REDUCING REFLECTION CRACKING IN BITUMINOUS OVERLAYS

UTILIZING A

STRAIN RELIEVING INTERLAYER OF RUBBERIZED SLURRY

FINAL REPORT

Report 77-1

February 1977

VERMONT DEPARTMENT OF HIGHWAYS

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16. Abstract Bituminous concrete overlays historically develop reflection cracking during the first winter in Vermont's climatic environment. In an effort to combat the reflection of these cracks the use of a strain relieving interlayer in the form of a rubberized slurry was tried. After preliminary laboratory investigation, a full scale field experiment was established in cooperation with the Federal Highway Administration on Interstate Route 91 in the Putney, Vermont area.

The results, after the first winter (1973-1974), had proved to be very encouraging. The control section experienced 43% reflection whereas the rubber treated areas experienced only 7% and 9%. The results after the second winter (1974-1975), indicated the control section had remained stable with 43% reflection whereas the rubber treated areas experienced only 9% and 16%. The results after the third winter (1975-1976), were quite different. While the control area had increased to 56% reflection, the rubber treated areas had increased to 49% and 41%. A third section which was treated with RS-1 showed 51% reflection after the third winter. Therefore, all areas were practically equalized after the third winter season.

It is therefore concluded that the rubberized slurry strain relieving interlayer concept is not viable in Vermont and should be discontinued based on first cost and short term benefits.

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ABSTRACT

Bituminous concrete overlays historically develop reflection cracking during the first winter in Vermont's climatic environment. The degree of severity depends upon several factors such as the first winter's weather, depth of overlay, preparation of the existing pavement and its condition.

In an effort to combat the reflection of these cracks, the majority of which are transverse in nature, the Vermont Department of Highways investigated the use of a strain relieving interlayer in the form of a rubberized slurry. After preliminary laboratory investigation, a full scale field experiment was established in cooperation with the Federal Highway Administration on Interstate Route 91 in the Putney, Vermont area.

The results, after the first winter (1973-1974), had proved to be very encouraging. The control section experienced 43% reflection whereas the rubber treated areas experienced only 7% and 9%. The freezing index for the 1973-1974 winter was 704 as calculated from the nearest official weather reporting station thirteen miles north of the project and at the same elevation. The results after the second winter (1974-1975), indicated the control section had remained stable with 43% reflection whereas the rubber treated areas experienced only 9% and 16%. The freezing index for 1974-1975 was 744. The results after the third winter (1975-1976), were quite different. While the control area had increased to 56% reflection, the rubber treated areas had increased to 49% and 41%. The freezing index for 1975-1976 was 1055.

A third section which was treated with RS-1 showed 51% reflection after the third winter. Although the rubber treated areas retained a 10% to 15% better record relative to transverse crack reflection, all areas were practically equalized after the third winter season.

It is therefore concluded that the rubberized slurry strain relieving interlayer concept is not viable in Vermont and should be discontinued based on first cost and short term benefits.

INTRODUCTION

Reflective cracking through bituminous concrete overlays is a recognized problem nationwide.[1] Approaches to the reduction of this problem vary from extra thick overlays to mesh fabrics laid between the pavement courses. One idea that is gaining favor is the use of a strain relieving interlayer (SRI) of some type placed between the old and new pavement. This idea was pursued in the spring of 1973 by the Materials Division of the Vermont Department of Highways with the emphasis on using reclaimed rubber shreds in the system.[2]

As laboratory experimentation appeared encouraging, a full scale field experiment was established with four distinct test sections within a proposed overlay on Interstate Route 91 in the town of Putney, Vermont.[3]

TEST SECTION NO. 1

On the northbound lane extending from the northerly end of the first bridge north of the Putney interchange (approximate MM 18/40), a distance of some 1.2 miles to the second bridge north of the Putney interchange (approximate MM 19/55).

Application:

1. Filling cracks in the old pavement
2. Strain relieving interlayer with rubberized asphalt slurry
3. One inch bottom course of bituminous concrete
4. One inch top course of bituminous concrete

TEST SECTION NO. 2

On the northbound lane extending from the northerly end of the second bridge north of the Putney interchange (approximate MM 19/55), a distance of approximately 0.9 miles to the median crossover just north of the Putney weighing station (approximate MM 20/50).

Application:

1. No crack filling
2. Strain relieving interlayer with rubberized asphalt slurry
3. One inch bottom course of bituminous concrete
4. One inch top course of bituminous concrete

TEST SECTION NO. 3 - CONTROL SECTION

On the southbound lane extending from the northerly end of the first bridge north of the Putney interchange (approximate MM 18/40), a distance of some 1.2 miles to the second bridge north of the Putney interchange (approximate MM 19/55).

Application:

1. Filling cracks in the old pavement
2. Regular slurry seal
3. One inch bottom course of bituminous concrete
4. One inch top course of bituminous concrete

TEST SECTION NO. 4

On the southbound lane extending from the northerly end of the second bridge north of the Putney interchange (approximate MM 19/55), a distance of approximately 0.9 miles to the median crossover just north of the Putney weighing station (approximate MM 20/50).

Application:

1. Filling cracks in the old pavement
2. Tack coat of asphalt emulsion
3. One inch bottom course of bituminous concrete
4. One inch top course of bituminous concrete

The balance of the project, approximately 12 miles, would be constructed with crack filling in the old pavement, conventional asphalt slurry seal (no rubber) and one inch bottom course of bituminous concrete followed by a one inch top course of bituminous concrete.

The standard typical for Interstates of the early 1960's is illustrated in Figure I. This was modified for the Putney project, which was completed during 1961, in that there were two 2 1/2" thick base courses instead of two 3" thick courses as shown on the typical. The bases were penetration macadam crushed stone with the 24" sub-base composed of 18" of crushed rock over 6" of sand cushion.

No information relative to the pavement condition is available except for the cracked condition shown in Appendix D which is summarized in Table I.

The overlay with experimental test sections was completed during the summer of 1973.

PROCEDURE

To be able to evaluate the success of each test section, the condition of the roadway prior to overlaying was recorded on aerial photographs. The flight was flown at a scale of 1" = 100' on May 10, 1973 with excellent results. Sufficient ground control targets were established at every other delineator throughout the test sections. Using these points as bench marks, a procedure was established to transpose the cracks from the aerial photographs to work sheets. As any variance in aircraft altitude and deviation from a level flying position would show up as a change in scale on the photographs, a proportional but varying scale was developed to locate the cracks. A template was made from a transparent material that would change as the distance between the photographed delineators changed (the standard distance between delineators is 1/20 mile with 1/10 mile or 528 feet between targeted delineators). The template was divided into 53 sections providing very nearly 10 foot intervals which proved to be the most practical scale. Fifty-four lines were drawn on the template radiating from a common point and diverging equidistant to the opposite side of the template. With this method, the outer lines of the template could be positioned to coincide with the marked delineators and any point in between could be scaled using the intermediate lines. The length, shape and type of cracks were taken from visual observation and proportional distances. Table I indicates the original lineal footage of each crack type for each test section.

Field survey schedules were established for the winter months beginning in December 1973 at approximate one month intervals. Photostatic copies[4] of the original crack patterns, as transcribed from the aerial photographs to master sheets, were taken on each field survey.

TABLE I - ORIGINAL LINEAL FOOTAGE OF CRACKS

Type of Crack	Test Section #1	#2	#3	#4
Type A - Transverse cracks that extend completely across the roadway from shoulder to shoulder.	4034'	2736'	3384'	2760'
Type B - Transverse cracks that extend across half the roadway from one shoulder to the centerline.	1296'	540'	1920'	1308'
Type C - Longitudinal cracks of any nature or cause.	183'	79'	163'	201'
Type D - Miscellaneous cracks; any cracks that do not fit the above description.	311'	203'	489'	330'

The field surveys were undertaken utilizing a "Rolatape", which is a hand pushed wheel that measures and records distances in feet. Adequate signing and traffic protection were provided for the two man recording crew. The test areas were walked with the distances recorded by the Rolatape. When cracks were observed, their location and length were recorded on the photostatic copies of the original pavement.

After each field survey was completed, the total lineal footage of each crack type was recorded for each test section. It is realized that there are many ways to present data when conducting surveys of this nature. This method allows direct comparison between sections based on the total percent of reflection.

No flights other than the original were attempted due to cost considerations. The original flight was incorporated with a flight that had been established for other purposes.

MATERIALS

The Materials Specifications[5] were written around the laboratory experiments for the composition of mixture. The vulcanized rubber shreds and aggregate combination meets the general slurry seal grading. As some reclaimed rubber has more fine granules than shreds, the specification was written to contain a maximum of 50% passing the No. 16 mesh sieve to give the rubber an appearance that is more shred-like than granular.

Vermont uses low viscosity asphalts for their paving and so requests CSS-1 for their emulsified asphalt.

The rubber and aggregate were blended at West Sand and Gravel, Walpole, Massachusetts on June 18, 1974. As it had been difficult to obtain rubber shreds that met the specification, a special rescreening was done by Eastern Products Corporation of South Boston, Massachusetts to provide specification material. The final gradation appears in Table II. The stone dust was provided by Brox Quarry, near Walpole, Massachusetts, and appears to be the universal source for general slurry aggregate. This appears in Table II and was also used in the general slurry without rubber on the control area, Test Section #3.

TABLE II - MATERIALS GRADATION

Sieve	% Passing Aggregate	Rubber	Combined Weight 27% Rubber, 73% Aggregate	Specification
#4	100	100	100	90 - 100
#8	84	89	86	65 - 90
#16	62	39	61	45 - 70
#30	47	--	40	30 - 50
#50	27	--	23	18 - 30
#200	9	--	7	5 - 15

Blending operations were done on a paved area with a front-end loader. Trucks were loaded with aggregate, weighed and dumped on the paved area. The proper weight of rubber was then calculated from the known weight of aggregate on a 73% aggregate to 27% rubber basis. The rubber was provided in 50 pound bags and was hand spread over the aggregate. This was then mixed thoroughly with the loader and loaded into haul vehicles to be transported to the job site.

The emulsion was supplied by Triram Corporation of Framingham, Massachusetts. Due to shortages in the industry, we were unable to obtain CSS-1 and used the hard based emulsion CSS-1h for the entire project.

The crack filling material was a hot poured joint sealer meeting Federal Specification SS-S-1401A. Cracks large enough to receive this material were prepared by routing, blowing and flame drying.

DISCUSSION

The aggregate and rubber were mixed, as previously described, on June 18, 1973 and then transported to the job site at Putney that evening. The material was stockpiled on a paved area at the north end of the test areas. The following morning, Tuesday, June 19, 1973, with the weather about 75°, overcast and breezy but with no rain forecast, laydown operations commenced. Two companies supplied slurry trucks to the project. A Massachusetts company had three six yard trucks that worked the travel lane with no augers in the slurry boxes. A Connecticut company had one eight and one ten yard truck that were used in the passing lane with augers in the boxes. These trucks filled with materials from the stockpile location which also had emulsion and water storage facilities. Even though the laboratory experimentation indicated cement was not necessary or even desirable in large quantities, it was decided in the field that a limited amount was needed and approximately two percent was used throughout the project.

From the outset, it appeared both companies were laying less than the desired 3/8" thickness so it was decided to place two passes to achieve that depth. The total first lift, of slightly over two miles, was placed in three and one-half hours. After lunch, the trucks set back to the beginning and tried to lay the second pass. However, even though the material had set well in one hour, the truck tires picked up the slurry and so it was decided to delay the second course until the following day. Traffic was routed over the adjacent barrel through the night.

On Wednesday, June 20, the weather was foggy in the morning, hot in the early afternoon and cloudy in the late afternoon. The second course of slurry was started with no pick up problems as it was foggy and cool. The companies were split by lane, as the previous day. At approximately MM 18/85 $\pm$ 150 feet, the material being laid on the travel lane became very thick approaching 1/2" depth. As the box could not be lowered to reduce the thickness, the truck was removed from the project at MM 18/95 due to an apparent proportioning malfunction. The second course of slurry was stopped at MM 19/20 + 50 feet, in Test Section #1, due to the concern that there would not be enough rubber slurry aggregate to double coat Test Section #2 which had no crack filler. Therefore, there is approximately 1800 feet at the north end of Test Section #1 that has only 3/16" to 1/4" of rubber slurry. As an experiment, one course of rubber slurry was put on the bridge dividing Test Section #1 and #2. In Test Section #2, the travel lane has two slurry courses from the bridge to MM 20/35 + 50 and the passing lane has two courses to the project end (MM 20/50 + 125'). The slurry was stopped in the travel lane at that station in order to provide entrance and exit to the stockpile areas. By noon, the weather was clear and hot enough that the slurry truck began picking up some of the previous day's slurry. Water was sprayed ahead of the tires to reduce this problem. When the weather clouded over later in the afternoon, this problem disappeared.

The following costs of the test sections are based on the 1973 bid prices for the project. The crack filler cost approximately $3,850.00 per mile based on the approximate 27 miles of 24 foot wide pavement programmed for crack filling. This includes routing, blowing and placing the hot poured rubber asphalt at $1.00 per pound. The rubber slurry cost approximately $16,230.00 per mile, 26 feet wide, in place. Should closer sources of acceptable aggregate be found, this could decrease somewhat. The aggregate was $14.60 per ton, the rubber was $205.00 per ton and the emulsion was $9.75 per hundred weight. General slurry was applied to nearly 25 miles of roadway 26 feet wide (thus allowing a one foot overlap on each shoulder) at a cost of approximately $4,280 per mile. The aggregate and emulsion price was the same as for the rubber slurry. The emulsified asphalt treatment for Test Section #4 cost $535.00 per mile based on a bid price of $0.35 per gallon with a 0.1 gallon per square yard application. The cost per mile for a particular application is shown in Table III.

TABLE III - COST PER MILE FOR APPLICATION TYPE

Test Section	Crack Filler	Emulsion Tack Coat	General Slurry	Rubber Slurry	Total Cost Per Mile
#1	$3,850	NO	NO	$16,230	$20,080
#2	NO	NO	NO	$16,230	$16,230
#3	$3,850	NO	$4,280	NO	$ 8,130
#4	$3,850	$535	NO	NO	$ 4,385

RESULTS

Nine field surveys have been done since the project was completed in 1973. These surveys were taken December 11, 1973; January 8, 1974; January 28 and 29, 1974; February 5 and 6, 1974; April 3 and 4, 1974; August 22 and 23, 1974; January 28 and 30, 1975; April 9 and 10, 1975; and March 30 and 31, 1976. The cracks that were recorded in the spring of 1974, 1975, and 1976 have been shown as a percentage of original cracks for each test section in Table IV. The count indicates that section #1 (crack filler and rubber slurry) has reflected approximately 49% of the original cracks through the third winter season. Section #2 (no crack filler but cracks blown and with rubber slurry) shows approximately 41% reflection. Section #3 (crack filler and regular slurry) is the poorest performer of any section with approximately 56% reflection after the third winter. This had been our standard overlay design. Section #4 (crack filler and RS-1 tack) has approximately 51% reflection at this time and was the lowest cost initial application.

Freezing indexes expressed in cumulative degree days as recorded near the test area for the three winter seasons were 704 for 1973-1974, 744 for 1974-1975 and 1055 for 1975-1976.

Traffic counts expressed in ADT for the test area were 8400 for 1973, 7400 for 1974, and 7800 for 1975.

The second bridge north of the Putney Interchange (approximate MM 19/55) which received one course of rubber slurry and one course of pavement indicated distress almost immediately. This indicates that one inch of pavement does not contain enough structural integrity to withstand traffic over rubberized slurry.

TABLE IV
PUTNEY I 91 - LINEAL FOOTAGE OF CRACKS - REFLECTING

Section	Crack Type	Originally 5/10/73	Surveyed 4/3&4/74	Percent of Original	Surveyed 4/9&10/75	Percent of Original	Surveyed 3/30&31/76	Percent of Original
#1	A	4034	0		48		720	
#1 crack filler	B	1296	0		120		1008	
#1 and	C	183	334	7	8	9	308	49
#1 rubber slurry	D	311	84		347		797	
Total		5824	418		523		2833	
#2 no crack filler	A	2736	0		120		672	
#2 cracks blown	B	540	72		144		432	
#2 and	C	79	90	9	0	16	80	41
#2 rubber slurry	D	203	150		305		277	
Total		3558	312		569		1461	
#3	A	3384	24		72		264	
#3 crack filler	B	1920	948		1632		2376	
#3 and	C	163	155	43	121	43	112	56
#3 regular slurry	D	487	1417		727		582	
Total		5954	2544		2552		3334	
#4	A	2760	0		144		744	
#4 crack filler	B	1308	384		720		1104	
#4 and	C	201	59	22	60	28	105	51
#4 RS-1 tack	D	330	557		383		391	
Total		4599	1000		1307		2344	

Crack type Definitions =
A = transverse from shoulder to shoulder
B = transverse from centerline to shoulder
C = longitudinal of any nature
D = miscellaneous

The counts taken in the spring of 1974 and 1975 indicated a substantial degree of success for the rubberized slurry areas when compared to control section #3 and the tack coat section #4. However, after the third winter all sections were sufficiently cracked to show no clear cut advantage to any particular system. The Freezing Indexes indicate previous winters were not as severe as the 1975-1976 winter season. A neighboring state documented a 70^{o} F. temperature change within 6 hours in January of 1976, which Vermont undoubtedly experienced also. This change in temperature apparently induced stresses that were too great for the rubberized slurry to overcome, and all sections were very nearly equalized. Transverse cracks showed the greatest increase during the third winter. These particular cracks were the ones Vermont was trying to overcome. While an evaluation of Table IV indicates transverse crack reflection percentages of 32% for section #1, 34% for section #2, 50% for section #3 and 45% for section #4, the 10% to 15% advantage for the rubber slurry areas could be reduced substantially during any severe temperature change.

It is evident that climatic conditions can occur at random times and nulify attempts with rubberized slurry to overcome the stresses of nature. As these conditions can not be predicted with any degree of certainty, it is recommended that rubberized slurry be discontinued in Vermont as a means of reducing reflection cracks in bituminous overlays. This recommendation is based on an initially high first cost and an unpredictable useful life span.

The reflective cracks documented during the final spring survey taken in 1976 have been shown as over lines on Appendix D.

CONCLUSIONS

1. Rubber slurry cannot prevent the reflection of cracks through a two inch dense graded bituminous concrete overlay when a large temperature change occurs during the winter season.
2. After a severe winter season, cracks in original pavements reflect through a two inch dense graded bituminous overlay at approximately the same rate for treatments which include rubberized slurry, crack filling, general slurry, tack coats or combinations thereof.
3. Other means of preventing reflection cracks through bituminous concrete overlays must be explored.

REFERENCES

1 "National Experimental & Evaluation Program Reducing Reflection Cracking in Bituminous Overlays", Appendix A.

2 "Use of Rubber Aggregate in Slurry Seal as a Strain Relieving Interlayer for Arresting Reflection Cracks", Appendix B.

3 "National Experimental & Evaluation Program Reducing Reflection Cracking in Bituminous Overlays, Vermont Department of Highways, Work Plan No. 1", Appendix C.

4 "Photostatic Copies of the Original Roadway Cracks", Appendix D.

5 "Vermont Department of Highways Rubberized Slurry Seal Supplemental Specifications", Appendix E.

