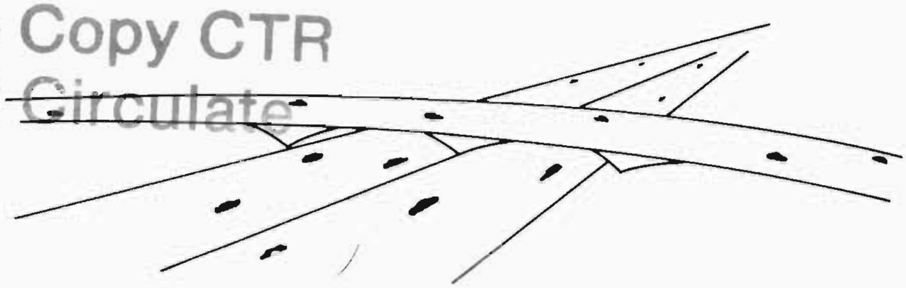

DEPARTMENTAL RESEARCH

Report Number 507-1F

DEMONSTRATION AND EVALUATION OF THE DELAMINATION DETECTOR

TEXAS HIGHWAY DEPARTMENT

DEMONSTRATION AND EVALUATION
OF THE DELAMINATION DETECTOR

by

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Research Report 507-1F
Field Evaluation and Comparison Tests
of Two Bridge Deck Delamination Detectors
and A Manual Inspection Method

Research Study 1-9-74-507

Conducted by
Materials & Tests Division, Research Section
Texas Highway Department
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

October 1974

ABSTRACT

The Texas Highway Department has performed a series of tests comparing three devices for locating bridge deck delaminations. These are a hammer used by tapping or dragging on the deck, the Texas prototype bridge deck delamination detector and the SIE, Inc., DelamTeck - a commercial version of the Texas prototype. It was concluded that when properly calibrated, the two detectors outlined an area of delamination essentially the same. Both detectors were found more accurate than the hand hammer and found flaws the hammer method often missed. Under certain conditions, the two detectors and hammer would locate vertical cracking, areas of thin deck construction and defects in the overlay.

KEY WORDS: Bridge Deck, Deck, Delamination, Delamination Detector

SUMMARY

In response to a Federal Highway Administration request, the Materials and Tests Division in cooperation with District 18 and SIE, Inc., of Fort Worth, ran a series of comparison tests on three methods for locating bridge deck delaminations. These are the hammer method used by bridge inspectors, the Texas prototype bridge deck detector and the SIE, Inc., DelamTeck, a commercial version of the Texas detector. It was concluded that: (a) the two detectors gave substantially the same results; (b) they were more accurate than the hand hammer and (c) three conditions (vertical cracking, thin deck, overlay faults) could result in delamination-like indications on the detector's recorder chart.

CONTENTS

I. PURPOSE

The purpose of this study is an objective evaluation of the field performance survey suitability and detection ability of a commercially produced concrete delamination detector, under bridge deck field survey conditions.

II. CONCLUSIONS AND RECOMMENDATIONS

The writer concludes the following from this study:

1. When properly calibrated on their respective calibrators, the Texas Highway Department and the SIE, Inc., electromechanical delamination detectors will give substantially the same results, i.e., borders for areas of delamination.

2. When properly calibrated, the two electromechanical delamination detectors will define the limits of areas of delamination more accurately than will an inspector using the hammer method.

3. The following three conditions, either separately or in combination, may give the same indication as a delaminated area.

   a. Vertical Cracking - In these tests the vertical cracks were usually found in long and very narrow (one to two inches) zones.

   b. Poor bond between the deck and surface overlay or between sealcoat and overlay.

   c. An unusually thin area in an otherwise thick deck construction.

The thicker and heavier the constructed section, the lower the residual or background noise in the recorder output; lighter areas tend to raise this background noise.

4. The above three conditions tend to produce low recorder outputs (less than 5 millimeters) when the instruments are properly calibrated. Increasing gain tends to produce charts that are difficult to correlate with core results or interpret.

The writer recommends the following:

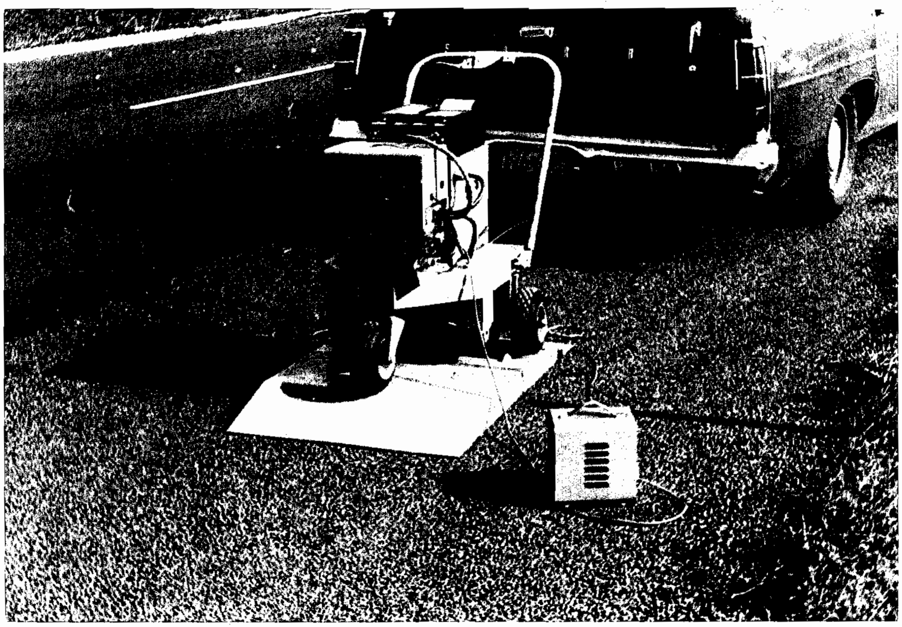
1. That the Federal Highway Administration continue to encourage implementation of these or similar instruments to aid in bridge deck inspection.

2. That each instrument be checked and adjusted for proper response at least once each day on its recommended calibration device.

III. EQUIPMENT

Three pieces of equipment were used for locating bridge deck delaminations. These are:

1. A geologist's hammer is used to tap the deck or by dragging the point of the hammer over the deck. Two hammers were used, one with a standard handle, the second with a handle about five feet long. This long handle permits dragging the hammer from a standing position.



The Texas Highway Department Prototype Bridge Deck Delamination Detector and Calibration Unit.

Figure 1

The DelamTeck by SIE, Inc., of Fort Worth, Texas.

Figure 2

2. The Texas Highway Department's Bridge Deck Delamination Detector shown in Figure 1, is the prototype instrument developed by Texas Transportation Institute of Texas A&M University, College Station, Texas, under Research Study 2-18-68-130, "Bridge Deck Deterioration." This instrument has two steel wheels 6 inches apart that are activated by a solenoid to tap the pavement 60 times per second. Two rubber tired acoustic wheels, 12 inches apart aligned axially with the tapper wheels, generate electrical signals representing the sounds (mechanical energy) received from the pavement. These signals are electronically processed and a voltage is sent to a two-channel recorder. This voltage represents the extent of delamination under each tapper. The unit uses two heavy duty six-volt lead-acid automotive batteries to operate a DC to AC inverter to power the system. An event marker for the chart recorder and a paint spray marker for the pavement are included. An acoustic calibrator is carried and used to ensure proper adjustment and operation of the electronic system.

3. The SIE bridge deck delamination detector, the DelamTeck, shown in Figure 2, is a production version of the Texas Highway Department prototype. The base, tapper wheels and acoustic wheels are essentially the same as in the original. Whereas the prototype uses a DC to AC inverter, the newer system is designed to operate off a single 12 volt automotive storage battery. All electronics including the recorder are enclosed in one package which may be carried by one

person. The total weight is about 160 pounds or 80 pounds less than the Texas Highway Department unit. A recorder event marker and a paint spray pavement marker are included. The calibrator is a metal bar designed to give a known chart deflection when the detector is set on it.

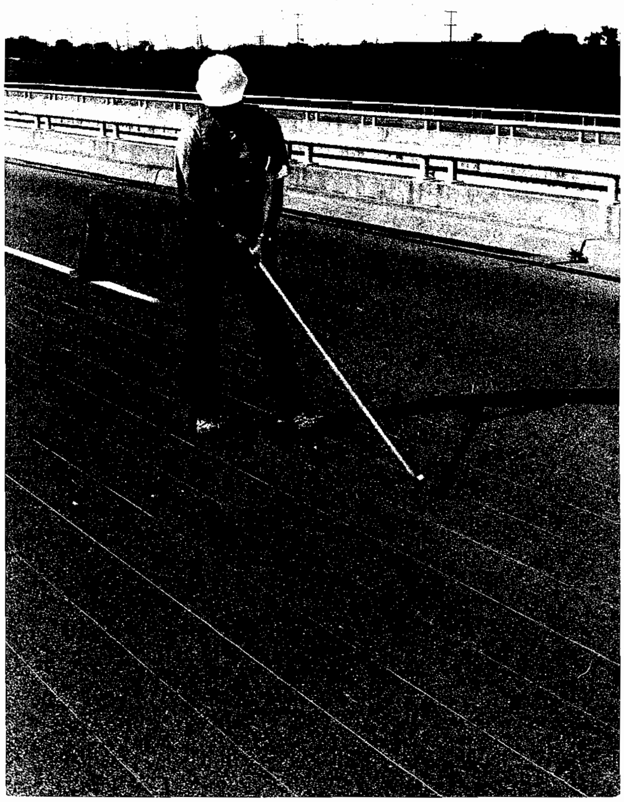
IV. TEST PROCEDURE

After the traffic control crew had finished placing all safety equipment, a chalk line was used to mark off the lane to be examined with longitudinal lines 12 inches apart. The center line stripe was used as the first mark. Ten foot marks were made in the gutter area to aid in mapping.

The hammer method was used to first examine the deck. Any areas of delamination were outlined with crayon. Usually the long handle hammer was dragged over the deck to locate flawed area (Figure 3). Then the area was outlined by tapping with a short handle hammer.

The Texas Highway Department detector was then used to examine the bridge deck. It was rolled back and forth on the deck with the acoustic wheels aligned on a pair of chalk lines. On each pass, the instrument would be moved over one chalk line. Since the tapper wheels are three inches from the acoustic wheels, this produced traces representing lines of examination every six inches across the deck. Lines of indicated delamination were marked with white spray paint. After the deck was traced out in longitudinal lines, traverse examinations were made as needed to produce a final outline of the flawed area.

The SIE DelamTeck was then used in the same manner as the Texas Highway Department delamination detector. Any flaw area found was marked with orange spray paint.



Operator Sweeping Deck with Hammer to Locate Delaminations.

Figure 3

Areas of delamination for each method were recorded on scaled maps. Locations for cores were then marked on both the deck and the maps. After cores were taken, each was photographed, measured and examined. The holes were filled with a quick setting patching material and the lane returned to service as soon as possible.

