this, the following procedure will be followed for each FWD Operational Category.

III. DATA ACQUISITION AND HANDLING

Test Sequence Setups (Main Menu Choice 1, Same as Testing) - See Below.

"RIGID/CRCP" Joint/Crack Test

11. Deflector distances: 12 18 24 36 60, with sensor number 2 actually located at -12 inches.
12. Drop Numbers 1-15
13. Heights CCC222233334444 (note: 4 drops at each of 3)
14. Test Plots ......*...*...* (optional, though recommended so that the operator may observe the plot as a data validity check)
15. Save Peaks ...************
16. Load His none stored
17. Whole His ......*...*...*

USING THE SOFTWARE IN THE FIELD

Field Data Collection Program - No Change. Note that the SHRP ID will be different for each test section at a SPS site, including any additional state sections.

Appendix B

Field Protocols

This appendix contains the protocols developed to standardize data collection conducted in field operations for SHRP study H-101, Pavement Maintenance Effectiveness. American Association of State Highway Officials (AASHTO) and American Society for Testing and Materials (ASTM) procedures were used in developing the protocols whenever possible (AASHTO 1990; ASTM 1992a; ASTM 1992b). Data collection sheets for these protocols are included in appendix C.

List of Field Protocols

SHRP Test Number	Protocol Number	Name
HF01	H21F	Standard Practice for Sampling of ASTM D 3405 Crack and Joint Sealant
HF02	H22F	Standard Practice for Sampling Bituminous Materials
HF03	H23F	Standard Practice for Sampling Aggregates
HF04	H24F	Standard Practice for Measuring Slurry Seal Application Rate
HF05	H25F	Standard Practice for Measuring Emulsified Asphalt Application Rate
HF06	H26F	Standard Practice for Measuring Aggregate Application Rate
HF07	H27F	Standard Practice for Determining Moisture in Slurry Seal and Chip Seal Aggregates
HF08	H28F	Standard Practice for Sampling Slurry Seal During Construction
HF09	H29F	Dynaflect Deflection Testing
HF10	H30F	Falling Weight Deflectometer Deflection Testing
HF11	H31F	Transient Dynamic Response System Testing
HF12	H32F	Benkelman Beam Deflection Testing
HF13	H33F	Sampling ASTM D 3405 Crack and Joint Sealant Material
HF14	H34F	Sampling Silicone
HF15	H35F	Flow of Grout Mixtures
HF16	H36F	Epoxy-Core Test for Void Detection

SHRP Protocol: H21F
For SHRP Test Designation: HF01
Standard Practice for Sampling of ASTM D 3405 Crack and Joint Sealant

This SHRP protocol covers the sampling of ASTM D 3405 crack and joint sealant materials at the point of manufacture, supply terminal, or at shipment delivery. It is intended that the sampling be performed on asphalts used in the H-101/SPS-3 studies. The sampling should be performed in accordance with ASTM D 3405, paragraph 6. The sample size will conform to the requirements of paragraph 6, 10 lb (4.5 kg) for each sample.

SHRP Protocol: H22F
For SHRP Test Designation: HF02
Standard Practice for Sampling Bituminous Materials

This SHRP protocol covers the sampling of bituminous materials at the point of manufacture, supply terminal, or at shipment delivery. It is intended that the sampling be performed on asphalts used in the H-101/SPS-3 studies. The sampling should be performed in accordance with AASHTO T 40-78, Standard Method of Sampling Bituminous Materials.

When sampling from tank cars or distributor trucks, use the Sampling Valve method described in paragraph 7.1. Use this method in place of ASTM D 140 when necessary. The container will conform to the requirements of paragraph 4, wide-mouth plastic jars, either quart or gallon. All jars must be filled as nearly full as possible. The sample size will conform to the following:

Sampling at the Construction Site:

Chip Seal:
Two Quarts to SHRP-Designated Lab

Slurry Seal:
Two Quarts to SHRP-Designated Lab

SHRP Protocol: H23F
For SHRP Test Designation: HF03
Standard Practice for Sampling Aggregates

This SHRP protocol covers sampling aggregates to be used in the H-101/SPS-3 and 4 field testing and sampling. The sampling of the aggregate should be completed in accordance with AASHTO T 2-78(1982), Standard Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials. The sample size will conform to the following:

Sampling at the Construction Site:

Chip Seal:
Twenty pounds to SHRP-Designated Lab

Slurry Seal:
Twenty pounds to SHRP-Designated Lab

SHRP Protocol: H24F
For SHRP Test Designation: HF04
Standard Practice for Measuring Slurry Seal Application Rate

This SHRP protocol covers the method for determining the application rate of slurry seals. A specific procedure cannot be provided because of differences in slurry seal equipment. Each slurry seal machine operator should be maintaining a daily operation log that will be helpful in determining quantities. From the revolution counter readings on the slurry machine, determine the readings before and after application of the treatment in each lane. Determine the pounds of wet aggregate applied, the moisture content of the aggregate using SHRP Protocol H27F (Test Method HF07), the amount of mineral filler applied, the quantity of emulsion applied, and the amount of water added.

SHRP Protocol: H25F
For SHRP Test Designation: HF05
Standard Practice for Measuring Emulsified Asphalt Application Rate

This SHRP protocol covers the method for determining the application rate of emulsified asphalt as a part of chip seals. A specific procedure cannot be provided because of differences in distributor equipment. The quantity of emulsified asphalt will be determined by physically measuring the quantity in the distributor before the application and the quantity in the distributor after application with a calibrated stick. Adjustments in quantity due to temperature will be made using the procedure and the correction factors in table C-1 in Basic Asphalt Emulsion Manual (MS 19), The Asphalt Institute, Second Edition, 1979 (AI 1979). In addition, the rate of application reading from the bitumen distributor will be recorded.

SHRP Protocol: H26F
For SHRP Test Designation: HF06
Standard Practice for Measuring Aggregate Application Rate

This SHRP protocol covers the method for determining the application rate of aggregates as a part of chip seals. Two grooved rubber pads cut to 3-ft by 3-ft (1-m by 1-m) will be used. The pads will be placed 1-ft to 2-ft (0.3-m to 0.6-m) beyond where the emulsion application stops, and the chip spreader will continue spreading 5-ft to 8-ft (2-m to 3-m) beyond where the emulsion application stops. One will be placed in the outside wheel path and the other in the center of the lane. The chips along the edge will be carefully swept onto the mat. The aggregate will be poured into preweighed tared bags. The bags will be weighed to the nearest quarter pound and the quantity of aggregate per square yard determined and recorded for both the wheel path and center of the lane. These samples may be used as representative samples for sending to the SHRP-Designated Laboratories as a part of HF03.

SHRP Protocol: H27F
For SHRP Test Designation: HF07
Standard Practice for Determining Moisture in Slurry Seal and Chip Seal Aggregates

This SHRP protocol covers the method for determining the moisture content of the aggregates for chip seals and slurry seals in the field. AASHTO Standard Method T 217, Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester, will be used. The 26-g tester will be used. It is not necessary to use steel balls. The tester will be shaken for three minutes.

The tester must be calibrated with the chip seal and slurry seal aggregate prior to field testing in accordance with Note 5.

SHRP Protocol: H28F
For SHRP Test Designation: HF08
Standard Practice for Sampling Slurry Seal During Construction

This SHRP protocol covers the method for sampling slurry seals during construction. A pan capable of holding one qt of slurry seal will be used. The slurry seal sample will be collected from both sides of the discharge chute that moves the slurry seal from the pug mill to the spreader box. One qt (1-l) will be collected. It will be helpful if the pan has a 2-ft to 2-ft (0.6-m to 1-m) handle attached. The sample will be placed in wide-mouth plastic jars, one qt (1-l) in size.

SHRP Protocol: H29F
For SHRP Test Designation: HF09
Dynaflect Deflection Testing

This SHRP protocol covers the use of a Dynaflect deflection device to obtain information on joint/crack load transfer and loss of support for SPS-4 sites. One pass in the outer wheel path will be made, testing each side of the joint/crack and the midslab. All slabs in the section will be tested.

Data for location, surface moisture condition, load, air and pavement temperatures, and measurements from deflection sensors should be recorded on the data sheets.

SHRP Protocol: H30F
For SHRP Test Designation: HF10
Falling Weight Deflectometer Deflection Testing

This SHRP protocol covers the use of a falling weight deflectometer (FWD) to obtain information on joint/crack load transfer, structural capacity, and loss of support for SPS-4 sites. Operation guidelines and data transfer directions are found in the latest version of the SHRP LTPP Manual for FWD Testing. The deflection testing for SPS-4 sites will consist of a single pass in the outer wheel path (OWP). Tests will be conducted on each side of the joint/crack and at the midslab using the load transfer test sensor configuration. The standard test procedure for joint/crack-sealing test sections, control sections, and state test sections will be to test the first joint and the center of the first slab. Every third joint and slab will be tested thereafter. Any cracks within the slabs tested will also be tested. For the underseal test sections, all slabs/panels in the section will be tested. For routine testing, the standard Rigid drop sequence will be used. When the FWD is being used in conjunction with other deflection equipment to test for void locations, the following drop sequence will be used:

Sequence No.	No. of Drops	Drop Height	Remarks
1	2	h_3	Note 1
2	3	h_1	Note 2
3	3	h_2	Note 2
4	3	h_3	Note 2

Note 1: Drops used for seating only, no data taken.
Note 2: Store deflection peaks only.

Data for the location and other information will be recorded on the data sheet in SPS-4 Attachment F. The deflection data will be recorded on diskettes in accordance with the SHRP LTPP Manual for FWD Testing.

Temperature measurements will be conducted in accordance with the latest version of the SHRP LTPP Manual for FWD Testing. However, temperature measurements need only be made at the GPS locations and at two additional locations within the treatment layout.

SHRP Protocol: H31F
For SHRP Test Designation: HF11
Transient Dynamic Response System Testing

This SHRP protocol covers the use of the transient dynamic response system (TDR) to obtain information on joint/crack load transfer as well as loss of support for SPS-4 sites. Each slab or panel in the test section will be tested at three longitudinal positions, 2-ft (0.6-m) from each joint or crack and at the slab midpoint. At each longitudinal position, simultaneous tests will be conducted in the outer wheel path, lane centerline and inner wheel path. Test positions are indicated on the attached figure.

Data for location, surface moisture condition, air and pavement temperatures, and description of slab/support condition will be recorded on data sheets.

SHRP Protocol: H32F
For SHRP Test Designation: HF12
Benkelman Beam Deflection Testing

This SHRP protocol covers the use of a Benkelman Beam to determine locations to be undersealed as a part of SPS-4. Benkelman Beams should comply with AASHTO T-256, Standard Recommended Practice for Pavement Deflection Measurements, Part 3.2

Each joint or crack defining a slab or panel should be tested. All testing should be limited to the hours of midnight to 10 a.m. The testing should be stopped earlier if there is evidence of slab lockup because of thermal expansion of the slabs. Testing may be continued after the hour specified if the slabs are not interlocked or under compression. However, a stronger foundation or other improved pavement feature could also result in decreased deflection. Joint interlock will have to be evaluated on a site-by-site basis.

Time of testing may be reduced by using two Benkelman Beams. In such a case, position each Benkelman Beam so that the probes are across from each other at a joint or crack on the corners of adjoining slabs. Zero the gauges with no load on the slab on either side of the joint or crack. Move the test vehicle parallel to the edge of the pavement so that the outside wheel of the test axle is within one ft. of the edge. Stop the vehicle when the center of the test axle is about one ft. from the joint or crack on the approach slab. Read both gauges and record the data. Move the test vehicle across the joint or crack to a similar position on the leave slab with the center of the test axle one ft. beyond the joint or crack. Read both gauges and record the data on the Data Sheets in SPS-4 Attachment F. Test adjoining slabs or panels for each joint or crack. All joints with deflections in excess of 0.020-in (0.5-mm) will be subsealed in accordance with the plans and specifications. If only one Benkelman Beam is used, the axle load will have to be repositioned to obtain loaded and unloaded data for each side of the joint or crack.

During deflection testing the Benkelman Beam will be positioned on the shoulders for two-lane roads or on an adjoining lane when there are more than two lanes.

SHRP Protocol: H33F
For SHRP Test Designation: HF13
Sampling of ASTM D 3405 Crack and Joint Sealant Material

This SHRP protocol covers the sampling of ASTM D 3405 crack and joint sealant materials at the point of manufacture, supply terminal, or at point of delivery. It is intended that the sampling be performed on crack and joint sealants used in the H-101/SPS-4 studies. The sampling should be performed in accordance with ASTM D 3405, paragraph 6. The sample size will conform to the requirements of paragraph 6, (ten lbs.). A sample from each individual source of sealant used will be taken.

SHRP Protocol: H34F
For SHRP Test Designation: HF14
Sampling Silicone

This SHRP protocol covers the sampling of Georgia Department of Transportation (GA DOT) 833.06 joint sealant materials at the point of manufacture, supply terminal, or at point of delivery. It is intended that the sampling be performed on joint sealants used in the H-101/SPS-4 studies. This sampling will require two qt.-size tubes or six 10 oz. tubes of sealant. A sample from each individual source of sealant will be taken. The GA DOT specification and testing requirements are given in SPS-4 Attachment G.

SHRP Protocol: H35F
For SHRP Test Designation: HF15
Flow of Grout Mixtures

This SHRP protocol covers the determination of flow of grout mixtures by the flow-cone method. It is intended that the testing be performed on the material used as grout for undersealing as a part of SPS-4. The test should be performed in accordance with ASTM C 939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow-Cone Method).

SHRP Protocol: H36F
For SHRP Test Designation: HF16
Epoxy-Core Test for Void Detection

The epoxy-core test should be done after deflection testing and before undersealing. This technique should be applied in the same time frame or under the same weather conditions (temperature/sun) as those when the deflection testing was conducted. It should be done in the early morning when the effects of slab curl have not had a chance to mask the presence of voids.

Drill the epoxy access holes in both the approach slab and the leave slab, approximately 18-in by 18-in (0.4-m by 0.4-m) away from the intersection of the joint/crack and edge of pavement. The epoxy core test should be applied at six to eight joints/cracks with small or no deflections and six or eight joints/cracks with large deflections. These small and large deflection groups will be based on the 0.020-in (0.5-mm) deflection criteria from the Benkelman Beam results. With an access hole on each side of the joints/cracks, 24 to 32 access holes will be required.

A rotohammer (not a core drill) using a 1 1/2-in to 2-in (38-mm to 50-mm) dry bit should be used to drill from the pavement and into the subgrade to a depth of about 1 in (25-mm). Scrape down the sides of the access hole using a long screw driver to make sure that any chips at the bottom of the hole are loose.

Vacuum the debris from the rotohammer operation out of the hole leaving a small reservoir at the bottom. A shop vacuum can be used for this purpose. Vacuum out any accumulated water.

To facilitate mixing and pouring of the epoxy, a coffee can (approximately one and one half lb. size), funnel, and disposable one-pt. measuring device are useful. A two-part epoxy is mixed with enough food coloring (i.e., red) to provide good color contrast and poured into the hole. The viscosity of the epoxy should be approximately 400 cps. An epoxy formulation can be selected that will set in from ten minutes to two hours. Thirty minutes has proven adequate in most cases. Access time to the pavement and how quickly the epoxy can be utilized will determine the appropriate set time. The supplier can help in selecting the correct epoxy formulation.

One indication of a large void is the rapid intake of epoxy. If up to a quart (liter) is rapidly taken into the hole, steps should be taken to prevent the waste of epoxy material. This can be accomplished by adding an equal part of clean masonry sand to additional epoxy introduced into the hole. The sand will thicken the epoxy so that it will not keep flowing into the void. This thickening process should be continued until the access hole is filled.

SHRP Protocol: H36F
For SHRP Test Designation: HF16
Epoxy-Core Test for Void Detection

Undersealing should take place after the epoxy sets. Subsequently, after the grout thoroughly sets, a core of 4-in to 6-in (100-mm to 150-mm) in diameter should be taken through the pavement that cross sections the access hole through the subbase/pavement interface. If the grout flows under the epoxy, then the core should show this fact and prove that the slab is being lifted. The subbase will generally be bonded to the bottom of the pavement with the voids (now a pink epoxy) trapped between the two. The thickness of this epoxy should be measured to the nearest 1/16 in (1.6-mm).

Data to be recorded includes weather conditions, viscosity of epoxy, location of holes, amount of epoxy per hole, and thickness of epoxy.

Appendix C

Field Data Collection Sheets

This appendix contains the data collection sheets used record data in field operations for SHRP study H-101, Pavement Maintenance Effectiveness. Protocols for collecting data are included in appendix B.

LTPP-SPS CONSTRUCTION DATA REFERENCE PROJECT STATION TABLE CONSTRUCTION DATA SHEET 1	* STATE CODE [__ __] * SPS PROJECT CODE [__ __] * TEST SECTION NO. [_0 _0]

ORDER	TEST SECTION ID NO (1)	REFERENCE PROJECT STATION NUMBER		(4) CUT-FILL[1]	
		(2) START	(3) END	TYPE	STATION
1	_ _ _ _ _ _ _	0 + 0 0	_ _ _ _ _ + _ _	_	_+_ _
2	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
3	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
4	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
5	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
6	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
7	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
8	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
9	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
10	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
11	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
12	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
13	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
14	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
15	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
16	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
17	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
18	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
19	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _
20	_ _ _ _ _ _ _	_ _ _ _ _ + _ _	_ _ _ _ _ + _ _	_	_+_ _

5. SPS - GPS TEST SECTION EQUALITIES
GPS section _ _ _ _ _ _ _ is the same as SPS section _ _ _ _ _ _ _
GPS section _ _ _ _ _ _ _ is the same as SPS section _ _ _ _ _ _ _

6. INTERSECTIONS BETWEEN TEST SECTION ON THE PROJECT

ROUTE	PROJECT STATION NO.	RAMPS EXIT	RAMPS ENT	INTERSECTION STOP	INTERSECTION SIGNAL	INTERSECTION UNSIG
____________	_ _ _ _ _ + _ _	___	___	___	___	___
____________	_ _ _ _ _ + _ _	___	___	___	___	___
____________	_ _ _ _ _ + _ _	___	___	___	___	___

Note 1. Indicate the type of subgrade section the test section is located on:
Cut........ 1 Fill....... 2 At-Grade....... 3 Cut and Fill.......4
If cut-fill transition is located in a test section, enter test section station of the cut-fill transition location.

PREPARER ____________ EMPLOYER ____________ DATE ____________

Revised January 24, 1991

Sheet 1 — *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP SECTION ID [_ _ _ _]

CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. ***DATE WORK BEGAN (MONTH/DAY/YEAR)** [_ _/_ _/_ _]

   ***DATE WORK WAS COMPLETED (MONTH/DAY/YEAR)** [_ _/_ _/_ _]

2. ***TIME WORK WAS BEGUN** (Hr/Min) [_ _/_ _]

   ***TIME OF DAY** (AM = 1, PM = 2) [_]

   ***TIME WORK WAS COMPLETED** (Hr/Min) [_ _/_ _]

   ***TIME OF DAY** (AM = 1, PM = 2) [_]

3. ***LENGTH OF TEST SECTION SEALED** (Feet) [_ _ _ _]

   ***WIDTH OF TEST SECTION SEALED** (Feet) [_ _._]

4. ***TYPE OF SEAL COAT** [3]
   AGGREGATE SEAL............3

5. ***TYPE/GRADE OF BITUMINOUS MATERIAL IN SEAL COAT**
   (SEE TABLE A.16 FOR TYPE CODE) [_ _]
   DESCRIPTION OF "OTHER CEMENT" [____________________]

   MANUFACTURER NAME [____________________]

   MANUFACTURER MATERIAL NAMES [____________________]

6. ***WAS APPLICATION RATE OF BITUMINOUS MATERIAL ADJUSTED AT JOB SITE TO CORRECT FOR SURFACE CONDITION** (YES = 1, NO = 2) [_]

7. ***TARGET APPLICATION RATE FOR BITUMINOUS MATERIAL** (Gallons/Sq Yd) [._ _ _]

8. ***ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR READINGS** (Gallons/Sq Yd) [._ _ _]

9. ***ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR TANK MEASUREMENTS** (Gallons/Sq Yd) [._ _ _]

Sheet 2 *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP SECTION ID [_ _ _ _]

CHIP SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

10. ***TARGET APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL** (°F) [_ _ _]

11. ***ACTUAL APPLICATION TEMPERATURE OF BITUMINOUS MATERIAL** (°F) [_ _ _]

12. ***TYPE OF AGGREGATE USED IN SEAL COAT**
    (SEE TABLE A.9 FOR TYPE CODE) [_ _]

    DESCRIPTION OF "OTHER AGGREGATE" [____________________]

    AGGREGATE SOURCE [____________________]

13. ***TARGET APPLICATION RATE FOR AGGREGATE** (Pounds/Sq. Yard) [_ _._]

14. ***ACTUAL APPLICATION RATE FOR AGGREGATE IN WHEEL PATHS**
    (Pounds/Sq. Yard) [_ _._]

15. ***ACTUAL APPLICATION RATE FOR AGGREGATE BETWEEN WHEEL PATHS**
    (Pounds/Sq. Yard) [_ _._]

16. ***INITIAL EXISTING PAVEMENT SURFACE PREPARATION** (SWEEPING REQUIRED) [_]
    NONE....................1 COLD MILL..................3
    SWEEP CLEAN ONLY.......2 SHOT BLAST.................4
    OTHER (SPECIFY) ____________________5

17. ***PAVEMENT CONDITIONS AT TIME SEAL COAT APPLIED**
    PAVEMENT TEMPERATURE (°F) (60 °F Required) [_ _ _]

    CONDITION OF SURFACE BEFORE SEALING [_]
    CLEAN ....1 MOSTLY CLEAN..........2
    SOMEWHAT DIRTY....3 DIRTY.................4

    SURFACE MOISTURE CONDITION [_]
    DRY .... 1 MOSTLY DRY............2
    SOMEWHAT MOIST.....3 WET...................4

18. ***AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED**
    AIR TEMPERATURE (°F) (60 °F Required) [_ _ _]

    RELATIVE HUMIDITY (Percent) [_ _ _]

Sheet 3 — *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP SECTION ID [_ _ _ _]

CHIP SEAL APPLICATION DATA FOR PAVEMENT WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

19. ***SURFACE CONDITION** [_]
    BADLY OXIDIZED ....1 NORMAL 3
    SLIGHTLY OXIDIZED.........2 SLIGHTLY FLUSHED.............4
    FLUSHED....................5 FLUSHED ONLY IN WHEEL PATHS..6
    OTHER (SPECIFY) ______________________________ 7

20. ***AVERAGE CRACK SEVERITY LEVEL** (SEE DISTRESS IDENTIFICATION MANUAL)
    LOW = 1, MODERATE = 2, HIGH = 3 [_]

21. ***PRIMARY TYPE OF CRACKS** (SEE TABLE A.22 FOR TYPE CODES) [_ _]
    SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

22. ***ESTIMATED PERCENT OF CRACKS SEALED** [_ _ _]

23. ***AGGREGATE CONDITION PRIOR TO USE** (CLEAN OR ONLY SLIGHTLY DIRTY REQUIRED)
    CLEAN = 1 ONLY SLIGHTLY DIRTY = 2 SOMEWHAT DIRTY = 3 DIRTY = 4 [_]

    VERY DRY...........1 DRY........... 2 ONLY SLIGHTLY DAMP..3
    SOMEWHAT DAMP..... 4 SLIGHTLY WET.. 5 WET................ 6 [_]

24. ***AGGREGATE MOISTURE CONTENT** (PERCENT BY WEIGHT) [_ _._]

25. ***ESTIMATED TIME BETWEEN APPLICATION OF BITUMINOUS MATERIAL AND SPREADING OF AGGREGATE MATERIAL** (SECONDS) [_ _ _]

26. ***ESTIMATED TIME BETWEEN APPLICATION OF AGGREGATE MATERIAL AND INITIAL ROLLING** (SECONDS) [_ _ _]

27. ***NUMBER OF COVERAGES PER ROLLER** (THREE REQUIRED) [_]

28. ***ESTIMATED TIME BETWEEN FINAL ROLLING AND BROOMING SECTION** (HOURS) [_ _ _._]

29. ***ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO REDUCED SPEED TRAFFIC** (HOURS) [_ _._]

30. ***MAXIMUM REDUCED SPEED ALLOWED** (MPH) [_ _]

31. ***ESTIMATED TIME BETWEEN FINAL ROLLING AND OPENING SECTION TO FULL SPEED TRAFFIC** (HOURS) [_ _._]

Sheet 4 *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP SECTION ID [_ _ _ _]

EQUIPMENT USED IN CHIP SEAL APPLICATION

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

32. ***ROLLER DATA**

ROLLER BRAND AND NUMBER	ROLLER DESCRIPTION	GROSS WT. (TONS)	TIRE PRES (PSI)	WIDTH (INCHES)	SPEED (MPH)
________	Pneumatic-tired	_ _._	_ _ _.	_ _.	_._
________	Pneumatic-tired	_ _._	_ _ _.	_ _.	_._
________	Pneumatic-tired	_ _._	_ _ _.	_ _.	_._
________	Pneumatic-tired	_ _._	_ _ _.	_ _.	_._

33. ***ROLLING INFORMATION** (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)
    - ROLLER SPEED EXCEEDS 5 MPH [_]
    - FINAL ROLLER COVERAGES IN DIRECTION OF TRAFFIC [_]

34. ***DISTRIBUTOR**
    - BRAND ________
    - MODEL ________
    - YEAR [_ _ _ _]
    - NOZZLE ANGLE (Degrees) [_ _]
    - SPRAY BAR HEIGHT (Inches) [_ _._]
    - NOZZLE SPACING (Inches) [_ _._]
    - NOZZLE BRAND ________
    - MODEL ________

35. ***DISTRIBUTOR DETAILS** (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4)
    - CLEANED BEFORE USE [_]
    - EQUIPPED WITH A BITUMETER THAT REGISTERS IN FT/MIN OR GAL/SY [_]
        - BITUMETER VISIBLE TO OPERATOR [_]
        - BITUMETER USED BY OPERATOR [_]
    - EQUIPPED WITH A TACHOMETER ON THE PUMP [_]
        - TACHOMETER VISIBLE TO THE OPERATOR [_]
        - TACHOMETER USED BY OPERATOR [_]
    - EQUIPPED WITH HEATERS THAT CAN BE USED TO BRING THE EMULSIFIED ASPHALT MATERIAL TO SPRAY APPLICATION TEMPERATURE [_]
    - THERMOMETER VISIBLE TO OPERATOR [_]
    - THERMOMETER WELL FREE OF CONTACT WITH THE HEATING TUBE? [_]
    - EQUIPPED WITH A FULL CIRCULATORY SYSTEM INCLUDING THE SPRAY BAR [_]

Sheet 5 *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP SECTION ID [_ _ _ _]

EQUIPMENT USED IN CHIP SEAL APPLICATION (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

36. ***DOUBLE OR TRIPLE LAP** (DOUBLE = 1, TRIPLE = 2) [_]

37. ***APPLICATION OF ASPHALT** (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - WAS UNIFORM SPRAY APPLIED [_]
    - WAS ATOMIZATION NOTICED [_]
    - WERE ANY LOCATIONS MISSED OR DEFICIENT IN ASPHALT [_]
    - WAS A HAND SPRAYER USED TO TOUCH UP MISSED SPOTS [_]
    - WAS BUILDING PAPER USED AT THE BEGINNING OF THE TREATMENT [_]
    - WAS BUILDING PAPER USED AT THE END OF THE TREATMENT [_]
    - WAS STREAKING OF THE ASPHALT NOTICED [_]
    - WERE END NOZZLES USED TO ALLOW FOR AN OVERLAP OF EMULSIFIED ASPHALT BINDER TO THE ADJACENT LANE [_]

38. ***AGGREGATE SPREADER**
    - BRAND ____________________
    - MODEL ____________________

39. ***IS A SELF-PROPELLED MECHANICAL SPREADER USED ?** (YES = 1, NO = 2) [_]

40. ***SPREADING OF AGGREGATE** (YES = 1, USUALLY = 2, SOMETIMES = 3, NO = 4, NA = 5)
    - IS AGGREGATE SPREAD UNIFORMLY [_]
    - IS STREAKING OF THE AGGREGATE NOTICED [_]

41. ***IS A MOTORIZED POWER BROOM USED TO REMOVE LOOSE MATERIAL FROM THE SURFACE AFTER ROLLING IS COMPLETE?** (YES = 1, NO = 2) [_]

42. ***NUMBER OF PASSES WITH BROOM** [_ _]

43. ***ESTIMATED PERCENT OF LOOSE MATERIAL REMOVED DURING BROOMING** [_]
    - NONE (<1%)...............1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%)............3
    - SUBSTANTIAL (>5%)........4

44. ***ESTIMATED PERCENT OF LOOSE MATERIAL REMAINING AFTER BROOMING** [_]
    - NONE (<1%)...............1
    - VERY LITTLE (1 - 3%).....2
    - SOME (3 - 5%)............3
    - SUBSTANTIAL (>5%)........4

45. **FIELD NOTES AVAILABLE** (YES = 1, NO = 2) [_]
    FIELD NOTE LOCATION [________________________________]

Revised January 24, 1991

Sheet 6 *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP SECTION ID [_ _ _ _]

SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. ***DATE WORK BEGAN (MONTH/DAY/YEAR)** [_ _ / _ _ / _ _]

   ***DATE WORK WAS COMPLETED (MONTH/DAY/YEAR)** [_ _ / _ _ / _ _]

2. ***TIME WORK WAS BEGUN** (Hr/Min) [_ _ / _ _]

   TIME OF DAY (AM = 1, PM = 2) [_]

   ***TIME WORK WAS COMPLETED** (Hr/Min) [_ _ / _ _]

   TIME OF DAY (AM = 1, PM = 2) [_]

3. ***LENGTH OF TEST SECTION SEALED** (Feet) [_ _ _ _]

   ***WIDTH OF TEST SECTION SEALED** (Feet) [_ _ . _]

4. ***TYPE OF SEAL COAT** [2]
   SLURRY SEAL.............2

5. ***TYPE/GRADE OF BITUMINOUS MATERIAL IN SLURRY SEAL**
   (SEE TABLE A.16 FOR TYPE CODE) [_ _]
   DESCRIPTION OF "OTHER CEMENT" [_____]

   MANUFACTURER NAME [_____]

   MANUFACTURER MATERIAL NAMES [_____]

6. ***TYPE OF AGGREGATE USED IN SLURRY SEAL**
   (SEE TABLE A.9 FOR TYPE CODE) [_ _]
   DESCRIPTION OF "OTHER AGGREGATE" [_____]

   AGGREGATE SOURCE [_____]

7. ***TYPE OF MINERAL FILLER USED IN SLURRY SEAL**
   (SEE TABLE A.15 FOR TYPE CODE) [_ _]
   DESCRIPTION OF "OTHER" [_____]

   MINERAL FILLER SOURCE [_____]

*STATE ASSIGNED ID [__ __ __ __]

*STATE CODE [__ __]

*SHRP SECTION ID [__ __ __ __]

SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONT.)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

8. *REVOLUTION COUNT OF SLURRY SEAL MACHINE BEFORE APPLICATION [__ __ __ __]

9. *REVOLUTION COUNT OF SLURRY SEAL MACHINE AFTER APPLICATION [__ __ __ __]

10. *TARGET APPLICATION RATE FOR BITUMINOUS MATERIAL (Gallons/Sq. Yd) [.__ __ __]

11. *ACTUAL APPLICATION RATE FOR BITUMINOUS MATERIAL MEASURED FROM DISTRIBUTOR READINGS (Gallons/Sq. Yd) [.__ __ __]

12. *WAS APPLICATION RATE OF BITUMINOUS MATERIAL ADJUSTED AT JOBSITE TO CORRECT FOR SURFACE CONDITION (YES = 1, NO = 2) [__]

13. *TARGET APPLICATION RATE FOR AGGREGATE (Pounds/Sq. Yard) [__ __.__]

14. *ACTUAL APPLICATION RATE FOR AGGREGATE FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__ __.__]

15. *GATE OPENING (INCHES) [__ __.__]

16. *TARGET APPLICATION RATE FOR MINERAL FILLER (Pounds/Sq. Yard) [__.__ __]

17. *ACTUAL APPLICATION RATE FOR MINERAL FILLER FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__.__ __]

18. *MINERAL FILLER SETTING [__ __.__ __]

19. *TARGET APPLICATION RATE FOR SLURRY MIXTURE (Pounds/Sq. Yard) [__ __.__]

20. *ACTUAL APPLICATION RATE FOR SLURRY MIXTURE FROM DISTRIBUTOR READINGS (Pounds/Sq. Yard) [__ __.__]

21. *AMOUNT OF WATER ADDED (Gallons per Gallon of Emulsion) [__.__ __]

Sheet 8 *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP SECTION ID [_ _ _ _]

SLURRY SEAL APPLICATION DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONT.)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

22. ***ACTUAL TEMPERATURE OF BITUMINOUS MATERIAL PRIOR TO APPLICATION (°F)** [___ ___ ___]

23. ***ACTUAL APPLICATION TEMPERATURE OF SLURRY MATERIAL (°F)** [_ _ _]

24. ***INITIAL EXISTING PAVEMENT SURFACE PREPARATION** (SWEEPING REQUIRED) [_]
    NONE....................1 COLD MILL..................3
    SWEEP CLEAN ONLY.......2 SHOT BLAST.................4
    OTHER (SPECIFY) ________________________________5

25. ***PAVEMENT CONDITIONS AT TIME SEAL COAT APPLIED**
    PAVEMENT TEMPERATURE (°F) (60 °F Required) [_ _ _]

    CONDITION OF SURFACE BEFORE SEALING [_]
    CLEAN ....1 MOSTLY CLEAN..........2
    SOMEWHAT DIRTY....3 DIRTY.................4

    SURFACE MOISTURE CONDITION [_]
    DRY .... 1 MOSTLY DRY............2
    SOMEWHAT MOIST.....3 WET...................4

26. ***AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED**
    AIR TEMPERATURE (°F) (60 °F Required) [_ _ _]

    RELATIVE HUMIDITY (Percent) [_ _ _]

SLURRY SEAL APPLICATION DATA FOR PAVEMENT WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

27. ***SURFACE CONDITION** [_]
    BADLY OXIDIZED ....1 NORMAL 3
    SLIGHTLY OXIDIZED.........2 SLIGHTLY FLUSHED.............4
    FLUSHED....................5 FLUSHED ONLY IN WHEEL PATHS..6
    OTHER (SPECIFY) ______________________________ 7

28. ***AVERAGE CRACK SEVERITY LEVEL** (SEE DISTRESS IDENTIFICATION MANUAL)
    LOW = 1, MODERATE = 2, HIGH = 3 [_]

29. ***PRIMARY TYPE OF CRACKS** (SEE TABLE A.22 FOR TYPE CODES) [_ _]
    SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

30. ***ESTIMATED PERCENT OF CRACKS SEALED** [_ _ _]

31. ***AGGREGATE CONDITION PRIOR TO USE** (CLEAN OR ONLY SLIGHTLY DIRTY REQUIRED)
    CLEAN = 1 ONLY SLIGHTLY DIRTY = 2 SOMEWHAT DIRTY = 3 DIRTY = 4 [_]

    VERY DRY...........1 DRY........... 2 ONLY SLIGHTLY DAMP..3
    SOMEWHAT DAMP..... 4 SLIGHTLY WET.. 5 WET................ 6 [_]

32. ***AGGREGATE MOISTURE CONTENT** (PERCENT BY WEIGHT) [_ _._]

33. ***ESTIMATED TIME BETWEEN APPLICATION AND OPENING SECTION TO REDUCED SPEED TRAFFIC** (HOURS) [_ _._]

34. ***MAXIMUM REDUCED SPEED ALLOWED** (MPH) [_ _]

35. ***ESTIMATED TIME BETWEEN APPLICATION AND OPENING SECTION TO FULL SPEED TRAFFIC** (HOURS) [_ _._]

EQUIPMENT USED IN SLURRY SEAL APPLICATION

36. ***SLURRY MIXING MACHINE**
BRAND ______________________
MODEL ______________________
YEAR [__ __ __ __]

37. ***SLURRY MIXING MACHINE DETAILS** (YES = 1, USUALLY = 2 SOMETIMES = 3, NO = 4)
CONTINUOUS FLOW MIXING [__]
ACCURATELY APPORTIONED MIX COMPONENTS [__]
DISCHARGED THOROUGHLY MIXED PRODUCT CONTINUOUSLY [__]
AGGREGATE PREWET IMMEDIATELY PRIOR TO MIXING WITH EMULSION [__]
INGREDIENTS THOROUGHLY BLENDED IN THE MIXING CHAMBER [__]
METERING DEVICE INTRODUCES PREDETERMINED PROPORTION OF MINERAL FILLER INTO THE MIXER [__]
MINERAL FILLER FED AT SAME TIME AND LOCATION AS THE AGGREGATE [__]
FINES FEEDER PROVIDED FOR MINERAL FILLER [__]
FOG SPRAY (WATER) USED PRIOR TO SLURRY SEAL [__]
EQUIPPED WITH A MECHANICAL TYPE SQUEEGEE DISTRIBUTOR [__]
FLEXIBLE REAR STRIKEOFF USED [__]
FLEXIBLE REAR STRIKEOFF KEPT IN CONTACT WITH PAVEMENT SURFACE [__]
WORKING STEERING DEVICE ON SPREADER BOX [__]
SPREADER BOX KEPT CLEAN AND FREE OF BUILDUP [__]
WAS SPREADER BOX OVERLOADED [__]
WAS SPREADER BOX EVENLY FILLED AT ALL TIMES [__]
WAS ANY LUMPING, BALLING, OR UNMIXED AGGREGATE NOTICED [__]
WAS SEGREGATION OF THE EMULSION AND AGGREGATE FINES FROM THE COARSE AGGREGATE NOTICED [__]
SLURRY REMAINED WELL MIXED IN SPREADER BOX [__]
WAS BREAKING OF EMULSION OBSERVED IN THE SPREADER BOX [__]
BUILD-UP OF MATERIAL ALONG LONGITUDINAL AND TRANSVERSE JOINT [__]

38. ***SETTING OF SPREADER BOX WIDTH** (Inches) [__ __ __.]

39. ***TYPE OF DRAG USED** (NONE = 1, BURLAP = 2, OTHER = 3) [__]
OTHER (SPECIFY) ______________________

40. ***SURFACE TEXTURE PROVIDED** [__]
ROUGH AND OPEN...............1
SOMEWHAT ROUGH AND OPEN 2
SOMEWHAT SMOOTH AND TIGHT....3
SMOOTH AND TIGHT.............4

41. **FIELD NOTES AVAILABLE** (YES = 1, NO = 2) [__]

FIELD NOTE LOCATION [______________________]

Revised January 24, 1991

Sheet 11 *STATE ASSIGNED ID [__ __ __ __]

SPS-3 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP SECTION ID [__ __ __ __]

CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

1. ***DATE WORK BEGAN (MONTH/DAY/YEAR)** [__ __/__ __/__ __]

   ***DATE WORK WAS COMPLETED (MONTH/DAY/YEAR)** [__ __/__ __/__ __]

2. ***TIME WORK WAS BEGUN** (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

   ***TIME WORK WAS COMPLETED** (Hr/Min) [__ __/__ __]

   TIME OF DAY (AM = 1, PM = 2) [__]

3. ***LENGTH OF TEST SECTION** (Feet) [__ __ __ __]

   ***WIDTH OF TEST SECTION** (Feet) [__ __.__]

4. ***INITIAL EXISTING PAVEMENT SURFACE PREPARATION** (SWEEPING REQUIRED) [__]
   NONE....................1 COLD MILL.................3
   SWEEP CLEAN ONLY.......2 SHOT BLAST................4
   OTHER (SPECIFY) ________________________________5

5. ***AMBIENT CONDITIONS AT TIME SEAL COAT APPLIED**
   AIR TEMPERATURE (°F) (60 °F Required) [__ __ __]

   RELATIVE HUMIDITY (Percent) [__ __ __]

6. ***PAVEMENT CONDITIONS AT TIME CRACK SEAL APPLIED**
   PAVEMENT TEMPERATURE (°F) (60 °F Required) [__ __ __]

   CONDITION OF SURFACE BEFORE SEALING [__]
   CLEAN ....1 MOSTLY CLEAN..........2
   SOMEWHAT DIRTY....3 DIRTY.................4

   SURFACE MOISTURE CONDITION [__]
   DRY .... 1 MOSTLY DRY............2
   SOMEWHAT DAMP......3 WET...................4

Sheet 12 — *STATE ASSIGNED ID [_ _ _ _]

SPS-3 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP SECTION ID [_ _ _ _]

CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

7. *SURFACE CONDITION [_]
   BADLY OXIDIZED ....1 NORMAL 3
   SLIGHTLY OXIDIZED.........2 SLIGHTLY FLUSHED.............4
   FLUSHED...................5 FLUSHED ONLY IN WHEEL PATHS..6
   OTHER (SPECIFY) ______________________

8. *AVERAGE CRACK SEVERITY LEVEL (SEE DISTRESS IDENTIFICATION MANUAL)
   LOW = 1, MODERATE = 2, HIGH = 3 [_]

9. *PRIMARY TYPE OF CRACKS (SEE TABLE A.22 FOR TYPE CODES) [_ _]
   SEE DISTRESS IDENTIFICATION MANUAL FOR DESCRIPTION

10. *ESTIMATED PERCENT OF CRACKS SEALED [_ _ _]

11. *APPROXIMATE TOTAL LENGTH OF CRACKS SEALED (FEET) [_ _ _ _]

12. *TYPE OF ASTM D3405 MATERIAL USED TO SEAL CRACKS
    MANUFACTURER NAME______________________
    MANUFACTURER SEALANT NAME______________________

13. *INFORMATION ON ROUTING (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)
    TRANSVERSE CRACKS ROUTED [_]
    DIAGONAL CRACKS ROUTED [_]
    LONGITUDINAL CRACKS ROUTED [_]
    ROUTING ACCOMPLISHED IN ONE PASS [_]

14. *DIMENSIONS OF CRACK OR ROUTED RESERVOIR (AFTER PREPARATION)
    WIDTH (INCHES)
    MINIMUM........[_._ _] MAXIMUM........[_._ _]
    MEAN...........[_._ _]

    DEPTH (INCHES)
    MINIMUM........[_._ _] MAXIMUM........[_._ _]
    MEAN...........[_._ _]

    TOTAL LENGTH OF CRACKS PREPARED [_ _ _ _]

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP SECTION ID [_ _ _ _]

CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

15. *CONDITION OF CRACK JUST PRIOR TO SEALING
    (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

    CLEAN [_]
    DRY [_]

    WAS HOT-AIR LANCE USED [_]
    WAS ASPHALT AROUND CRACK CHARRED AFTER HEATING [_]
    WAS CRACK STILL HOT FROM THE HOT-AIR LANCE WHEN SEALANT WAS PLACED [_]

16. *MAKE AND MODEL OF SEALANT HEATING KETTLE AND APPLICATOR
    MODEL NAME ____________________
    MODEL NUMBER ____________________

17. *MAXIMUM ALLOWABLE TEMPERATURE OF THE SEALANT (°F) [_ _ _]

18. *ACTUAL TEMPERATURE OF THE SEALANT AT THE BEGINNING OF APPLICATION (°F) [_ _ _]

19. *ACTUAL TEMPERATURE OF THE SEALANT AT THE END OF APPLICATION (°F) [_ _ _]

20. *WAS ANY SEALANT REHEATED (YES =1, NO = 2) [_]

21. *HOW MANY TIMES WAS SEALANT REHEATED [_]

Revised January 24, 1991
*STATE ASSIGNED ID [_ _ _ _]
*STATE CODE [_ _]
*SHRP SECTION ID [_ _ _ _]

CRACK SEAL DATA FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

MEASUREMENTS TO BE TAKEN ON BOTH LANES, BUT ENTERED ONLY FOR THE LANE CONTAINING THE SPS-3 TEST SECTION

22. ***SEALANT APPLICATION** (YES = 1, USUALLY = 2, SOMETIMES = 3, NEVER = 4)

BACKFLUSHED HOSE [_]
CRACK FILLER FLUSHED [_]
SEALANT CHAMBER HEATED [_]
HOSE BETWEEN WAND AND SEALANT CHAMBER HEATED [_]
MATERIAL IN CHAMBER UNDER CONSTANT AGITATION [_]
THERMOMETER VISIBLE TO THE ENGINEER [_]
BLOTTING MATERIAL USED ON THE CRACKS [_]

DISTANCE BETWEEN APPLICATOR WAND AND SQUEEGEE (FEET) [_ _]
AVERAGE WIDTH OF COMPLETED SEALED CRACK [_._]

23. ***THICKNESS OF FINISHED SEALANT** [_]
CRACK OVERFILLED..........1 RECESSED 2
LEVEL WITH SURFACE........3

APPROXIMATE AVERAGE THICKNESS OF SEALANT ABOVE OR BELOW PAVEMENT SURFACE (INCHES) [._ _]

24. ***LENGTH OF TIME BETWEEN**
COMPLETION OF CRACK PREPARATION AND SEALANT PLACEMENT (MINUTES) [_ _._]

COMPLETION OF CRACK SEALANT AND OPENING TO TRAFFIC AT END WHERE SEALING BEGAN (HOURS) [_ _._._]

COMPLETION OF CRACK SEALANT AND OPENING TO TRAFFIC AT END WHERE SEALING ENDED (HOURS) [_ _._._]

25. **FIELD NOTES AVAILABLE** (YES = 1, NO = 2) [_]

FIELD NOTE LOCATION [_______________________________]

Sheet 1 | *STATE ASSIGNED ID [__ __ __ __]
SPS-4 DATA | *STATE CODE [__ __]
LTPP PROGRAM | *SHRP PROJECT ID [__ __ __ __]

JOINT AND CRACK SEALING

(THESE DATA SHEETS APPLY TO CONCRETE PAVEMENT/ASPHALT SHOULDER LONGITUDINAL JOINTS AND CONCRETE PAVEMENT TRANSVERSE JOINTS, LONGITUDINAL JOINTS AND CRACKS. LEAVE BLANK WHEN DATA ELEMENT DOES NOT APPLY)

1. ***DATES** (MONTH/DAY/YEAR)
   DATE WORK BEGAN [__ __/__ __/__ __]
   DATE WORK COMPLETED [__ __/__ __/__ __]

TIME (24 HOUR CLOCK-HR/MIN)

	DAY 1	DAY 2	DAY 3
TIME WORK BEGAN	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]
TIME WORK COMPLETED	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]

2. ***LENGTH OF TEST SECTION TO BE MONITORED** (Feet) [__ __ __ __]

LANE WIDTH OF TEST SECTION (Feet) [__ __.__]

3. ***WEATHER CONDITIONS**

AIR TEMPERATURE (°F)	DAY 1	DAY 2	DAY 3
AT BEGINNING OF SEALING	[__ __ __]	[__ __ __]	[__ __ __]
AT END OF SEALING	[__ __ __]	[__ __ __]	[__ __ __]

HUMIDITY (%)	DAY 1	DAY 2	DAY 3
AT BEGINNING OF SEALING	[__ __ __]	[__ __ __]	[__ __ __]
AT END OF SEALING	[__ __ __]	[__ __ __]	[__ __ __]

4. ***TYPE OF JOINTS AND CRACKS SEALED** (ALL SEALED=1, MOST SEALED=2, FEW SEALED =3, NONE SEALED=4, NONE PRESENT TO SEAL=5)

CONCRETE PAVEMENT/ASPHALT SHOULDER JOINT [__]
TRANSVERSE PAVEMENT JOINTS [__]
LONGITUDINAL PAVEMENT JOINTS [__]
TRANSVERSE RANDOM CRACKS [__]
LONGITUDINAL RANDOM CRACKS [__]
DIAGONAL RANDOM CRACKS [__]

Sheet 2 *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP PROJECT ID [_ _ _ _]

JOINT AND CRACK SEALING (CONTINUED)

5. ***JOINT SEALANT MATERIAL** (ASTM D3405=1, SILICONE=2, OTHER=3)
DESCRIBE IF OTHER ______________________

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
MATERIAL TYPE	[_]	[_]	[_]
BRAND	[______] [______]	[______] [______]	[______] [______]
SOURCE (NAME AND ADDRESS)	[______] [______] [______] [______]	[______] [______] [______] [______]	[______] [______] [______] [______]
DATE OF PRODUCTION (MONTH/YEAR)	[_ _/_ _]	[_ _/_ _]	[_ _/_ _]
LOT NUMBER	[______]	[______]	[______]
UNIT OF SUPPLY FOR SEALANT	[_]	[_]	[_]

OUNCES 1
GALLONS 3
FEET 5
QUARTS 2
POUNDS 4

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
SMALLEST QUANTITY OF MATERIAL SUPPLIED	[_ _ _ _ _]	[_ _ _ _ _]	[_ _ _ _ _]

Sheet 3	*STATE ASSIGNED ID [__ __ __ __]
SPS-4 DATA	*STATE CODE [__ __]
LTPP PROGRAM	*SHRP PROJECT ID [__ __ __ __]

JOINT AND CRACK SEALING (CONTINUED)

6. *MANUFACTURER'S SEALANT HANDLING RECOMMENDATIONS

LIQUID SEALANT

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
INDIRECT OIL HEATING (YES=1, NO=2)	[__]	[__]	[__]
OIL TEMPERATURE (°F)			
MINIMUM	[__ __ __]	[__ __ __]	[__ __ __]
MAXIMUM	[__ __ __]	[__ __ __]	[__ __ __]
SEALANT TEMPERATURE (°F)			
MINIMUM	[__ __ __]	[__ __ __]	[__ __ __]
MAXIMUM	[__ __ __]	[__ __ __]	[__ __ __]
TIME OF HEATING (HR)			
MINIMUM	[__ __.__]	[__ __.__]	[__ __.__]
MAXIMUM	[__ __.__]	[__ __.__]	[__ __.__]
AGITATION (YES=1, NO=2)	[__]	[__]	[__]

SILICONE SEALANT

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
SHELF LIFE (MONTHS)	[__ __]	[__ __]	[__ __]
SUGGESTED MAXIMUM STORAGE TEMPERATURE (°F)	[__ __]	[__ __]	[__ __]
SUGGESTED MINIMUM STORAGE HUMIDITY (%)	[__ __]	[__ __]	[__ __]
APPLICATION METHOD (HAND=1, PRESSURE=2)	[__]	[__]	[__]
APPLICATION PRESSURE (PSI) (0 IF HAND APPLICATION)	[__ __ __]	[__ __ __]	[__ __ __]
OTHER CONDITIONS	[______________]	[______________]	[______________]

Sheet 4 | *STATE ASSIGNED ID [_ _ _ _]
SPS-4 DATA | *STATE CODE [_ _]
LTPP PROGRAM | *SHRP PROJECT ID [_ _ _ _]

JOINT AND CRACK SEALING (CONTINUED)

7. *BACKER MATERIAL UNDER SEALANT

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
BACKER TYPE	[_]	[_]	[_]
DIAMETER (WIDTH) (1/16TH INCH)	[_ _]	[_ _]	[_ _]
BRAND	[________] [________]	[________] [________]	[________] [________]
SOURCE (NAME AND ADDRESS)	[________] [________] [________] [________]	[________] [________] [________] [________]	[________] [________] [________] [________]

BACKER TYPE codes:
NONE 1
TAPE 2
ROD 3
OTHER 4

8. *OLD SEALANT REMOVAL FROM JOINTS

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
METHOD OF REMOVING OLD SEALANT	[_]	[_]	[_]
DESCRIBE IF OTHER	[________] [________]	[________] [________]	[________] [________]
AMOUNT OF SPALLING CAUSED BY JOINT SEALANT REMOVAL	[_]	[_]	[_]
WATER USED WITH SAWING? (YES=1, NO=2)	[_]	[_]	[_]

METHOD OF REMOVING OLD SEALANT codes:
NO SEALANT 1
NOT REMOVED 2
JOINT PLOW - V-SHAPED 3
JOINT PLOW - RECTANGULAR 4
HIGH PRESSURE WATER BLASTING ...5
DIAMOND BLADE SAW 6
CARBIDE BLADE SAW 7
PULL-OUT OF OLD COMPRESSION SEALANT ..8
OTHER 9

AMOUNT OF SPALLING codes:
NONE 1
VERY LITTLE 2
SOME 3
CONSIDERABLE 4

Sheet 5	*STATE ASSIGNED ID [__ __ __ __]
SPS-4 DATA	*STATE CODE [__ __]
LTPP PROGRAM	*SHRP PROJECT ID [__ __ __ __]

JOINT AND CRACK SEALING (CONTINUED)

9. *REFACING OF JOINTS

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
JOINT SAWED?	[__]	[__]	[__]

NO ....1 YES - ONE-BLADE ..2
YES - TWO-BLADE ..3 OTHER (SPECIFY) ..4

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
DIAMETER OF SAW BLADE (0 IF SAW NOT USED) (INCHES)	[__ __.__ __]	[__ __.__ __]	[__ __.__ __]
WATER USED WITH SAWING? (YES=1, NO=2)	[__]	[__]	[__]
SAWING ACCOMPLISHED IN ONE PASS? (YES=1, NO=2)	[__]	[__]	[__]

10. *AMOUNT OF SPALLING OR SECONDARY CRACKING IN CONCRETE CAUSED BY SAWING

SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
[__]	[__]	[__]

NONE ....1 VERY LITTLE 2
SOME ....3 CONSIDERABLE 4

11. *PATCHING

REQUIRED SHOULDER PATCHING COMPLETED? (YES=1, NO=2) [__]

REQUIRED CONCRETE PATCHING COMPLETED? (YES=1, NO=2) [__]

12. *JOINT/CRACK PREPARATION - WALL(S) SAWED VERTICALLY?

SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
[__]	[__]	[__]

NEVER ....1 SOMETIMES 2
USUALLY ....3 ALWAYS 4

Sheet 6 — *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP PROJECT ID [_ _ _ _]

JOINT AND CRACK SEALING (CONTINUED)

13. *INFORMATION ON JOINT/CRACK SEALANT RESERVOIR PREPARATION

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
WATER BLASTING USED TO CLEAN RESERVOIR? (YES=1, NO=2)	[_]	[_]	[_]
WATER PRESSURE (PSI) (0 IF NOT WATER BLASTED)	[_ _ _]	[_ _ _]	[_ _ _]
WATER VOLUME (GPM) (0 IF NOT WATER BLASTED)	[_ _ _]	[_ _ _]	[_ _ _]
WATER FLUSHING USED TO CLEAN RESERVOIR? (YES=1, NO=2)	[_]	[_]	[_]
AIR USED TO CLEAN AND DRY RESERVOIR? (YES=1, NO=2)	[_]	[_]	[_]
AIR PRESSURE (PSI) (0 IF AIR NOT USED)	[_ _ _]	[_ _ _]	[_ _ _]
HOT COMPRESSED AIR LANCE USED TO CLEAN, DRY AND HEAT RESERVOIR? (YES=1, NO=2)	[_]	[_]	[_]
AIR PRESSURE OF AIR LANCE (PSI) (0 IF NOT USED)	[_ _ _]	[_ _ _]	[_ _ _]
SANDBLASTING USED TO CLEAN THE RESERVOIR? (YES=1, NO=2)	[_]	[_]	[_]
OTHER SEALANT RESERVOIR PREPARATION (DESCRIBE)	[____________]	[____________]	[____________]

14. *ASPHALT SHOULDER MATERIAL BURNED BY THE HOT COMPRESSED AIR LANCE? [_]

NEVER ....1 SOMETIMES 2
USUALLY ....3 ALWAYS 4

Sheet 7 | *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA | *STATE CODE [_ _]

LTPP PROGRAM | *SHRP PROJECT ID [_ _ _ _]

JOINT AND CRACK SEALING (CONTINUED)

15. *DIMENSIONS OF RESERVOIR AFTER PREPARATION AND BEFORE SEALING

AVERAGE WIDTH OF RESERVOIR (MEASURE TEN RANDOM LOCATIONS) (1/16TH INCH)

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS
1.	[_ _]	[_ _]	[_ _]	[_ _]
2.	[_ _]	[_ _]	[_ _]	[_ _]
3.	[_ _]	[_ _]	[_ _]	[_ _]
4.	[_ _]	[_ _]	[_ _]	[_ _]
5.	[_ _]	[_ _]	[_ _]	[_ _]
6.	[_ _]	[_ _]	[_ _]	[_ _]
7.	[_ _]	[_ _]	[_ _]	[_ _]
8.	[_ _]	[_ _]	[_ _]	[_ _]
9.	[_ _]	[_ _]	[_ _]	[_ _]
10.	[_ _]	[_ _]	[_ _]	[_ _]
MINIMUM	[_ _]	[_ _]	[_ _]	[_ _]
MAXIMUM	[_ _]	[_ _]	[_ _]	[_ _]
AVERAGE	[_ _]	[_ _]	[_ _]	[_ _]

AVERAGE DEPTH OF RESERVOIR (MEASURE TEN RANDOM LOCATIONS) (1/16TH INCH)

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS
1.	[_ _]	[_ _]	[_ _]	[_ _]
2.	[_ _]	[_ _]	[_ _]	[_ _]
3.	[_ _]	[_ _]	[_ _]	[_ _]
4.	[_ _]	[_ _]	[_ _]	[_ _]
5.	[_ _]	[_ _]	[_ _]	[_ _]
6.	[_ _]	[_ _]	[_ _]	[_ _]
7.	[_ _]	[_ _]	[_ _]	[_ _]
8.	[_ _]	[_ _]	[_ _]	[_ _]
9.	[_ _]	[_ _]	[_ _]	[_ _]
10.	[_ _]	[_ _]	[_ _]	[_ _]
MINIMUM	[_ _]	[_ _]	[_ _]	[_ _]
MAXIMUM	[_ _]	[_ _]	[_ _]	[_ _]
AVERAGE	[_ _]	[_ _]	[_ _]	[_ _]

TOTAL LENGTH OF JOINTS/CRACKS PREPARED (FEET)

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS
	[_ _ _ _]	[_ _ _ _]	[_ _ _ _]	[_ _ _ _]

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JOINT AND CRACK SEALING (CONTINUED)

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS

16. *SEALANT RESERVOIR CONDITIONS AT TIME SEALANT APPLIED

SEALANT RESERVOIR CONDITION BEFORE SEALANT APPLIED

	SHOULDER JOINTS	TRANSVERSE	LONGITUDINAL	RANDOM CRACKS
	[_]	[_]	[_]	[_]

CLEAN ....1 MOSTLY CLEAN 2
SOMEWHAT DIRTY ...3 DIRTY 4

SEALANT RESERVOIR MOISTURE CONDITION BEFORE SEALANT APPLIED

	SHOULDER JOINTS	TRANSVERSE	LONGITUDINAL	RANDOM CRACKS
	[_]	[_]	[_]	[_]

DRY ....1 MOSTLY DRY 2
SOMEWHAT DAMP ....3 WET 4

17. *TIME BETWEEN CLEANING AND INSTALLATION? (DAYS/HRS)

	SHOULDER JOINTS	TRANSVERSE	LONGITUDINAL	RANDOM CRACKS
	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]

18. *BACKER MATERIAL MEASUREMENTS AFTER JOINT PREPARATION AND BEFORE SEALING

AVERAGE DEPTH OF BACKER MATERIAL OR TAPE FROM PAVEMENT SURFACE (MEASURE TEN RANDOM LOCATIONS) (16TH INCH)

	SHOULDER JOINTS	TRANSVERSE	LONGITUDINAL	RANDOM CRACKS
1.	[__ __]	[__ __]	[__ __]	[__ __]
2.	[__ __]	[__ __]	[__ __]	[__ __]
3.	[__ __]	[__ __]	[__ __]	[__ __]
4.	[__ __]	[__ __]	[__ __]	[__ __]
5.	[__ __]	[__ __]	[__ __]	[__ __]
6.	[__ __]	[__ __]	[__ __]	[__ __]
7.	[__ __]	[__ __]	[__ __]	[__ __]
8.	[__ __]	[__ __]	[__ __]	[__ __]
9.	[__ __]	[__ __]	[__ __]	[__ __]
10.	[__ __]	[__ __]	[__ __]	[__ __]
MINIMUM	[__ __]	[__ __]	[__ __]	[__ __]
MAXIMUM	[__ __]	[__ __]	[__ __]	[__ __]
AVERAGE	[__ __]	[__ __]	[__ __]	[__ __]

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SPS-4 DATA | *STATE CODE [__ __]
LTPP PROGRAM | *SHRP PROJECT ID [__ __ __ __]

JOINT AND CRACK SEALING (CONTINUED)

	SHOULDER JOINT	PAVEMENT JOINT	RANDOM CRACK
19. *SILICONE SEALANT APPLICATION			
SILICONE SEALANT TOOLED? (YES=1, NO=2)	[_]	[_]	[_]
TIME BETWEEN END OF SILICONE JOINT AND CRACK SEALING AND END OF TRAFFIC CONTROL (24 HR CLOCK) (HR/MIN)	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]
20. *LIQUID SEALANT APPLICATION			
HOSE CONNECTING THE WAND TO THE SEALANT CHAMBER HEATED DURING SEALING OPERATIONS? (YES=1, NO=2)	[_]	[_]	[_]
SEALANT TEMPERATURE AT THE BEGINNING OF APPLICATION (°F)	[__ __ __]	[__ __ __]	[__ __ __]
SEALANT TEMPERATURE AT END OF APPLICATION (°F)	[__ __ __]	[__ __ __]	[__ __ __]
HOSE BACKFLUSHED BEFORE SEALING BEGINS? (YES=1, NO=2)	[_]	[_]	[_]
TIME BETWEEN END OF SEALING AND END OF TRAFFIC CONTROL (24 HR CLOCK) (HR/MIN)	[__ __/__ __]	[__ __/__ __]	[__ __/__ __]
21. *DISTANCE FROM SURFACE OF PAVEMENT TO TOP OF SEALANT			
DEPTH TO TOP OF SEALANT (MEASURE TEN RANDOM LOCATIONS) (1/16TH INCH) (NEGATIVE IF SEALANT IS ABOVE PAVEMENT SURFACE)			
1.	[__ __ __]	[__ __ __]	[__ __ __]
2.	[__ __ __]	[__ __ __]	[__ __ __]
3.	[__ __ __]	[__ __ __]	[__ __ __]
4.	[__ __ __]	[__ __ __]	[__ __ __]
5.	[__ __ __]	[__ __ __]	[__ __ __]
6.	[__ __ __]	[__ __ __]	[__ __ __]
7.	[__ __ __]	[__ __ __]	[__ __ __]
8.	[__ __ __]	[__ __ __]	[__ __ __]
9.	[__ __ __]	[__ __ __]	[__ __ __]
10.	[__ __ __]	[__ __ __]	[__ __ __]
MINIMUM	[__ __ __]	[__ __ __]	[__ __ __]
MAXIMUM	[__ __ __]	[__ __ __]	[__ __ __]
AVERAGE	[__ __ __]	[__ __ __]	[__ __ __]

Sheet 10
SPS-4 DATA
LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]
*STATE CODE [_ _]
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JOINT AND CRACK SEALING (CONTINUED)

INSPECTIONS TO BE COMPLETED DAY AFTER APPLICATION OF SEALANT

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS
22. *SEALANT BONDED TO BOTH SURFACES OF JOINT OR CRACK AS CHECKED WITH A FLAT TOOL?	[_]	[_]	[_]	[_]
23. *FILM DEVELOPED ON SILICONE SEALANT? (YES=1, NO=2, N/A=3)	[_]	[_]	[_]	[_]
24. *BUBBLES PRESENT IN SURFACE OF LIQUID JOINT SEALER?	[_]	[_]	[_]	[_]
25. *LIQUID JOINT SEALANT TACKY? (YES=1, NO=2, N/A=3)	[_]	[_]	[_]	[_]

Item 22: LITTLE BONDING ...1 MOSTLY BONDED ...2 ALL BONDED ...3

Item 24: SIGNIFICANT BUBBLES ...1 FEW BUBBLES ...2 NO BUBBLES ...3 N/A ...4

31. FIELD NOTES AVAILABLE? (YES=1, NO=2) [_]
FIELD NOTE LOCATION [_______________________________]

SUBMITTED BY, DATE

____
DATA RECORDER

AFFILIATION _______________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE

AFFILIATION _______________

Sheet 11 *STATE ASSIGNED ID [__ __ __ __]

SPS-4 DATA *STATE CODE [__ __]

LTPP PROGRAM *SHRP PROJECT ID [__ __ __ __]

UNDERSEALING

1. ***DATES OF UNDERSEALING** (MONTH/DAY/YEAR) WORK BEGAN [__ __/__ __/__ __]
WORK COMPLETED [__ __/__ __/__ __]

TIME OF DAY (24 HOUR CLOCK)

	INITIAL GROUTING	REGROUTING
BEGAN (HR/MIN)	[__ __/__ __]	[__ __/__ __]
COMPLETED (HR/MIN)	[__ __/__ __]	[__ __/__ __]

(LEAVE BLANK IF NO REGROUTING)

2. ***LENGTH OF UNDERSEALING TEST SECTION** (FEET) [__ __ __ __]

*LANE WIDTH OF UNDERSEALING TEST SECTION (FEET) [__ __.__]

3. ***PAVEMENT SURFACE MOISTURE CONDITION AT TIME OF UNDERSEALING**

INITIAL GROUTING	REGROUTING
[__]	[__]
[__]	[__]

DRY ....1 MOSTLY DRY 2
SOMEWHAT DAMP ....3 WET 4

4. ***WEATHER CONDITIONS**

	INITIAL GROUTING	REGROUTING
TEMPERATURE (°F)		
BEGINNING OF UNDERSEALING	[__ __ __]	[__ __ __]
END OF UNDERSEALING	[__ __ __]	[__ __ __]
HUMIDITY (%)		
BEGINNING OF UNDERSEALING	[__ __ __]	[__ __ __]
END OF UNDERSEALING	[__ __ __]	[__ __ __]

(LEAVE BLANK IF NO REGROUTING)

5. ***CEMENT USED PER AASHTO M85** (TYPE I=41, TYPE II=42, TYPE III=43) [__ __]

SOURCE [____________________]
ADDRESS [____________________]
[____________________]
[____________________]

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UNDERSEALING (CONTINUED)

6. ***FLY ASH USED PER ASTM C618** (NATURAL POZZOLAN=09,CLASS F=10, CLASS C=11) [_ _]

SOURCE [________________]
ADDRESS [________________]
[________________]
[________________]

7. ***SOURCE OF WATER**

SOURCE [________________]
ADDRESS [________________]
[________________]
[________________]

8. ***METHOD OF SELECTING SLABS/PANELS TO BE UNDERSEALED** [_]
   BLANKET UNDERSEALING 1
   DEFLECTION CRITERIA 2
   VISUAL SIGNS 3
   OTHER (SPECIFY) 4
   DESCRIBE IF OTHER ________________

9. ***UNDERSEAL HOLE INSTALLATION METHOD** [_]
   CORING ......1 IMPACT DRILL ....2 OTHER 3

	INITIAL GROUTING	REGROUTING
10. ***TIME OF DAY HOLES DRILLED** (24 HOUR CLOCK - HR/MIN)		
BEGAN	[_ _/_ _]	[_ _/_ _]
COMPLETED	[_ _/_ _]	[_ _/_ _]
11. ***WATER USED TO FLUSH OUT HOLES?** (YES=1, NO=2)	[_]	[_]
12. ***HOLES RETAIN DRILLING OR FLUSHING WATER?**	[_]	[_]

NEVER ....1 SOMETIMES 2
USUALLY ....3 ALWAYS 4

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LTPP PROGRAM	*SHRP PROJECT ID [_ _ _ _]

UNDERSEALING (CONTINUED)

	INITIAL GROUTING	REGROUTING
13. *GROUT MIXING CHAMBER CLEANLINESS	[_]	[_]
CLEAN ....1 / MOSTLY CLEAN ......2 / SOMEWHAT DIRTY ...3 / DIRTY 4		
14. *NUMBER OF BAGS OF CEMENT USED PER BATCH	[_ _ _]	[_ _ _]
15. *NUMBER OF BAGS OF FLY ASH USED PER BATCH	[_ _ _]	[_ _ _]
16. *NUMBER OF GALLONS OF WATER USED PER BATCH	[_ _ _]	[_ _ _]
17. *GROUT MIXING		
MIXING SPEED? (RPM)	[_ _ _ _]	[_ _ _ _]
TIME GROUT MIXED? (MINUTES)	[_ _ _]	[_ _ _]
GROUT WELL BLENDED?	[_]	[_]
NEVER ....1 / SOMETIMES ....2 / USUALLY ....3 / ALWAYS 4		
18. *MAXIMUM ALLOWABLE PUMPING PRESSURE (GAUGE AT PLANT) (PSI)	[_ _ _]	[_ _ _]
19. *MAXIMUM SURGE PRESSURE (PSI)	[_ _ _]	[_ _ _]