INTERSTATE TYPICALS

W/i Submission #2

3" SURFACE COURSE
2-3" BASE COURSES
SINGLE TACK COAT WITH SAND COVER

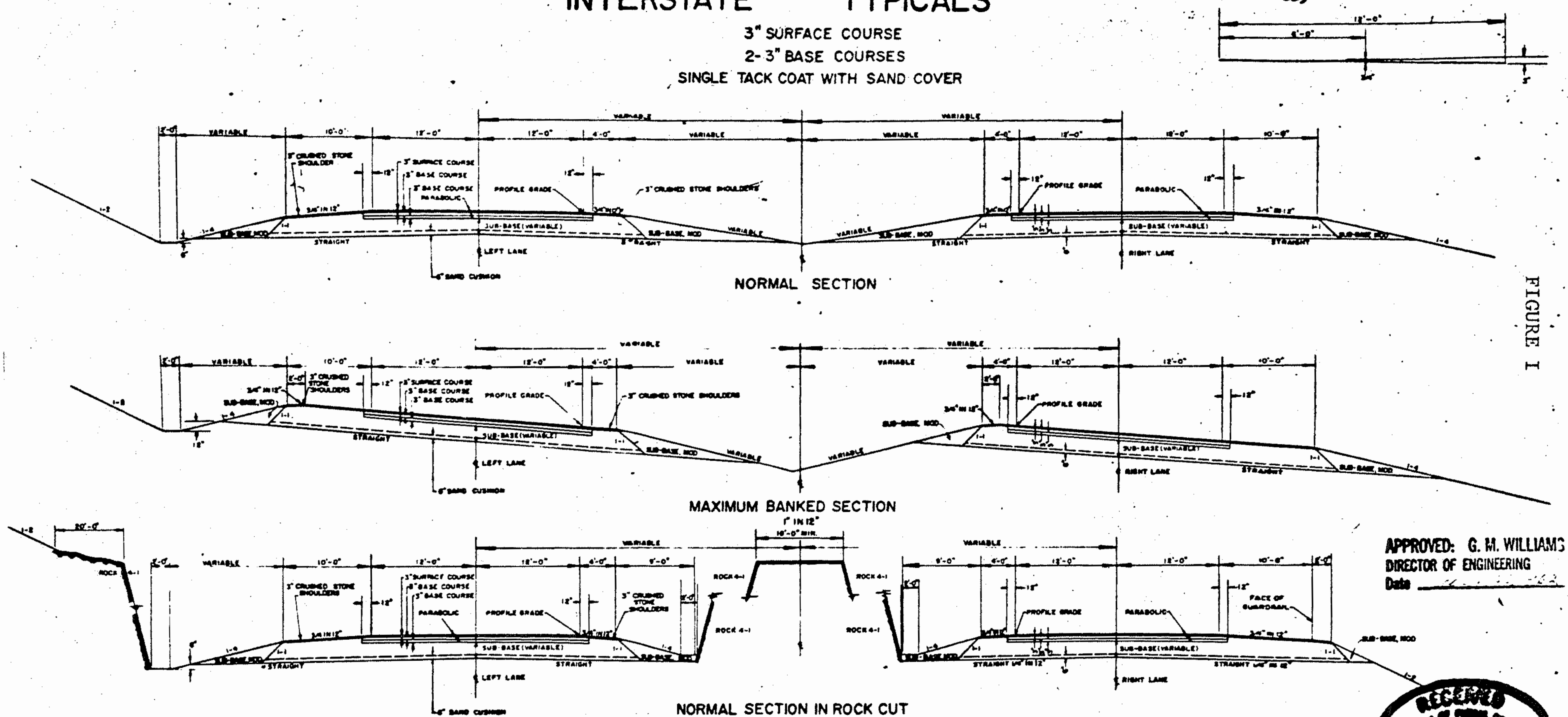


FIGURE I

APPROVED: G. M. WILLIAMS
DIRECTOR OF ENGINEERING
Date

RECEIVED
MAR 10 1961
ENGINEERING

REVISIONS AND CORRECTIONS	APPROVED DATE FEB 8, 1960 A. D. Bishop CHIEF ENGINEER G. M. Lang HIGHWAY ENGINEER C. H. Stickney CONSTRUCTION ENGINEER DRAWN R.L.E. TRACED R.L.E.	STANDARD INTERSTATE TYPICALS	VERMONT DEPARTMENT OF HIGHWAYS STANDARD	A-1

PROJECT NEEP - 10: REDUCING REFLECTIVE CRACKING IN BITUMINOUS OVERLAYS
INFORMATIONAL MEMORANDUM CMPB-16-70 (MAY 12, 1970)

Objective: To obtain a solution to the problem of preventing or greatly minimizing the development of cracks reflected through overlays on old cracked bitminous pavements. This project was not directed to solving the problem of reflection cracks in bituminous overlays over cracked portland cement concrete pavements where stresses and movements are considered to be more severe.

The following States have participated in various degrees in this program to date: Arizona, California, Colorado, Florida, Louisiana, New Hampshire, North Dakota, North Carolina, Oklahoma, South Carolina, Wyoming, and Virginia.

To date, there have been no significant promising trends reported with respect to one or more of the seven test features suggested in the memorandums dated May 12, 1970, October 13, 1970, and July 16, 1971. Most test sections have been in place less than 2 years and the first possible important trends are not anticipated until 1973 spring inspections.

Considerable interest has been manifested in the use of synthetic fabrics for reflection cracking reduction mostly due, it is believed, to strong industry promotion campaigns. According to reports from the field, there is no indication at this time that synthetic fabrics are the answer to the problem, but also the converse is also true, that no evidence of obvious unsatisfactory performance has been demonstrated. A number of fabrics are now being promoted for use in this NEEP work, including Phillips Petroleum's "Petromat;" Monsanto Chemical Company's "Cerex," a spun bonded nylon; Pittsburgh Plate Glass Company's fiberglass mat; Burlington Glass Fabrics Company, glass fabric and "Structofors," polyester fiber mat. Fabrics of this kind apparently offer the advantage of resistance to effects of contact with roadway deicing solutions that accelerated the demise of steel mesh reinforcement in bituminous overlays.

North Dakota, which placed six test sections and a control section on its Interstate 94 project, advised in a March 1972 report that reflection cracks have occurred in all of the sections. Average crack spacings were recorded and on the basis of those average values, the test section utilizing the slurry seal which contains a high percentage of ground reclaimed automobile and truck tires was performing better than the other sections. In order of decreasing values of crack spacing the sections ranked as follows: (1) rubber slurry, 105 feet; (2) "Petromat," 91 feet; (3) plant-mix seal, 86 feet; (4) East slurry seal, 79 feet; (5) control section, 78 feet; (6) "Structofors," 76 feet; (7) asphalt cement treated sand, 70 feet; and (8) West slurry seal. Slurry seals, East and West, are similar sections.

With but scattered reporting received to date on projects under this program, it is strongly urged that a concerted inspection of all test sites be conducted in April or May 1973, depending upon the local climatic conditions, and reports made on the results of the inspections. Possible significant trends may be evident at that time. FHWA is presently considering the development of a summary of States' findings on this NEEP project in mid-1973 and any input from those States participating in this program would be valuable.

USE OF RUBBER AGGREGATE IN SLURRY SEAL AS A STRAIN RELIEVING INTERLAYER FOR ARRESTING REFLECTION CRACKS

REPORT 73-2

March 1973

VERMONT DEPARTMENT OF HIGHWAYS

J. T. Gray, Commissioner

R. H. Arnold, Chief Engineer

A. W. Lane, Materials Engineer

Report Prepared By

Bituminous Concrete Subdivision

APPENDIX B

INTRODUCTION

During the fall of 1971, the Bituminous Concrete Subdivision initiated a memorandum relative to reflective cracking in which it was stated that:

> "Reducing reflection cracking in bituminous overlays is a national concern (see FHWA CMPB 16-70 and HO-31 of October 13, 1970) as well as a State concern (observe the condition of overlays placed in 1969 and 1970)".

It was also pointed out that the application of a slurry seal does little to rectify this particular problem as our overlays using slurry showed reflection cracks the first winter to a large degree.

In January 1973, a follow up memorandum was sent from the Bituminous Concrete Subdivision which stated:

> "The need for some means of preventing or reducing the reflection of cracks through our overlays is evident. Each year miles of cracked pavement is covered with up to two inches of new mix and after the first winter, it is sometimes difficult to know which section of the highway has or has not been repaved. This problem is not unique to Vermont and various agencies have worked on this problem over a span of years. The use of wire or fabric reinforcing has been used, along with a multitude of others. Basically, however, these other ideas did not provide for a stable bond breaker. They provided for a definite bond between the two layers and even though concepts such as softer asphalts were used in the new layer on top, it was bonded in such a manner that as the old pavement moved, the new material was not sufficiently elastic to absorb the movement.

In March of 1972, this section researched what we called 'Investigation of Recovered Ground Rubber as a Sandwich Course to Prevent Reflection Cracking'. Rubber shreds from a local tire recapping firm were mixed approximately 50/50 with asphalt cement to which slabs of hot mix were secured. With the slabs secured at one end, the lateral displacement of the base containing the rubber-asphalt blend was attempted prior to the cracking of the asphalt slab. However, as so many physical problems occurred, this research was suspended. The concept was considered valuable and while attending the Slurry Seal Seminar on November 10, 1972 at Concord, New Hampshire, it was mentioned that Massachusetts was working on this same concept. Subsequent contact with Mr. Gene Bastanza, Chief of Laboratory, Massachusetts Department of Public Works, has provided us with their proposed specification and a back up paper titled 'Use of Rubber Aggregate in a Strain Relieving Interlayer for Arresting Reflection Cracks in Pavements' by Gallaway and LaGrone.

This paper was prepared for presentation at the International Symposium on "The Use of Rubber in Asphalt Pavements" at Salt Lake City, Utah in May of 1971. Briefly stated, this paper indicated:

"A most troublesome problem encountered in design and maintenance of asphalt concrete pavements is that of reflection cracking caused by some type of foundation movement or shrinkage problem. These reflection cracks reduce the effectiveness of the pavement by loss of structural strength, by allowing intrusion of water into the pavement and down into the supporting structure, and/or by reducing the long-lasting smooth-riding quality of the surface.

It has been demonstrated that a 'Strain Relieving Interlayer' composed of approximately equal parts by volume of vulcanized rubber aggregate, mineral aggregate, and residual asphalt emulsion will produce a waterproof membrane that can accommodate substantial base movement without transmitting excessive strain to the surface course and will, thus, alleviate reflection cracks.

Laboratory data developed using an analog of a layered highway system has shown that allowable foundation movement before cracks reflected to the surface course would be 300% greater for a pavement system utilizing a 1/8 inch layer of the SRI composition and 440% greater for a 1/4 inch layer of the SRI composition. Strain relieving interlayers of more than 1/2 inch are not recommended due to possible stability problems".

With this background, a slurry seal company was contacted for materials so that experimentation could be conducted in our own laboratory.

PROCEDURE

In the manufacture and testing of these slurry seals, certain steps were laid down and adhered to. To begin with, all apparatus and materials were kept at room temperature (approximately 75°F). Also, each series of five samples were based around a 210 gram sample with slight variations due to varying the amount of one component of mix within that series. The weighing apparatus (Mettler P 11 N) has a range of 10 kg. with a precision of 0.1 gm. The hand mixing apparatus consisted of a cylindrical tin 2" deep and 3 1/2" in diameter and standard spatula.

First, air dry aggregate was placed in the mixing tin. Cement (Type I) was then added and mixed thoroughly with the aggregate. The shredded rubber was then added and also mixed thoroughly. After this, the desired water content was added and mixed to completely cover the dry material, thus being used as a carrying agent for the asphalt emulsion. Finally, the emulsion was added and the mixing time was set at two minutes to duplicate field mixing.

After the mixing was completed, the material was spread on a piece of 6"x8" sheet metal flashing with the sample being enclosed by a template of rectangular shape (4"x6" interior dimensions) and a depth of 3/16 of an inch. It was then allowed to cure at room temperature for a period of 18 hours. At the end of this time, the enclosing template was carefully removed and the supporting metal and specimen were placed in a freezer at 0°F for four hours.

To test the elasticity and rebound qualities of the mix, each sample was removed from the freezer and immediately bent over a 4" diameter mandrel. Pictures were taken and descriptions were noted of the results of bending the samples to an angle of 90°

After each series was tested, the specimen displaying the best overall qualities was noted and the following series were run using this as a standard and using some other ingredient of the mix as the variable.

APPENDIX B

MATERIALS

Preliminary tests were started with materials submitted by a Massachusetts slurry seal company. However, we were unable to combine the aggregate and CSS-1h emulsion in any reasonable proportions even though the materials were basically the same as were used on the Westminster-Rockingham overlay of 1972.

Sieve Size	Brox "A" 1972	Brox "B" 1973	Average 1972
4	100	100	100
8	95	96	91
16	70	71	64
30	47	52	47
50	31	37	30
200	10	13	12

Brox "A"	Original gradation submitted in 1972 as preliminary samples to be used on the Westminster-Rockingham overlay.
Brox "B"	Submitted for use with rubberized slurry seals.
Average 1972	This is the average grading of materials used on Westminster-Rockingham overlay.

During this period of preliminary testing, all materials were checked against the specifications and were found to be within reasonable compliance. Nothing was found that would indicate poor compatibility. The slurry seal company had duplicate samples of these materials and checked the results of our testing at their laboratory. Our results were substantiated by their people. It was determined by the emulsion supplier that a change in the gradation of Brox's aggregate was the source of trouble regarding the incompatibility of the materials. The emulsion supplier indicated the particular problem was due to a change in gradation on the No. 325 sieve.

APPENDIX B

New materials supplied by the slurry seal company were delivered to our laboratory in late January. These materials came from West Sand and Gravel, Walpole, Massachusetts.

CRUSHED STONE AGGREGATE

Sieve Size	Fine Aggregate "A"	Coarse Aggregate "B"	As Supplied Blend Used in Tests	Slurry Spec. General
4		100	100	90-100
8		78	85	65-90
16	100	39	61	45-70
30	96	20	48	30-50
50	56	9	26	18-30
200	16	2	7	5-15

Preliminary tests were made on these new materials and they were found to be compatible with the CSS-1h emulsion.

The vulcanized rubber shreds supplied were number 4 buffings without metal or fiber cord. This material passes the #4 sieve 100 percent.

APPENDIX B

DISCUSSION

Four preliminary samples were made to familiarize ourselves with a rubberized slurry seal. These four samples were made as follows (all weights in grams).

Sample No.	Aggregate	Cement	Rubber	Water	Emulsion	Original Appearance
101	100	4	40	20	36	ok
102	110	4	40	10	36	ok
103	120	4	40	0	36	dry
201	110	4	40	15	40	wet

After curing these materials at room temperature for two days, we decided to establish a basic mix formula and revolve our testing around it. The basic sample that was decided upon is indicated by the sample marked 201. This was due to its appearance after it had cured. During the initial curing period, it was felt this sample was too wet to be used but after it had set up, it gave a better overall appearance.

The "A" series was formulated around sample #201, varying the water content for A-1 through A-4 and can be found in Table I. A-5 was made by increasing the emulsion content. The A-5 sample appears to be the best in regards to tensile quality and for recovering to normal appearance. However, it starts out as a very fluid and wet mix and might cause problems during lay down operations.

The "B" series was formulated with a varying emulsion content (Table I), but not run. This was because the "A" series indicated emulsion contents less than 40 grams would not be worthwhile to run.

The "C" series was tried by varying the rubber content around the A-5 sample (Table I). The "C" series samples did not prove to give the exact results that were expected. C-3, which should have equaled A-5 in recovery, broke straight and it appeared that C-1 was more equal to A-5, although it had more rubber in it. However, it was decided to continue with the A-5 formulation and vary the water content for the "D" series. At this time, a series of photographs was returned which proved to be inadequate to show the failures for the "A" series.

The "D" series (Table I) was, therefore, observed more astutely concerning setting times and failure performance. After four hours of curing, both D-1 and D-2 were still slightly tacky but D-3 and D-4 were set. After three hours, D-3 was slightly tacky and D-4 was firm but not completely set. This indicated that decreasing water contents shortens setting times. Following the 18 hour cure and the four hour freezer periods, D-3 and D-4 had a coarse texture and had definite breaks with no recovery. D-2 had a medium texture and cracked approximately halfway through the sample but closed when returned to a flat position. D-1 was fine textured and when bent 90^{o} over the 4" mandrel, a fine hairline crack appeared which disappeared when the sample was returned to its original position. This series indicates that water in proper proportions is important as far as texture, mixability, spreading and flexibility of the mix.

The "E" series (Table I) was run changing the cement content. This particular series was started late in the day and observations on setting could only be made up to two hours. At the end of the two hour period, only E-5 was nearly set or cured. After removal from the freezer and bending over the 4" mandrel, E-1 cracked halfway through the sample and returned acceptably when flattened out. E-2 and E-3 responded similarly to E-1 except the crack was not as deep. E-4 had a fine crack with good rebound qualities while E-5 had a hairline crack with excellent rebound qualities. This showed that while using this type of aggregate, cement was not needed to retard setting of the material while mixing and that better results were achieved when no cement was used as far as setting time and quality of material after set up.

It should be mentioned here, that at the beginning of the experimentation, that the "A" series was bent 90° over a 1" bar after being removed from the freezer. However, as this proved to be too restrictive a test, the "A" series was duplicated and a 4" mandrel was used for bending all samples.

APPENDIX B

CONCLUSION

By starting with a basic mix and then varying one component of the mix throughout a series of slurry mixes, it was attempted to transcend from one series to the next, basing the new series on the most favorable findings of the latter. In this way, it was hoped to arrive at the most suitable mix, bearing the desired qualities, using specified percentages of materials used.

As mentioned in the text of the report (Series "D"), the amount of water used is very important as far as texture, mixability and spreading and also in the finished quality of the mix. In Series "E", it was found cement was not needed in lengthening the mixing time for suitable mixing. It was also noted that with the absence of cement, the set up time was reduced and a better quality product resulted. Before this, it had been assumed cement was needed to lengthen mixing time, but this did not prove true using this type of aggregate. However, other aggregate sources may need cement.

Our tests indicate that the materials submitted in 1972 and 1973 were basically the same and yet one set of aggregates were not good. This would indicate a grading problem could exist in an aggregate and not be found until being incorporated on a project without proper laboratory investigation.

In view of literature reviews as well as our own laboratory findings, we wholeheartedly endorse the SRI concept in theory, as well as the use of a rubberized emulsion slurry in particular. It is considered that this is possibly an exciting breakthrough in the solution of one of our major maintenance problems. The cost of the rubberized slurry will be approximately twice that of normal slurry that is presently used prior to overlays, but the crack filling process may hopefully be bypassed, thus equalizing the cost.

APPENDIX B

RECOMMENDATION

It is recommended that the Department investigate rubberized slurry seal from an economic standpoint based around the following proportioning of ingredients.

