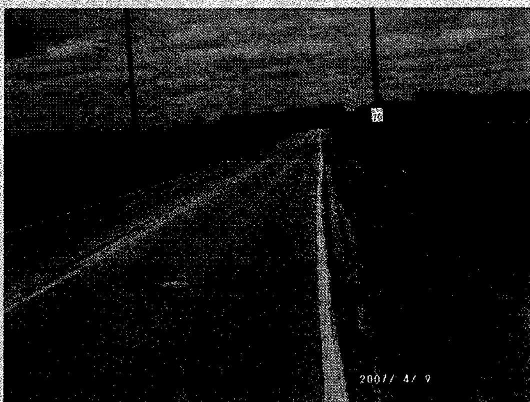
APPENDIX J

Geotechnical Investigation Report



PAVEMENT DESIGN REPORT

Guelph Line

Derry Road to Steeles Avenue

Region of Halton Request PR-2385

Halton
A World Class Place To Be.

Submitted to:

The Regional Municipality of Halton
Engineering & Services Division
1151 Bronte Road
Oakville, Ontario
L6M 3L1

August 23, 2007

ARA Project Number 18780

5401 Eglinton Avenue West, Suite 204 | Toronto, Ontario M9C 5K6 | transportation@ara.com | p 416.621.9555 | f 416.621.4917

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APPLIED RESEARCH ASSOCIATES, INC.

September 27, 2007

Ms. Brenda Kingsmill
Design Supervisor
Engineering Services Division
Planning & Public Works Department
The Regional Municipality of Halton
1151 Bronte Road
Oakville, Ontario
L6M 3L1

Subject: Region of Halton 2007 / 2008 Asphalt Resurfacing Program
Expanded Asphalt Stabilization
ARA Project No. 17870

Dear Ms. Kingsmill:

It is our understanding that Halton Region has elected to use an Expanded Asphalt Stabilization process as part of the rehabilitation of Guelph Line, from Derry Road to Steeles Avenue, and Steeles Avenue, from Tremaine Road to Bronte Street. The pulverizing option can be supplemented with expanded asphalt stabilization.

The expanded/foamed asphalt method is an in-place recycling technique that uses foamed asphalt as a stabilizing agent. Foaming occurs when small amounts of water are added to hot asphalt in a controlled expansion chamber. The advantages of foamed asphalt stabilization over other stabilization techniques, include: can have lower costs, an acceptable driving surface immediately after placing and compaction, reduces the overall grade raise required, and the method is relatively insensitive to environmental constraints (ambient weather) during placement. The following pulverizing and expanded asphalt strategy is recommended for these roadways, should this alternative be considered.

50 mm	SP 12.5FC1 Surface Course
150 mm	Stabilization with Foamed Asphalt
	Pulverize Existing Pavement

TRANSPORTATION SECTOR
5401 EGLINTON AVE., WEST, SUITE 204 ■ TORONTO, ONTARIO, CANADA M9C 5K6
(416) 621-9555 ■ FAX: (416) 621-4917 ■ WWW.ARA.COM/TRANSPORTATION

Expanded asphalt stabilization of Guelph Line and Steeles Avenue should be carried out in accordance with OPSS 331, *Construction Specification for Full Depth Reclamation With Expanded Asphalt Stabilization.*

Should you have any questions, or comments, please feel free to call our offices. We look forward to a continued working with you on this project.

Sincerely,

Applied Research Associates, Inc.

Mark Popik

Mark Popik, M.Eng, P.Eng.
Pavement Engineer

August 23, 2007

GUELPH LINE RESURFACING
FROM DERRY ROAD TO STEELES AVENUE
HALTON REGION, ONTARIO

Submitted to:

The Regional Municipality of Halton

ARA Project 18780

By:

Applied Research Associates Inc.
5401 Eglinton Avenue West, Suite 204
Toronto, Ontario M9C 5K6
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TABLE OF CONTENTS

1. INTRODUCTION

Applied Research Associates Inc. (ARA) was retained by The Regional Municipality of Halton (Halton Region) to complete a pavement evaluation for the proposed rehabilitation of Guelph Line, from Derry Road to Steeles Avenue, a distance of approximately 3.5 km. Written authorization to proceed with this assignment was provided in Purchase Order 4500058620, dated February 5, 2007.

We understand that Halton Region is considering resurfacing this section of Guelph Line as part of their 2007/2008 asphalt-resurfacing program.

The purpose of this assignment was to determine the existing condition of the in-situ pavement and subgrade materials, estimate the remaining life of the in-place pavement structure, identify potential rehabilitation options, and recommend a cost-effective pavement rehabilitation strategy.

2. INVESTIGATION METHODOLOGY

The field investigation for this assignment consisted of the following tasks:

- A detailed pavement surface condition survey to determine the location, extent and severity of pavement distresses. Visible distresses were identified in 100 m sections for both lanes on Guelph Line.
- Falling weight deflectometer (FWD) testing of the pavement to determine structural adequacy.
- Cross fall and rut depth measurements at regular intervals throughout the project limits.
- Pavement coring was completed at roughly 100 m intervals to determine information on the type and thickness of the various asphalt layers throughout the roadway. Additional cores were also advanced at each intersection to determine the asphalt thickness at the tie-in locations.
- Boreholes to determine both the type and thickness of the existing pavement structure components, as well as the subgrade and groundwater conditions at the site. Borehole locations were established at a frequency of roughly 500 m, with two boreholes advanced in distress areas.

Project stationing for the field investigation was provided by the Halton Region, and was referenced from the intersection of Guelph Line and Derry Road. The chainage at this intersection was Station 0+000.

The pavement surface condition survey was completed on March 14 and 18, 2007. The survey consisted of a detailed examination of the pavement surface noting the general conditions of the pavement, including areas of pavement distress and distortion. The survey was conducted in general accordance with the *MTO Manual for Condition Rating of Flexible Pavements for Municipalities*.

The structural adequacy of the existing pavement was evaluated by Falling Weight Deflectometer (FWD) pavement load/deflection testing. At each test location, a series of four load applications was applied to the pavement surface. The first application was a "seating" load to ensure the FWD load plate was firmly resting on the pavement surface. The next three loads were approximately 30, 40, and 50 kN. Pavement surface deflections under the load were measured by sensors (velocity transducers) placed at fixed spacing from the load plate in accordance with SHRP testing protocols. The FWD testing was conducted in each lane at roughly 100 m intervals. The testing was completed on May 2, 2007.

The geotechnical work for this investigation was carried out on May 14, 2007 and comprised a total of 43 cores through the asphalt surface. In addition, seven boreholes were advanced at randomly selected locations to determine the pavement structure thickness, with two additional boreholes advanced to investigate a structurally deficient location identified through the FWD testing and condition survey. The boreholes were extended to a depth of 1.5 m below existing grade.

The boreholes were advanced using a truck-mounted drill rig equipped with continuous flight solid stem augers supplied and operated by Malone's Soil Samples Company Ltd. A member of the ARA technical staff provided full-time supervision of the drilling operations.

Representative samples of the granular base/subbase and subgrade materials encountered in the boreholes were retained for detailed visual examination and laboratory classification testing. Routine laboratory testing consisted of grain size analysis, moisture content determination, and Atterberg Limits. Groundwater conditions were recorded during and on completion of drilling.

3. PHYSIOGRAPHIC SETTING

The site lies within the physiographic region known as the Peel Plain, *The Physiography of Southern Ontario, 3rd edition, L.J. Chapman and D.F. Putnam.* The underlying geological material of the plain consists predominately of till containing large amounts of shale and limestone. In much of the Peel Plain, this material has been modified by a veneer clay which, when deep enough, can be varved. The area has a gradual and fairly uniform slope towards Lake Ontario

4. SITE CONDITIONS

4.1 Condition Survey

The pavement section on Guelph Line from Derry Road to Steeles Avenue comprises a two lane rural arterial roadway for the majority of the study area. At the south end of the project, the intersection at Derry Road has been previously upgraded to a three lane urban section. The southerly 800 m of the project contains intermittent partial (mountable) curb.