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LTPP PROGRAM | *SHRP PROJECT ID [_ _ _ _]

UNDERSEALING (CONTINUED)

20. *VOLUME OF GROUT FOR EACH HOLE DETERMINED? [_]
    NEVER 1   SOMETIMES 2
    USUALLY 3   ALWAYS 4

21. *TOTAL VOLUME OF INSTALLED GROUT DETERMINED? (YES=1, NO=2) [_]

22. *HOLES PLUGGED? (YES=1, NO=2) [_]

23. *ESTIMATED EXCESS GROUT SUBTRACTED FROM TOTAL GROUT QUANTITY? [_]
    NEVER 1   SOMETIMES 2
    USUALLY 3   ALWAYS 4

24. *UPLIFT MONITORED FOR EACH SLAB/PANEL? [_]
    NEVER 1   SOMETIMES 2
    USUALLY 3   ALWAYS 4

25. *CONSTRUCTION TRAFFIC RESTRICTED? [_]
    NEVER 1   SOMETIMES 2
    USUALLY 3   ALWAYS 4

26. *METHOD TO DETERMINE USER TRAFFIC RESTRICTION [_]
    TIME OF SET 1   MINIMUM CURE TIME ...2
    OTHER 3
    SPECIFY IF OTHER ____________________

Sheet 15

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

UNDERSEALING (CONTINUED)

USE MULTIPLE SHEETS IF NECESSARY

27. *PRESSURE GROUTING

JOINT NUMBER	HOLE NUMBER	HOLE LOCATION STATION*	HOLE LOCATION OFFSET (FEET)	HOLE DEPTH (INCHES)	GROUT PUMPED PER HOLE (CU. FEET)	CUTOFF CRITERIA**	INITIAL OR REGROUT***
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___
_ _	_ _ _	_ _+_ _._	_ _._	_ _	_ _._	___	___

* USE SHRP STATION NUMBERS; ** REFUSAL=1, RAISED SLAB=2, GROUT EXTRUSION=3, OTHER=4

*** INITIAL GROUT APPLICATION=1, REGROUTING=2

Sheet 16 *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP PROJECT ID [_ _ _ _]

UNDERSEALING (CONTINUED)

MEASUREMENTS MADE DAY AFTER APPLICATION

	AFTER INITIAL GROUTING	AFTER REGROUTING
28. ***SLAB/PANEL STABILITY CHECKED?** (YES=1, NO=2)	[_]	[_]
29. ***UNSTABLE SLABS REGROUTED?** (YES=1, NO=2)	[_]	[_]

30. ***SAME CONTROLS USED FOR REGROUTING AS WERE USED FOR INITIAL GROUTING?** [_]
    NEVER ....1 SOMETIMES 2
    USUALLY ....3 ALWAYS 4

31. **FIELD NOTES AVAILABLE** (YES=1, NO=2) [_]
FIELD NOTE LOCATION [_______________________________________]

SUBMITTED BY, DATE

____
DATA RECORDER

AFFILIATION _______________________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE

AFFILIATION _______________________

Sheet 17A | *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA | *STATE CODE [_ _]

LTPP PROGRAM | *SHRP PROJECT ID [_ _ _ _]

BENKELMAN BEAM DEFLECTION MEASUREMENTS
(18 KIP SINGLE AXLE LOAD)

1. ***DATES** (MONTH /DAY/YEAR) **AND TIME** (24 HOUR CLOCK-HR/MIN) **OF TESTING**

DATE WORK BEGAN [_ _/_ _/_ _]
DATE WORK COMPLETED [_ _/_ _/_ _]

TIME BEGAN [_ _/_ _]
TIME COMPLETED [_ _/_ _]

2. ***WEATHER CONDITIONS:** AIR TEMPERATURE (°F) AND HUMIDITY (%)

AIR TEMPERATURE (°F)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

HUMIDITY (%)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

3. ***PAVEMENT SURFACE MOISTURE CONDITION AT TIME OF TESTING** [_]
   DRY ....1 MOSTLY DRY 2
   SOMEWHAT DAMP ....3 WET 4

4. ***PURPOSE OF TESTING** [_]
   DETERMINE NEED FOR UNDERSEALING 1
   SLAB STABILITY AFTER INITIAL GROUTING ...2
   SLAB STABILITY AFTER REGROUT 3
   POST CONSTRUCTION MONITORING 4

5. ***SOURCE OF TESTING DEVICE** [_]
   SHRP ....1 HOST STATE OR PROVINCE ..2
   OTHER STATE ....3 OTHER 4

Sheet 17B

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

BENKELMAN BEAM DEFLECTION MEASUREMENTS (CONTINUED)
(18 KIP SINGLE AXLE LOAD)
USE MULTIPLE SHEETS IF NEEDED

5.*LOCATION (STATION) OF JOINT OR CRACK	6.*JOINT NUMBER	7.*TESTING AT: (JOINT=1, CRACK=2)	8.*LOCATION OF AXLE (APPROACH=1, LEAVE=2)	DEFLECTION (MILS) 9.*APPROACH	DEFLECTION (MILS) 10.*LEAVE
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _
_ _+_ _._	_ _ _	_	_	_ _._	_._ _

Sheet 17C

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

BENKELMAN BEAM DEFLECTION MEASUREMENTS (CONTINUED)
(18 KIP SINGLE AXLE LOAD)

5.*LOCATION (STATION) OF JOINT OR CRACK	6.*JOINT NUMBER	7.*TESTING AT: (JOINT=1, CRACK=2)	8.*LOCATION OF AXLE (APPROACH=1, LEAVE=2)	DEFLECTION (MILS) 9.*APPROACH	DEFLECTION (MILS) 10.*LEAVE
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_._ _

SUBMITTED BY, DATE

DATA RECORDER

AFFILIATION ______________

CHECKED AND APPROVED, DATE

SHRP REPRESENTATIVE

AFFILIATION ______________

Revised 2/91

Sheet 18 — *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP PROJECT ID [_ _ _ _]

FALLING WEIGHT DEFLECTOMETER MEASUREMENTS

1. *DATES (MONTH /DAY/YEAR) **AND TIME** (24 HOUR CLOCK-HR/MIN) **OF TESTING**

DATE WORK BEGAN [_ _/_ _/_ _]
DATE WORK COMPLETED [_ _/_ _/_ _]

TIME BEGAN [_ _/_ _]
TIME COMPLETED [_ _/_ _]

2. *WEATHER CONDITIONS: AIR TEMPERATURE (°F) AND HUMIDITY (%)

AIR TEMPERATURE (°F)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

HUMIDITY (%)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

3. *PAVEMENT SURFACE MOISTURE CONDITION AT TIME OF TESTING [_]

DRY ....1 MOSTLY DRY 2
SOMEWHAT DAMP ....3 WET 4

4. *PURPOSE OF TESTING [_]

DETERMINE NEED FOR UNDERSEALING 1
SLAB STABILITY AFTER INITIAL GROUTING ...2
SLAB STABILITY AFTER REGROUT 3
POST CONSTRUCTION MONITORING 4

5. *FILE IDENTIFICATION WITH FWD TEST RESULTS [_ _ _ _ _ _]

6. *SOURCE OF TESTING DEVICE [_]

SHRP ....1 HOST STATE OR PROVINCE ..2
OTHER STATE ....3 OTHER 4

SUBMITTED BY, DATE

____
DATA RECORDER

AFFILIATION _______________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE

AFFILIATION _______________

Revised January 24, 1991

Sheet 19 | *STATE ASSIGNED ID [_ _ _ _]
SPS-4 DATA | *STATE CODE [_ _]
LTPP PROGRAM | *SHRP PROJECT ID [_ _ _ _]

EPOXY-CORE TEST

1. ***DATES** (MONTH /DAY/YEAR) **AND TIME** (24 HOUR CLOCK-HR/MIN) **OF TESTING**

DATE WORK BEGAN [_ _/_ _/_ _]
DATE WORK COMPLETED [_ _/_ _/_ _]

TIME BEGAN [_ _/_ _]
TIME COMPLETED [_ _/_ _]

2. ***WEATHER CONDITIONS:** AIR TEMPERATURE (°F) AND HUMIDITY (%)

AIR TEMPERATURE (°F)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

HUMIDITY (%)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

3. ***LENGTH OF TEST SECTION** (FEET) [_ _ _ _]

LANE WIDTH OF TEST SECTION (FEET) [_ _._]

4. ***HOLES 18 INCHES FROM THE JOINT/CRACK AND EDGE OF PAVEMENT INTERSECTION?** [_]
   NEVER ....1 SOMETIMES 2
   USUALLY ....3 ALWAYS 4

5. ***METHOD OF HOLE INSTALLATION** [_]
   ROTOHAMMER ......1 CORING 2
   OTHER 3

6. ***SIZE OF DRILL BIT** (INCHES) [_ _._]

7. ***SIDES SCRAPED DOWN?** (YES=1, NO=2) [_]

Sheet 20 *STATE ASSIGNED ID [_ _ _ _]

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LTPP PROGRAM *SHRP PROJECT ID [_ _ _ _]

EPOXY-CORE TEST (CONTINUED)

8. *DEBRIS AT BOTTOM OF HOLES REMOVED? [_]
   NEVER ....1 SOMETIMES 2
   USUALLY ....3 ALWAYS 4

9. *VACUUM NOZZLE REACHES BOTTOM OF HOLE? (YES=1, NO=2) [_]

10. *WATER IN HOLES? [_]
   NEVER ....1 SOMETIMES 2
   USUALLY ....3 ALWAYS 4

11. *WATER VACUUMED OUT OF HOLES? [_]
   NEVER ....1 SOMETIMES 2
   USUALLY ....3 ALWAYS 4

12. *EPOXY MATERIAL

   BRAND [____________________]
   TYPE [____________________]
   SOURCE (NAME AND ADDRESS) [____________________]
   [____________________]
   [____________________]

13. *FORMULATED TIME OF SET (MINUTES) [_ _ _]

14. *EPOXY VISCOSITY (CENTISTOKES PER SECOND) [_ _ _]

15. *DIAMETER OF CORES (INCHES) [_._ _]

16. *TIME BETWEEN DRILLING AND VACUUMING (DAYS/HR/MIN) [_ _/_ _/_ _]

17. *TIME BETWEEN VACUUMING AND FILLING (DAYS/HR/MIN) [_ _/_ _/_ _]

18. *TIME BETWEEN FILLING AND UNDERSEALING (DAYS/HR/MIN) [_ _/_ _/_ _]

19. *TIME BETWEEN UNDERSEALING AND CORING (DAYS/HR/MIN) [_ _/_ _/_ _]

Sheet 21A

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

EPOXY-CORE TEST (CONTINUED)

USE MULTIPLE SHEETS IF NECESSARY

20.*HOLE LOCATION STATION	20.*HOLE LOCATION OFFSET(FT)	21.*JOINT NUMBER	22.*LOCATION AT (JOINT=1, CRACK=2)	23.*SIDE OF JOINT/ CRACK (APPROACH=1, LEAVE=2)	24.*TOTAL AMOUNT OF EPOXY PER HOLE (PINTS)	25.*THICKNESS OF HARDENED EPOXY AFTER CORING (1/16th INCH)	26.*WAS SAND ADDED? (YES=1, NO=2)	27.*GROUT UNDER EPOXY (YES=1, NO=2)
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_

Sheet 21B

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

EPOXY-CORE TEST (CONTINUED)

20.*HOLE LOCATION STATION	20.*HOLE LOCATION OFFSET(FT)	21.*JOINT NUMBER	22.*LOCATION AT (JOINT=1, CRACK=2)	23.*SIDE OF JOINT/CRACK (APPROACH=1, LEAVE=2)	24.*TOTAL AMOUNT OF EPOXY PER HOLE (PINTS)	25.*THICKNESS OF HARDENED EPOXY AFTER CORING (1/16th INCH)	26.*WAS SAND ADDED? (YES=1, NO=2)	27.*GROUT UNDER EPOXY (YES=1, NO=2)
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_
_ _+_ _._	_ _._	_ _ _	_	_	_ _._ _	_ _ _	_	_

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Revised January 24, 1991

Sheet 22A — *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA — *STATE CODE [_ _]

LTPP PROGRAM — *SHRP PROJECT ID [_ _ _ _]

DYNAFLECT DEFLECTION MEASUREMENTS

1. ***DATES** (MONTH /DAY/YEAR) **AND TIME** (24 HOUR CLOCK-HR/MIN) **OF TESTING**

DATE WORK BEGAN [_ _/_ _/_ _]
DATE WORK COMPLETED [_ _/_ _/_ _]

TIME BEGAN [_ _/_ _]
TIME COMPLETED [_ _/_ _]

2. ***WEATHER CONDITIONS:** AIR TEMPERATURE (°F) AND HUMIDITY (%)

AIR TEMPERATURE (°F)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

HUMIDITY (%)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

3. ***PAVEMENT SURFACE MOISTURE CONDITION AT TIME OF TESTING** [_]

DRY ....1 MOSTLY DRY 2
SOMEWHAT DAMP ....3 WET 4

4. ***PURPOSE OF TESTING** [_]

DETERMINE NEED FOR UNDERSEALING 1
SLAB STABILITY AFTER INITIAL GROUTING ...2
SLAB STABILITY AFTER REGROUT 3
POST CONSTRUCTION MONITORING 4

5. ***SOURCE OF TESTING DEVICE** [_]

SHRP ....1 HOST STATE OR PROVINCE ..2
OTHER STATE ....3 OTHER 4

Sheet 22B

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

DYNAFLECT DEFLECTION MEASUREMENTS (CONTINUED)

USE MULTIPLE SHEETS IF NEEDED

5.*POINT LOCATION (STATION)	6.*JOINT NUMBER	7.*LOCATION (JOINT=1, CRACK=2, NEITHER=3)	8.*SIDE OF JOINT/CRACK (APPROACH=1, LEAVE=2, NEITHER=3)	9. *MEASUREMENTS FROM DEFLECTION SENSORS (MILS) 1	2	3	4	5
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _

Sheet 22C

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

DYNAFLECT DEFLECTION MEASUREMENTS (CONTINUED)

5.*POINT LOCATION (STATION)	6.*JOINT NUMBER	7.*LOCATION (JOINT=1, CRACK=2, NEITHER=3)	8.*SIDE OF JOINT/CRACK (APPROACH=1, LEAVE=2, NEITHER=3)	9. *MEASUREMENTS FROM DEFLECTION SENSORS (MILS) 1	2	3	4	5
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _
_ _+_ _._	_ _ _	_	_	_ _._ _	_ _._ _	_ _._ _	_ _._ _	_ _._ _

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Sheet 23A
SPS-4 DATA
LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]
*STATE CODE [_ _]
*SHRP PROJECT ID [_ _ _ _]

TRANSIENT DYNAMIC RESPONSE SYSTEM MEASUREMENTS

1. ***DATES** (MONTH /DAY/YEAR) **AND TIME** (24 HOUR CLOCK-HR/MIN) **OF TESTING**

DATE WORK BEGAN [_ _/_ _/_ _]
DATE WORK COMPLETED [_ _/_ _/_ _]

TIME BEGAN [_ _/_ _]
TIME COMPLETED [_ _/_ _]

2. ***WEATHER CONDITIONS:** AIR TEMPERATURE (°F) AND HUMIDITY (%)

AIR TEMPERATURE (°F)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

HUMIDITY (%)
BEGINNING OF TESTING [_ _ _]
END OF TESTING [_ _ _]

3. ***PAVEMENT SURFACE MOISTURE CONDITION AT TIME OF TESTING** [_]

DRY ....1 MOSTLY DRY 2
SOMEWHAT DAMP ....3 WET 4

4. ***PURPOSE OF TESTING** [_]

DETERMINE NEED FOR UNDERSEALING 1
SLAB STABILITY AFTER INITIAL GROUTING ...2
SLAB STABILITY AFTER REGROUT 3
POST CONSTRUCTION MONITORING 4

Sheet 23B

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

TRANSIENT DYNAMIC RESPONSE SYSTEM MEASUREMENTS
USE MULTIPLE SHEETS IF NEEDED

4. *POINT LOCATION (STATION)	5. *POINT OFFSET(FT)	6. *LOCATION AT (JOINT=1, CRACK=2, MIDPOINT=3)	7. *SIDE OF JOINT/ CRACK (APPROACH=1, LEAVE=2, NEITHER=3)	TEMPERATURE (°F) 8. *AIR	9. *PAVEMENT	10. *DESCRIPTION OF LOCATION (GOOD CONCRETE/GOOD SUPPORT=1, POOR/DISTRESSED CONCRETE=2, POOR SUPPORT=3, SMALL VOID=4, MEDIUM VOID=5, LARGE VOID=6, VOID/POOR SUPPORT=7)
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	___

Sheet 23C

SPS-4 DATA

LTPP PROGRAM

*STATE ASSIGNED ID [_ _ _ _]

*STATE CODE [_ _]

*SHRP PROJECT ID [_ _ _ _]

TRANSIENT DYNAMIC RESPONSE SYSTEM MEASUREMENTS

4. *POINT LOCATION (STATION)	5. *POINT OFFSET(FT)	6. *LOCATION AT (JOINT=1, CRACK=2, MIDPOINT=3)	7. *SIDE OF JOINT/ CRACK (APPROACH=1, LEAVE=2, NEITHER=3)	TEMPERATURE (°F) 8. *AIR	TEMPERATURE (°F) 9. *PAVEMENT	10. *DESCRIPTION OF LOCATION (GOOD CONCRETE/GOOD SUPPORT=1, POOR/DISTRESSED CONCRETE=2, POOR SUPPORT=3, SMALL VOID=4, MEDIUM VOID=5, LARGE VOID=6, VOID/POOR SUPPORT=7)
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____
_ _+_ _._	_ _._ _	_	_	_ _ _	_ _ _	____

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Sheet 24 *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP PROJECT ID [_ _ _ _]

CONTROL SECTION

(THESE DATA SHEETS APPLY TO CONCRETE PAVEMENT CONTROL SECTIONS)

1. ***DATE** (MONTH/DAY/YEAR) [_ _/_ _/_ _]

   TIME (24 HOUR CLOCK-HR/MIN) [_ _/_ _]

2. ***LENGTH OF CONTROL SECTION TO BE MONITORED** (Feet) [_ _ _ _]

LANE WIDTH OF CONTROL SECTION (Feet) [_ _._]

3. ***WEATHER CONDITIONS**

AIR TEMPERATURE (°F) [_ _ _]

HUMIDITY (%) [_ _ _]

4. ***TYPE OF JOINTS AND CRACKS PRESENT** (ALL SEALED=1, MOST SEALED=2, FEW SEALED =3, NONE SEALED=4, NONE PRESENT TO SEAL=5)

CONCRETE PAVEMENT/ASPHALT SHOULDER JOINT [_]
TRANSVERSE PAVEMENT JOINTS [_]
LONGITUDINAL PAVEMENT JOINTS [_]
TRANSVERSE RANDOM CRACKS [_]
LONGITUDINAL RANDOM CRACKS [_]
DIAGONAL RANDOM CRACKS [_]

5. ***PROCESS USED TO OPEN JOINTS** (SEALANT REMOVED=1, SEALANT CUT=2, SEALANT NOT EFFECTIVE AND LEFT IN PLACE=3, SEALANT SOMEWHAT EFFECTIVE AND LEFT IN PLACE=4, OTHER=5) [_]

DEFINE OTHER [______________________________]

6. ***PATCHING COMPLETED ON CONTROL SECTION** (NO PATCHING=1, MINOR PATCHING=2, MODERATE PATCHING=3, MAJOR PATCHING=4) [_]

Revised 2/91

Sheet 25 *STATE ASSIGNED ID [_ _ _ _]

SPS-4 DATA *STATE CODE [_ _]

LTPP PROGRAM *SHRP PROJECT ID [_ _ _ _]

CONTROL SECTION (CONTINUED)

7. *DIMENSIONS OF JOINTS AND CRACKS

AVERAGE WIDTH OF JOINTS/CRACKS (MEASURE TEN RANDOM LOCATIONS) (1/16TH INCH)

	SHOULDER JOINTS	PAVEMENT JOINTS TRANSVERSE	PAVEMENT JOINTS LONGITUDINAL	RANDOM CRACKS
1.	[_ _]	[_ _]	[_ _]	[_ _]
2.	[_ _]	[_ _]	[_ _]	[_ _]
3.	[_ _]	[_ _]	[_ _]	[_ _]
4.	[_ _]	[_ _]	[_ _]	[_ _]
5.	[_ _]	[_ _]	[_ _]	[_ _]
6.	[_ _]	[_ _]	[_ _]	[_ _]
7.	[_ _]	[_ _]	[_ _]	[_ _]
8.	[_ _]	[_ _]	[_ _]	[_ _]
9.	[_ _]	[_ _]	[_ _]	[_ _]
10.	[_ _]	[_ _]	[_ _]	[_ _]
MINIMUM	[_ _]	[_ _]	[_ _]	[_ _]
MAXIMUM	[_ _]	[_ _]	[_ _]	[_ _]
AVERAGE	[_ _]	[_ _]	[_ _]	[_ _]

Appendix D

Laboratory Protocols

This appendix contains the protocols developed to standardize laboratory testing for SHRP study H-101, Pavement Maintenance Effectiveness. American Association of State Highway Officials (AASHTO) and American Society for Testing and Materials (ASTM) procedures were used in developing the protocols whenever possible (AASHTO 1990; ASTM 1992a; ASTM 1992b). Data collection sheets for these protocols are included in appendix E.

SHRP Protocol: H01L
For SHRP Test Designation: AC08
Preparation of Asphalt Cores for Aging Tests

This procedure will be used to prepare asphalt cores for testing to determine how the asphalt material ages. It will be conducted after core examination in accordance with SHRP Method AC01. It will be completed prior to extracting asphalt for the aging tests. The top 1-in (25-mm) of the core will be removed using a diamond blade saw. The aging tests will be conducted on the asphalt cement extracted from the top 1-in (25-mm) of the core. Abson recovery, penetration, and viscosity will be tested in accordance with SHRP H02L, H03L, and H04L protocols. The next 1-in (25-mm) layer will also be removed using a diamond blade saw, for moisture content analysis.

After the treatments have been placed, the hot-mix asphalt concrete overlay, chip seal, or slurry seal will be removed from the remainder of the core using a diamond blade saw. Then the top 1-in (25-mm) of the core will be removed and tested as described above.

SHRP Protocol: H02L
For SHRP Test Designation: AE01
Recovery of Asphalt from Solution by Abson Method

This SHRP protocol covers the recovery of asphalt cement from cores recovered from pavements as part of SPS-3 studies. The recovery will be performed in accordance with AASHTO T 170-89I, Standard Method of Test for Recovery of Asphalt from Solution by Abson Method.

The extraction shall be performed in accordance with AASHTO T 164-89I, Standard Method of Test for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures, except as designated below. Reagent-grade trichloroethylene shall be used as the reagent required in paragraph 4. Method A will be followed.

The moisture in the sample will be tested in accordance with AASHTO T 110-88I, Standard Method of Test for Moisture or Volatile Distillates in Bituminous Mixtures, except as designated below. Xylene will be used as the solvent required by paragraph 2.4. Tests listed in paragraph 6 will be omitted. Instead of the requirements of paragraph 3, the following will be used: The top 1-in (25-mm) of each core will be removed in accordance with SHRP Protocol H01L and used in the extraction and subsequent testing. The moisture content will be determined from the next 1-in (25-mm) layer, which must also be removed using a diamond blade saw.

This protocol includes no testing of the extracted material. All tests on the extracted material are required by SHRP Protocols H03L and H04L.

The results will be recorded on SHRP Test Sheet H01.

SHRP Protocol: H03L
For SHRP Test Designation: AE02
Penetration of Bituminous Materials

This SHRP protocol covers the determination of the penetration of asphalt cements at 25°C (77°F). It is intended to be used on asphalt cements extracted from cores recovered from pavements as part of SPS-3 studies. The test will be performed in accordance with AASHTO T 49-89I, Standard Method of Test for Penetration of Bituminous Materials, except as designated below. The test will be conducted at 25°C (77°F). The 50-g weight will be placed on the needle providing a 100-g weight total. Use this test in place of ASTM D5 when necessary. When performing the test in accordance with ASTM D3407-78, use a penetration cone in place of the needle, meeting the requirements established in paragraph 5 of ASTM D3407-78.

The results will be recorded on SHRP Test Sheet H02 for SPS-3. The results will be recorded on SHRP Test Sheet H15 for SPS-4.

SHRP Protocol: H04L
For SHRP Test Designation: AE06
Viscosity of Asphalts

This SHRP protocol covers the determination of absolute viscosity. It is intended to be used on asphalt cements extracted from cores taken as part of SPS-3 studies.

The absolute viscosity of asphalt cements will be determined by vacuum capillary viscometers at 60°C (140°F). The test will be performed in accordance with AASHTO T 202-89I, Standard Method of Test for Viscosity of Asphalts by Vacuum Capillary Viscometer, except as designated below. Asphalt Institute viscometers will be used.

The results will be recorded on SHRP Test Sheet H03.

SHRP Protocol: H05L

For SHRP Test Designation: SC01
Standard Methods of Testing Emulsified Asphalts

This SHRP protocol covers the tests performed on an emulsified asphalt. These tests are intended for emulsions in slurry and chip seals used as part of SPS-3 studies. The tests are to be run in accordance with AASHTO T 59-89I, Standard Methods of Test for Testing Emulsified Asphalts, except Procedure B of Residue by Evaporation will be used to determine the quantity of residual asphalt and to recover the base asphalt for further testing. The following tests are not required: Identification of Residue by Evaporation, Oil Distillate by Micro-Distillation; Settlement; Coating; Freezing; and Coating Ability and Water Resistance. Testing will begin within five days of the sample date.

The results will be recorded on SHRP Test Sheets H04A, H04B, and H04C. The following table was prepared to define the specific tests to be applied to the samples of materials sent to the laboratory. Only those tests identified with an X are required. Separate sets of columns show the tests for rapid-setting emulsions used with chip seals (Sample Material Code AECS) and for slow-setting emulsions used with slurry seals (Sample Material Code AESL). Each of these have two columns SO01 and Other. All tests shown under the column SO01 will be completed on the respective emulsion when the sample location code is SO01, SO02, and so on. In addition, every fourth sample with other location codes will receive the testing shown under the respective column identified as SO01. The remaining samples will receive only the tests shown under the respective columns identified as Other.

Table of Tests for Chip Seal and Slurry Seal Emulsions

	Chip Seal Emulsion		Slurry Seal Emulsion	
Sample Material Code	AECS		AESL	
Sample Location Code	SO01	Other	SO01	Other
Residue by Distillation	X	X	X	X
Particle Charge	X	X	X	X
Viscosity (Saybolt Furol)	X	X	X	X
Demulsibility	X			
Cement Mixing			X	X
Sieve Test	X	X	X	X
Miscibility with Water	X		X	
Storage Stability	X	X	X	X
Classification Test for Rapid Setting	X	X		
Field Coating	X			
Weight per Gallon		X		X
Examination of Residue				
Specific Gravity	X		X	
Solubility in Trichloroethylene	X	X	X	X
Penetration	X	X	X	X
Ductility	X	X	X	X

SHRP Protocol: H06L
For SHRP Test Designation: SC02
Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

This SHRP protocol covers the test to indicate the proportions of clay-like or plastic fines and dusts in granular soils and fine aggregates. This test is intended for the aggregates in slurry seals used as part of SPS-3 studies. The test will be performed in accordance with AASHTO T176-86, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test, except that the Mechanical Shaker Method (Referee Method) must be used.

The results will be recorded on SHRP Test Sheet H06.

SHRP Protocol: H07L
For SHRP Test Designation: SC03
Testing Crushed Stone, Crushed Slag, and Gravel for Single or Multiple Bituminous Surface Treatments

This SHRP protocol covers testing for the quality and size of crushed aggregate to be used in single or multiple bituminous surface treatments. All tests required by ASTM D1139-83, Standard Specifications for Crushed Stone, Crushed Slag, and Gravel For Single or Multiple Bituminous Surface Treatments, will be completed in accordance with ASTM D1139 with the following exceptions:

1. Resistance to Degradation will be determined in accordance with AASHTO T96-87I.
2. Unit Weight will be determined in accordance with AASHTO T19-88I, using the rodding procedure described in paragraph 7.
3. Sulfate Soundness will be determined in accordance with AASHTO T104-86I using Sodium Sulfate.
4. Sieve Analysis will be determined in accordance with SHRP Test SC10, H14L.
5. Clay Lumps and Friable Particles will be determined in accordance with AASHTO T112-87I.
6. Lightweight Pieces will be determined in accordance with AASHTO T113-86. The liquid will be a zinc chloride solution with a specific gravity of 2.0.
7. No measure of flat or elongated pieces is required.

The results will be recorded on SHRP Test Sheet H07.

SHRP Protocol: H08L
For SHRP Test Designation: SC04
Determination of Flakiness Index of Aggregates

This SHRP protocol covers the procedure of determining the percentage by weight of particles with a thickness of less than three-fifths of their mean dimension. This test is to be performed on the aggregate used in the chip seal applied as part of SPS-3 studies. This test will be performed in accordance with the Determination of Flakiness Index of Aggregates as described in "Asphalt Surface Treatments," (MS-13) dated January 1975 and Basic Asphalt Emulsion Manual (MS-19) Second Edition, March 1979, by the Asphalt Institute (AI 1975; AI 1979).

The results will be recorded on SHRP Test Sheet H08.

SHRP Protocol: H09L
For SHRP Test Designation: SC05
Design, Testing, and Construction of Slurry Seal

This SHRP protocol covers the design, testing, and construction of slurry seal mixtures. It is intended that the tests be performed on the slurry seals to be used as part of SPS-3 studies. All tests required by ASTM D3910-84 are to be performed in accordance with ASTM D3910-84, Standard Practices for Design, Testing, and Construction of Slurry Seals. Set Time, Cure Time, Traffic Time, and System Classification will be conducted in accordance with International Slurry Seal Association (ISSA) TB-139, 1982 - Revised 1990. Consistency is measured in accordance with paragraph 6.1 as modified by ISSA TB 106, 1976 - Revised 1990.

The results will be recorded on SHRP Test Sheet H09.

SHRP Protocol: H10L
For SHRP Test Designation: SC06
Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded-Wheel Tester and Sand Cohesion

This SHRP protocol covers the loaded-wheel test that is used to compact fine aggregate bituminous mixtures. This test is to be performed on slurry seals to be used in SPS-3 studies. It is to be performed in accordance with ISSA technical bulletin TB-109, 1976 -Revised 1978. The testing will be completed using 125 lb applied load at 77 °F ± 2 °F (25 °C ± 1 °C). The number of cycles required in paragraph 6.5 will be 1,000.

The results will be recorded on SHRP Test Sheet H10.

SHRP Protocol: H11L
For SHRP Test Designation: SC07
Wet Stripping for Cured Slurry Seal Mixes

This SHRP protocol aids in selecting a compatible slurry seal system with a given aggregate. It is intended for use on the slurry seals to be used as part of SPS-3 studies. The test is to be performed in accordance with ISSA TB-114 - Revised 1990.

The results will be recorded on SHRP Test Sheet H11.

SHRP Protocol: H12L
For SHRP Test Designation: SC08
Determination of Slurry System Compatibility

This SHRP protocol covers the compatibility of a slurry seal system. It is intended for slurry seal to be used as part of SPS-3 studies. The test is to be performed in accordance with ISSA TB-115 - Revised 1990. The Mix and Workability Test is not required. The Wet-Stripping Test is performed in SHRP Test Designation SC07 and need not be repeated as a part of this test.

The results will be recorded on SHRP Test Sheet H12.

SHRP Protocol: H13L
For SHRP Test Designation: SC09
Mixing, Setting, and Water Resistance Test to Identify "Quick Set" Emulsified Asphalts

This SHRP protocol covers the procedures used to identify a quick set emulsified asphalt. The test is to be performed in accordance with ISSA TB-102, 1978 - Revised 1990, Mixing, Setting, and Water Resistance Test to Identify "Quick Set" Emulsified Asphalts.

The results will be recorded on SHRP Test Sheet H13.

SHRP Protocol: H14L
For SHRP Test Designation: SC10
Sieve Analysis of Seal Coat Aggregates

This SHRP protocol covers the procedures used determine the size distribution of aggregates for chip seals and slurry seals for use in the H-101 SPS-3 study. The test is to be performed in accordance with AASHTO T 27-82 as modified herein. The sieve sizes shall conform to the following:

Chip Seal	Slurry Seal
1/2	
3/8	5/16
#4	#4
#8	#8
#10	
	#16
	#30
	#50
	#100
#200	#200

The results of tests on chip seal aggregates (AGCS) will be recorded on SHRP Test Sheets H16A. The results for slurry seal aggregates (AGSL) will be recorded on SHRP Test Sheet H16B.

SHRP Protocol: H15L
For SHRP Test Designation: SC11
Chip Seal Mix Design

This SHRP protocol covers the procedures for determining the chip seal design to be used as part of SPS-3 studies. The design procedure will be performed in accordance with Appendix C, Design of Surface Treatments, Procedure B, of the Asphalt Surface Treatments Handbook, (MS-13), 1975, published by the Asphalt Institute (AI 1975). Use AASHTO T 85-88I for determining the bulk specific gravity of the aggregates. Allow for 10 percent aggregate waste (E). Assume a traffic factor (T) of 0.65 and a surface adjustment variable (V) of 0.00. These latter two will be adjusted in the field to modify the residual asphalt spread rate as needed for site specific conditions. The asphalt spread rate will be used to determine the emulsified asphalt spread rate.

The results will be recorded on SHRP Test Sheet H14.

SHRP Protocol: H16L
For SHRP Test Designator: CS01
Joint Sealants, Hot-Poured, for Cement and Asphalt Pavements

This SHRP protocol covers the test for bituminous hot-poured types of joint sealants for portland cement concrete and asphaltic concrete pavements. These tests are intended to be used on hot-poured joint or crack sealants. The tests will be performed in accordance with ASTM D3407-78, Standard Method of Testing Joint Sealants, Hot-Poured, for Concrete and Asphalt Pavements. Alternate Procedure 7.4.1, may not be used, and Preparation of Specimens under 9.1.1 must be completed in accordance with AASHTO T 245-89I. Penetration tests required in paragraph 5 shall be completed in accordance with SHRP Protocol H03L.

The results will be recorded on SHRP Test Sheet H15.

SHRP Protocol: H17L
For SHRP Test Designator: CS02
Joint Sealants, Silicone

This SHRP protocol covers the tests for silicone joint sealants for portland cement concrete pavements. The tests will be performed in accordance with Georgia (GA DOT) DOT Standards Specifications 833.06, Silicone Sealants and Bond Breakers (Modification).

The results will be recorded on SHRP Test Sheet H19.

SHRP Protocol: H18L
For SHRP Test Designator: US01
Compressive Strength of Hydraulic Cement Mortar

This SHRP protocol covers the tests for compressive strength of hydraulic cement mortars for testing undersealing materials as part of SPS-4. The tests will be performed in accordance with AASHTO T106-88I.

SHRP Protocol: H19L
For SHRP Test Designation: SC12
Determination of Asphalt Content from Slurry Seal Sample

This SHRP protocol covers the determination of asphalt cement content from slurry seal samples taken in the field as part of SPS-3 studies. The extraction will be performed in accordance with AASHTO T 164-89I, Standard Method of Testing for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures, except as designated below. Reagent-grade trichloroethylene shall be used as the reagent required in paragraph 4. Method A will be followed. The sample will be taken from the slurry seal sample taken in the field. A 3-lb to 3.5-lb (1.4-kg to 1.6-kg) representative sample will be taken from the sample submitted for testing.

The moisture in the sample will be tested in accordance with AASHTO T 110-88I, Standard Method of Test for Moisture or Volatile Distillates in Bituminous Mixtures, except as designated below. Xylene will be used as the solvent required by paragraph 2.4. Tests listed in paragraph 6 will be omitted.

The results will be recorded on SHRP Test Sheet H17.

SHRP Protocol: H20L
For SHRP Test Designation: SC13
Accelerated Polishing of Aggregate Using the British Wheel

This SHRP protocol covers the procedures for determining the polish value of aggregates for the chip seals used as part of SPS-3 studies. The tests will be performed in accordance with AASHTO T 279-83, Accelerated Polishing of Aggregate Using the British Wheel.

The results will be recorded on SHRP Test Sheet H18.

Appendix E

Laboratory Data Collection Sheets

This appendix contains the data collection sheets to be used in laboratory testing for SHRP study H-101, Pavement Maintenance Effectiveness. The test protocols are included in appendix D.

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H01

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF ASPHALT CEMENTS EXTRACTED FROM CORES
ABSON RECOVERY

SHRP TEST DESIGNATION: AE01 — SHRP PROTOCOL H02L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   (a) Moisture in Mixture % _ _ . _ %
   (b) Asphalt Content _ _ . _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

LABORATORY CHIEF
Affiliation ____________

SHRP REPRESENTATIVE
Affiliation ____________

Form H01, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H02

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF ASPHALT CEMENTS EXTRACTED FROM CORES
PENETRATION OF BITUMINOUS MATERIALS

SHRP TEST DESIGNATION: AE02 — SHRP PROTOCOL H03L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS

   Average Penetration _ _ _ (0.1 MM)
   Test Temperature _ _ _ °C

6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________________

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H02, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H03

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF ASPHALT CEMENTS EXTRACTED FROM CORES
VISCOSITY OF BITUMINOUS MATERIALS

SHRP TEST DESIGNATION: AE06 — SHRP PROTOCOL H04L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS

   Vacuum Capillary (Absolute) Viscosity _ _ _ _ poise
   Test Temperature _ _ _ °C
   Vacuum _ _ _ mm Hg

6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H03, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H04A

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ___________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF EMULSIFIED ASPHALTS
TESTS ON EMULSION (Sheet 1 of 3)

SHRP TEST DESIGNATION: SC01 — SHRP PROTOCOL H05L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Residue and Oil Distillate by Distillation
      Percent residue by distillation _ _ . _ %
      Oil Distillate _ _ . _ %
   b. Ductility of Residue
      Distance (cm/min) _ _ _
   c. Penetration of Residue
      Penetration (1/10 mm) _ _ _
   d. Solubility of Residue _ _ . _ %
   e. Cement Mixing, mass _ _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

______________________ ______________________
LABORATORY CHIEF — SHRP REPRESENTATIVE
Affiliation____________ Affiliation____________

Form H04A, November 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA TEST SHEET H04B

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF EMULSIFIED ASPHALTS
TESTS ON EMULSION (Sheet 2 of 3)

SHRP TEST DESIGNATION: SC01 SHRP PROTOCOL H05L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Consistency (Saybolt Viscosity)
      Viscosity (25°C) _ _ _ seconds
      Viscosity (50°C) _ _ _ seconds
   b. Particle Charge of Emulsified Asphalts Polarity ____________
      (positive or negative)
   c. Sieve Test, mass _ _ %
   d. Storage Stability of Asphalt Emulsion _ _ %
   e. Classification Test For Rapid Setting Cationic Emulsified Asphalt
      Aggregate surface coated by emulsion less than
      uncoated aggregate surface area (yes or no) ___
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE CHECKED AND APPROVED, DATE

______________________ ______________________
LABORATORY CHIEF SHRP REPRESENTATIVE
Affiliation__________ Affiliation__________

Form H04B, November 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H04C

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF EMULSIFIED ASPHALTS
TESTS ON EMULSION (Sheet 3 of 3)

SHRP TEST DESIGNATION: SC01 — SHRP PROTOCOL H05L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Field-Coating Test on Emulsified Asphalt
      Coating of stone (good, fair, or poor) ______
      Free water present (yes or no)
   b. Demulsibility, mass _ _ %
   c. Miscibility with Water
      Coagulation of asphalt cement (yes or no) ______
   d. Specific Gravity of Residue _ . _ _ _
   e. Weight Per Gallon of Emulsified Asphalt
      Unit weight of emulsion (lb/gal) _ _ . _ _
      Temperature of test (°C) _ _ _
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

____
LABORATORY CHIEF
Affiliation______________

____
SHRP REPRESENTATIVE
Affiliation______________

Form H04C, November 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ______________

LABORATORY MATERIAL TEST DATA   TEST SHEET H06

SAMPLES FROM: (a) SHRP REGION ______________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF AGGREGATES
PLASTIC FINES IN GRADED AGGREGATES
BY USE OF THE SAND EQUIVALENT TEST

SHRP TEST DESIGNATION: SC02   SHRP PROTOCOL H06L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. SAND EQUIVALENCY _ _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE   CHECKED AND APPROVED, DATE

______________________   ______________________
LABORATORY CHIEF   SHRP REPRESENTATIVE
Affiliation____________   Affiliation____________

Form H06, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H07

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ____________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF AGGREGATES
TESTING CRUSHED STONE FOR SINGLE BITUMINOUS SURFACE TREATMENTS

SHRP TEST DESIGNATION: SC03 — SHRP PROTOCOL H07L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Resistance to Degradation by Los Angeles Machine
      Percentage of wear _ _ %
   b. Unit Weight _ _ _ lb/ft^3
   c. Soundness (total % loss) _ _ %
   d. Clay Lumps and Friable Particles (% weight) _ _ %
   e. Material Floating on a Liquid with a Specific Gravity of 2.0
      Percentage of lightweight material _ _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation ____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation ____________

Form H07, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA TEST SHEET H08

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ____________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF AGGREGATES
DETERMINATION OF FLAKINESS INDEX OF AGGREGATES

SHRP TEST DESIGNATION: SC04 SHRP PROTOCOL H08L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. FLAKINESS INDEX _ _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS:____

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H08, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H09

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT ________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ____________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
TESTING OF SLURRY SEAL

SHRP TEST DESIGNATION: SC05 — SHRP PROTOCOL H09L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Consistency (Flow) _ . _ cm
   b. Set Time _ _ . _ _ hr
   c. Cure Time _ _ . _ _ hr
   d. Traffic Time _ _ . _ _ hr
   e. System Classification _ _ - _ _ _
   f. Wet Track Abrasion (Loss) _ _ _ . _ gm/ft^2
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____________________

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation ________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation ________

Form H09, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA TEST SHEET H10

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY __________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
MEASUREMENT OF EXCESS ASPHALT IN BITUMINOUS MIXTURES
BY USE OF A LOADED-WHEEL TESTER AND SAND COHESION

SHRP TEST DESIGNATION: SC06 SHRP PROTOCOL H10L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Weight before Testing _ _ _ gm
   b. Specimen Thickness _ . _ _ in
   c. Tack Point _ _ _ _ cycles
   d. Weight on Test Wheel _ _ _ _ lbs
   e. Temperature of Test _ _ _ °F
   f. Weight after Testing _ _ _ gm
   g. Sand Adhesion _ _ _ gm
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE CHECKED AND APPROVED, DATE

____________________ ____________________
LABORATORY CHIEF SHRP REPRESENTATIVE
Affiliation__________ Affiliation__________

Form H10, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA TEST SHEET H11

SAMPLES FROM: (a) SHRP REGION ______________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
WET-STRIPPING TEST FOR CURED SLURRY SEAL MIXES

SHRP TEST DESIGNATION: SC07 SHRP PROTOCOL H11L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. AGGREGATE SURFACE RETAINING COATING _ _ _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H11, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H12

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ____________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ____________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
DETERMINATION OF SLURRY SYSTEM COMPATIBILITY

SHRP TEST DESIGNATION: SC08 — SHRP PROTOCOL H12L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Consistency _ tacky _ satisfactory
   b. Split Consistency
      Asphalt and aggregate distribution _ uniform _ nonuniform
      Surface of specimen _ tacky _ satisfactory
   c. Referee Cup (% AC difference) _ _ % AC Difference
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H12, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ______________

LABORATORY MATERIAL TEST DATA TEST SHEET H13

SAMPLES FROM: (a) SHRP REGION ______________ (b) STATE ___________ (c) STATE CODE _ _
(d) LTPP EXPT ______________ (e) SHRP SECTION ID _ _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ___________________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
MIXING, SETTING AND WATER RESISTANCE TEST TO
IDENTIFY "QUICK SET" EMULSIFIED ASPHALTS

SHRP TEST DESIGNATION: SC09 SHRP PROTOCOL H13L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Mixing Time _ _ _ seconds
   b. Paper Towel Stained _ yes _ no
   c. Water Discoloration _ none _ slight _ more than slight
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE

____
LABORATORY CHIEF
Affiliation____________

CHECKED AND APPROVED, DATE

____
SHRP REPRESENTATIVE
Affiliation____________

Form H13, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H14

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF CHIP SEALS
CHIP SEAL MIX DESIGN

SHRP TEST DESIGNATION: SC11 — SHRP PROTOCOL H15L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   a. Bulk Specific Gravity of Aggregate _ . _ _
   b. Average Least Dimension _ . _ _ in
   c. Aggregate Wastage Factor (E) _ . _ _
   d. Aggregate Spread Rate _ _ . _ lb/yd^2
   e. Traffic Factor (T) _ . _ _
   f. Surface Condition Variable (V) _ . _ _ gal/yd^2
   g. Residual Asphalt Spread Rate _ . _ _ gal/yd^2
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

______________________ — ______________________

LABORATORY CHIEF — SHRP REPRESENTATIVE

Affiliation__________ — Affiliation__________

Form H14, May 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA TEST SHEET H16A

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF CHIP SEALS
AGGREGATE GRADATION

SHRP TEST DESIGNATION: SC10 SHRP PROTOCOL H14L

1. LAYER NUMBER _ _ _

2. SHRP LABORATORY TEST NUMBER _

3. LOCATION NUMBER _ _ _

4. SHRP SAMPLE NUMBER _ _ _ _

5. GRADATION, % PASSING EACH SIEVE

Standard	
1/2	_ _ . _
3/8	_ _ . _
#4	_ _ . _
#8	_ _ . _
#10	_ _ . _
#200	_ _ . _

6. TEST DATE _ _-_ _-_ _ _ _-_ _-_ _

GENERAL REMARKS: ________________________________

SUBMITTED BY, DATE CHECKED AND APPROVED, DATE

________________ ____________________
LABORATORY CHIEF SHRP REPRESENTATIVE
Affiliation__________ Affiliation__________

Form H16A, June 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H16B

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY __________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
AGGREGATE GRADATION

SHRP TEST DESIGNATION: SC10 — SHRP PROTOCOL H14L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. GRADATION, % PASSING EACH SIEVE

Standard	
5/16	_ _ . _
#4	_ _ . _
#8	_ _ . _
#16	_ _ . _
#30	_ _ . _
#50	_ _ . _
#100	_ _ . _
#200	_ _ . _

6. TEST DATE _ _-_ _-_ _ _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

LABORATORY CHIEF
Affiliation____________

SHRP REPRESENTATIVE
Affiliation____________

Form H16B, June 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H17

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF SLURRY SEALS
DETERMINATION OF ASPHALT CONTENT FROM SLURRY SEAL SAMPLE

SHRP TEST DESIGNATION: SC12 — SHRP PROTOCOL H19L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS
   (a) Moisture in Mixture % _ _ . _ %
   (b) Asphalt Content _ _ . _ %
6. TEST DATE _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

______________________ ______________________
LABORATORY CHIEF — SHRP REPRESENTATIVE
Affiliation____________ — Affiliation____________

Form H17, June 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H18

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE ________ (c) STATE CODE _ _
(d) LTPP EXPT __________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY __________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF CHIP SEAL AGGREGATES
POLISH VALUE

SHRP TEST DESIGNATION: CS13 — SHRP PROTOCOL H20L

1. LAYER NUMBER _ _ _
2. SHRP LABORATORY TEST NUMBER _
3. LOCATION NUMBER _ _ _
4. SHRP SAMPLE NUMBER _ _ _ _
5. TEST RESULTS

(A) Gradation of Sample Tested, % Passing Each Sieve

Standard	
1/2	_ _ . _
3/8	_ _ . _
#4	_ _ . _
#8	_ _ . _
#10	_ _ . _
#200	_ _ . _

(b) Initial Friction Value _ _ _ . _

(c) Polish Value _ _ _

6. TEST DATE _ _-_ _-_ _ _ _-_ _-_ _

GENERAL REMARKS: ______________________________

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

LABORATORY CHIEF
Affiliation____________

SHRP REPRESENTATIVE
Affiliation____________

Form H18, July 1990

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LABORATORY SOURCE: (a) LTPP REGIONAL LABORATORY (b) STATE AGENCY LABORATORY
(c) OTHER ______________________
LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ______________

LABORATORY MATERIAL TEST DATA — TEST SHEET H15

SAMPLES FROM: (a) SHRP REGION ______________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ______________ (e) SHRP SECTION ID _ _ _ _ _ _ (f) FIELD SET NUMBER __
SAMPLED BY ________________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF JOINT SEALANTS, HOT-POURED

SHRP TEST DESIGNATION: CS01 — SHRP PROTOCOL H16L

1. LAYER NUMBER _ _ _

2. SHRP LABORATORY TEST NUMBER _

3. LOCATION NUMBER _ _ _

4. SHRP SAMPLE NUMBER _ _ _ _

5. TEST RESULTS

		Initial	After Prolonged Heating
a.	Average Penetration Temperature	_ _ _ (0.1 mm) _ _ °C	_ _ _ (0.1 mm) _ _ °C
b.	Flow (change in length)	_ _ . _ mm	_ _ . _ mm
c.	Bond (all three samples)	_ pass _ fail	_ pass _ fail
d.	Resilience (average recovery)	_ _ %	_ _ %
e.	Asphalt Compatibility Compatibility results	_ pass _ fail approved	_ pass _ fail rejected

6. TEST DATE _ _-_ _-_ _   _ _-_ _-_ _

GENERAL REMARKS: ____

SUBMITTED BY, DATE — CHECKED AND APPROVED, DATE

______________________ LABORATORY CHIEF
Affiliation______________

______________________ SHRP REPRESENTATIVE
Affiliation______________

Form H15, January 1991

SHRP-LTPP
LABORATORY MATERIAL
HANDLING AND TESTING

LABORATORY SOURCE: (a) LTPP REGIONAL LABORATORY (b) STATE AGENCY LABORATORY
(c) OTHER ____________________
LTPP REGIONAL LABORATORY FOR ASPHALTIC MATERIAL, AGGREGATE AND SOILS ____________

LABORATORY MATERIAL TEST DATA — TEST SHEET H19

SAMPLES FROM: (a) SHRP REGION ____________ (b) STATE __________ (c) STATE CODE _ _
(d) LTPP EXPT ____________ (e) SHRP SECTION ID _ _ _ _ (f) FIELD SET NUMBER _
SAMPLED BY ______________________________ DATE SAMPLED _ _-_ _-_ _ _ _

PROPERTIES OF JOINT SEALANTS, SILICONE
SHRP TEST DESIGNATION: CS02 SHRP PROTOCOL H17L

1. LAYER NUMBER _ _ _

2. SHRP LABORATORY TEST NUMBER _

3. LOCATION NUMBER _ _ _

4. SHRP SAMPLE NUMBER _ _ _ _

5. TEST RESULTS
   A. TENSILE STRESS AT 150% STRAIN __________PSI

   B. DUROMETER HARDNESS (SHORE A) __________

   C. BONDING STRENGTH ON CONCRETE MORTAR (AVERAGE OF 5 TESTED) __________PSI

   D. TACK FREE TIME __________MIN

   E. EXTRUSION RATE __________G/MIN

   F. NONVOLATILE __________%

   G. SPECIFIC GRAVITY __________

   H. MOVEMENT CAPABILITY AND ADHESION SATISFACTORY __________
      UNSATISFACTORY __________

   I. OZONE AND U.V. RESISTANCE SATISFACTORY __________
      UNSATISFACTORY __________

6. TEST DATE ___/___/___

SUBMITTED BY, DATE ______________ CHECKED AND APPROVED, DATE ______________

LABORATORY CHIEF ______________ SHRP REPRESENTATIVE ______________

AFFILIATION ______________ AFFILIATION ______________

Form H19, January 1991

Appendix F

Status of SPS-3 and SPS-4 Test Sections

This appendix contains information on the status of the SPS-3 and SPS-4 test sections arranged by SHRP region.

North Atlantic

SPS-3 Sites

GPS No.	SPS No.	Location	Supplemental Sections
241634	24A	Salisbury, MD	Overlay, Crack Seal
361643	36A	Glen Falls, NY	Slurry Seal, Crack Seal
361644	36B	Tupper Lake, NY	Crack Seal, Four Chip Seal
421605	42A	Milton, PA	Chip Seal
421597	42B	Farmington, PA	Done by state forces, no Slurry Seal
511023	51A	Petersburg, VA	Slurry Seal
871620	87A	Orillia, ON	Overlay
871622	87B	Bracebridge, ON	Overlay, Three Chip Seal/DynaPatch
891021	89A	Trois Rivieres, PQ	

SPS-3 Site Problems

GPS No.	Location	Treatment	Problems
361643	Glen Falls, NY	Chip Seal	Lost some aggregate immediately. Snowplows have damaged except for wheel paths.
361644	Tupper Lake, NY	Chip Seal	Lost some aggregate immediately. Snowplows have caused damaged except in wheel paths.
421597	Farmington, PA	All	All treatments by state forces. No slurry seal placed.
421605	Milton, PA	Chip Seal	Lost some aggregate immediately. Intermittent snowplow damage.
511023	Petersburg, VA	Chip Seal Crack Seal	Losing aggregate. Sealant pulling out of a number of cracks.
871620	Orillia, ON	Chip Seal	Province not happy with treatments. All treatments overlaid except slurry and thin overlay.
871622	Bracebridge, ON	Chip Seal	Chip seal deleted because of construction problems.
891021	Trois Rivieres, PQ	Chip Seal	Lost some aggregate immediately. Snowplows have caused damage except in wheel paths.

SPS-4 Sites

GPS No.	SPS No.	Location	Supplemental Sections
421606	42	Fredericksburg, PA	CRACFO Silicone sealant.
421690	42	Williamsport, PA	

North Central

SPS-3 Sites

GPS No.	SPS No.	Location	Supplemental Sections
171003	17A	East St. Louis, IL	
171002	17B	Freeport, IL	
181028	18A	Evansville, IN	
196150	19A	Sac City, IA	
201005	20A	Ottawa, KS	
201010	20B	Ford, KS	
211010	21A	Boonesville City, KY	
211034	21B	Glascow, KY	
261013	26A	Big Rapids, MI	Slurry Seal
261012	26B	Big Rapids, MI	Slurry Seal
261001	26C	Harrison, MI	Chip Seal
261010	26D	Flint, MI	Chip Seal
271016	27A	Bimidji, MN	
276251	27B	Bimidji, MN	
271028	27C	Fargo/Moorhead, MN	
271019	27D	Princeton, MN	
291005	29A	Lake Ozark, MO	Chip Seal
291002	29B	Jefferson City, MO	Chip Seal
311030	31A	Arapahoe, NE	
831801	83A	Brandon, MB	Chip Seal
901802	90A	Whitewood, SK	
906405	90B	Plunkett, SK	

SPS-3 Site Problems

GPS No.	Location	Treatment	Problem
171002	Freeport, IL	Control Section	Illinois DOT crack sealed the control section. Constructed 08/90, surveyed 10/90, cracks sealed before next distress survey of 06/91.
181028	Evansville, IN	Slurry Seal	Premature failure because of rainy weather after placement. Traffic allowed on section too soon, caused rutting in wheel paths.
201010	Ford, KS	Slurry Seal	Alligator cracking in slurry seal section will need to be patched (02/92).

SPS-4 Sites

GPS No.	SPS No.	Location	Supplemental Sections
183031	18A	Mt. Vernon, IN	
193055	19A	Fort Dodge, IA	
193009	19B	Cedar Rapids, IA	
204054	20A	Enterprise City, KS	
204016	20B	Topeka, KS	
213016	21A	Elizabethtown, KY	
295000	29A	Cameron, MO	
295503	29B	Lamar, MO	
313023	31A	Grand Island, NE	
313028	31B	Lincoln, NE	
314019	31C	Sioux City, NE	
394018	39A	Fairborn, OH	Joint Seal (2)
393801	39B	Wheeling, OH	Joint Seal (1)
466000	46A	Yankton, SD	Joint Seal (2), Underseal (3)

SPS-4 Site Problems

GPS No.	Location	Treatment	Problem
394018	Fairborn, OH	All	Not yet constructed.
393801	Wheeling, OH	All	Not yet constructed.

Southern

SPS-3 Sites

GPS No.	SPS No.	Location	Supplemental Sections
014125	01A	Montgomery, AL	
011019	01B	Sunflower, AL	
014155	01C	Clayhatchee, AL	
053071	05A	Springdale, AR	
129054	12A	Yulee, FL	Overlay, Slurry Seal, Chip Seal (2)
123997	12B	Greencove Spr, FL	Overlay, Slurry Seal, Chip Seal (2)
124154	12C	New Smyrna, FL	Slurry Seal, Chip Seal (2)
281802	28A	Laurel, MS	
404087	40A	Altus, OK	
401015	40B	Seminole, OK	
404088	40C	Tonkawa, OK	
473101	47A	Auburntown, TN	
473075	47B	Cookeville, TN	

471023	47C	Lake City, TN	Overlay
481094	48A	Helotes, TX	SPS-3 Pilot Site
481069	48B	Crindall, TX	
482172	48D	Colorado City, TX	
481183	48E	Southland, TX	Chip Seal
483579	48F	Canton, TX	
481169	48G	Henderson, TX	
481050	48H	Stoneham, TX	
483559	48I	Huntsville, TX	
481122	48J	Floresville, TX	
489005	48K	Helotes, TX	Chip Seal
483769	48L	El Paso, TX	
483749	48M	Freer, TX	
483739	48N	Sarita, TX	
483865	48Q	Mullin, TX	Chip Seal

SPS-3 Site Problems

GPS No.	Location	Treatment	Problem
404087	Altus, OK	Overlay	Not yet placed.
473101	Auburntown, TN	Chip Seal	Lost aggregate on test section lane. Mostly first 300 ft-400 ft. Original surface is open grade friction course. Will be taken out of service April 92.
481183	Southland, TX	GPS/Control	Alligator cracking developed.
		Crack Seal	Required patching for safety reasons. Other treatments performing better with fewer transverse cracks broken down, little or no alligator.
483865	Mullin, TX	Chip Seal	Losing cracking aggregate. Fog sealed 11/20/90.
483559	Huntsville, TX	Chip Seal	Lost some aggregate following construction, now stabilized. Cold weather before and during construction.
483739	Sarita, TX	Slurry Seal	End of slurry seal has come up, caused by problems during construction.
		Crack Seal	Have had to patch areas with alligator cracking. Required patching for safety reasons. Other treatments performing better with fewer transverse cracks broken down; little or no alligator.
482172	Colorado City, TX	Control/GPS Crack Seal	Diluted fog seal on control and crack seal sections.

SPS-4 Sites

GPS No.	SPS No.	Location	Supplemental Sections
054021	05A	Cabot, AR	
054019	05B	Pine Bluff, AR	
053059	05C	Fort Smith, AR	
284024	28A	Greenville, MS	
404160	40A	Ada, OK	
483003	48A	Irving, OK	
484143	48B	China, TX	
483589	48C	Vernon, TX	
484152	48D	Liberty, TX	
484142	48E	Jasper, TX	

SPS-4 Site Problems

GPS No.	Location	Treatment	Problem
483003	Irving, TX	Control	Not yet established.
484152	Liberty, TX	Control	Not yet established.
484142	Jasper, TX	Control	Not yet established.

Western

SPS-3 Sites

GPS No.	SPS No.	Location	Supplemental Sections
041036	04A	Kingman, AZ	
041021	04B	Kingman, AZ	
041017	04C	Kingman, AZ	
041016	04D	Nogales, AZ	
061253	06A	Chico, CA	Slurry Seal, Chip Seal (4), Overlay (3)
081053	08A	Grand Junction, CO	
082008	08B	Las Animas, CO	
161020	16A	Twin Falls, ID	
161021	16B	Idaho Falls, ID	
161010	16C	Idaho Falls, ID	
301001	30A	Great Falls, MT	4 Supplemental Sections
321021	32A	Reno, NV	Chip Seal (2)
327000	32B	Wendover, NV	
322027	32C	Wells, NV	
491004	49A	Panguitch, UT	Crack Seal, Chip Seal(3), Plant Mix Seal
491017	49B	Sevier, UT	Crack Seal, Chip Seal(3), Plant Mix Seal

491006	49C	Gunnison, UT	Crack Seal, Chip Seal(2), Plant Mix Seal
531008	53A	Spokane, WA	
531501	53B	Coulee City, WA	
531801	53C	Vancouver, WA	
561007	56A	Cody, WY	4 Supplemental Sections
567775	56B	Green River, WY	3 Supplemental Sections

SPS-3 Site Problems

GPS No.	Location	Treatment	Problem
041036	Kingman, AZ	Chip Seal	Lost chip seal.
041021	Kingman, AZ	Chip Seal	Some chip loss.
041016	Nogales, AZ	Slurry Seal	Pavement deformation at end.
081053	Grand Junction, CO	Chip Seal	Some chip loss.
082008	Las Animas, CO	Chip Seal	Chip seal overlaid (subgrade failure)
161021	Idaho Falls, ID	Chip Seal	Some chip loss.
161010	Idaho Falls, ID	Chip Seal	Some chip loss.
301001	Great Falls, MT	Chip Seal	Lost chip seal.
321021	Reno, NV	Chip Seal	State chip seals overlaid.
322027	Wells, NV	All	Treatments out of service.
327000	Wendover, NV	Chip Seal	Minor chip loss.
491004	Panguitch, UT	Chip Seal	Considerable chip loss.
491017	Sevier, UT	Chip Seal	Considerable chip loss.
491006	Gunnison, UT	Chip Seal	Considerable chip loss.
531008	Spokane, WA	Chip Seal	Lost chip seal.
531501	Coulee City, WA	Chip Seal	Lost chip seal.
561007	Cody, WY	Chip Seal	Lost chip seal.
567775	Green River, WY	Chip Seal	Lost chip seal.

SPS-4 Sites

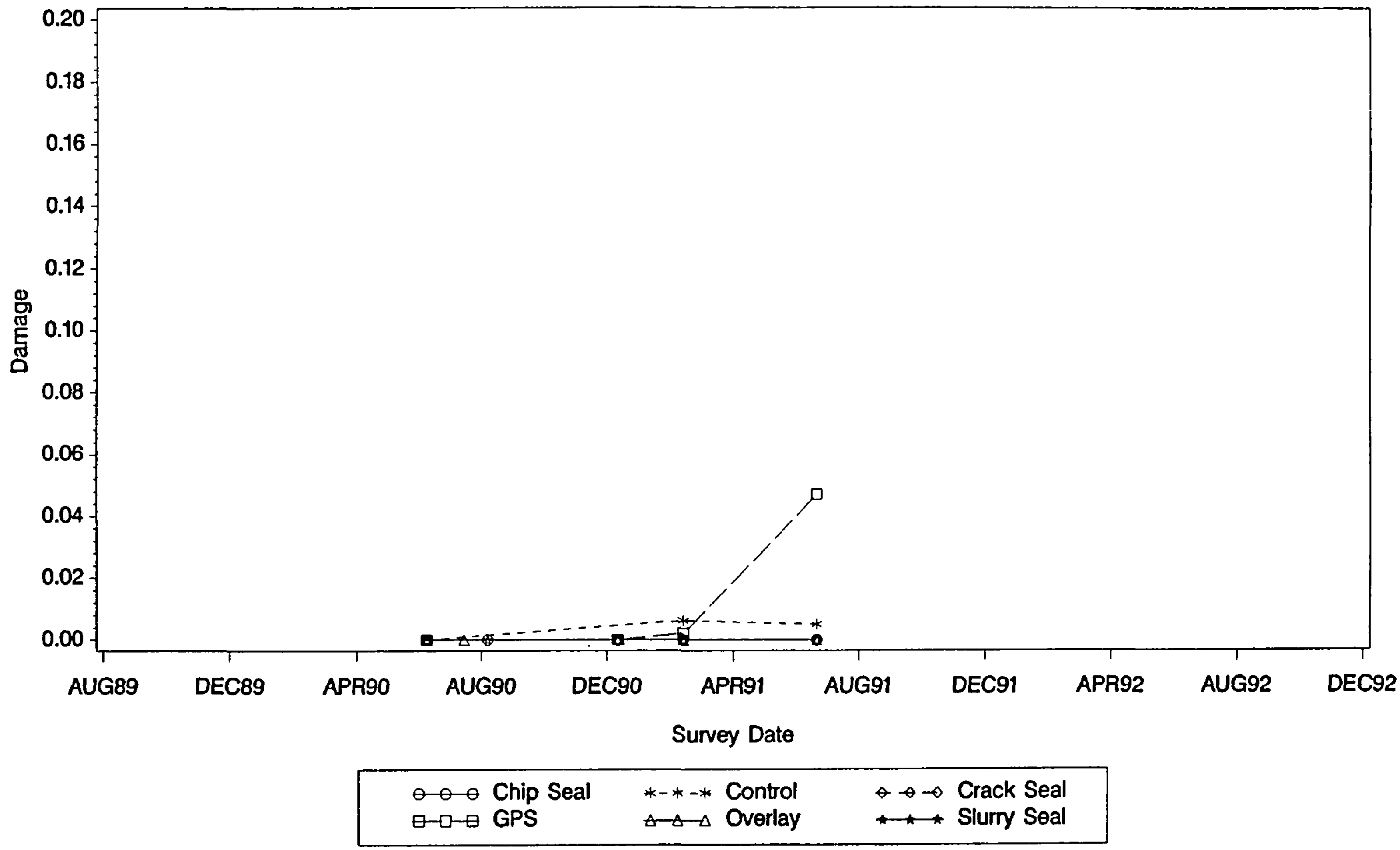
GPS No.	SPS No.	Location	Supplemental Sections
047613	04A	Phoenix, AZ	Joint Seal (20)
063021	06A	San Diego, CA	Joint Seal (2), Underseal (3), Spall (3)
067456	06B	Tracy, CA	Jt Seal (3), Undersl (2), Spall (3), Crk Sl (3)
089998	08A	Broomfield, CO	
089999	08B	Broomfield, CO	
323010	32A	Wells, NV	Joint Seal (14)
497082	49C	Tremonton, UT	Joint Seal (18)
497086	49D	Salt Lake City, UT	Joint Seal (19)
497085	49E	Heber City, UT	Joint Seal (19)

SPS-4 Site Problems

GPS No.	Location	Treatment	Problem
089998	Broomfield	All	Not yet built. Possibly 1993.
089999	Broomfield	All	Not yet built. Possibly 1993.