	Aggregate	Cement	Rubber	Water	Emulsion
% by weight	52	0	20	7	21
% by volume	38	0	35	7	20

APPENDIX B

TABLE I

	Aggregate	Cement	Rubber	Water	Emulsion
			BASIC FORMULA (WEIGHTS IN GRAMS)		
	110	4	40	15	40
			"A" SERIES		
A-1	110	4	40	15	40
A-2	110	4	40	10	40
A-3	110	4	40	5	40
A-4	110	4	40	0	40
A-5	110	4	40	15	45
			"B" SERIES		
B-1	110	4	40	15	35
B-2	110	4	40	15	30
B-3	110	4	40	15	25
B-4	110	4	40	15	20
B-5	110	4	40	15	15
			"C" SERIES		
C-1	110	4	50	15	45
C-2	110	4	45	15	45
C-3	110	4	40	15	45
C-4	110	4	35	15	45
C-5	110	4	30	15	45
			"D" SERIES		
D-1	110	4	40	15	45
D-2	110	4	40	10	45
D-3	110	4	40	5	45
D-4	110	4	40	0	45
			"E" SERIES		
E-1	110	4	40	15	45
E-2	110	3	40	15	45
E-3	110	2	40	15	45
E-4	110	1	40	15	45
E-5	110	0	40	15	45

APPENDIX C

NATIONAL EXPERIMENTAL & EVALUATION PROGRAM
REDUCING REFLECTION CRACKING IN BITUMINOUS OVERLAYS

VERMONT DEPARTMENT OF HIGHWAYS
WORK PLAN - No. 1

OBJECTIVE OF EXPERIMENT

To determine the effectiveness of a strain relieving interlayer composed of a rubberized asphaltic slurry seal designed to reduce reflective cracking in bituminous overlays. The rubberized slurry seal sections will be compared with a section treated with a regular slurry seal and a section treated with an asphalt emulsion tack coat.

PROJECT

Brattleboro-Westminster I 91-1(40)

PROJECT LOCATION

In the county of Windham, Vermont beginning at a point approximately 1.012 miles south of the Brattleboro-Dummerston Town Line on Interstate 91 and extending in a northerly direction 14.027 miles.

TEST SECTION NO. 1

On the northbound lane extending from the northerly end of the first bridge north of the Putney interchange, a distance of some 1.2 miles to the second bridge north of the Putney interchange.

Application:

1. Filling cracks in the old pavement
2. Strain relieving interlayer with rubberized asphalt slurry
3. Bottom course of bituminous concrete
4. Top course of bituminous concrete

TEST SECTION NO. 2

On the northbound lane extending from the northerly end of the second bridge north of the Putney interchange, a distance of approximately 0.9 miles to the median crossover just north of the Putney weighing station.

Application:

1. No crack filling
2. Strain relieving interlayer with the rubberized asphalt slurry
3. Bottom course of bituminous concrete
4. Top course of bituminous concrete

TEST SECTION NO. 3 - CONTROL SECTION

On the southbound lane extending from the northerly end of the first bridge north of the Putney interchange, a distance of some 1.2 miles to the second bridge north of the Putney interchange.

APPENDIX C

Application:

1. Filling cracks in the old pavement
2. Regular slurry seal
3. Bottom course of bituminous concrete
4. Top course of bituminous concrete

TEST SECTION NO. 4

On the southbound lane extending from the northerly end of the second bridge north of the Putney interchange, a distance of approximately 0.9 miles to the median crossover just north of the Putney weighing station.

Application:

1. Filling cracks in the old pavement
2. Tack coat of asphalt emulsion
3. Bottom course of bituminous concrete
4. Top course of bituminous concrete

The balance of the project, approximately 12 miles, would be constructed with joint filling in the old pavement, the conventional asphalt slurry (no rubber) and bottom course of bituminous concrete followed by the top course of bituminous concrete.

DURATION OF STUDY

The evaluation period shall continue for two years or for the length of time required to obtain valid conclusions on the effectiveness of the experimental treatments.

SURVEILLANCE

During the application of the experimental and control treatments and at least twice yearly for the duration of the study.

REPORTS

A. Initial Report
Shall include information on:

1. Roadway typical design being overlaid.
2. Pavement condition prior to overlay
3. Application of treatments
4. Initial observations
5. Initial costs

B. Interim Reports
Shall include information on:

1. Field observations describing the pavement performance
2. Climatic conditions
3. Traffic data

C. Final Report
Shall include information on:

1. All data included in initial and interim reports
2. Conclusions on the effectiveness of each treatment
3. Recommendations with respect to continued use or to further experimentation.

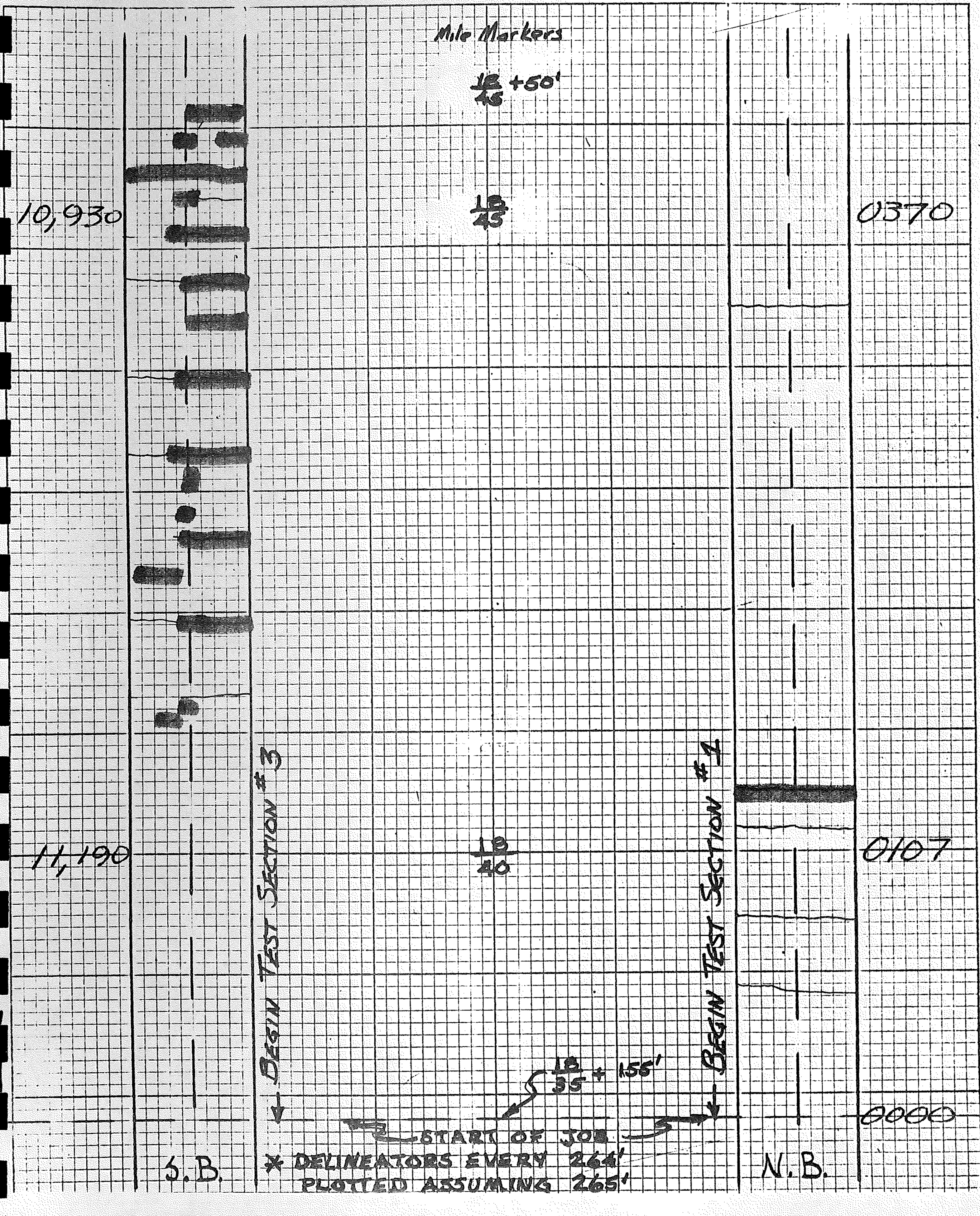
BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

APPENDIX D

* SCALE 1" = 50'

CROSS SECTION - 10 SQUARES TO INCH



BRATTLEBORO-WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

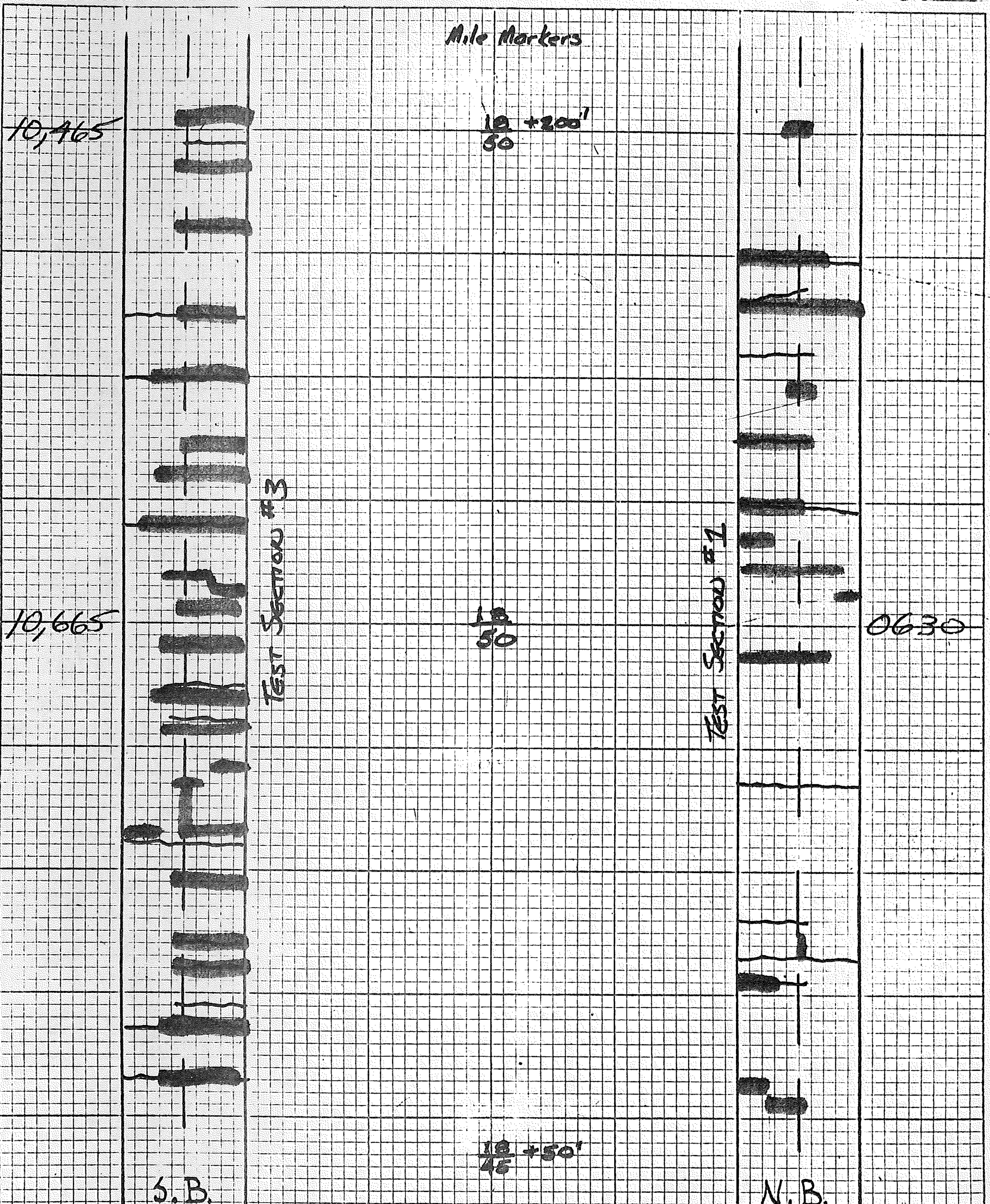
"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SHEET 2 OF 27

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)

REFLECTIVE CRACKING SURVEY

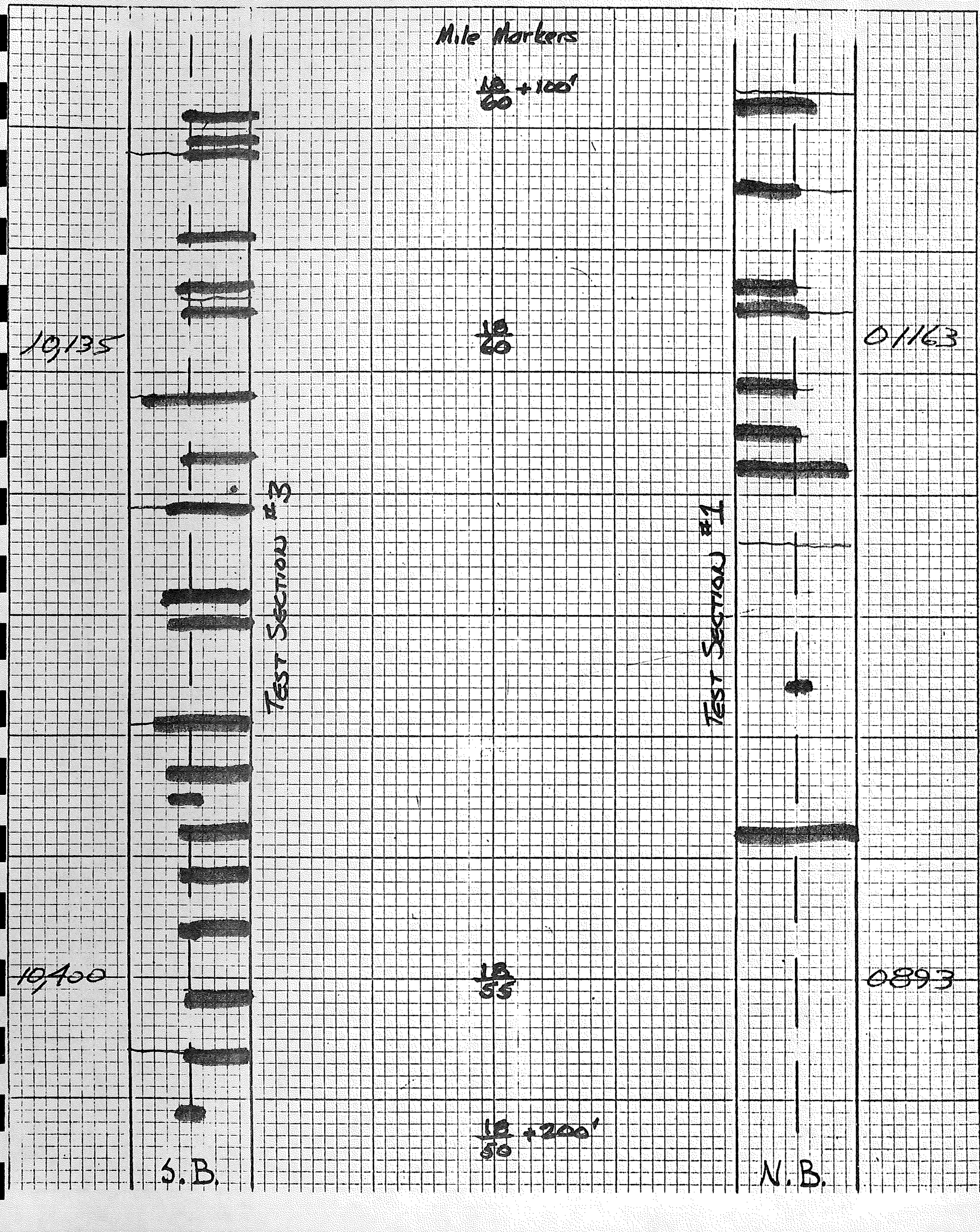
"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SHEET 3 OF 27

SCALE 1" = 50'