The condition of the existing pavement was assessed to be in fair condition with localized poor areas. The ride quality was considered to be fair with few to intermittent bumps or depressions. The predominate distresses throughout this pavement section included longitudinal cracking in the wheel paths, transverse cracking, alligator cracking, and pavement rutting. Many of the older longitudinal cracks had been sealed. Localized areas of patching and rutting were noted within this pavement section.

A summary of the detailed surface distress survey is presented in Appendix A. Typical photographs of the site have been provided in Appendix B.

The current pavement quality index (PQI) of Guelph Line, based on a combination of the pavement distress manifestation and ride quality, was estimated to be in the order of 4.4.

In addition to the detailed distress survey, wheel path rut depth and transverse cross fall was measured along the sections. The wheel path rut depth typically varied from 0 to 20 mm, however, 70 mm of rut depth was measured at Station 2+182. The cross fall measurements varied from 0 to 7.0 percent, with an average pavement cross fall of 2.2 percent. At three locations, the cross fall was measured to be negative, which indicated a super-elevated pavement section. The negative cross fall values were not included in the averages. A summary of the rut and cross fall survey is presented in Table 4.1, while the detailed measurements have been included in Appendix C.

Table 4.1 Summary of Rut Depth and Cross Fall Measurements

Lane	Mean Rut Depth (mm)		Mean Cross Fall (%)
	Left Wheelpath	Right Wheelpath	
Northbound	5	11	2.0
Southbound	11	8	2.4

4.2 Falling Weight Deflectometer Testing

Several analysis methodologies were used to analyse the FWD deflection data.

Materials Characterization: The pavement thickness data from the boreholes was used in conjunction with the FWD results to estimate the stiffness (strength) of the existing pavement. Pavement layer stiffness back-calculation uses closed form models to estimate layer elastic modulus values, given the layer thickness and FWD data. The FWD data provides the magnitude and contact area of the load and the output from the FWD deflection sensors.

The procedure as outlined in the *AASHTO 1993 Guide for Design of Pavement Structures*, Part III, Chapter 5, was used to determine the properties of the as-constructed flexible pavements. The resultant data includes the composite elastic modulus (E_p) for the combination of all bound layers above the subgrade (e.g., the asphalt concrete and granular bases), the subgrade elastic modulus (E_s), and the subgrade resilient modulus (M_r). Typically, M_r is calculated from E_s by reducing the value of E_s by a factor of 3.

Maximum Normalized Deflection: The maximum deflection (D_0), measured in the centre of the load plate, is a good indicator of overall pavement strength. The deflection at this location is a function of the pavement layer stiffness, as well as the support capacity of the subgrade. Because deflection is a function of load, and because of slight variations in measured load at each test point, a linear extrapolation of the measured deflection is made to adjust deflections at all test locations to a "standard" load level of 40 kN.

Effective Structural Number: Based on the back-calculated pavement moduli, the effective structural number (SN_{eff}) of the existing pavement was calculated using the 1993 AASHTO Guide for Design of Pavement Structures procedure.

The detailed results of the pavement load/deflection testing and data analysis are presented in Appendix D and summarized in Table 4.2.

Table 4.2 Summary of FWD Results

Lane	D_0 (μm)		M_R (MPa)		E_P (MPa)		SN_{eff} (cm)	
	Mean	**St. Dev**	**Mean**	**St. Dev**	**Mean**	**St. Dev**	**Mean**	**St. Dev**
NB	304	100	44	17	635	272	17.2	2.3
SB	361	175	42	15	542	217	16.3	2.4

The FWD test results were divided by direction to show any variation between the lanes. The normalized deflection, D_0 ,varied between 147 and 756 μm, with an average value of 333 μm. The resilient modulus, M_r, of the subgrade was found to be in the order of 43 MPa. These values indicate fair to good subgrade support.

The effective structural number, SN_{eff}, for the entire roadway varied between 11.7 and 22.2 cm. The average SN_{eff} for roadway was 16.8 cm.

The FWD testing identified two locations with generally higher deflections; at Station 3+395 NB and from Station 1+922 to 2+182 SB. These areas were highlighted for additional investigation.

4.3 Subsurface Conditions

Based on the results of the geotechnical field investigation, the subsurface conditions comprise a flexible pavement structure underlain by the silty clay till subgrade.

Based on the cores/boreholes completed as part of this assignment, the existing asphalt thickness on the traveled portion of Guelph Line was found to range from a low of 100 mm to a high of 210 mm but was typically found to be in the order of 130 to 170 mm. At several locations along the project, substantial differences in asphalt thickness were found between the northbound and southbound lanes. On average the asphalt thickness in the northbound lane was 150 mm, while the average asphalt thickness for the southbound lanes was 130 mm. The asphalt layer thicknesses have been provided in Appendix E.

Examining the core extracted from Station 1+012, found that cracking was observed in the lower two layers of the asphaltic concrete. The cracking had not progressed to the surface course.

Granular base course was encountered beneath the surficial asphalt. The granular base course comprised brown sand and gravel. For roughly the southern 800 m of the roadway, the granular base course comprised crusher run limestone. The typical thickness of the granular base layer varied from 400 to 1040 mm. Granular subbase was encountered in the southern 800 m of the project. Here, the granular base was underlain by 50 mm crusher run limestone in one borehole and brown sand and gravel in the other. The base course in this section varied from 200 to 550 mm, and the subbase extended to depths of 670 and 820 mm, respectively. For ease of reference, the pavement layer thickness, as determined from the cores and boreholes is presented in Table 4.3.

The moisture content of samples tested from the granular base and subbase varied from 3 to 5 percent indicating moist conditions. The grain size analyses of selected granular base/subbase samples indicated that none of the tested samples met the OPSS gradation requirements for Granular A and Granular B. In general, the material was found to be finer than specified with some 12 to 17 percent passing the 75 µm sieve.

Table 4.3 Summary of Pavement Layer Thickness

Station	Lane	Asphalt Thickness (mm)	Granular Thickness (mm)		Total Thickness (mm)
			Base	Subbase	
0+270	NB	130	200	670	1,000
0+637	SB	130	550	820	1,520
1+263	NB	110	590	--	700
1+652	SB	130	460	--	590
1+922	***SB***	***110***	***580***	**--**	***690***
2+270	NB	210	400	--	610
2+744	SB	160	1,040	--	1,200
3+260	SB	130	720	--	850
3+395	***NB***	***150***	***490***	**--**	***640***
Average		140	559		866

Note: ***The boreholes in bold italics were advanced through distress areas***

Underlying the pavement structure, the subgrade generally consisted of brown silty clay till to the termination depth of the boreholes. The moisture content of the till was in the order of 12 to 20 percent, which ranges from drier than the plastic limit to wetter than the plastic limit. The only exception was the borehole at Station 2+744 SB, where silty sand and gravel materials were encountered to the termination depth of the borehole.

Borehole logs summarizing the subsurface investigation have been provided in Appendix F. The results of the laboratory testing completed on the granular and subgrade materials have been included in Appendix G.

The two boreholes advanced in areas of high deflection, at Station 1+922 SB and Station 3+395 NB, showed that the pavement section found was consistent with the other locations investigated.

4.4 Groundwater Conditions

On completion of drilling, free water was not encountered in any of the boreholes. The regional ground water table is likely lower than the depth investigated.

5. ENGINEERING CONSIDERATIONS

An important component of the pavement rehabilitation process is estimating the remaining life of the in-service pavements. Remaining life should be defined in terms of both structural capacity and functional serviceability.

To evaluate the structural adequacy of the existing pavement structure, new pavement designs were developed to support the future traffic loading anticipated for Guelph Line. The designs were completed in accordance with the AASHTO *Guide for the Design of Pavement Structures, 1993.*

Key inputs for the pavement design include; subgrade support, pavement layer material types and thickness, current and projected traffic data including heavy vehicle volumes and distributions and consideration of the roadway classification and utilization. The output of the 1993 AASHTO flexible model is a structural number (SN) that characterizes the structural capacity of the pavement layers required for the given set of inputs. This design SN is then distributed in terms of thickness among the various pavement layers (e.g., HMA, granular base, and granular subbase) according to coefficients characterizing the relative structural support of each material. The AASHTO design method and input parameters were adapted and verified for pavement designs in Ontario as outlined in the MTO publication *Adaptation and Verification of the AASHTO Design Guide for Ontario Conditions* (MI-183). Details on the input data used for the pavement designs are given in the following sections.