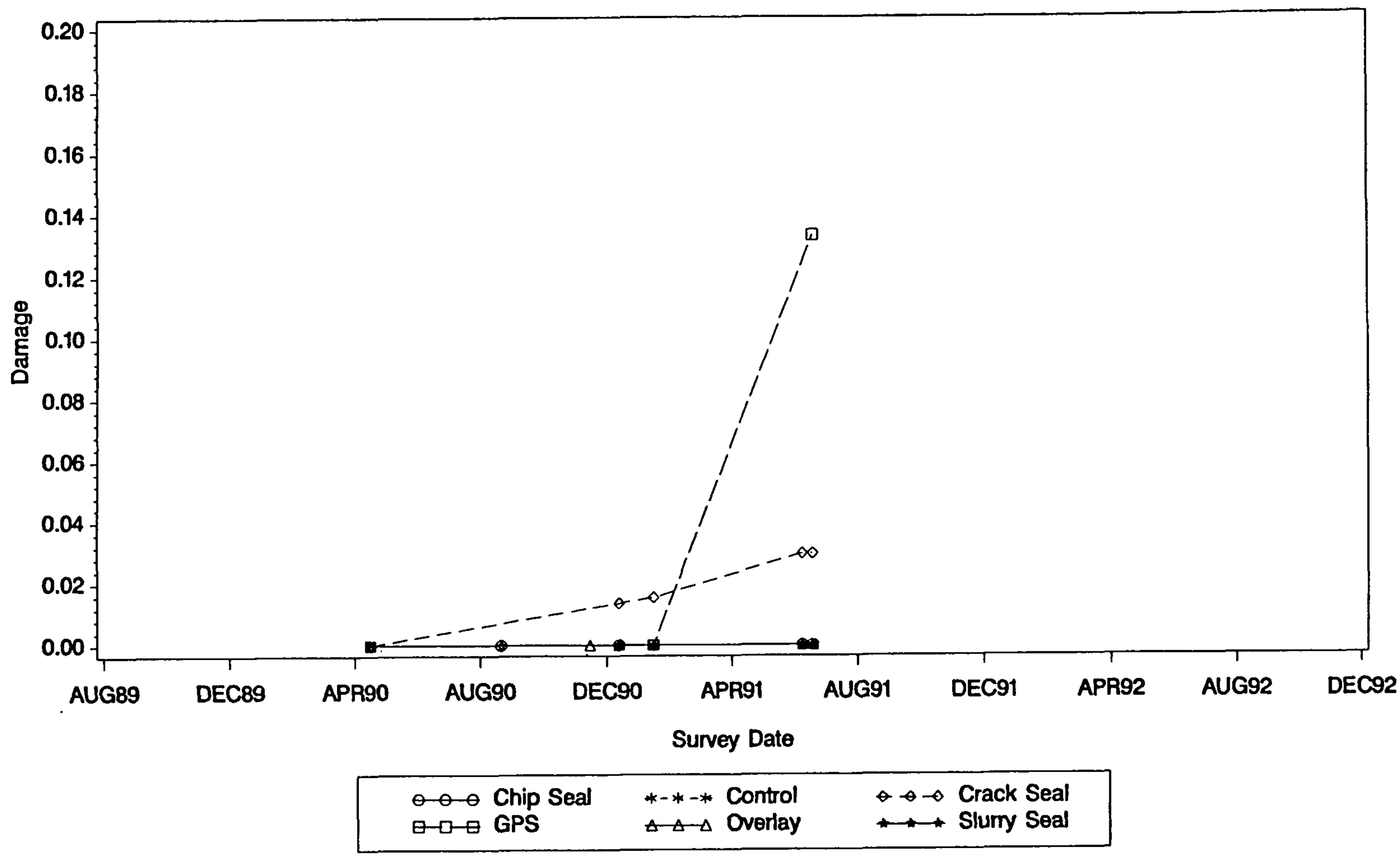
Appendix G

Displays of Southern Region SPS-3 Cracking Information



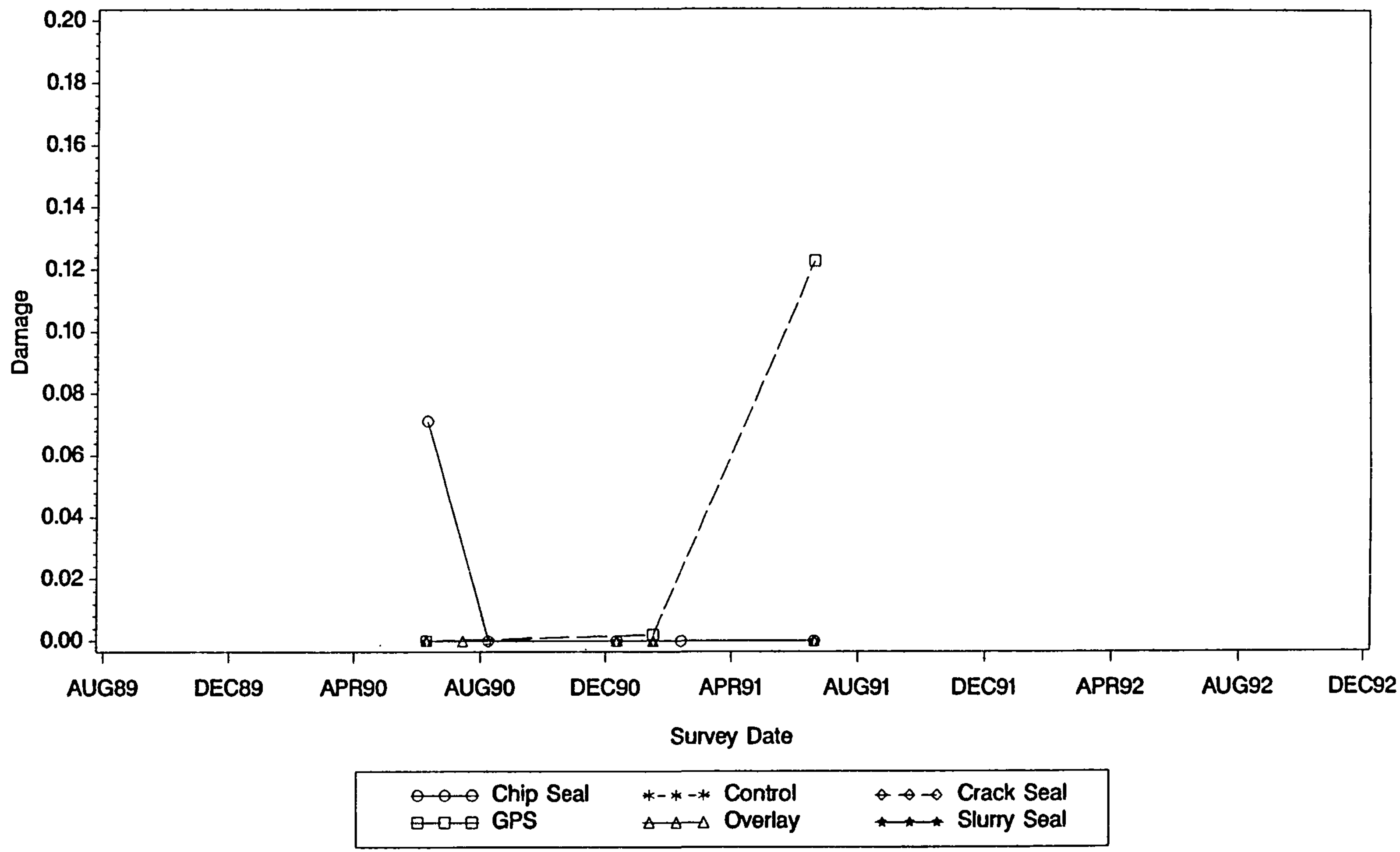
Treatment dates: Overlay-15JUL1990 Slurry Seal-07AUG1990 Crack Seal-07AUG1990 Chip Seal-07AUG1990 Construction date: 01JUN 1972

Figure G-1. Display of alligator cracking on sections selected for analysis at site 01A



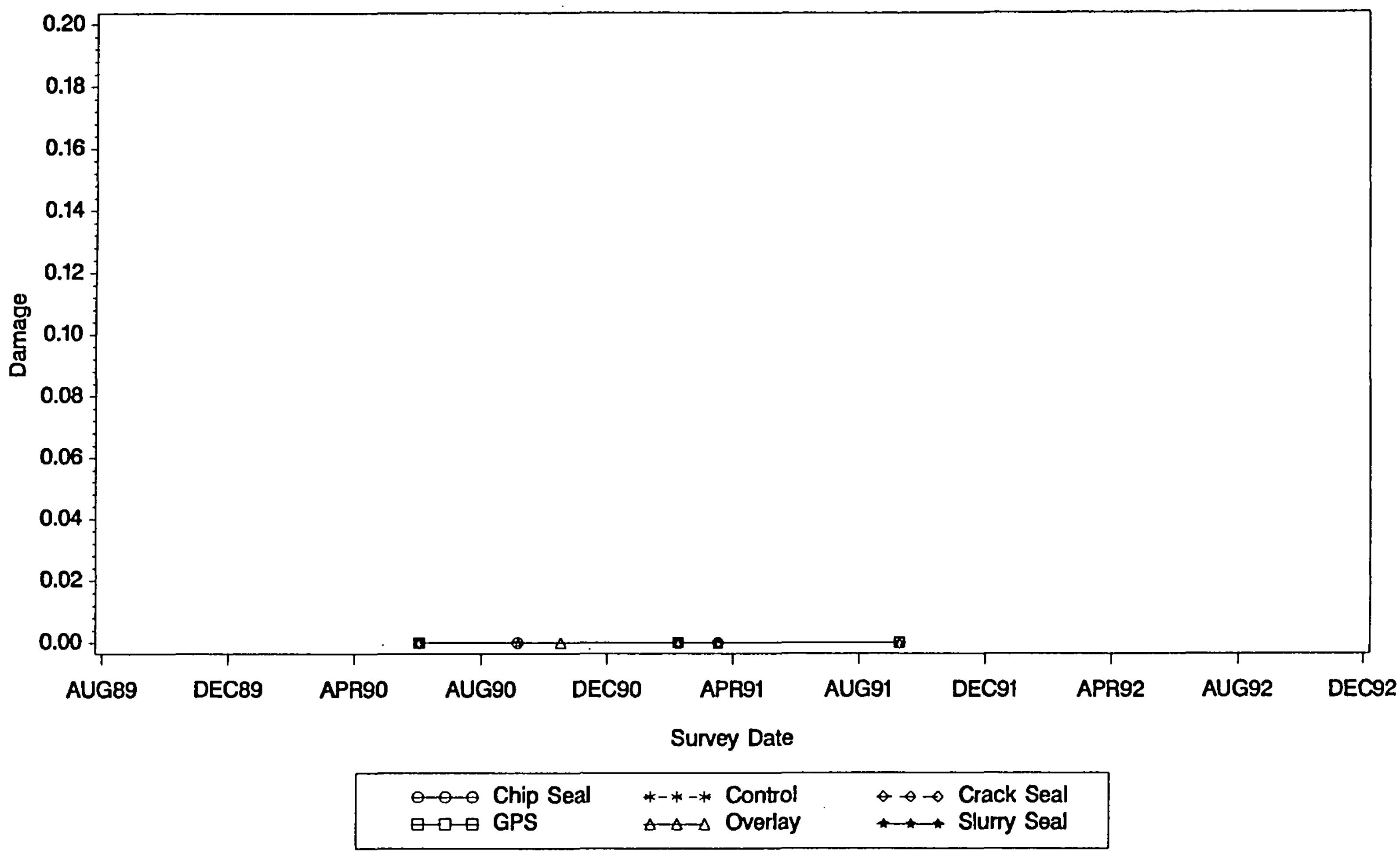
Treatment dates: Slurry Seal-21AUG1990 Crack Seal-21AUG1990 Chip Seal-21AUG1990 Overlay-15NOV1990 Construction date: 01OCT1986

Figure G-2. Display of alligator cracking on selections selected for analysis at site 01B



Rejected section(s): Crack Seal Control
Treatment dates: Overlay-15JUL1990 Slurry Seal-09AUG1990 Crack Seal-09AUG1990 Chip Seal-09AUG1990 Construction date: 01JUN1976

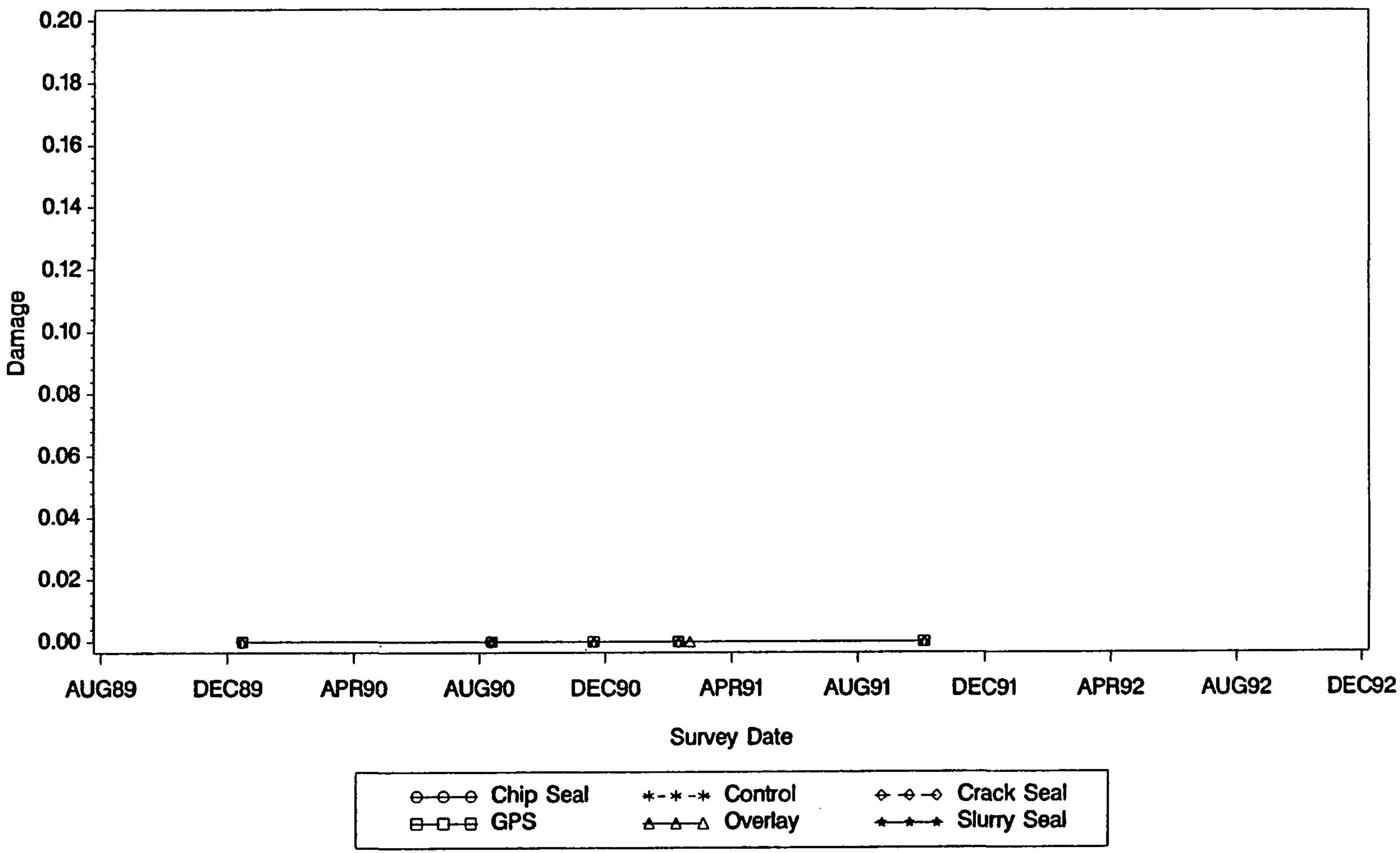
Figure G-3. Display of alligator cracking on sections selected for analysis at site 01C



No control section

Treatment dates: Slurry Seal-05SEP1990 Crack Seal-05SEP1990 Chip Seal-05SEP1990 Overlay-17OCT1990 Construction date: 01FEB1988

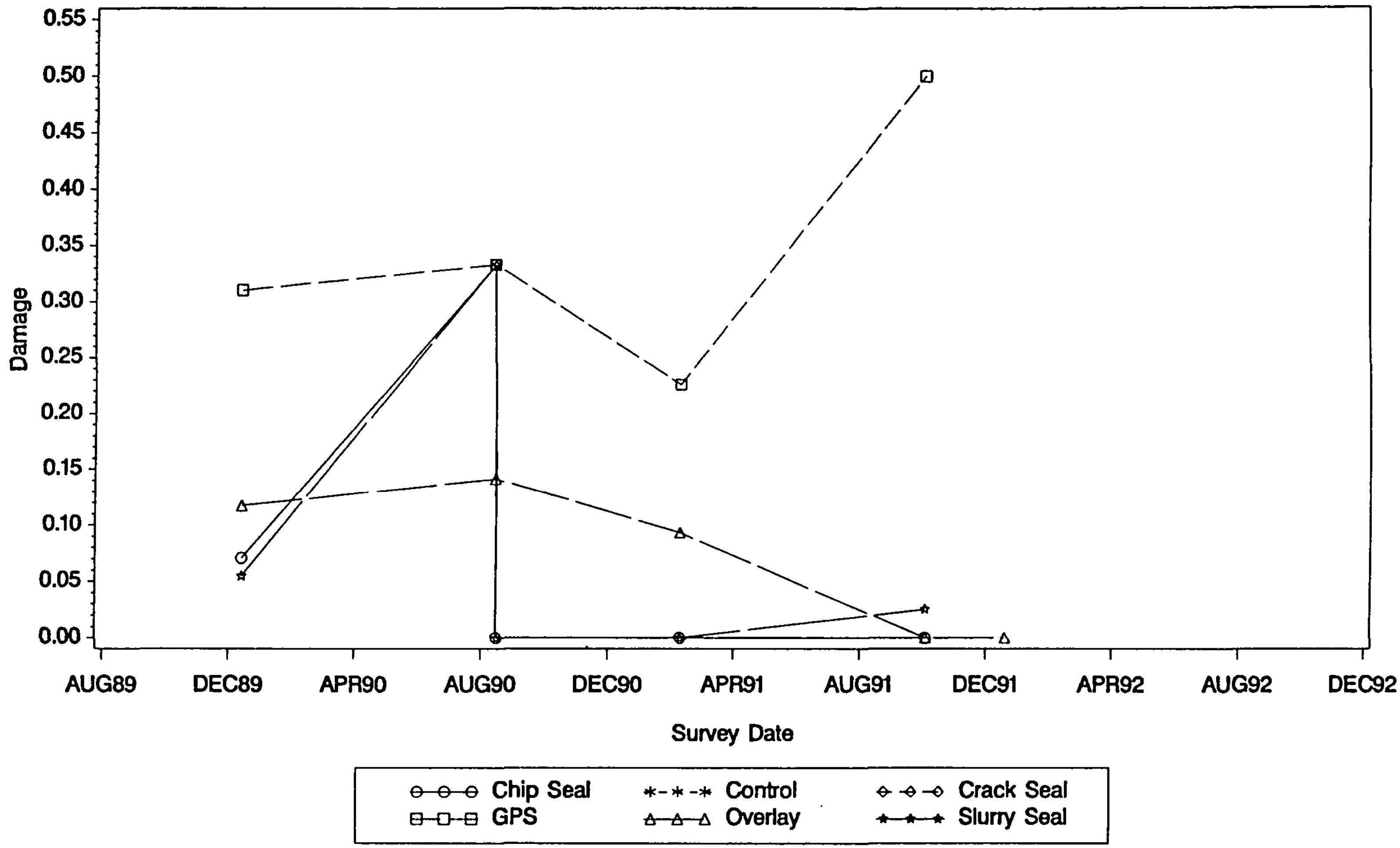
Figure G-4. Display of alligator cracking on sections selected for analysis at site 05A



Rejected section(s): Crack Seal — No control section

Treatment dates: Slurry Seal-13AUG1990 Crack Seal-13AUG1990 Chip Seal-13AUG1990 Overlay-20FEB1991 Construction date: 01OCT1974

Figure G-5. Display of alligator cracking on selections selected for analysis at site 12A

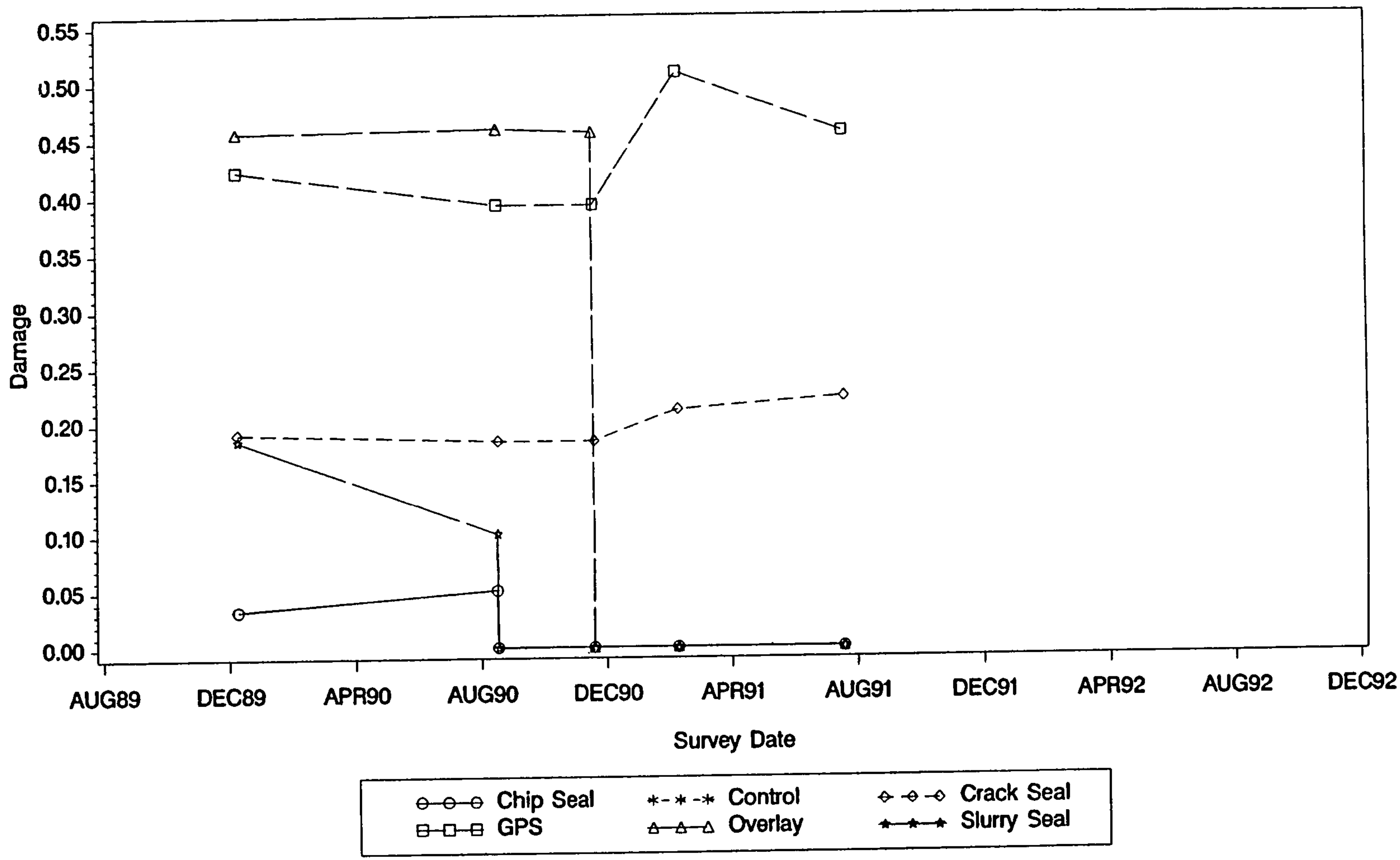


Rejected section(s): Crack Seal

No control section

Treatment dates: Slurry Seal-16AUG1990 Crack Seal-16AUG1990 Chip Seal-16AUG1990 Overlay-20DEC1991 Construction date: 01JUNE 1974

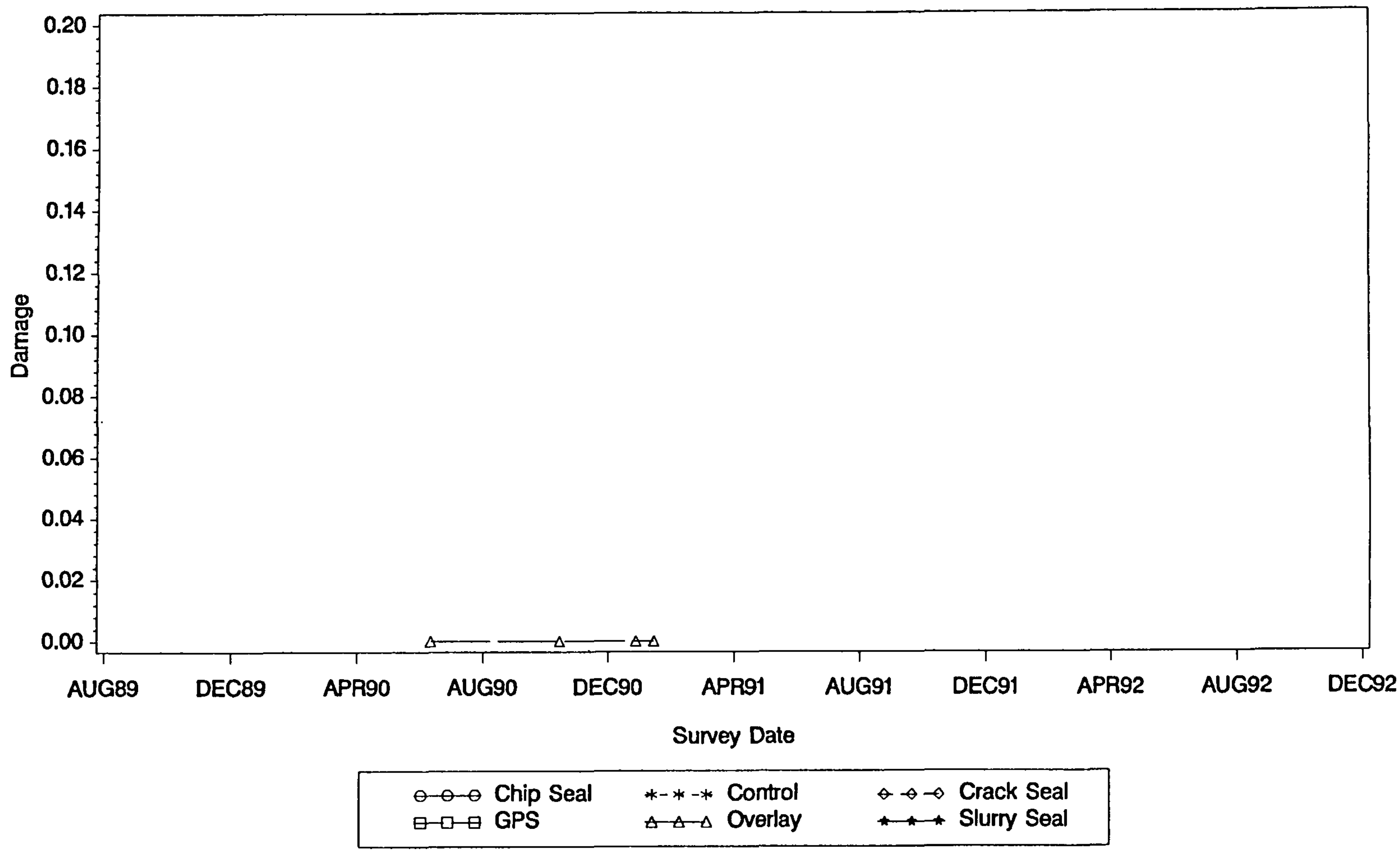
Figure G-6. Display of alligator cracking on sections selected for analysis at site 12B



No control section

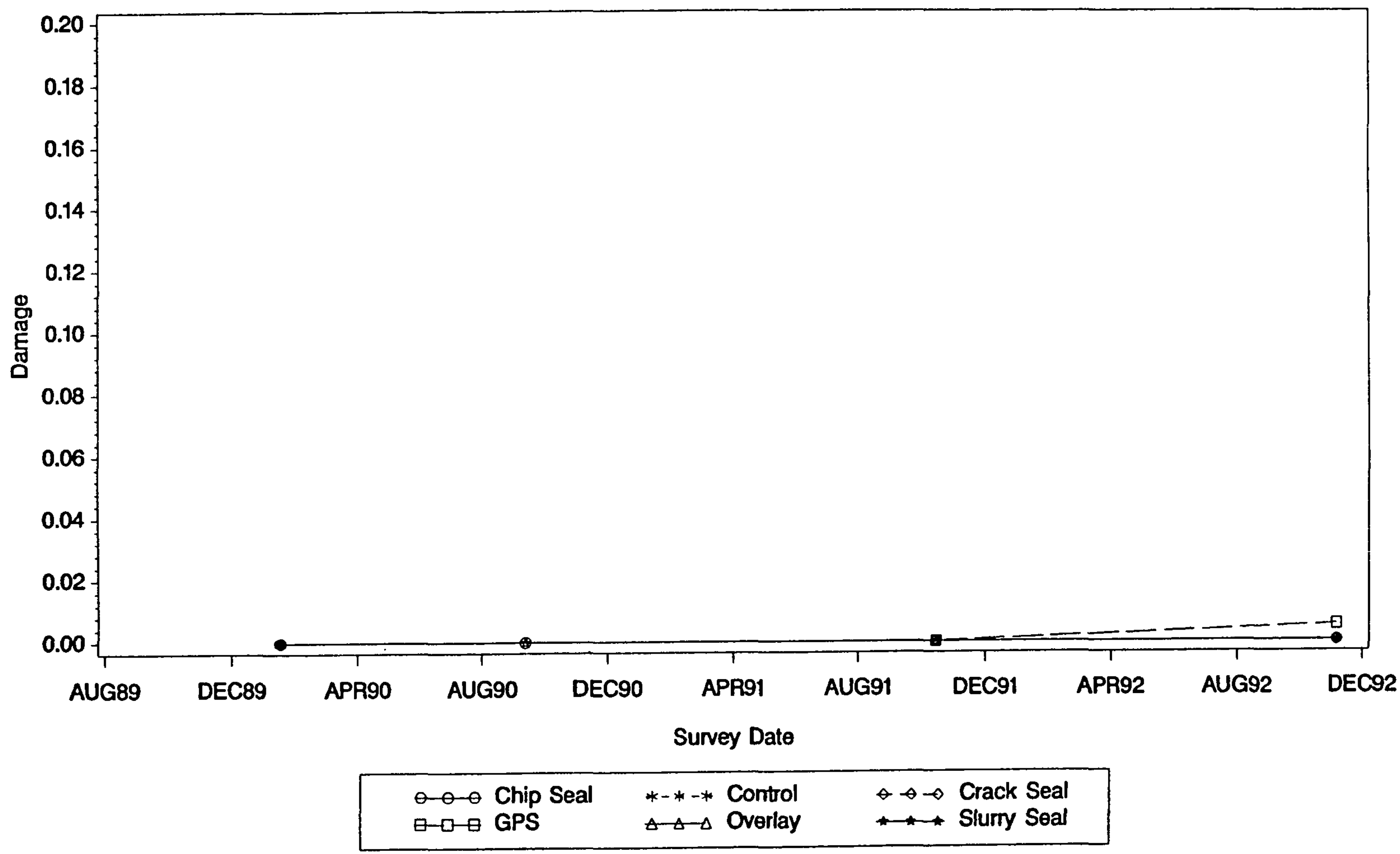
Treatment dates: Slurry Seal-17AUG1990 Crack Seal-17AUG1990 Chip Seal-17AUG1990 Overlay-19NOV1990 Construction date: 01JUN1970

Figure G-7. Display of alligator cracking on sections selected for analysis at site 12C



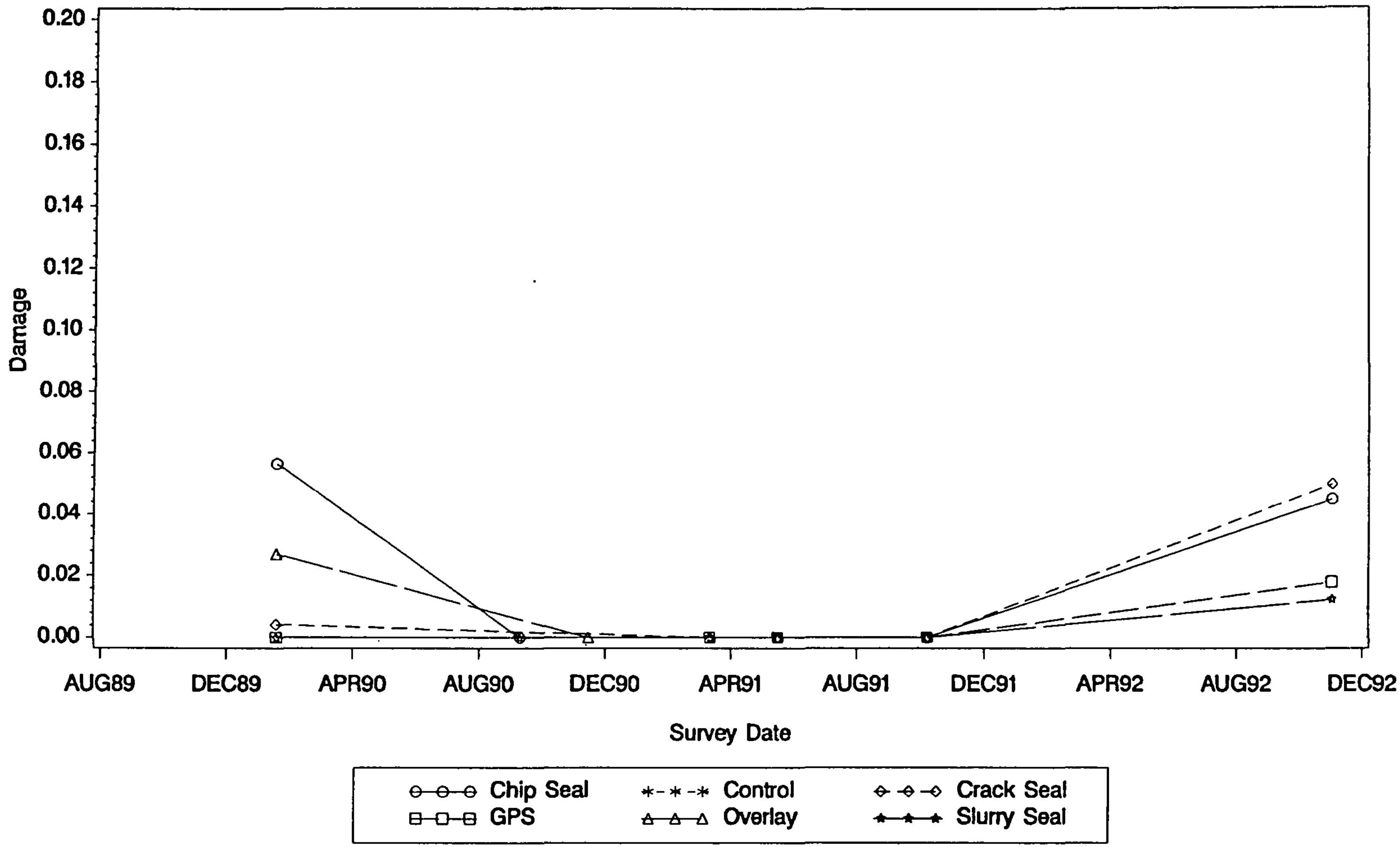
Rejected section(s) GPS Slurry Seal Crack Seal Chip Seal No control section
Treatment dates: Slurry Seal-23AUG1990 Crack Seal-23AUG1990 Chip Seal-23AUG1990 Overlay-15OCT1990 Construction date: 01JUN1982

Figure G-8. Display of alligator cracking on sections selected for analysis at site 28A



Rejected section(s): Overlay
Treatment dates: Overlay-Missing Slurry Seal-12SEP1990 Crack Seal-12SEP1990 Chip Seal-12SEP1990 Construction date: Missing

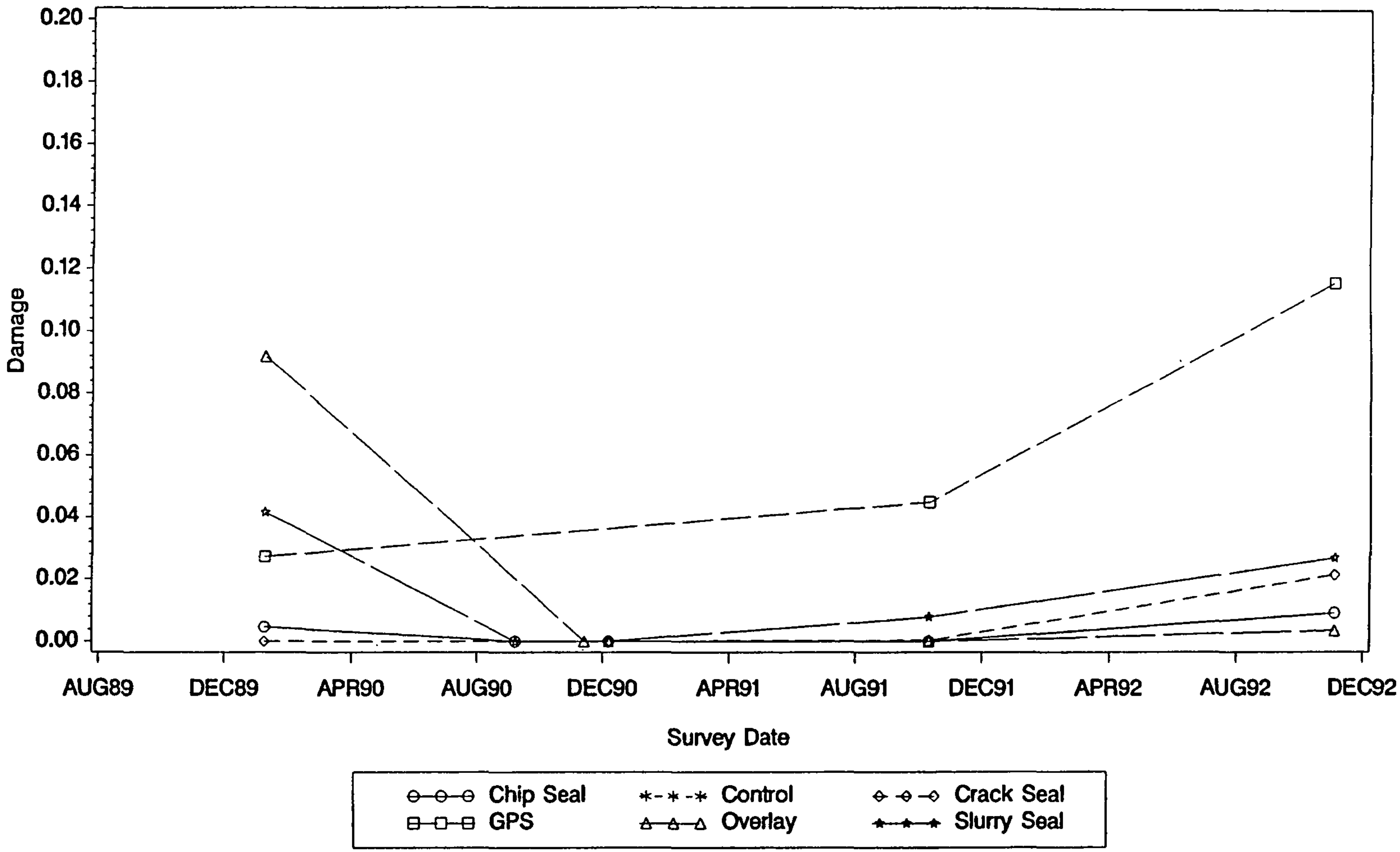
Figure G-9. Display of alligator cracking on sections selected for analysis at site 40A



No control section

Treatment dates: Slurry Seal-10SEP1990 Crack Seal-10SEP1990 Chip Seal-10SEP1990 Overlay-15NOV1990 Construction date: 01APR1978

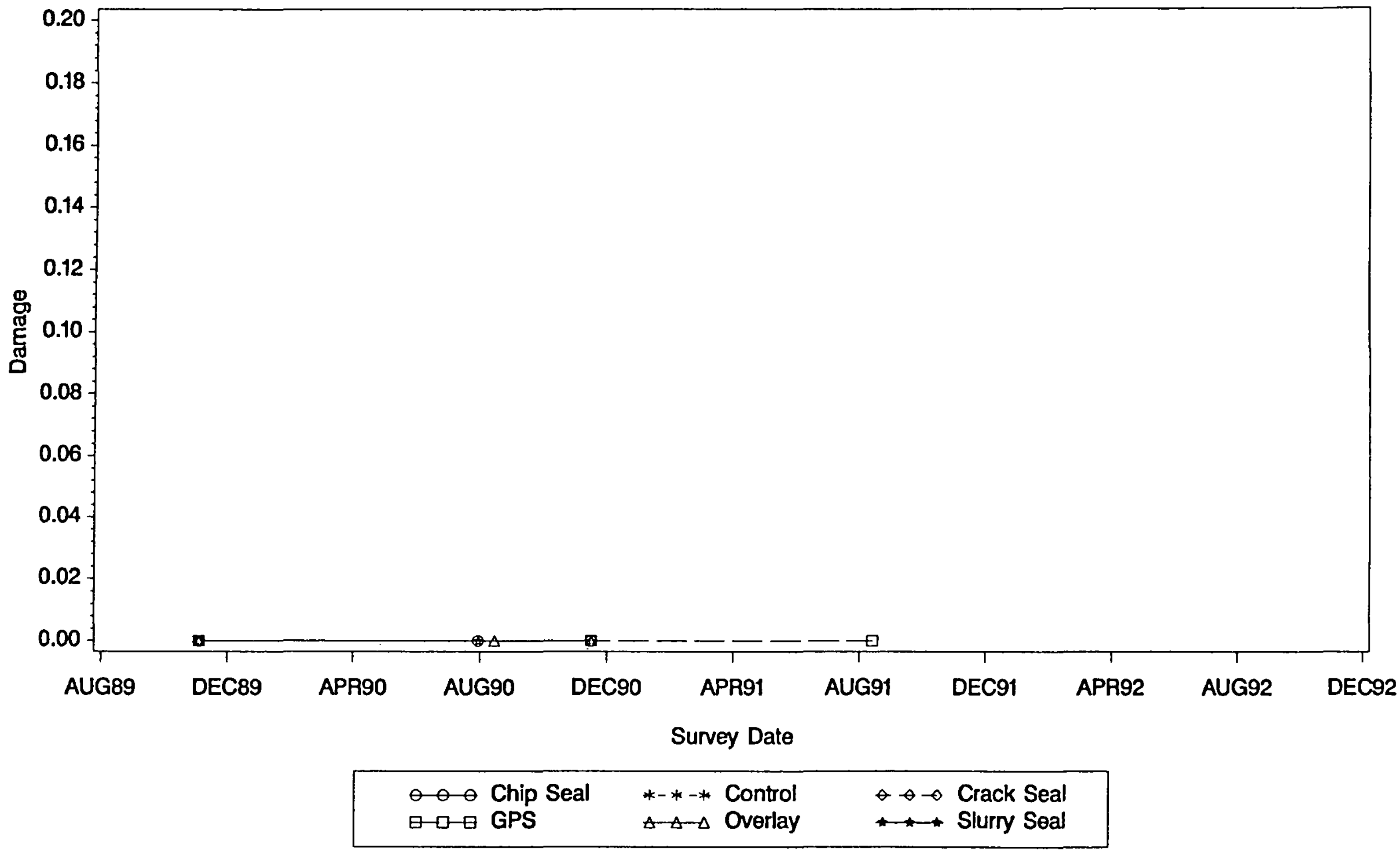
Figure G-10. Display of alligator cracking on sections selected for analysis at site 40B



No control section

Treatment dates: Slurry Seal-07SEP1990 Crack Seal-07SEP1990 Chip Seal-07SEP1990 Overlay-14NOV1990 Construction date: 01JUN1975

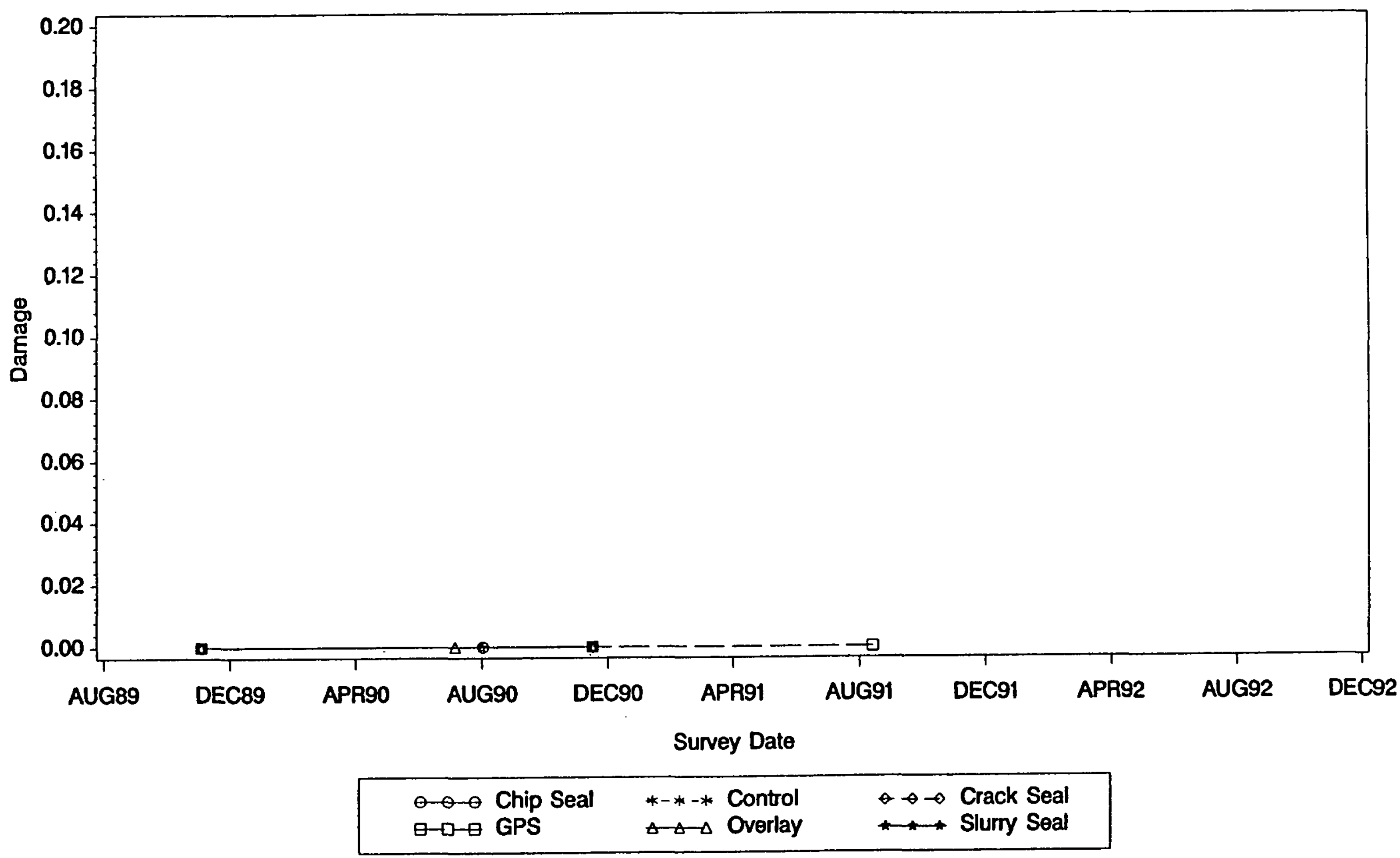
Figure G-11. Display of alligator cracking on sections selected for analysis at site 40C



No control section

Treatment dates: Slurry Seal-30JUL1990 Crack Seal-30JUL1990 Chip Seal-30JUL1990 Overlay-15AUG1990 Construction date: 01JAN1980

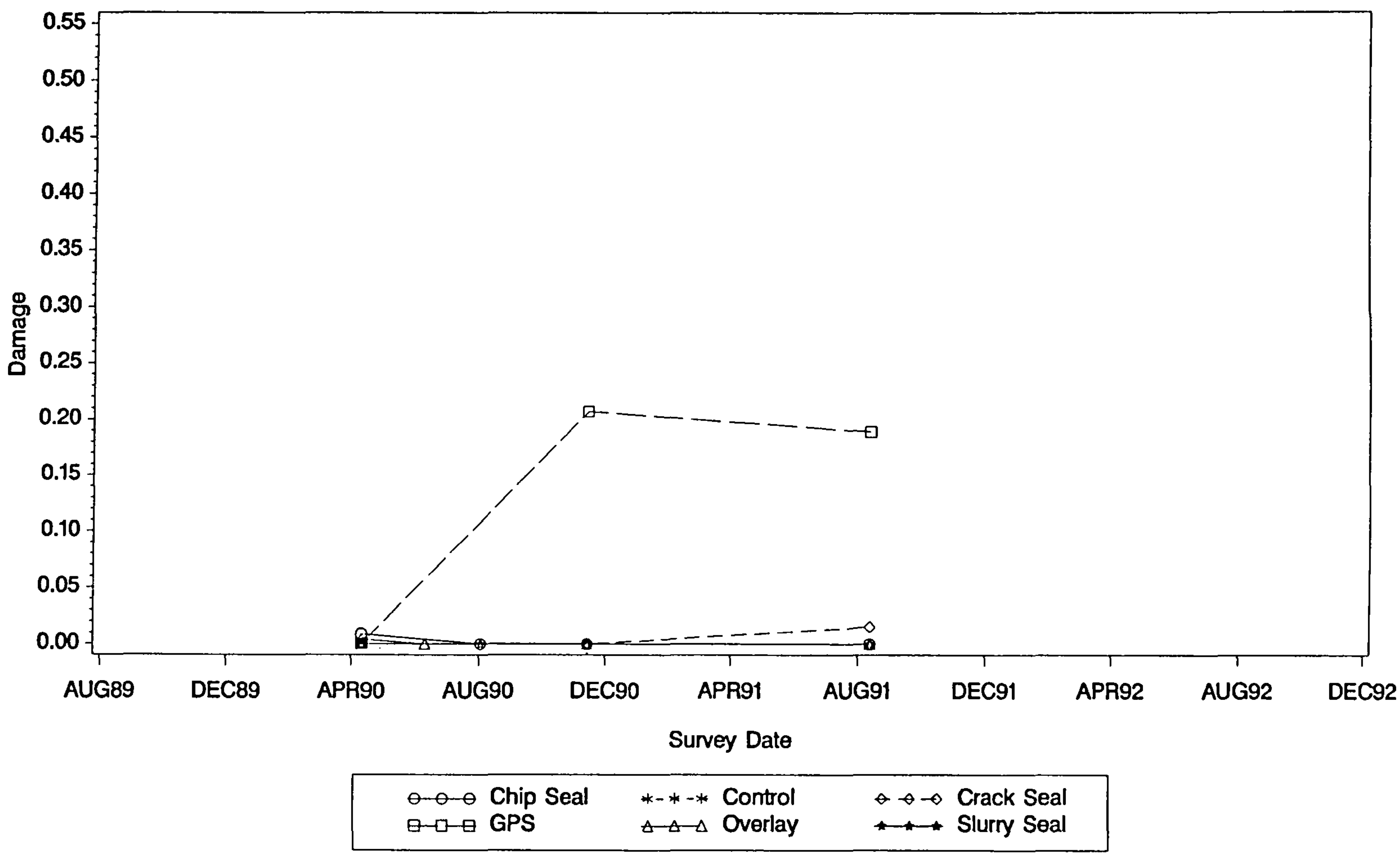
Figure G-12. Display of alligator cracking on sections selected for analysis at site 47A



No control section

Treatment dates: Overlay-06JUL1990 Slurry Seal-01AUG1990 Crack Seal-01AUG1990 Chip Seal-02AUG1990 Construction date: 01JUN1971

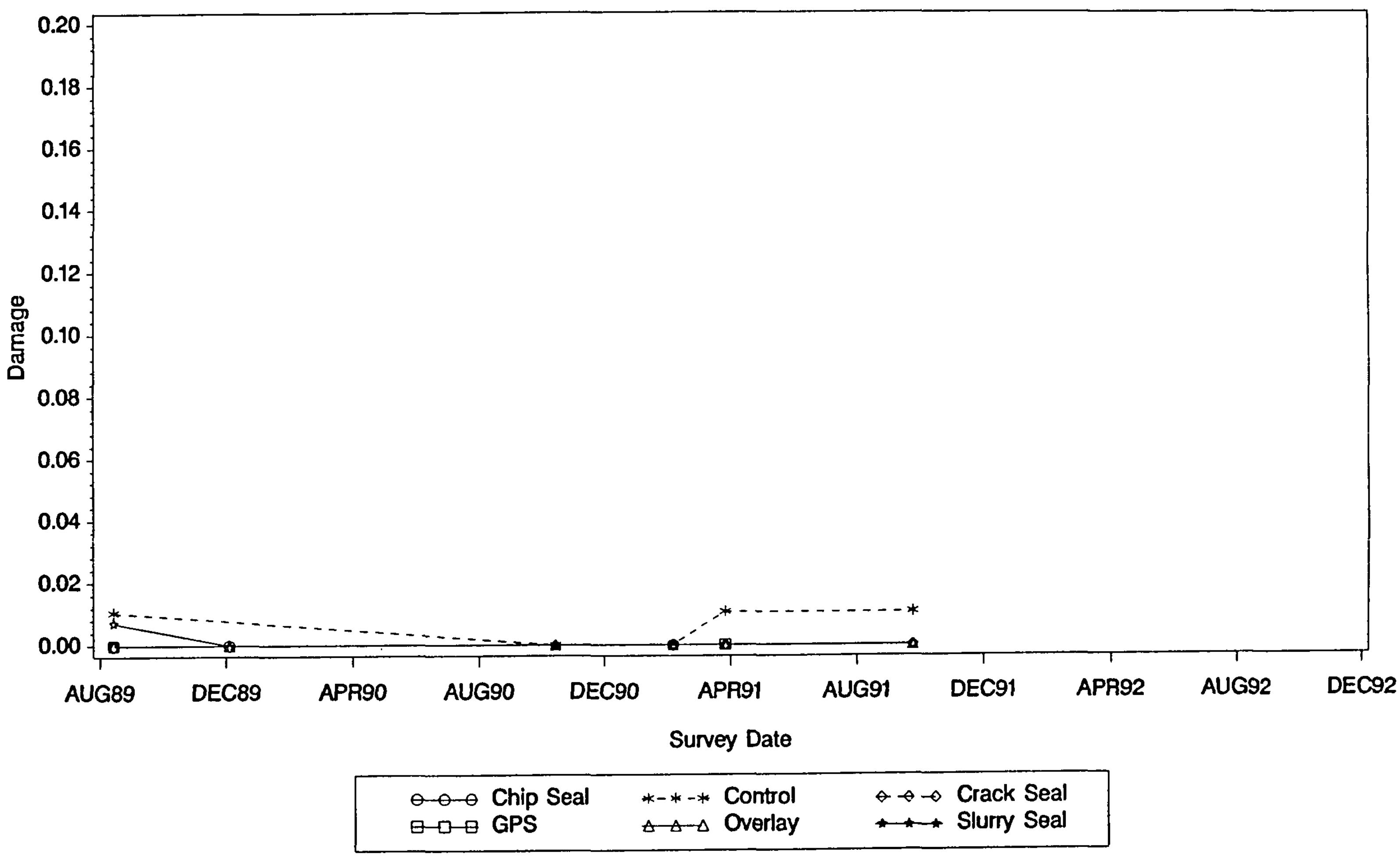
Figure G-13. Display of alligator cracking on sections selected for analysis at site 47B



No control section

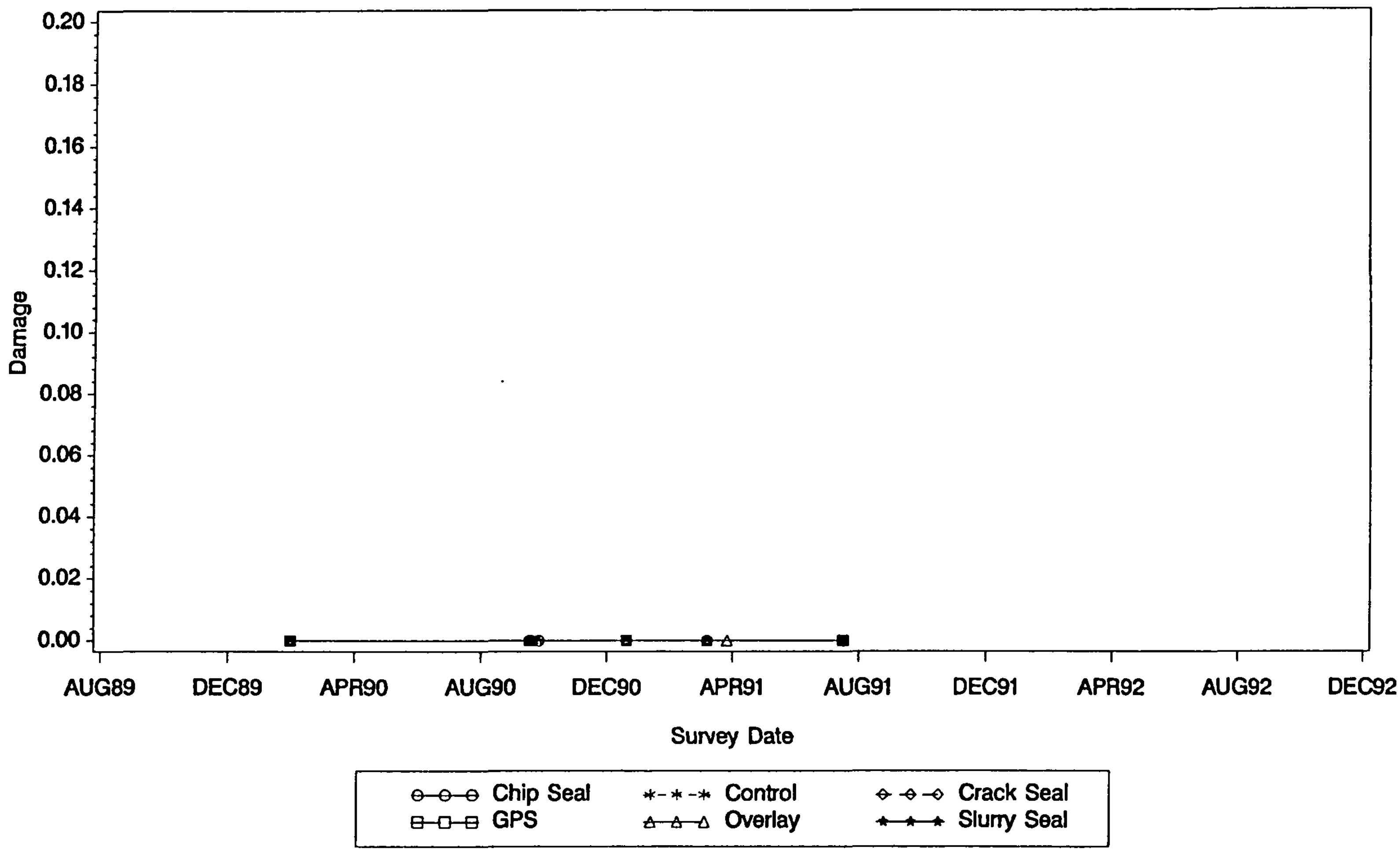
Treatment dates: Overlay-11JUN1990 Slurry Seal-03AUG1990 Crack Seal-03AUG1990 Chip Seal-03AUG1990 Construction date: 01JUN1972

Figure G-14. Display of alligator cracking on sections selected for analysis at site 47C



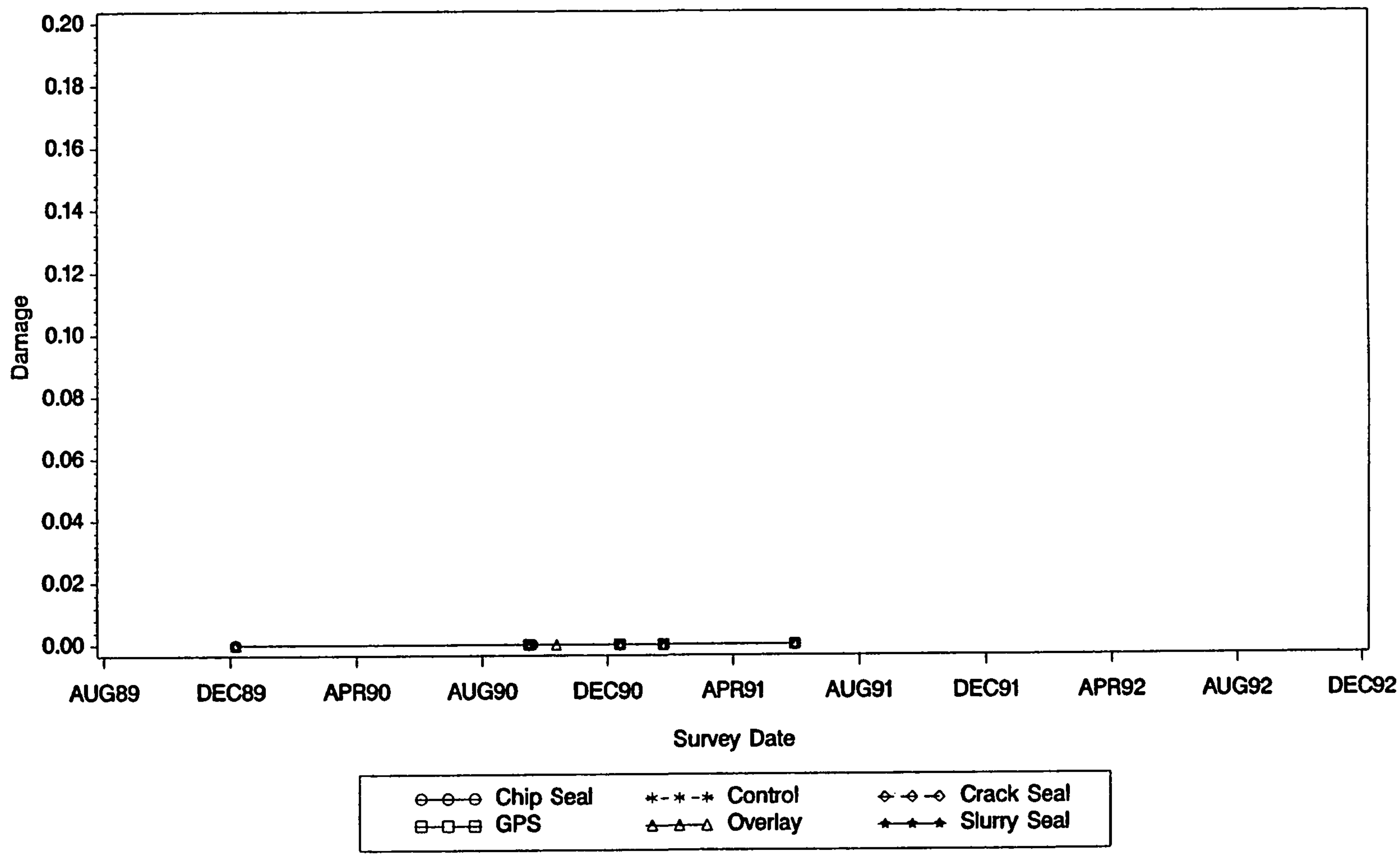
Treatment dates: Overlay-04DEC1989 Slurry Seal-04DEC1989 Crack Seal-04DEC1989 Chip Seal-04DEC1989 Construction date: 01AUG1976

Figure G-15. Display of alligator cracking on sections selected for analysis at site 48A



Treatment dates: Overlay-19SEP1990 Slurry Seal-26SEP1990 Crack Seal-26SEP1990 Chip Seal-26SEP1990 Construction date: 01JUN1977

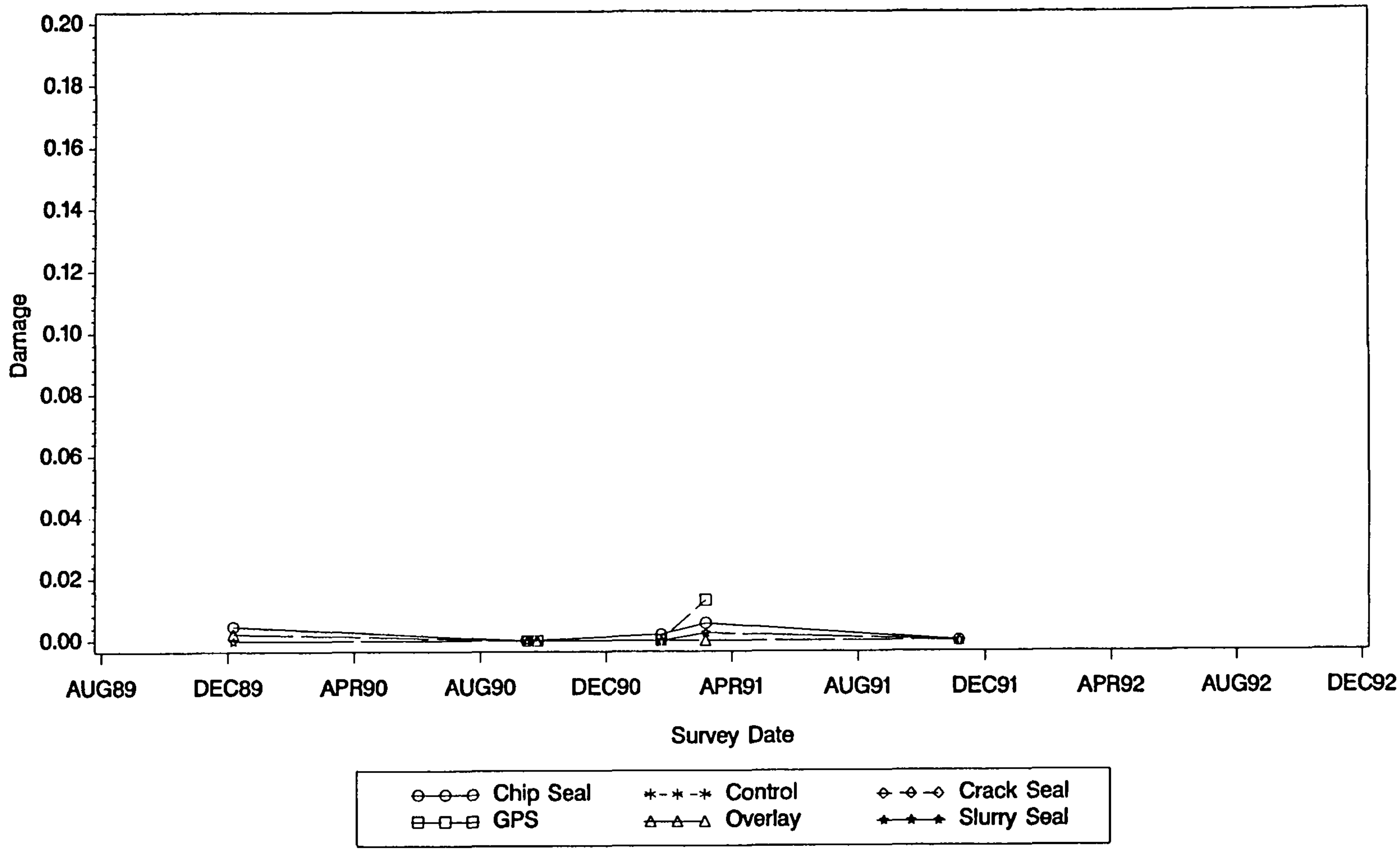
Figure G-16. Display of alligator cracking on sections selected for analysis at site 48B



No control section

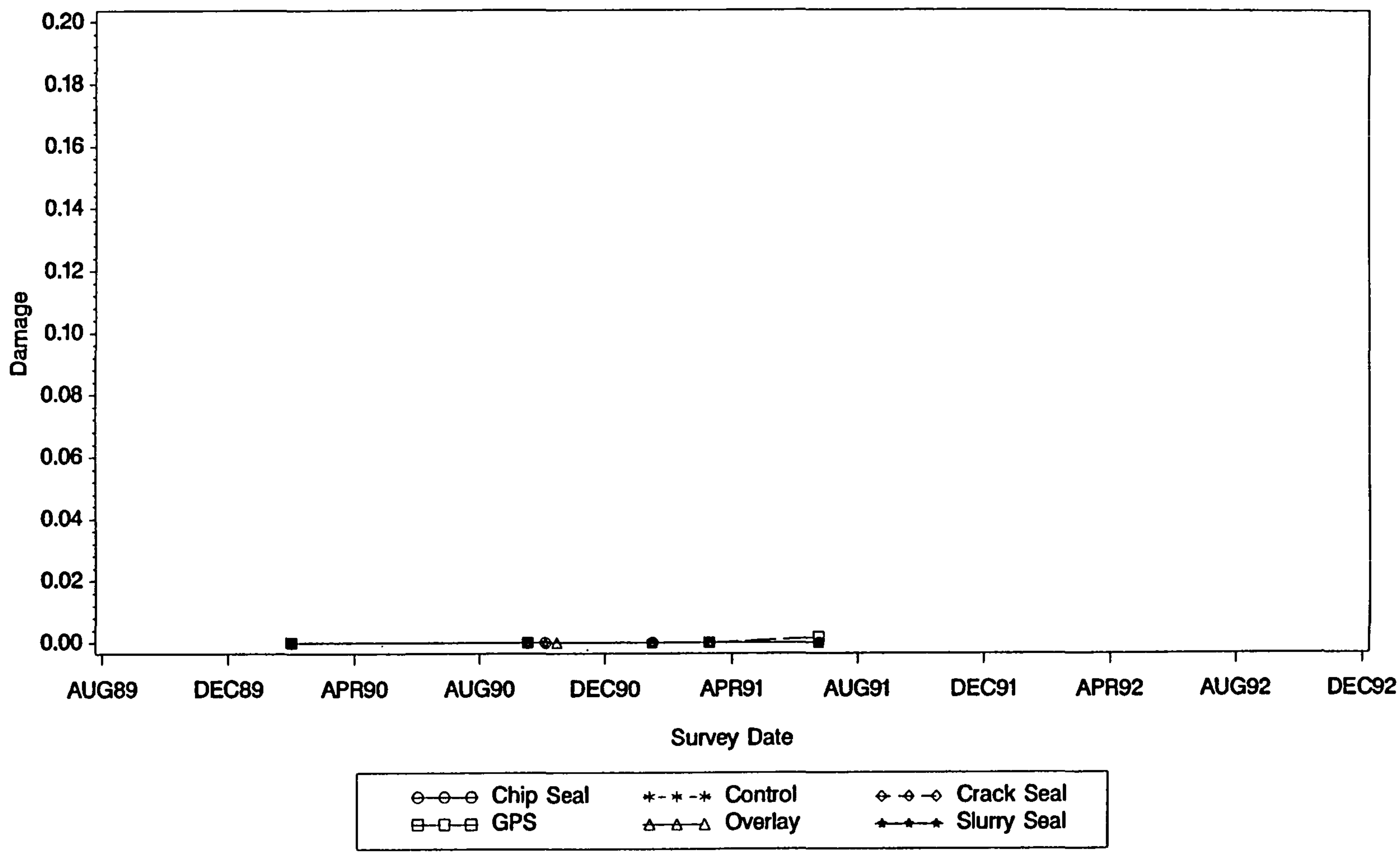
Treatment dates: Slurry Seal-18SEP1990 Crack Seal-18SEP1990 Chip Seal-18SEP1990 Overlay-12OCT1990 Construction date: 01AUG1982