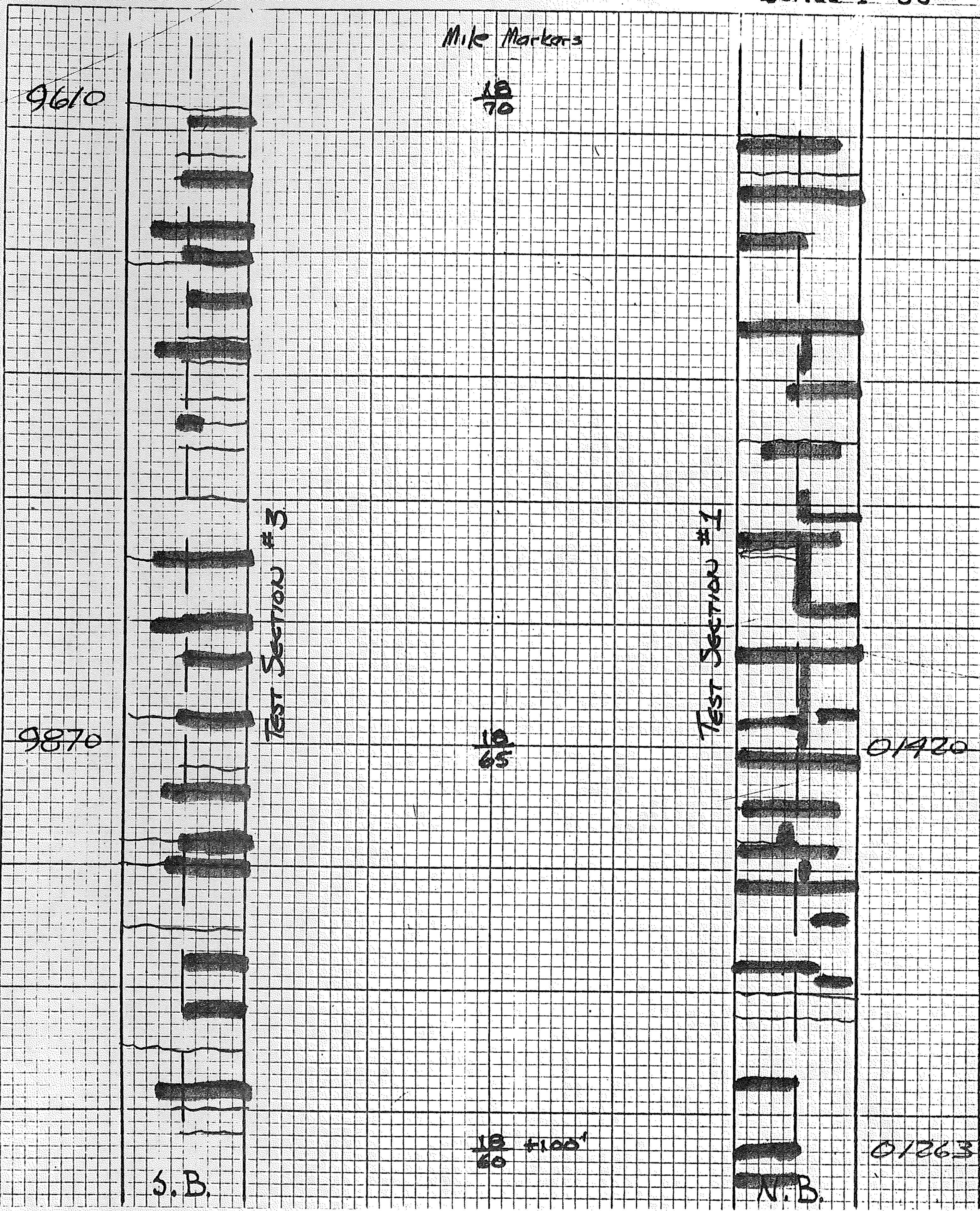


BRATTLEBORO-WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

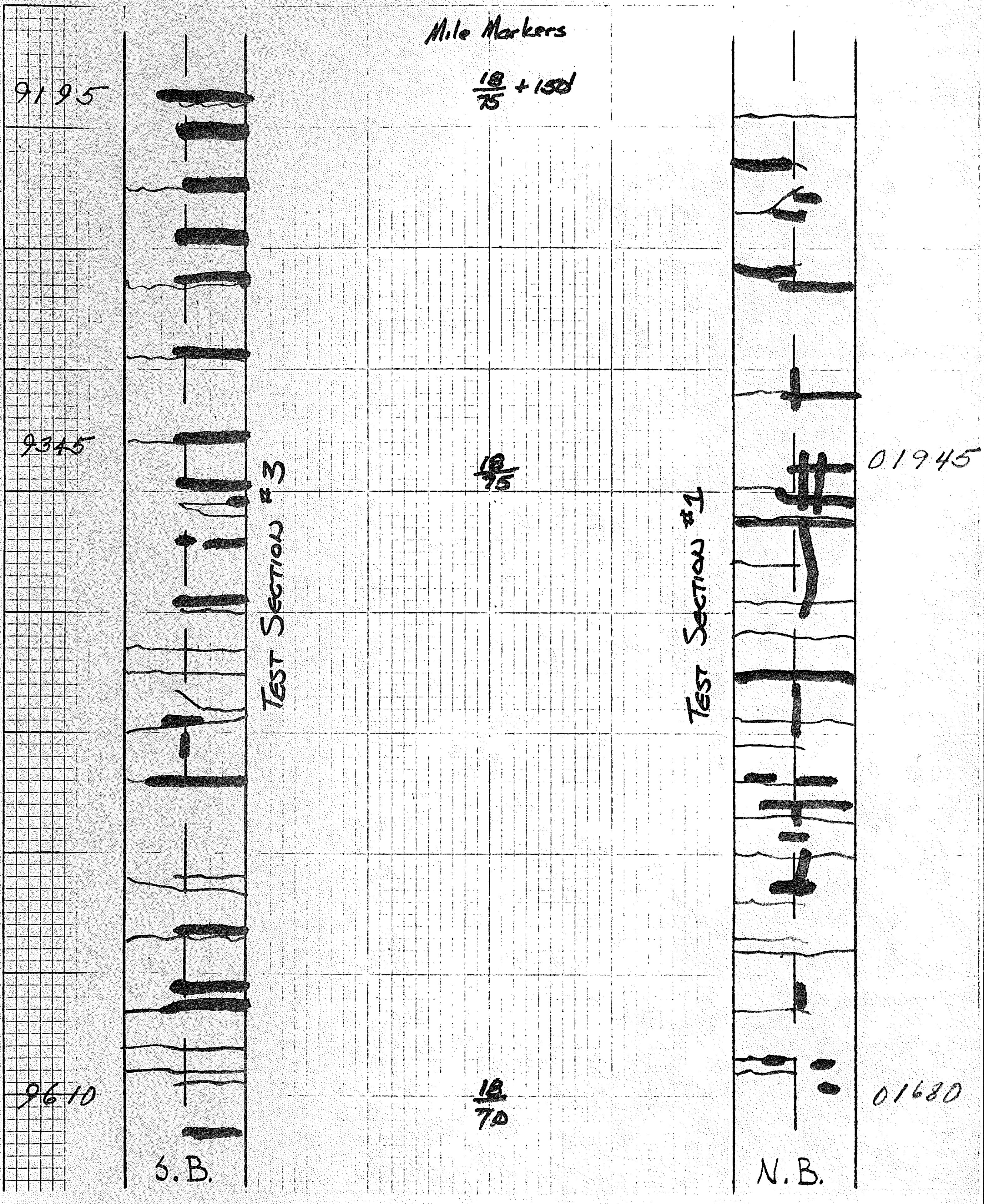
SCALE 1" = 50'



BRATTLEBORO - WESTMINSTER I 91 - 1 (40)
REFLECTIVE CRACKING SURVEY

SHEET 5 OF 27

SCALE 1" = 50'



BRATTLEBORO - WESTMINSTER I 91-1(40)

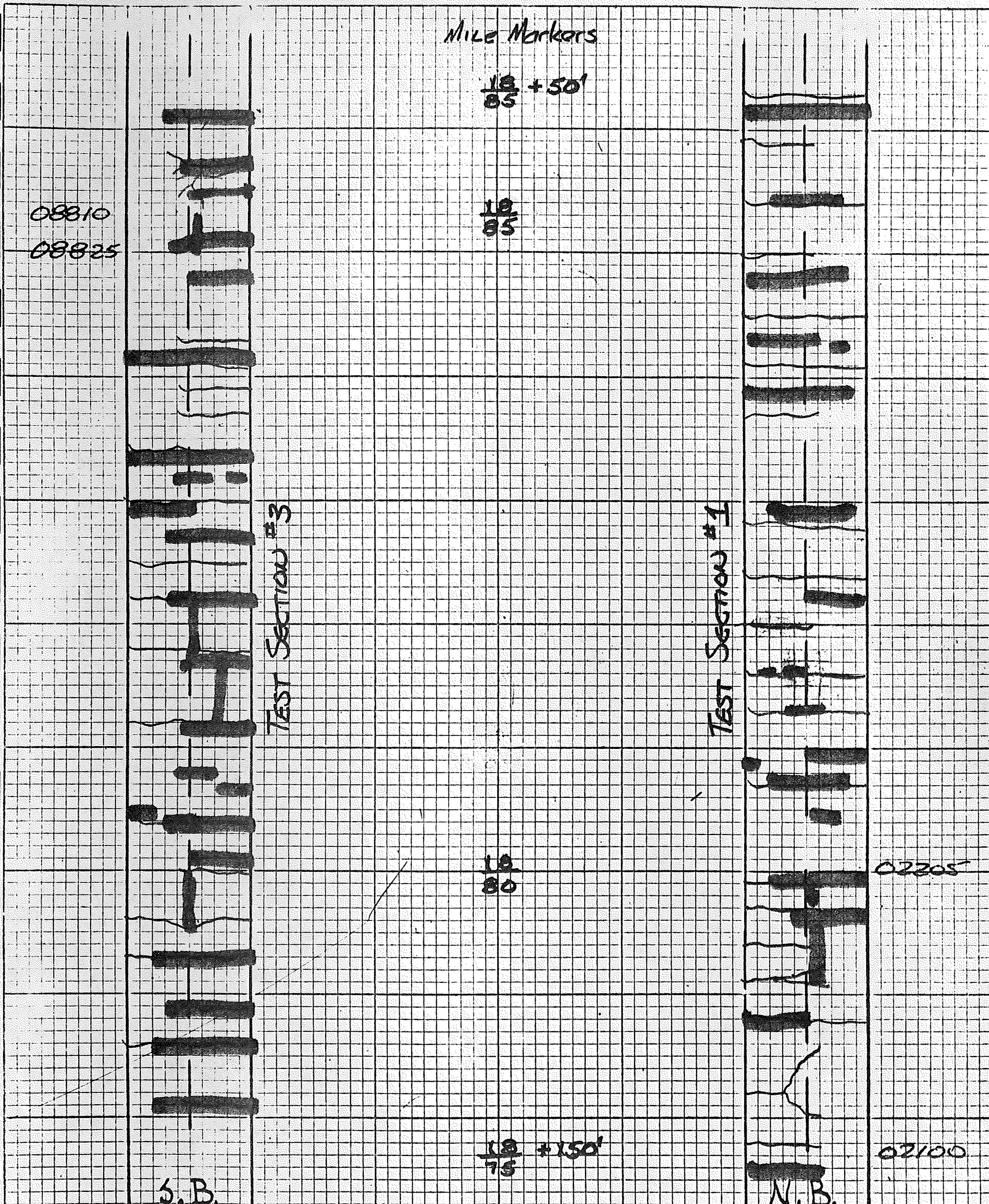
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

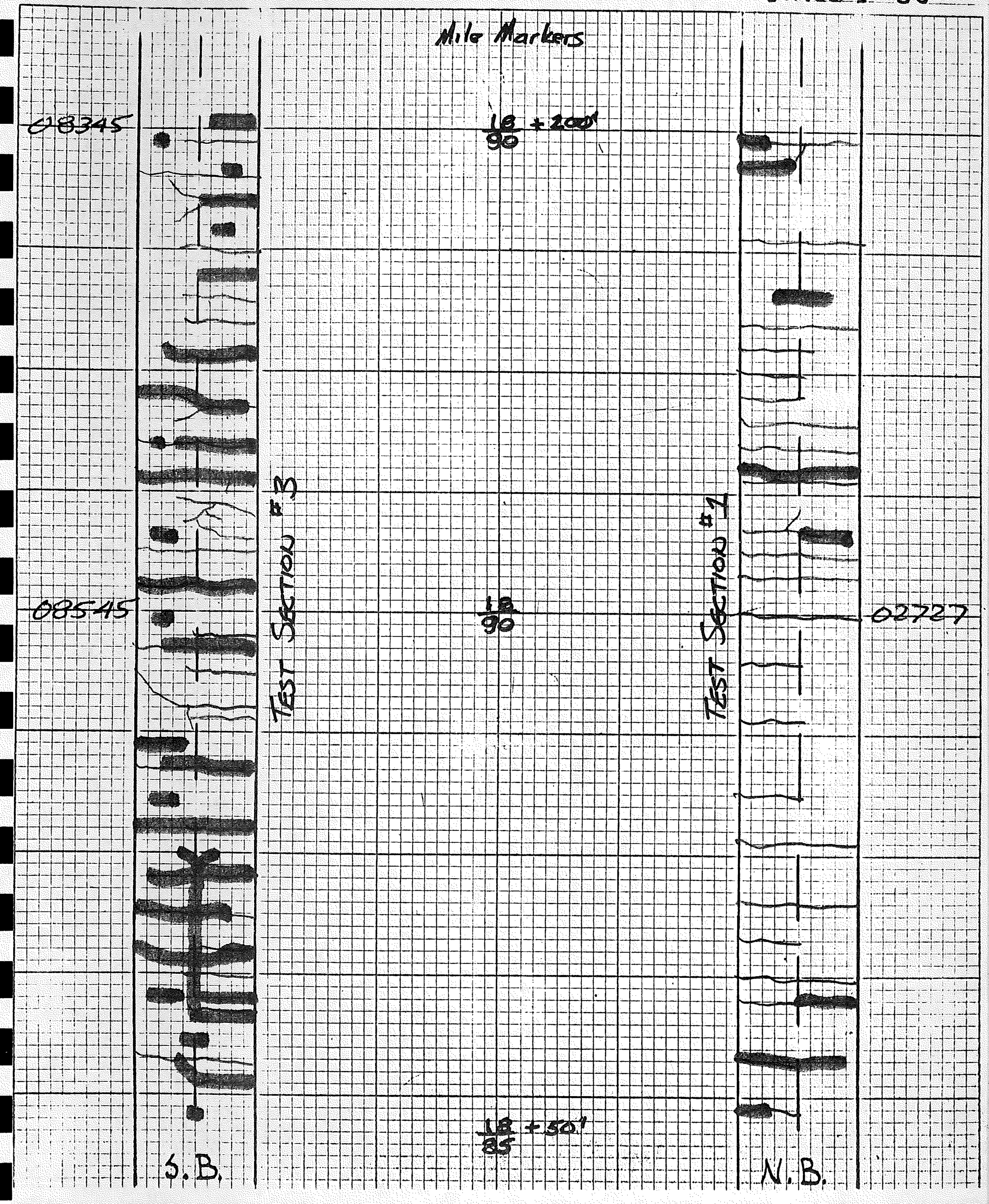
SHEET 7 OF 27

"THE CHAMPION LINE" NO. 010

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)

REFLECTIVE CRACKING SURVEY

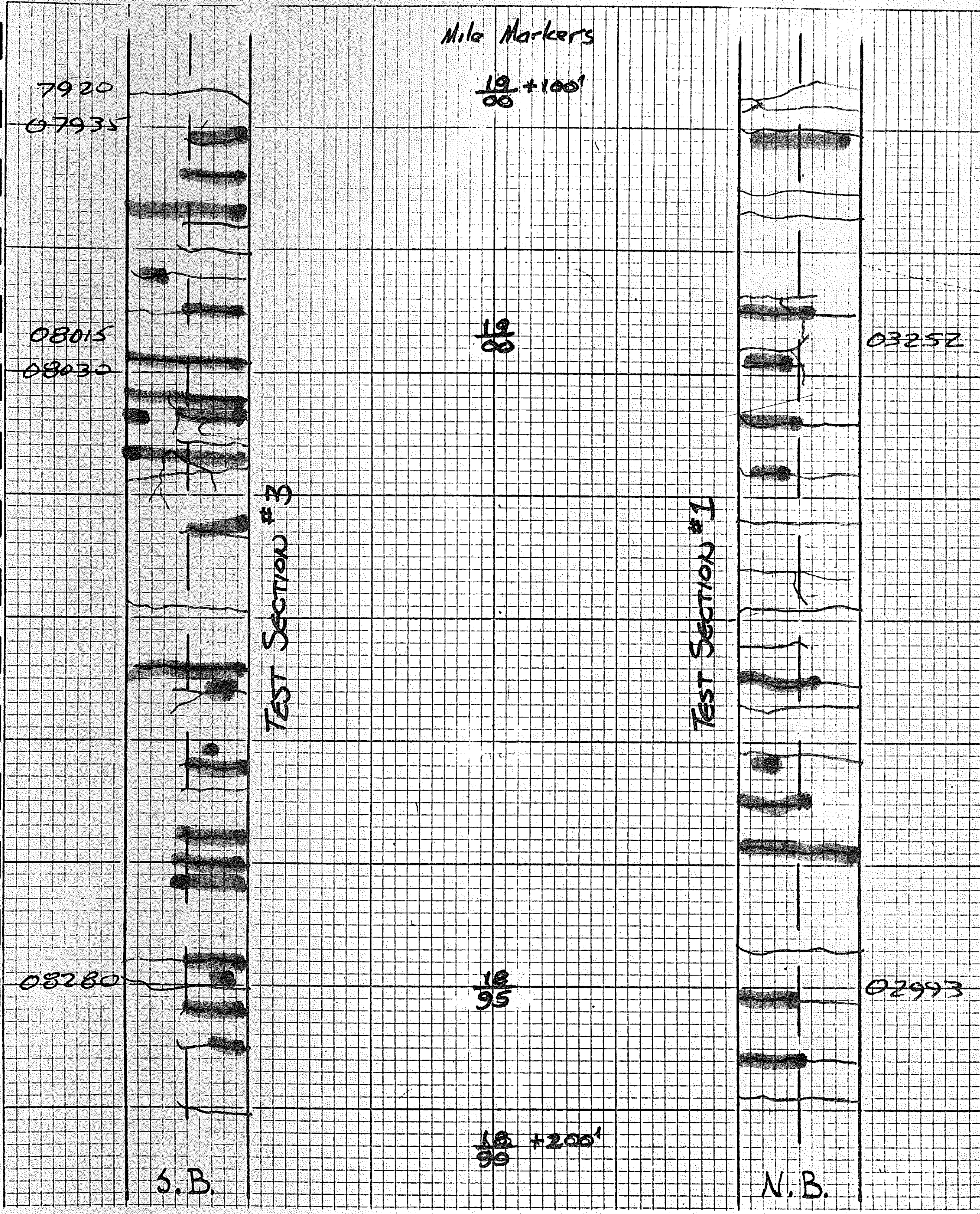
SHEET 8 OF 21

"THE CHAMPION LINE" NO 810

CROSS SECTION 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

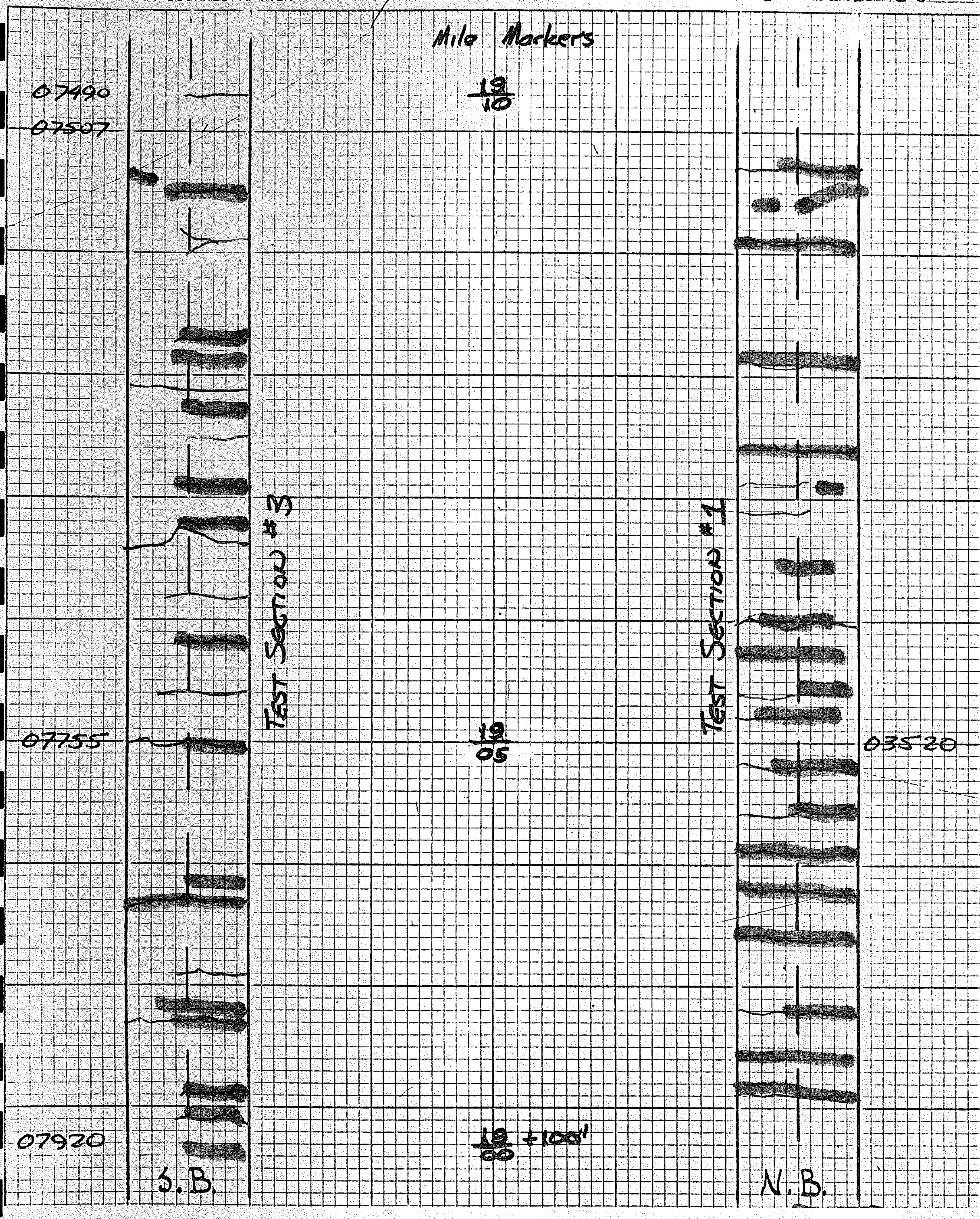
SHEET 9 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