5.1 Traffic Loading

The traffic data was provided for our use by Halton Region has been summarized in Table 5.1.

Table 5.1. Guelph Line Traffic Data – North of Derry Road

2006 AADT	2016 AADT	Truck Percentage
5,163	6,294	4.7

The distribution of vehicles was broken down into the following vehicle categories; 95.3, 1.0, 1.1, and 2.6 percent, for cars, small trucks, medium trucks, and heavy trucks respectively. A growth rate of 2.0 percent was projected over the period from 2006 to 2016.

The AASHTO pavement design methodology measures the damaging effect of traffic loading using the concept of equivalent single axle loads (ESAL's). An ESAL is defined as an 80 kN single axle load. Truck factors (representing the number of ESALs per truck) are assigned to the major vehicle classifications. The following truck factors were used to calculate the projected design ESALs for Guelph Line:

Vehicle Type	Estimated Truck Factor
Cars	0.0006
Small Trucks	0.5
Medium Trucks / Bus	2.3
Heavy Trucks	1.5

Assuming a 20-year design period, these traffic parameters yield some 1.6 million ESALs.

5.2 Structural Requirements

5.2.1 New Pavement Design

New pavement designs were completed based on the type and frost susceptibility of the roadbed soils (silty clay and sandy silt– low frost susceptibility), along with the anticipated traffic volumes over a 20-year design period. The following inputs were chosen for calculation of the required structural number (SN_{des}) for flexible pavements in the AASHTO method:

- Design ESAL's = 1.6 million
- Design Period = 20 years
- Initial serviceability, $P_i = 4.4$
- Terminal serviceability, $P_t = 2.2$
- Subgrade resilient modulus = 40 MPa
- Reliability level, R = 90 percent
- Overall standard of deviation, $S_0 = 0.44$
- HMA layer coefficient, $a_i = 0.42$
- Granular A layer coefficient, $a_i = 0.14$
- Granular B layer coefficient, $a_i = 0.09$
- Drainage coefficient for all layers, $m_i = 1.0$

In accordance with the AASHTO *1993 Design Guide,* and based on the back-calculated in-situ subgrade strength, along with the anticipated traffic volumes over a 20-year design period, a design SN of 9.8 cm was calculated.

The following new pavement section is considered appropriate for supporting the future traffic loading for pavement widening.

50 mm	SP 12.5FC1 Surface Course
75 mm	SP 19 mm Lower Binder Course
150 mm	Granular A
300 mm	Granular B

5.2.2 Existing Pavement

To determine the structural adequacy of the pavement, the SN_{eff} is compared to the SN_{des} calculated above. If SN_{eff} is greater than SN_{des}, the pavement is considered to be structurally adequate. With an average SN_{eff} of 16.8 cm and SN_{des} of 9.8 cm, Guelph Line was considered to be structurally adequate to support the anticipated traffic loading over the next 20 years.

5.3 Pavement Functional Requirements

As noted in the previous section, the structural capacity of the pavement is generally adequate for future traffic requirements.

The functional performance of a pavement is the users' perceived ride quality. Based on the ARA condition survey of the existing pavements, the roadway is in fair functional condition. The open cupped transverse cracks, rutting, and various other distresses observed throughout the roadway have had the effect of reducing the ride quality of the pavement.

6. RECOMMENDATIONS

The existing pavement on Guelph Line is generally considered to be structurally adequate and functionally fair. The rehabilitation of the existing pavement should therefore address the functional performance of the pavement.

6.1 Available Options for the Rehabilitation of the Existing Pavement

Based on the AASHTO pavement design analysis presented in Section 5, the section was deemed to be structurally adequate. However, the pavement surface shows considerable cracking distress and requires functional improvements. A prioritized needs assessment synthesizing rehabilitation, replacement, and operational improvement components was required to develop cost-effective rehabilitation strategies for the existing rural section.

Further, the selection of the most appropriate rehabilitation strategy for Guelph Line may be affected by the strategies and budgets developed by other disciplines. After identifying all potential options for rehabilitating the roadway, the following feasible options emerge for the existing flexible pavement.

6.1.1 Partial-Depth Removal and Placement HMA Overlay

A common technique for the rehabilitation of asphalt concrete pavements is a mill and overlay strategy. This strategy involves the partial depth removal of the existing HMA followed by an overlay, of similar thickness, with new HMA. This strategy does not include remediation of existing distress areas that will likely lead to premature deterioration of the pavement as a result of reflection cracking. As the existing pavement distresses are not being treated, a service life of less than 5 years is expected. This option is often referred to as a temporary, or holding, strategy until such time that other infrastructure improvements can be programmed.

We note from examination of the core from Station 1+012, that cracking was observed in the lower two layers of the asphaltic concrete. This would lead us to believe that the base course contains untreated distresses which will likely reflect through into the surface course if not treated.

6.1.2 Partial-Depth Removal, Localized Repairs and Placement of an HMA Overlay

An enhanced mill/overlay strategy that would mitigate the occurrence of reflection cracking would include repair of distressed pavement sections. However, to be successful, existing pavement distresses would need to be remediated. Untreated cracks in old asphalt layers have a tendency to reflect through overlays, resulting in a reduced overlay service life.

Areas exhibiting fatigue or multiple cracking would require full depth removal of the asphalt to the granular base. Treatment of existing distress would include a combination of saw cut with removal/replacement of larger areas or crack strip milling. Due to the density of the cracks and distressed pavement encountered, this type of repair option would require over 50 percent removal and replacement of the existing asphalt. The service life of this alternative is expected to range from 8 to 12 years.

As noted in Sections 4.3 and 6.1.2, there are locations where the base course contains untreated distresses which will likely reflect through into the surface course if not treated. As these have yet to reflect through the surface course, there may be sections left untreated that would shorten the service life of the overlay.

6.1.3 Pulverize and Overlay

An alternative rehabilitation solution to address cracked flexible pavements is to pulverize (Full Depth In-Place Reclamation) the existing HMA, grade and compact, followed by placement of a new HMA overlay. Pulverizing of the existing roadway should be carried out in accordance with OPSS 330, *Construction Specification for In-Place Reclamation of Bituminous Pavement and Underlying Granular*. This rehabilitation method would eliminate the occurrence of reflection cracking, permit reprofiling the road grade, and improve the overall ride quality of the pavement.

The following pulverizing and overlay strategy is recommended for the existing main lanes should this alternative be considered.

50 mm	SP 12.5FC1 Surface Course
75 mm	SP 19 mm Lower Binder Course
50 mm	New Granular A (for fine grading)
	Pulverized HMA

The Granular A addition is often beneficial for fine grading the granular base layer and minor reprofiling for crossfall. The use of this layer is considered to be optional. The service life expected for this option approximately 15 to 17 years.

6.1.4 Full Depth Asphalt Removal with HMA Reconstruction

Another potential rehabilitation option is to completely reconstruct the existing traffic lanes, or portions of them. Reconstruction is usually considered when the cost of restoration for the amount of existing distresses is too high, there is little remaining life in the original pavement, or the original pavement no longer serves the purpose for which it was intended (e.g., geometrics, structural capacity).

The following reconstruction strategy is recommended for the existing main lanes should this alternative be considered.

50 mm	SP 12.5FC1 Surface Course
75 mm	SP 19 mm Lower Binder Course

The expected service life for this option is 15 to 17 years.

6.2 Rehabilitation of Existing Pavement

The three feasible rehabilitation alternatives presented above were compared based on the initial construction costs as well as the expected maintenance and rehabilitation costs over a 30-year analysis period. Assuming a discount rate of 5 percent, the life-cycle cost analysis of the pavement alternatives are summarized in Table 6.1.

Table 6.1. Life Cycle Cost Analysis Summary

Rehabilitation Option	Estimated Initial Construction Cost ($)	Estimated Life-Cycle Cost ($)
Pulverize and Overlay	87,690	121,320
HMA Reconstruction	92,574	126,204
Mill and Overlay, with Distress Repair	80,627	145,132

Note: Assumed costs based on lane-km.
Alternatives ranked based on assumed 30 year life-cycle.