Figure G-17. Display of alligator cracking on sections selected for analysis at site 48D



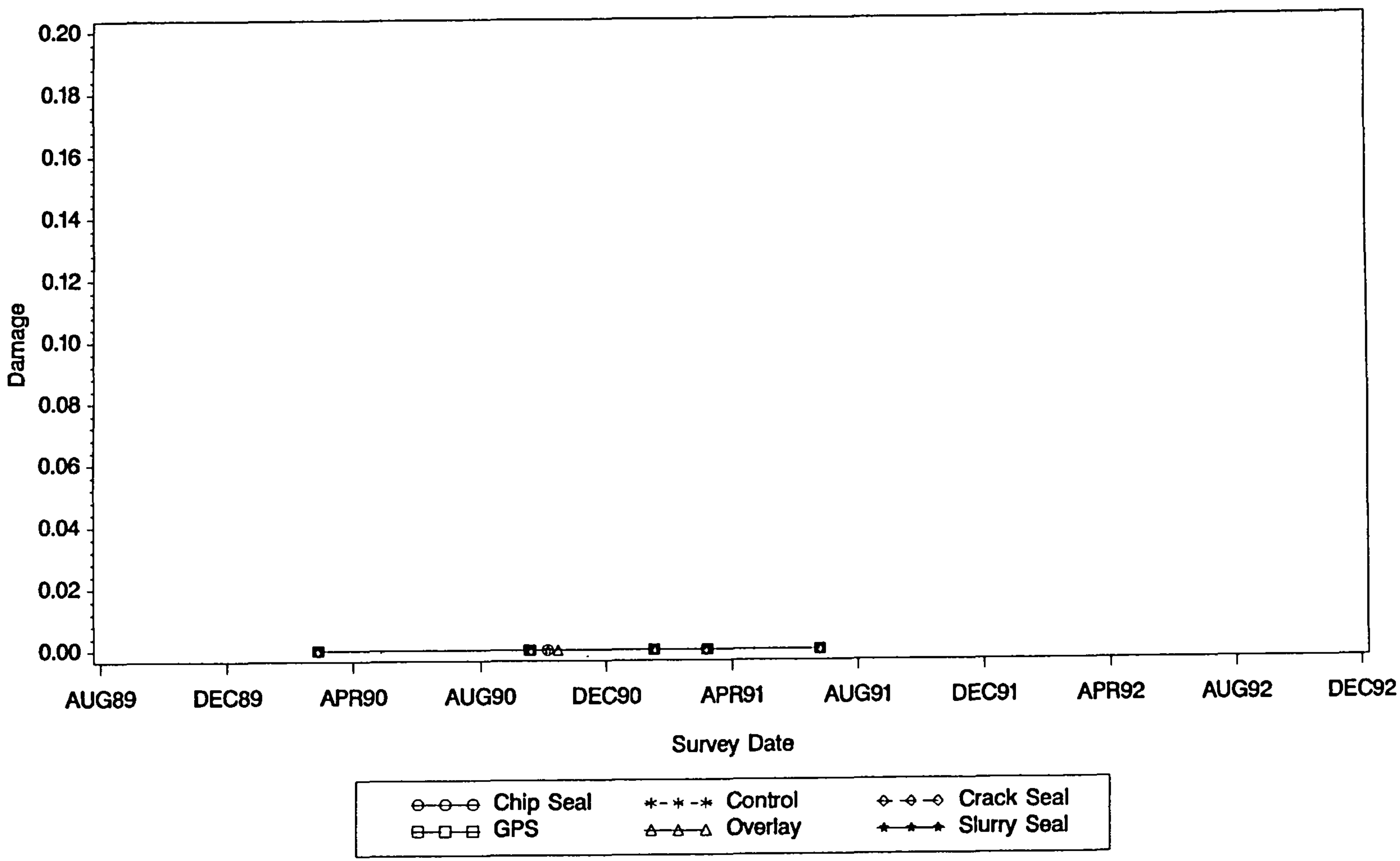
Rejected section(s): Crack Seal Control
Treatment dates: Slurry Seal-14SEP1990 Crack Seal-14SEP1990 Chip Seal-14SEP1990 Overlay-25SEP1990 Construction date: 01FEB1975

Figure G-18. Display of alligator cracking on sections selected for analysis at site 48E



Treatment dates: Slurry Seal-04OCT1990 Crack Seal-04OCT1990 Chip Seal-04OCT1990 Overlay-15OCT1990 Construction date: 01NOV1987

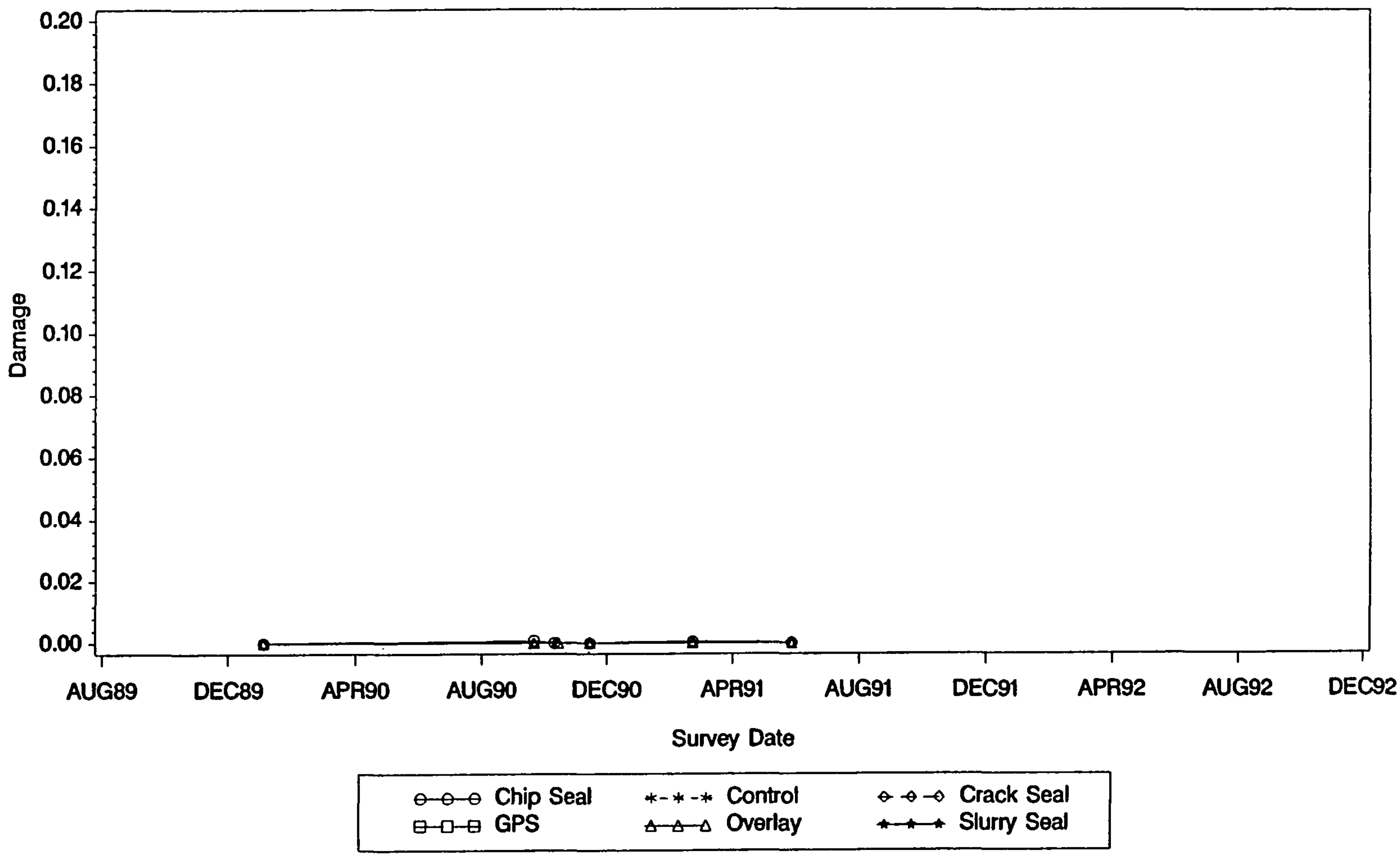
Figure G-19. Display of alligator cracking on sections selected for analysis at site 48F



No control section

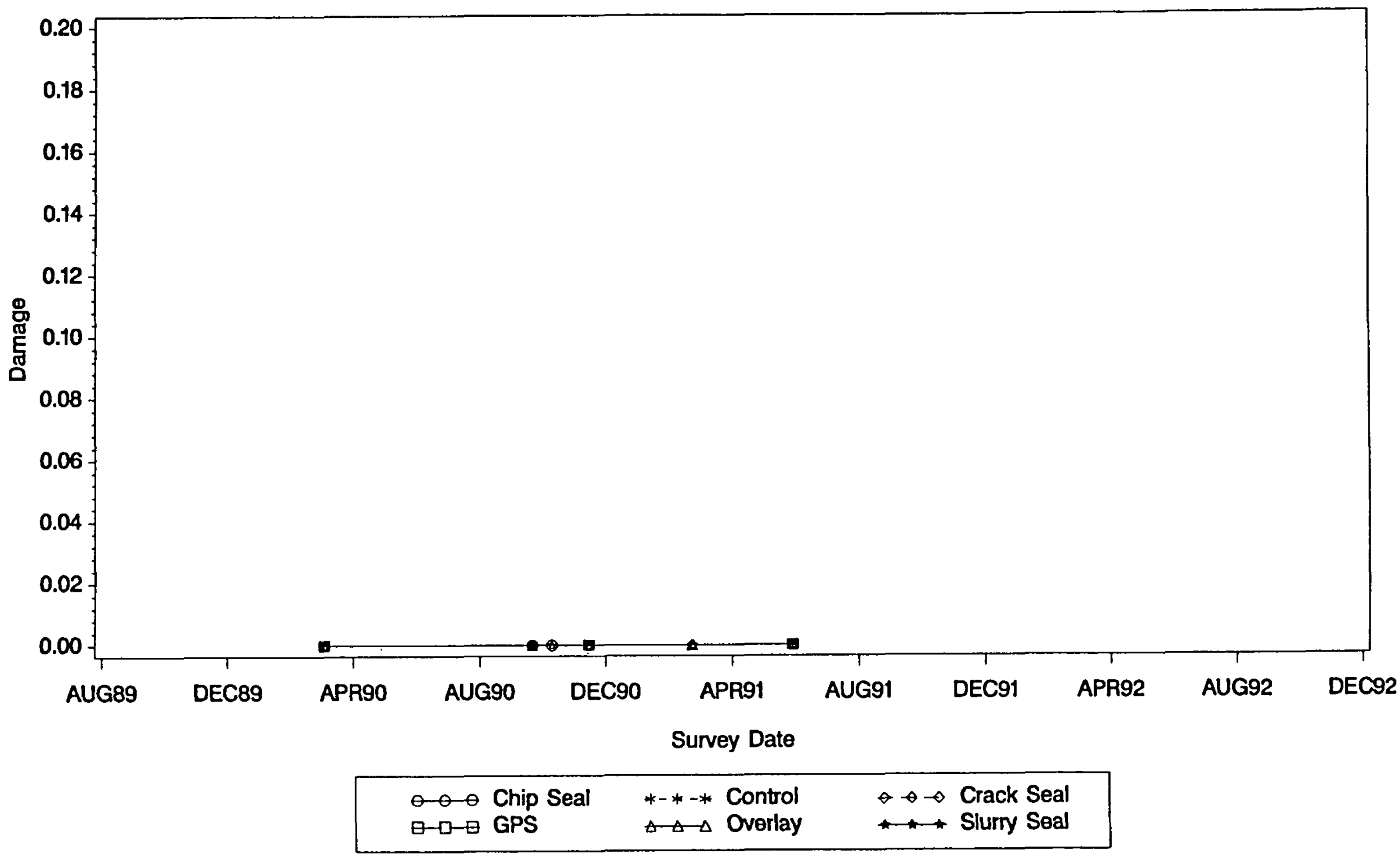
Treatment dates: Slurry Seal-05OCT1990 Crack Seal-05OCT1990 Chip Seal-05OCT1990 Overlay-01SOCT1990 Construction date: 01AUG1972

Figure G-20. Display of alligator cracking on sections selected for analysis at site 48G



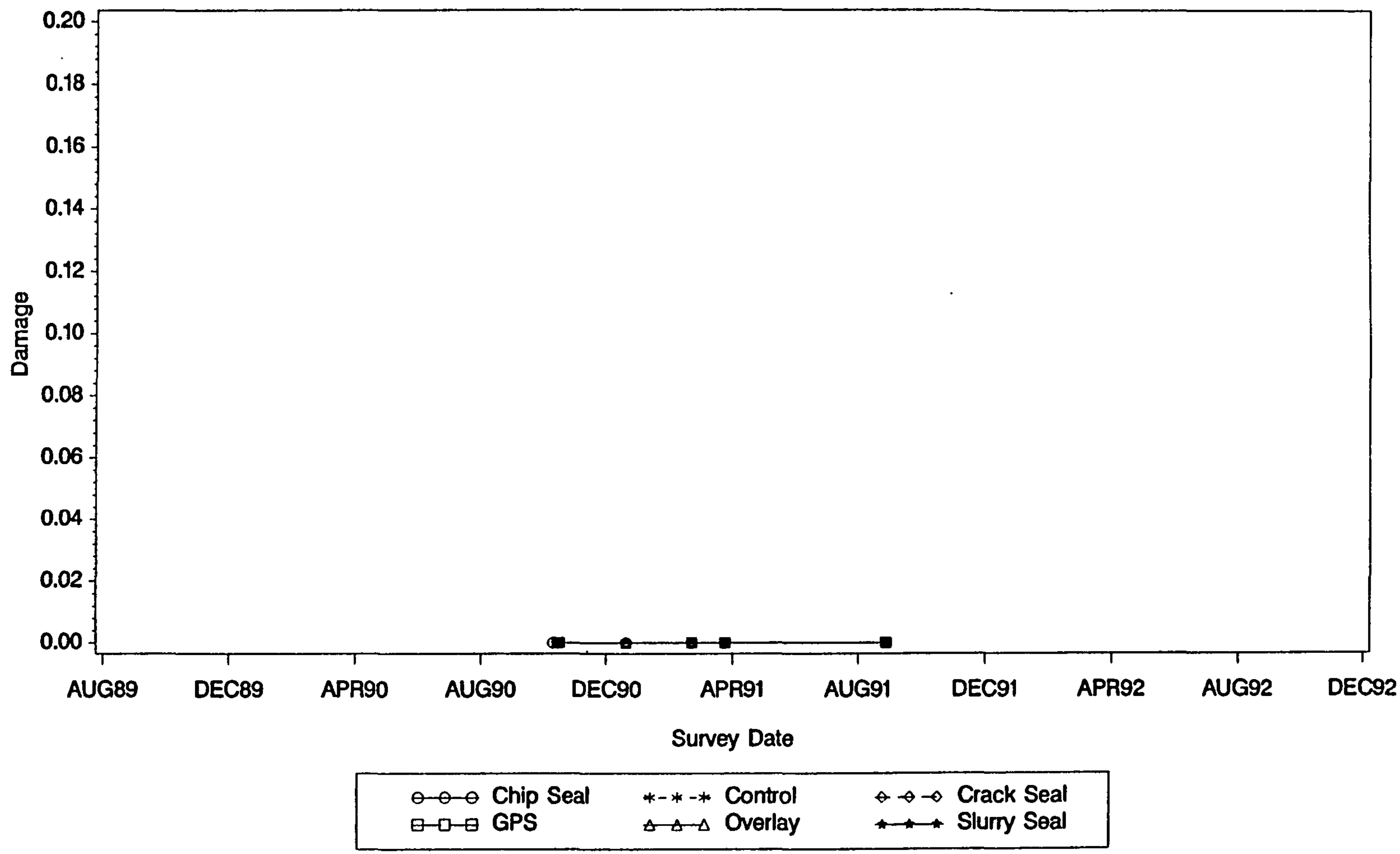
Rejected section(s): GPS Control
Treatment dates: Slurry Seal-11OCT1990 Crack Seal-11OCT1990 Chip Seal-11OCT1990 Overlay-15OCT1990 Construction date: 01JUL1985

Figure G-21. Display of alligator cracking on sections selected for analysis at site 48H



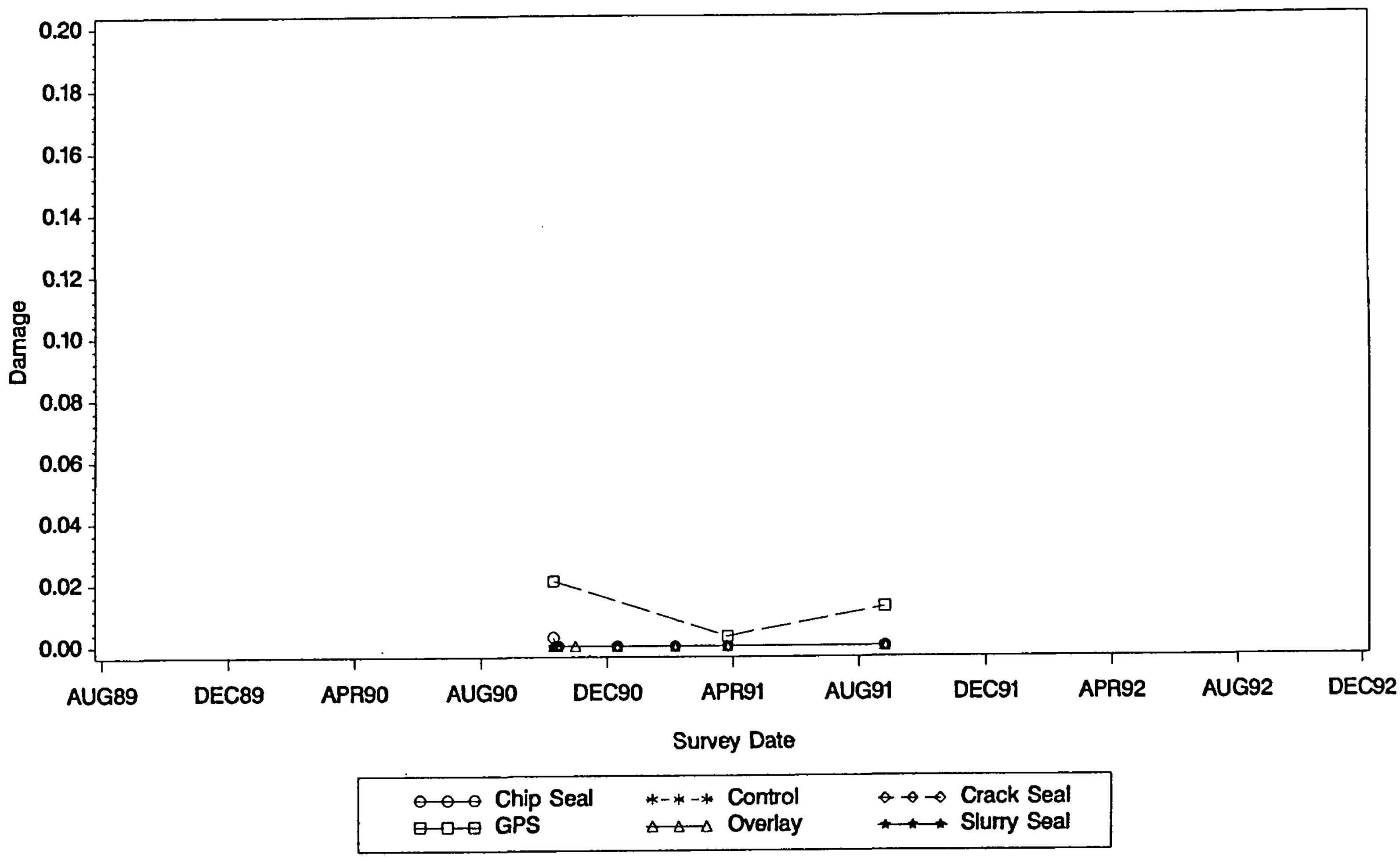
Treatment dates: Slurry Seal-10OCT1990 Crack Seal-10OCT1990 Chip Seal-10OCT1990 Overlay-15NOV1990 Construction date: 01JUN1970

Figure G-22. Display of alligator cracking on sections selected for analysis at site 48I



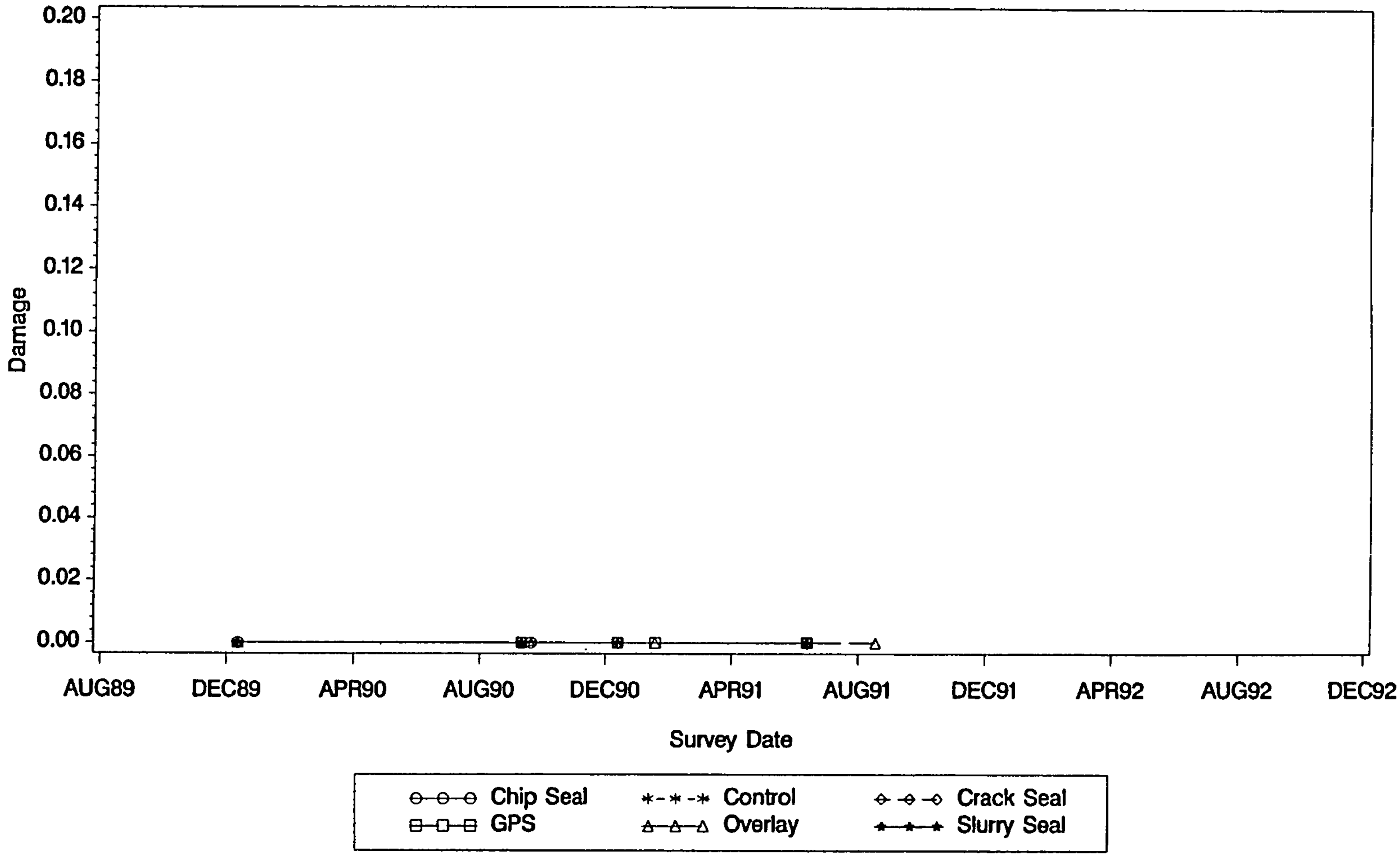
Treatment dates: Overlay-16OCT1990 Slurry Seal-16OCT1990 Crack Seal-16OCT1990 Chip Seal-16OCT1990 Construction date: 01FEB1974

Figure G-23. Display of alligator cracking on sections selected for analysis at site 48J



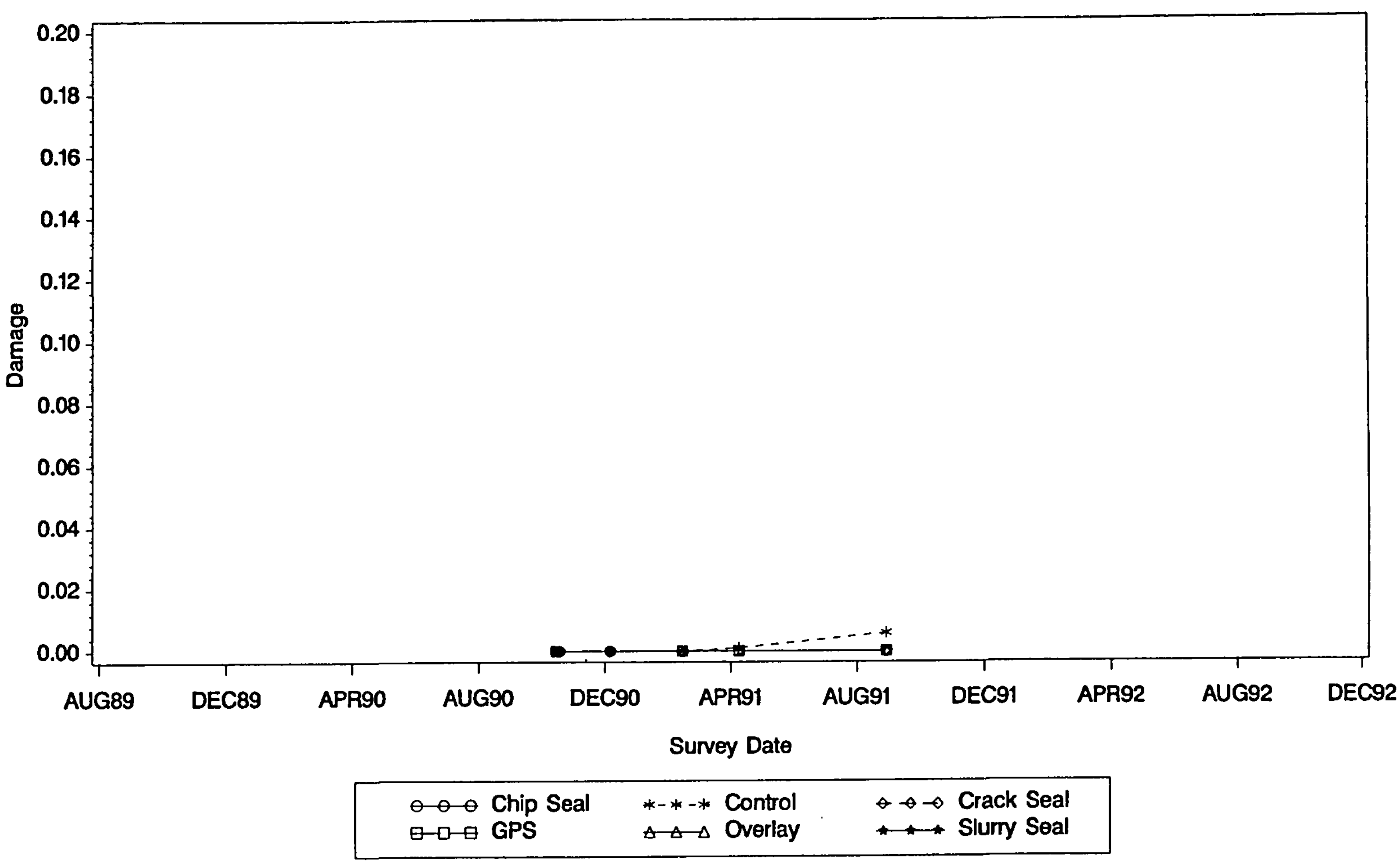
Rejected section(s): Control
Treatment dates: Slurry Seal-15OCT1990 Crack Seal-15OCT1990 Chip Seal-15OCT1990 Overlay-31OCT1990 Construction date: 01SEP1986

Figure G-24. Display of alligator cracking on sections selected for analysis at site 48K



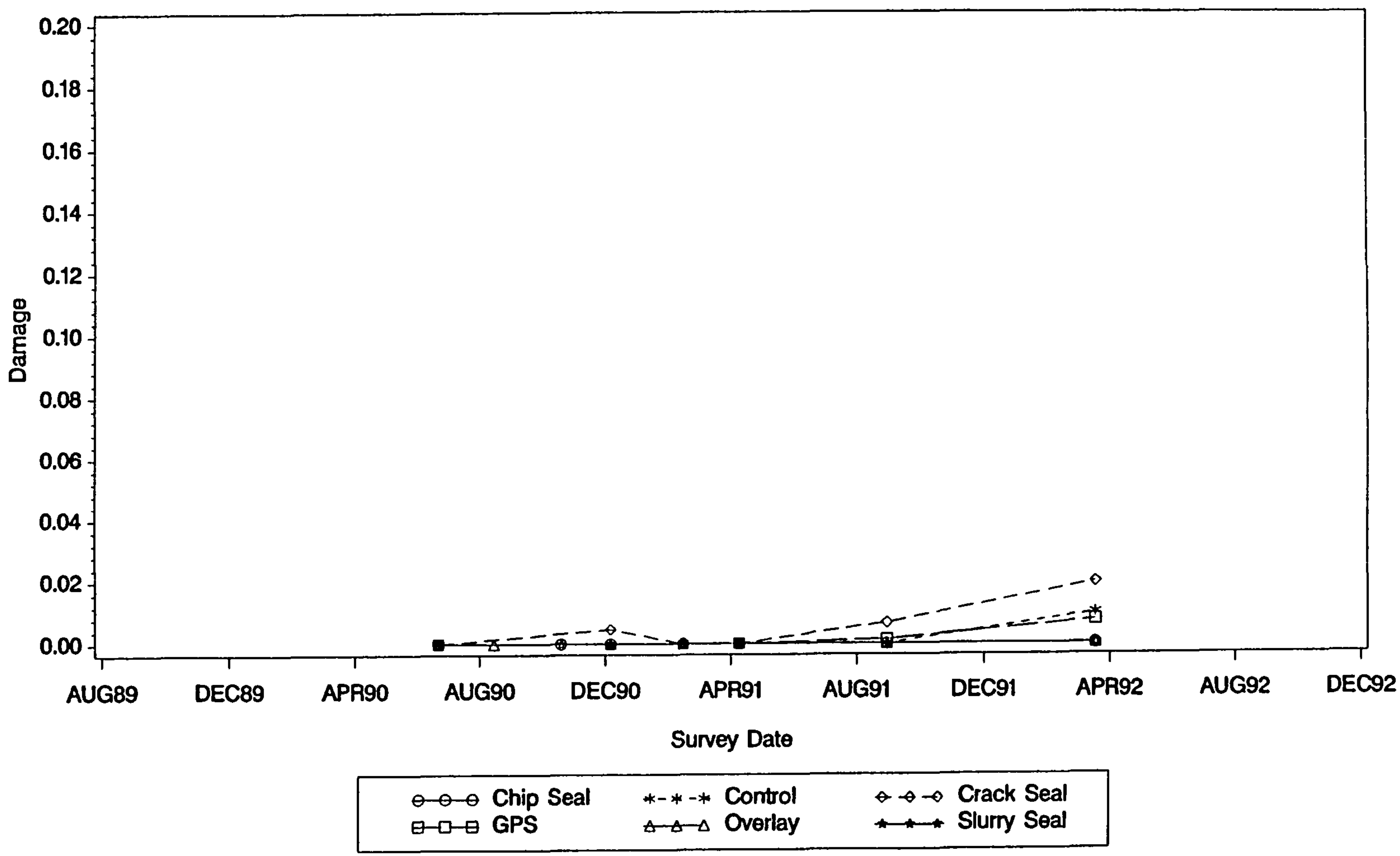
Rejected section(s): Crack Seal
Treatment dates: slurry Seal-20SEP1990 Crack Seal-20SEP1990 Chip Seal-20SEP1990 Overlay-18AUG1991 Construction date: 01JUN1976

Figure G-25. Display of alligator cracking on sections selected for analysis at site 48L



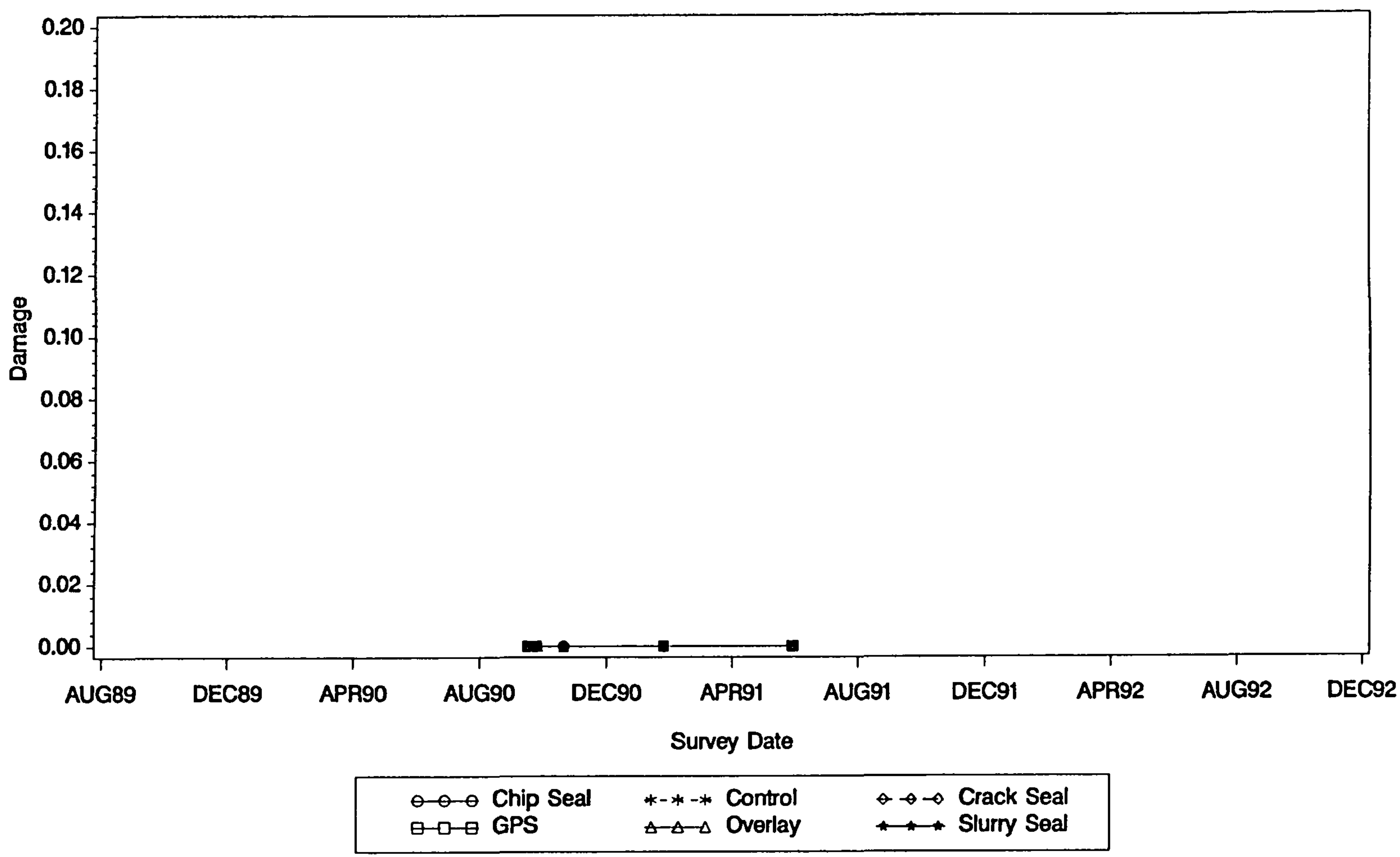
Rejected section(s): Overlay
Treatment dates: Overlay-15AUG1990 Slurry Seal-18OCT1990 Crack Seal-18OCT1990 Chip Seal-18OCT1990 Construction date: 01MAR1981

Figure G-26. Display of alligator cracking on sections selected for analysis at site 48M



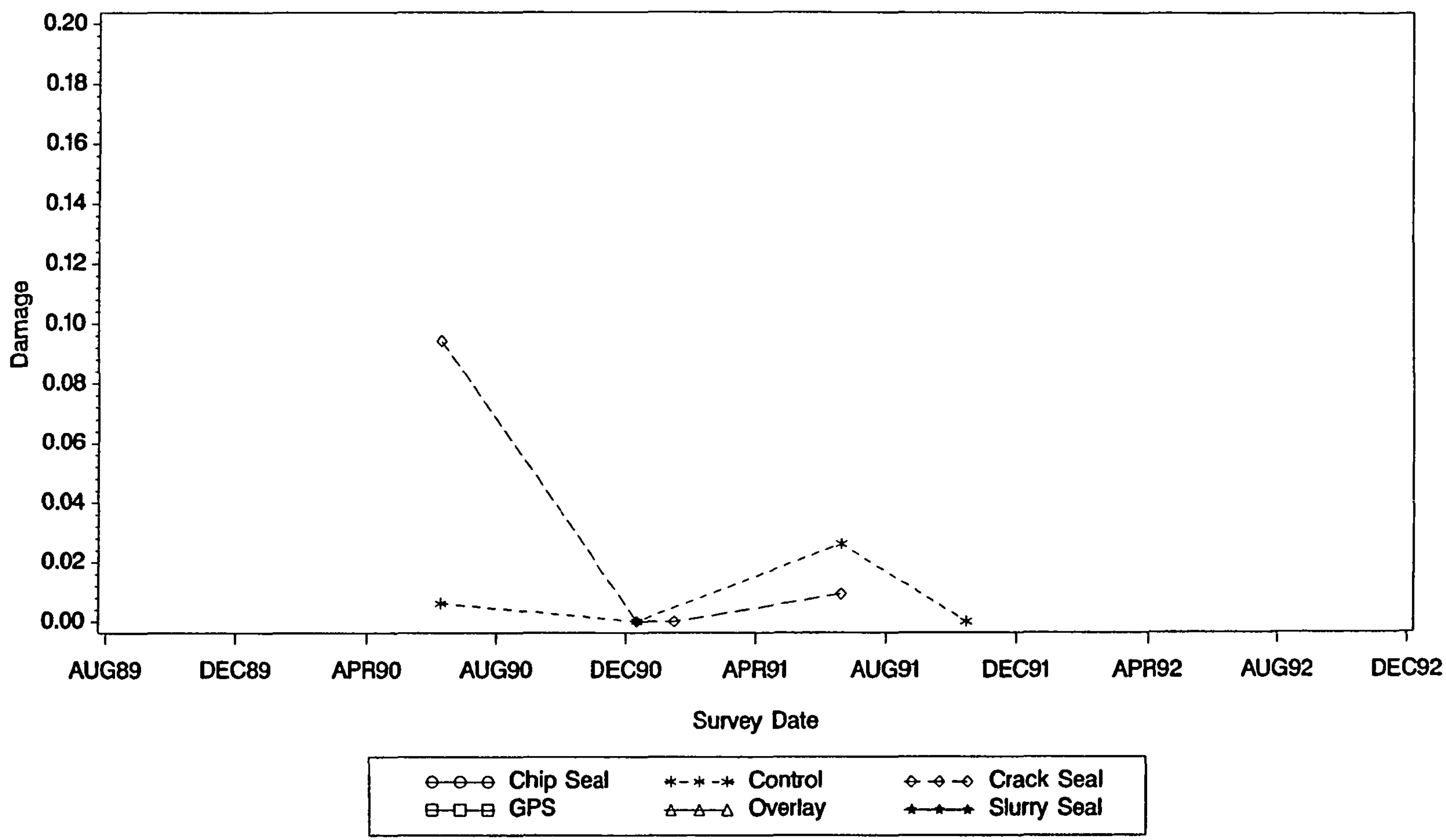
Treatment dates: Overlay-15AUG1990 Slurry Seal-19OCT1990 Crack Seal-19OCT1990 Chip Seal-19OCT1990 Construction date: 01MAY1982

Figure G-27. Display of alligator cracking on sections selected for analysis at site 48N



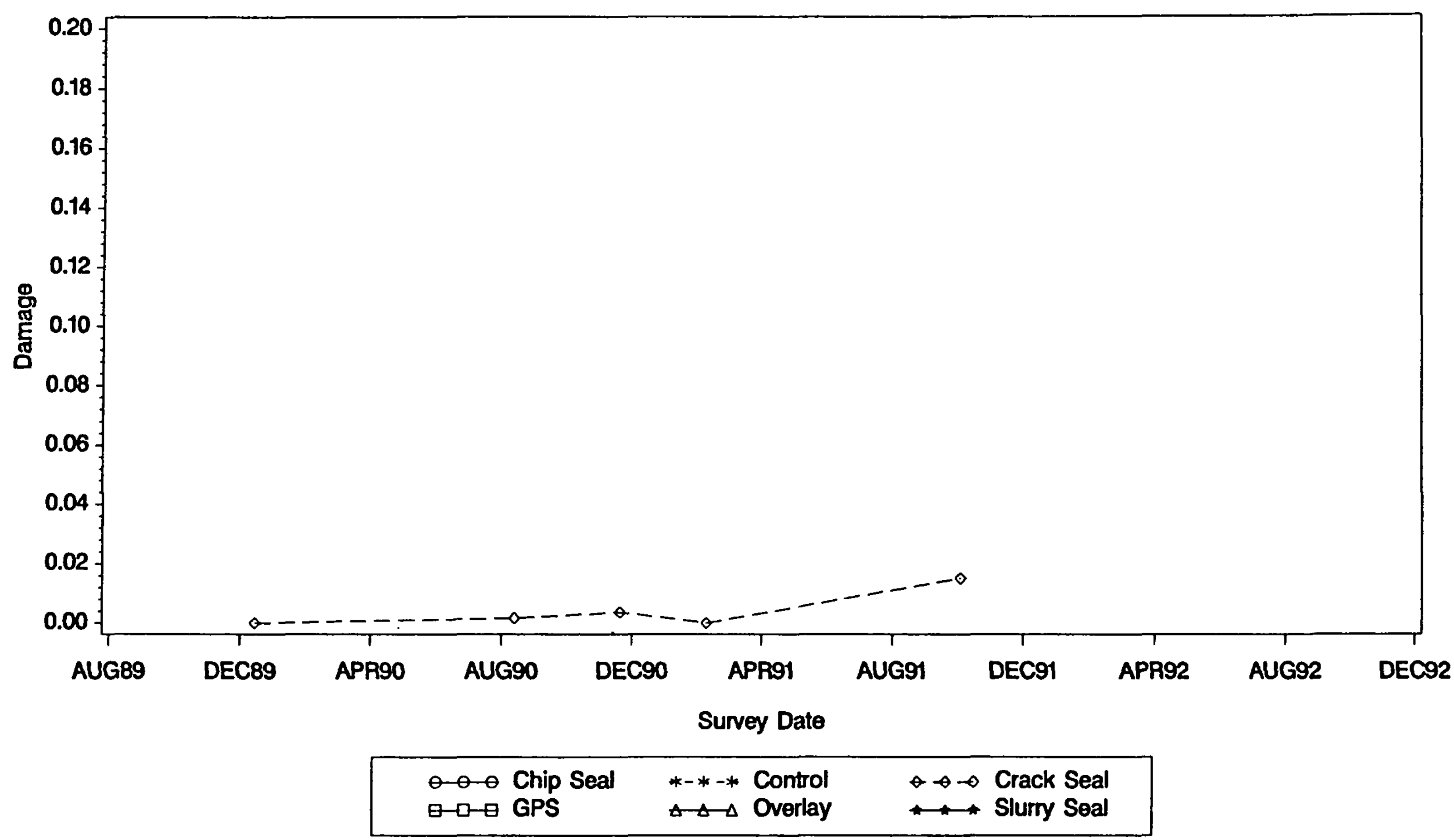
Treatment dates: Slurry Seal-24SEP1990 Crack Seal-24SEP1990 Chip Seal-24SEP1990 Overlay-25SEP1990 Construction date: 01JUL1969

Figure G-28. Display of alligator cracking on sections selected for analysis at site 48Q



Rejected section(s): Crack Seal Control
Treatment dates: Overlay-15JUL1990 Slurry Seal-09AUG1990 Crack Seal-09AUG1990 Chip Seal-09AUG1990 Construction date: 01JUN1976

Figure G-29. Display of alligator cracking on sections rejected for analysis at site 01C

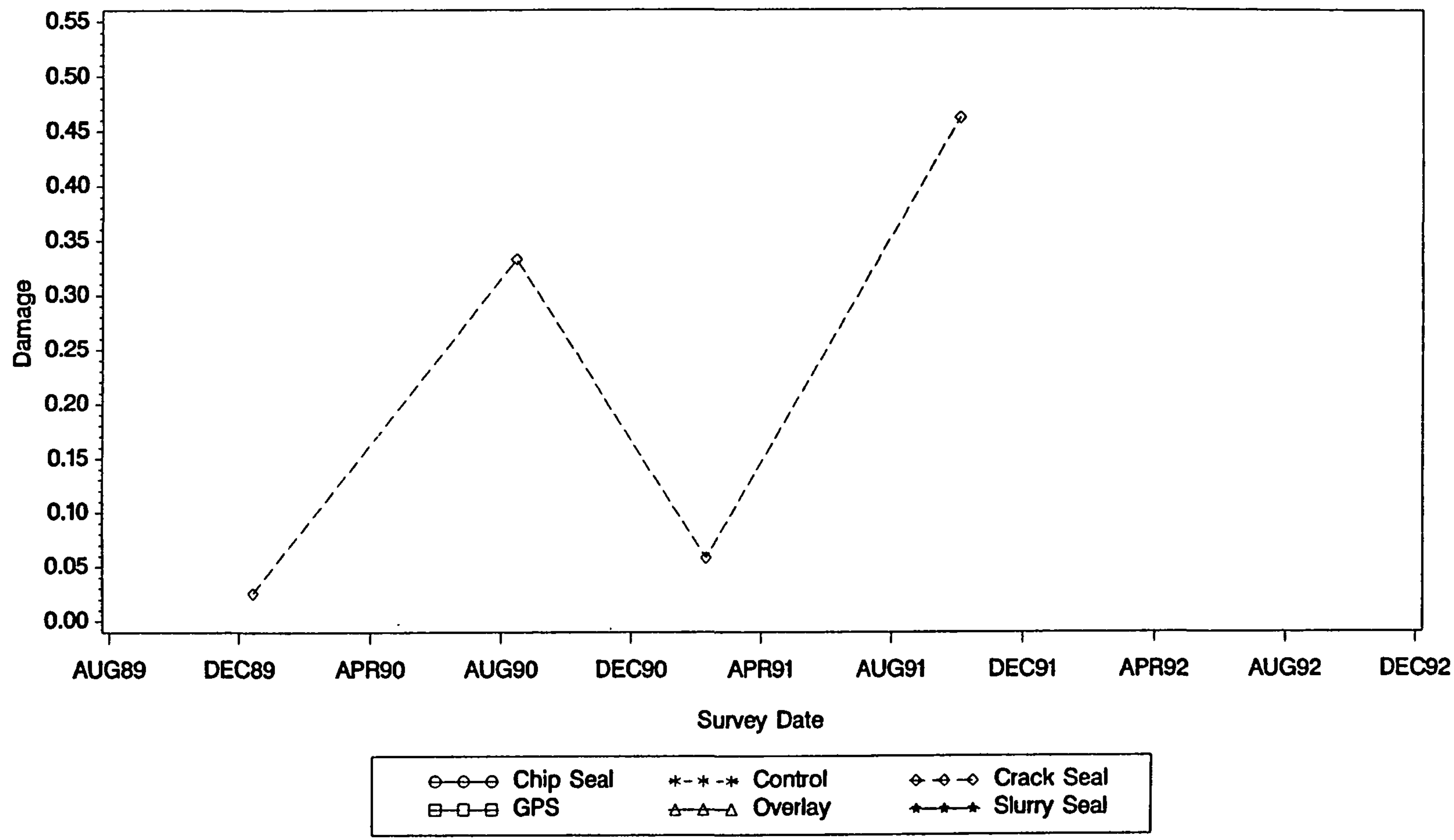


Rejected section(s): Crack Seal

No control section

Treatment dates: Slurry seal-13AUG1990 Crack Seal-13AUG1990 Chip Seal-13AUG1990 Overlay-20FEB1991 Construction date: 01OCT1974

Figure G-30. Display of alligator cracking on sections rejected for analysis at site 12A

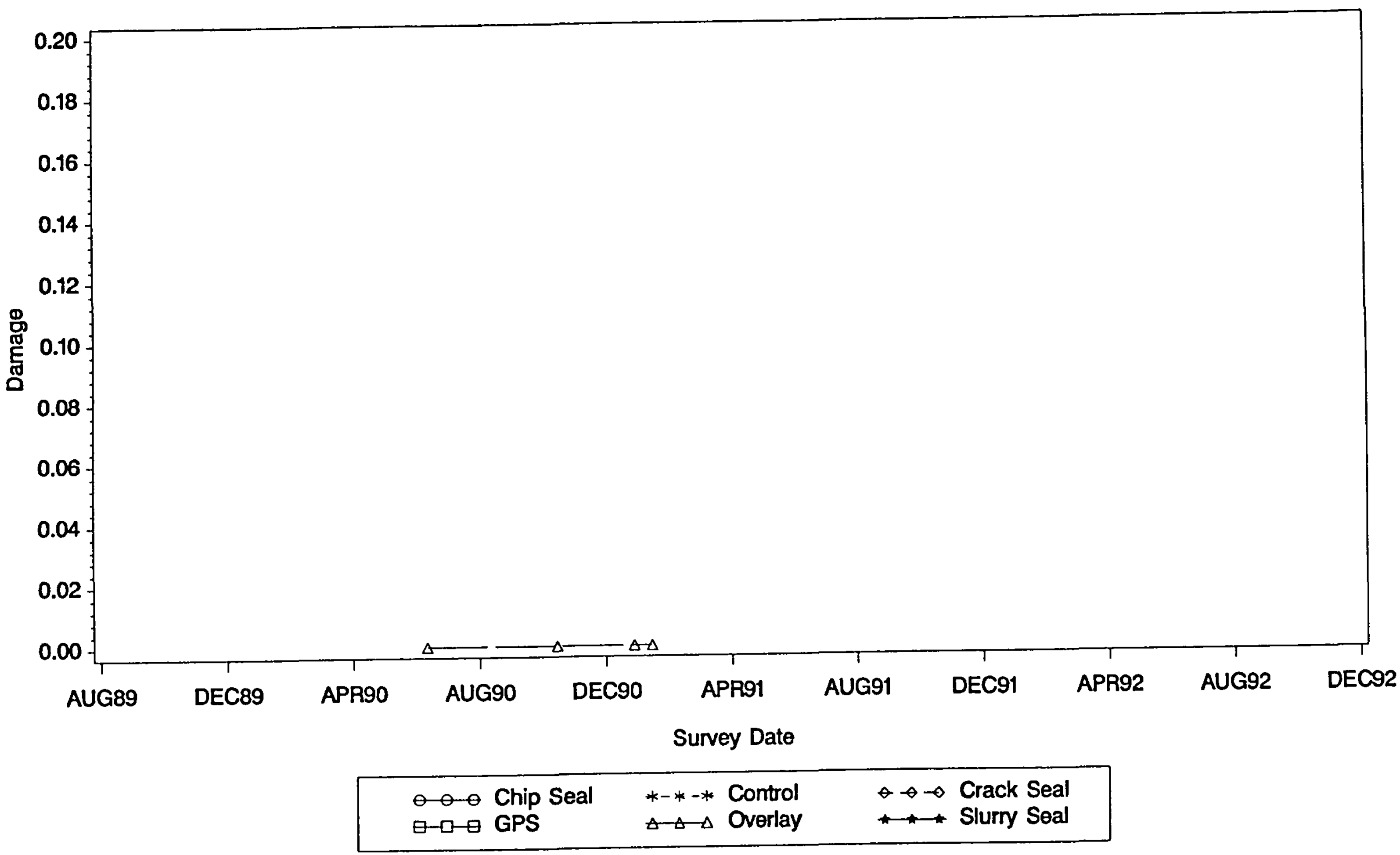


Rejected section(s): Crack Seal

No control section

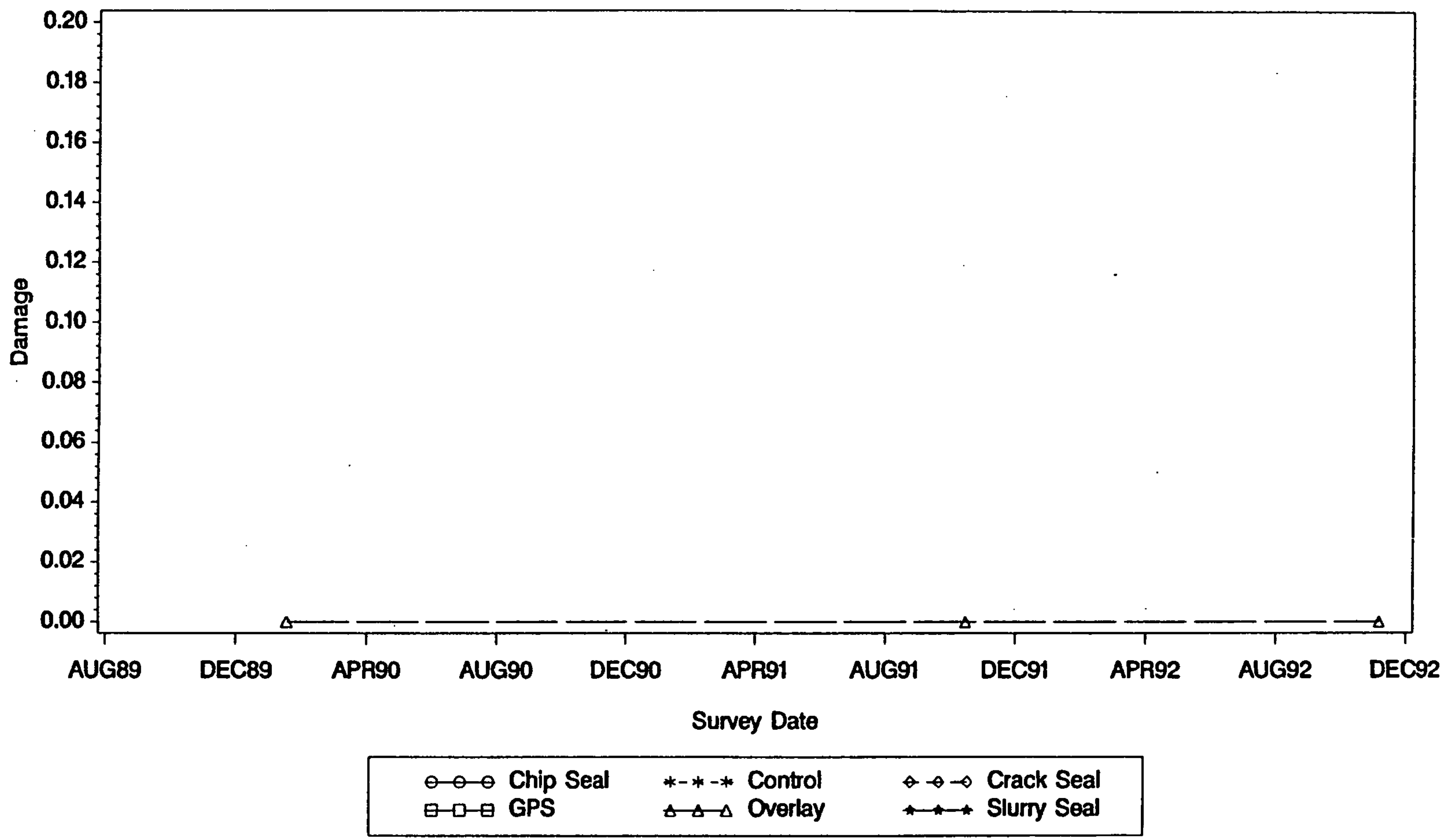
Treatment dates: Slurry Seal-16AUG1990 Crack Seal-16AUG1990 Chip Seal-16AUG1990 Overlay-20DEC1991 Construction date: 01JUN1974

Figure G-31. Display of alligator cracking on sections rejected for analysis at site 12B



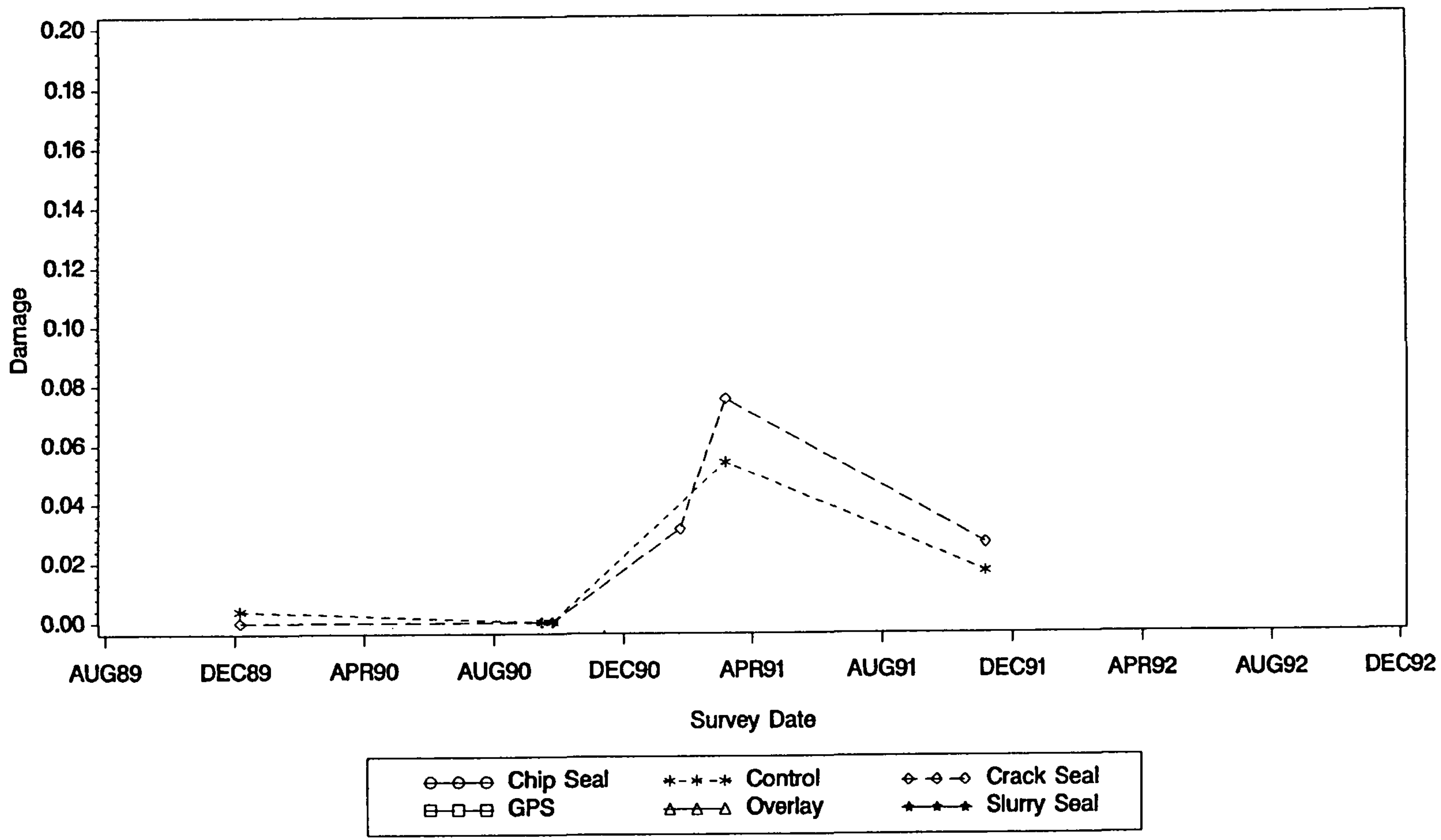
Rejected section(s): GPS Slurry Seal Crack Seal Chip Seal
Treatment dates: Slurry Seal-23AUG1990 Crack Seal-23AUG1990 Chip Seal-23AUG1990 Overlay-15OCT1990 Construction date: 01JUN1982

Figure G-32. Display of alligator cracking on sections rejected for analysis at site 28A



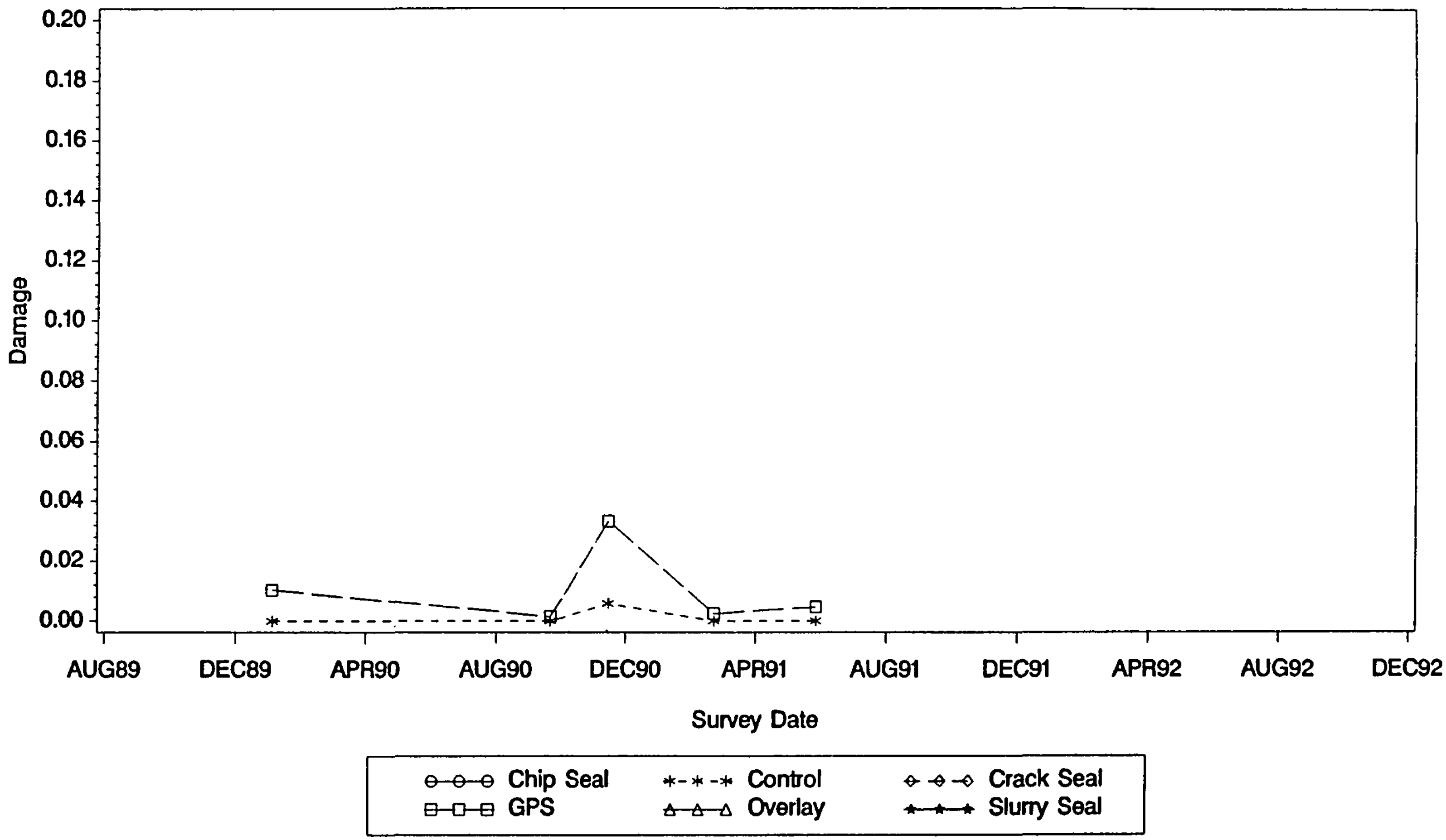
Rejected section(s): Overlay
Treatment dates: Overlay-Missing Slurry Seal-12SEP1990 Crack Seal-12SEP1990 Chip Seal-12SEP1990 Construction date: Missing

Figure G-33. Display of alligator cracking on sections rejected for analysis at site 40A