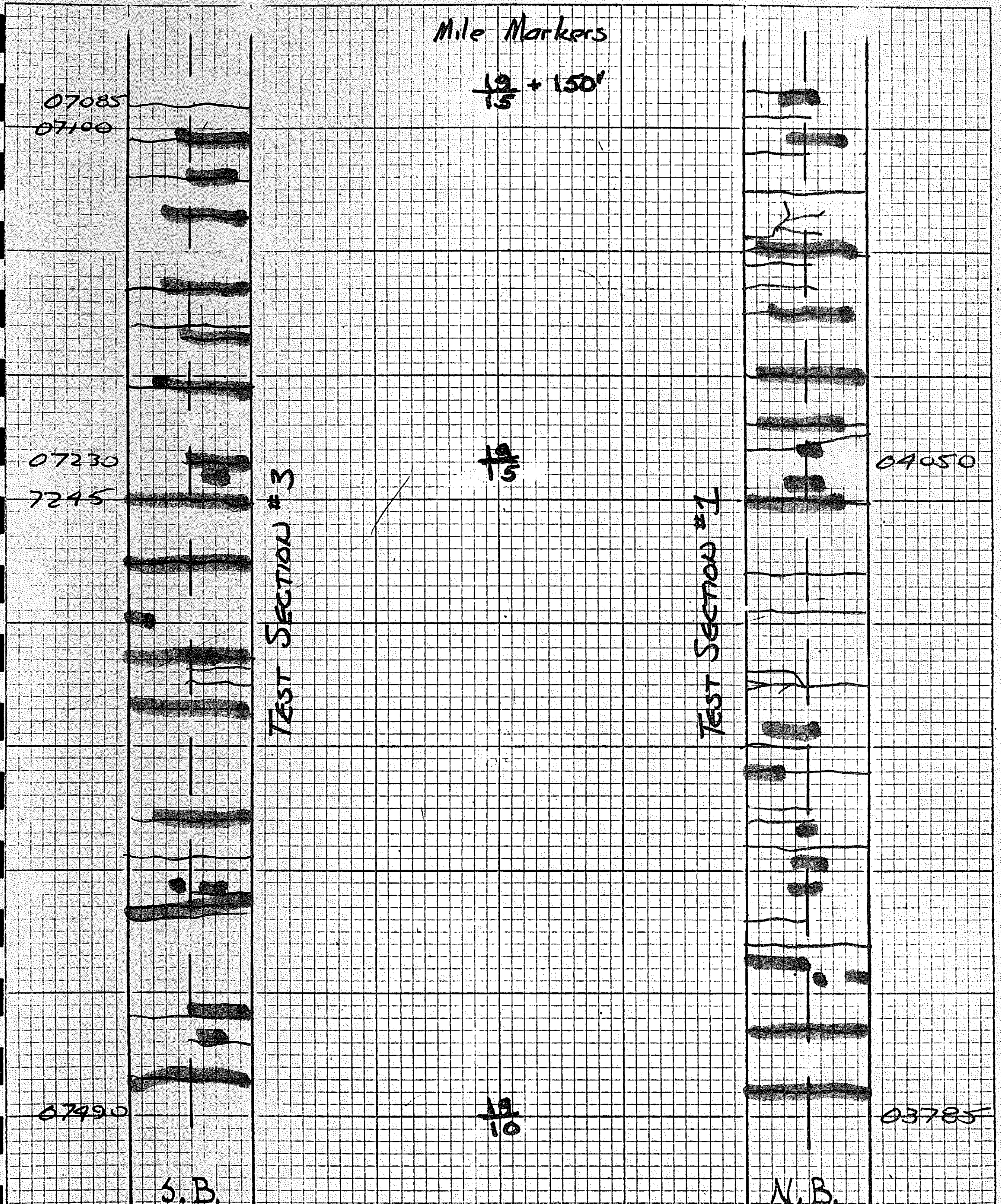
BRATTLEBORO - WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 010
CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SHEET 10 OF 27

SCALE 1" = 50'



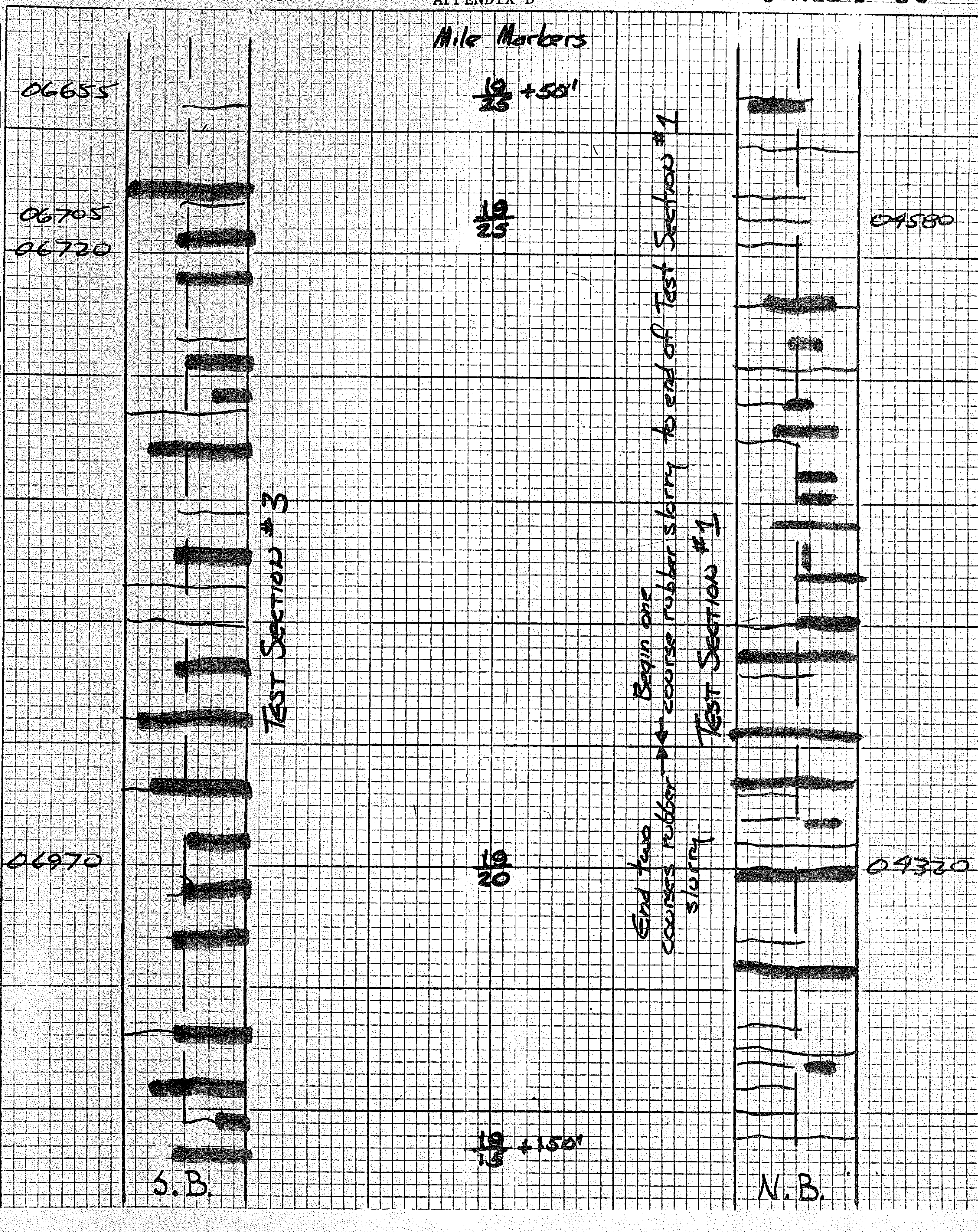
BRATTLEBORO-WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO - WESTMINSTER I 91 - 1 (40)
REFLECTIVE CRACKING SURVEY

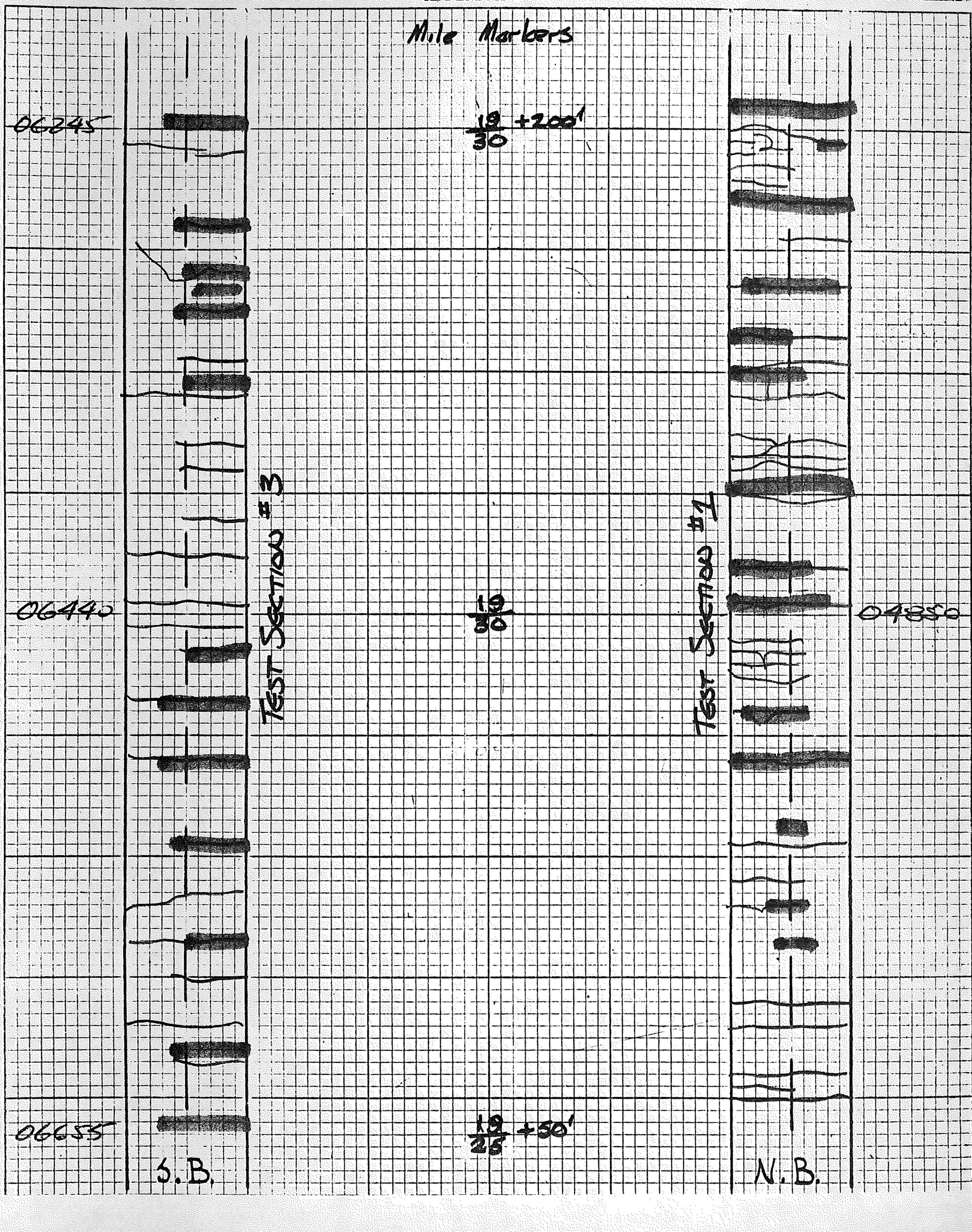
SHEET 12 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

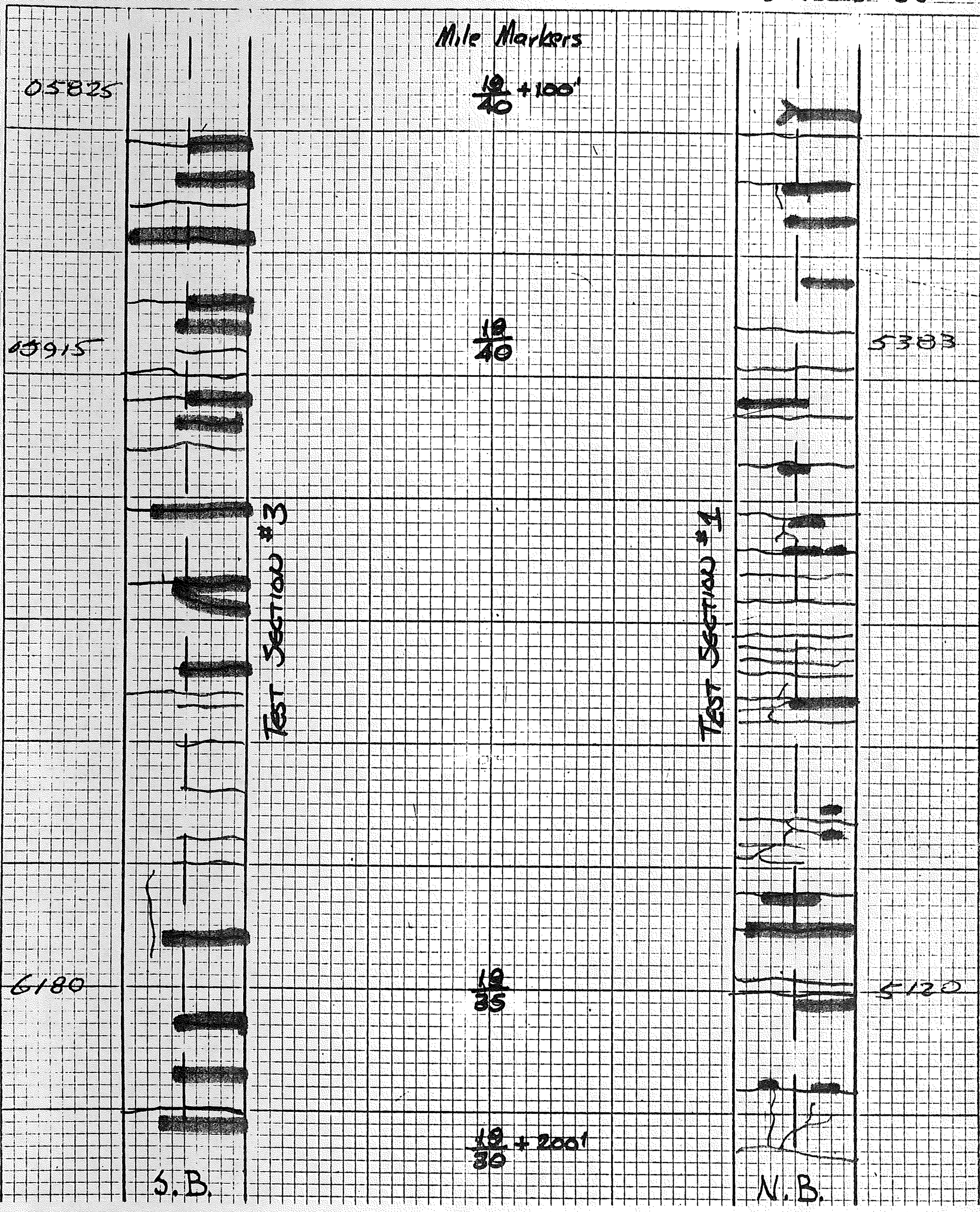
"THE CHAMPION LINE" NO 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SHEET 13 OF 27

SCALE 1" = 50'



BRATTLEBORO - WESTMINSTER I91-1(40)

REFLECTIVE CRACKING SURVEY

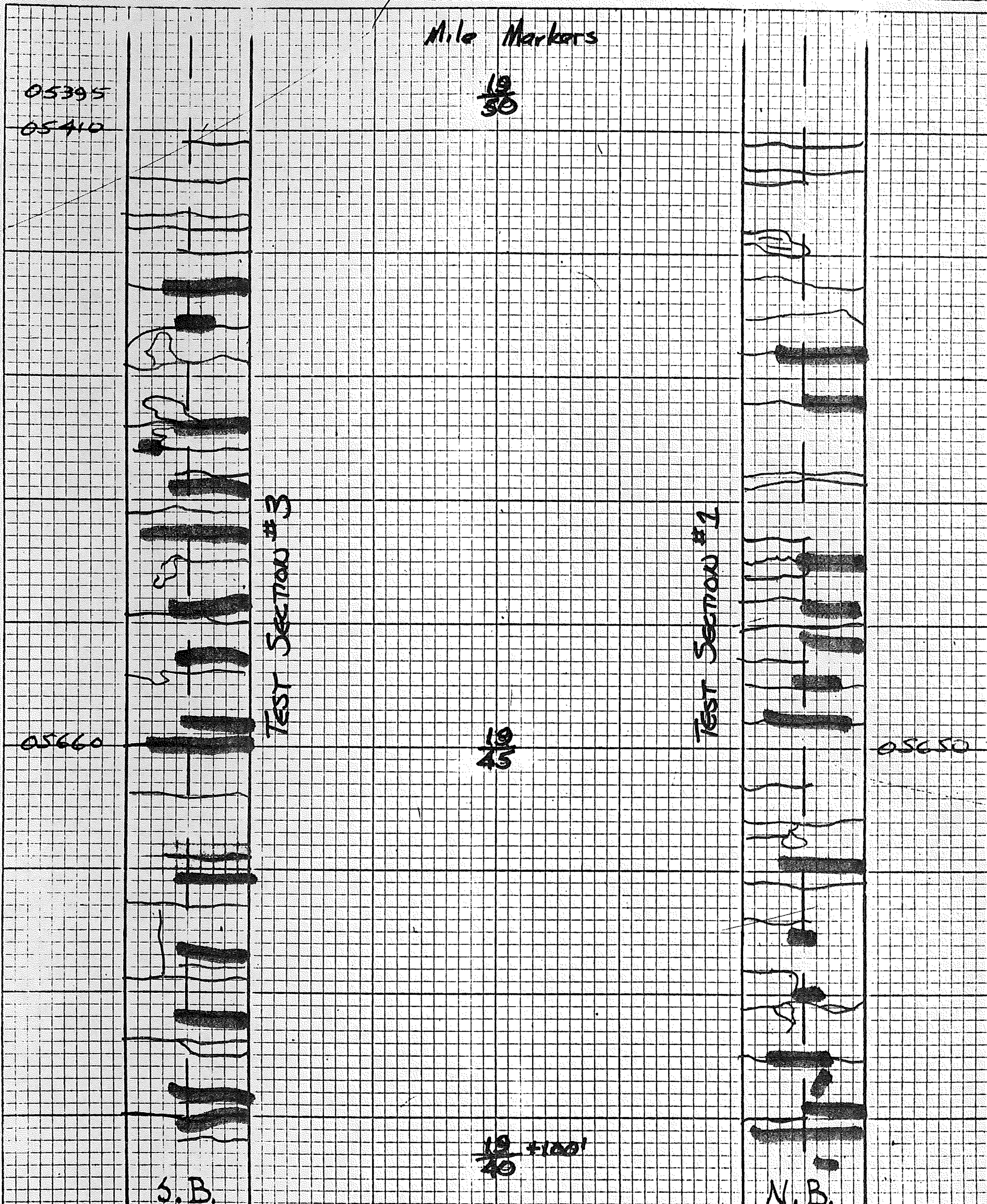
SHEET 14 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