Based on the results of the simplified life-cycle cost analysis, the pulverize and overlay option is considered to be the life-cycle cost efficient alternative when considering a 30-year analysis period. This alternative will mitigate reflective cracking, as well as, allow for reprofiling with granular material rather than padding with HMA.

The recommended pavement design for the pulverizing strategy is:

50 mm	SP 12.5FC1 Surface Course
75 mm	SP 19 mm Lower Binder Course
50 mm	New Granular A (for fine grading)
	Pulverized HMA

Typically, to ensure the existing roadway can be properly pulverized, milling is recommended to bring the HMA thickness to no greater than 200 mm. There are two locations where the identified thickness of the pavement structure is 210 mm. It should not be required to mill these two isolated locations prior to pulverization.

6.3 Crossfall

The site measurements indicated cross-slopes averaging from 2.0 to 2.4 percent. The crossfall grades only require minor reprofiling and can be restored after the pulverizing operations through the addition of the 50 mm of new Granular A.

6.4 Grade Raises

The pulverize alternative will require grade raises in the order of 175 mm. The geometric issues arising from the grade raise as it applies to shoulders, driveways, intersecting roadways, and other ancillary road features should be reviewed as part of the detailed design process. This is particularly applicable for the south portion of the project, where there is intermittent partial curbing to Station 0+800.

6.5 Transition Treatments

Smooth transitions will be required where the new pavement meets the existing pavement at the limits of the work project.

At the ends of the work project, as well as at all intersections, the tie-ins at the existing pavement should be cold planed to a depth of 40 mm, full width, to ensure that the new surface course can be placed flush with the top of the existing pavement surface. A tack coat should be utilized between all asphalt courses and at all tie-ins and vertical surfaces.

At potential widenings and/or turn tapers, tie-ins must be constructed to ensure positive drainage from the base of the existing granular sub-base. This can be achieved by constructing the base of the new pavement granular at or below the base of the existing granular.

6.6 Materials

6.6.1 New Construction Materials

All HMA materials should meet the requirements of the Halton Region Specifications for Hot Mix Asphalt Paving, Materials, Sampling and Testing and be compacted to at least 93 percent of the MRD. PG 64-28 asphalt cement is required for all mixes not containing recycled materials.

6.6.2 Recycling Existing Materials

The removal of the existing HMA pavement materials will produce millings that can be used as recycled asphalt pavement (RAP) in the new binder course asphalt mixes. In accordance with Halton Region specification requirements, PG 58-34 asphalt cement will be required for RAP mixes containing in excess of 20 percent.

7. CLOSURE

The recommendations provided in this report are for the use of the Regional Municipality of Halton and their design engineers. Contractors undertaking the work must do their own interpretation and/or complete their own investigation as to how the recommendations and soil conditions will affect their proposed construction work and for staging the project. Details of the investigation and the recommendations given in this report are considered to be complete. However, should any questions arise, please do to hesitate to contact our office.

Sincerely,
Applied Research Associates, Inc.

LICENSED PROFESSIONAL ENGINEER
Aug 23, 2007
A. L. HOLT
PROVINCE OF ONTARIO

Anne Holt, P.Eng.
Senior Engineer

Chris Olidis, P.Eng.
Senior Engineer

APPENDIX A

DETAILED DISTRESS SURVEY RESULTS

APPLIED RESEARCH ASSOCIATES, INC.

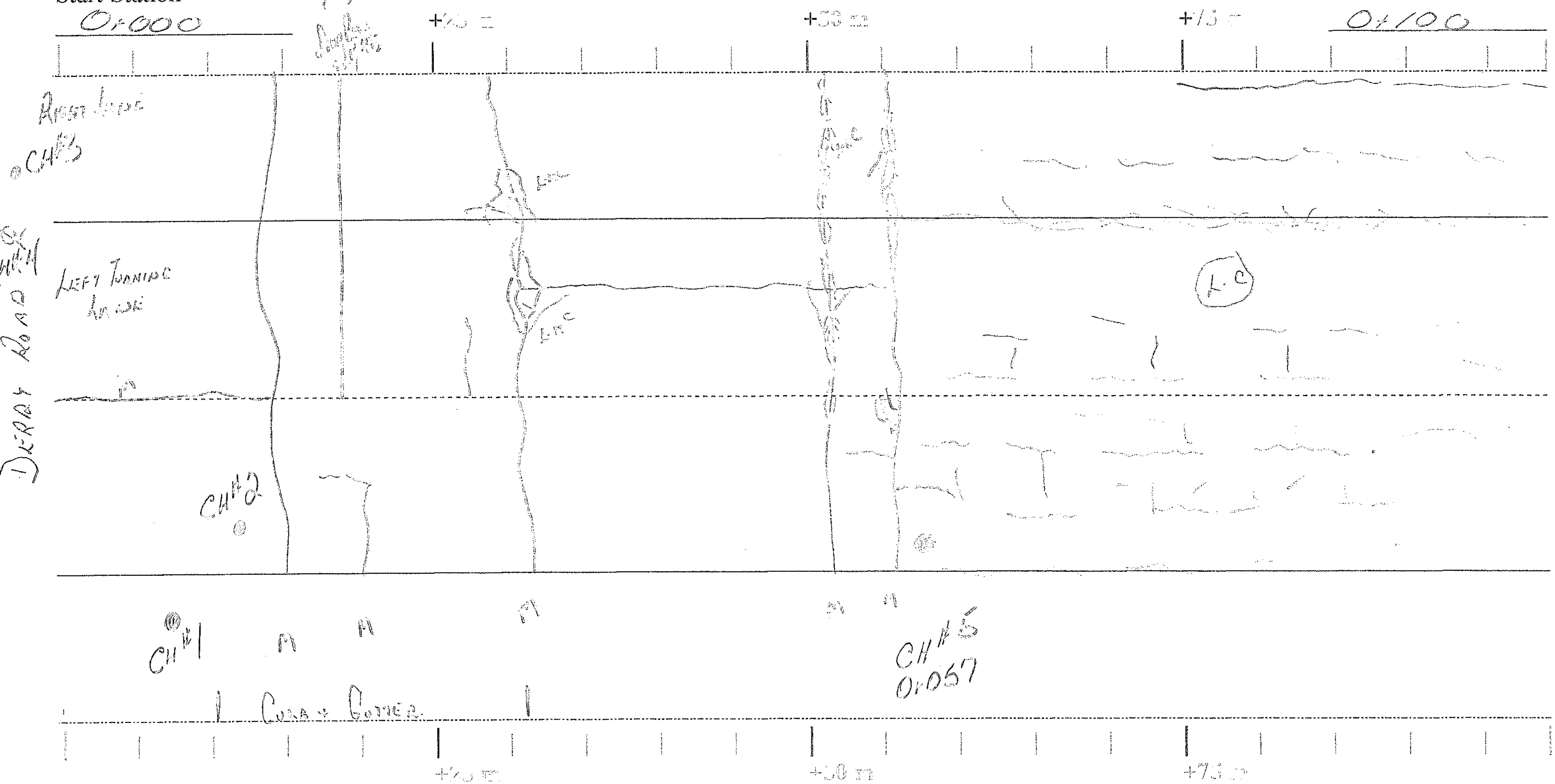
ARA Project No 12820

PAVEMENT DISTRESS MAPPING SURVEY

Highway Guelph Line Direction Derry To Rhodes From Station 0+000 To Station 3+429