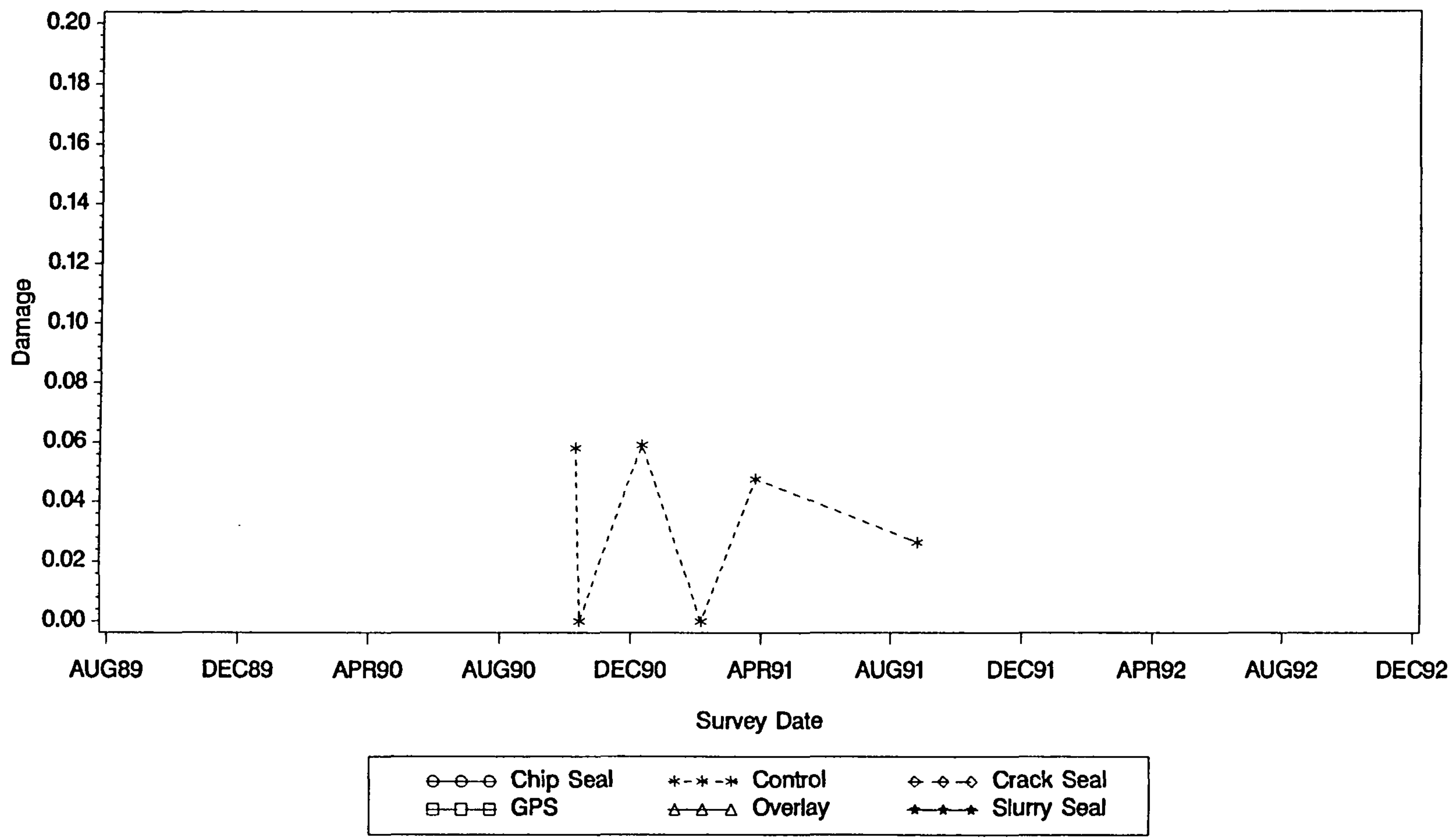
Rejected section(s): Crack Seal Control
Treatment dates: Slurry Seal-14SEP1990 Crack Seal-14SEP1990 Chip Seal-14SEP1990 Overlay-25SEP1990 Construction date: 01FEB1975

Figure G-34. Display of alligator cracking on sections rejected for analysis at site 48E



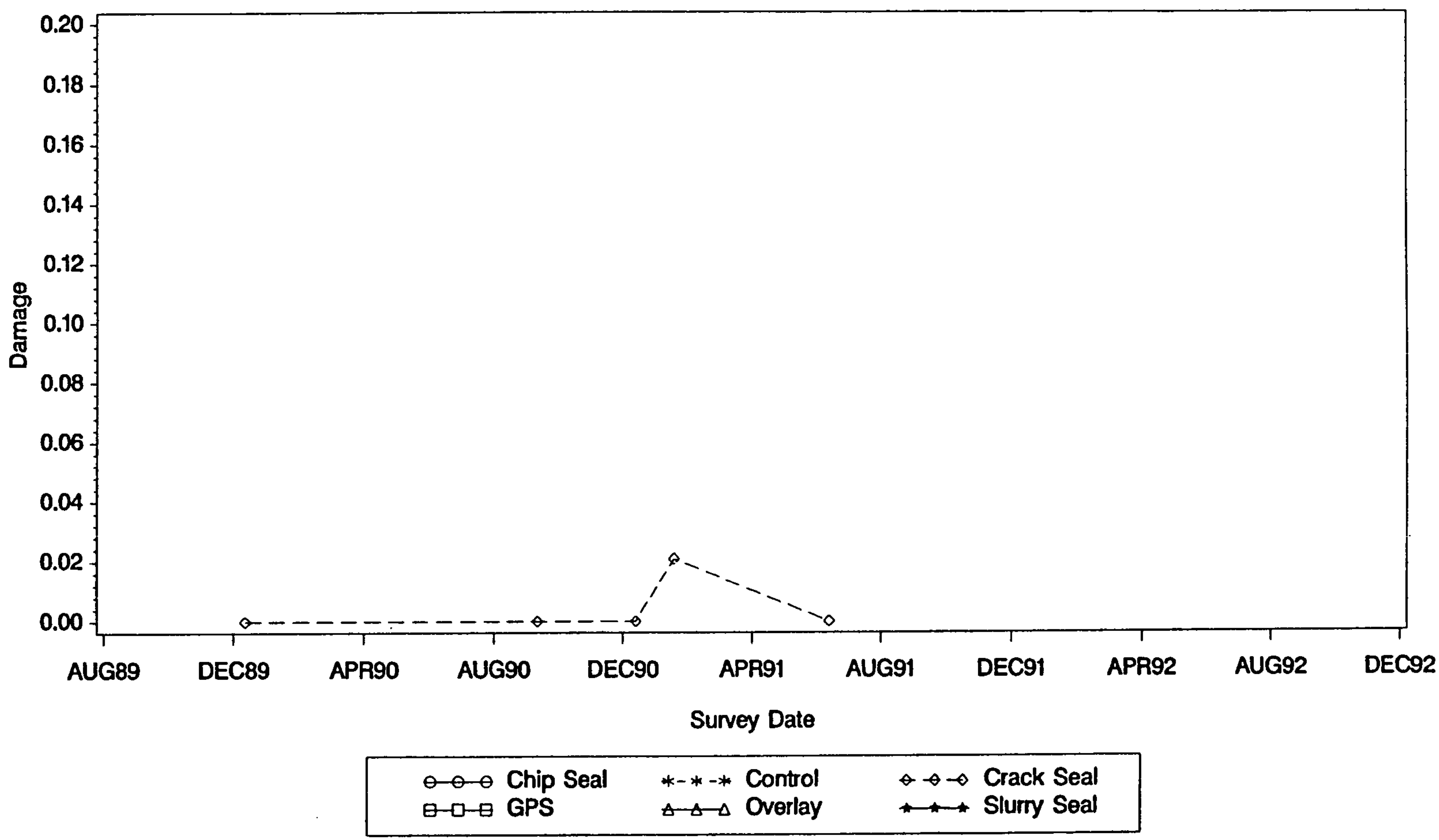
Rejected section(s): GPS Control
Treatment dates: Slurry Seal-11OCT1990 Crack Seal-11OCT1990 Chip Seal-11OCT1990 Overlay-15OCT1990 Construction date: 01JUL1985

Figure G-35. Display of alligator cracking on sections rejected for analysis at site 48H



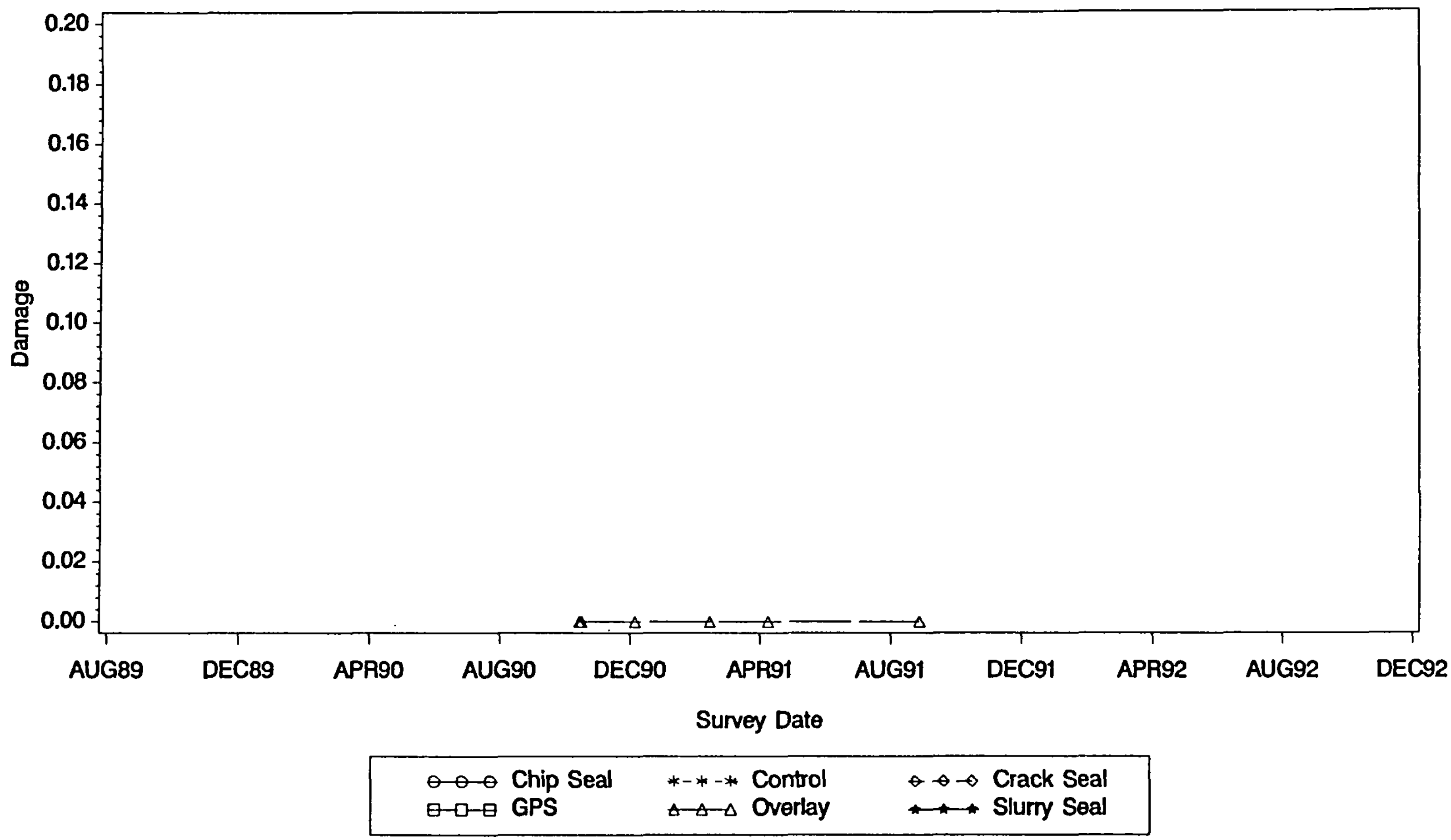
Rejected section(s): Control
Treatment dates: Slurry Seal-15OCT1990 Crack Seal-15OCT1990 Chip Seal-15OCT1990 Overlay-31OCT1990 Construction date: 01SEP1986

Figure G-36. Display of alligator cracking on sections rejected for analysis at site 48K



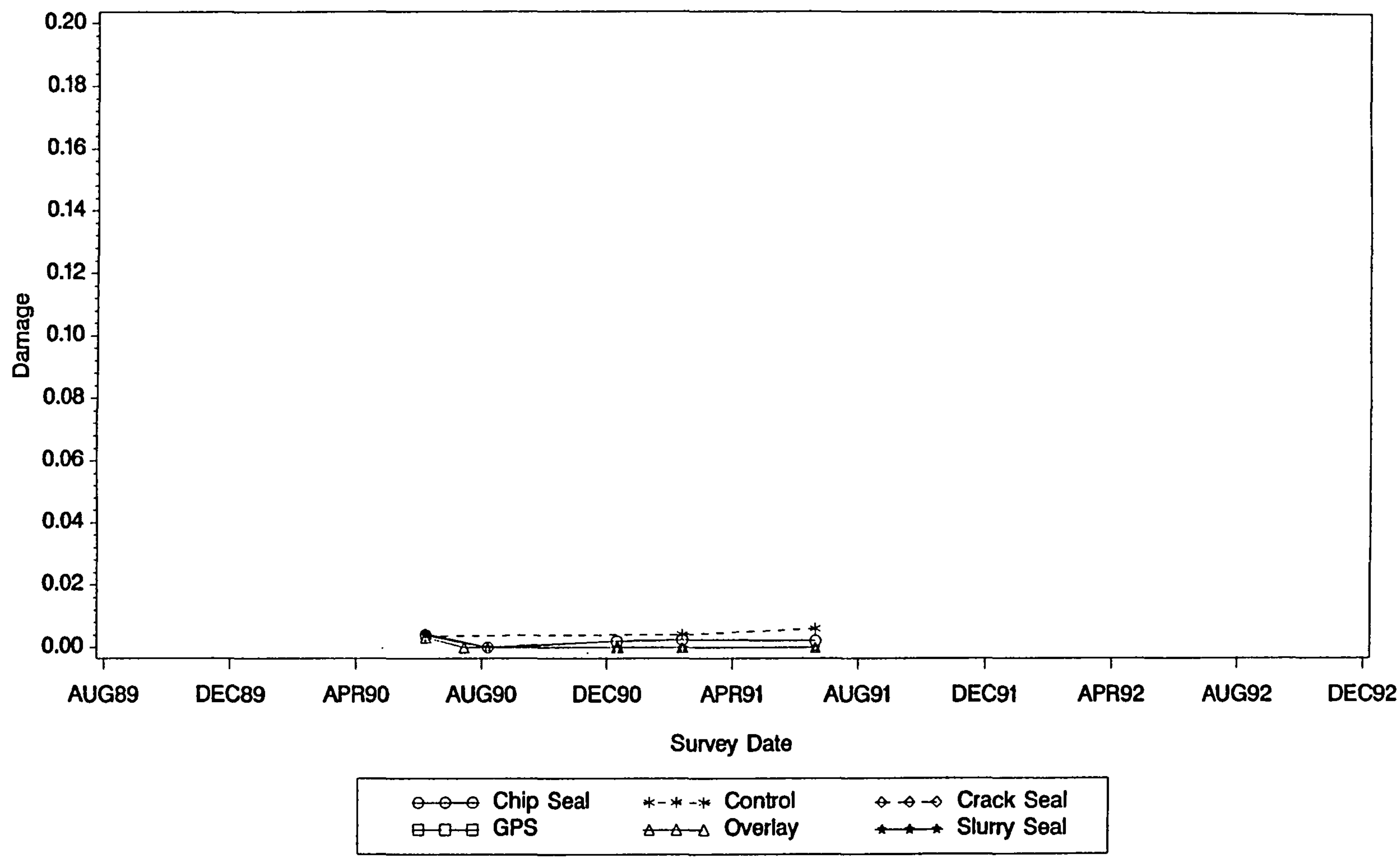
Rejected section(s): Crack Seal
Treatment dates: Slurry Seal-20SEP1990 Crack Seal-20SEP1990 Chip Seal-20SEP1990 Overlay-18AUG1991 Construction date: 01JUN1976

Figure G-37. Display of alligator cracking on sections rejected for analysis at site 48L



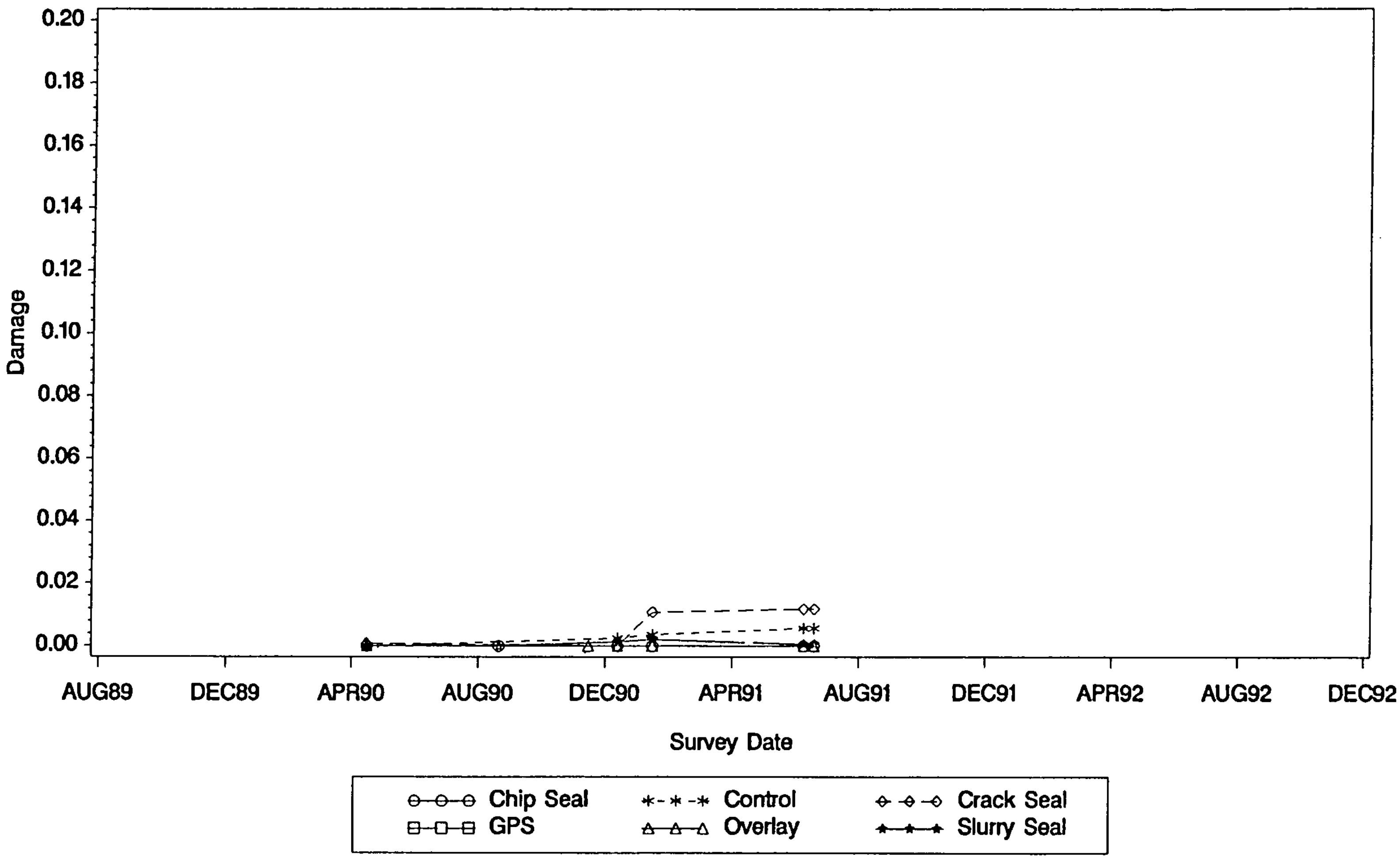
Rejected section(s): Overlay
Treatment dates: Overlay-15AUG1990 Slurry Seal-18OCT1990 Crack Seal-18OCT1990 Chip Seal-18OCT1990 Construction date: 01MAR1981

Figure G-38. Display of alligator cracking on sections rejected for analysis at site 48M



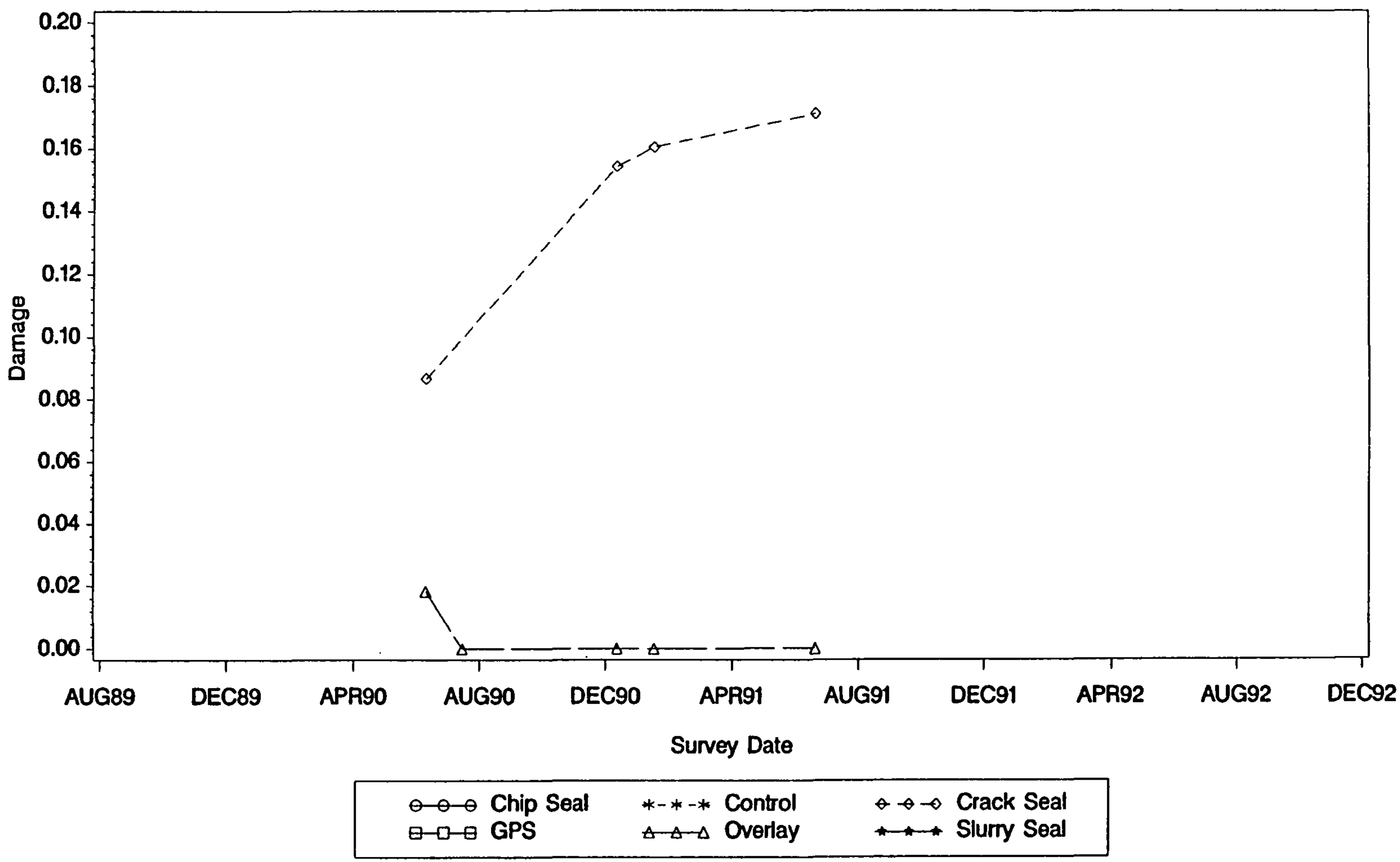
Rejected section(s): GPS Crack Seal
Treatment dates: Overlay-15JUL1990 Slurry Seal-07AUG1990 Crack Seal-07AUG1990 Chip Seal-07AUG1990 Construction date: 01JUN1972

Figure G-39. Display of longitudinal and transverse cracking on sections selected for analysis at site 01A



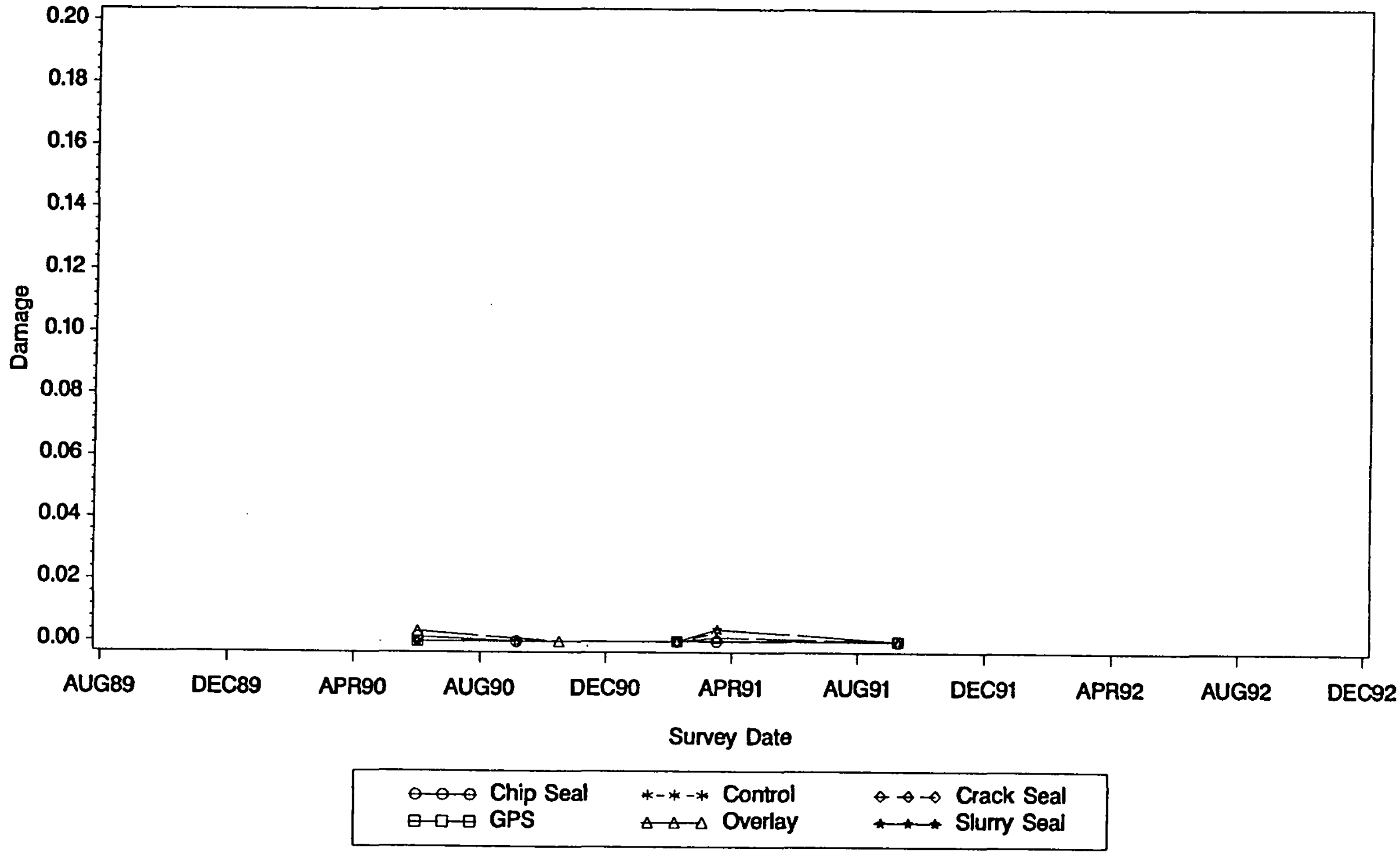
Rejected section(s): GPS
Treatment dates: Slurry Seal-21AUG1990 Crack Seal-21AUG1990 Chip Seal-21Aug1990 Overlay-15NOV1990 Construction date: 01OCT1986

Figure G-40. Display of longitudinal and transverse cracking on sections selected for analysis at site 01B



Rejected section(s): GPS Slurry Seal Control Chip Seal
Treatment dates: Overlay-15JUL1990 Slurry Seal-09AUG1990 Crack Seal-09AUG1990 Chip Seal-09AUG1990 Construction date: 01JUN1976

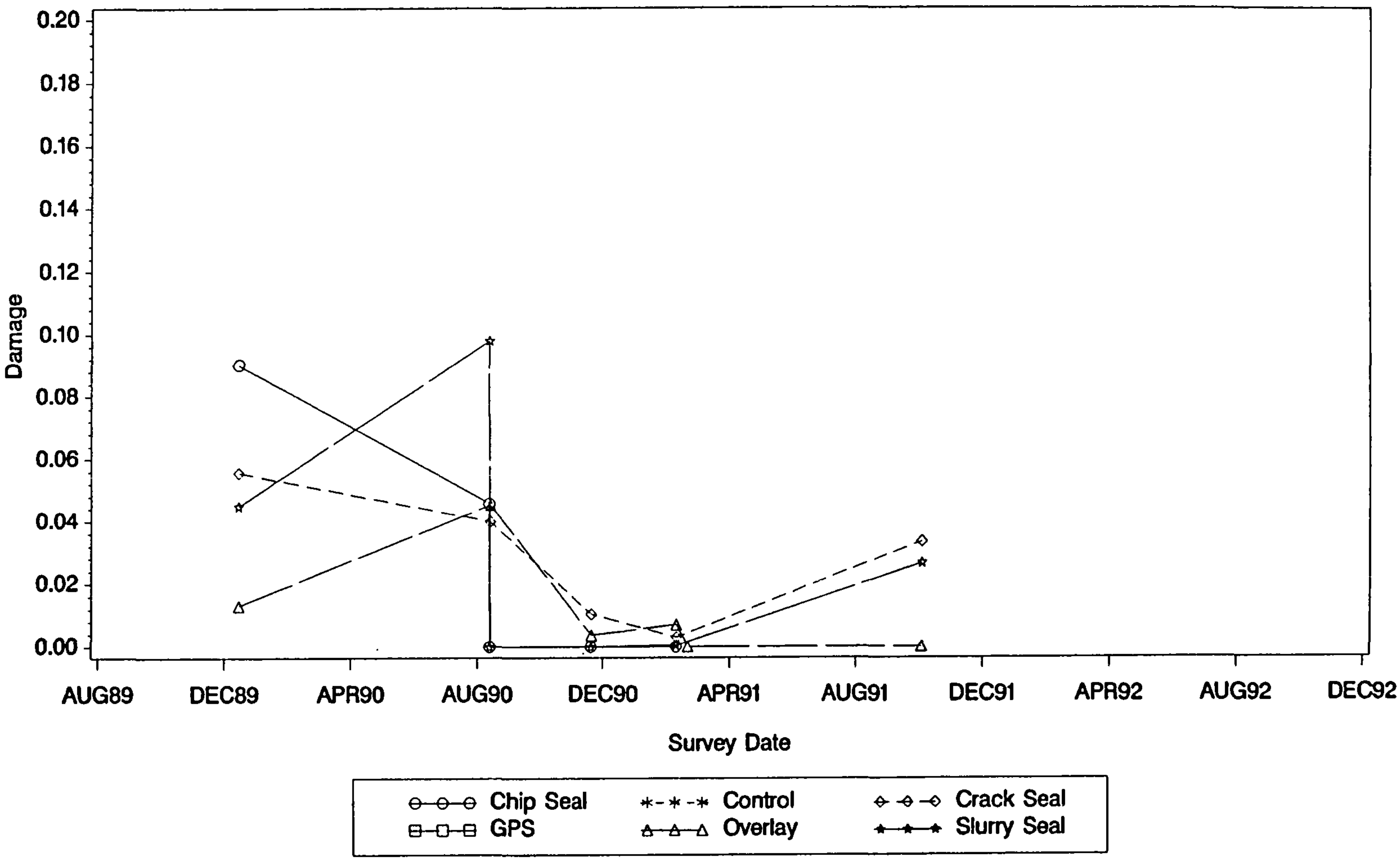
Figure G-41. Display of longitudinal and transverse cracking on sections selected for analysis at site 01C



No control section

Treatment dates: Slurry Seal-05SEP1990 Crack Seal-05SEP1990 Chip Seal-05SEP1990 Overlay-17OCT1990 Sonctruction date: 01FEB1988

Figure G-42. Display of longitudinal and transverse cracking on sections selected for analysis at site 05A

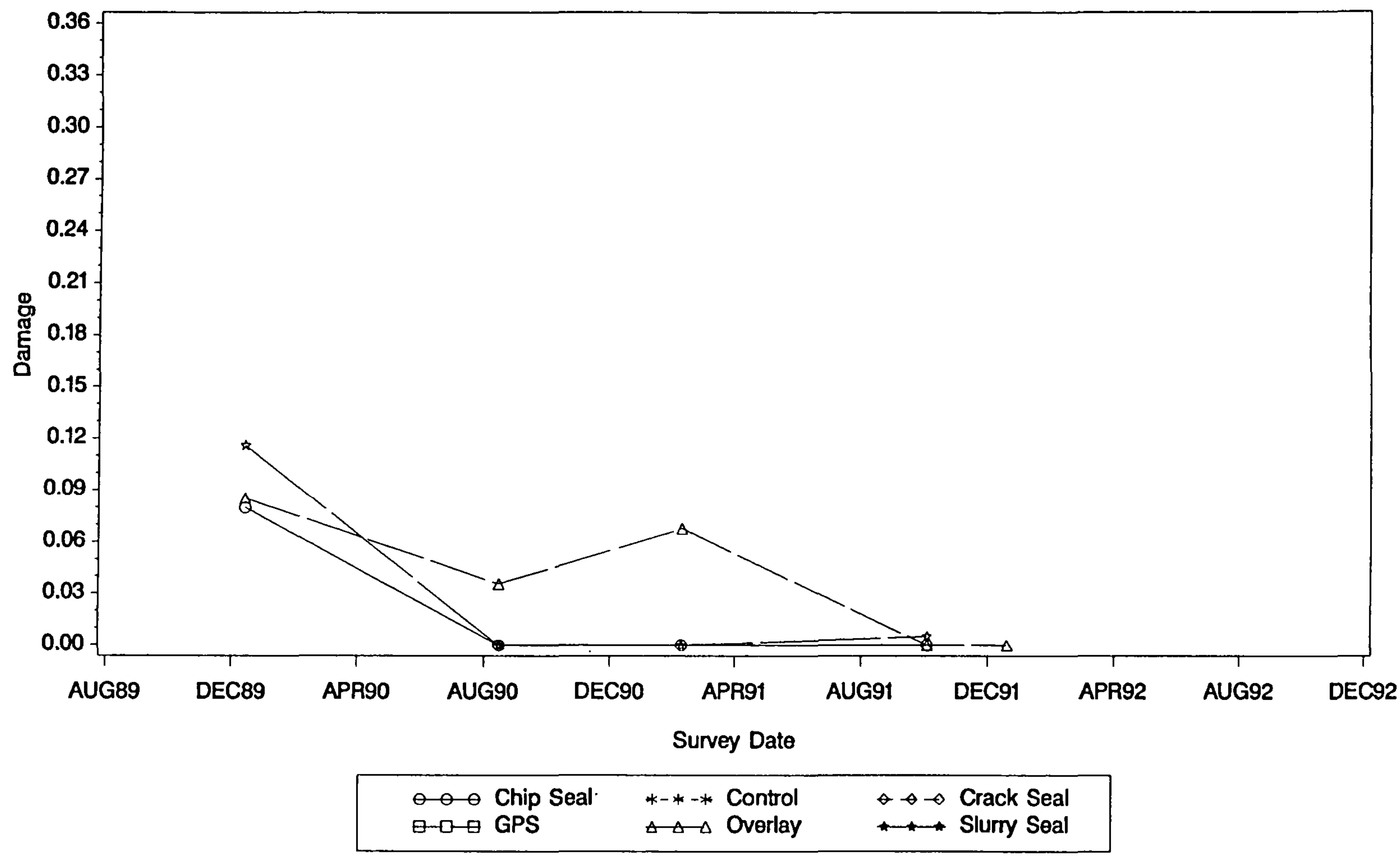


Rejected section(s): GPS

No control section

Treatment dates: Slurry Seal-13AUG1990 Crack Seal-13AUG1990 Chip Seal-13AUG1990 Overlay-20FEB1991 Construction date: 01OCT1974

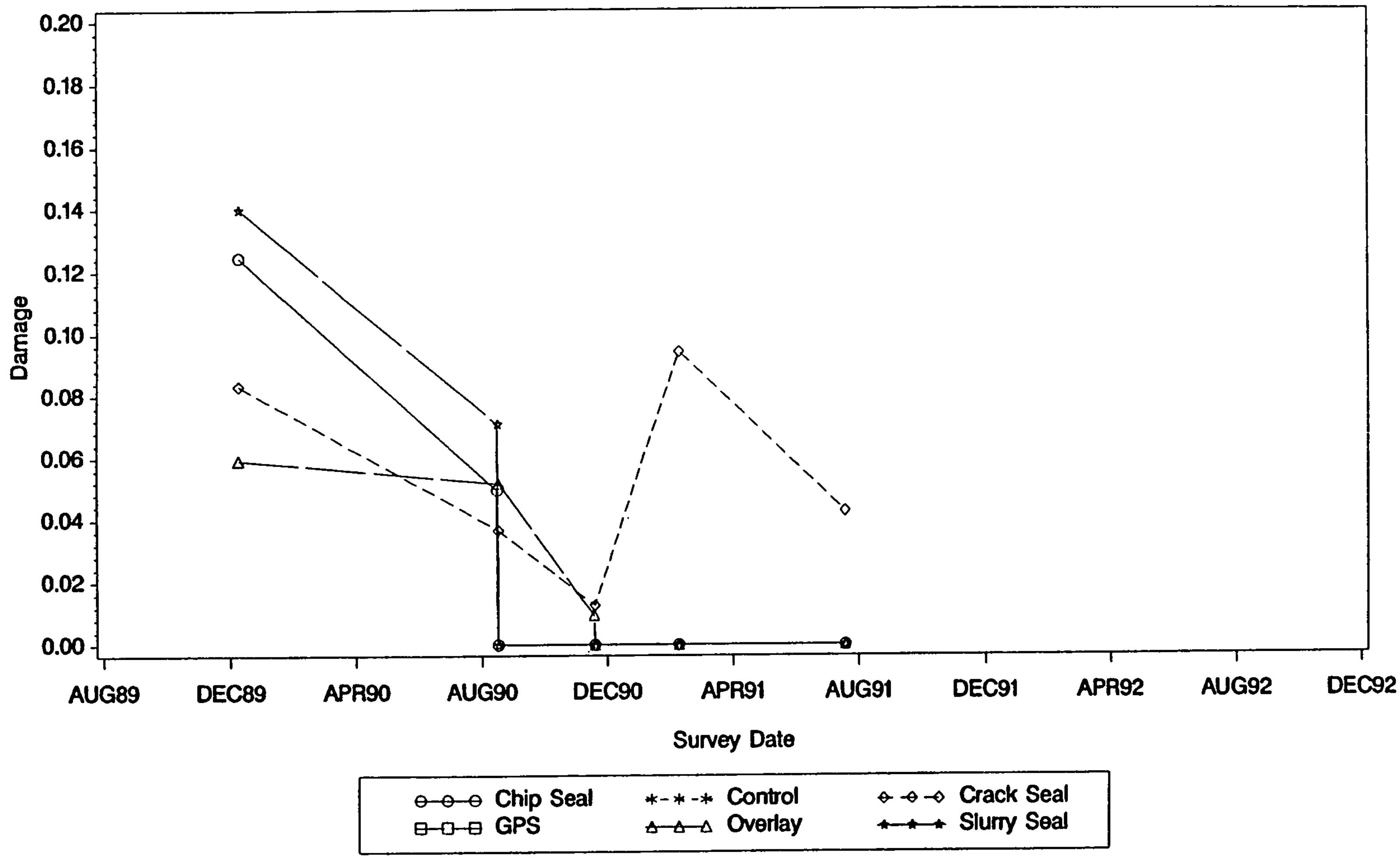
Figure G-43. Display of longitudinal and transverse cracking on sections selected for analysis at site 12A



Rejected section(s): GPS Crack Seal — No control section

Treatment dates: Slurry Seal-16AUG1990 Crack Seal-16AUG1990 Chip Seal-16AUG1990 Overlay-20DEC1991 Construction date: 01JUN1974

Figure G-44. Display of longitudinal and transverse cracking on sections selected for analysis at site 12B

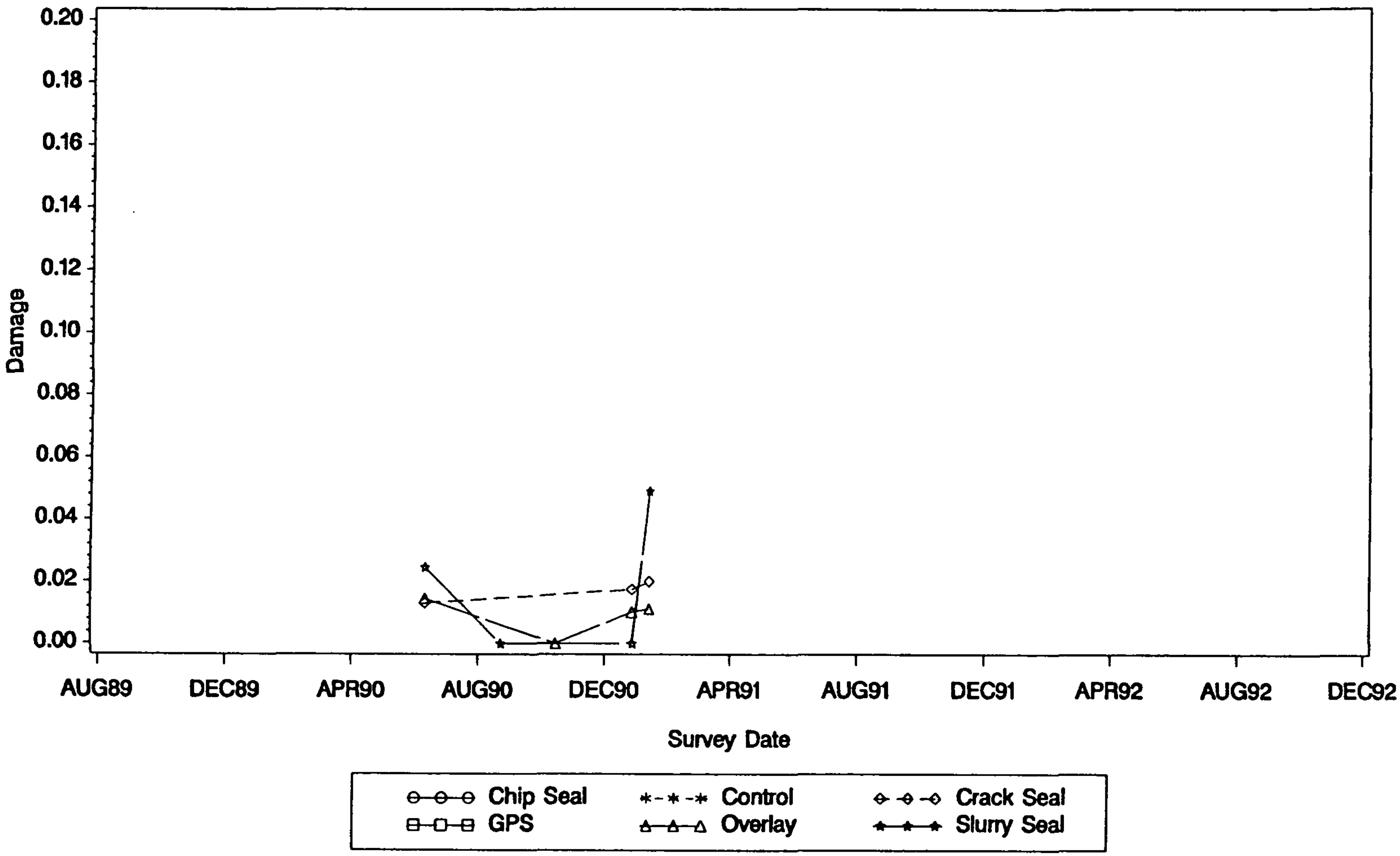


Rejected section(s): GPS

No control section

Treatment dates: Slurry Seal-17AUG1990 Crack Seal-17AUG1990 Chip Seal-17AUG1990 Overlay-19NOV1990 Construction date: 01JUN1970

Figure G-45. Display of longitudinal and transverse cracking on sections selected for analysis at site 12C

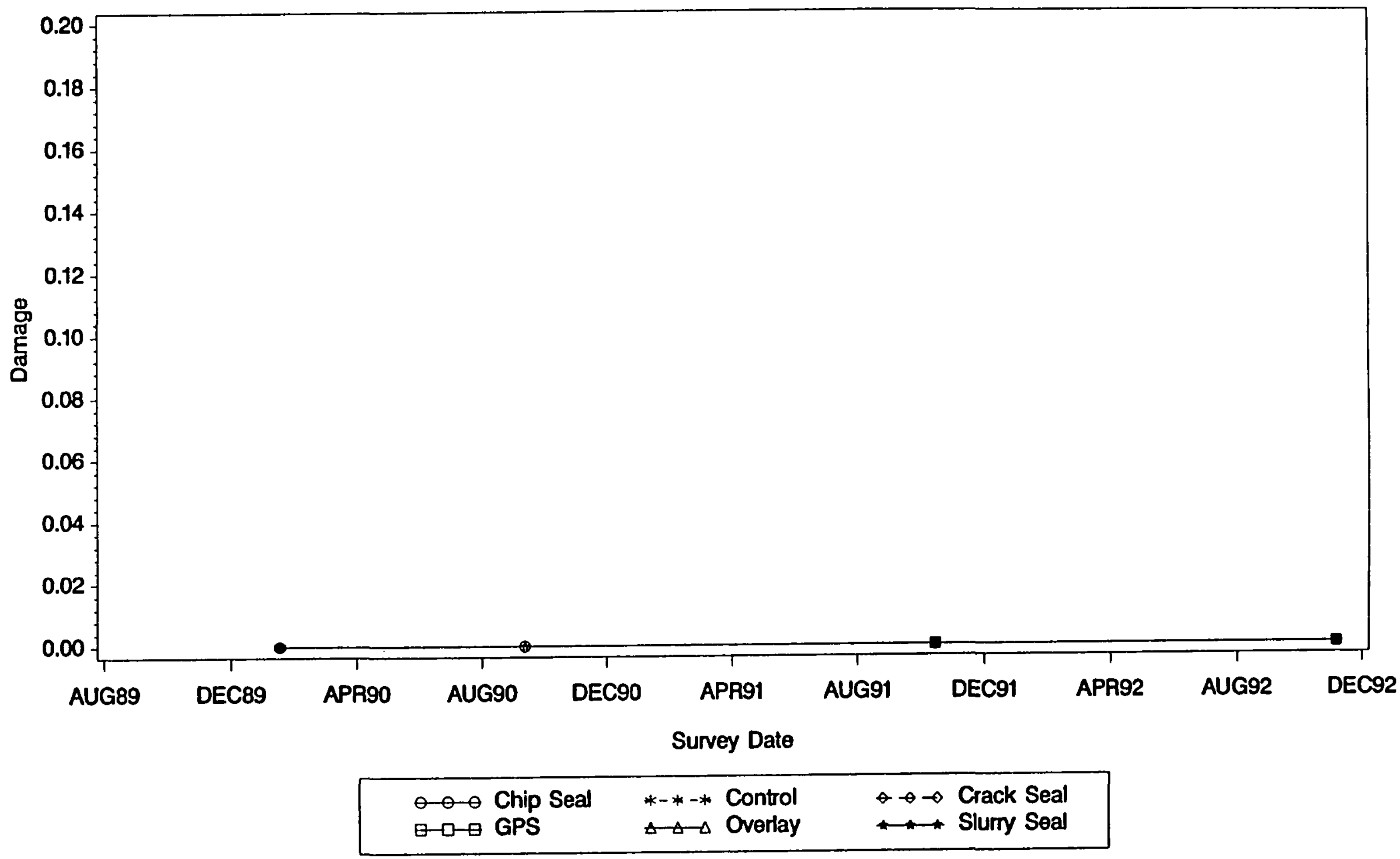


Rejected section(s): GPS Chip Seal

No control section

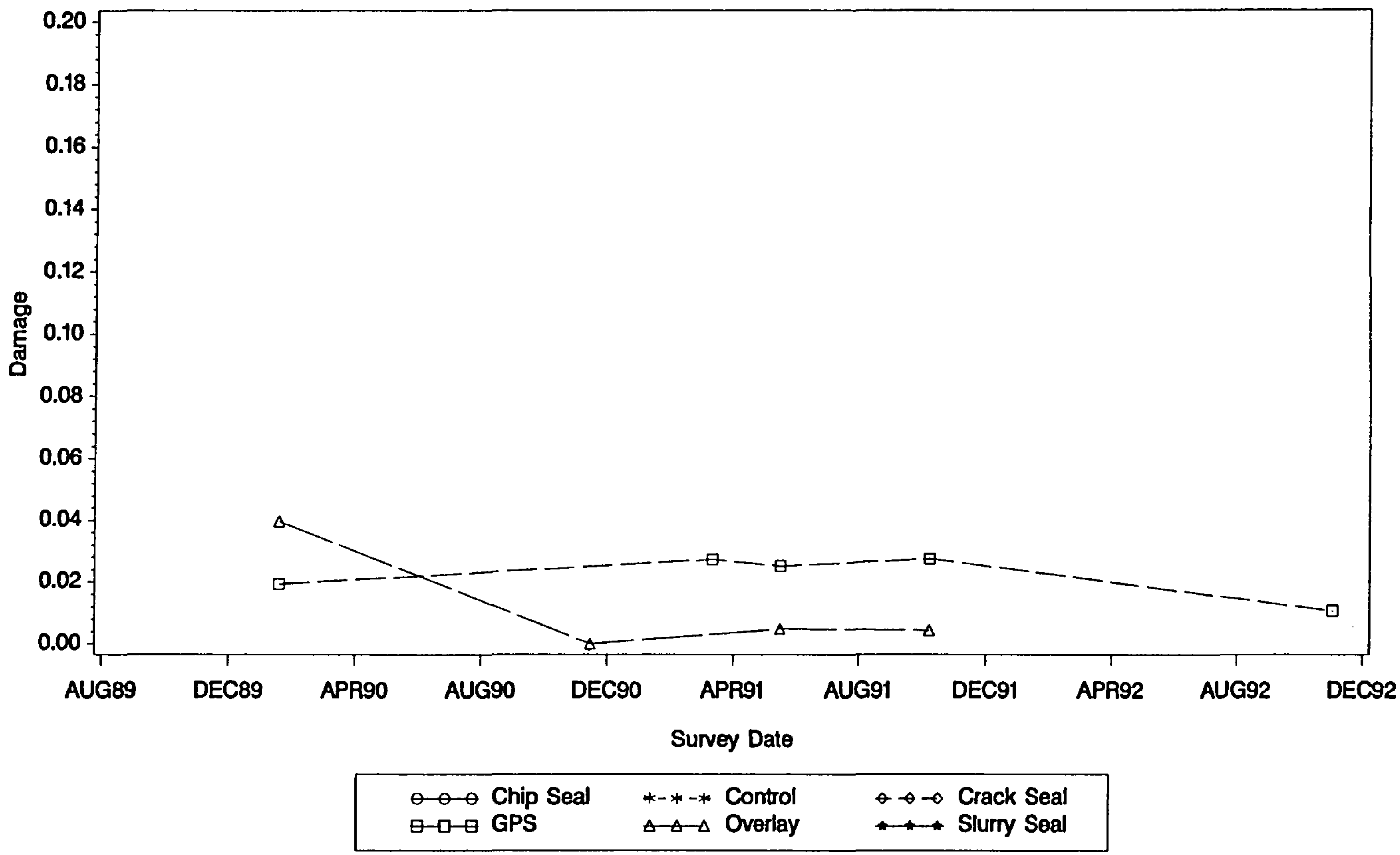
Treatment dates: Slurry Seal-23AUG1990 Crack Seal-23AUG1990 Chip Seal-23AUG1990 Overlay-15OCT1990 Construction date: 01JUN1982

Figure G-46. Display of longitudinal and transverse cracking on sections selected for analysis at site 28A



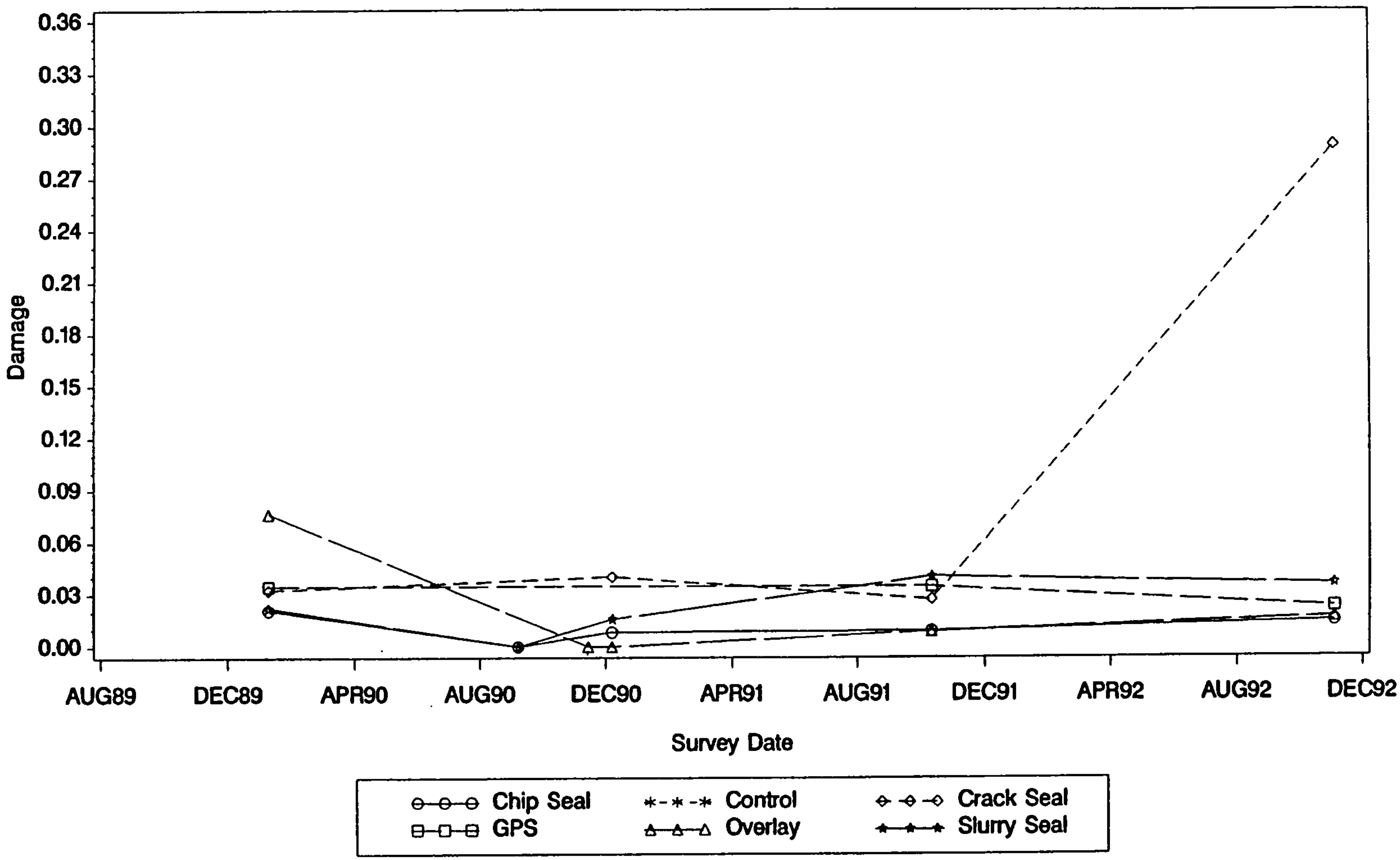
Rejected section(s): Overlay
Treatment dates: Overlay-Missing Slurry Seal-12SEP1990 Crack Seal-12SEP1990 Chip Seal-12SEP1990 Construction date: Missing

Figure G-47. Display of longitudinal and transverse cracking on sections selected for analysis at site 40A



Rejected section(s): Slurry Seal Crack Seal Chip Seal No control section
Treatment dates: Slurry Seal-10SEP1990 Crack Seal-10SEP1990 Chip Seal-10SEP1990 Overlay-15NOV1990 Construction date: 01APR1978

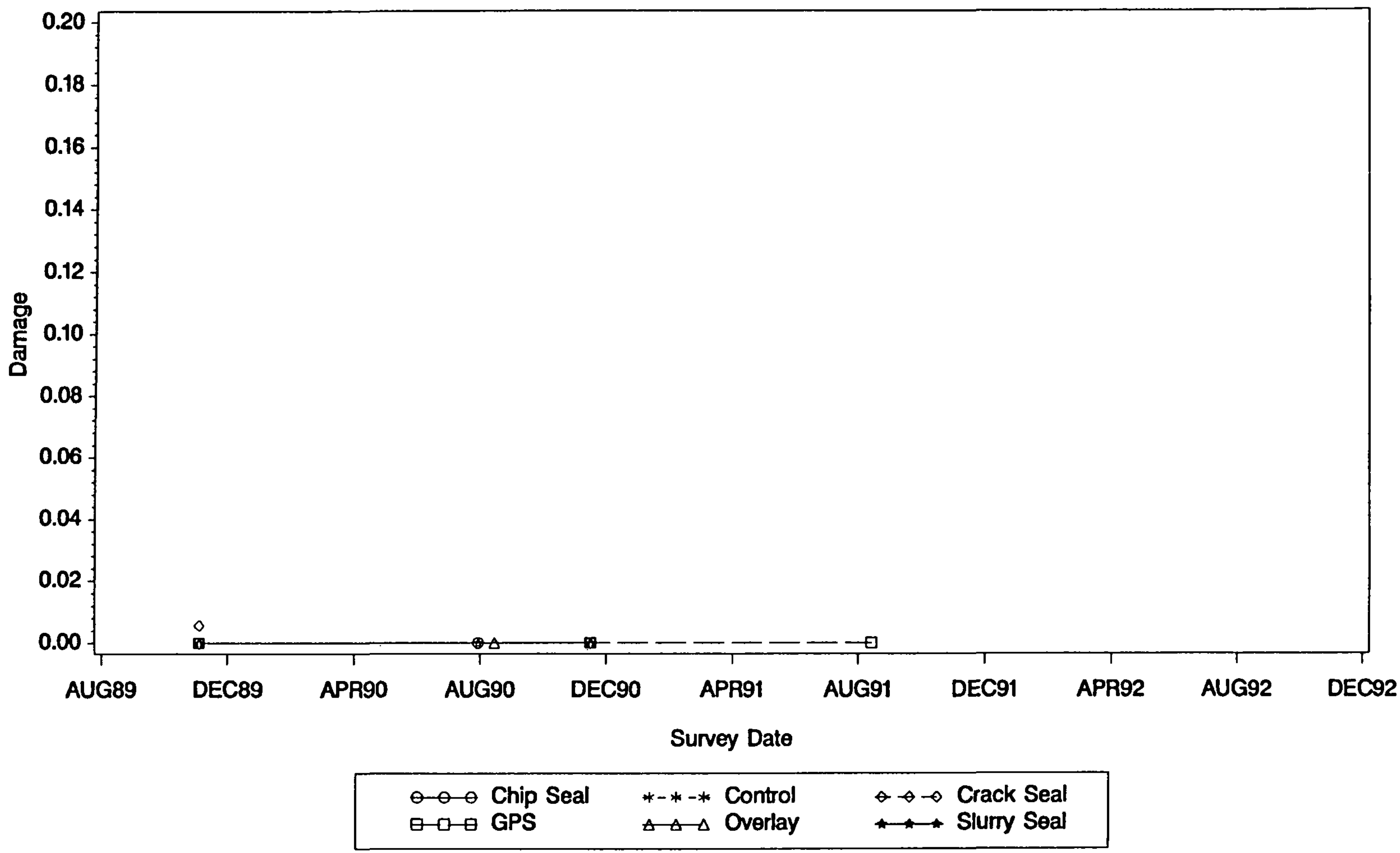
Figure G-48. Display of longitudinal and transverse cracking on sections selected for analysis at site 40B



No control section

Treatment dates: Slurry Seal-07SEP1990 Crack Seal-07SEP1990 Chip Seal-07SEP1990 Overlay-14NOV1990 Construction date: 01JUN1975

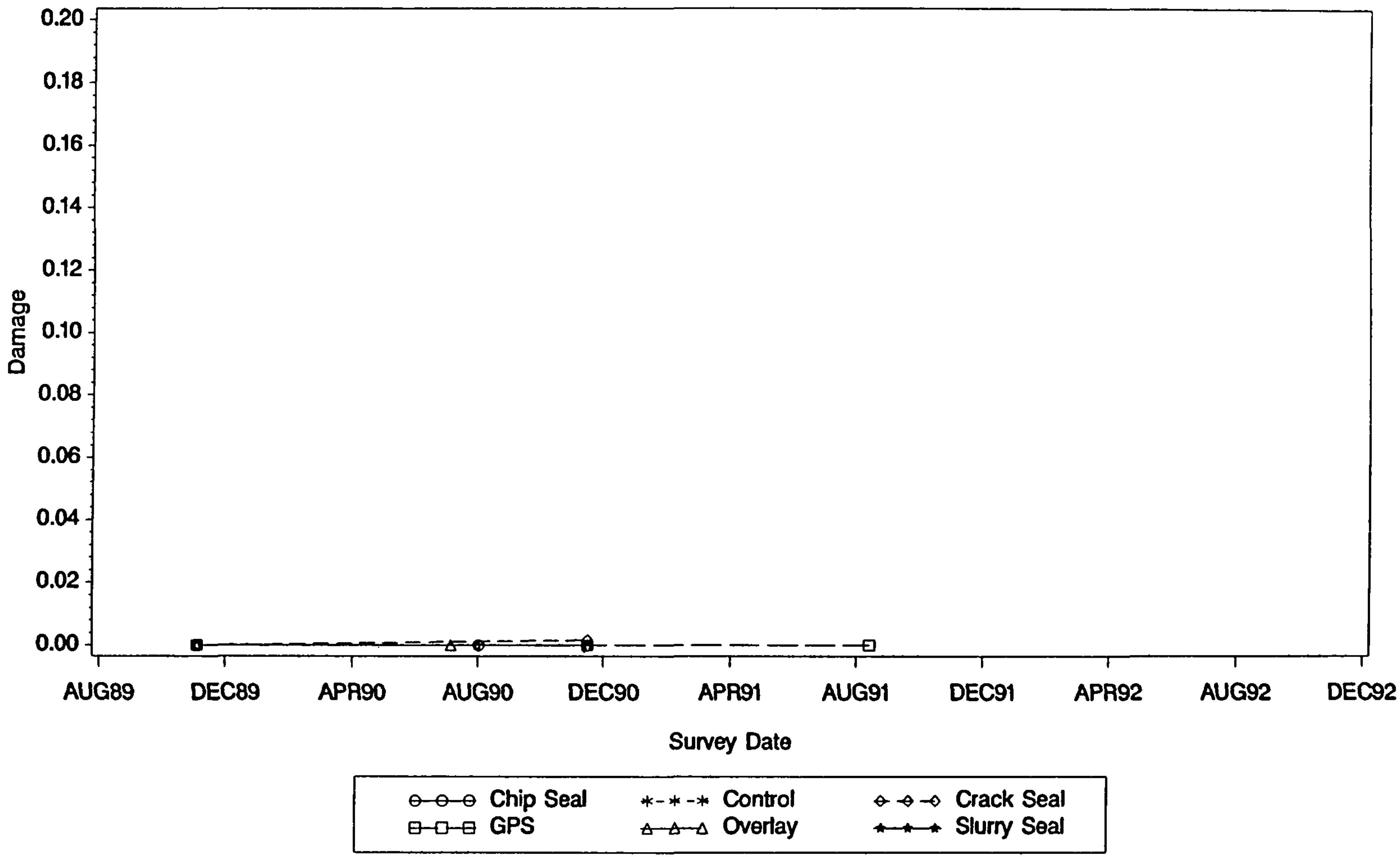
Figure G-49. Display of longitudinal and transverse cracking on sections selected for analysis at site 40C



No control section

Treatment dates: Slurry Seal-30JUL1990 Crack Seal-30JUL1990 Chip Seal-30JUL1990 Overlay-15AUG1990 Construction date: 01JAN1980

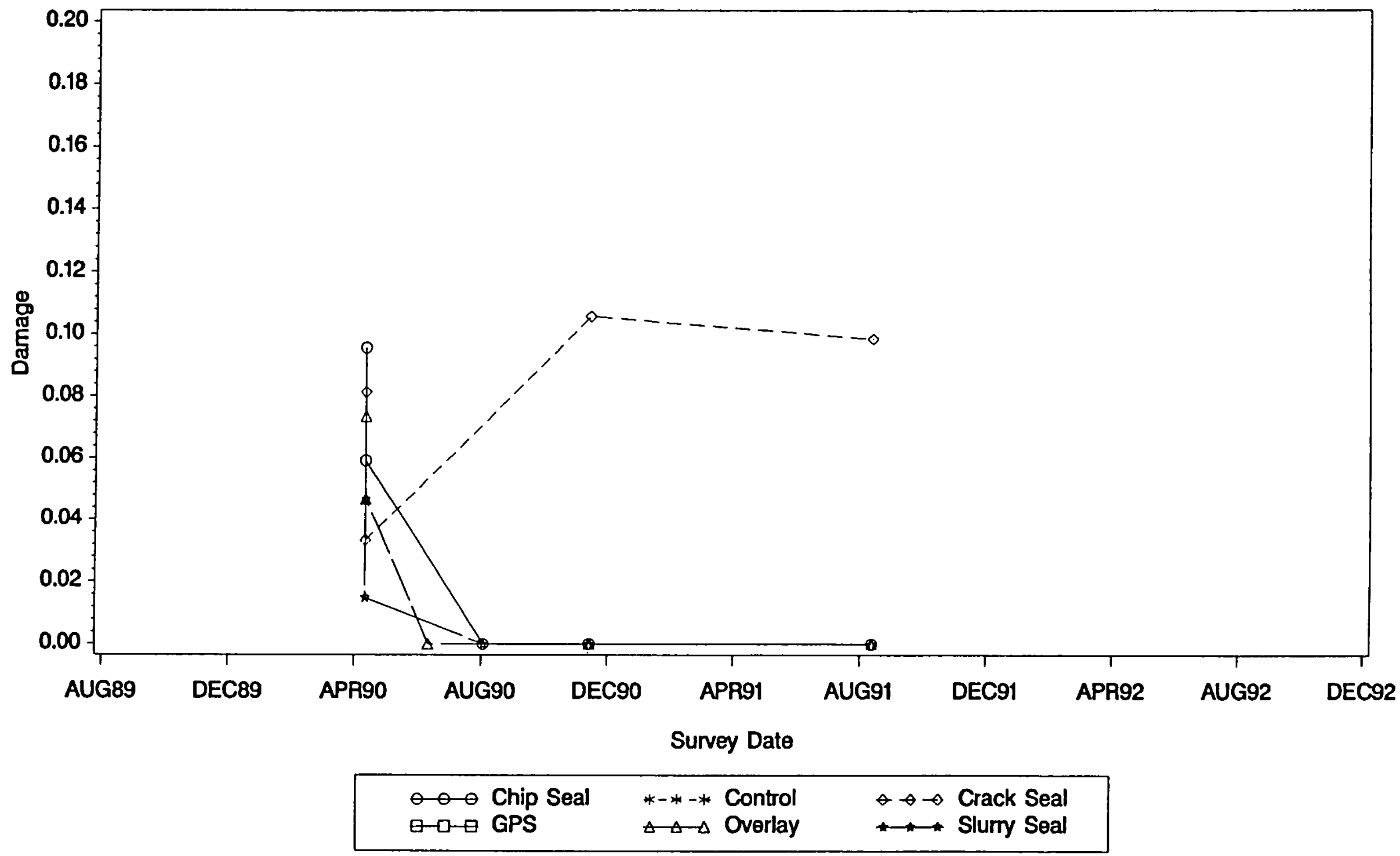
Figure G-50. Display of longitudinal and transverse cracking on sections selected for analysis at site 47A