V. DISCUSSION

This study project was undertaken at the request of the Research Division of the Federal Highway Administration (FHWA). They had arranged for the commercial version of the bridge deck delamination detector to be evaluated by another State. This State reported that they had better and faster results with a manual chain drag. Personnel in another State who used a duplicate detector reported excellent results with the unit. In July of 1974, the Texas Highway Department's Materials and Tests Division was asked to make a series of comparison tests to determine whether or not there was substantial agreement between the Texas Highway Department's prototype delamination detector, the DelamTeck built by SIE, Inc., of Fort Worth, Texas, and a manual hand method. This Division agreed to perform these tests and a contract was drawn up. The hand method chosen was to use a hammer (geologist's pick) as the Department's personnel were experienced in its use. The cooperation of the Department's District 18 was obtained for use of a traffic control crew and an experienced bridge deck inspector. SIE, Inc., agreed to transport and to help operate the units manufactured by them. The study required the use of at least three structures and at least 1000 total lane feet of deck to be checked.

Work started on August 6, 1974, in the northbound outside traffic lane of I-45, Ellis County, Structure No. S119.T50, Brushy Creek Bridge. Within one hour of starting work, rain forced personnel to stop and remove all safety equipment for the day.

The day of August 7 was partly cloudy but work was resumed. As soon as traffic control was established, work resumed as outlined in the above section on Test Procedures. The entire outside lane was examined for a total of 485 lane feet in 16 slabs.

The bridge inspector using the hammer method took 2-1/2 hours to examine the deck with the hammer. The Texas prototype took about three hours to examine the same area. The SIE detector would have taken about the same amount of time but for the fact that the electronics in one channel failed. The SIE personnel left to have the factory personnel repair the unit. Both the electromechanical instruments found areas of delamination that the hammer method had missed. The inspector returned to these areas and in most cases was also able to locate an area of delamination.

An approaching rainstorm permitted only two cores to be taken. These are described in Appendix B, Table I. Both were taken in an area found delaminated by the two electromechanical detectors and just outside of the area found delaminated by the hammer method. Core B-1 was apparently taken at the edge of the delaminated area, part of it was apparently delaminated, the other portion broke during drilling. Core B-2 was severely deteriorated in the delamination area.

Continued rain forced postponement of work until the next week. Work resumed on August 13 on the outside lane of the northbound Bear Creek Bridge, Structure S108.T50 for 243 lane feet. Work proceeded rapidly on this structure. No flaws were found except in the sixth slab from the north end. Inspection was stopped after eight slabs were checked for a total of 243 lane feet. A quick run with one detector down the wheel paths found no other flaws in the remainder of the deck.

The recorder response of the Texas and SIE detectors was compared on a number of flaws in this slab. It was found that the Texas detector generally had a chart deflection three to four times that of the SIE detector. This had caused no problems as both defined the borders of flaw areas within four to six inches of each other. It should be noted here that it was found not practical to push the Texas detector with reasonable speed, note a flaw on the recorder, stop and mark that spot with less than a four inch possible error. The SIE instrument, being 80 pounds lighter and thus easier to stop, could work to a little closer tolerance than this.

A second SIE detector belonging to the FHWA was set up and calibrated. Trial runs with it were made on the slab. A cursory examination of the second SIE detector's chart showed no essential difference between it and the first SIE instrument. A more detailed examination was not made as SIE personnel kept this chart.

SIE personnel readjusted the gain of the first detector so that its recorder chart indication was essentially equal to that of the Texas detector.

Appendix A, Map II, shows the result of test runs with this readjusted instrument. The recalibrated SIE instrument picked up flaw indications in several places where no delamination type flaws were found by the Texas detector. Two cores, BR-1 and BR-2 were taken at these points. Vertical cracks were found in both and both were taken in a thin part of the slab. No concrete flaws were found in three cores where both detectors had a positive but low response. In these three cores there was visual indication of spots with poor bonding between the sealcoat and deck. All three were taken from a thin part of the slab. The inspector using the hammer method found an indication of flaws in two of these three core areas. Another core from an area no method indicated as flawed also showed some indication of poor bond between sealcoat and deck. Both the Texas and SIE detector had high deflection amplitudes in all areas that cores revealed as actually being delaminated.

The third structure investigated was the northbound Brushy Creek Relief Bridge, Structure S112.T50. The outside lane was examined on August 14 and the inside on the 15th for a total of 304 lane feet. The mechanical recorder chart drive on the Texas detector broke at the start of these tests. An electric drive system enabled the instrument to be used to outline areas of delamination. These charts were not scaled and can not be used for accurate mapping purposes. The test procedure was altered somewhat for examining the inner lane only. The Texas detector was used first, then the inspector using the hammer method outlined the areas of delamination as found by the detector. This was done to save time. It was felt that this was justified in that it was already established that the hammer method would miss a number of flaws.

In this structure, four cores showing delamination were taken from areas that were found delaminated by all test methods. No flaws were found in three cores taken from areas where no delaminations were indicated. A group of three cores were from areas all methods indicated to be delaminated yet only vertical cracking was found. One core was found to have vertical cracks although all test methods found no delamination. Of the remaining three cores, one showing a vertical crack was taken from an area that only the SIE detector found defective. Another core (S112-5) was from a spot flaw found only by the SIE instrument. No concrete flaws were found here but there are visual signs of poor deck-sealcoat bond. Another core (S112-8) was from a spot flaw located by both the Texas Highway Department and SIE detectors. This core contained a vertical crack.

Most of these cores were taken from questionable areas. The borders outlined by the SIE and Texas Highway Department delamination detectors were generally within six inches of each other. Only in the thin area of a deck containing vertical cracking did the hammer method outline an area substantially larger than that found by the two detectors being tested. In this area the inspector could only report the sound as different and acknowledged that the borders were not distinct. The border determined by the hammer method were usually from six to twelve inches inside those found by the test instruments.

Despite the fact that the last two bridges were examined with the SIE delamination detector adjusted to a higher gain than normal, areas confirmed to be delaminated by coring were outlined essentially the same as by the Texas detector. But the higher gain did result in the locating of several spot overlay flaws and large areas of vertical cracking in thin sections. A few of these were also found by the Texas detector and the hammer method. In general, chart indications of vertical cracking, thin areas and spot overlay flaws were of low amplitude (five millimeters or less) on both detectors. At the present experience level with the delamination detectors, all areas suspected of being delaminated should be confirmed by coring before repairs are made, even if high amplitude chart deflections are present.

The event markers included on the detectors are useful for referencing slab joints or other aids to mapping. It was attempted to also use them for noting where the detector entered and left the areas where the inspector using the hammer method found delaminations. This required the detector operator to work very slowly in order to attempt this type of correlation. The scale of the charts (approximately six inches of deck to one millimeter of chart) virtually made such marks useless in analyzing for agreement.

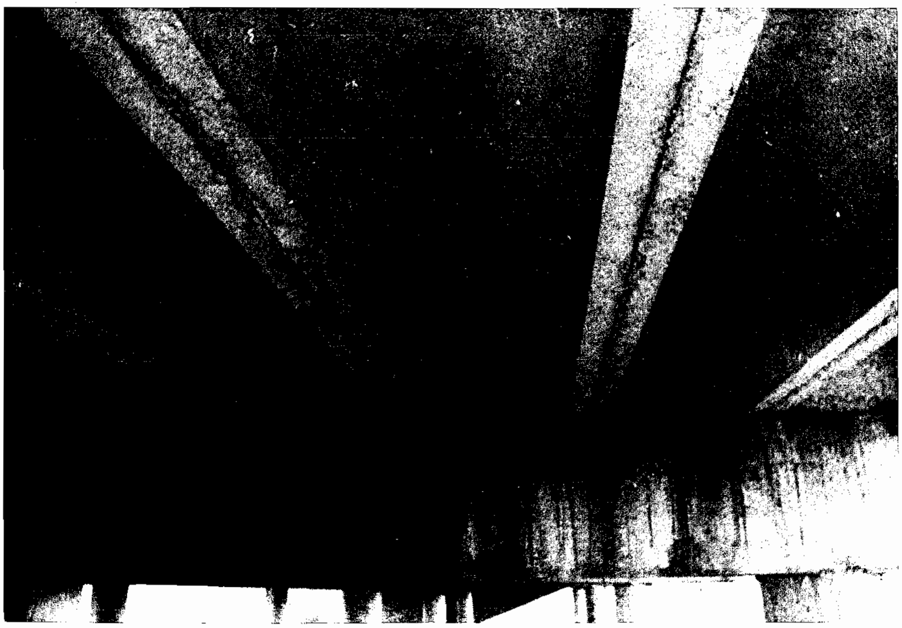
It was found in these comparison tests examining the entire deck, that the inspector using a hammer method generally worked faster than the two detectors. However, the inspector often missed areas of delamination.

Usually these were of less than one square foot in area but sometimes larger. The detectors will relentlessly indicate any spot flaw or larger flaw area that the tapper wheel passes over.

Speed runs were attempted by pushing the two detectors while running. Large flaws were found but small ones can be missed easily. The SIE DelamTeck's tapper operates at approximately 42 taps per second. At ten miles per hour (14.7 feet per second) the tapper hits the pavement about once every four inches. The chart recorder on the instrument is not designed for the response rate needed for this speed even if the tapper rate were increased.

The pan girder deck used in these three structures is shown from underneath in Figure 4. The relatively narrow longitudinal zone of thinly constructed deck often contained a line of vertical cracks. These often could not be found if the detector were moved over one to two inches. The inspector using the hammer method might acknowledge a different sound but could not exactly define any borders on the flaw area. In another type of construction where vertical cracking occurs more frequently and in a somewhat random pattern, this would serve to raise the effective background noise level on the recorder chart. Such cracking, in this case, might not be readily noticed at all.

The cores were all transported to the Materials and Tests Laboratory in Austin for examination. Diamond blade saws were used to section the cores. The overlay was first separated by sawing off about one-quarter inch of concrete. Then both were sectioned as required for visual examination.