Surveyed By Walter Lupton Date Surveyed March 14-07 Conditions Cool + Cloudy

Start Station 0+000 End Station 0+100



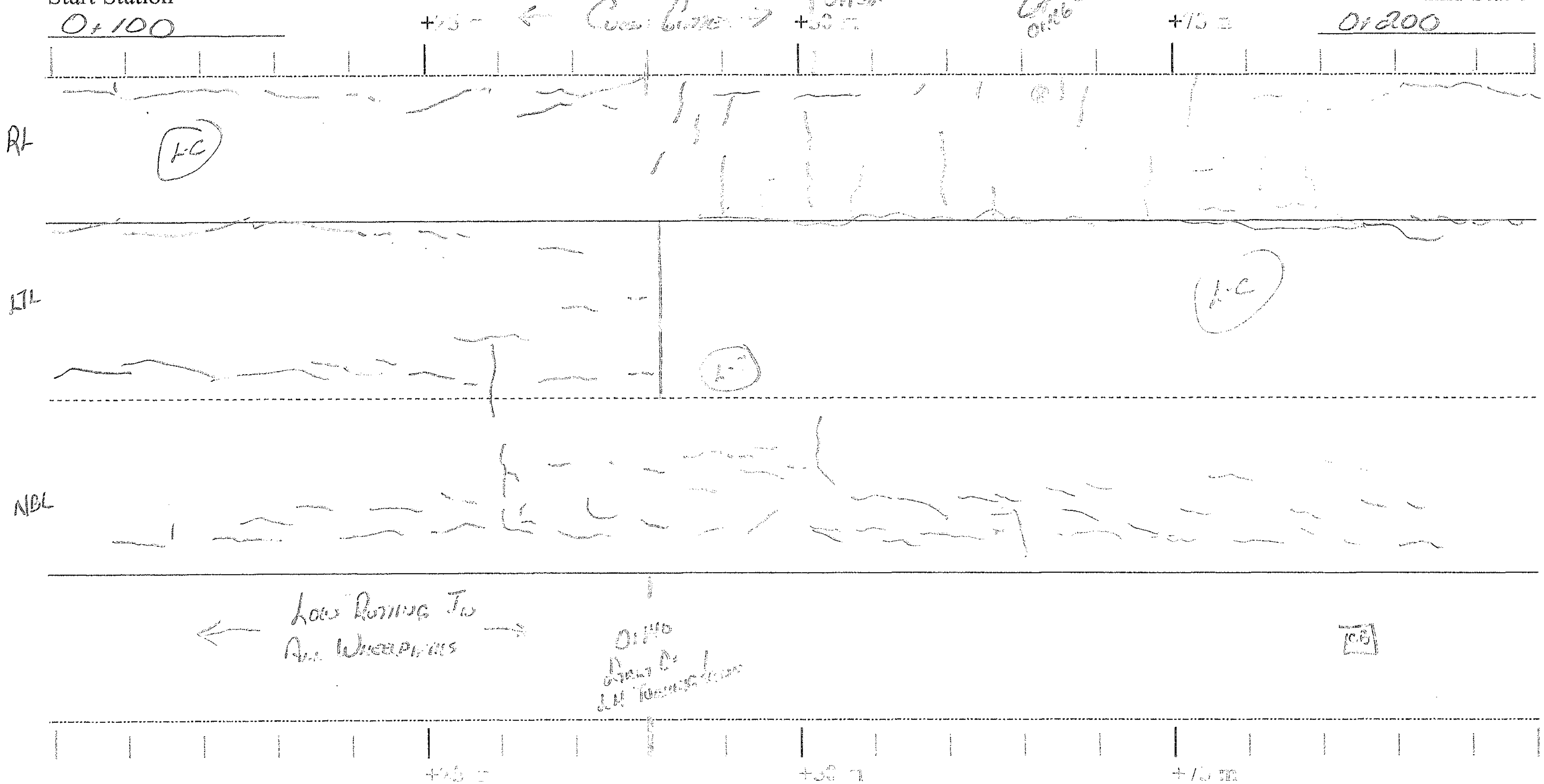
ARA Project No 19870

PAVEMENT DISTRESS MAPPING SURVEY

Highway Guelph Line Direction Derry To Britannia From Station 0+000 To Station 3+429

Surveyed By Walter Norton Date Surveyed March 14 07 Conditions Cool Cloudy

Start Station 0+100 End Station 0+200



APPLIED RESEARCH ASSOCIATES, INC.