No control section

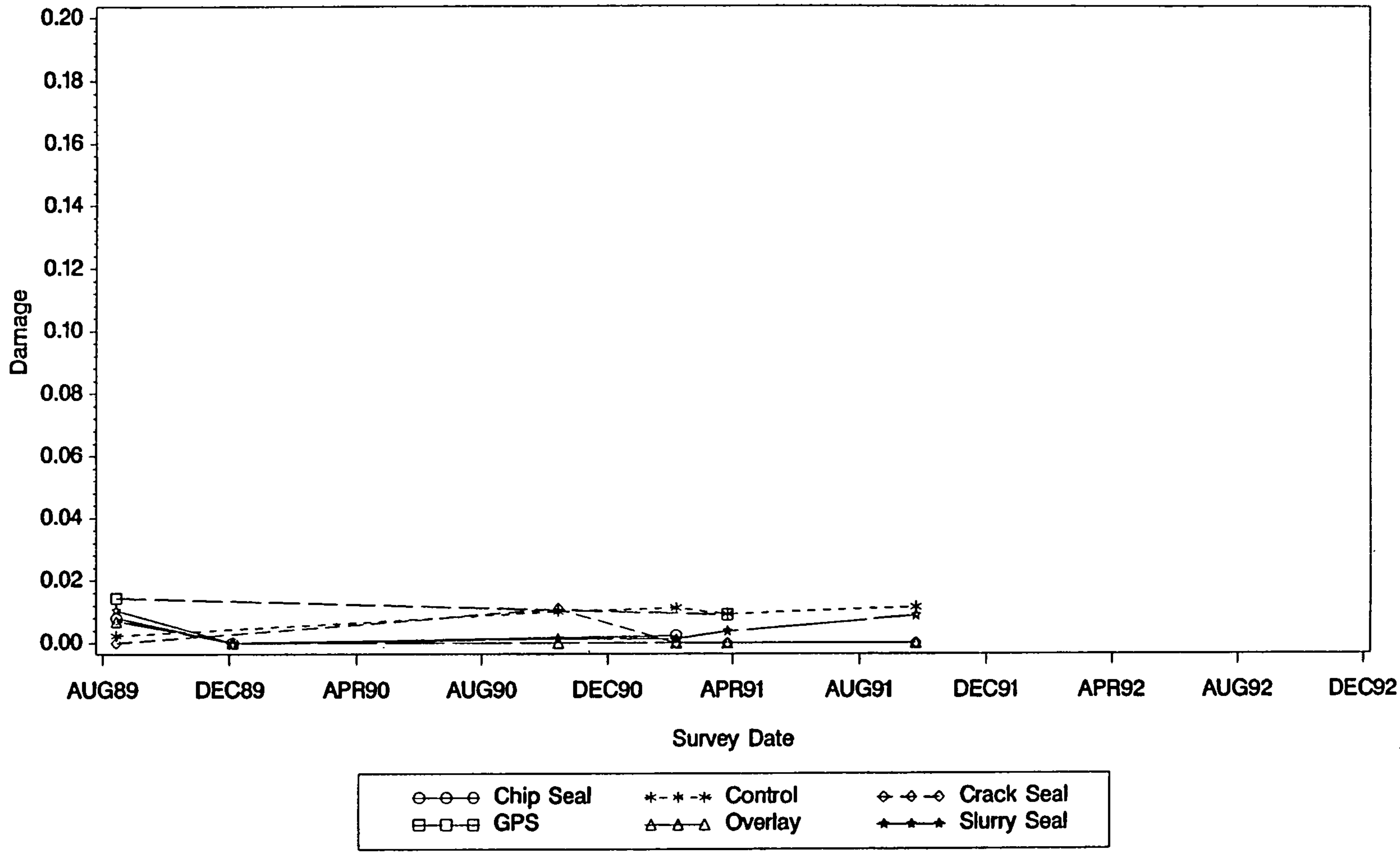
Treatment dates: Overlay-06JUL1990 Slurry Seal-01AUG1990 Crack Seal-01AUG1990 Chip Seal-02AUG1990 Construction date: 01JUN1971

Figure G-51. Display of longitudinal and transverse cracking on sections selected for analysis at site 47B



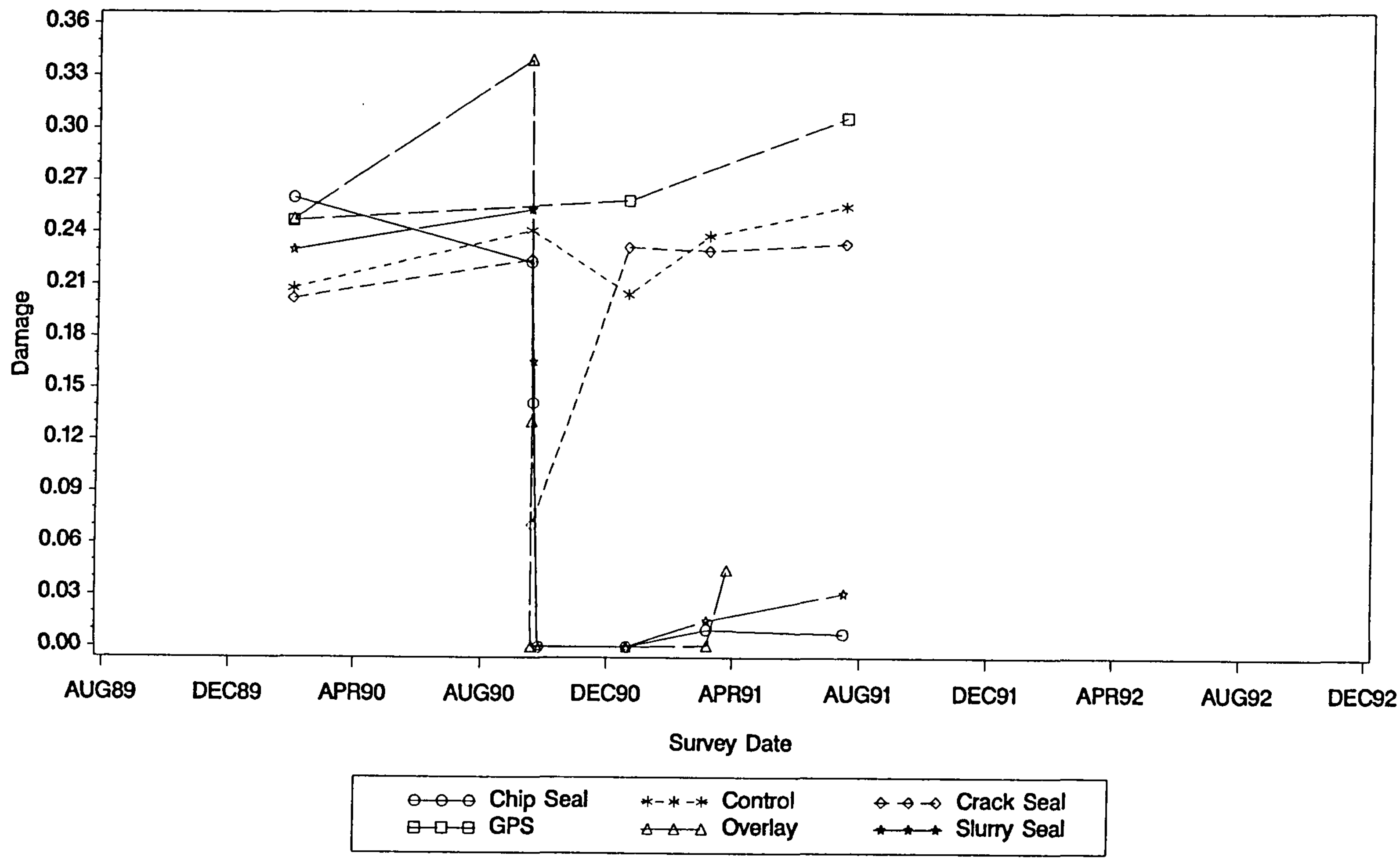
Rejected section(s): GPS
Treatment dates: Overlay-11JUN1990 Slurry Seal-03AUG1990 Crack Seal-03AUG1990 Chip Seal-03AUG1990 Construction date: 01JUN1972

Figure G-52. Display of longitudinal and transverse cracking on sections selected for analysis at site 47C



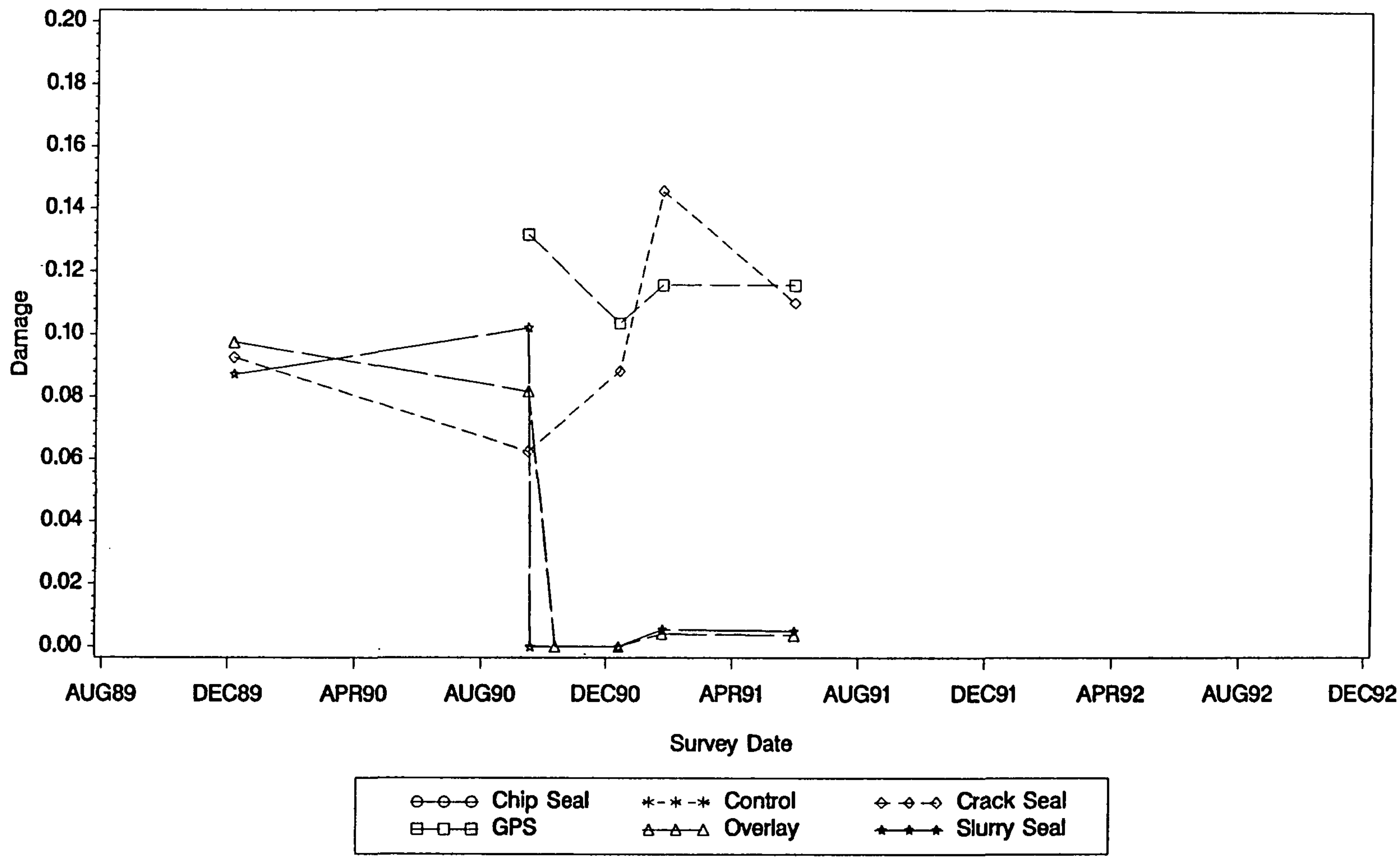
Treatment dates: Overlay-04DEC1989 Slurry Seal-04DEC1989 Crack Seal-04DEC1989 Chip Seal-04DEC1989 Construction date: 01AUG1976

Figure G-53. Display of longitudinal and transverse cracking on sections selected for analysis at site 48A



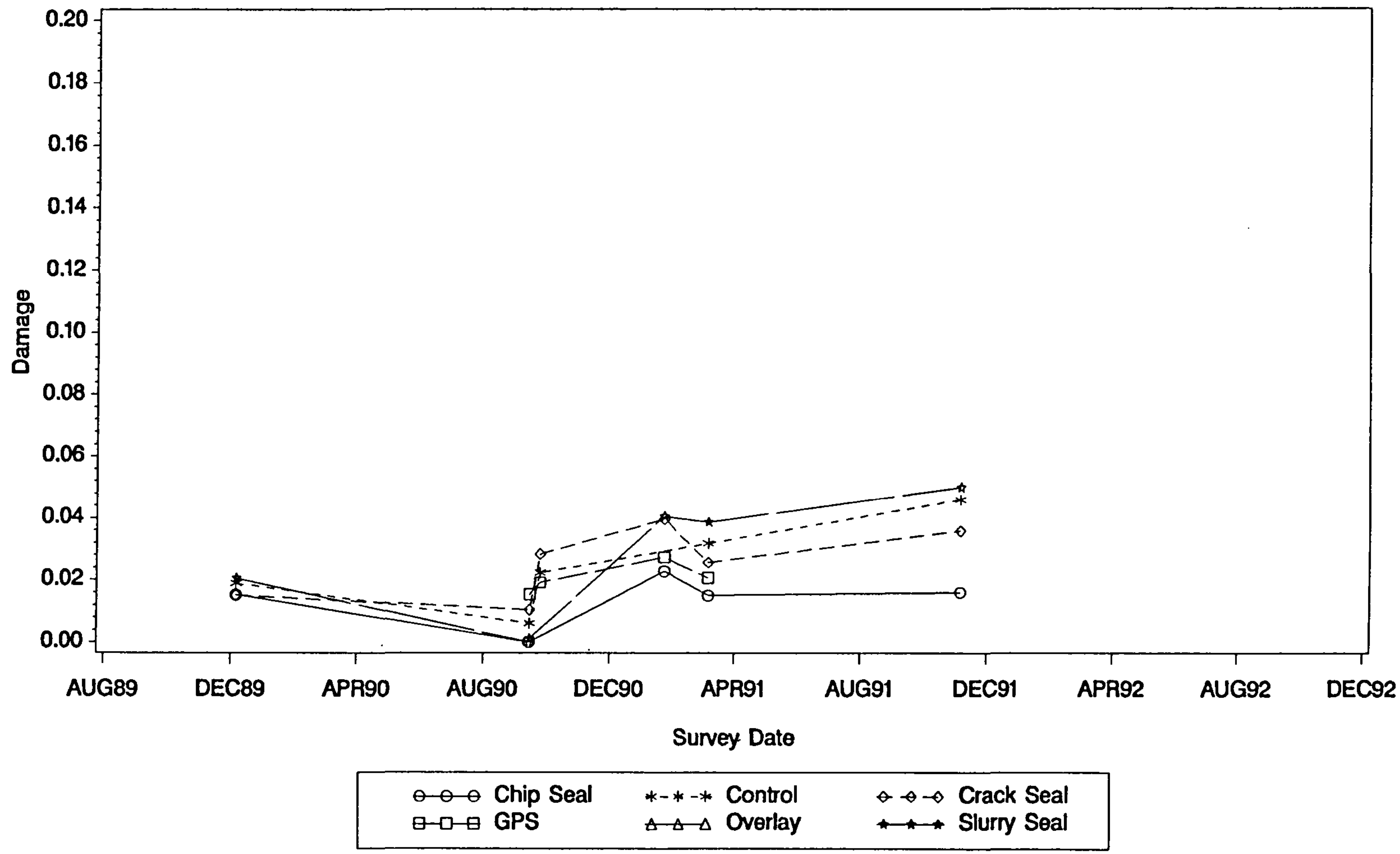
Tractment dates: Overlay-19SEP1990 Slurry Seal-26SEP1990 Crack Seal-26SEP1990 Chip Seal-26SEP1990 Construction date: 01JUN1977

Figure G-54. Display of longitudinal and transverse cracking on sections selected for analysis at site 48B



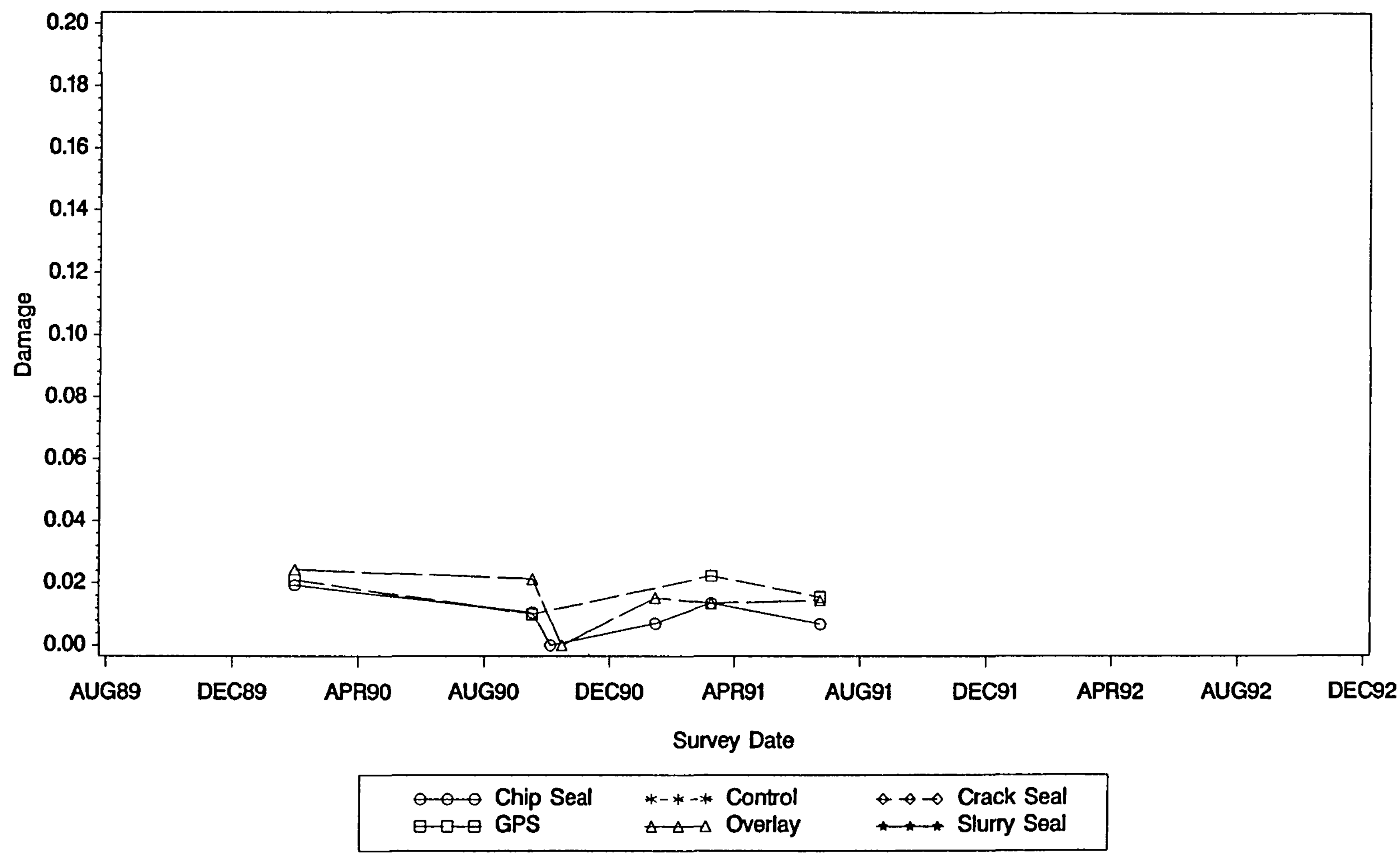
Rejected section(s): Chip Seal
No control section
Treatment dates: Slurry Seal-18SEP1990 Crack Seal-18SEP1990 Chip Seal-18SEP1990 Overlay-12OCT1990 Construction date: 01AUG1982

Figure G-55. Display of longitudinal and transverse cracking on sections selected for analysis at site 48D



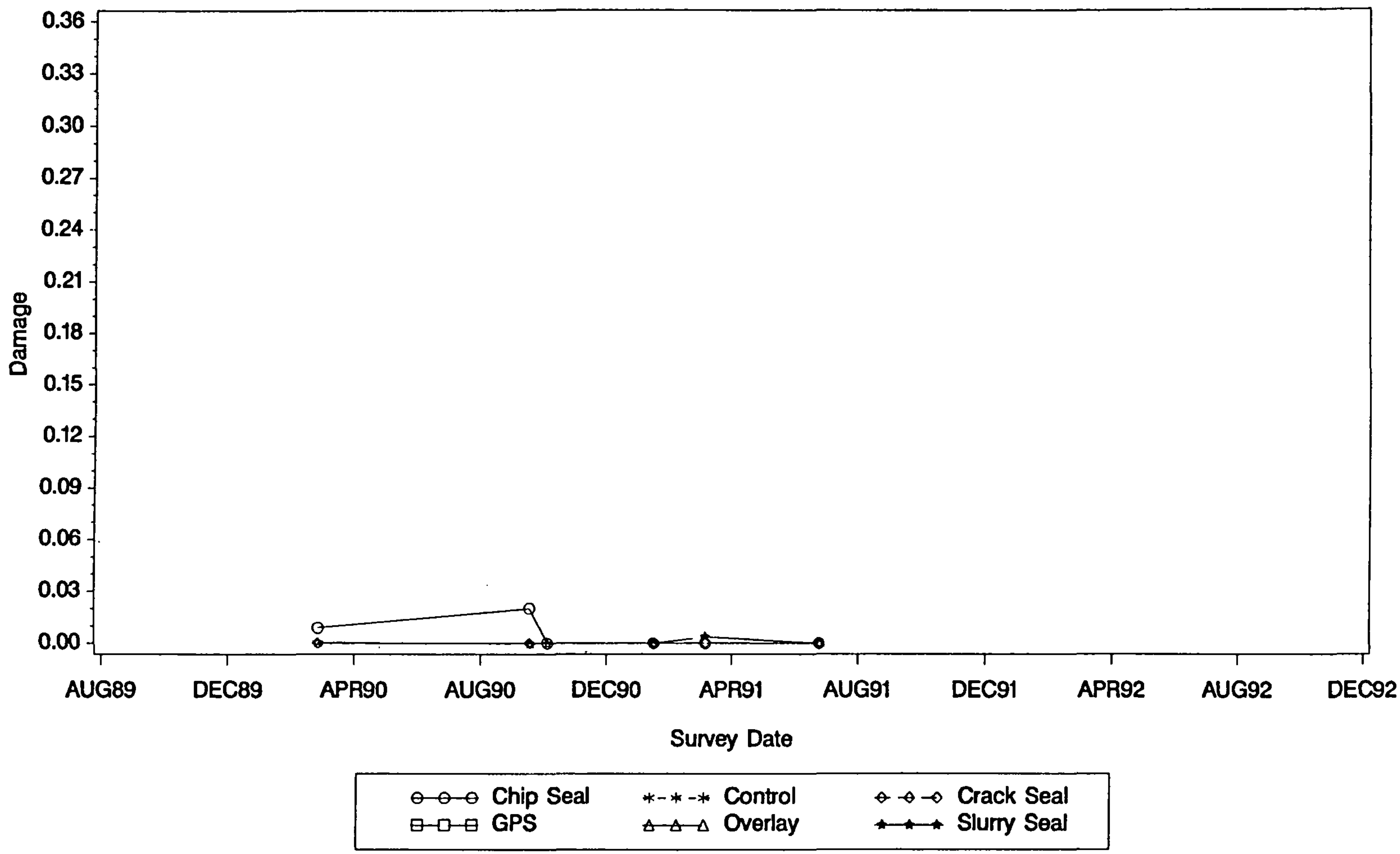
Rejected section(s): Overlay
Treatment dates: Slurry Seal-14SEP1990 Crack Seal-14SEP1990 Chip Seal-14SEP1990 Overlay-25SEP1990 Construction date: 01FEB1975

Figure G-56. Display of longitudinal and transverse cracking on sections selected for analysis at site 48E



Rejected section(s): Slurry Seal Crack Seal Control
Treatment dates: Slurry Seal-04OCT1990 Crack Seal-04OCT1990 Chip Seal-04OCT1990 Overlay-15OCT1990 Construction date: 01NOV1987

Figure G-57. Display of longitudinal and transverse cracking on sections selected for analysis at site 48F

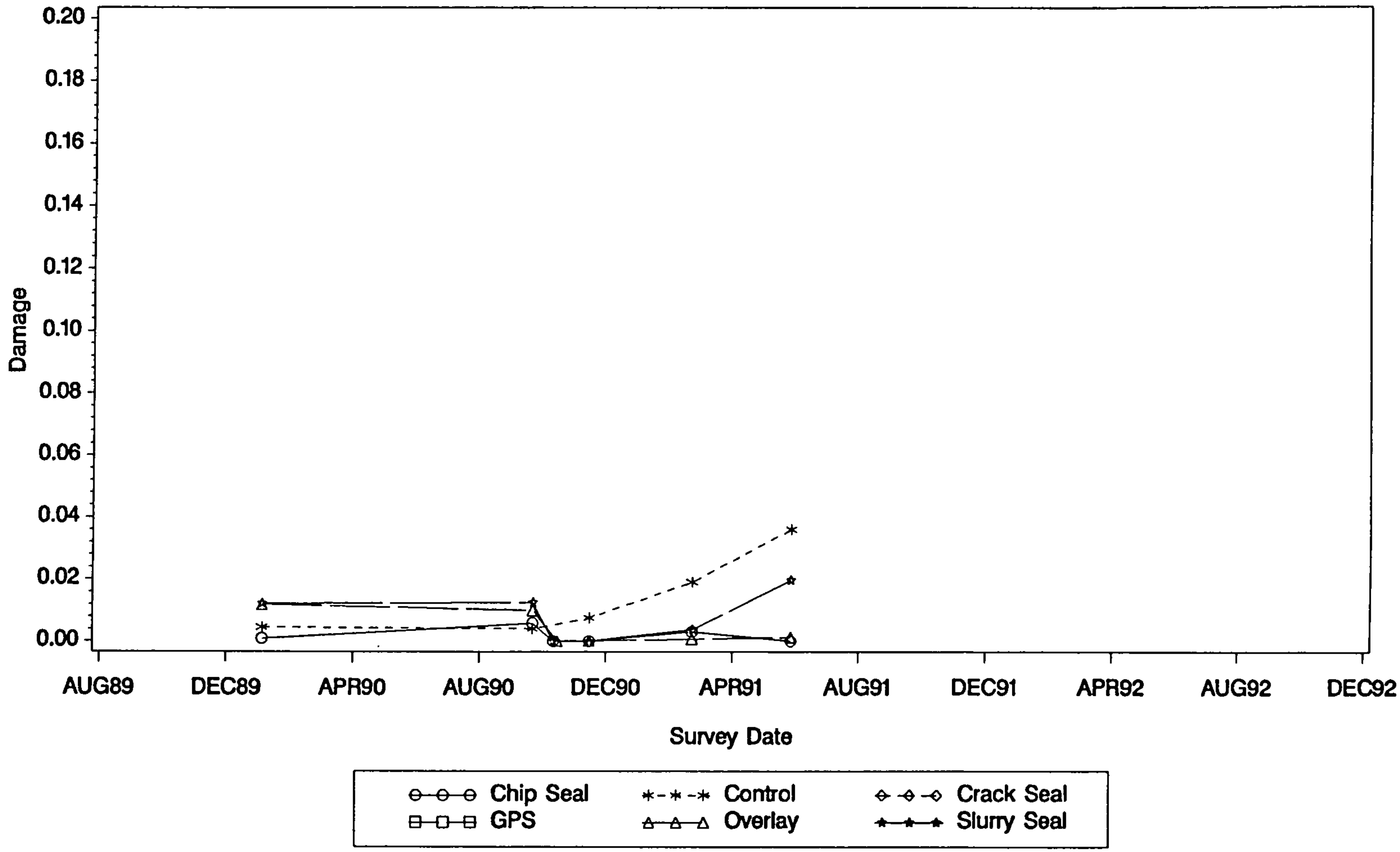


Rejected section(s): GPS Overlay

No control section

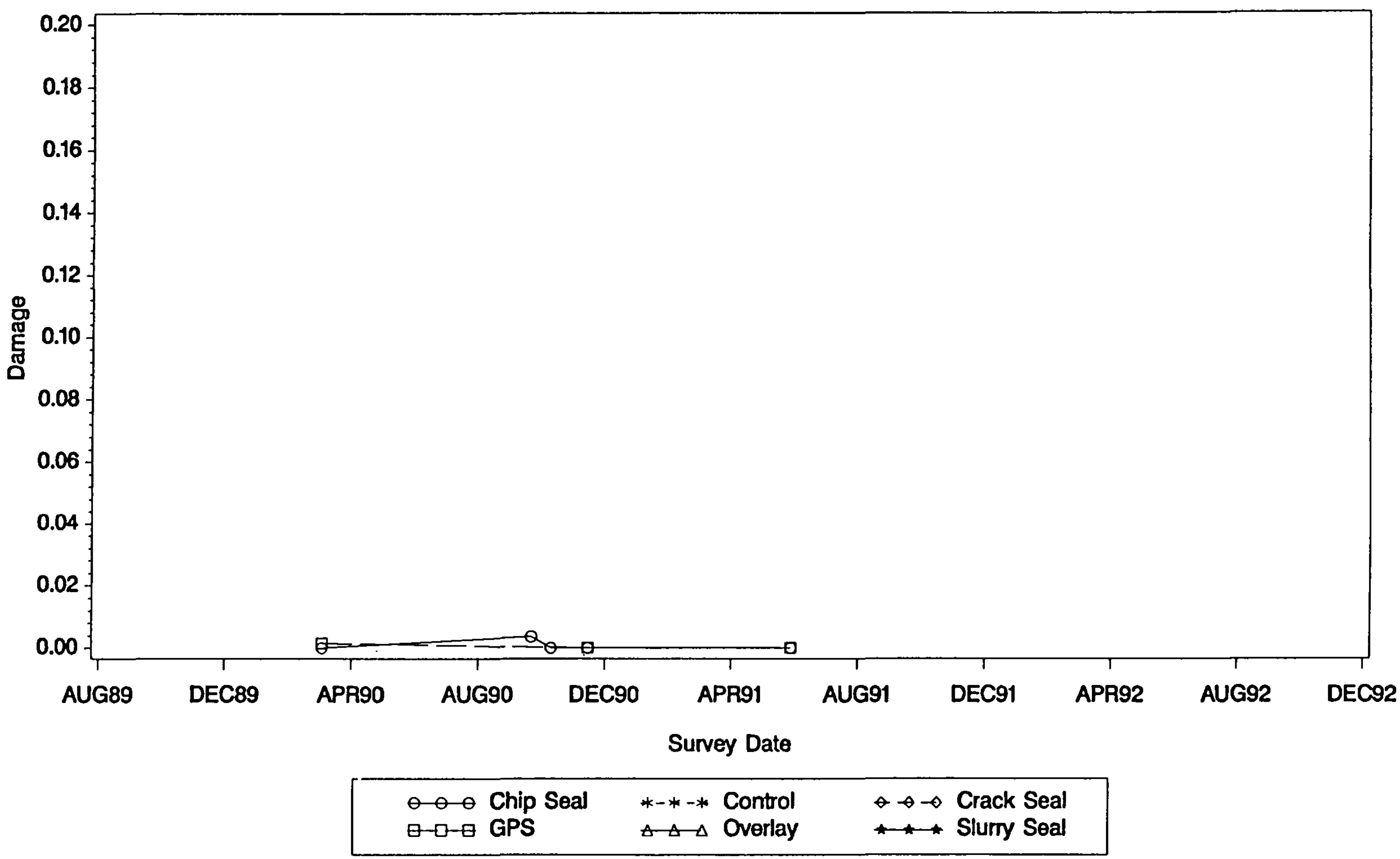
Treatment dates: Slurry Seal-05OCT1990 Crack Seal-05OCT1990 Ship Seal-05OCT1990 Overlay-15OCT1990 Construction date: 01AUG1972

Figure G-58. Display of longitudinal and transverse cracking on sections selected for analysis at site 48G



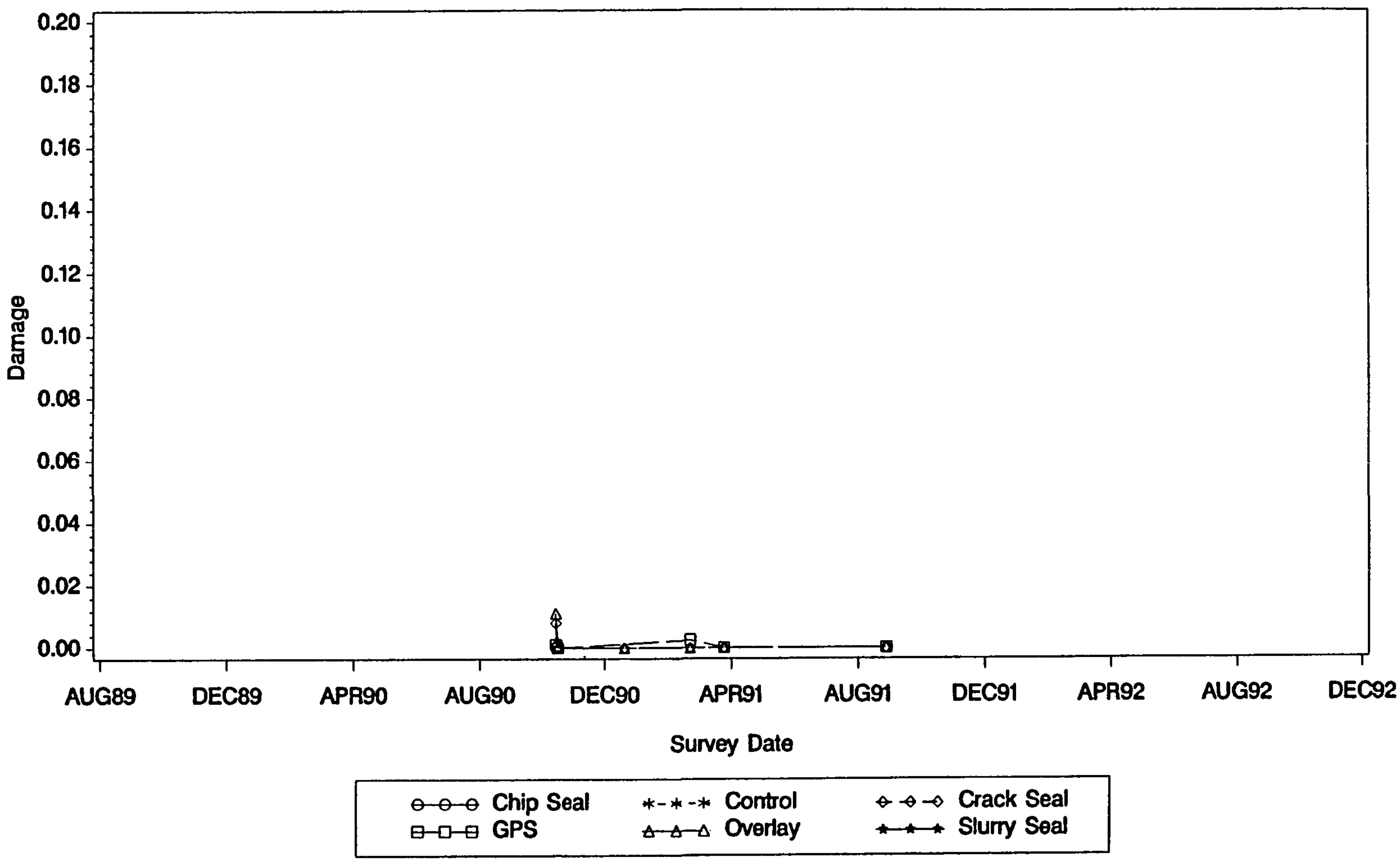
Rejected section(s): GPS Crack Seal
Treatment dates: Slurry Seal-11OCT1990 Crack Seal-11OCT1990 Chip Seal-11OCT1990 Overlay-15OCT1990 Construction date: 01JUL1985

Figure G-59. Display of longitudinal and transverse cracking on sections selected for analysis at site 48H



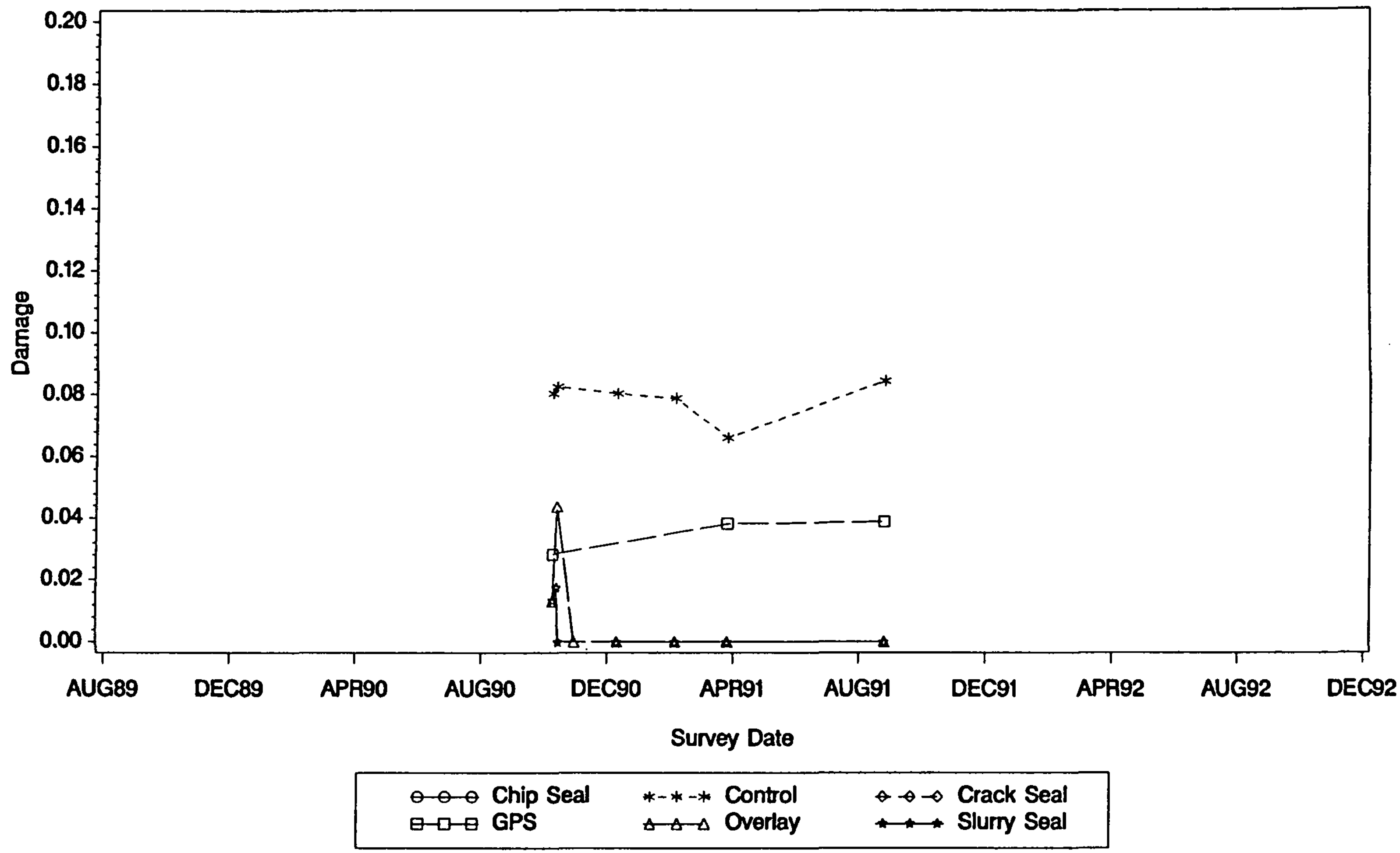
Rejected section(s): Overlay Slurry Seal Crack Seal Control
Treatment dates: Slurry Seal-10OCT1990 Crack Seal-10OCT1990 Chip Seal-10OCT1990 Overlay-15NOV1990 Construction date: 01JUN1970

Figure G-60. Display of longitudinal and transverse cracking on sections selected for analysis at site 48I



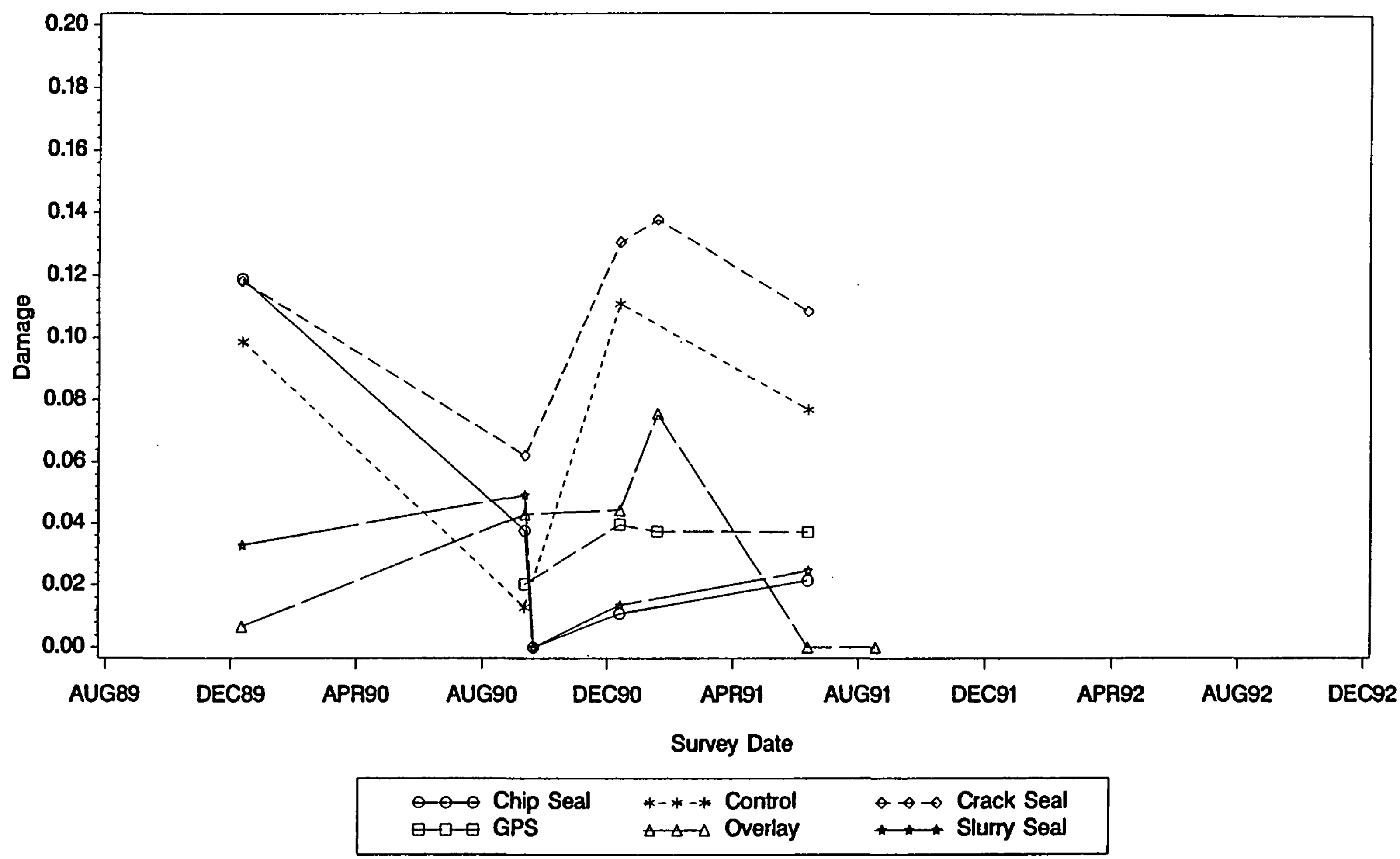
Rejected section(s): Slurry Seal Control Chip Seal
Treatment dates: Overlay-16OCT1990 Slurry Seal-16OCT1990 Crack Seal-16OCT1990 Chip Seal-16OCT1990 Construction date: 01FEB1974

Figure G-61. Display of longitudinal and transverse cracking on sections selected for analysis at site 48J



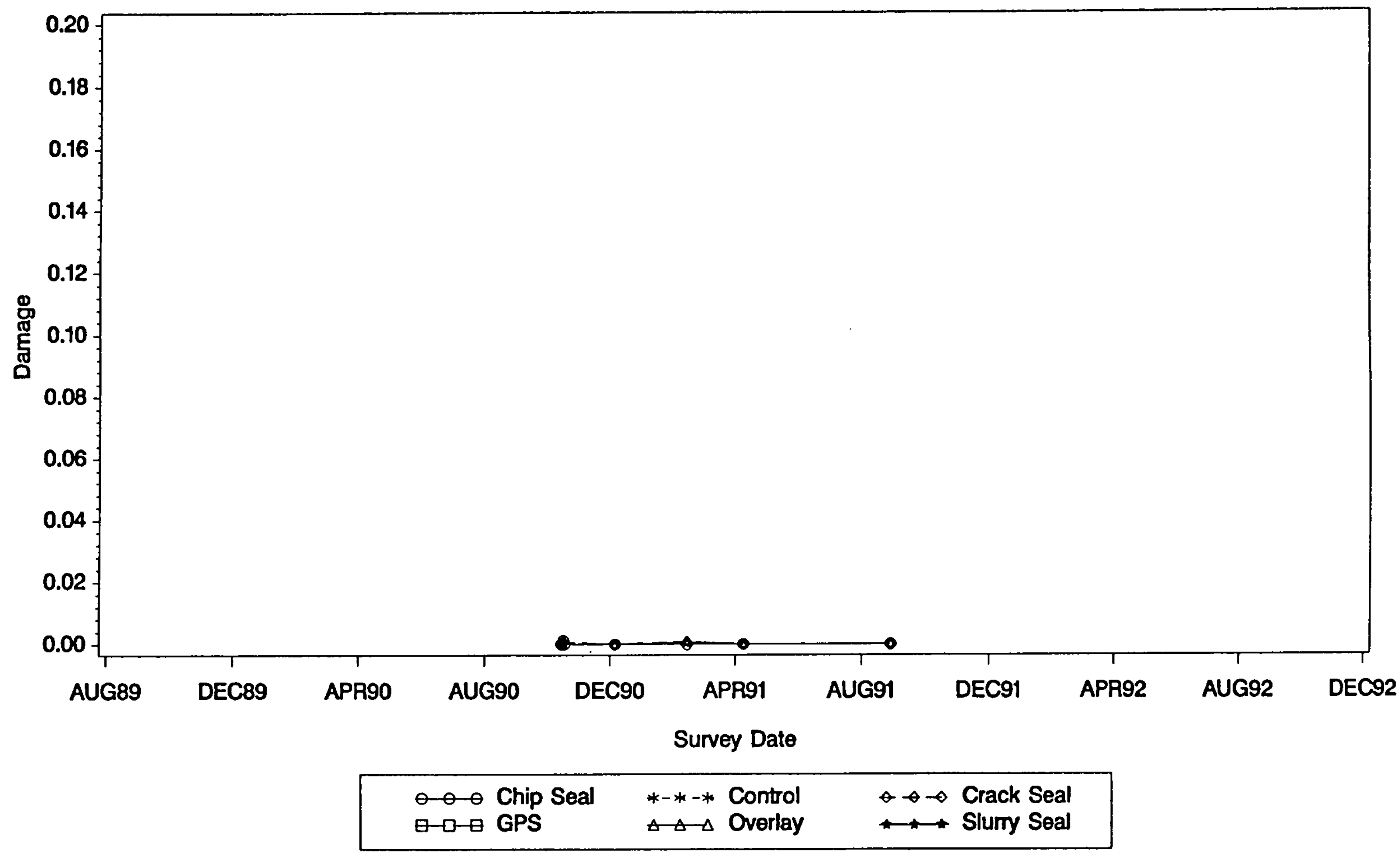
Rejected section(s): Crack Seal Chip Seal
Treatment dates: Slurry Seal-15OCT1990 Crack Seal-15OCT1990 Overlay-31OCT1990 Construction date: 01SEP1986

Figure G-62. Display of longitudinal and transverse cracking on sections selected for analysis at site 48K



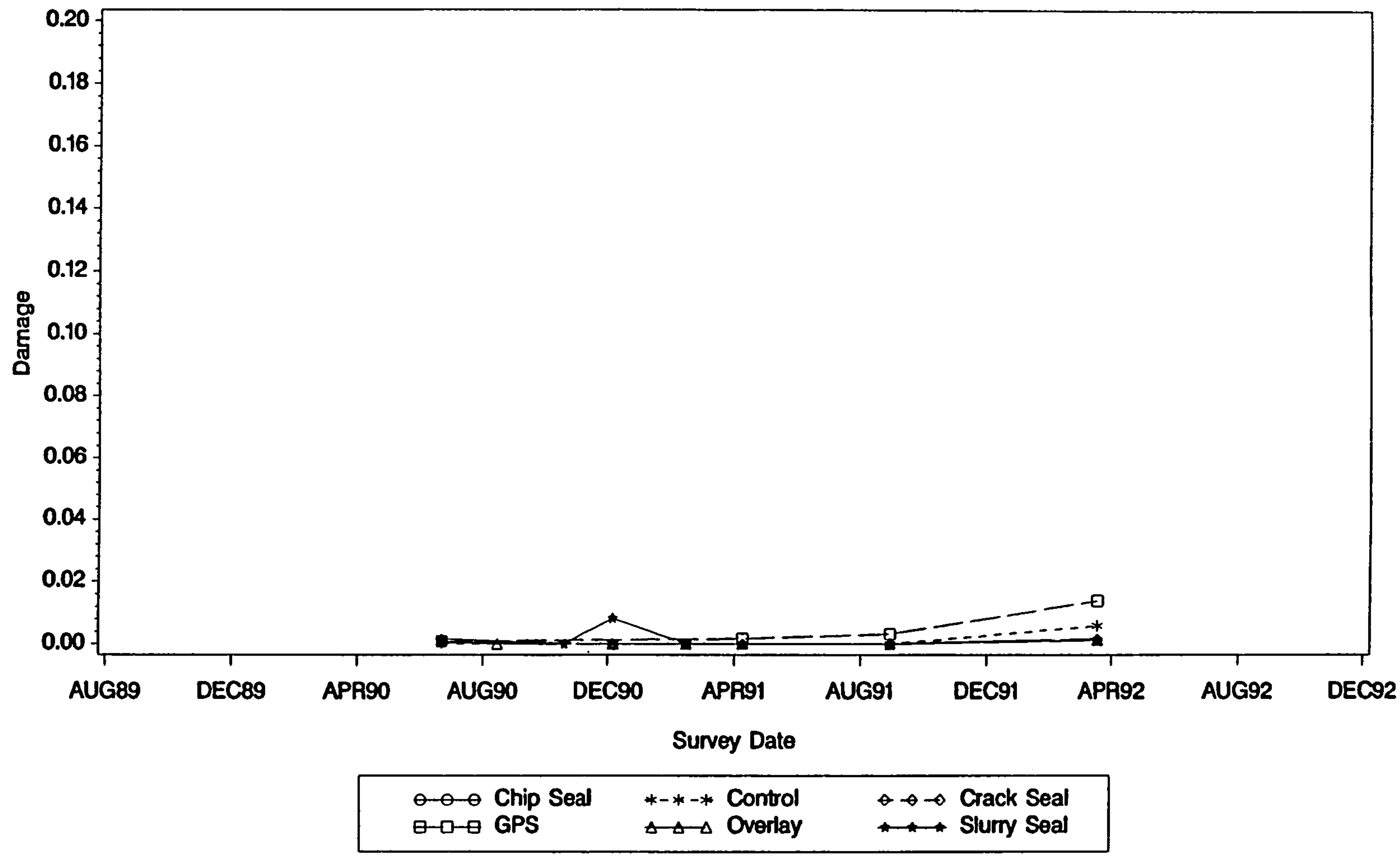
Treatment dates: Slurry Seal-20SEP1990 Crack Seal-20SEP1990 Chip Seal-20SEP1990 Overlay-18AUG1991 Construction date: 01JUN1976

Figure G-63. Display of longitudinal and transverse cracking on sections selected for analysis at site 48L



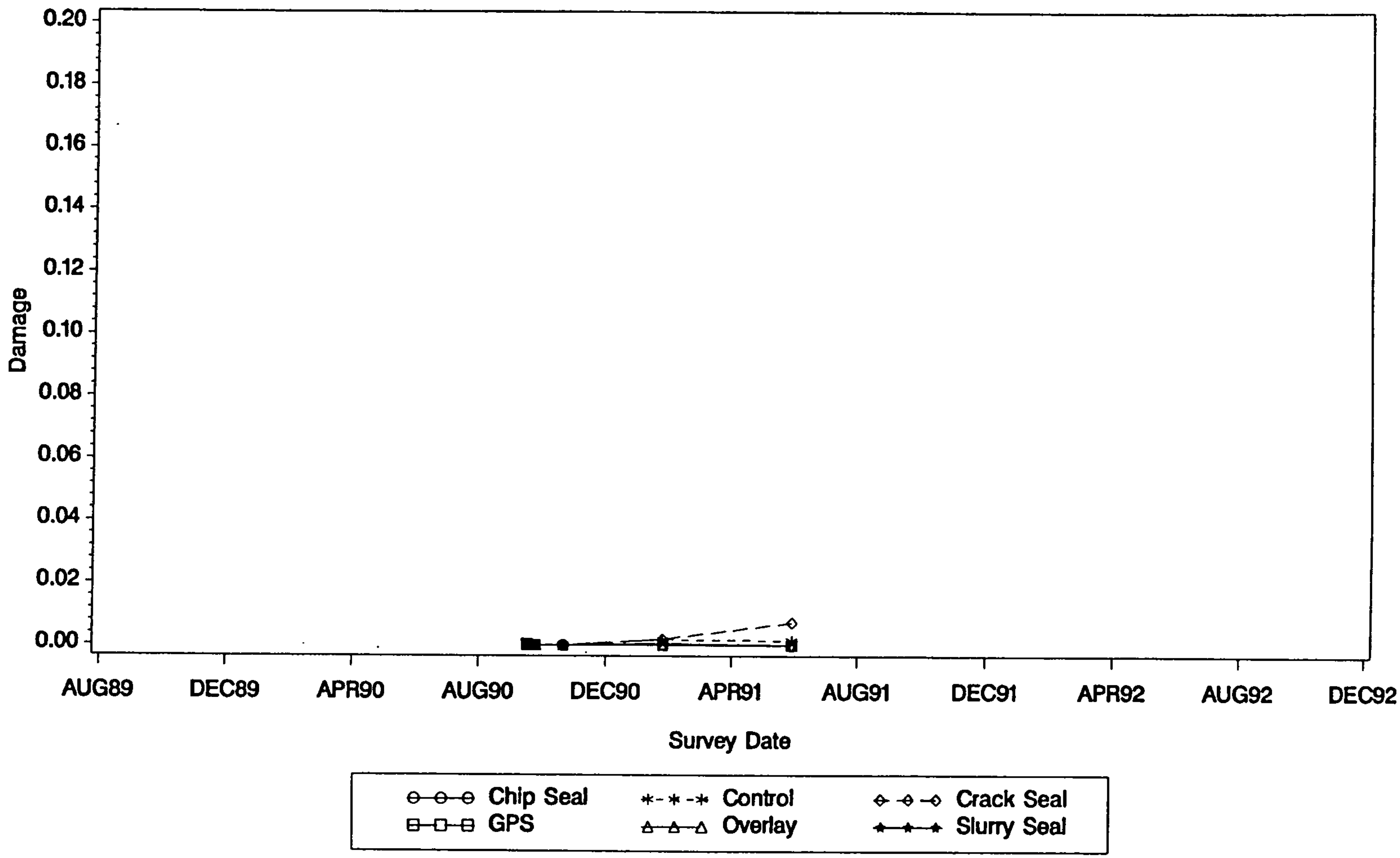
Rejected section(s): GPS Overlay Control
Treatment dates: Overlay-15AUG1990 Slurry Seal-18OCT1990 Crack Seal-18OCT1990 Chip Seal-18OCT1990 Construction date: 01MAR1981

Figure G-64. Display of longitudinal and transverse cracking on sections selected for analysis at site 48M



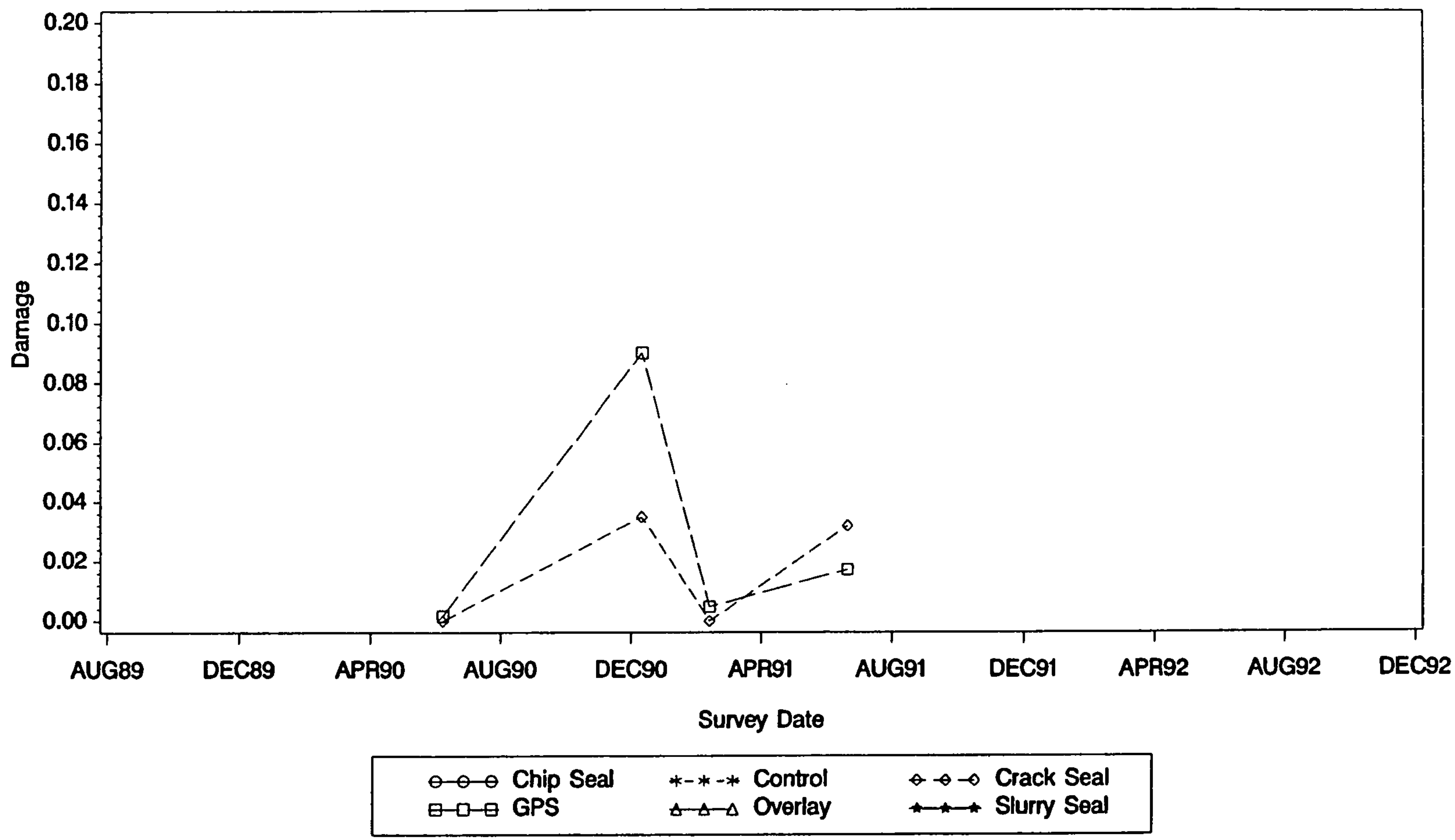
Rejected section(s): Chip Seal
Treatment dates: Overlay-15AUG1990 Slurry Seal-19OCT1990 Crack Seal-19OCT1990 Chip Seal-19OCT1990 Construction date: 01MAY1982

Figure G-65. Display of longitudinal and transverse cracking on sections selected for analysis at site 48N



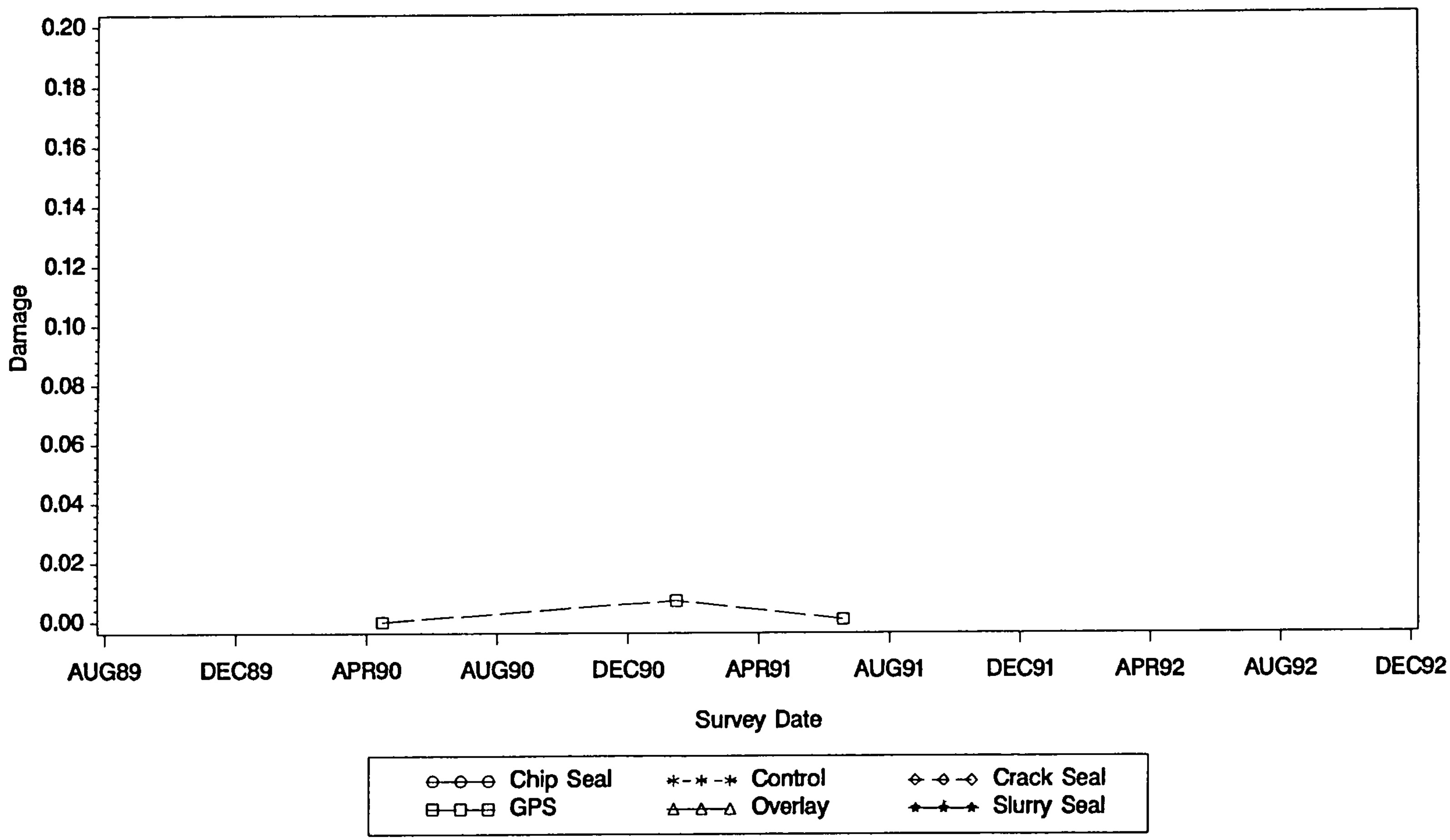
Treatment dates: Slurry Seal-24SEP1990 Crack Seal-24SEP1990 Chip Seal-24SEP1990 Overlay-25SEP1990 Construction date: 01JUL1969

Figure G-66. Display of longitudinal and transverse cracking on sections selected for analysis at site 48Q



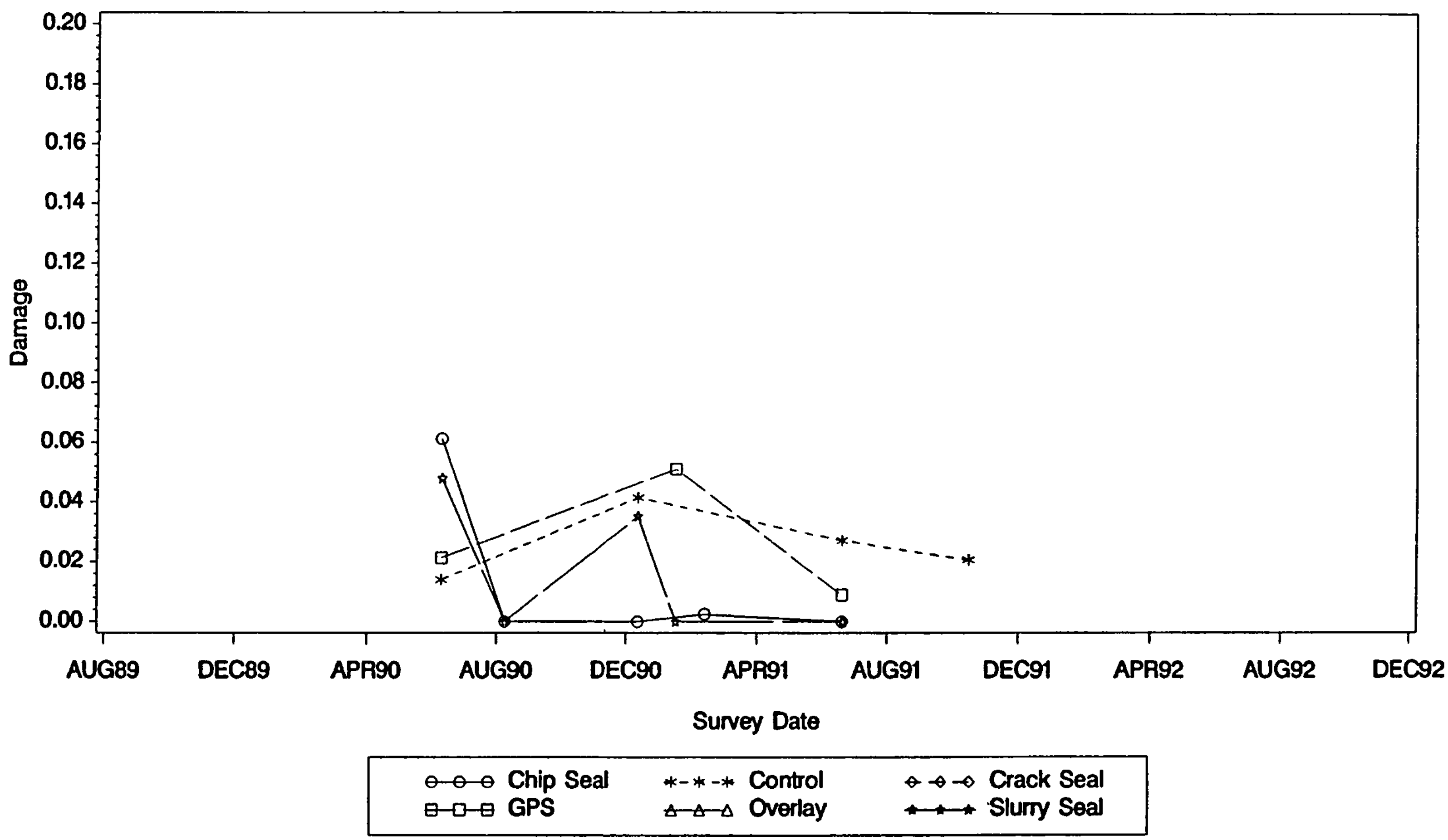
Rejected section(s): GPS Crack Seal
Treatment dates: Overlay-15JUL1990 Slurry Seal-07AUG1990 Crack Seal-07AUG1990 Chip Seal-07AUG1990 Construction date: 01JUN1972

Figure G-67. Display of longitudinal and transverse cracking on sections rejected for analysis at site 01A