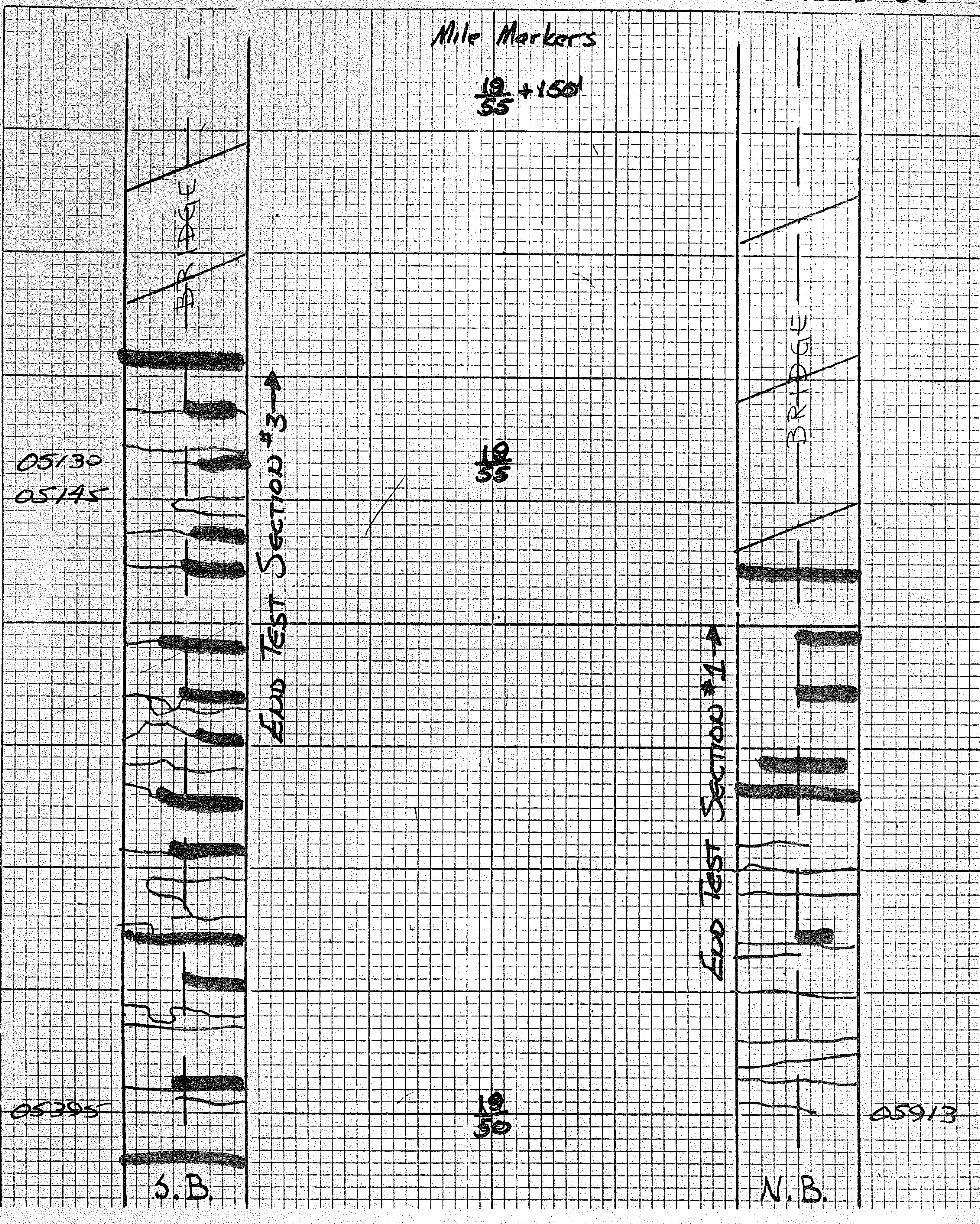
SHEET 15 OF 27

"THE CHAMPION LINE" NO. 010

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

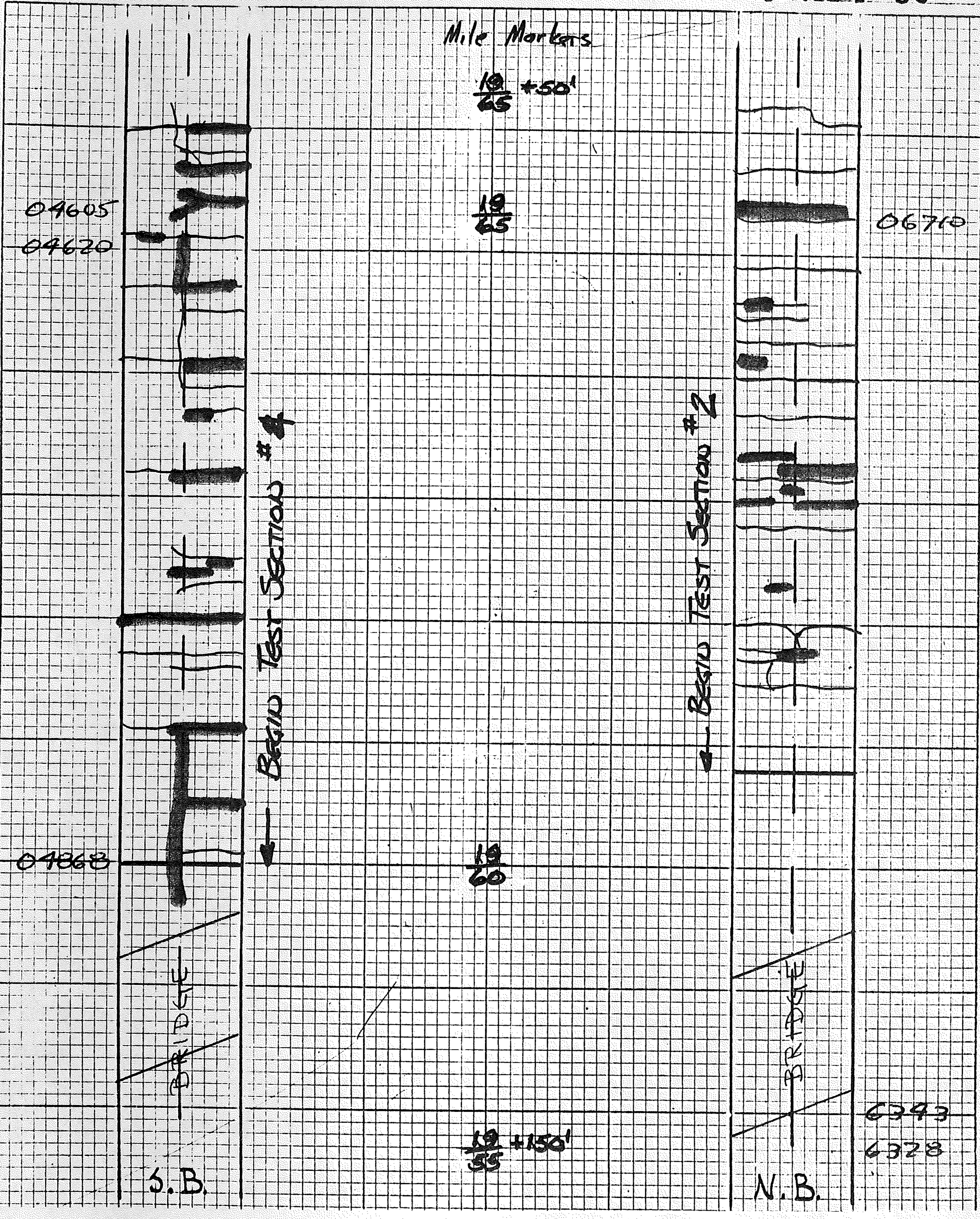
SHEET 16 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

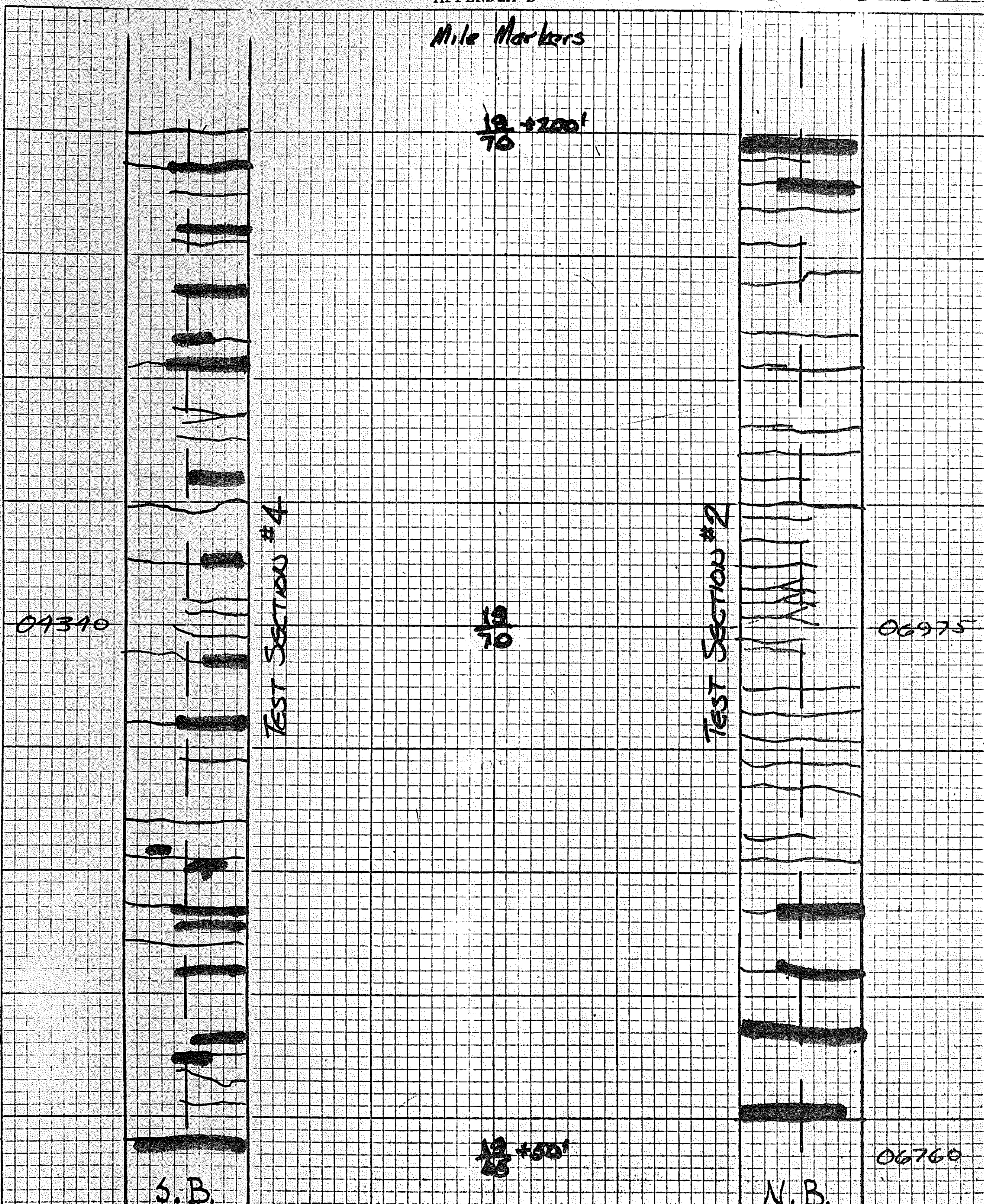
"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SHEET 17 OF 27

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

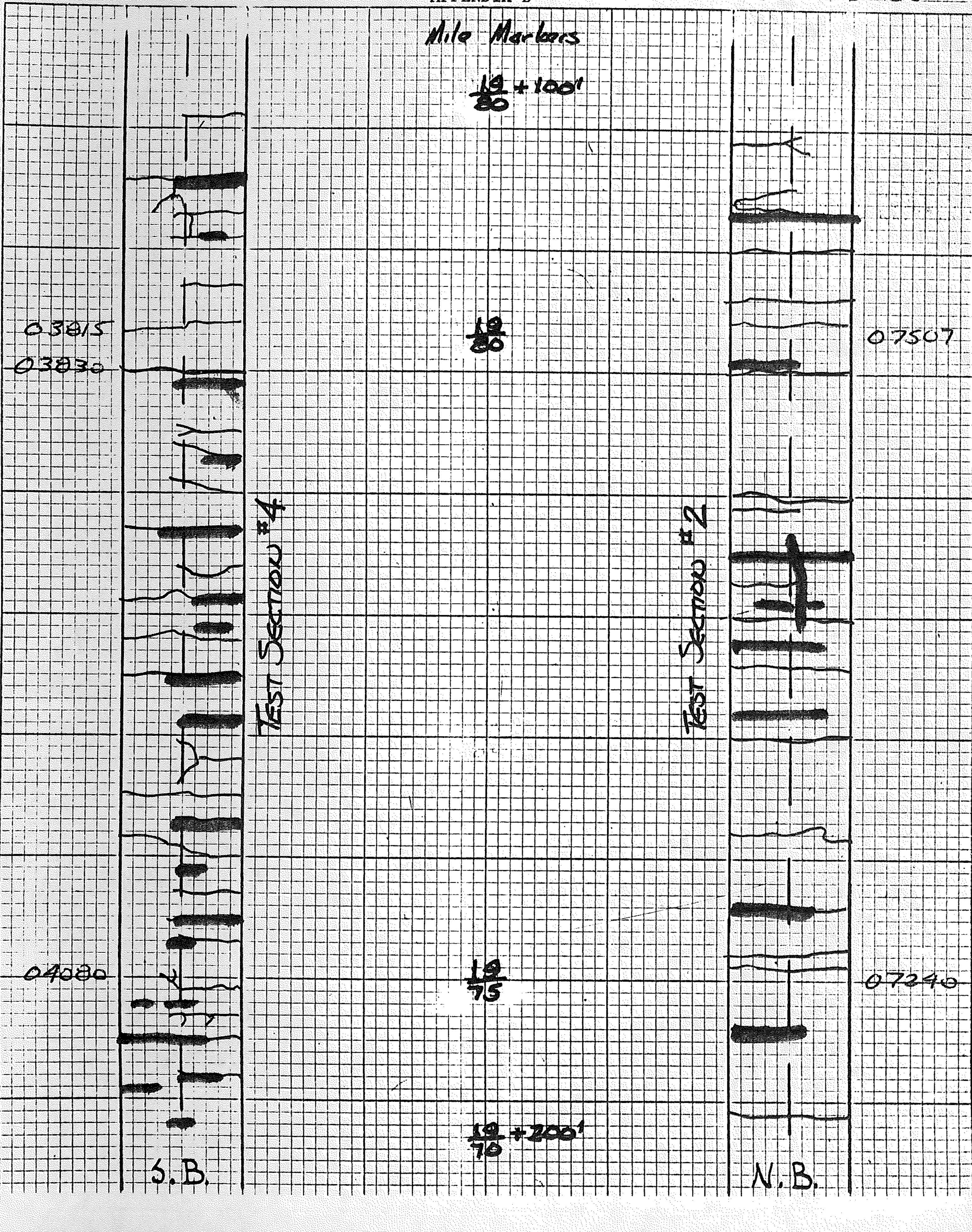
"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

SHEET 18 OF 27

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO - WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

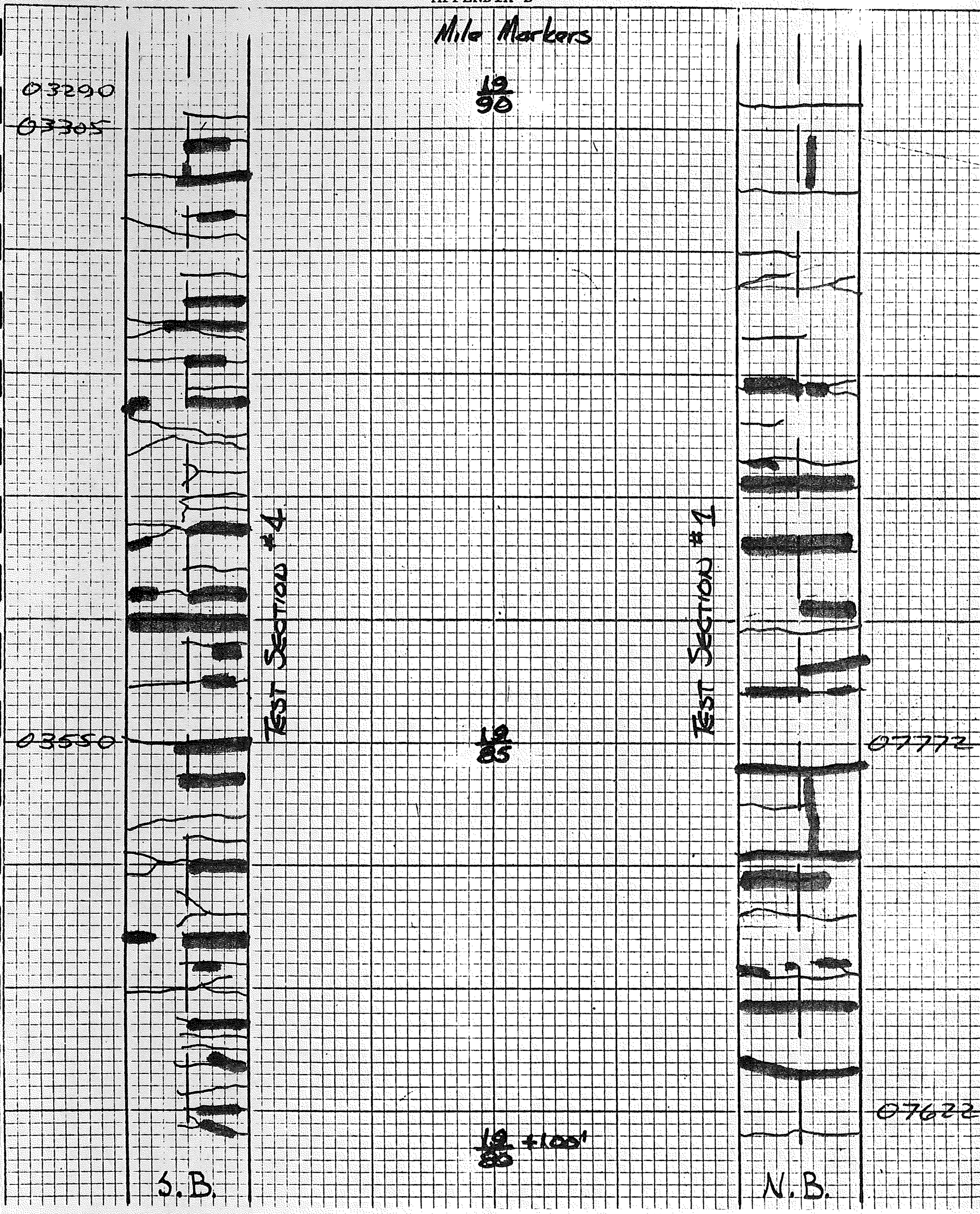
SHEET 19 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