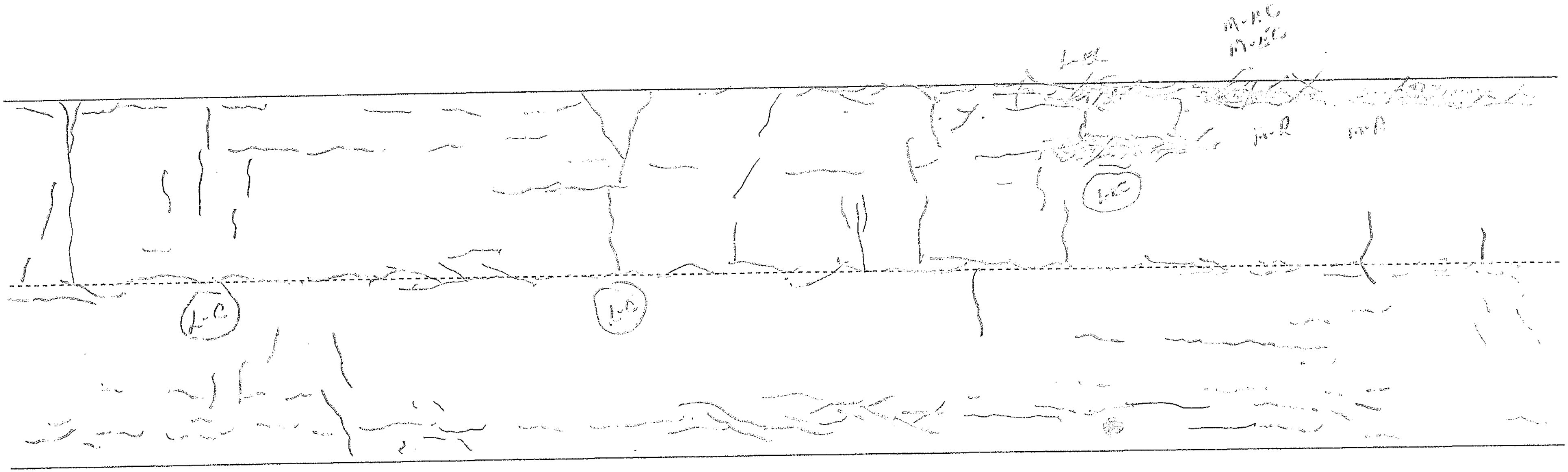
ARA Project No 17820

PAVEMENT DISTRESS MAPPING SURVEY

Highway Gordon Line Direction Dean to Downs From Station 0+020 To Station 3+429

Surveyed By Walter Loomis Date Surveyed March 14 07 Conditions Cool & Overcast

Start Station 0+200 +25 m +50 m +75 m End Station 0+300



L-AC
Low To Medium Rutting
In All Lanes

CH
01290

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

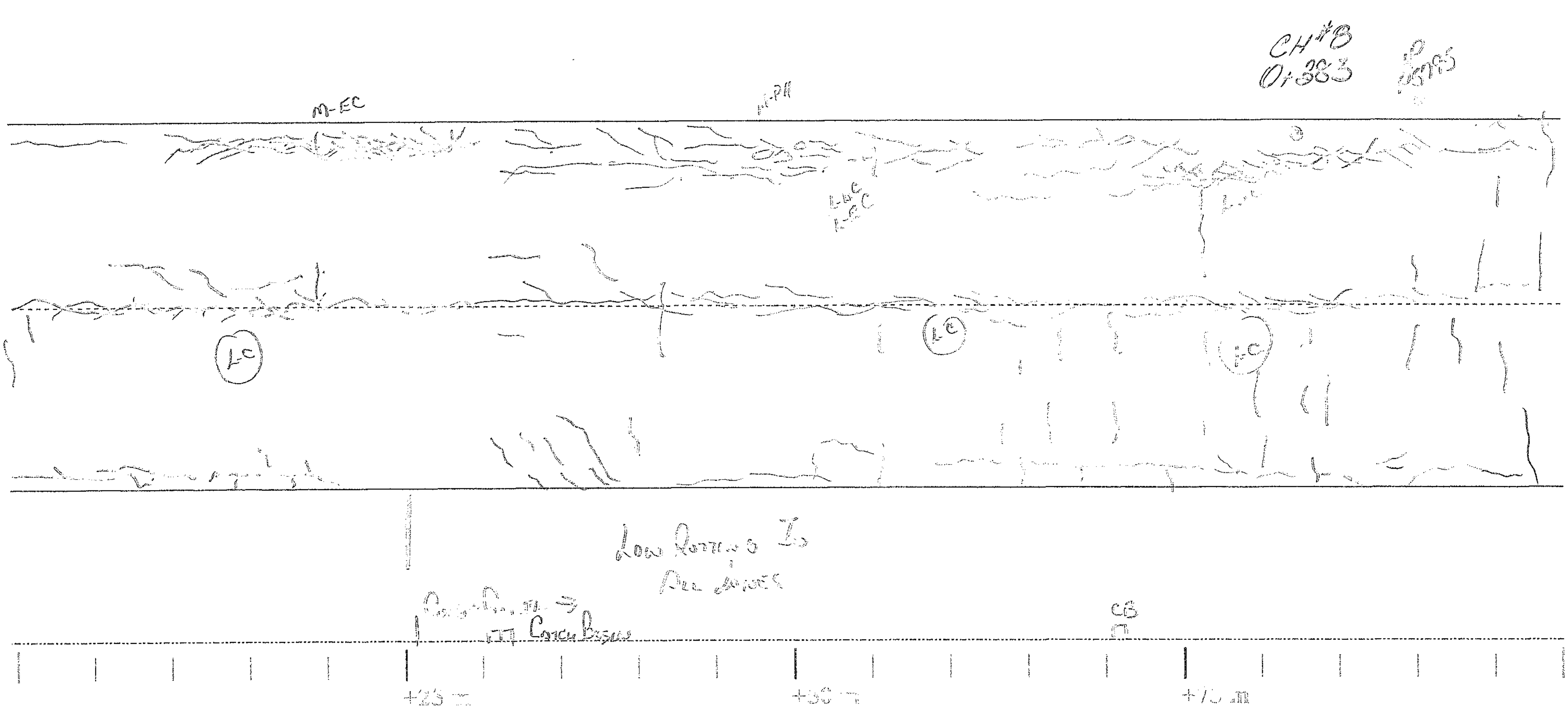
ARA Project No 17820

PAVEMENT DISTRESS MAPPING SURVEY

Highway Cumberland   Direction [illegible]   From Station 0+000   To Station 3+427

Surveyed By [illegible]   Date Surveyed March 11 07   Conditions [illegible]

Start Station 0+300   +25 m   +50 m   +75 m   End Station 0+400



ARA Project No 19870

PAVEMENT DISTRESS MAPPING SURVEY

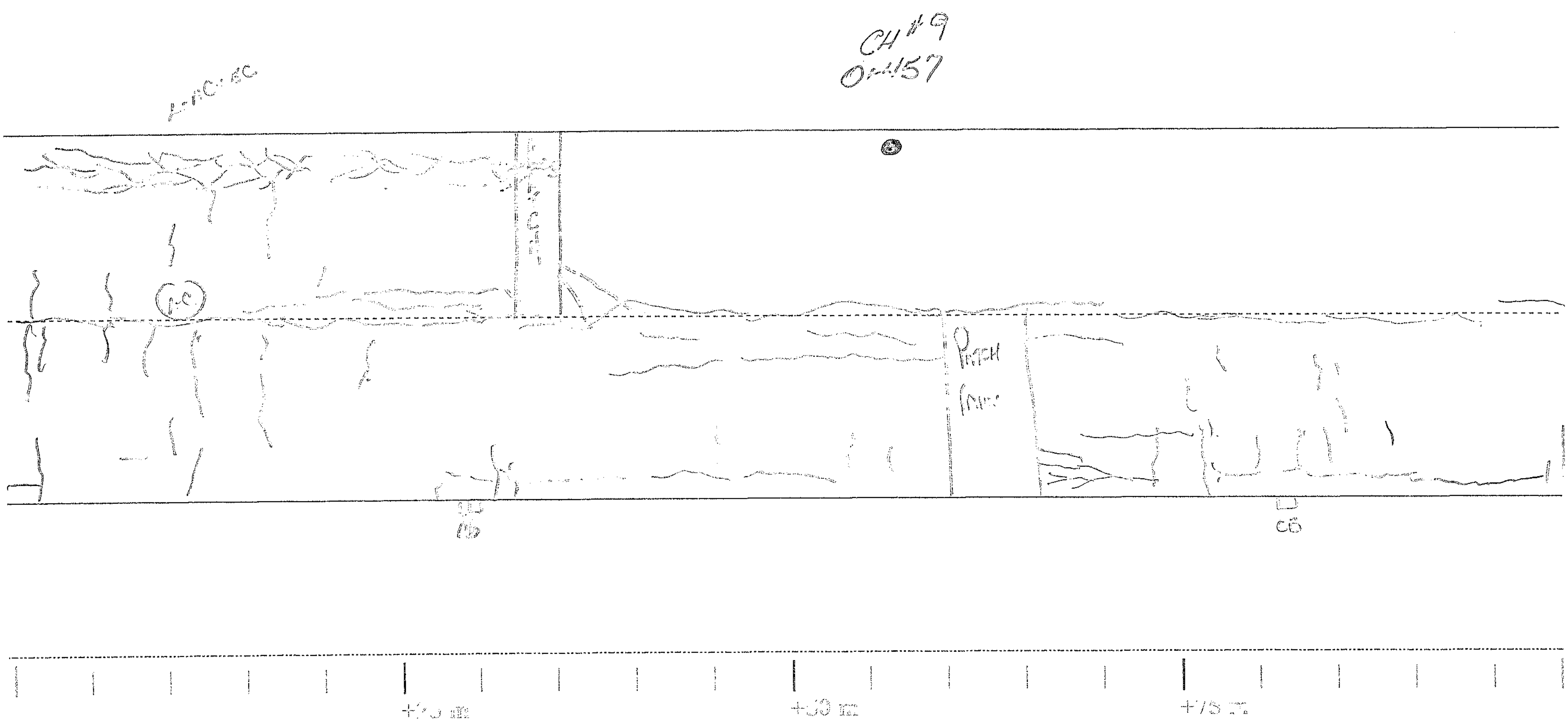
Highway [illegible] Direction [illegible] From Station 0+000 To Station [illegible]

Surveyed By [illegible] Date Surveyed March 14-07 Conditions [illegible]

Start Station 0+400 End Station 0+500

+25 m +50 m +75 m

CH #9
0+457



APPLIED RESEARCH ASSOCIATES, INC.