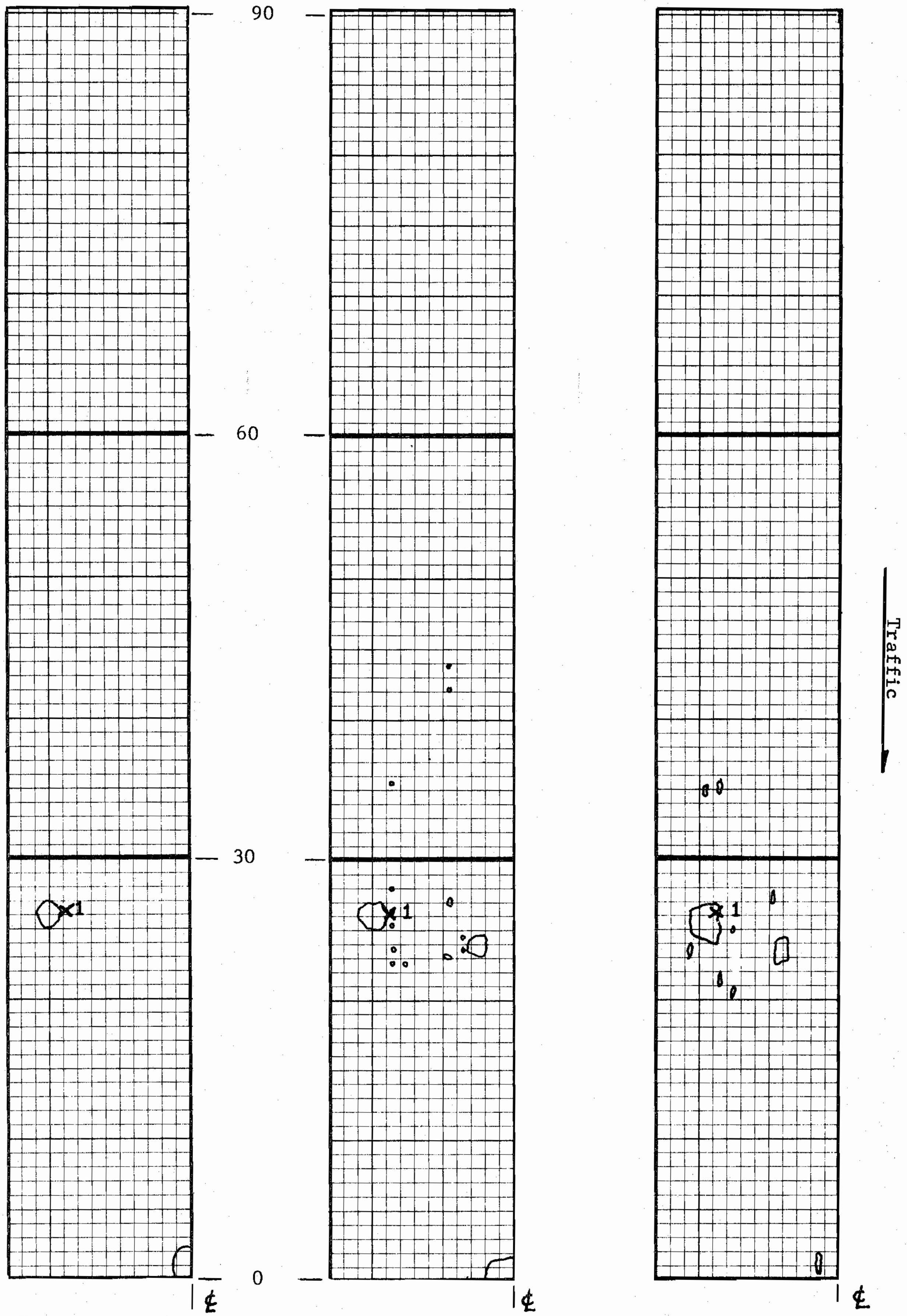


Pan Girder Construction as Viewed from Below

Figure 4

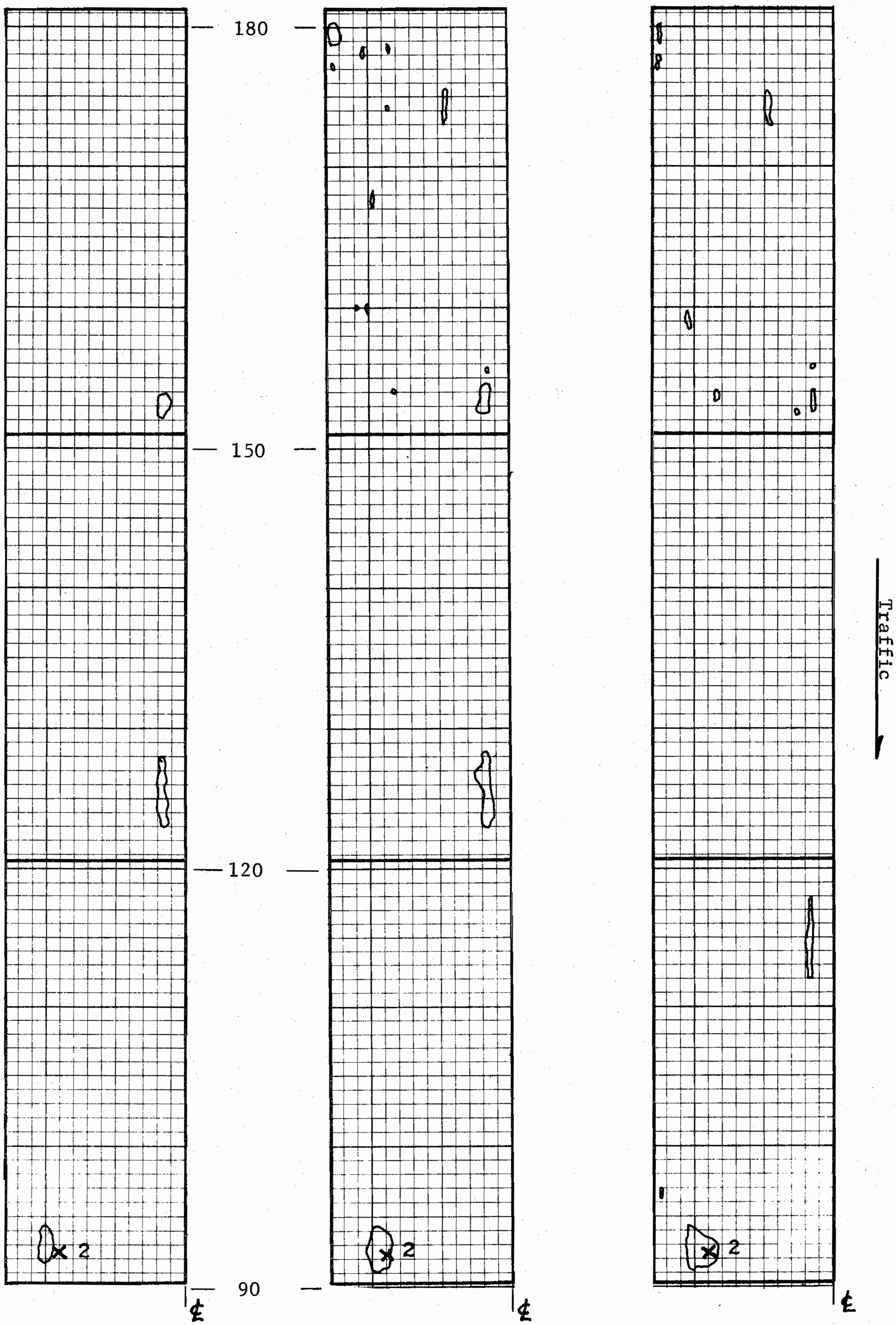
APPENDIX A

MAP I
Brushy Creek - S119.T50
Outer Lane - Northbound



Hammer Method | THD Prototype | SIE, Inc., DelamTeck

MAP I
Brushy Creek - S119.T50
Outer Lane - Northbound

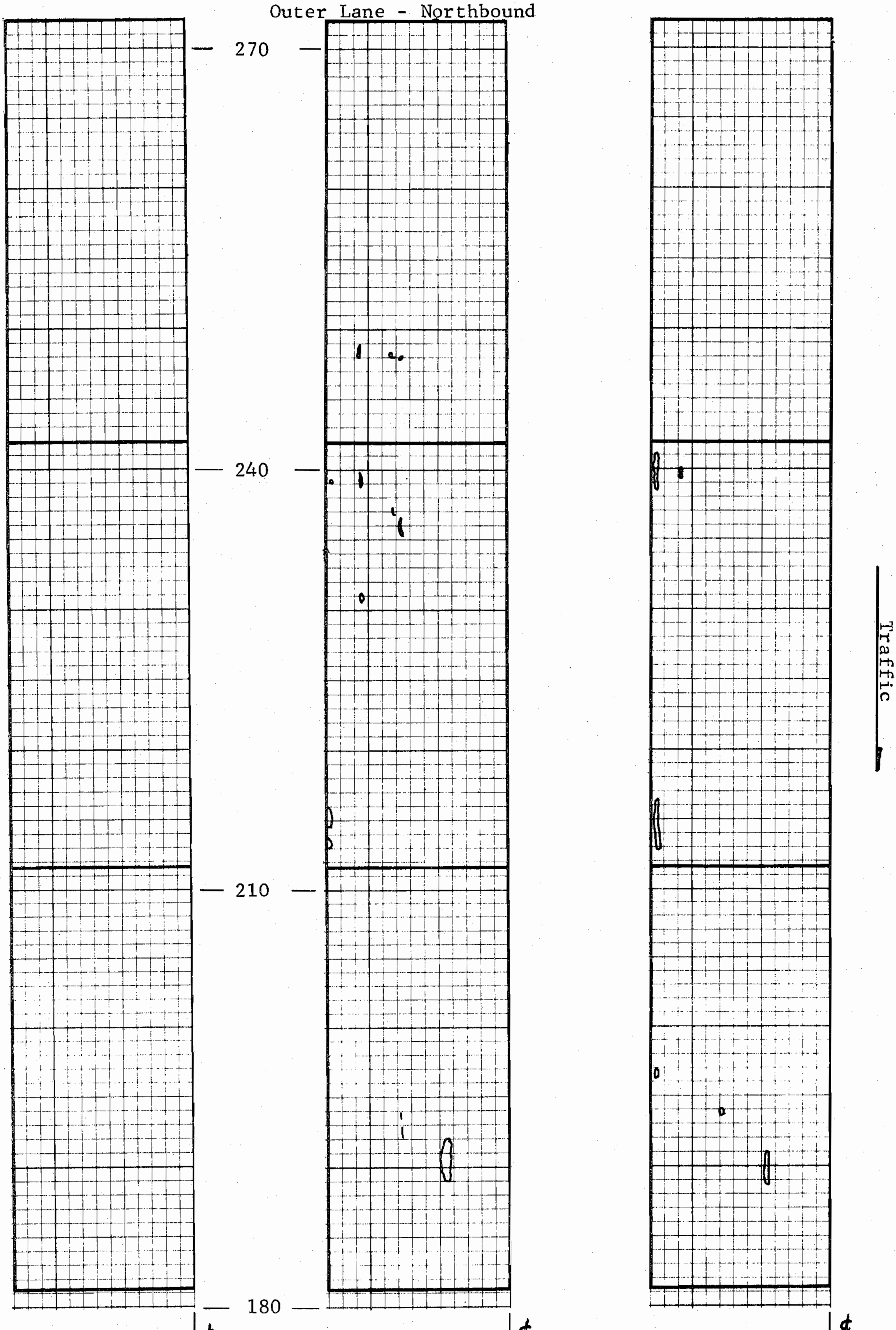