SCALE 1" = 50'

APPENDIX D



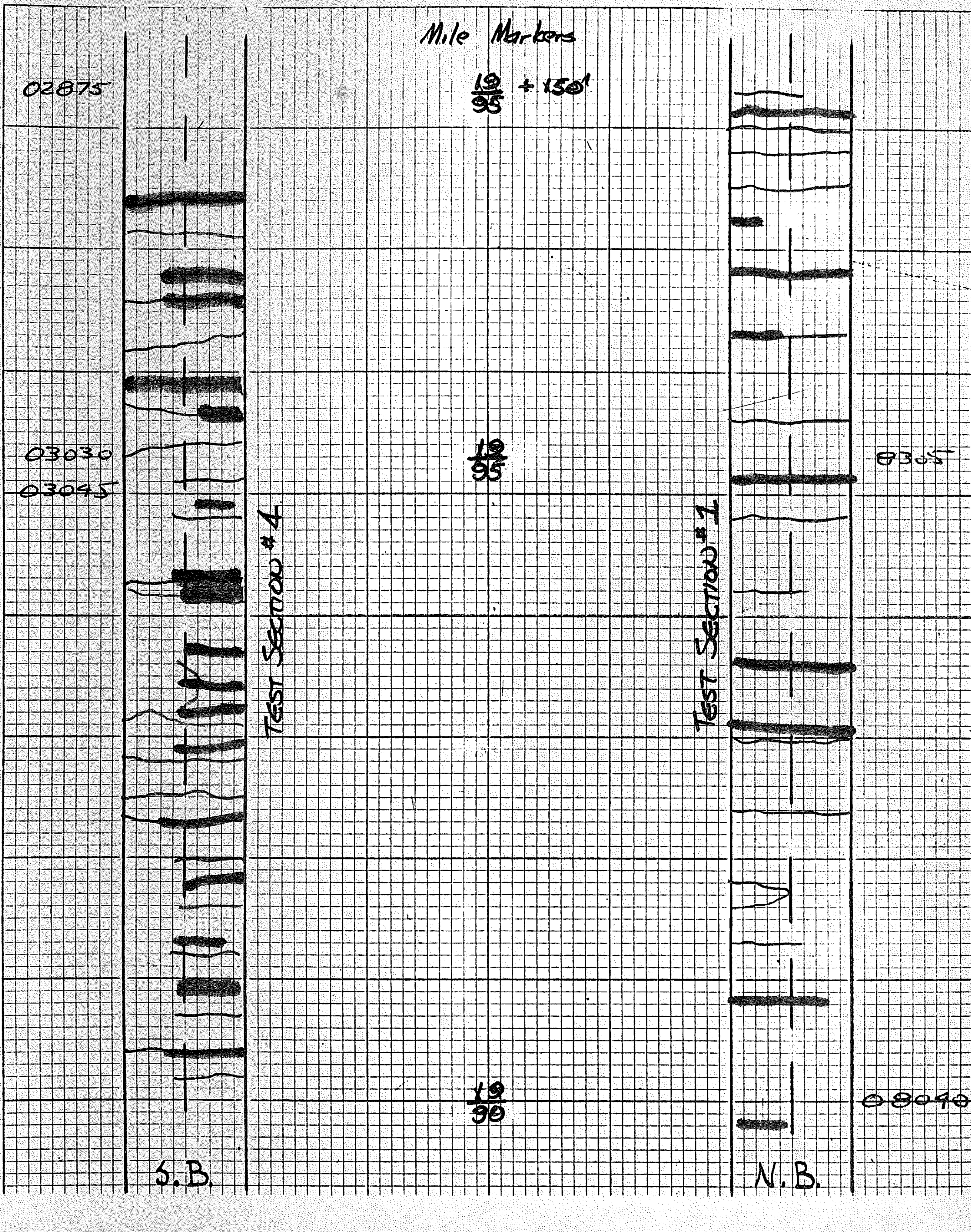
BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

CROSS SECTION 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)

SHEET 21 OF 27

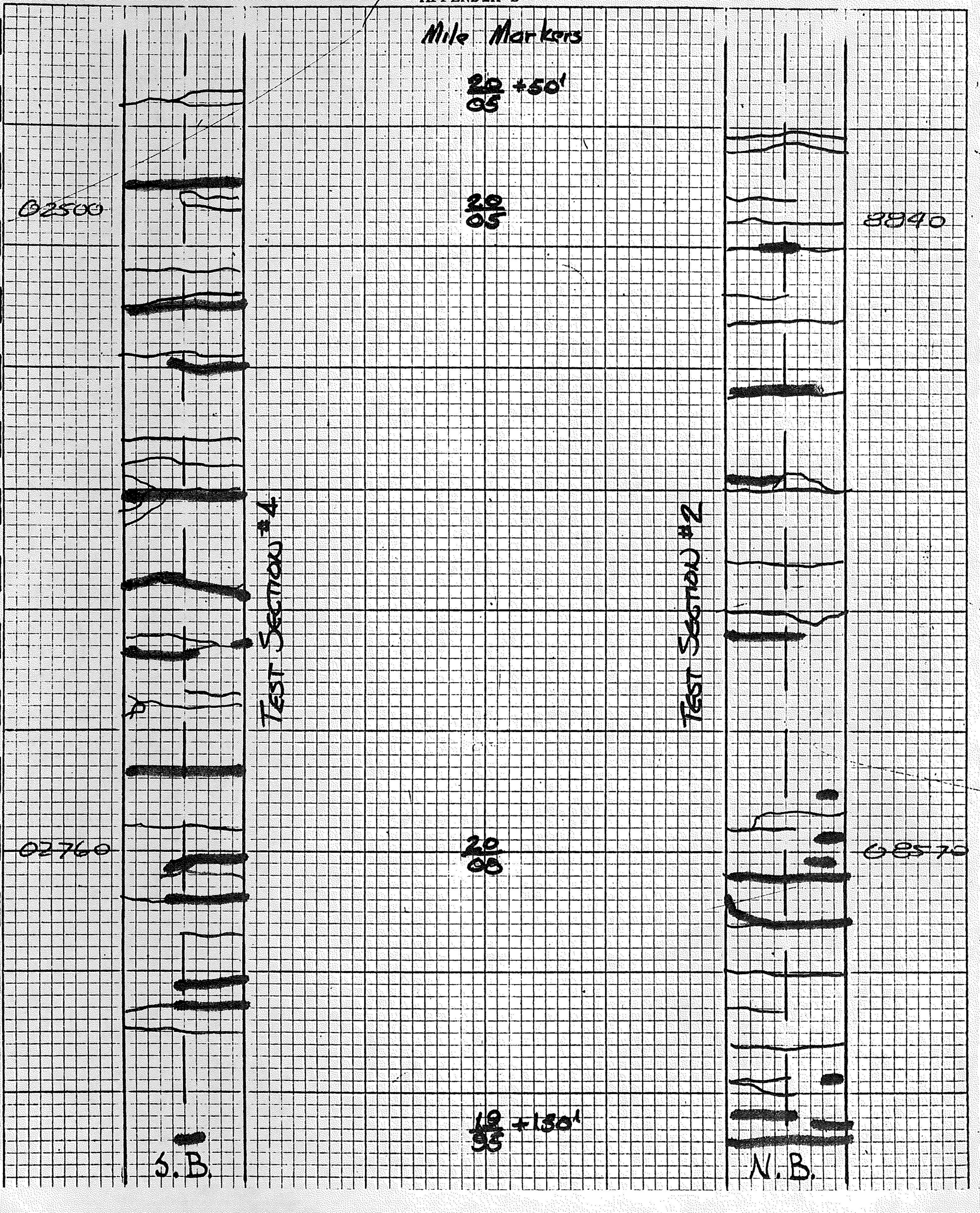
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

SCALE 1" = 50'

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D



BRATTLEBORO-WESTMINSTER I91-1(40)

REFLECTIVE CRACKING SURVEY

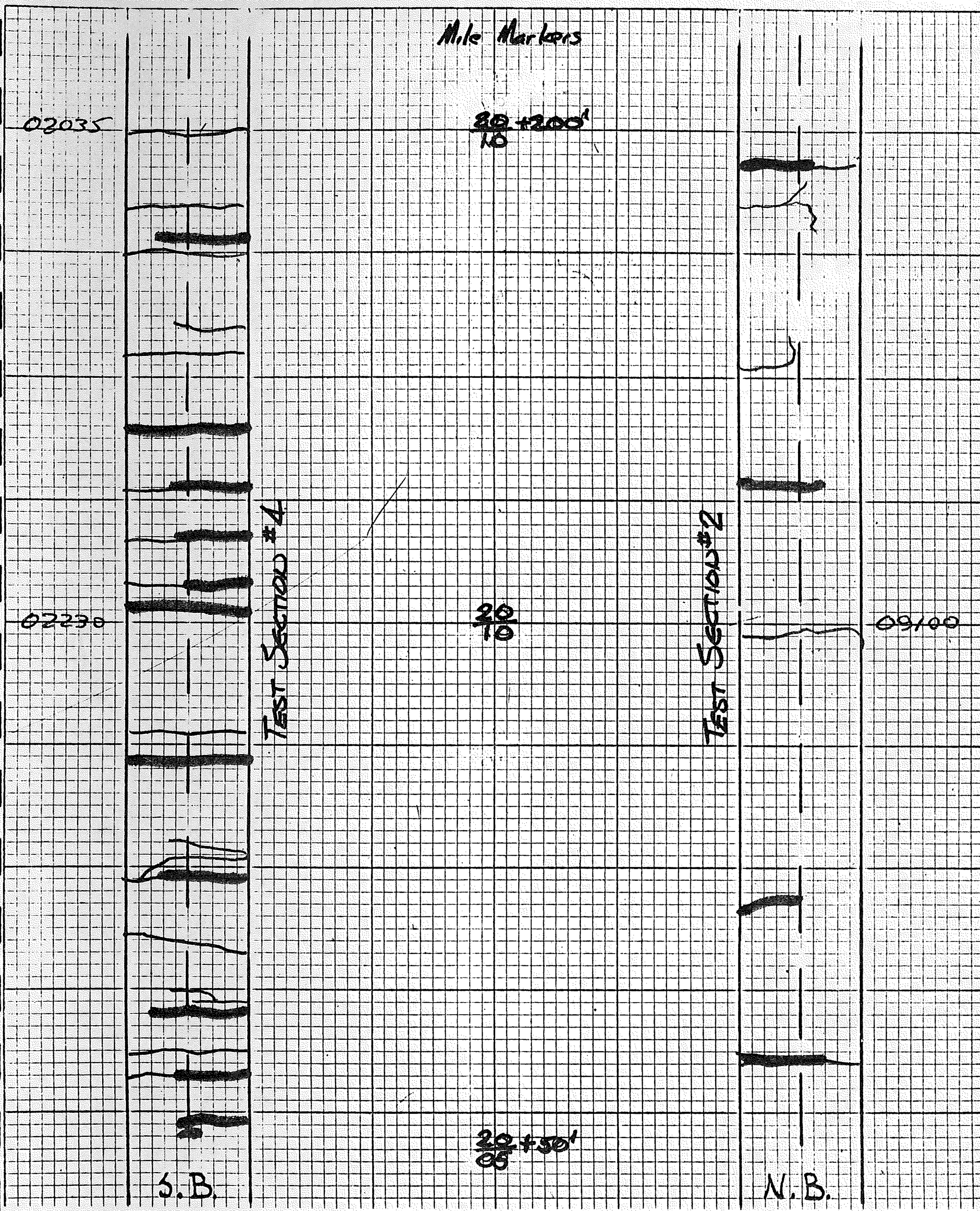
SHEET 22 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



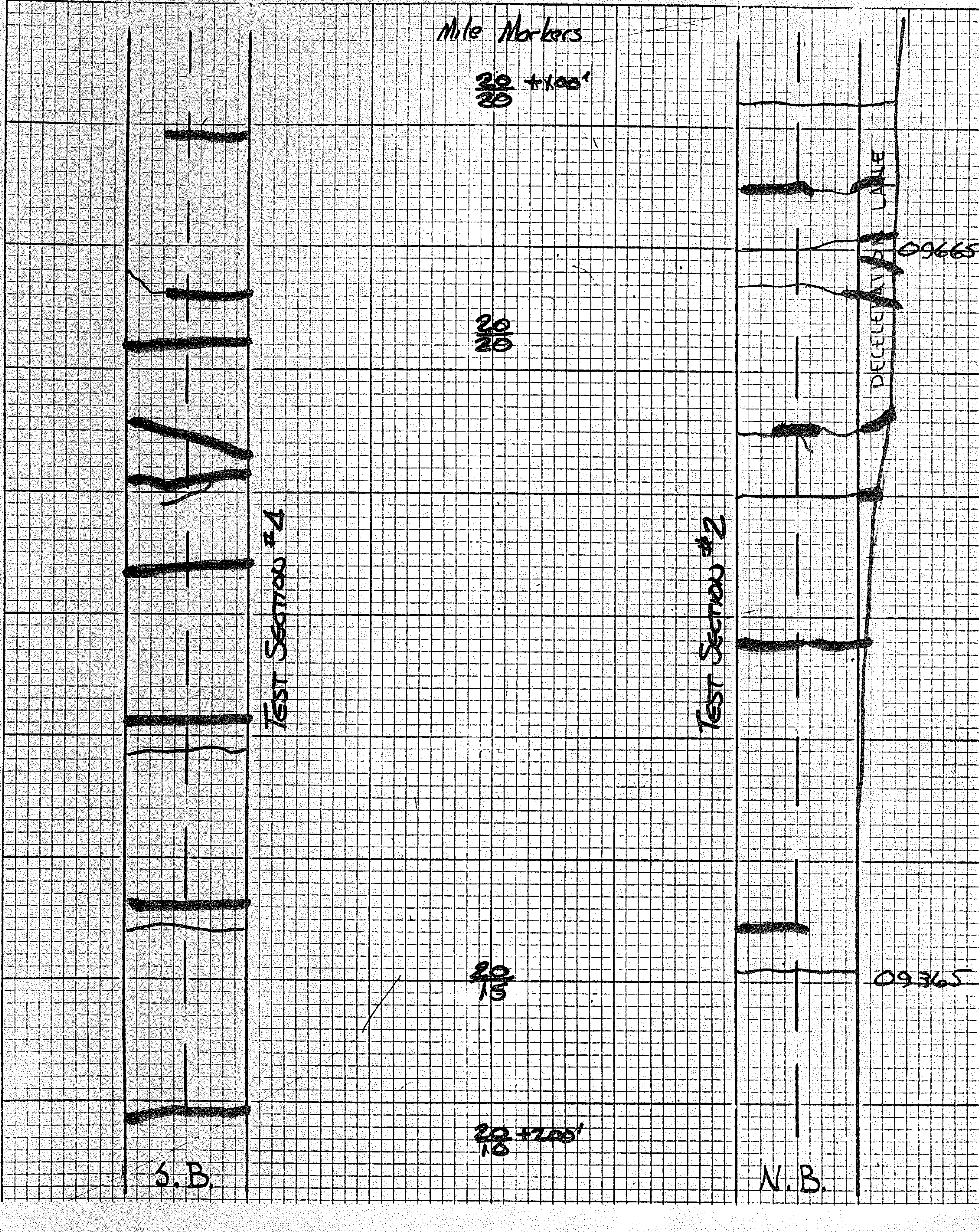
BRATTLEBORO - WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'

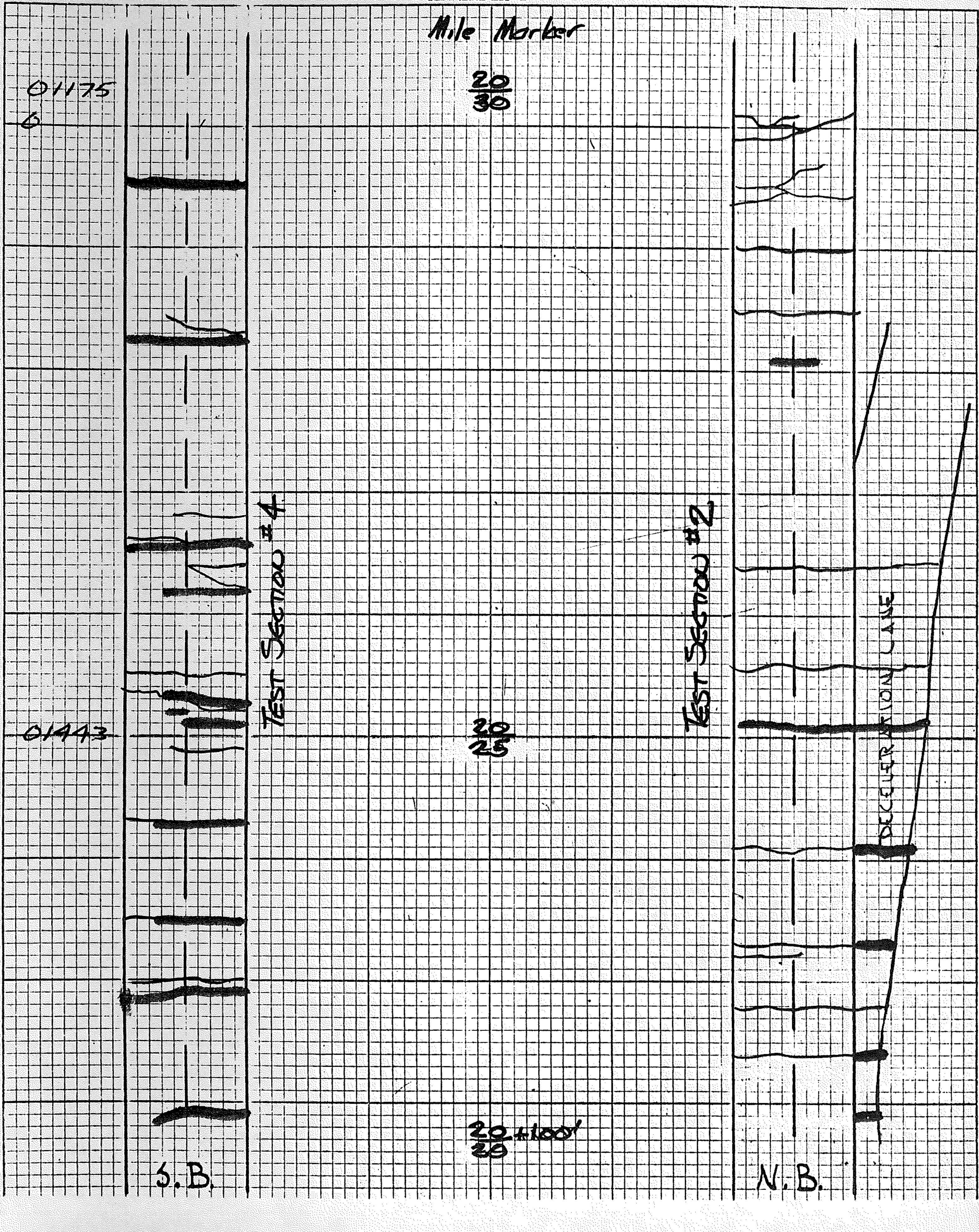


BRATTLEBORO-WESTMINSTER I91-1(40) SHEET 24 OF 27

REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 610

CROSS SECTION - 10 SQUARES TO INCH APPENDIX D SCALE 1" = 50'