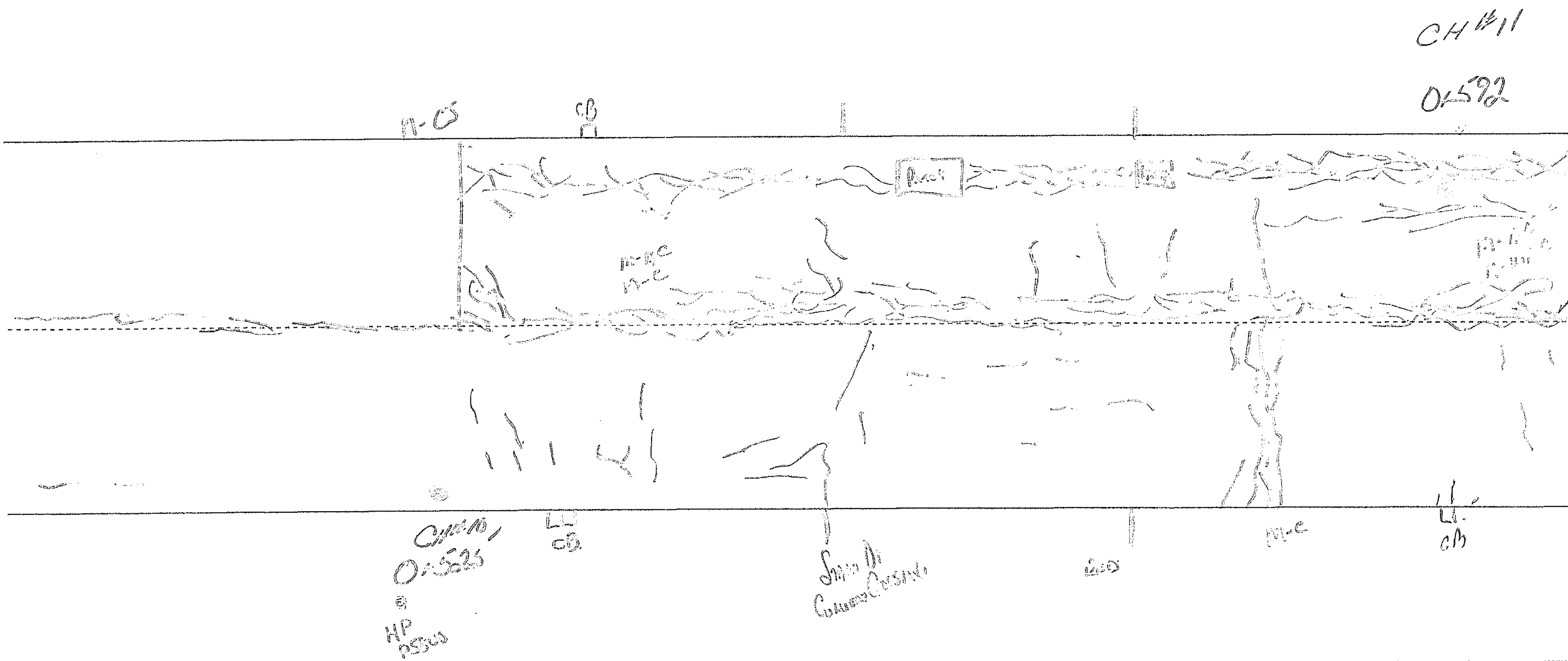
ARA Project No 17820

PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed [illegible] Conditions [illegible]

Start Station 0+500 +25 +50 +75 End Station 0+600



+25 +50 +75

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

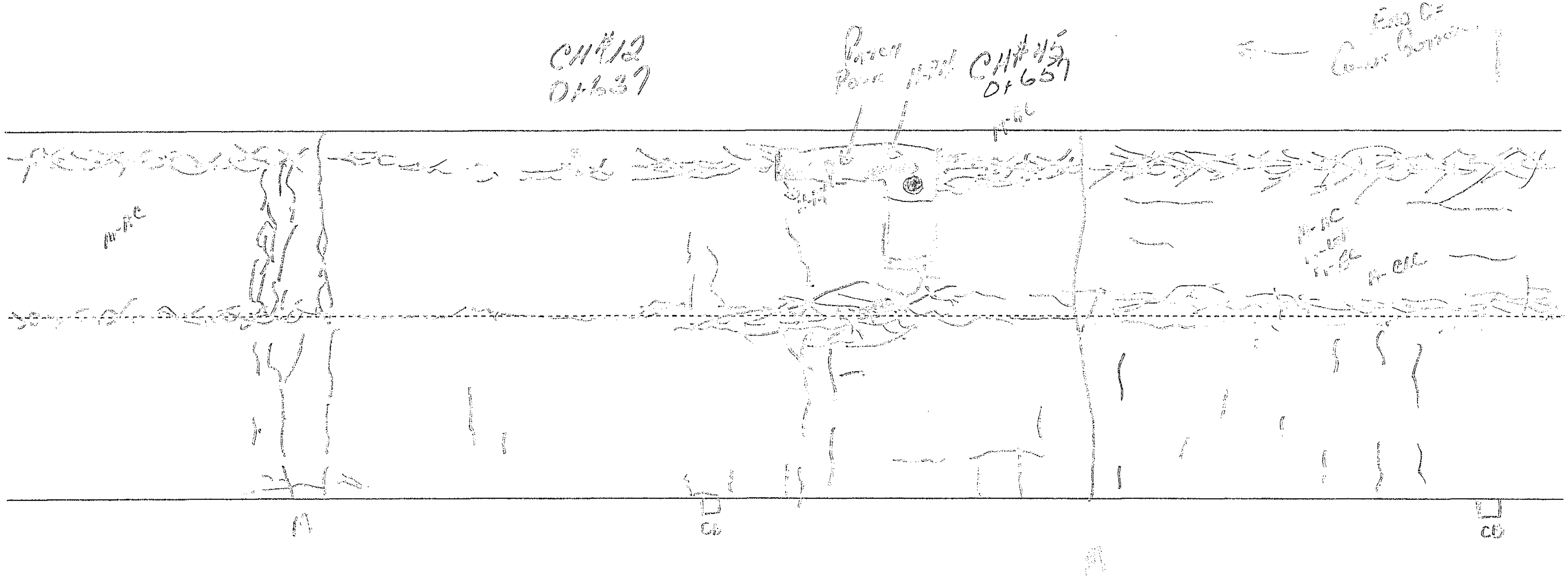
Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 14-07 Conditions [illegible]

Start Station 0+600 +25 m +50 m +75 m End Station 0+700

CH#12
0+637

CH#15
0+651



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

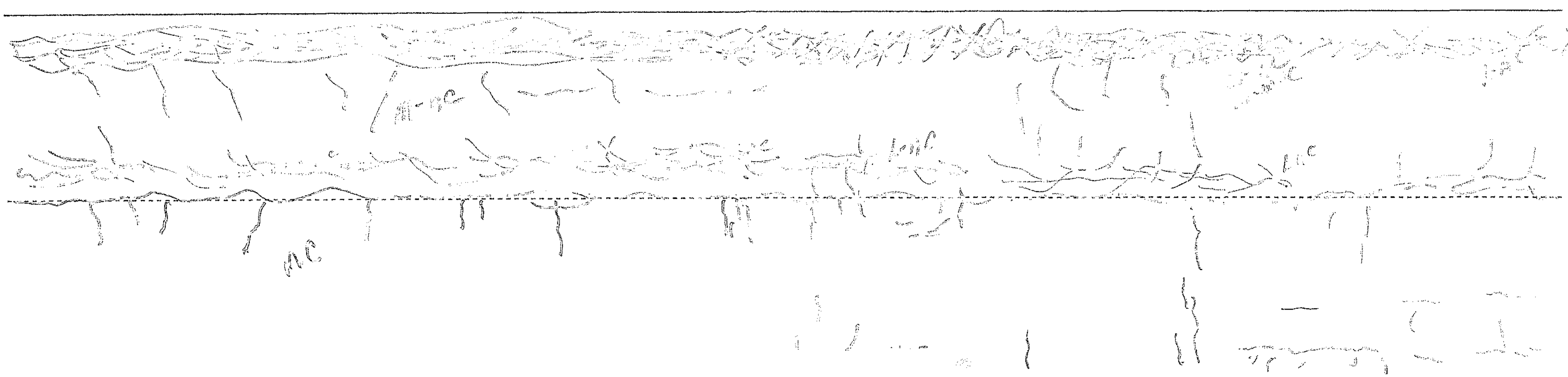
ARA Project No 17890

PAVEMENT DISTRESS MAPPING SURVEY

Highway County Line Direction Denver to Lines From Station 0+000 To Station 3+429