Hammer Method

THD Prototype

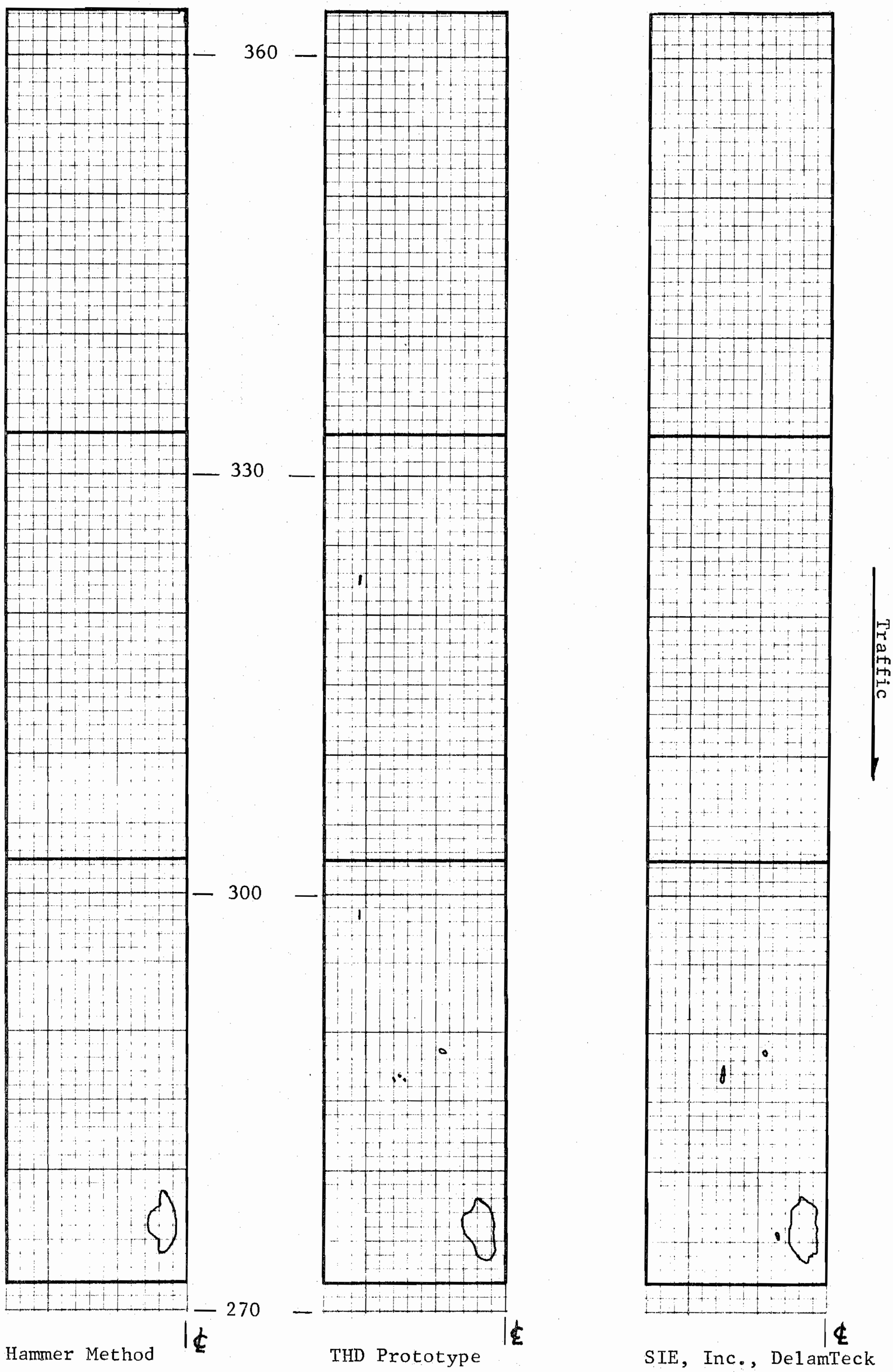
SIE, Inc., DelamTeck

MAP I
Brushy Creek - S119.T50
Outer Lane - Northbound

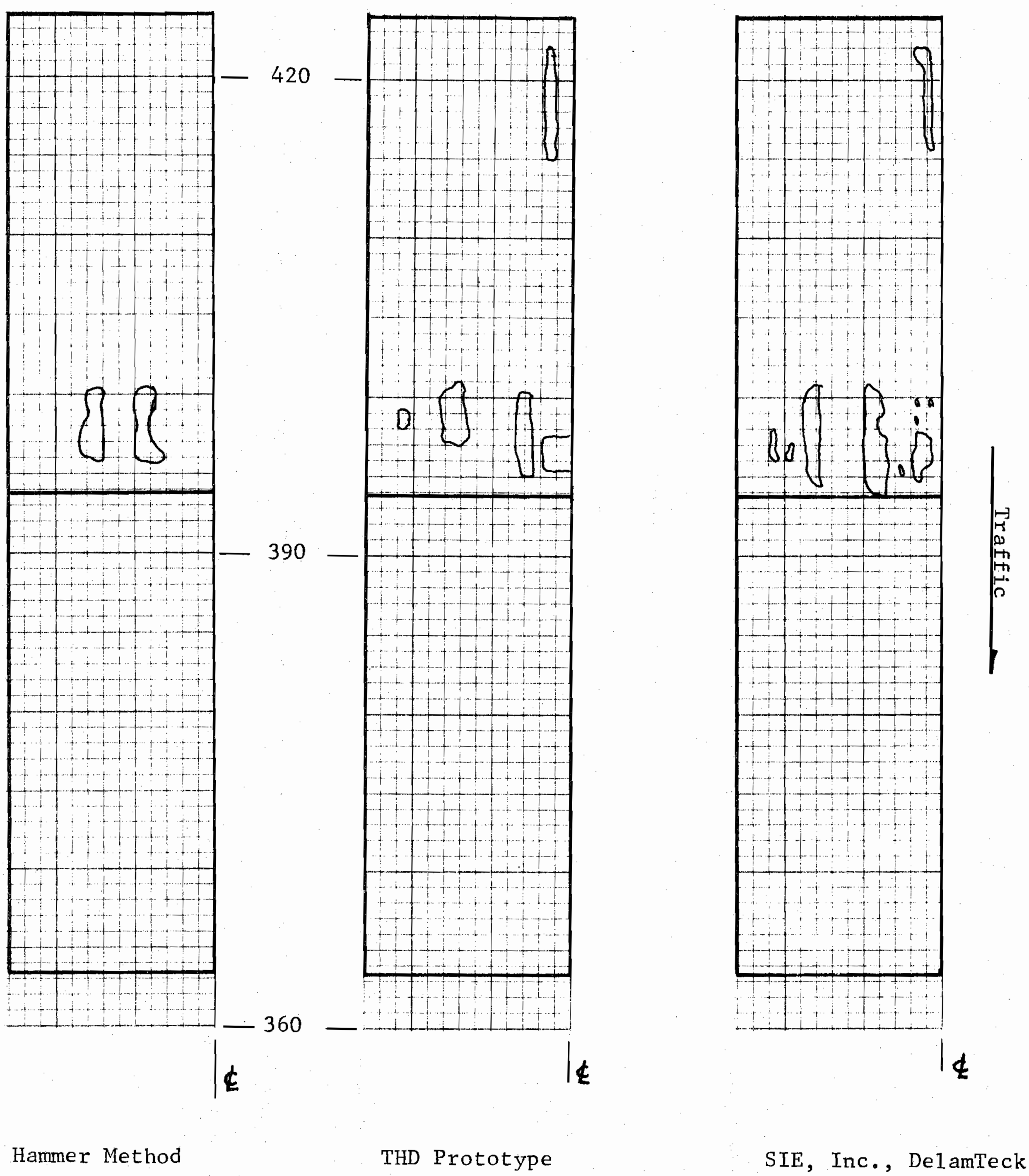


Hammer method THD Prototype SIE, Inc., DelamTeck

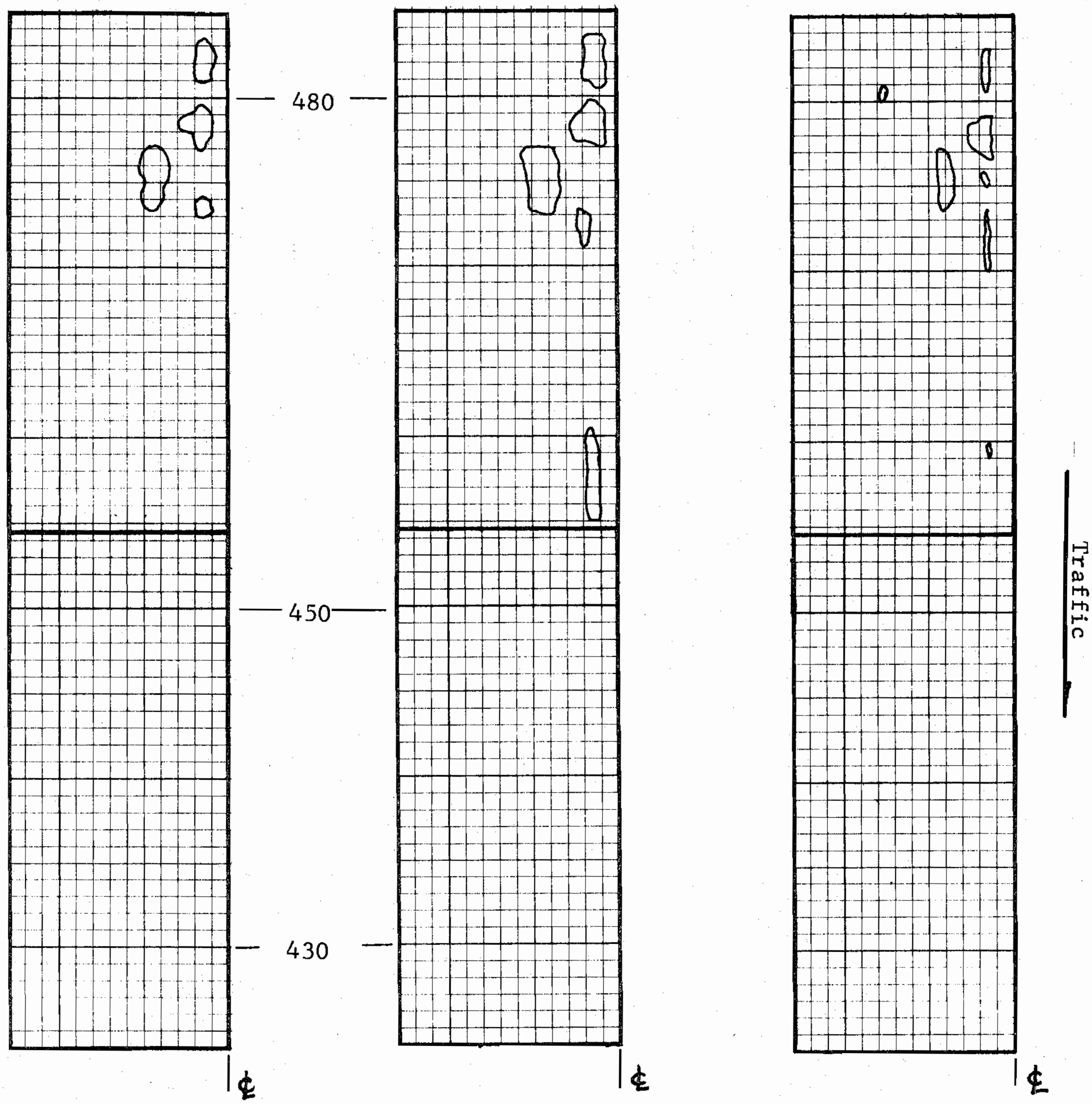
Brushy Creek - S119.T50
Outer Lane - Northbound