BRATTLEBORO-WESTMINSTER I91-1(40)
REFLECTIVE CRACKING SURVEY

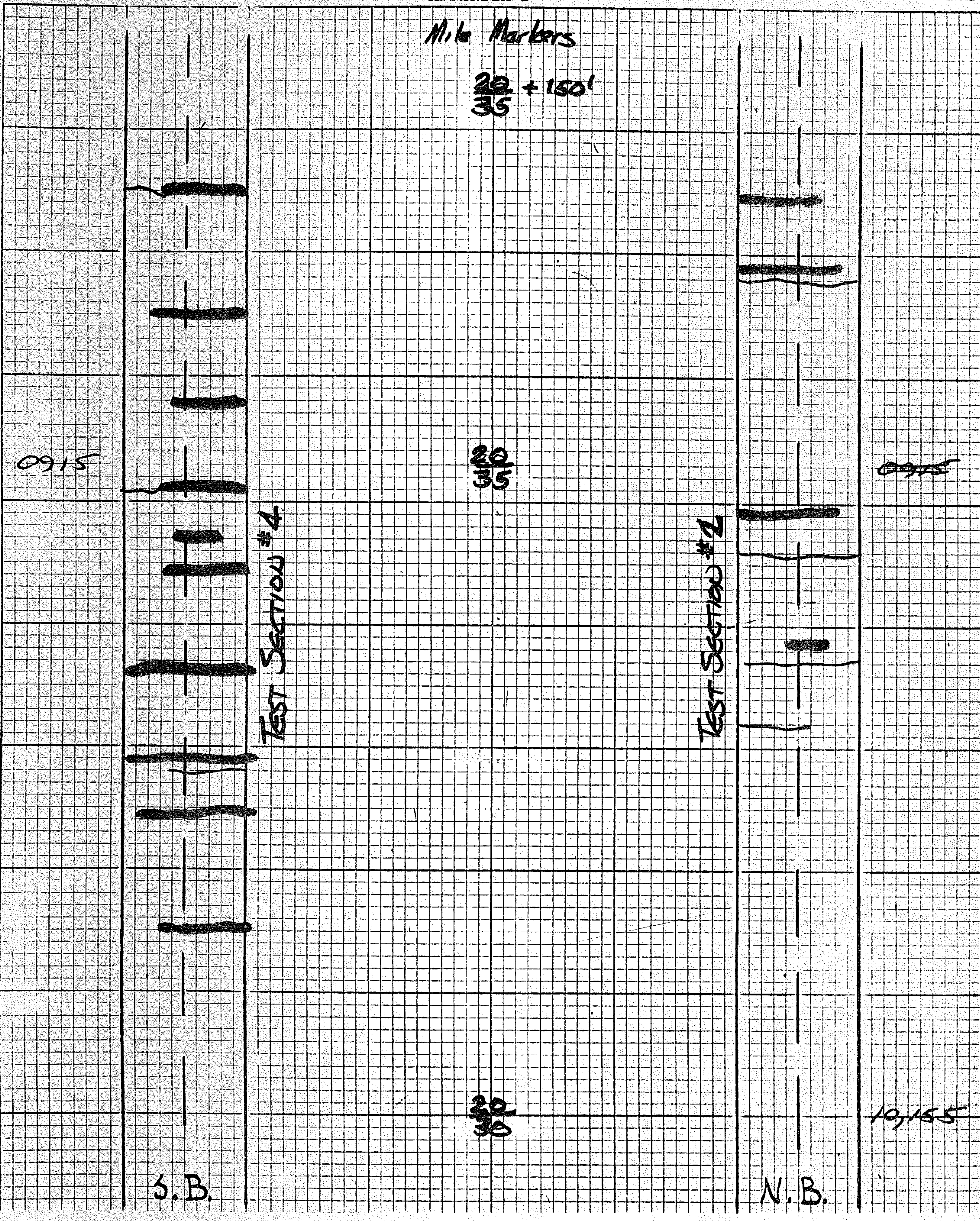
SHEET 25 OF 27

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



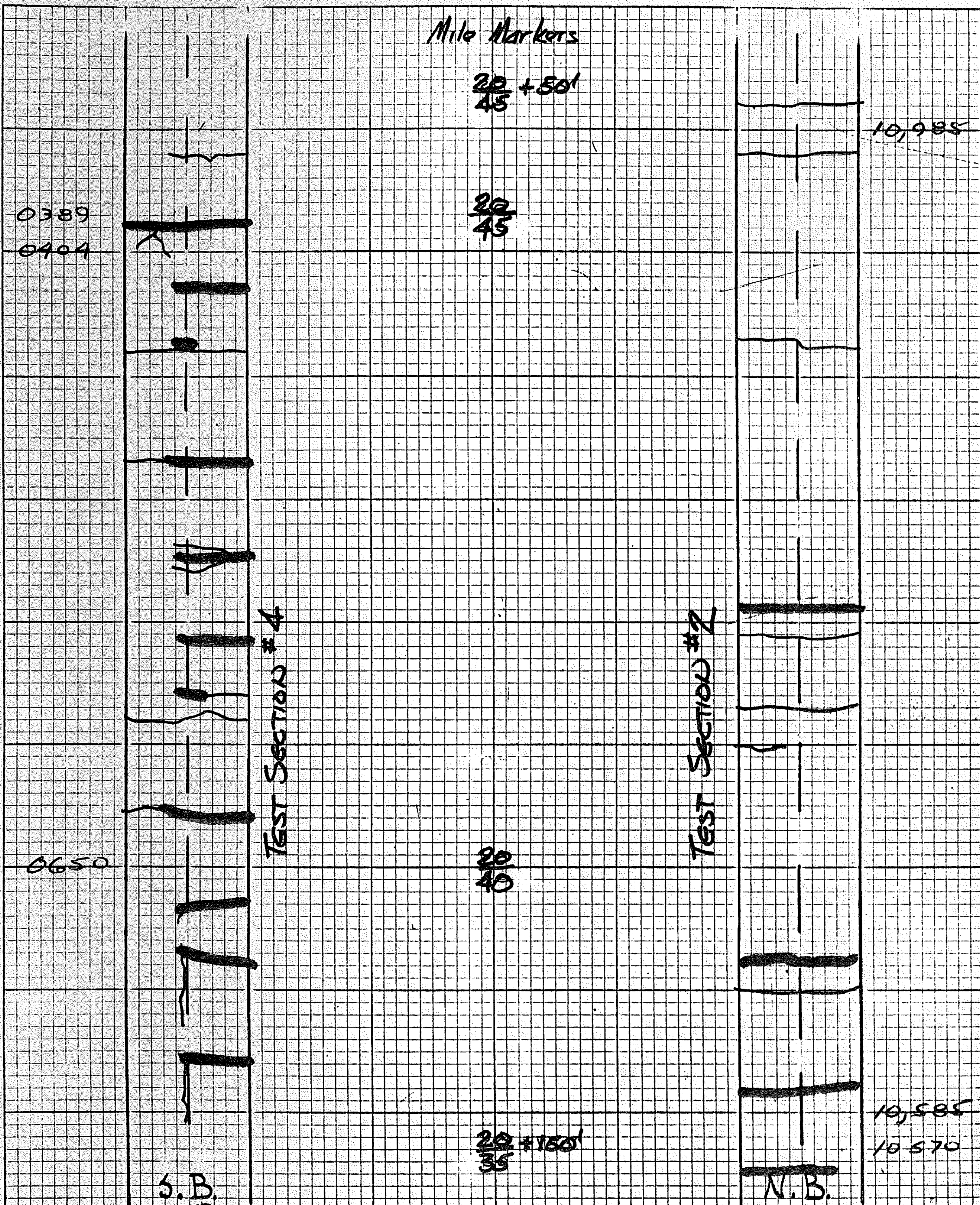
BRATTLEBORO-WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 010

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



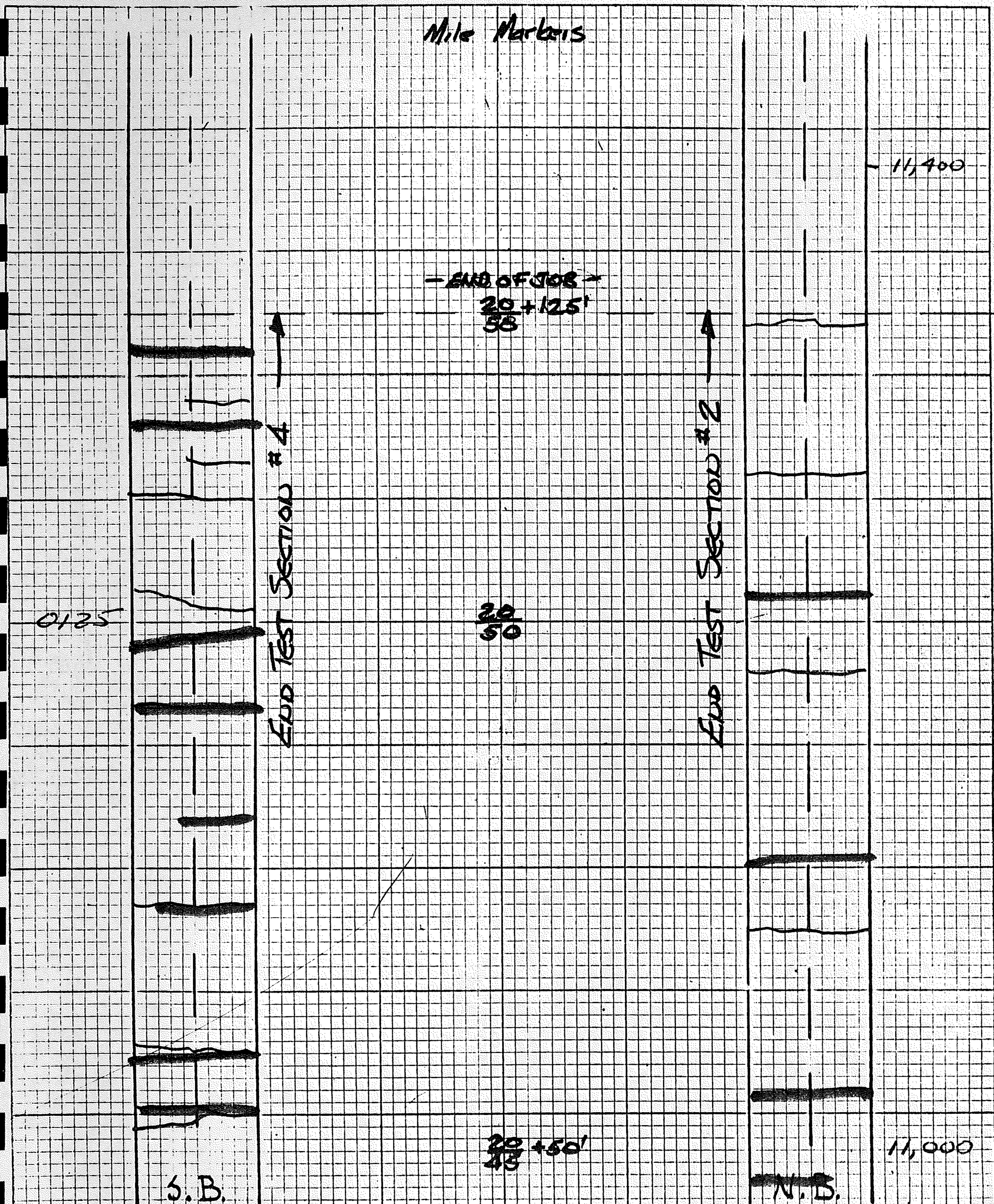
BRATTLEBORO-WESTMINSTER I 91-1(40)
REFLECTIVE CRACKING SURVEY

"THE CHAMPION LINE" NO. 810

CROSS SECTION - 10 SQUARES TO INCH

APPENDIX D

SCALE 1" = 50'



State of Vermont
Department of Highways

Supplemental Specification
March 21, 1973

SECTION 405 - RUBBERIZED SLURRY SEAL

405.01 DESCRIPTION. This work shall consist of furnishing and placing one or more courses of emulsified asphalt, vulcanized rubber shreds, aggregate and water; proportioned, mixed and spread at the locations indicated on the plans, in accordance with these specifications and as ordered by the Engineer.

405.02 MATERIALS. Materials shall meet the requirements of the following subsections of Division 700 - Materials.

Water	745.01
Emulsified Asphalt	702.04

The grade of emulsified asphalt shall be CSS-1 unless otherwise specified.

(a) Aggregate. Aggregate shall consist of natural or manufactured sands, crusher fines and fillers or a combination thereof. The aggregate shall be clean, free from vegetable matter and other deleterious material.

(b) Vulcanized Rubber Shreds. Vulcanized rubber shreds shall be the product of used rubber tires processed to produce fiber-like rubber shreds meeting the following gradation:

TABLE 405.02A - VULCANIZED RUBBER SHREDS

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
No. 4	100
No. 16	0-50

The material shall be obtained only from the rubber portion of the tire and shall not contain any metal or fiber cord.

(c) Mineral Filler. The mineral filler shall consist of approved limestone dust, talc dust, portland cement or other approved materials, and shall be used if needed. Mineral filler shall be considered as part of the blended aggregate.

(d) Composition of Mixture. The slurry components shall be combined to meet the following composition limits:

TABLE 405.02B - COMPOSITION OF MIXTURE

Material	Percentage By Weight
Asphalt Emulsion	20 - 25
Aggregate	45 - 55
Rubber	20 - 25
Theoretical Asphalt Content	12 - 17.5

Equal parts by volume of aggregate and vulcanized rubber shreds shall be combined in advance of mixing and spreading operations such that the stockpiles of the combined materials meet the following gradation:

TABLE 405.02C - VULCANIZED RUBBER SHREDS AND AGGREGATE

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
3/8 inch	100
No. 4	90 - 100
No. 8	65 - 90
No. 16	45 - 70
No. 30	30 - 50
No. 50	18 - 30
No. 200	5 - 15

Combinations of aggregate and rubber shreds shall be blended by approved methods to insure positive control of blending at all times.

(e) Samples. The Contractor shall submit to the Laboratory representative samples of approximately 50 pounds each of the aggregates and rubber shreds and a one (1) gallon sample of Asphalt Emulsion that are proposed for use in slurry seal, together with a job mix formula, not less than two weeks in advance of the anticipated construction. The job mix formula shall be submitted to and approved by the Engineer prior to use.

CONSTRUCTION REQUIREMENTS

405.03 EQUIPMENT. All equipment and machines used in the performance of this work shall be maintained in satisfactory working order at all times. Slurry mixing and placing equipment shall be inspected and approved by the Engineer prior to use on the project.

(a) Mixer. The slurry mixing machine shall be a continuous flow mixing unit capable of accurately delivering a predetermined proportion of aggregate, water and asphalt emulsion to a mixing tank and discharging the thoroughly mixed product on a continuous basis. The aggregate shall be pre-wetted immediately prior to being mixed with the emulsion. The spiral multiblades of the mixing unit shall be capable of thoroughly blending all ingredients. No violent mixing shall be permitted.

The mixing machine shall be equipped with an approved fines feeder capable of accurately metering a predetermined proportion of filler into the mixing tank at the same time and location the aggregate is fed. The fines feeder shall be used whenever added mineral filler is a part of the aggregate blend.

The Contractor shall provide the necessary containers, scales and manpower to check the discharge rates of the aggregates, fines and emulsion prior to use of the mixer unit.

The mixing machine shall be equipped with a water pressure system and fog type spray bar adequate for completely fogging the surface preceding the spreading equipment with a maximum application rate of 0.05 gallon per square yard.

The slurry machine shall have sufficient storage capacity for a balanced load of composition materials.

(b) Spreaders. A mechanical type squeegee spreader box shall be attached to the mixer machine. The spreader box shall be equipped with flexible material in contact with the surface to prevent loss of slurry. It shall be maintained and adjusted to prevent loss of slurry on varying grades and crown and to assure uniform spread. There shall be a steering device and flexible strike-off. The spreader box shall be adjustable for width from 8 to 13 feet at any 1 foot increment and adjustable for crown variations. The box shall be kept clean, and buildup of asphalt and aggregate on the box shall not be permitted. The slurry mix shall be uniformly distributed in the box by a system of augers, screws, or other approved methods to insure a uniform application of mix on the roadway surface.

(c) Auxiliary Equipment. Hand squeegees, shovels and hauling equipment shall be provided as necessary to perform the work.

405.04 SURFACE PREPARATION. Immediately prior to applying the slurry, the surface shall be cleaned of all loose material, soil, vegetation and other objectionable material by brooming or other methods approved by the Engineer. Flushing with water will not be permitted in areas where considerable cracking is present in the existing pavement surface.

405.05 WEATHER LIMITATIONS. Slurry seal shall not be placed unless the air temperature is at least 50°F in the shade and rising.

405.06 PLACING. Immediately preceding the spreading of the slurry, the surface shall be fogged with water at a rate determined by the Engineer. The slurry mixture shall be of the desired consistency when deposited on the surface. Total time of mixing shall not exceed 4 minutes. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. Lumping, balling, unmixed aggregate, or the segregation of the emulsion and aggregate fines from the coarse aggregate shall not be permitted. If coarse aggregate settles to the bottom of the mix, the slurry will be removed from the pavement. Excessive breaking of the emulsion in the spreader box shall not be allowed. Streaks in the finished pavement caused by oversized aggregate shall be immediately removed. The mixture shall be uniform and homogeneous after spreading on the roadway surface and shall not show separation of the emulsion and aggregate after setting.

No excessive buildup nor unsightly appearance shall be permitted on the longitudinal or transverse joints. The use of burlap or other type drags shall be approved by the Engineer.

Slurry mixture to be spread in areas inaccessible to the spreader box shall be spread by other methods approved by the Engineer.

Immediately after the slurry mixture is placed, any areas of streaks or roughness shall be corrected by use of squeegees or other approved methods satisfactory to the Engineer.

When rolling is required by the Engineer, a 5-ton pneumatic roller operating at a tire pressure of 50 p.s.i. shall be used. The paved area shall be subjected to at least 5 coverages.

During the curing period adequate means shall be provided to protect the finished surface from damage by traffic.

405.07 METHOD OF MEASUREMENT. The quantity to be measured for payment of asphalt emulsion will be the amount in hundredweight actually used in the completed work as determined from delivery slips. The quantity of aggregate and rubber shreds to be measured for payment will be the number of tons actually used in the completed work as determined from weight tickets. Weighing shall be done in the presence of a State Inspector.

405.08 BASIS OF PAYMENT. The accepted quantity of slurry seal will be paid for at the contract unit price per hundredweight for Asphalt Emulsion of the grade specified and at the contract unit price per ton for aggregate and rubber shreds of the type specified.

The above contract unit prices shall be full compensation for furnishing, transporting, handling and placing the material specified and furnishing all flagmen, labor, tools, equipment, water, filler material and incidentals necessary to complete the work.

Payment will be made under:

	Pay Item	Pay Unit
405.10	Asphalt Emulsion for Slurry Seal	Hundredweight
405.15	Aggregate for Slurry Seal	Ton
405.20	Vulcanized Rubber Shreds	Ton