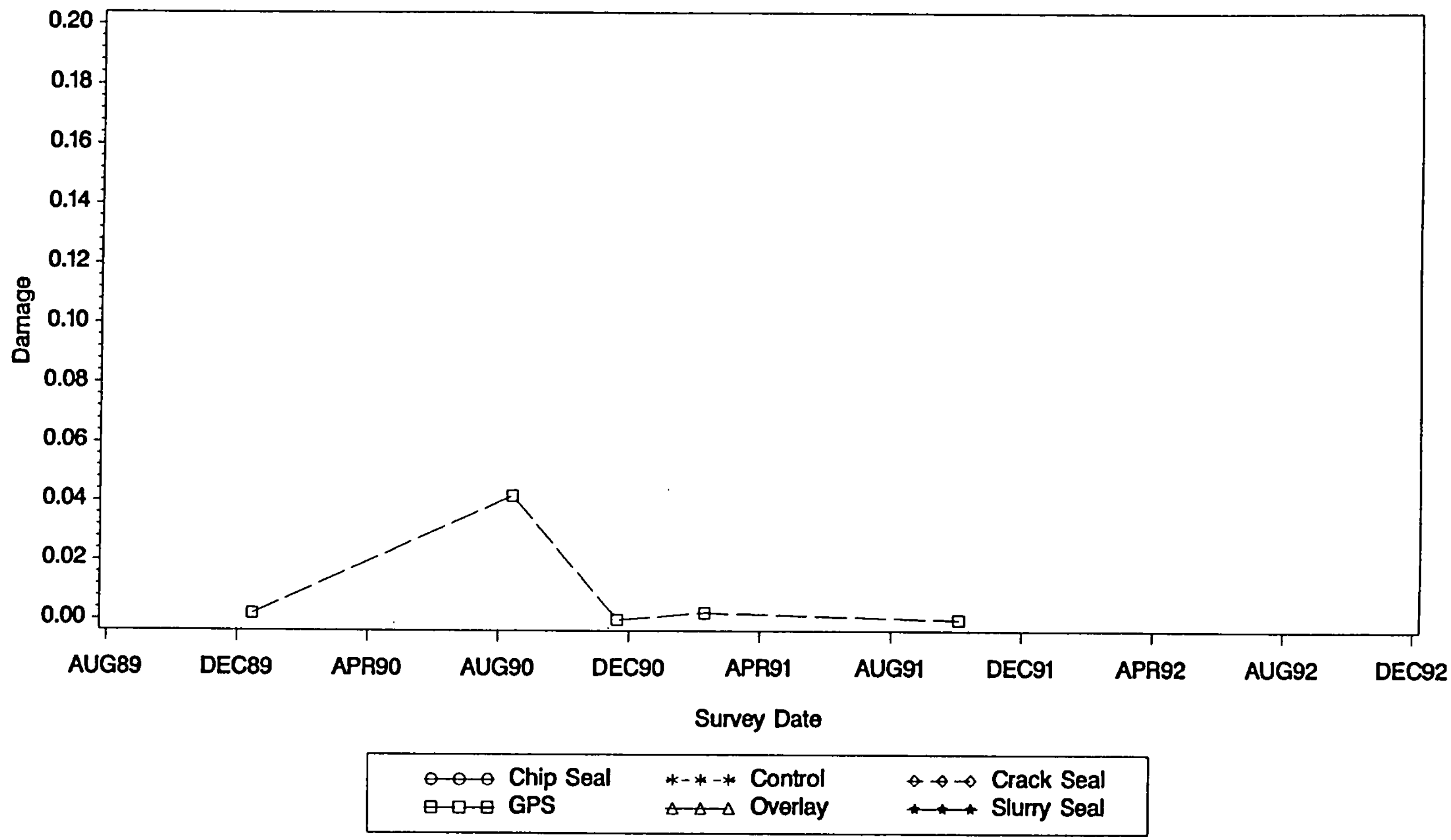
Rejected section(s): GPS
Treatment dates: Slurry Seal-21AUG1990 Crack Seal-21AUG1990 Chip Seal-21AUG1990 Overlay-15NOV1990 Construction date: 01OCT1986

Figure G-68. Display of longitudinal and transverse cracking on sections rejected for analysis at site 01B



Rejected section(s): GPS SLurry Seal Control Chip Seal
Treatment dates: Overlay-15JUL1990 Slurry Seal-09AUG1990 Crack Seal-09AUG1990 Chip Seal-09AUG1990 Construction date: 01JUN1976

Figure G-69. Display of longitudinal and transverse cracking on sections rejected for analysis at site 01C

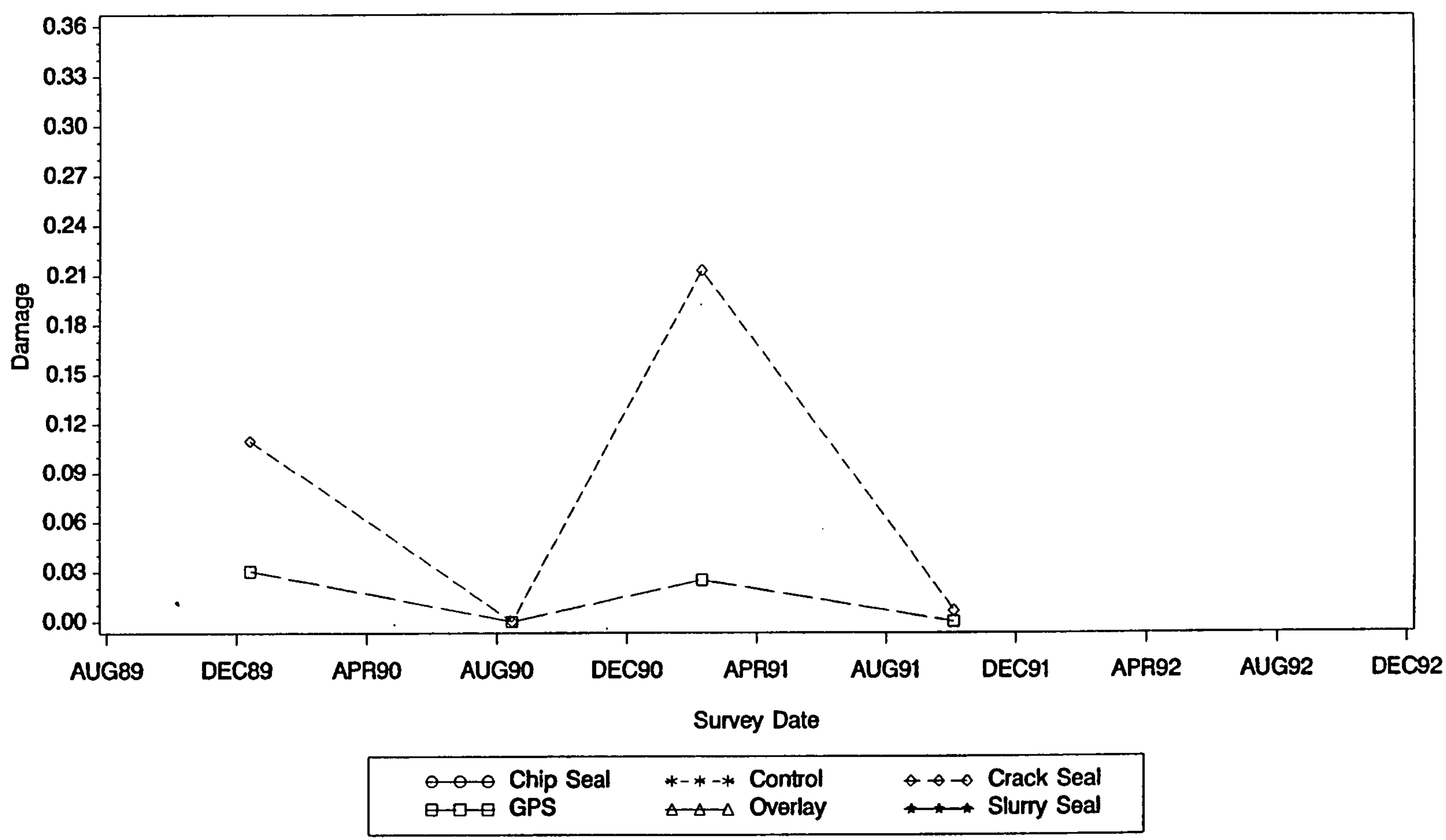


Rejected section(s): GPS

No control section

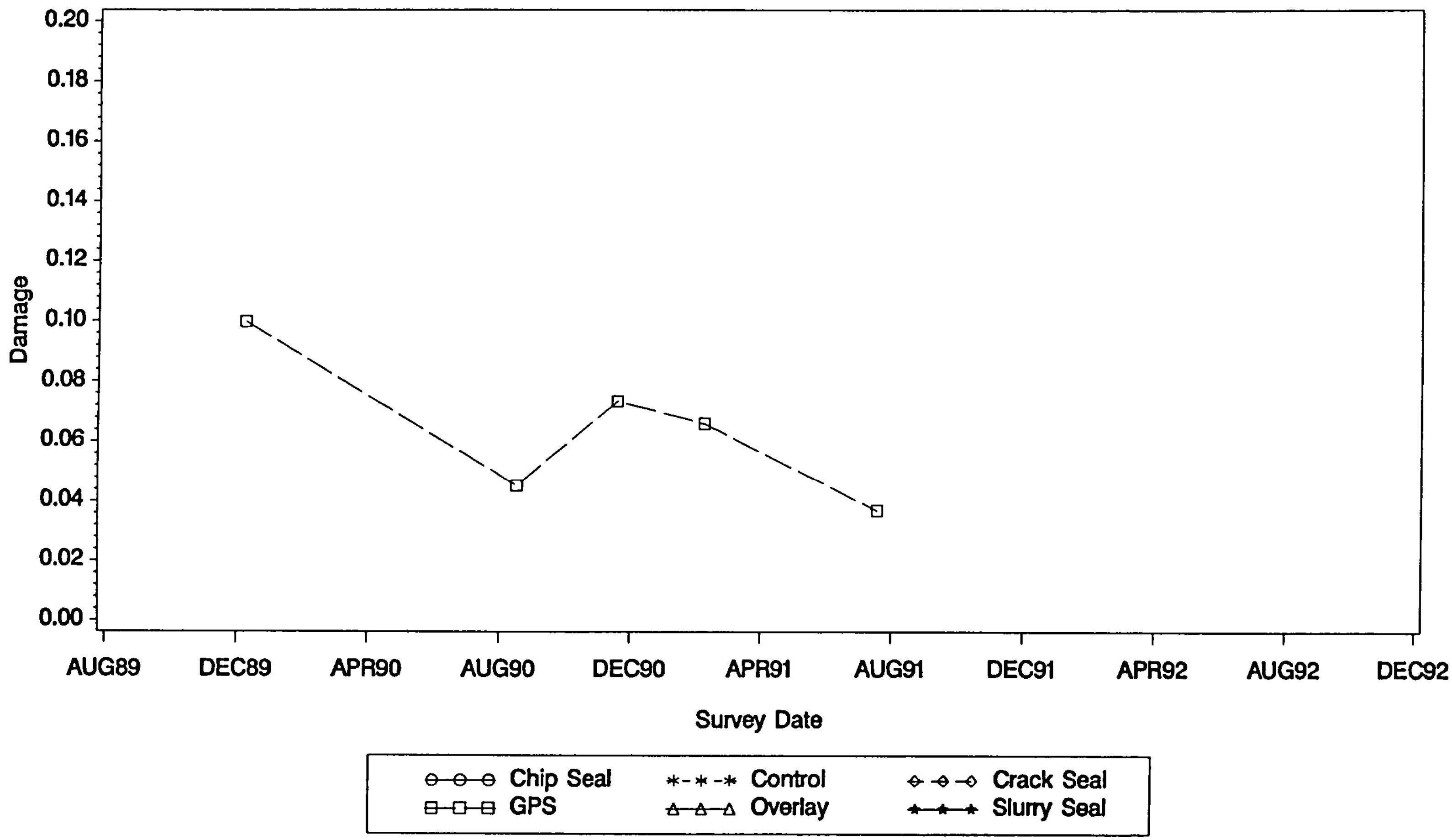
Treatment dates: Slurry Seal-13AUG1990 Crack Seal-13AUG1990 Chip Seal-13AUG1990 Overlay-20FEB1991 Construction date: 01OCT1974

Figure G-70. Display of longitudinal and transverse cracking on sections rejected for analysis at site 12A



Rejected section(s): GPS Crack Seal No control section
Treatment dates: Slurry Seal-16AUG1990 Crack Seal-16AUG1990 Chip Seal-16AUG1990 Overlay-20DEC1991 Construction date: 01JUN1974

Figure G-71. Display of longitudinal and transverse cracking on sections rejected for analysis at site 12B

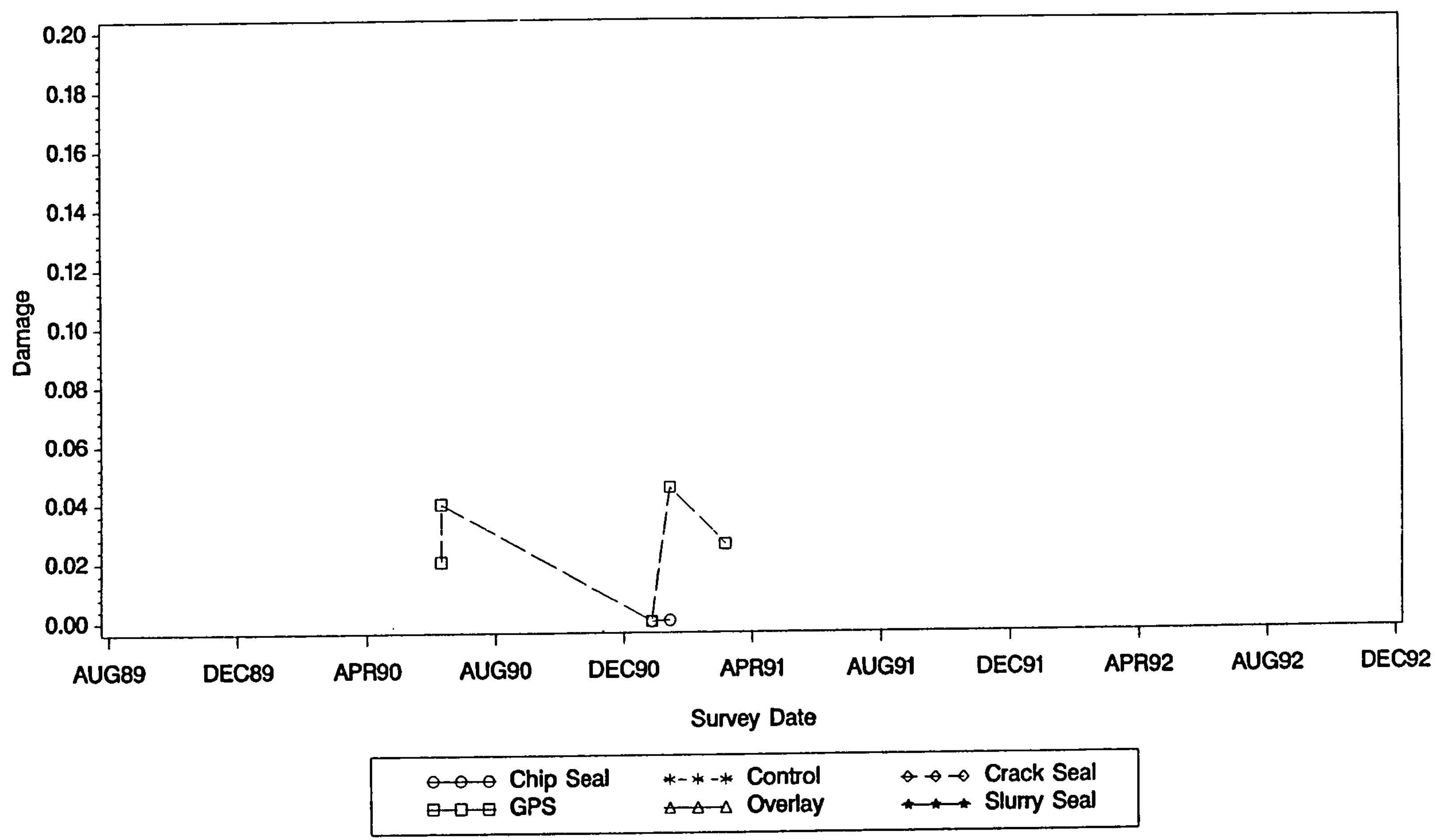


Rejected section(s): GPS

No control section

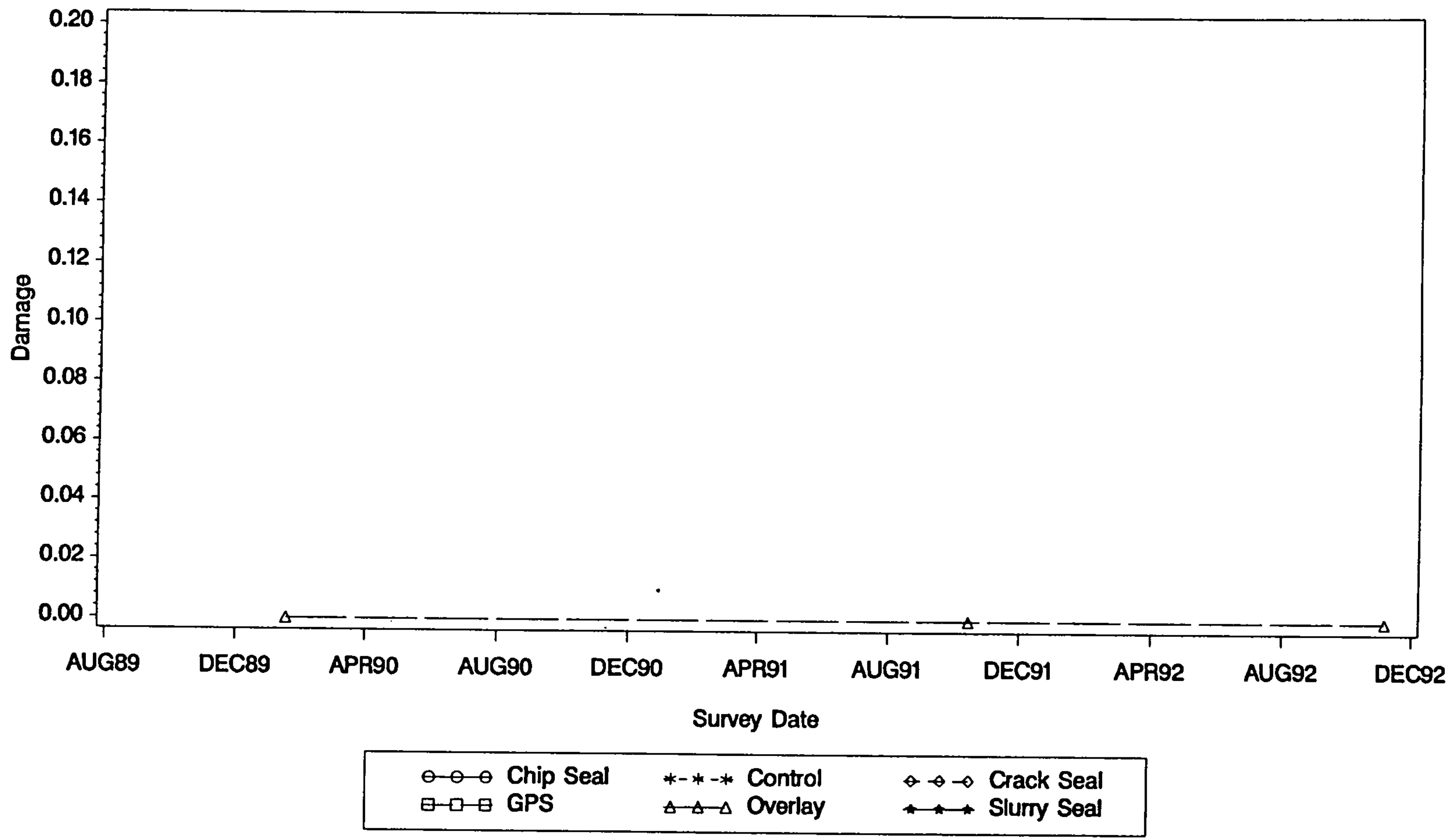
Treatment dates: Slurry Seal-17AUG1990 Crack Seal-17AUG1990 Chip Seal-17AUG1990 Overlay-19NOV1990 Construction date: 01JUN1970

Figure G-72. Display of longitudinal and transverse cracking on sections rejected for analysis at site 12C



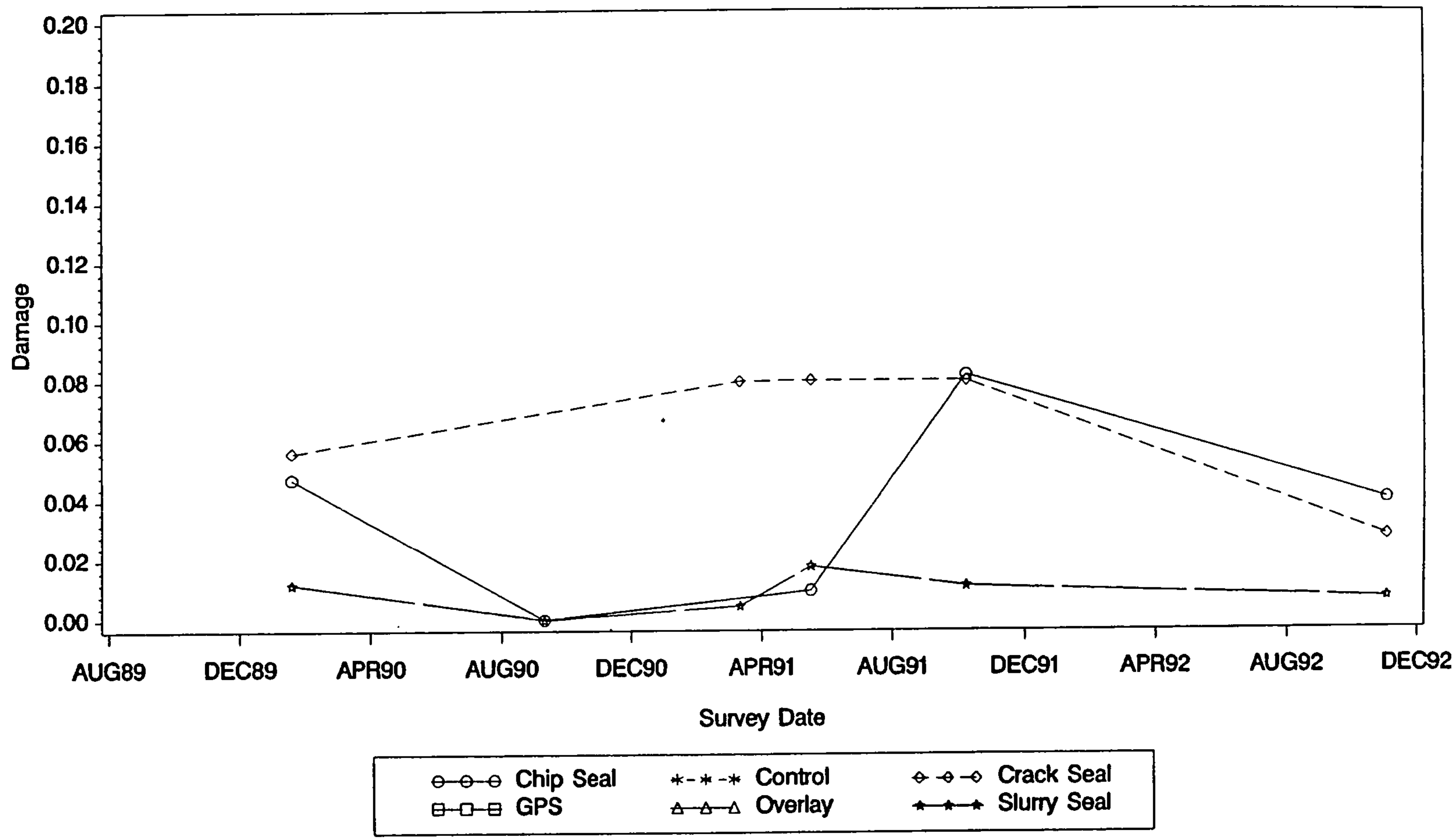
Rejected section(s): GPS Chip Seal
No control section
Treatment dates: Slurry Seal-23AUG1990 Crack Seal-23AUG1990 Chip Seal-23AUG1990 Overlay-15OCT1990 Construction date: 01JUN1982

Figure G-73. Display of longitudinal and transverse cracking on sections rejected for analysis at site 28A



Rejected section(s): Overlay
Treatment dates: Overlay-Missing Slurry Seal-12SEP1990 Crack Seal-12SEP1990 Chip Seal-12SEP1990 Construction date: Missing

Figure G-74. Display of longitudinal and transverse cracking on sections rejected for analysis at site 40A

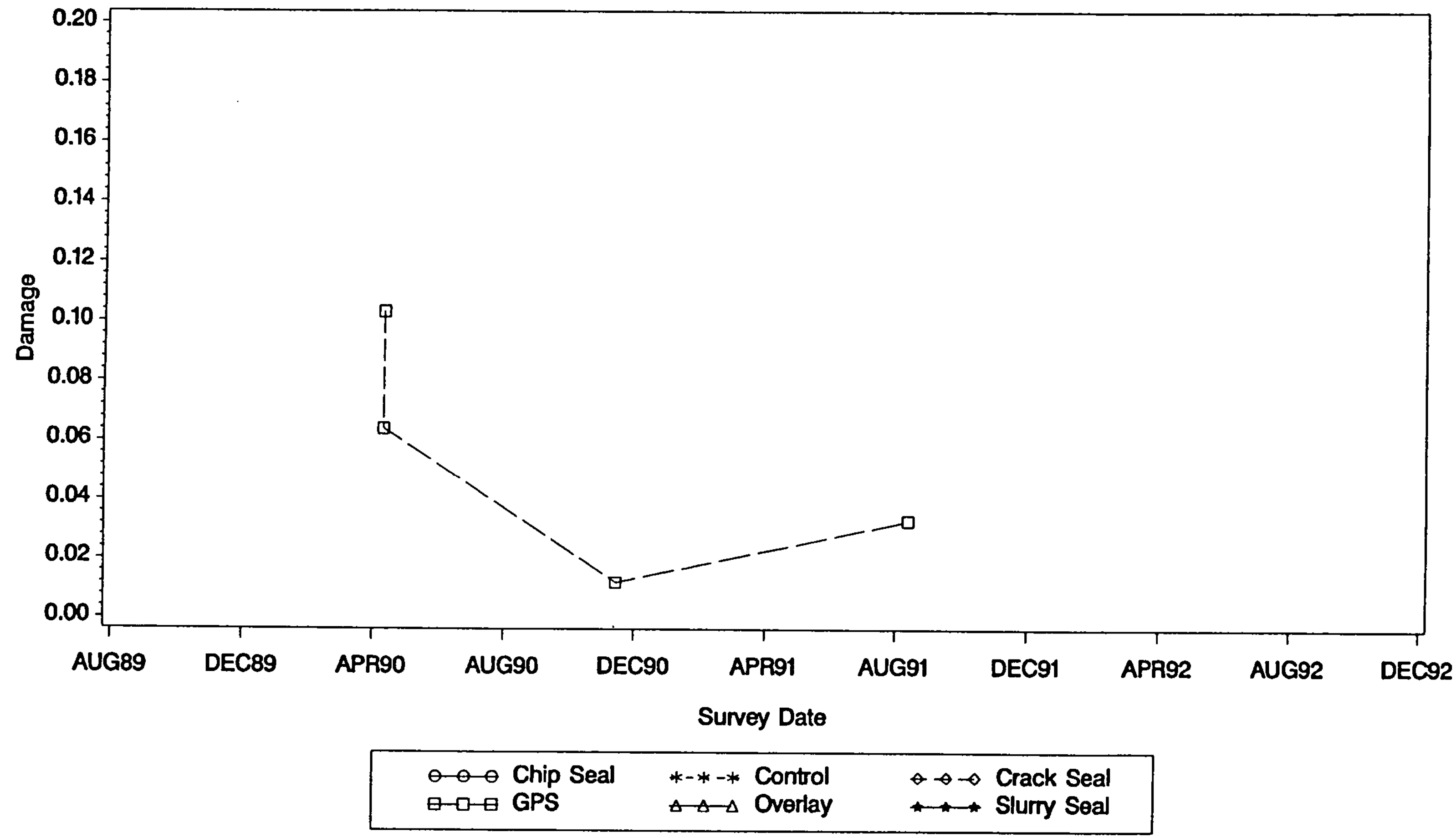


Rejected section(s): Slurry Seal Crack Seal Chip Seal

No control section

Treatment dates: Slurry Seal-10SEP1990 Crack Seal-10SEP1990 Chip Seal-10SEP1990 Overlay-15NOV1990 Construction date: 01APR1978

Figure G-75. Display of longitudinal and transverse cracking on sections rejected for analysis at site 40B

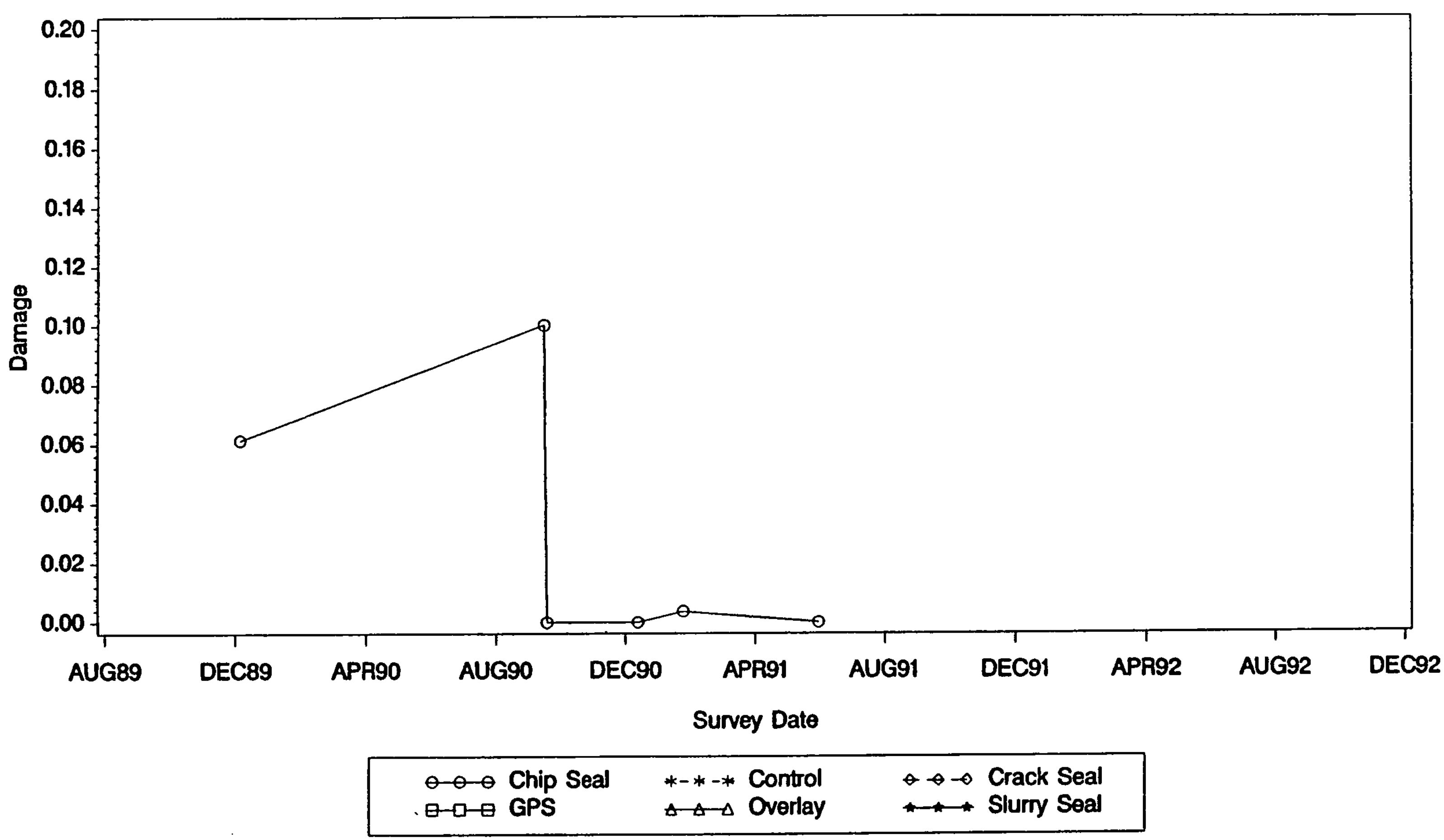


Rejected section(s): GPS

No control section

Treatment dates: Overlay-11JUN1990 Slurry Seal-03AUG1990 Crack Seal-03AUG1990 Chip Seal-03AUG1990 Construction date: 01JUN1972

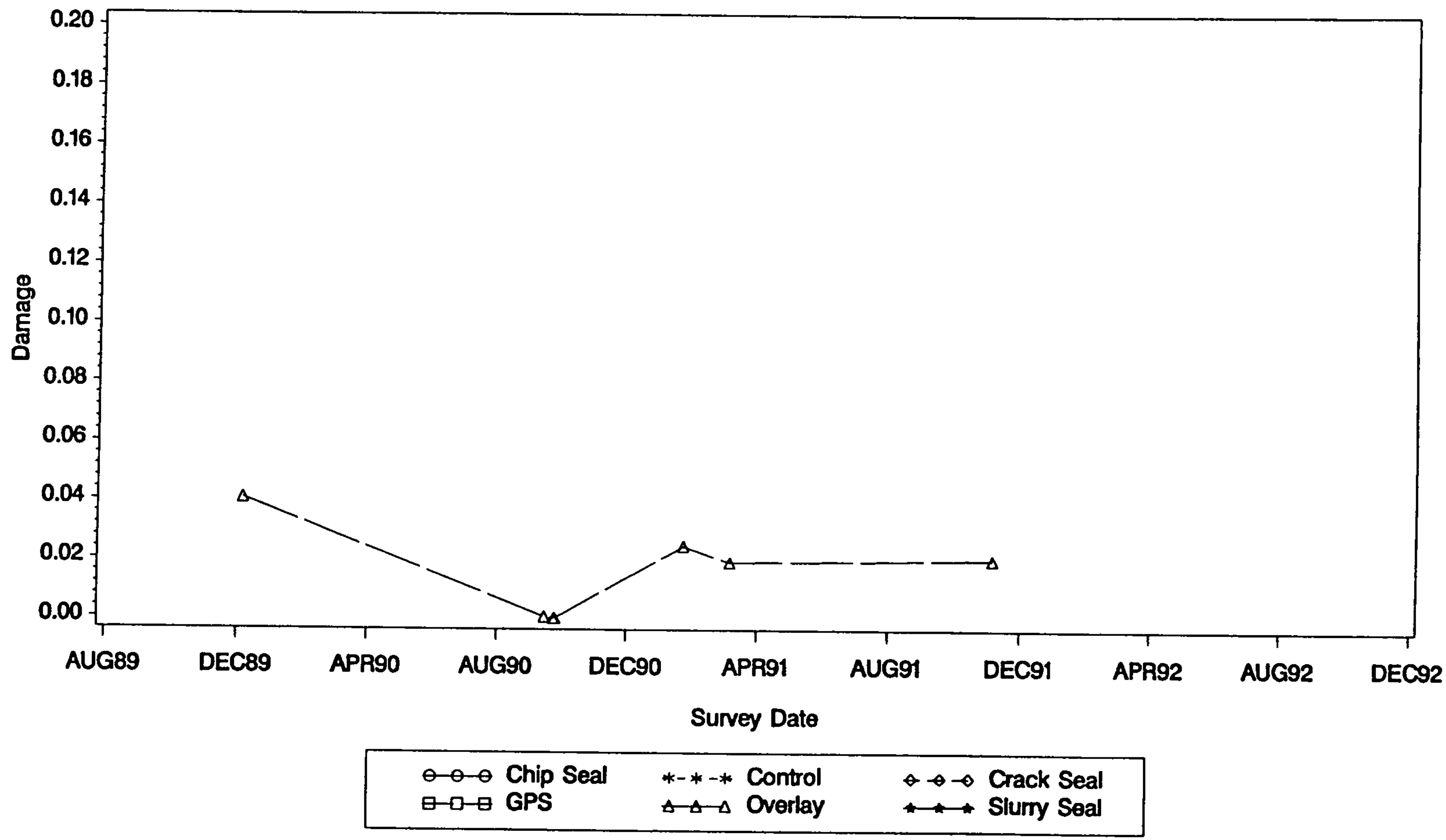
Figure G-76. Display of longitudinal and transverse cracking on sections rejected for analysis at site 47C



Rejected section(s): Chip Seal — No control section

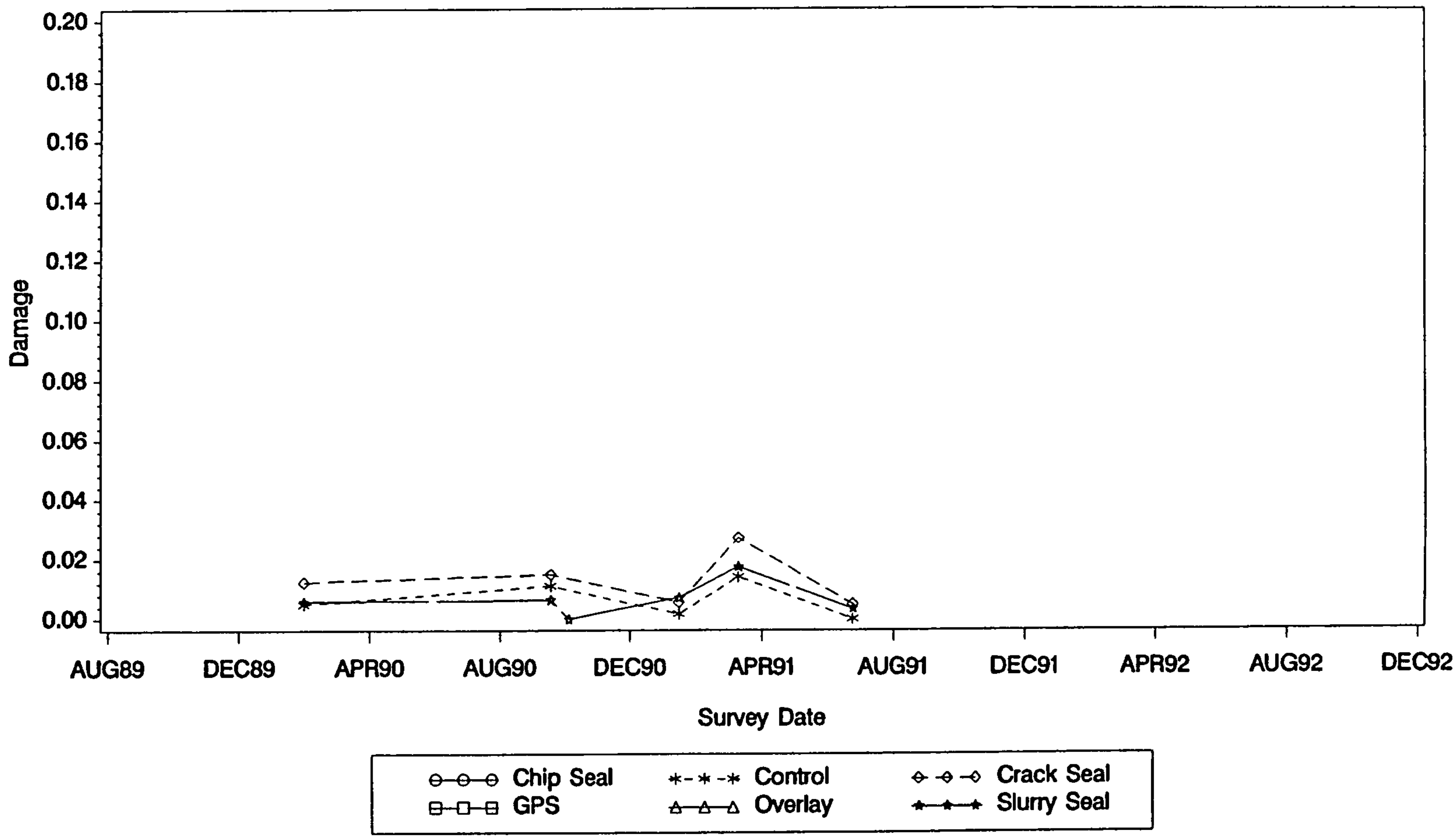
Treatment dates: Slurry Seal-18SEP1990 Crack Seal-18SEP1990 Chip Seal-18SEP1990 Overlay-12OCT1990 Construction date: 01AUG1982

Figure G-77. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48D



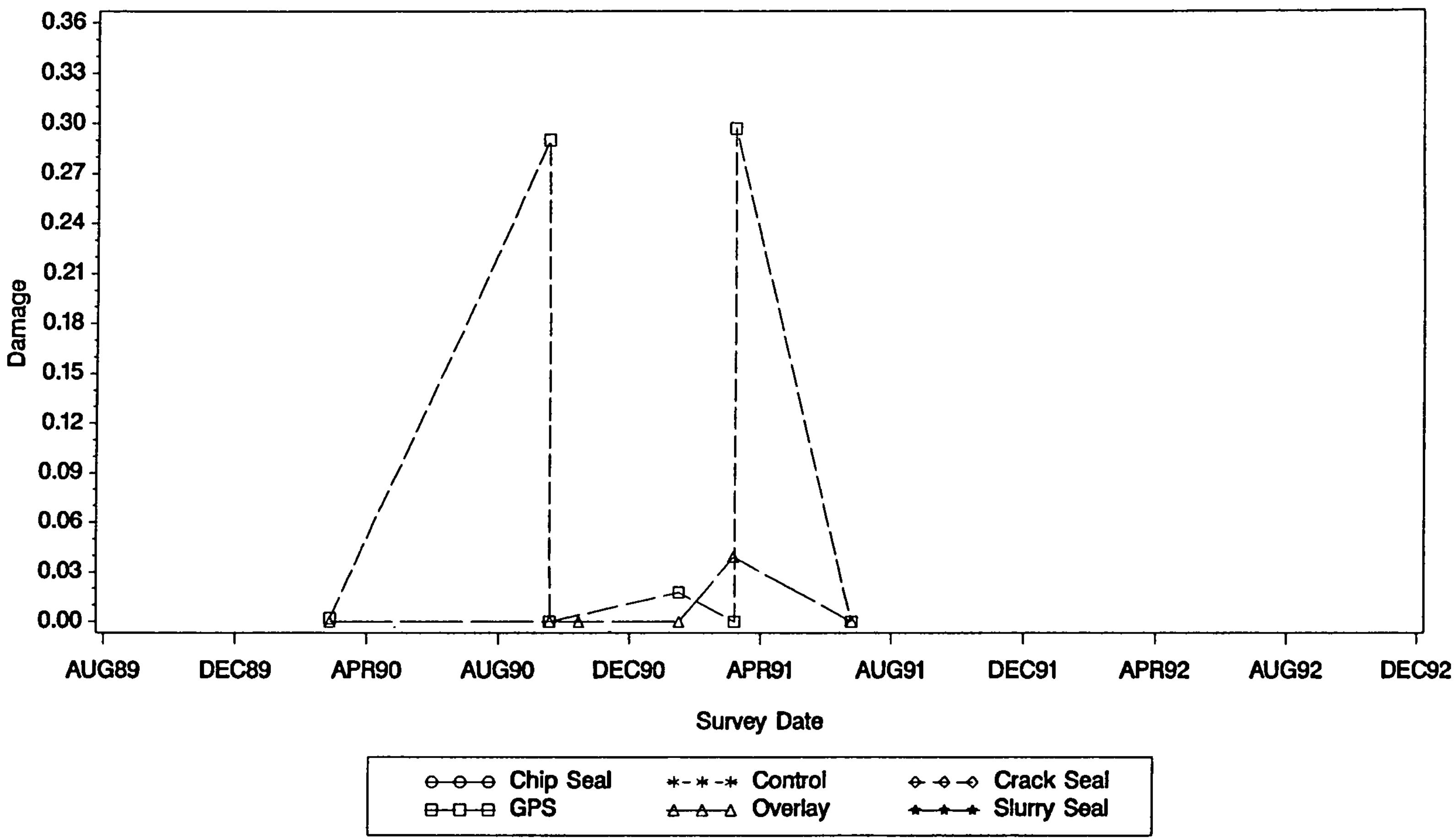
Rejected section(s): Overlay
Treatment dates: Slurry Seal-14SEP1990 Crack Seal-14SEP1990 Chip Seal-14SEP1990 Overlay-25SEP1990 Construction date: 01FEB1975

Figure G-78. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48E



Rejected section(s): Slurr Seal Crack Seal Control
Treatment dates: Slurry Seal-04OCT1990 Crack Seal-04OCT1990 Chip Seal-04OCT1990 Overlay-15OCT1990 Construction date: 01NOV1987

Figure G-79. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48F

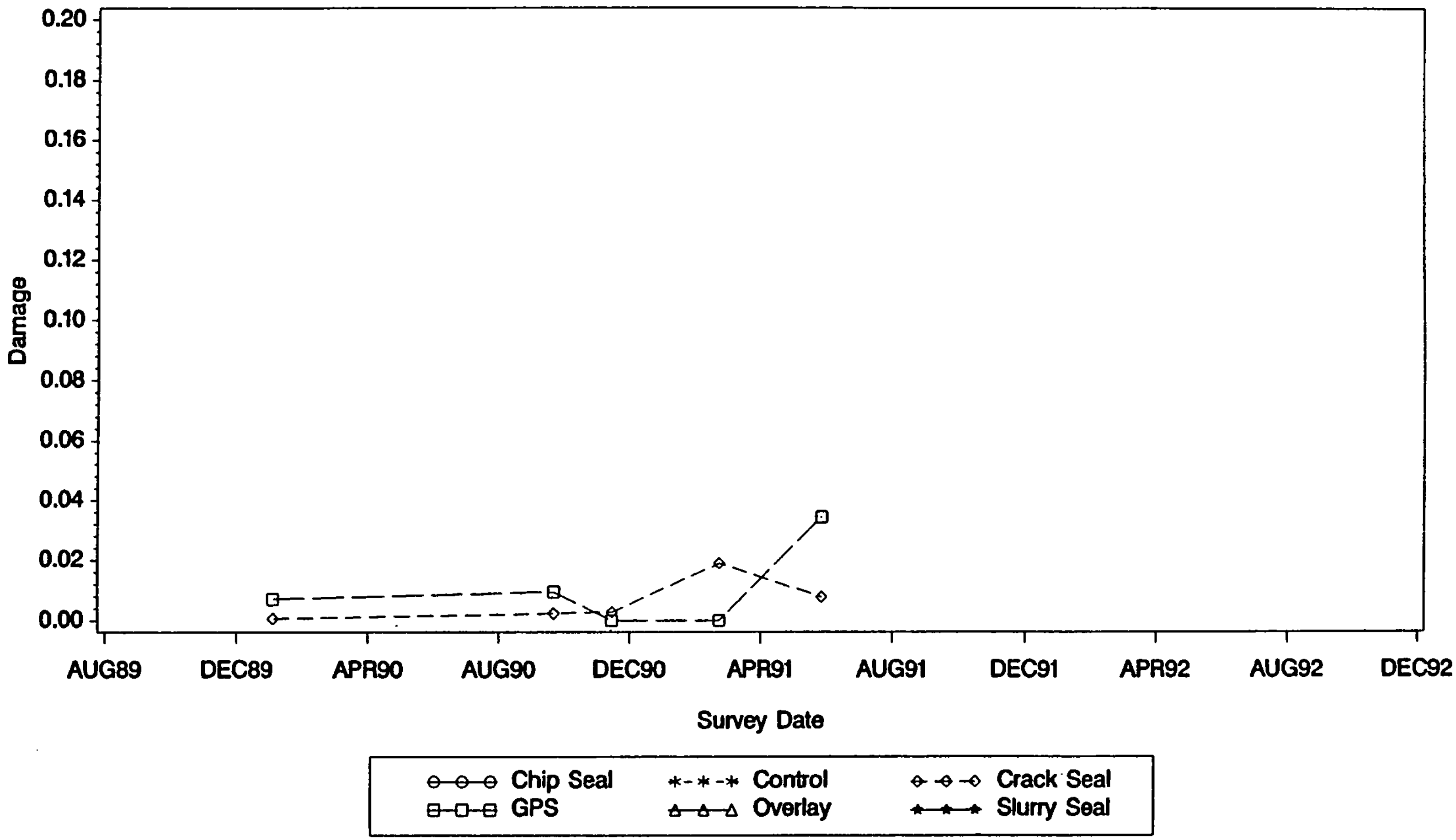


Rejected section(s): GPS Overlay

No control section

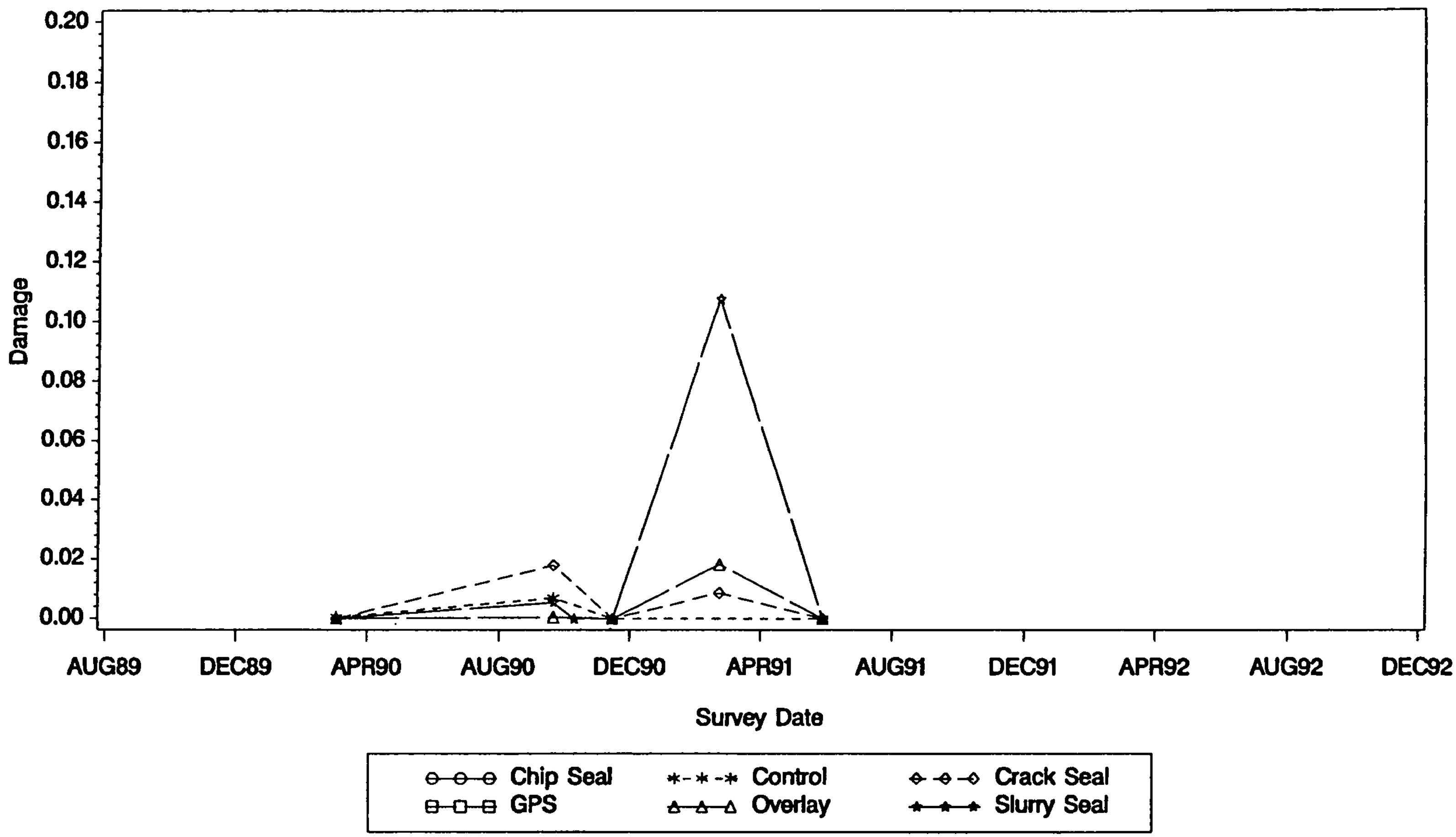
Treatment dates: Slurry Seal-05OCT1990 Crack Seal-05OCT1990 Chip Seal-05OCT1990 Overlay-15OCT1990 Construction date: 01AUG1972

Figure G-80. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48G



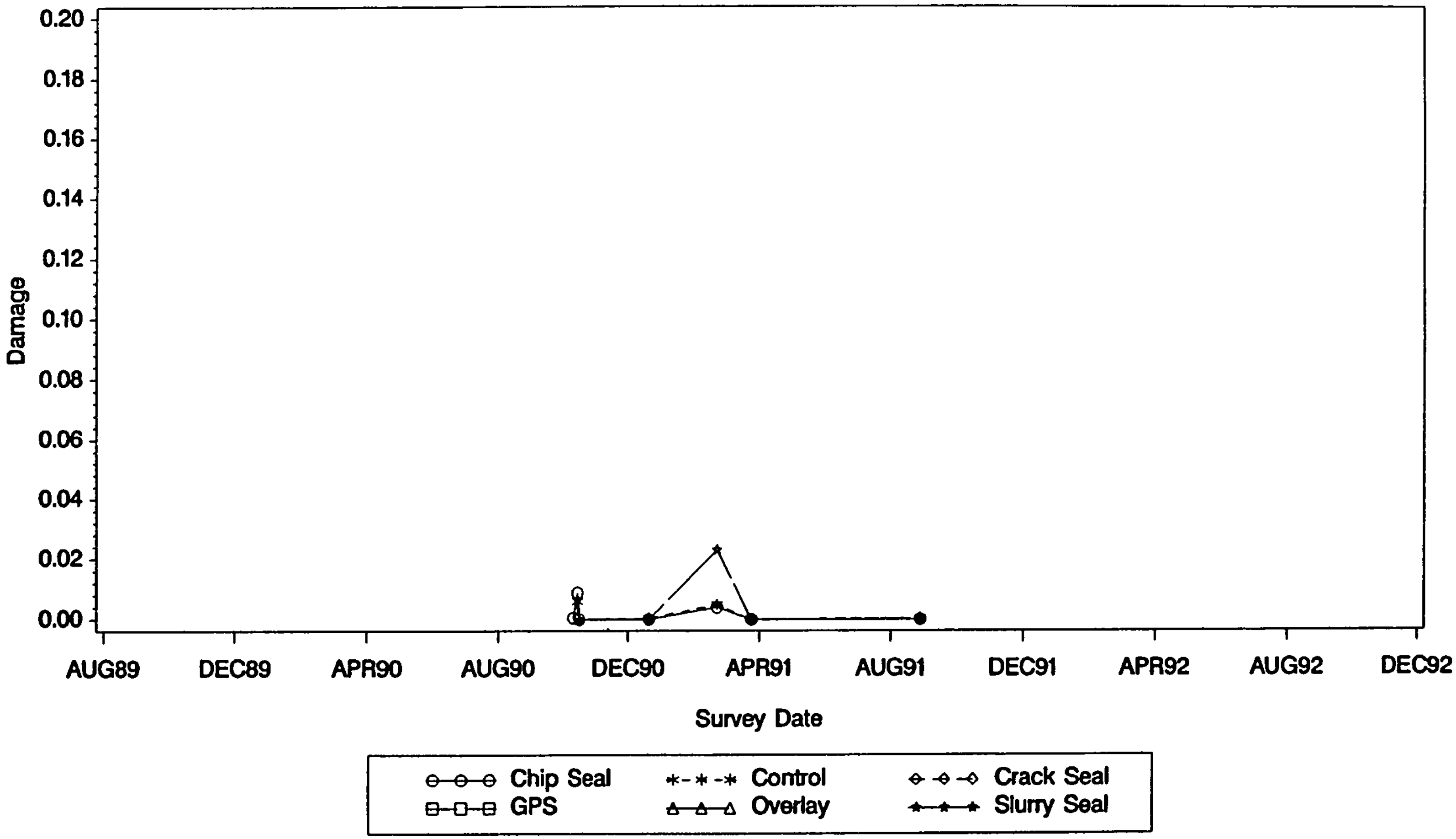
Rejected section(s): GPS Crack Seal
Treatment dates: Slurry Seal-11OCT1990 Crack Seal-11OCT1990 Chip Seal-11OCT1990 Overlay-15OCT1990 Construction date: 01JUL1985

Figure G-81. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48H



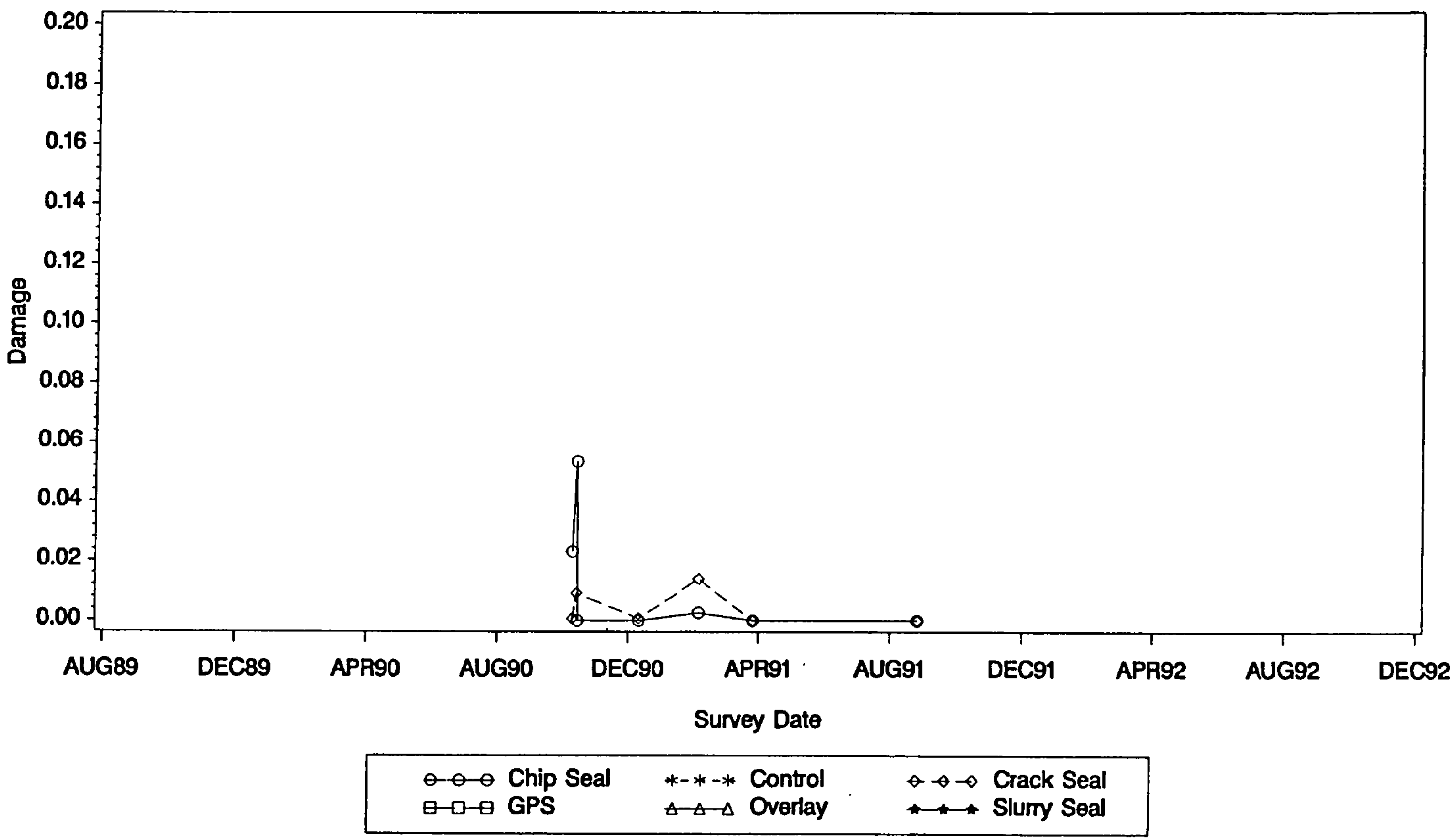
Rejected section(s): Overlay Slurry Seal Crack Seal Control
Treatment dates: Slurry Seal-10OCT1990 Crack Seal-10OCT1990 Chip Seal-10OCT1990 Overlay-15NOV1990 Construction date: 01JUN1970

Figure G-82. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48I



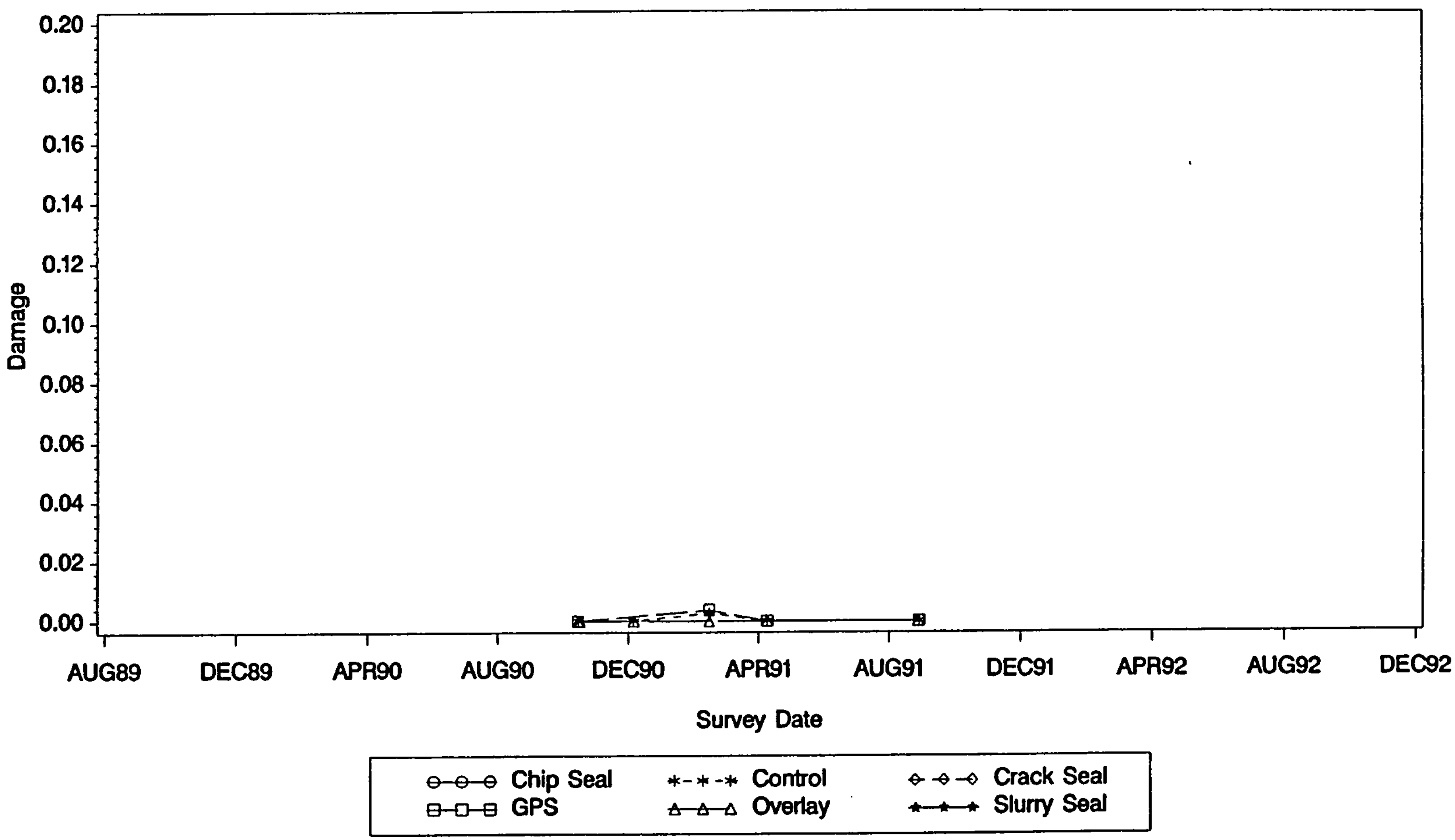
Rejected section(s): Slurry Seal Control Chip Seal
Treatment dates: Overlay-16OCT1990 Slurry Seal-16OCT1990 Crack Seal-16OCT1990 Chip Seal-16OCT1990 Construction date: 01FEB1974

Figure G-83. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48J



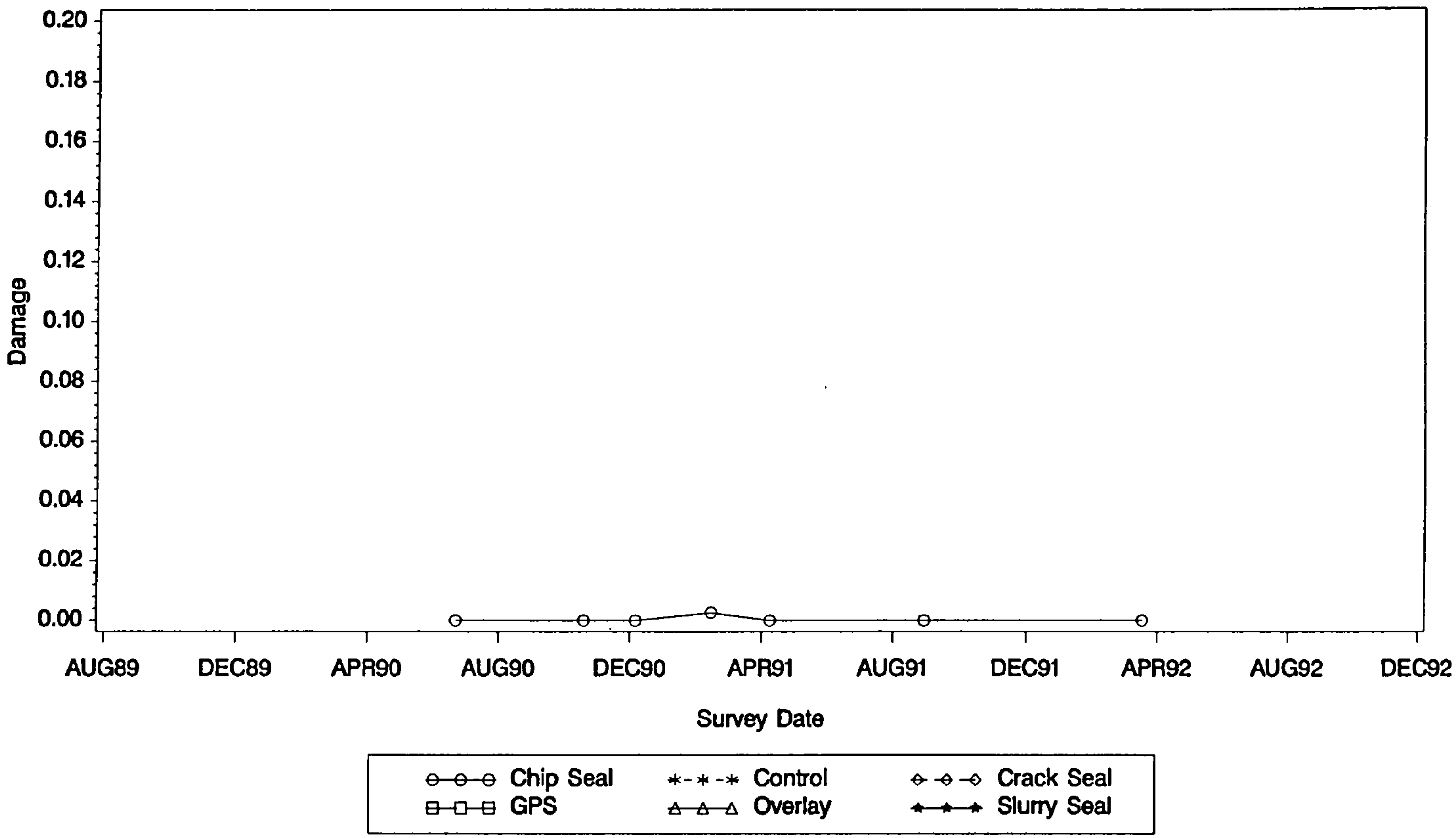
Rejected section(s): Crack Seal Chip Seal
Treatment dates: Slurry Seal-15OCT1990 Crack Seal-15OCT1990 Chip Seal-15OCT1990 Overlay-31OCT1990 Construction date: 01SEP1986

Figure G-84. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48K



Rejected section(s): GPS Overlay Control
Treatment dates: Overlay-15AUG1990 Slurry Seal-18OCT1990 Crack Seal-18OCT1990 Chip Seal-18OCT1990 Construction date: 01MAR1981

Figure G-85. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48M



Rejected section(s): Chip Seal
Treatment dates: Overlay-15AUG1990 Slurry Seal-19OCT1990 Crack Seal-19OCT1990 Chip Seal-19OCT1990 Construction date: 01MAY1982

Figure G-86. Display of longitudinal and transverse cracking on sections rejected for analysis at site 48N