MAP I
Brushy Creek - S119.T50
Outer Lane - Northbound



MAP I
Brushy Creek - S119.T50
Outer Lane - Northbound

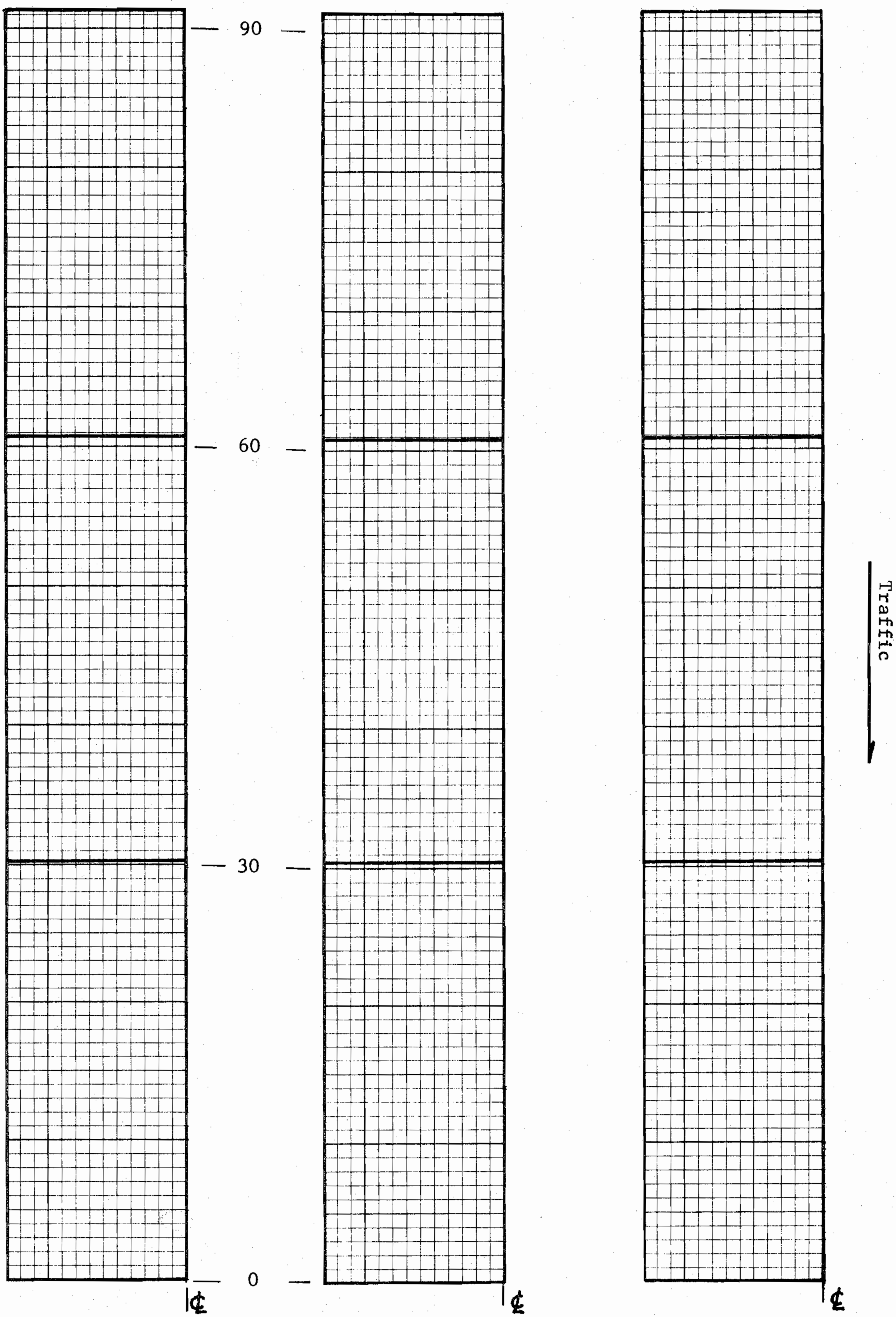


Hammer Method

THD Prototype

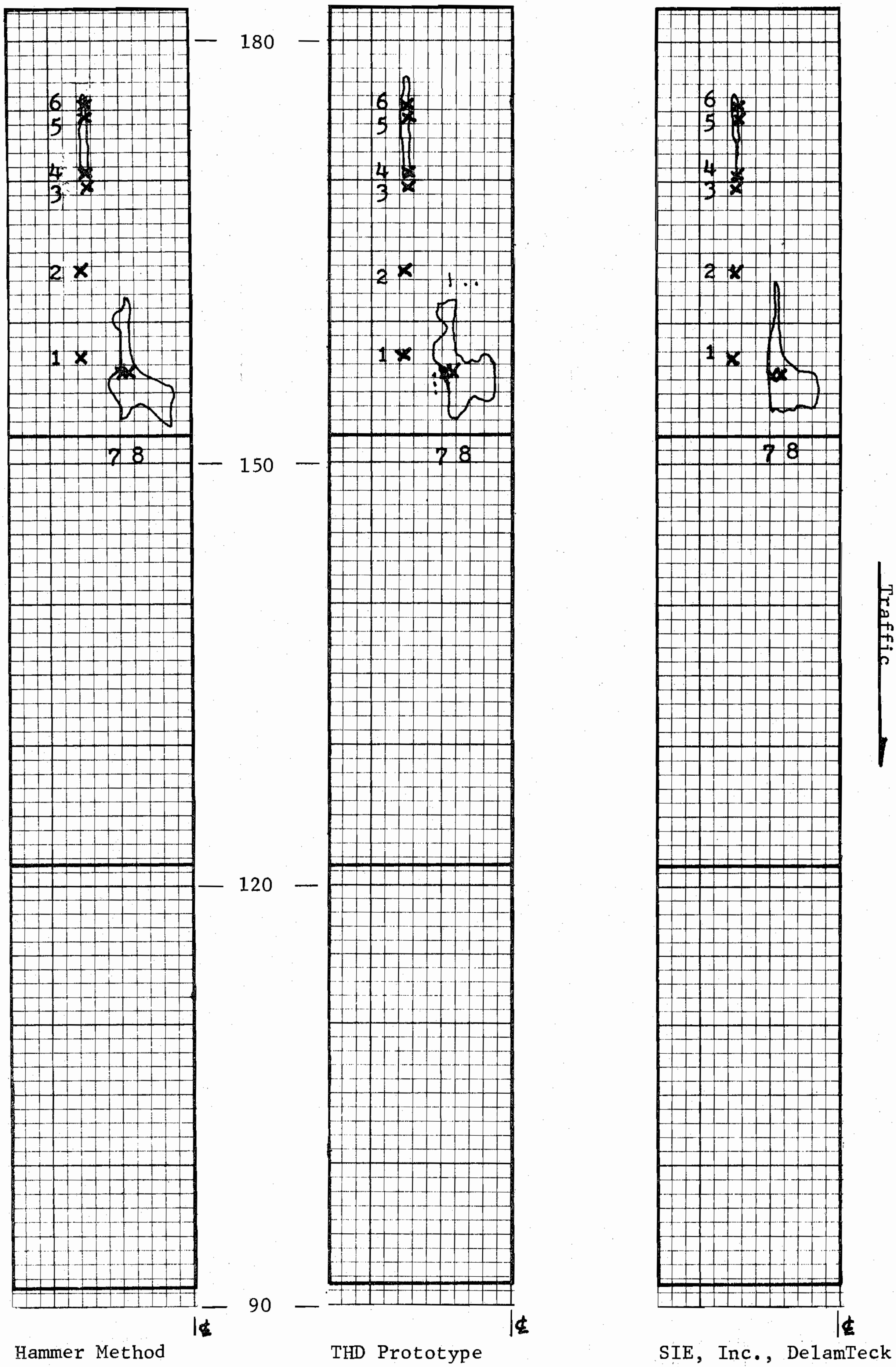
SIE, Inc., DelamTeck

MAP II
Bear Creek - S108.T50
Outer Lane - Northbound

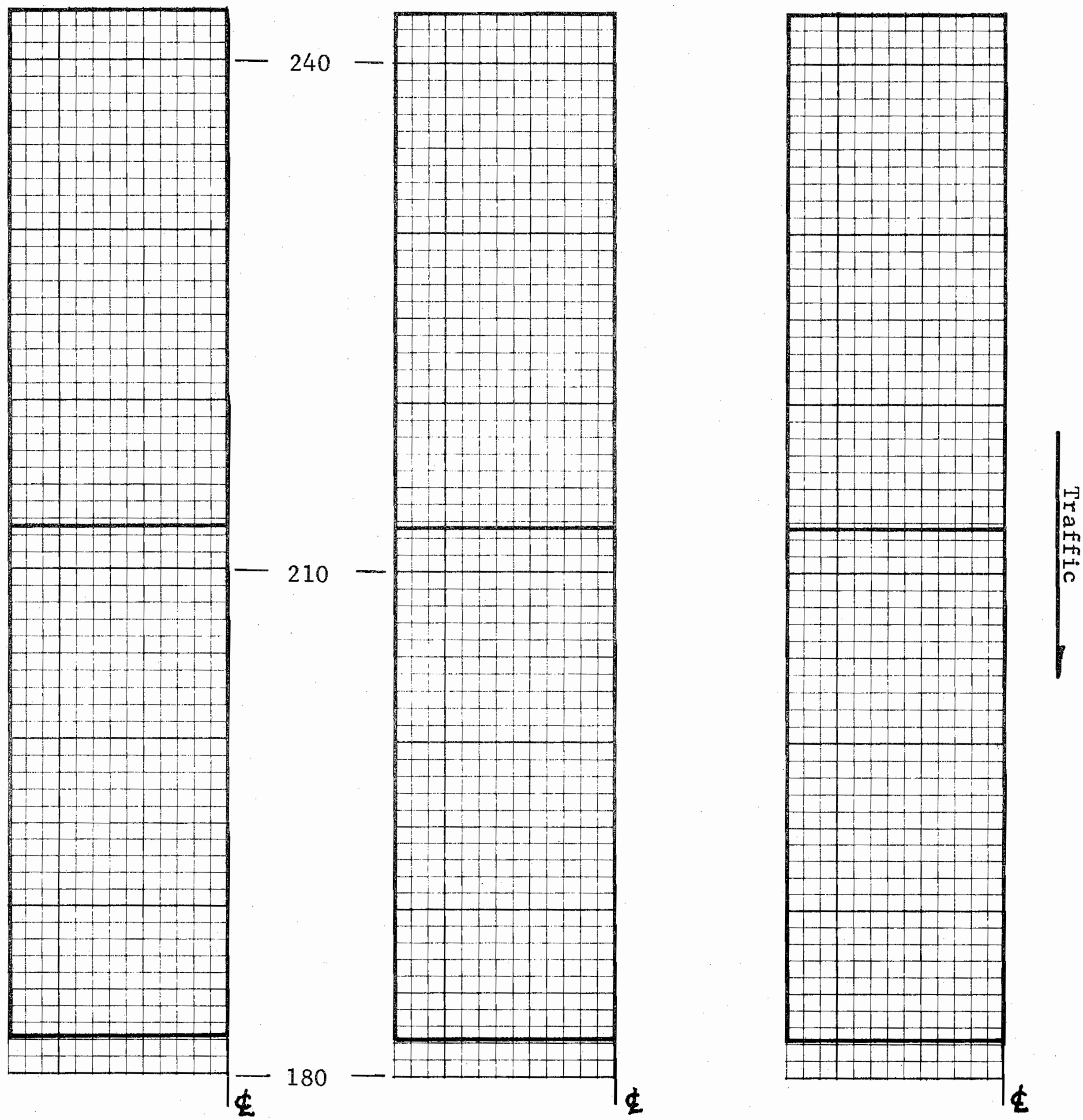


Hammer Method THD Prototype SIE, Inc., DelamTeck

MAP II
Bear Creek - S108.T50
Outer Lane - Northbound



MAP II
Bear Creek - S108.T50
Outer Lane - Northbound

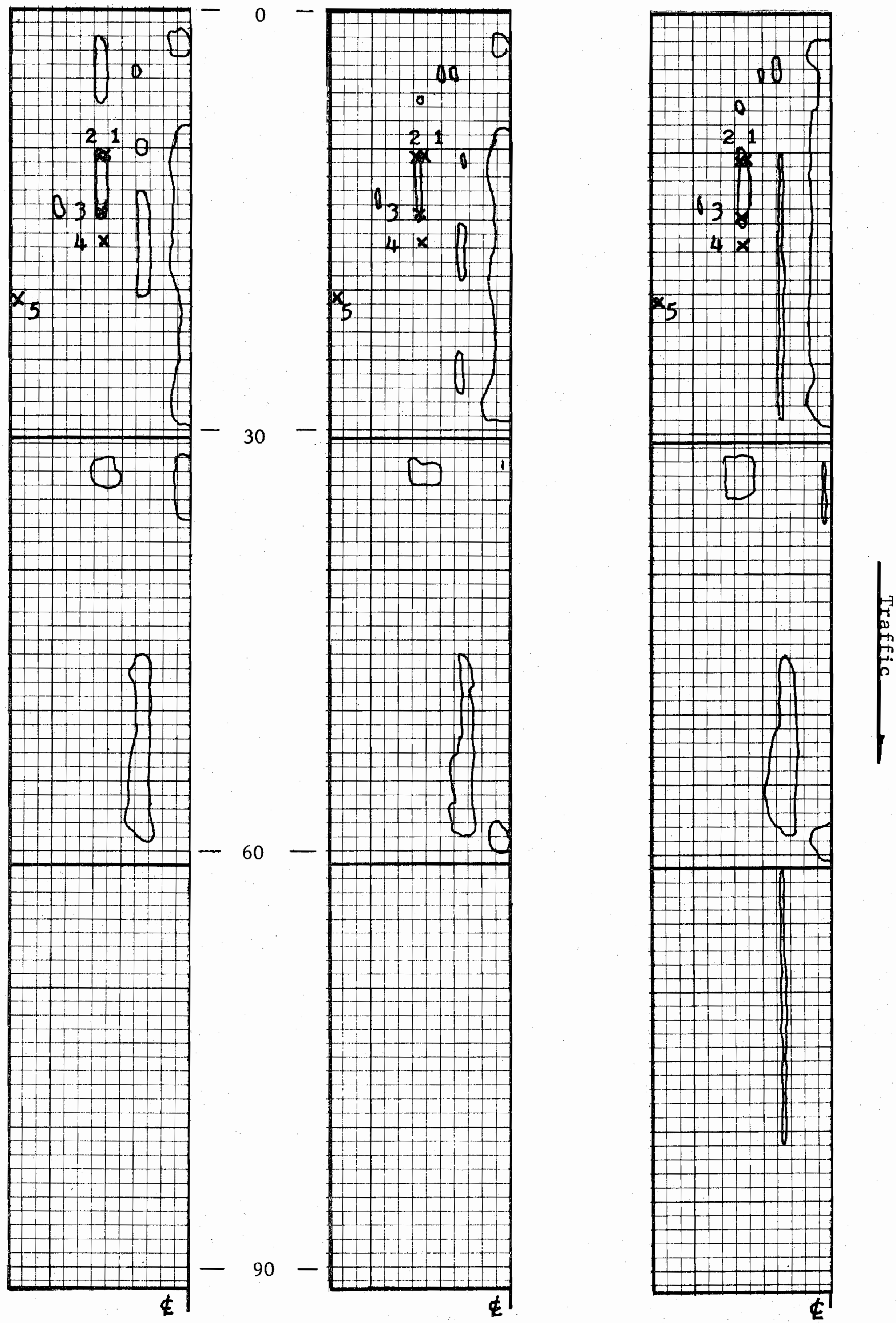


Hammer Method

THD Prototype

SIE, Inc., DelamTeck

MAP III
Brushy Creek Relief - S112.T50
Outer Lane - Northbound

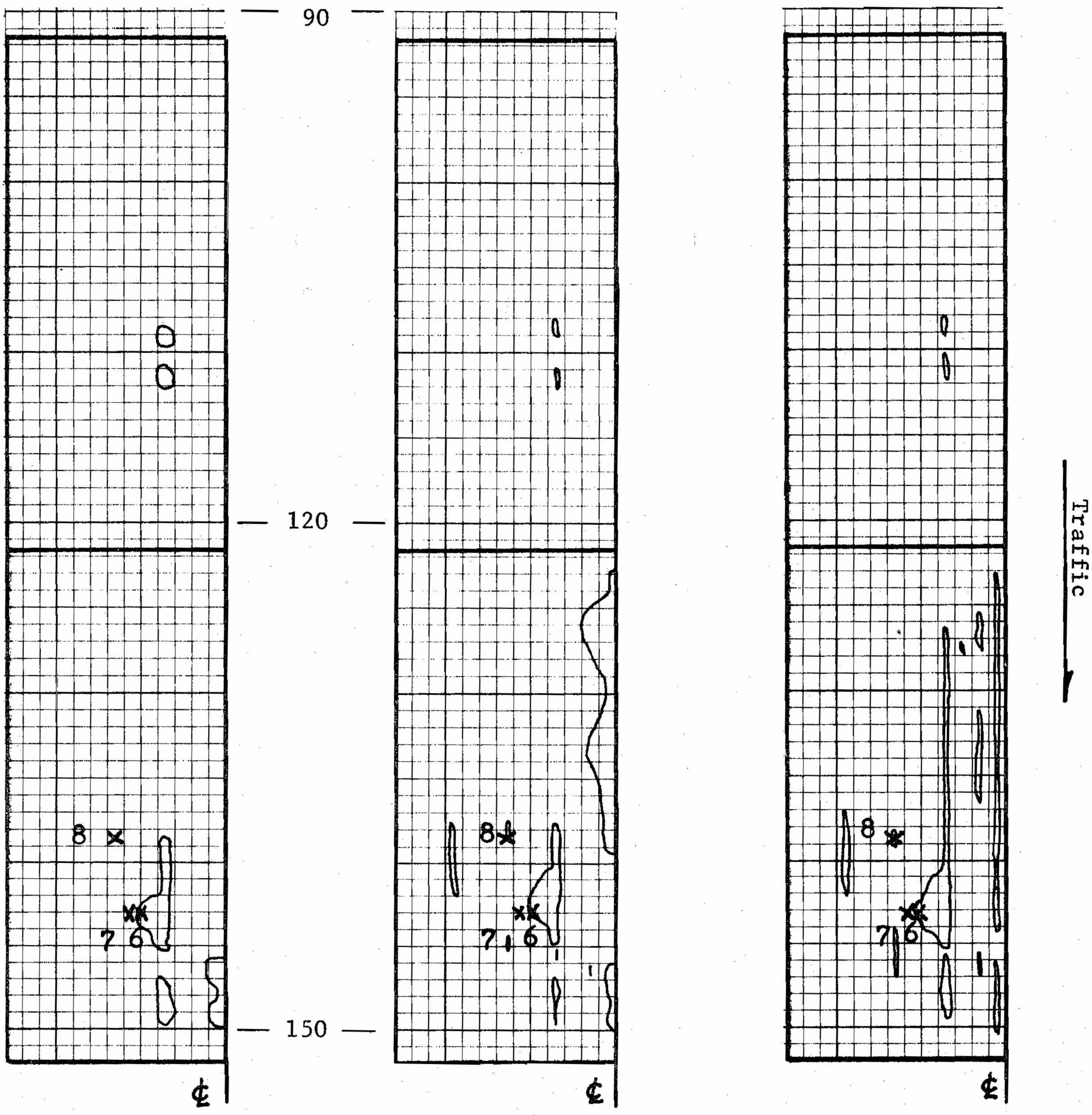


Hammer Method

THD Prototype

SIE, Inc., DelamTeck

MAP III
Brushy Creek Relief - S112.T50
Outer Lane - Northbound

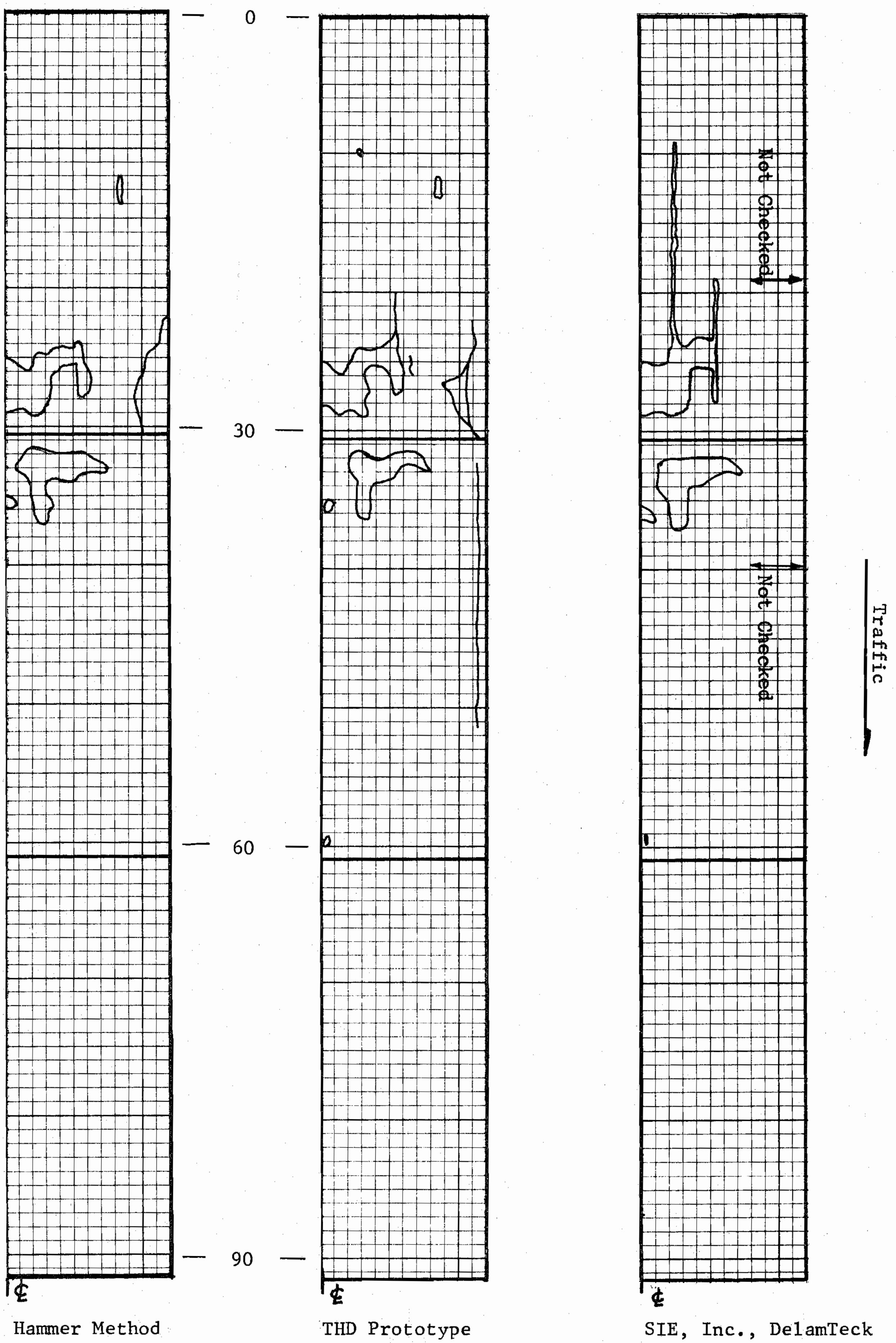


Hammer Method THD Prototype SIE, Inc., DelamTeck

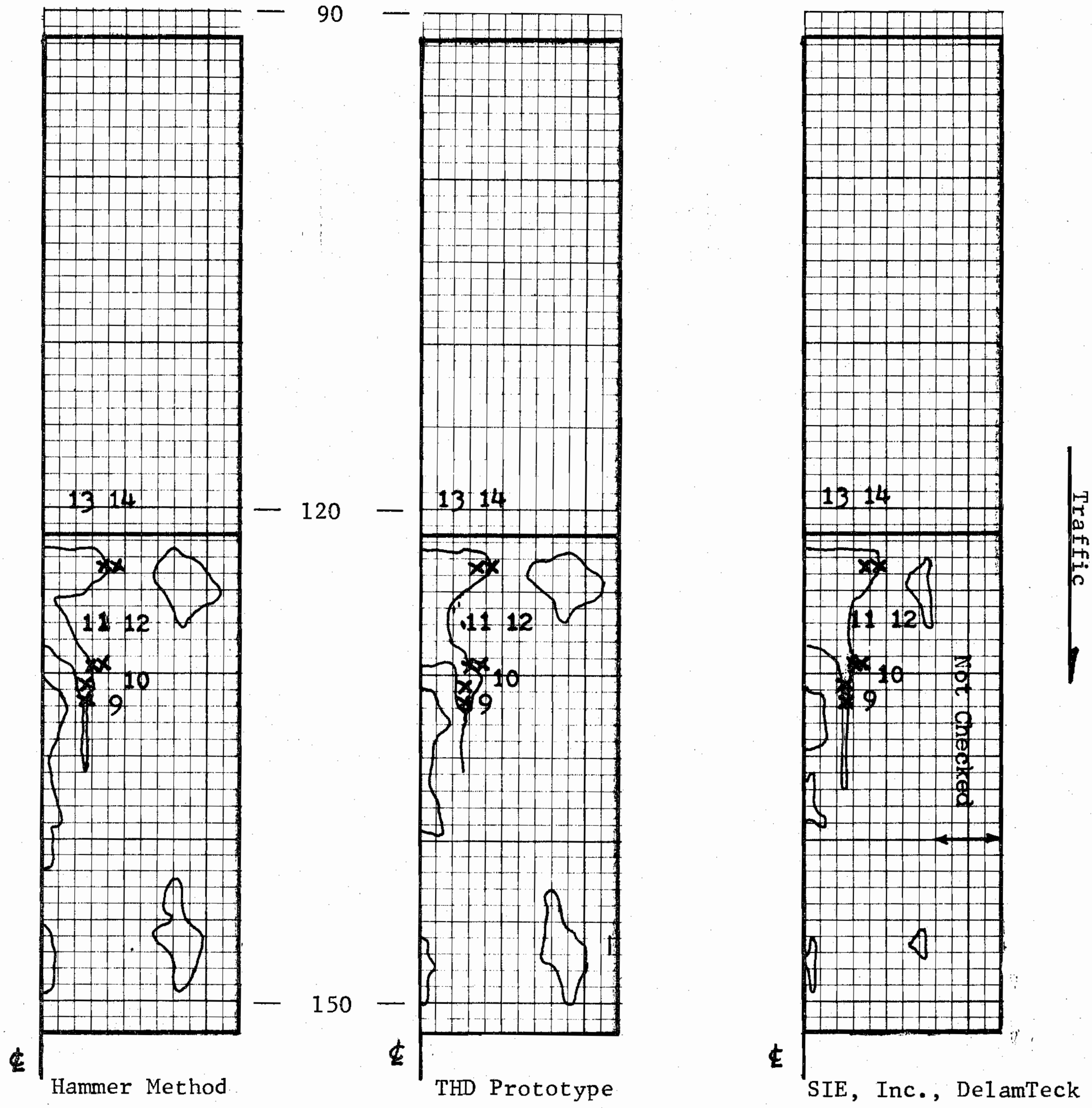
MAP III

Brushy Creek Relief - S112.T50

Inner Lane - Northbound



MAP III
Brushy Creek Relief - S112.T50
Inner Lane - Northbound



APPENDIX B

Table I

Core Data From S119.T50
Brushy Creek Bridge, Ellis Co., I-45,
Northbound, Outside Lane

Core	Description
B-1	Located in northmost slab. Core taken in area found delaminated by both SIE and Texas Highway Department detectors but outside the area found delaminated by the hammer method. The core was nine inches long plus 15/16 inch of overlay. It was through an old patch varying from one to 1-1/4 inch thick. The patch had vertical cracking from top to about 1/4 inch deep. A vertical crack below the patch crossed steel reinforcing. The steel was clean. Broken aggregate over 3/4 of the area indicates that the break probably occurred during drilling. The remainder 1/4 appears, from the poor paste condition and lack of bond to aggregate, to have already been delaminated. This area was located from the patch-concrete junction to 1/4 inch below the patch.
B-2	Located in fourth slab from north end of bridge. Core taken in area found delaminated by both SIE and Texas Highway Department detectors but outside the area found delaminated by the hammer method. The core was 9-1/2 inches long plus 7/8 inch of overlay.

There was a horizontal delamination varying from one-half to one inch below the top. This area was filled with dirt and debris. Steel was in the delamination but only had tight rust.

Table II

Core Data From S108.T50
Bear Creek Bridge, Ellis Co., I-45,
Northbound, Outside Lane,
Sixth Slab from North End of Structure

Core	Description
BR-1	This core was taken at a spot flaw located only by the SIE detector readjusted to higher than normal gain. The core was located in the thin section of the deck. It is 3-3/4 inches long plus 1-1/4 inches of overlay. The steel bar cut is clean. A vertical tension crack is visible at the bottom and penetrates about 3/4 inch.
BR-2	The core was taken in a spot flaw located only by the SIE detector operating at higher than normal gain. The core was taken in the thin section of the deck. It is 4-1/8 inches long plus 1-1/8 inches of overlay. There is one continuous but not open vertical crack running from top to bottom. The steel cut is clean.
BR-3	The core was located just outside flaw zones as found by all methods. The core was taken in the thin portion of the deck. It is 4-1/2 inches long plus 1-1/8 inches of overlay. The overlay broke off the sealcoat to the deck during drilling. There is some visible indication of separation of sealcoat to deck. No other flaws are noted.

BR-4 The core was taken from an area where the Texas Highway Department and SIE detectors indicated flaws. The core was just outside the edge of the hammer method located flaw zone. The SIE detector recorder deflection was four millimeters, a low response. The Texas Highway Department detector recorder deflection was about three millimeters, also a low response. The core was taken in the thin portion of the deck. It is 4-1/2 inches long plus 1-1/8 inches of overlay. No flaws are found in the concrete. Spots of apparent poor bonding between the sealcoat and the deck are visible.

BR-5 The core was taken in an area all methods defined as flawed. Both the Texas Highway Department and SIE detector responses were low. The core was taken in the thin portion of the deck. It is 4-1/2 to 5-1/2 inches thick plus 1-1/8 inches of overlay. No flaws are visible in the concrete. Spots of apparent poor bonding between the sealcoat and deck are visible.