Appendix H

Posttreatment Cracking Damage Compared to Pretreatment Cracking Damage

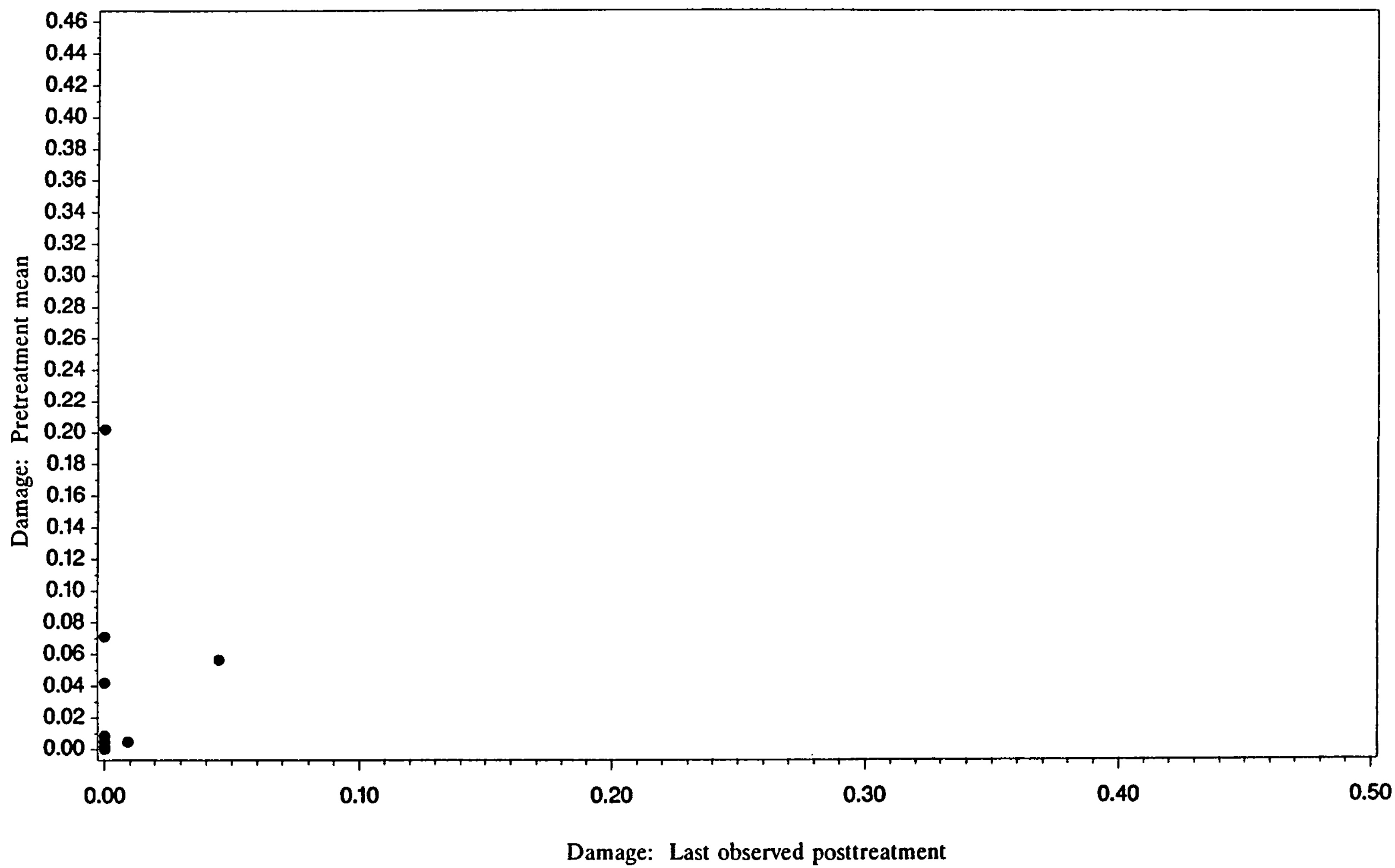


Figure H-1. Comparison of alligator cracking damage before and after chip sealing

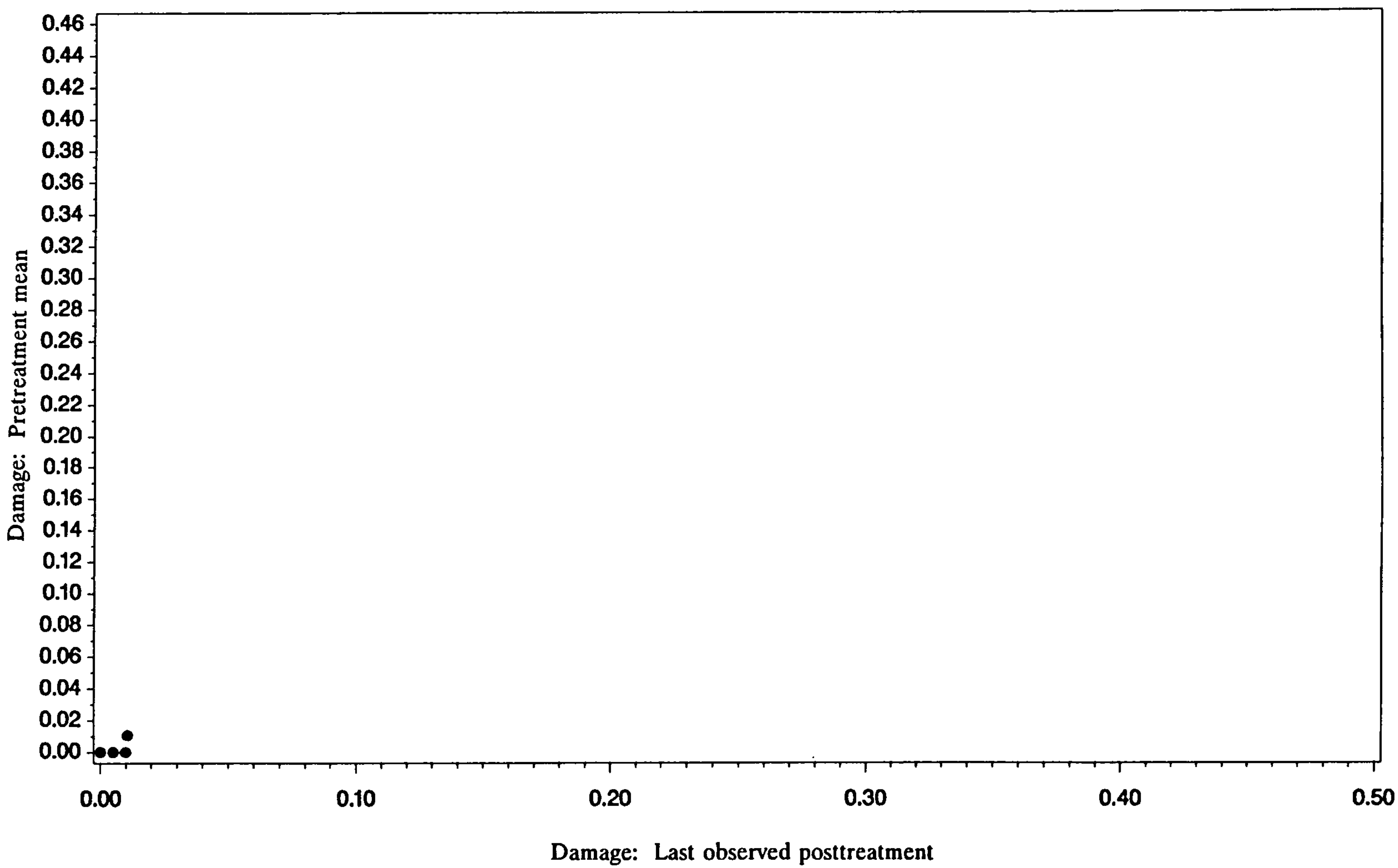


Figure H-2. Comparison of alligator cracking damage before and after control

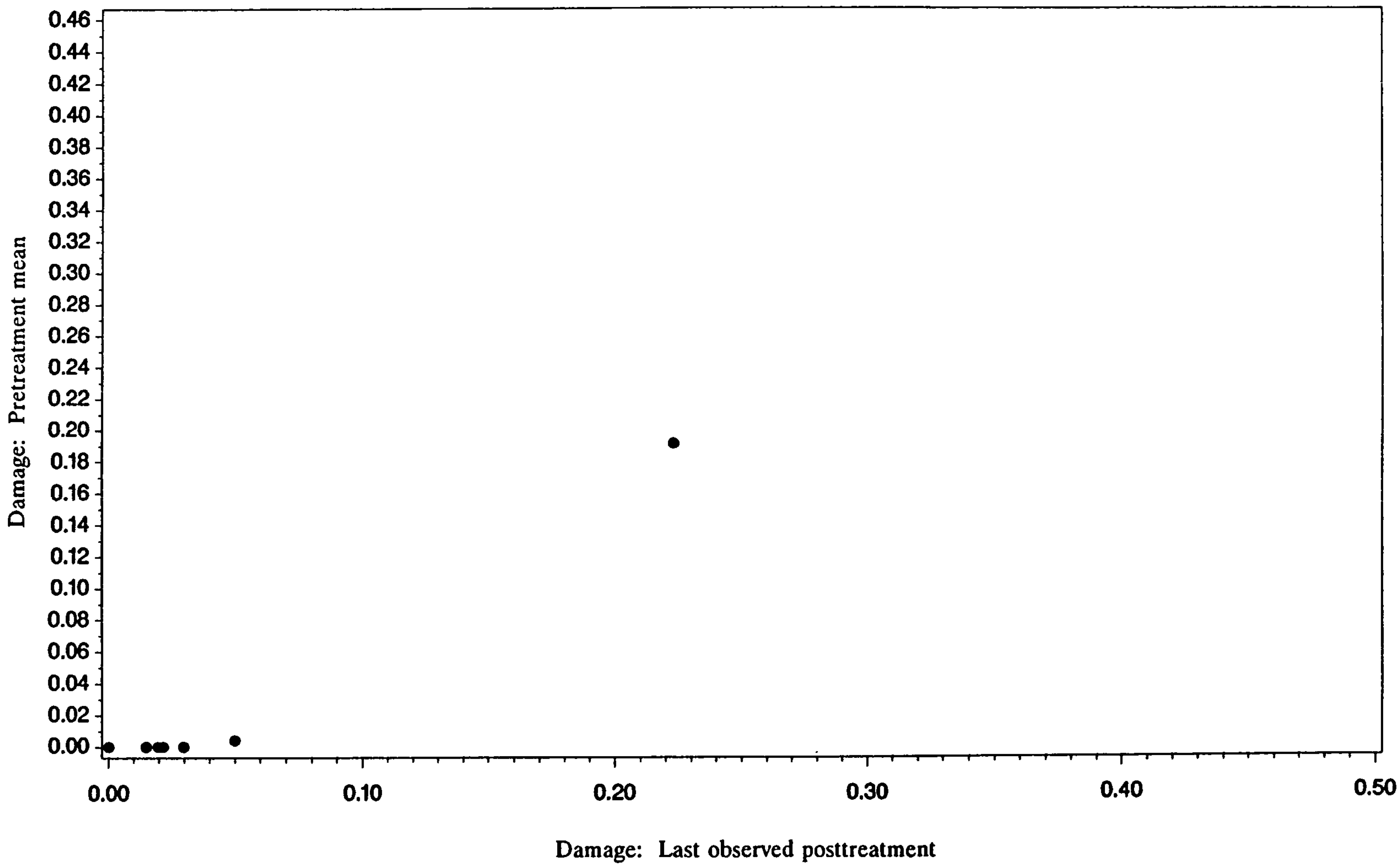


Figure H-3. Comparison of alligator cracking damage before and after crack sealing

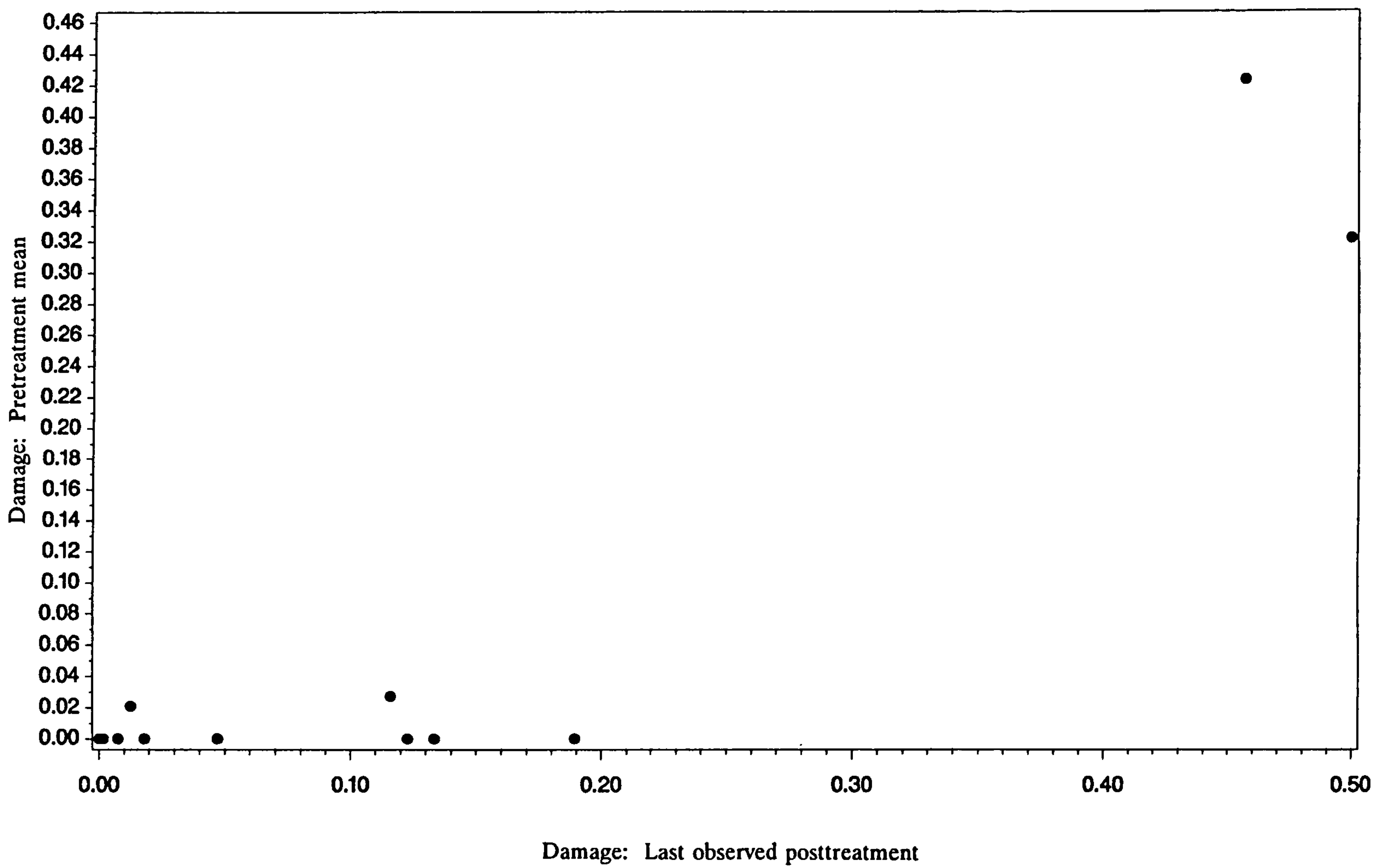


Figure H-4. Comparison of alligator cracking damage before and after GPS

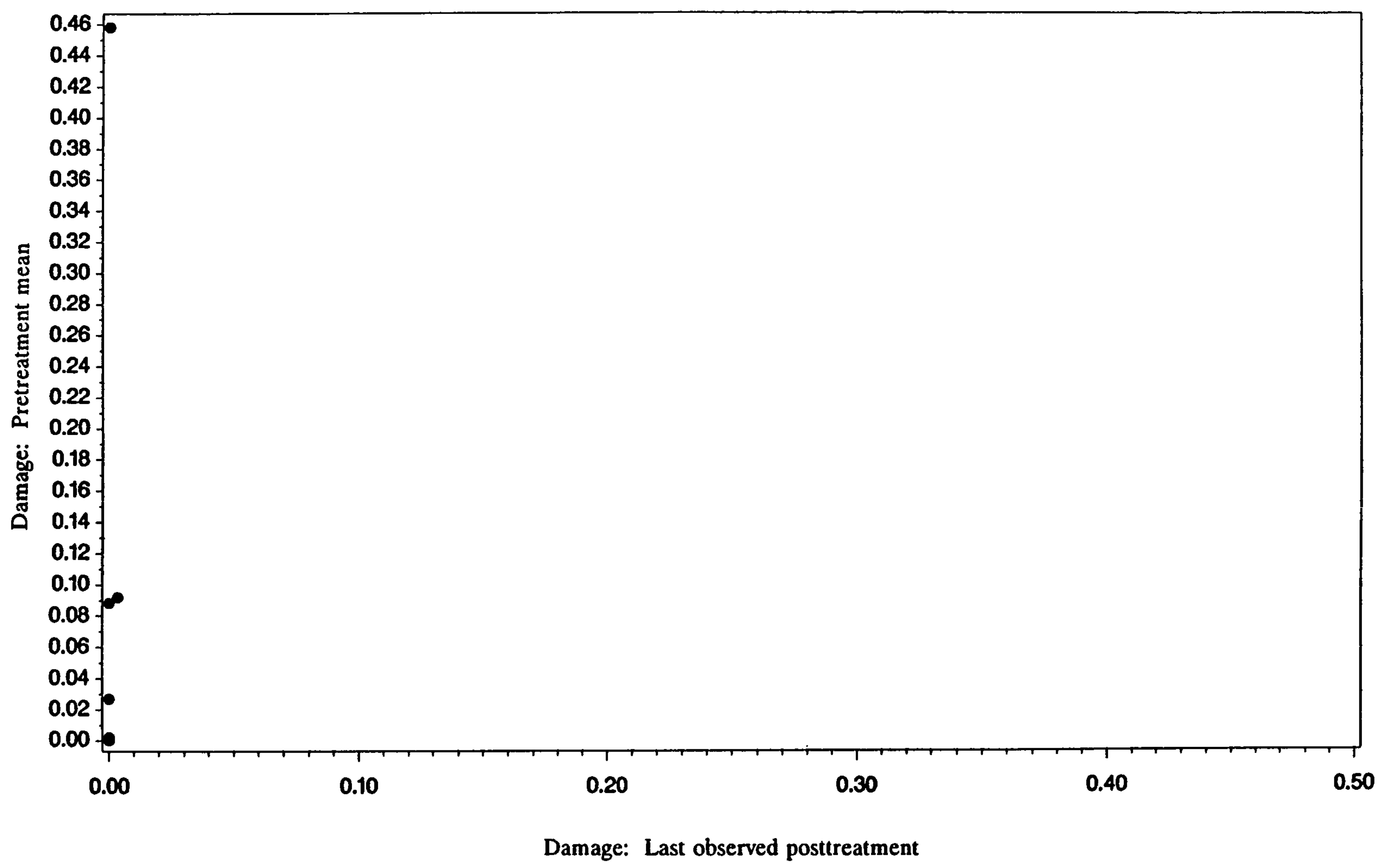


Figure H-5. Comparison of alligator cracking damage before and after overlay

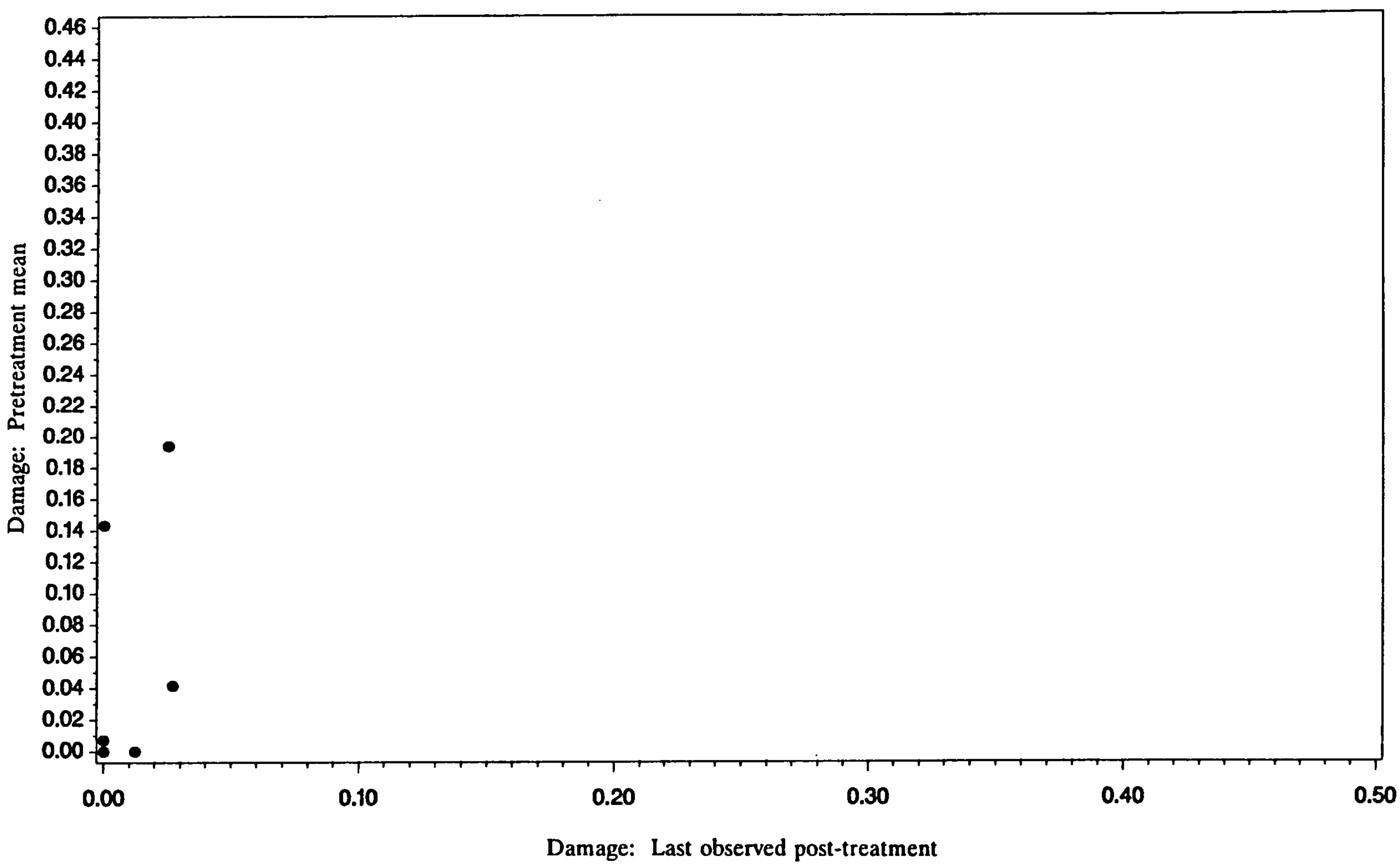


Figure H-6. Comparison of alligator cracking damage before and after slurry seal

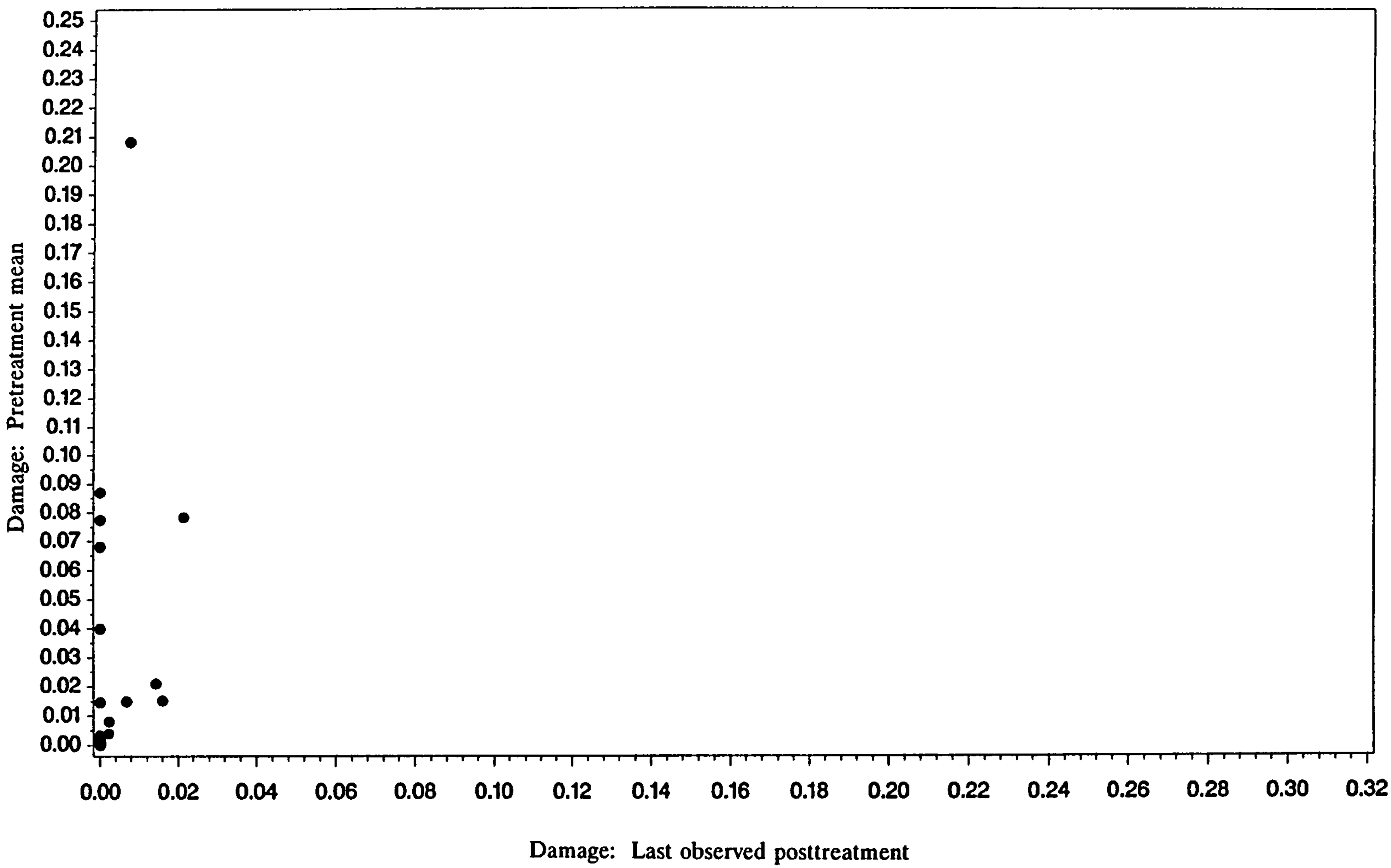


Figure H-7. Comparison of longitudinal and transverse cracking damage before and after chip sealing

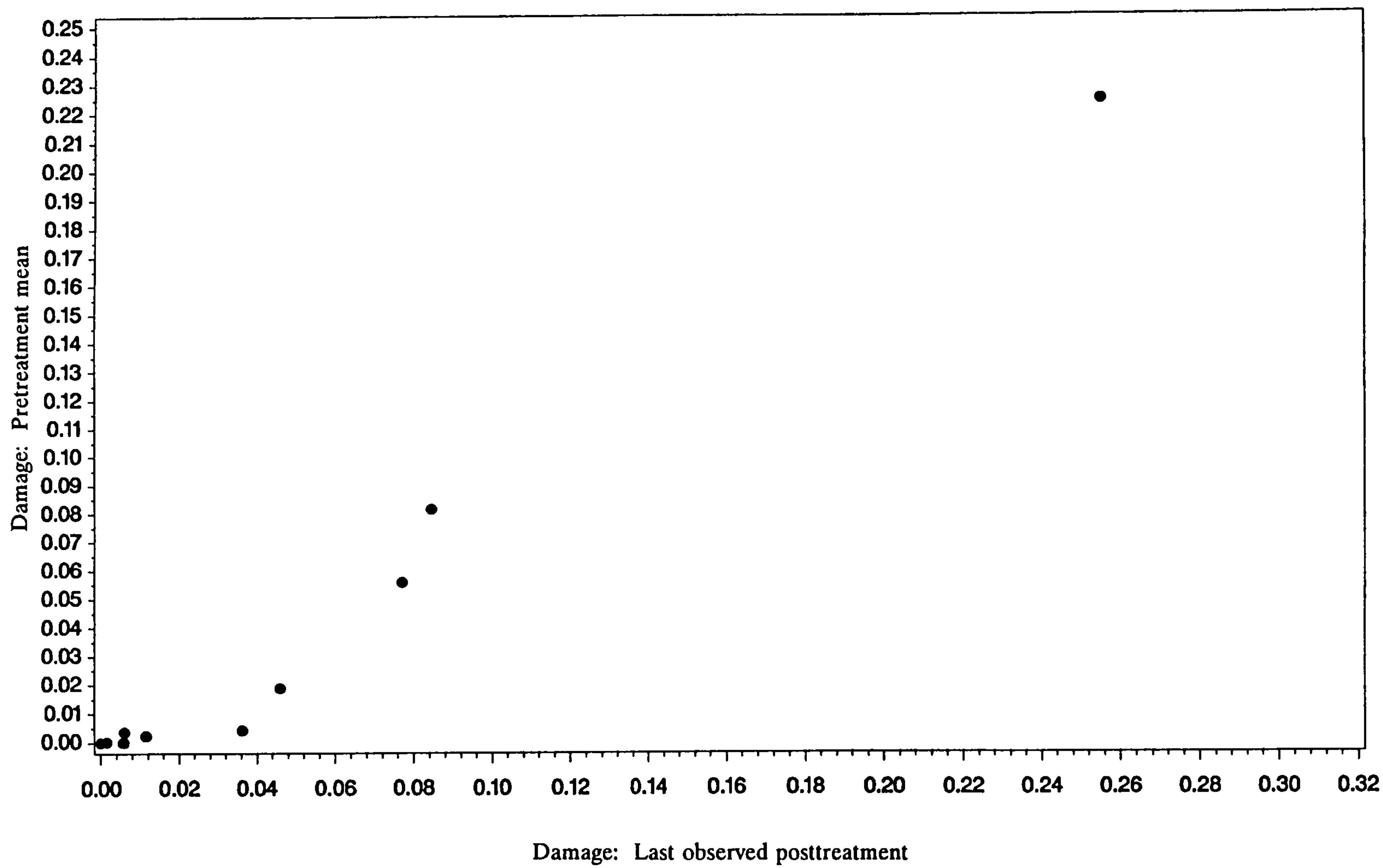


Figure H-8. Comparison of longitudinal and transverse cracking before and after control

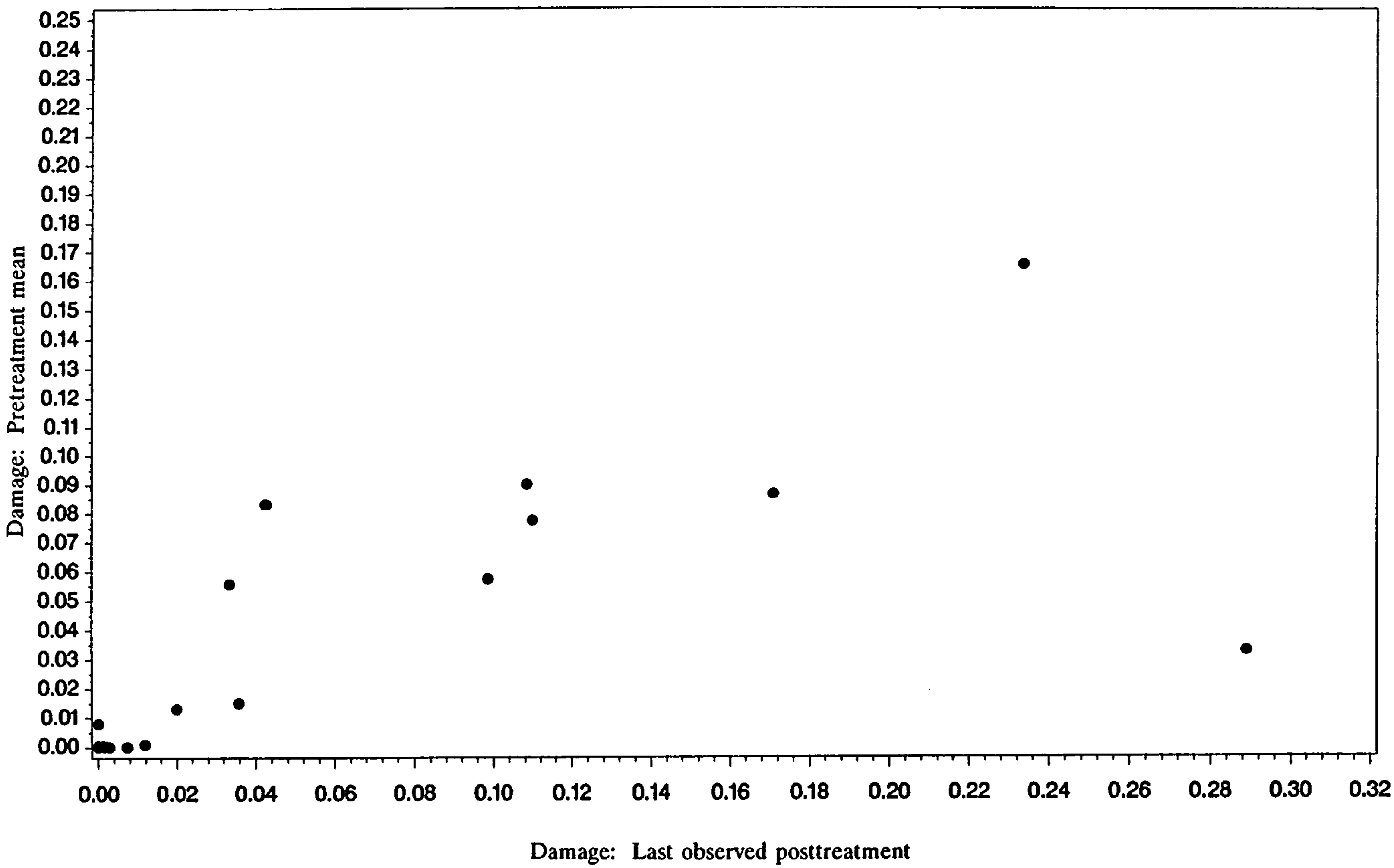


Figure H-9. Comparison of longitudinal and transverse damage before and after crack sealing

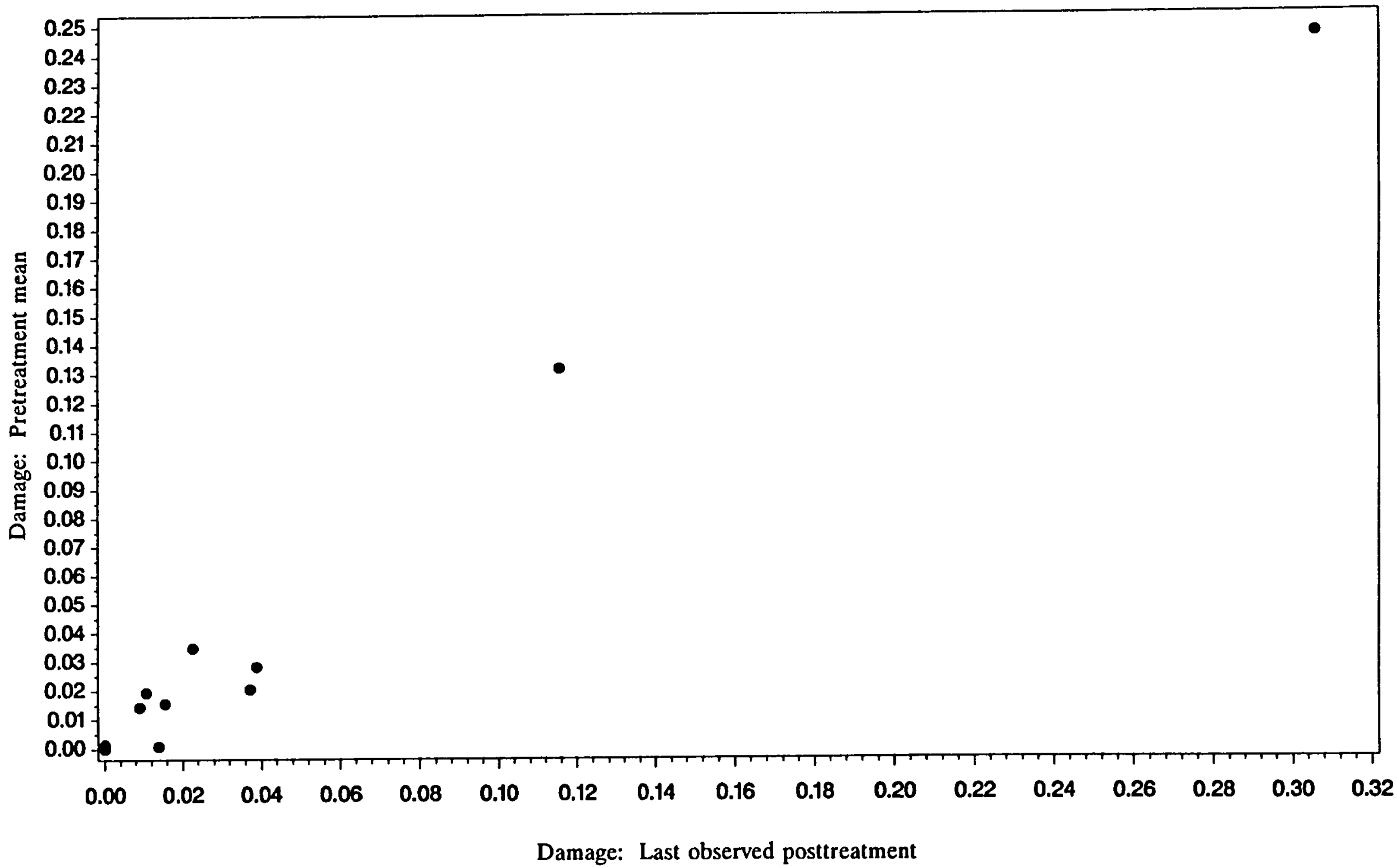


Figure H-10. Comparison of longitudinal and transverse cracking damage before and after GPS

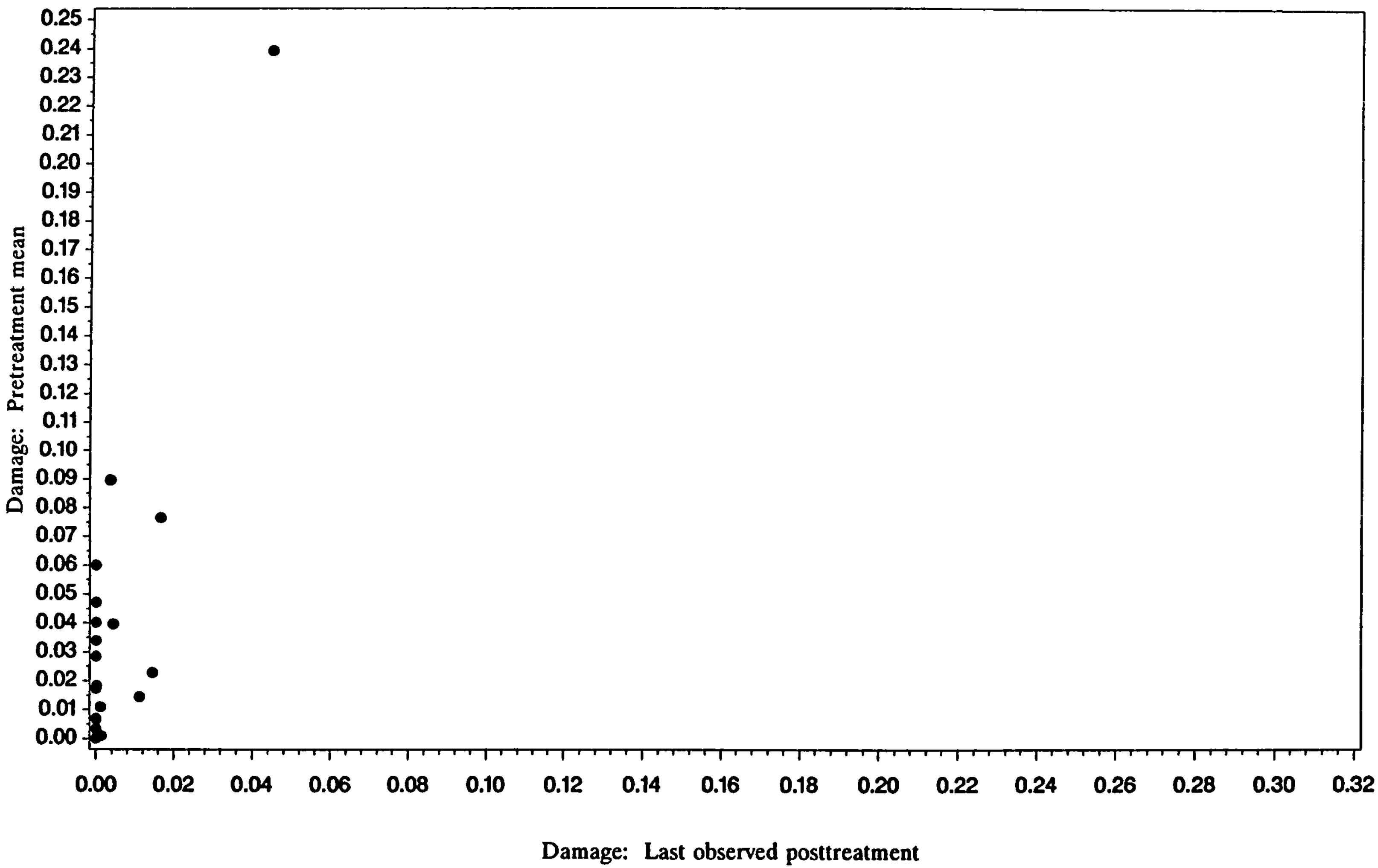


Figure H-11. Comparison of longitudinal and transverse damage before and after overlay

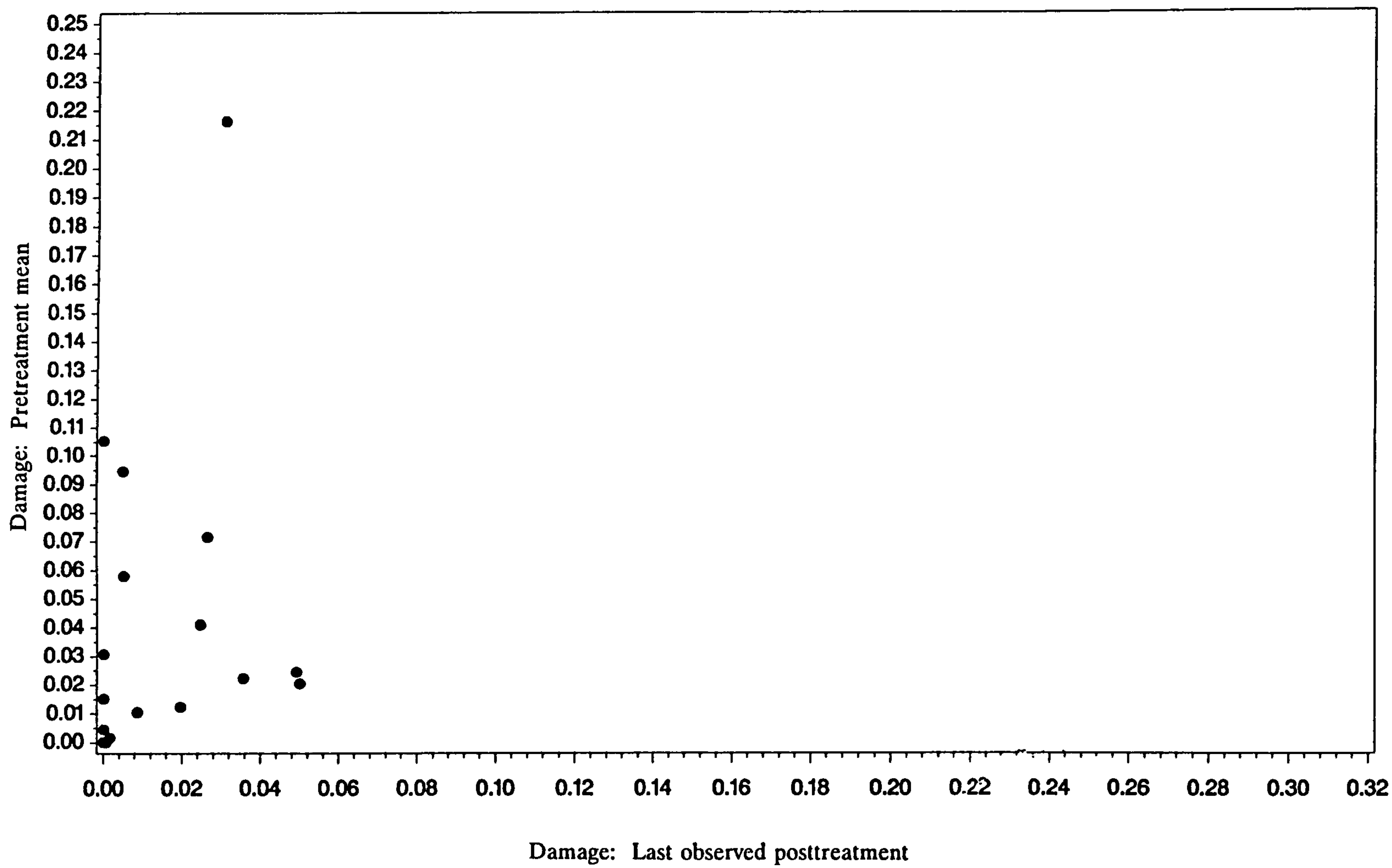


Figure H-12. Comparison of longitudinal and transverse cracking damage before and after slurry seal

Appendix I

Posttreatment Surface Friction (Skid) Compared to Pretreatment Surface Friction

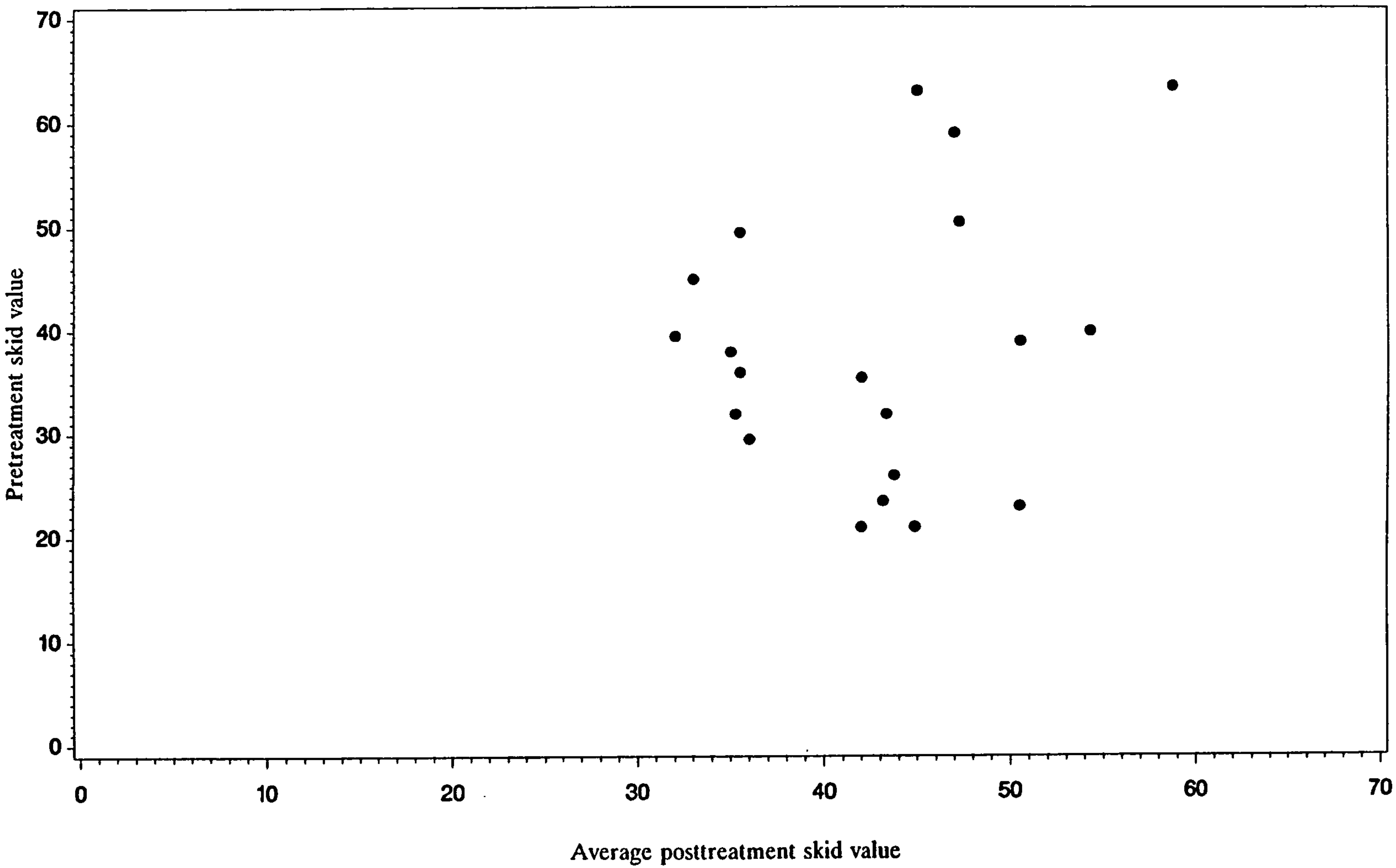


Figure I-1. Comparison of skid values before and after chip sealing

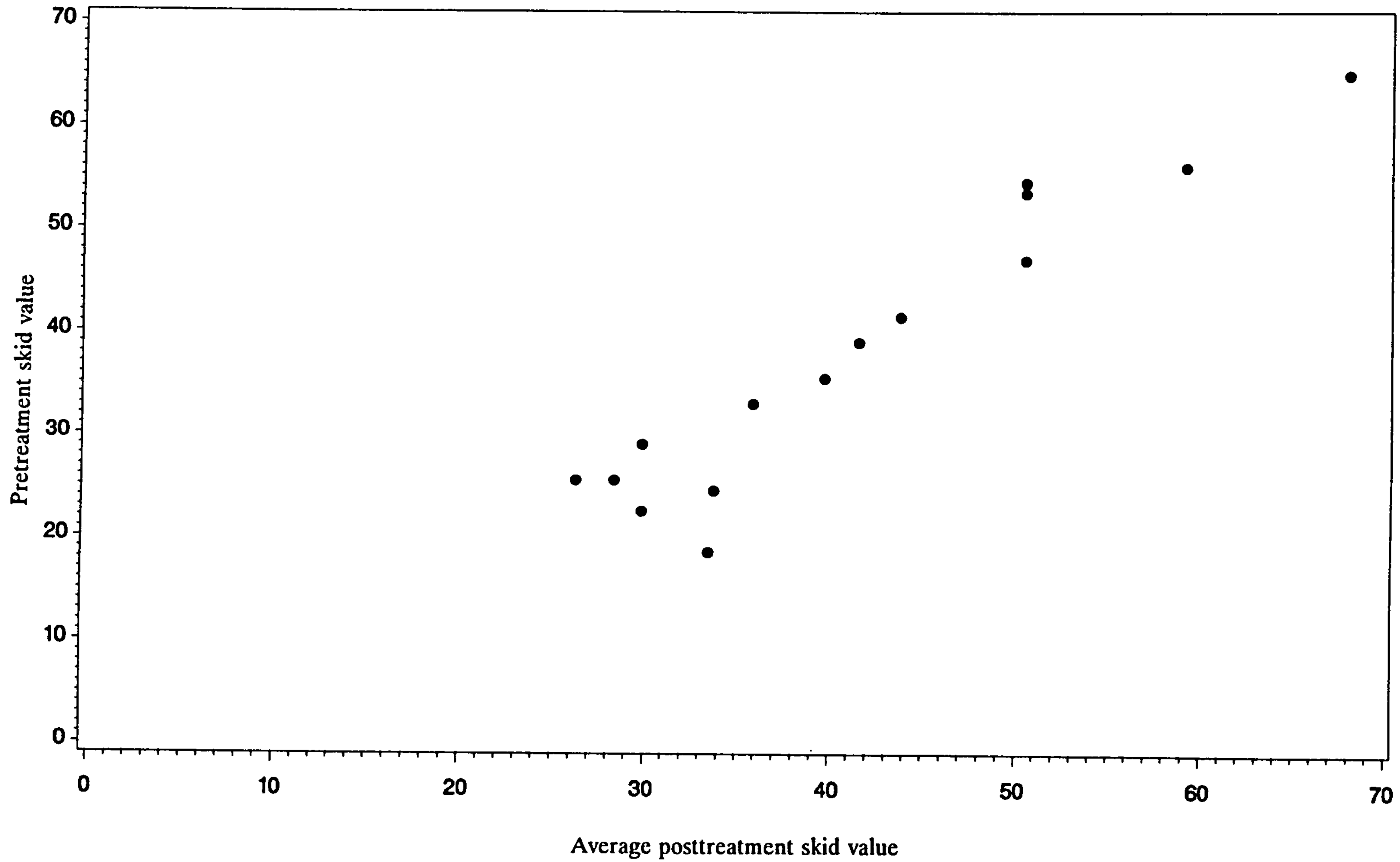


Figure I-2. Comparison of skid values before and after control

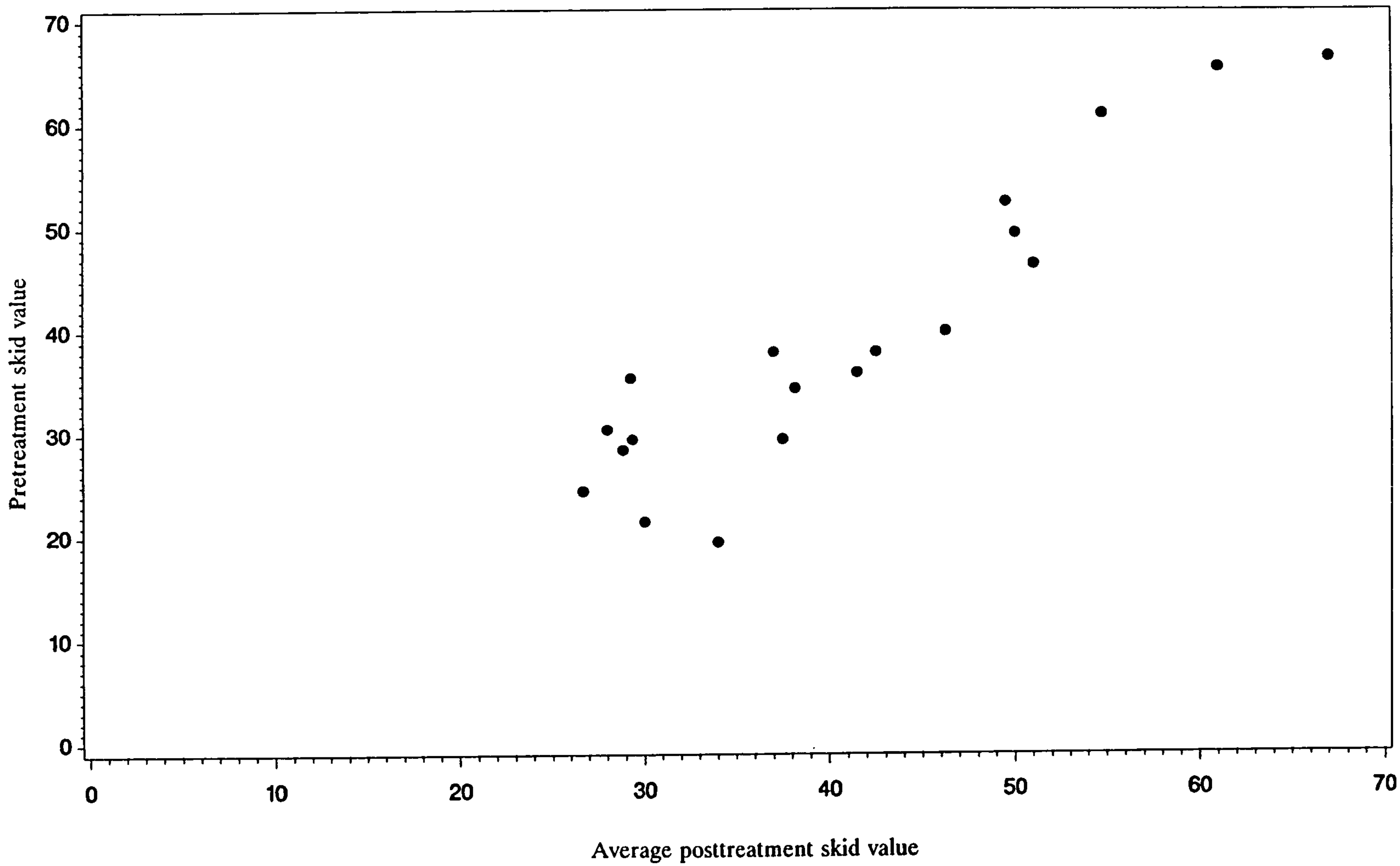


Figure I-3. Comparison of skid values before and after crack sealing

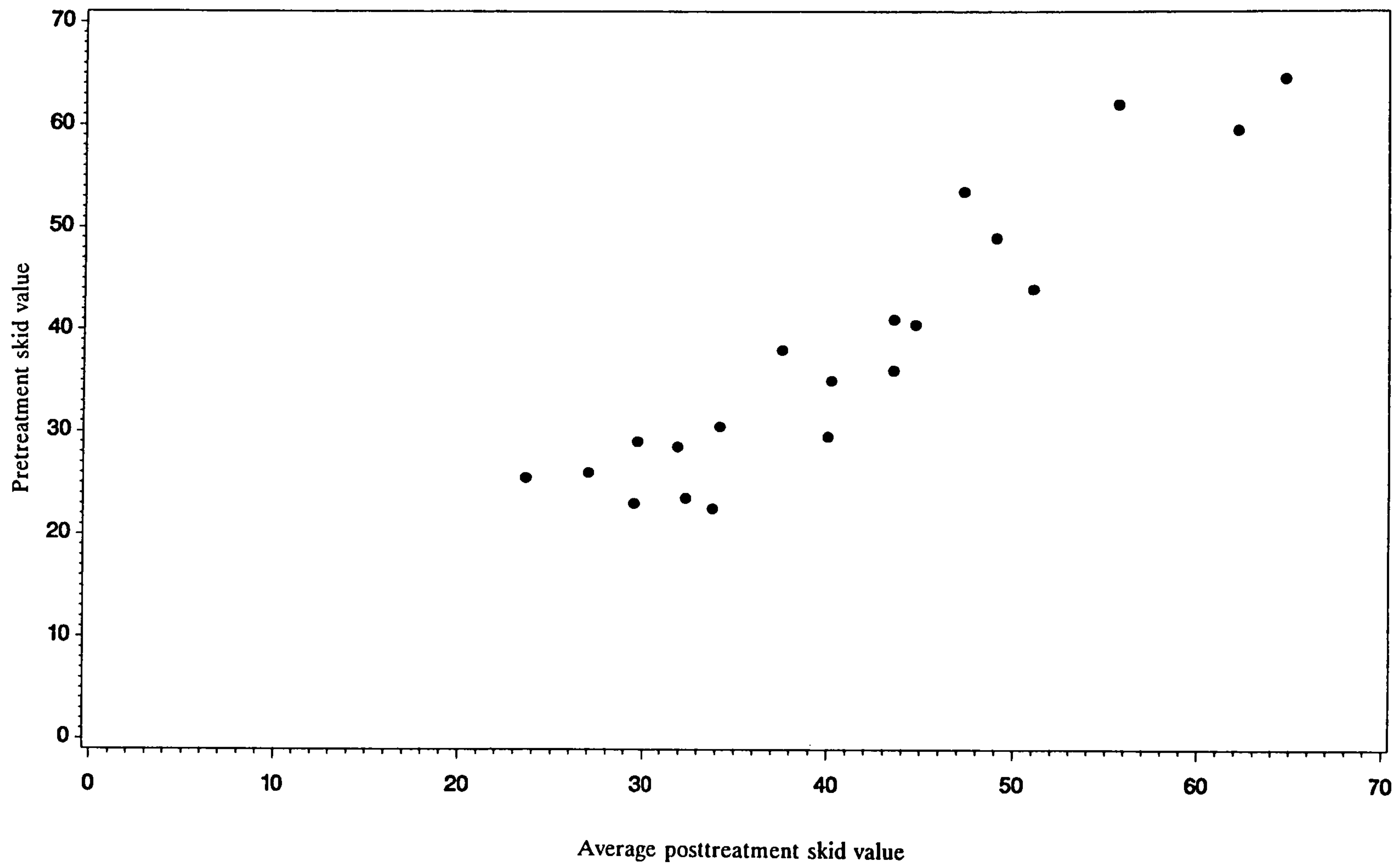


Figure I-4. Comparison of skid values before and after GPS

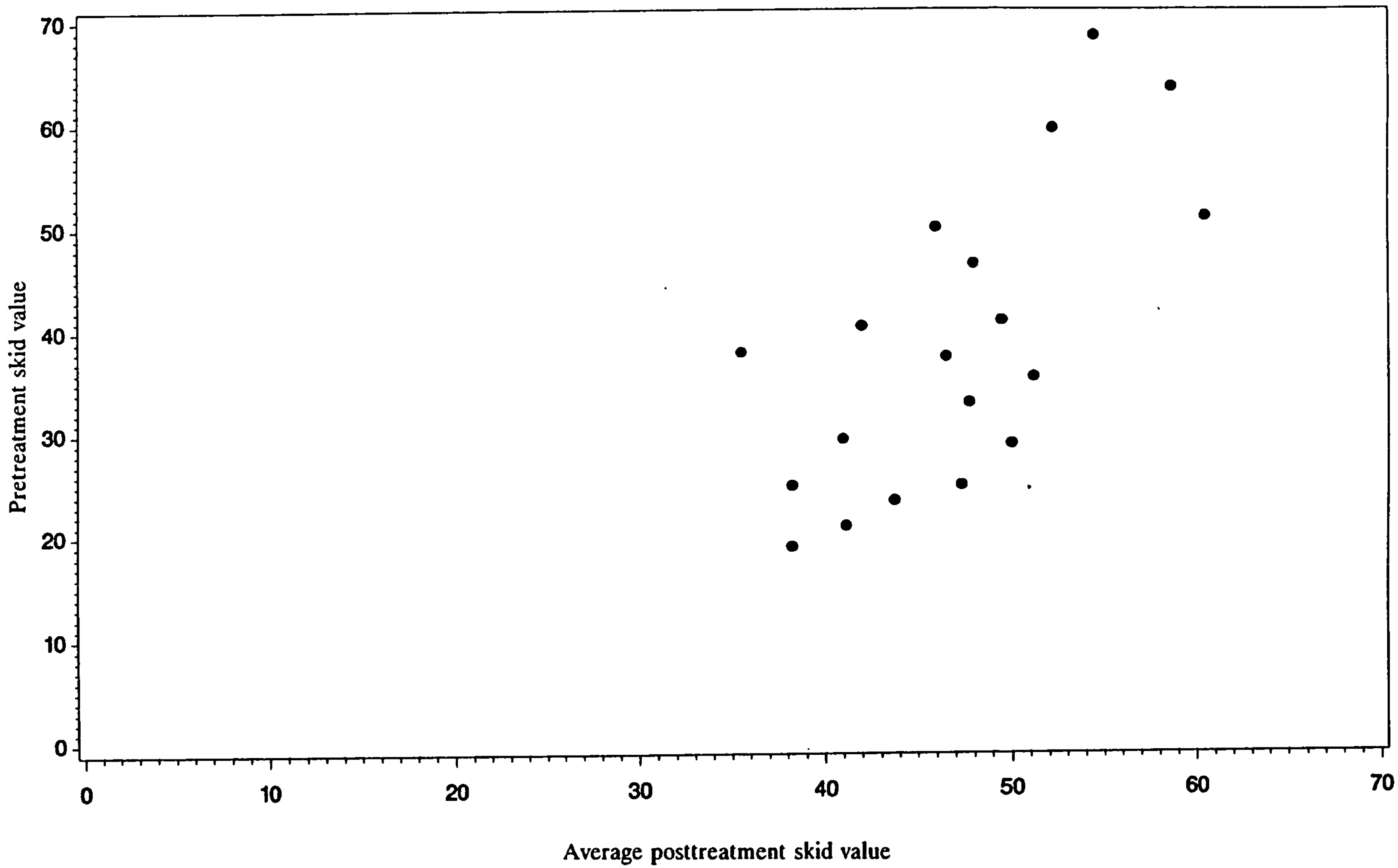


Figure I-5. Comparison of skid values before and after overlay

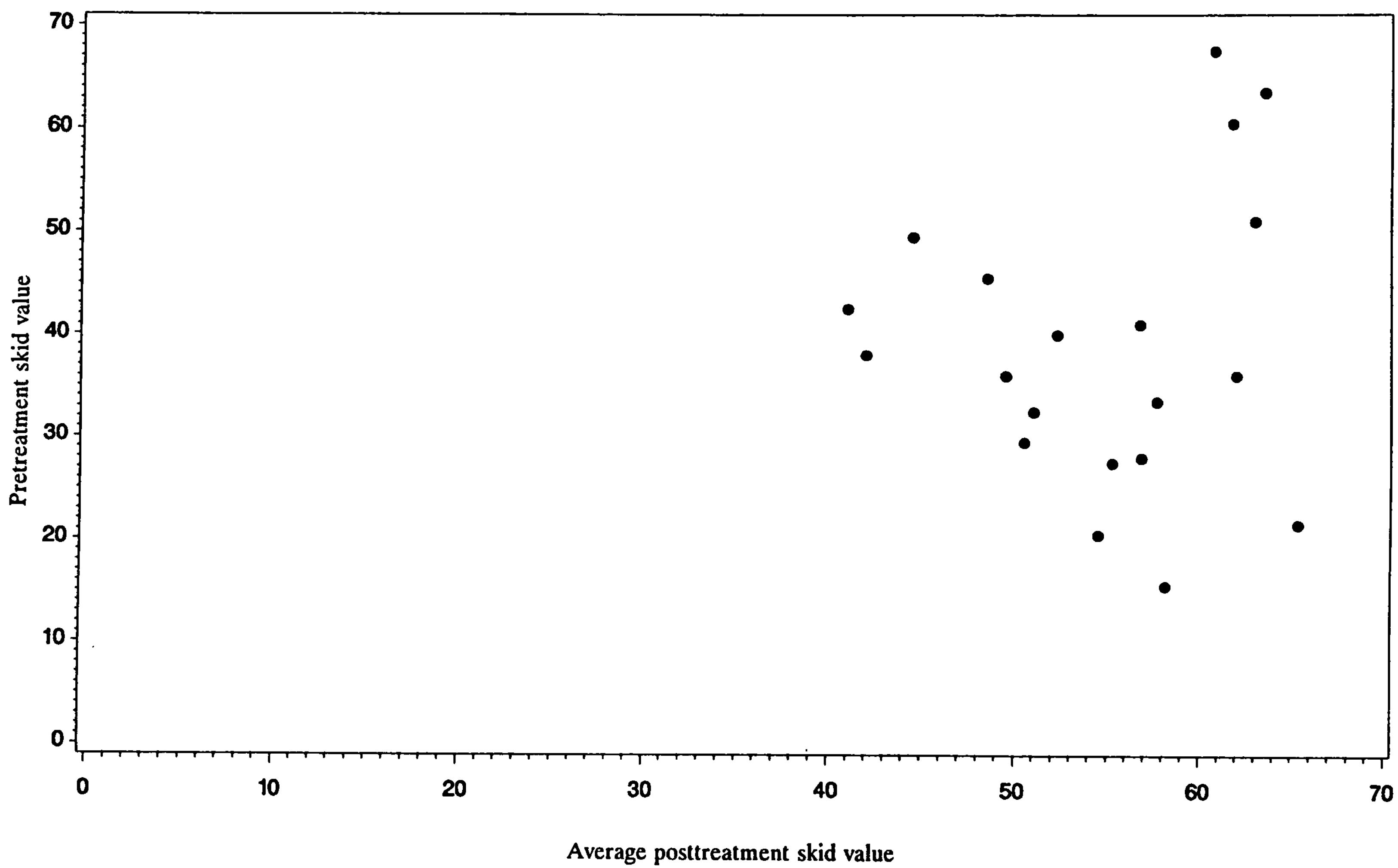


Figure I-6. Comparison of skid values before and after slurry seal

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