BR-6 The core was taken in an area all methods defined as flawed but just inside the edge of the SIE detector defined zone. Both the Texas Highway Department and SIE detector responses were low. The core was taken from a thin portion of the deck. It is 4-1/2 to 6 inches long plus 1-1/8 inch of overlay. No flaws are visible in the concrete. Spots of apparent poor bonding between the sealcoat and deck are visible.

BR-7 The core was taken in a zone found flawed by the hammer method and at the inside edge of flaw zones as defined by the Texas Highway Department and SIE detectors. Both detectors had a strong response. The core was taken in the thin portion of the arch. It is 3-1/2 inches long plus 1-3/8 inch of overlay. There is a horizontal delamination varying from 1-1/2 to 2 inches below the concrete surface. A vertical crack runs from top to bottom. A steel bar was heavily corroded.

BR-8 The core was taken inside areas found delaminated by all three methods. Both detectors had a strong response. It is located one foot inside of BR-7. The core is from 1 to 2 inches long plus 1-3/8 inch of overlay. It broke during drilling. As almost no aggregate is broken, a delamination is assumed. The core was through an old patch which contains some vertical cracking.

Table III

Core Data From S112.T50
Brushy Creek Relief, Ellis Co., I-45,
Northbound, All Lanes

Core	Description
S112-1	This core was taken in the southmost slab, outside lane. It is located just inside the edge of an area defined as flawed by the SIE detector (low response). It was outside the delaminated area as defined by the hammer method and Texas Highway Department detectors. The core was taken near the thin portion of the deck. It varies from 5 to 6-1/4 inches long plus a 3/4 inch overlay. There is some vertical cracking visible at the bottom.
S112-2	This core was taken in the southmost slab, outside lane. It is inside a zone defined as flawed by the hammer method and both the Texas Highway Department and SIE detectors. The Texas Highway Department detector only located a long narrow (3 to 4 inches) flaw zone. The hammer defined zone was indistinct, the operator described it as only "different sounding." The core was taken in the thin section of the deck. It is 4-3/4 inches long plus 3/4 inch of overlay. There is a tight vertical crack from top to bottom at one side. There was no rust on the steel.

S112-3 The core was taken in the southmost slab, outside lane. It was located in a zone defined as delaminated by both detectors and the hammer method. The Texas Highway Department and SIE detectors both found long narrow (three to four inches) flawed zones. The hammer border was larger but admittedly indistinct by the operator.

The core was taken in the top portion of the deck. It varies from 4-3/4 to 5-1/2 inches long plus a 1/2 inch overlay. A few vertical cracks can be found in the top. The steel bar cut was clean.

S112-4 The core was located in the southmost slab, outside lane. It is outside of any delaminated area located by all three test devices.

The core was taken in the thin portion of the deck. It varies from 4-1/2 to 5-1/2 inches long plus 3/4 inch of overlay. There is some vertical tension cracking visible at the bottom of the core.

S112-5 The core was located in the southmost slab, outside lane. It is in a spot flaw in the gutter area found only by the SIE detector.

The core was broken off at a length of about 8-1/4 inches plus

3/4 inch of overlay. No flaws are visible in the concrete. There is visual evidence of a poor bond between the sealcoat and the deck.

S112-6 The core was located in the northmost slab. It is in an area found delaminated by both detectors and the hammer method.

The core was broken off at a length of 8-3/4 inches plus 7/8 inch of overlay. A horizontal delamination occurs on a slope from 1/4 inch to one inch below the top. A second delamination occurs one inch below that. No vertical cracking is visible.

S112-7 This core was taken in the northmost slab, outside lane. It is eight inches outside of Core S112-6 above. It is just outside the edge of an area found delaminated by the Texas Highway Department and SIE detectors and well outside the area found by the hammer method.

The core was 6-1/2 inches long plus 3/4 inch of overlay when broken off during drilling. The steel cut was clean. No vertical tension cracking or delamination was found.

S112-8 This core was taken in the northmost slab, outside lane. It was from a small spot located by the Texas Highway Department and SIE detectors but not by the hammer method.

The core was taken in the thin section of the deck. It is four inches long plus 1/2 inch of overlay. A vertical crack in the top of deck penetrated about 1/2 inch. The crack area was opened and found to be discolored inside.

S112-9 The core was taken from the northmost slab, inside lane. The core was in a narrow strip found to be delaminated by all methods.

The core was taken in the thin portion of the deck. It is 3-3/4 inches long plus 1 inch of overlay. A vertical crack ran from top to bottom through the center of the core. The crack is discolored inside for 1-1/2 from top due to dirt penetration. There is light rust on the steel.

S112-10 The core was taken from the northmost slab, inside lane. It is from a narrow strip found to be delaminated by both detectors and the hammer method. This core is located one foot south of Core S112-9. The core was taken in the thin portion of the deck. It is about 4 inches long plus 7/8 inch of overlay. An old patch was cut. There is vertical cracking through the patch. A horizontal crack is 1/2 inch below the top of the concrete in the patch. The patch-sealcoat area appears to be spalling. The core has a delamination 1/4 inch below the patch-concrete junction. Steel in the area is rusty. The entire delamination was about 1/2 inch thick and severely deteriorated.

S112-11 The core was taken from the northmost slab, inside lane. It is from an area found delaminated by all methods.

The core was taken through the wall of the arch in the deck. It varies on the slant from 5 to 6-1/2 inches long plus a 7/8 inch overlay. An old patch area was partially cut. The patch-sealcoat junction appears to be spalling. There is a delamination varying from 1 to 1-1/2 inches below the top of the concrete.

S112-12 The core was taken from the northmost slab, inside lane. It is located nine inches outside of Core S112-11 above. It is just out of an area found delaminated by all instruments. The core was broken during drilling at 5-3/4 inches long plus 1 inch of overlay. No flaws were found.

S112-13 The core was taken in the northmost slab, inside lane. It is in a large area found delaminated by both detectors and the hammer method.

The core was broken off during drilling at 7-1/2 inches long plus 3/4 inch of overlay. A delamination occurs on a slant from 1/2 to 1 inch below the top of the concrete. As some aggregate was broken, this could have occurred during drilling. There is also some vertical cracking and visual signs of spalling at the concrete-sealcoat junction.

S112-14 This core was taken in the northmost slab, inside lane. It is nine inches outside of core S112-13 above. It is outside the delamination areas found by all devices.

The core was broken off in drilling at seven inches long plus 3/4 inch of overlay. No flaws were found. The steel cut is clean.

APPENDIX C

FHWA SUPPLEMENTAL INFORMATION SHEET

1. Question

Are there any suggested changes or modifications in the detector that would significantly improve its utility and/or performance?

Answer

a. The SIE delamination detector needs an improved arrangement for adjustment of amplifier gain for calibration purposes. A ten-turn potentiometer with a ten-turn dial readout (mounted under cover) is suggested. The dial readout would enable the operator to note significant long term changes that may indicate impending electronic problems.

b. A built-in meter indicating battery voltage would be a useful addition.

c. See additional comments under question 3.

2. Question

How many hours of operating time can realistically be expected from each full charging of the battery?

Answer

The battery was never discharged enough in our tests to affect operation (approximately 5-6 hours continuous operation for SIE detector). It was our understanding that at least 10 hours of operation could be expected from a fully charged new battery.

3. Question

Are the operating and adjustment switches satisfactory as to type and convenience of location? If no, what changes should be made?

Answer

No. The SIE detector event marker switch is now located on the side of the push-bar. It should be moved to a higher position, preferably on the horizontal portion of the handle.

4. Question

Is the spray paint attachment with operator control on push-bar, to mark specific locations on the bridge deck an attractive attachment?

Answer

Yes.

5. Question

Do you feel there is any need for a training workshop on operation and essential routine maintenance for purchases of the detector? If yes, how extensive?

Answer

Yes. One to two days should be sufficient to cover normal operation, calibration, interpretation and maintenance.

6. Question

Do you feel that the modular design of the detector components achieved the easy portability that was intended, with respect to loading and unloading from the trunk of an automobile?

Answer

Yes. The SIE unit is 80 pounds lighter and far easier to handle than the Texas Highway Department prototype. The enclosed compartments for storage of cables and connectors are also very good.

7. Question

In operation of the detector, does travel speed within a range of 1 to 4 mph seem to affect the detector response, i.e., does increased speed affect performance adversely?

Answer

Within this speed range, no adverse affects were noted. At higher speeds, the tapper will contact the pavement at intervals far enough apart to seriously affect the accuracy of the test results. At 10 mph, the SIE machine will tap the pavement only once every 4 inches at its present 42 cycles per second tapping rate. The recorder pen response is also slow enough to seriously affect the overall system response at these speeds.

8. Question

What travel speed do you consider optimum for the detector in programming of work schedules?

Answer

No faster than a moderate walking pace - perhaps two to three miles per hour.

9. Question

Does the graphic record of the recorder chart provide easy conversion to grid coordinates on the bridge deck, or for plotting contour maps of the bridge deck? Comments:

Answer

The SIE scale is convenient to use for plotting on either the deck or a map. Each millimeter scales to approximately six inches.

10. Question

Does detector performance indicate any evidence of adverse effects from the following field conditions?

Answer

a. Ambient temperature - no effects noted in this test. Maximum temperatures were in the high 90's, low temperatures about 75.

b. Low voltage - although both the commercial and prototype detectors were left on for periods of up to six hours, no low voltage problems were encountered. Low voltage conditions would most likely affect the tapper solenoid first, resulting in lowered output energy.

c. Moisture or water on the bridge deck - no effects noted in showers in this project. None should be expected unless water depth was appreciable (1/16-inch or more).

d. Dirt, gravel or other debris typically present on the bridge deck - the bridges used in this project had been swept by machine several weeks earlier. No problems were experienced here. Prior experience in Texas has resulted in puncture to the acoustic wheels from glass and, in certain areas of the State, from large thorns and burrs that have blown into the bridge deck, especially the gutter.

11. Question

Was it found necessary to sweep or otherwise clean the surface of any bridge deck before surveying for delamination?

Answer

Not for this project. See comments under 10-d above. A hand broom to clean up small amounts of debris should always be available.

12. Question

It is presumed, but not definitely confirmed, that any lack of bonding between the concrete deck and a bituminous overlay surfacing would show on the detector chart graph as a delamination. It is also presumed that detector evidence of delamination under a bituminous overlay deck would not distinguish between (1) lack of bond between concrete and bituminous overlay, (2) delamination in the concrete, or (3) the presence of both delamination and lack of bonding between concrete and the bituminous overlay. Were there any conditions encountered where the detector response together with any other information available contributed either negative or positive support of the assumption.

Answer

Yes. Several cores in structure S108.T50 had apparent flaws in the overlay. In taking core BR-3 the overlay separated from the sealcoat on the deck. No recorder response was noted at this location, however.

Cores BR-4, BR-5 and BR-6 had no visible faults in the concrete, yet all were indicated to be in a flaw zone by the hammer and both detectors. All three showed apparent poor bond between deck and sealcoat when sectioned and examined. Response was low in all these cases.

13. Question

What was the depth of the deepest delamination found by the detector and confirmed by core drillings?

Answer

In this series of tests, the deepest delamination found was under a 1-3/8 inch overlay plus two inches of concrete. Earlier tests with the Texas Highway Department prototype have located delaminations under overlays over four inches thick. In December of 1973, tests were run on an 18-inch thick slab (no overlay) cast on the ground. A crack starting at the surface was traced out for several feet. Cores revealed the crack to be 14 inches deep at the end. The recorder was operated at 20 times its normal gain during this test.

14. Question

Where bituminous overlays are encountered over confirmed delaminated areas, is the delamination detectable with the hammer (indicate at what depth), and can the delaminated areas be accurately determined?

Answer

Yes, an area of delamination could be found with the hammer (up to 1-3/8 inch overlay, delamination two inches below top of concrete). The hammer could not be expected to accurately determine the delaminated area. In several cases, the hammer outlined a delaminated area up to one foot inside the actual confirmed borders.

15. Question

What was the amount of down time incurred for the detector, and the reasons for same?

Answer

The SIE detector lost about one hour on the first bridge because of calibration and drift problems in one channel. The channel later failed entirely. The other channel continued to operate satisfactory. The failure was in the electronics.

The Texas Highway Department prototype lost the chart recorder drive chain on the last bridge. The electric drive was used (with no scaling factors for mapping) and testing continued. That drive chain was four years old. A spare chain is now carried.

16. Question

Based on experience from the bridges surveyed with the detector, indicate for the typical bridge situation encountered, the following approximate data with respect to detector survey work performance capabilities.

Answer

a. Average travel time and distance to bridge site - in this project, about 20 minutes and 15 miles. The answer to this question would vary greatly from bridge to bridge and project to project. In one of our western districts in Texas, the inspectors live over 200 miles from many of the structures they inspect.

b. Total time required by traffic control crew to set up and dismantle traffic control paraphernalia at the bridge site is about 75 minutes. Size of traffic control crew was four men.

c. Total detector time (excluding traffic control set-up and dismantle time) spent at bridge site - approximately ten minutes to set up, ten minutes to warm up and calibrate, ten minutes to dismantle for a total of 30 minutes. Set up and calibration can often be done while the traffic crew is putting out their warning signs.