Surveyed By Walter Lorton Date Surveyed March-19-01 Conditions Cool & Cloudy

Start Station 0+700 +25 +50 +75 End Station 0+800



CH#13
0+761

+25 +50 +75

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17820

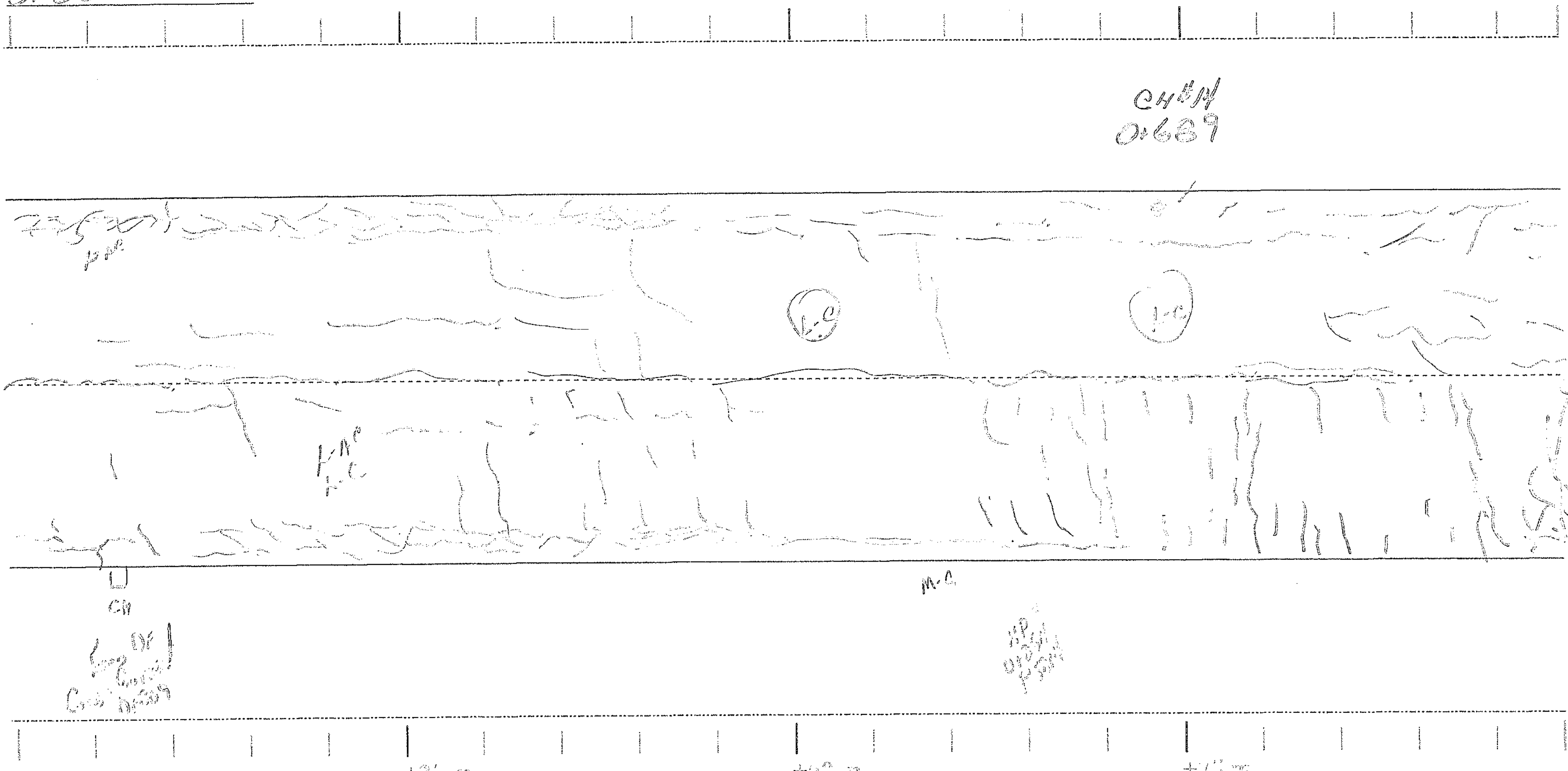
PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+030 To Station 3+429

Surveyed By [illegible] Date Surveyed March 14-07 Conditions [illegible]

Start Station 0+600 End Station 0+900

CH 0+689



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 12870

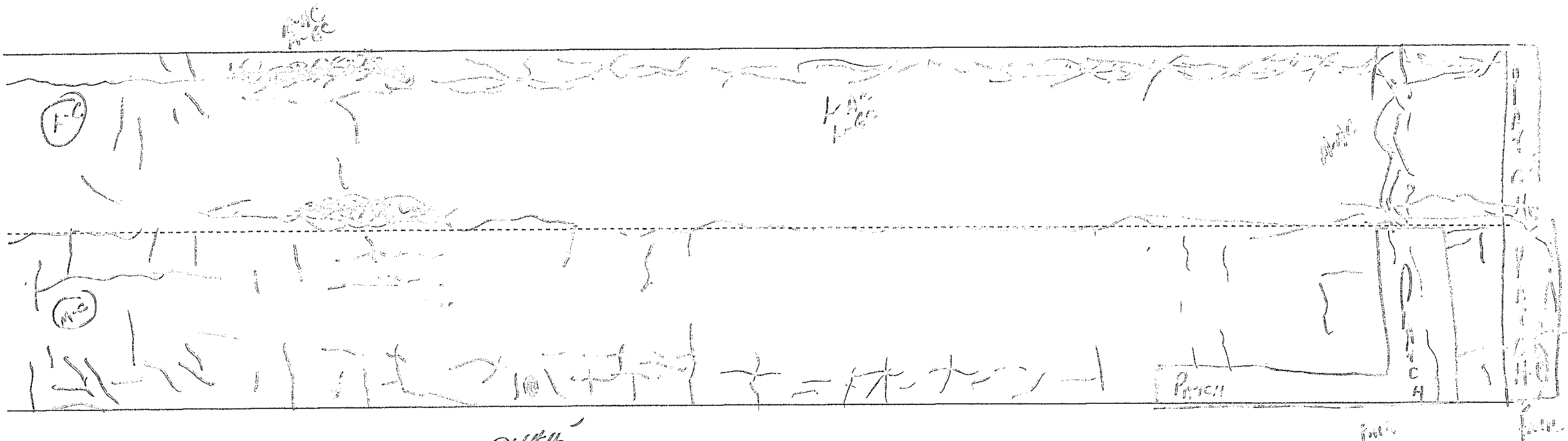
PAVEMENT DISTRESS MAPPING SURVEY

Highway Gulfway Drive Direction [illegible] From Station 0+000 To Station 3+429.

Surveyed By Walter [illegible] Date Surveyed [illegible] 02 Conditions Cool & Cloudy

Start Station 0+900 End Station 1+000

+25 m +50 m +75 m



CH#16 0+934

[illegible]

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

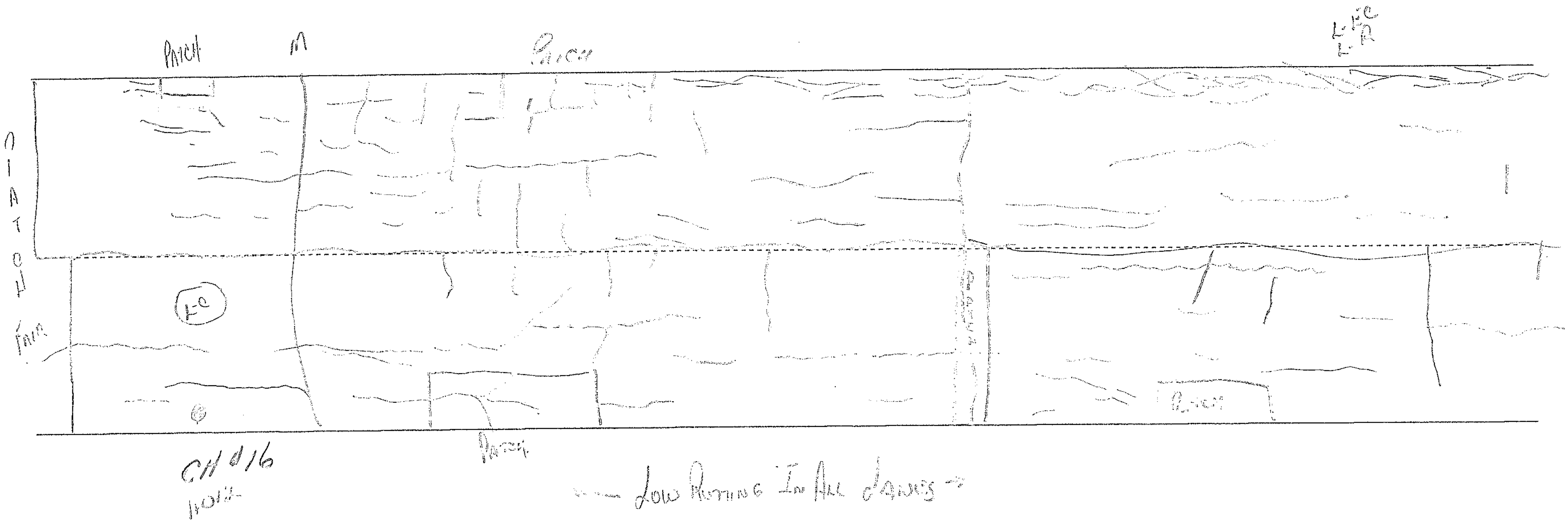
PAVEMENT DISTRESS MAPPING SURVEY

Highway Guelph Line Direction Derry to Dundas From Station 0+000 To Station 3+489

Surveyed By Walter Lupton Date Surveyed March 14-07 Conditions Cool & Cloudy

Start Station 1+000 End Station 1+100

+25 +50 +75



+25 +50 +75

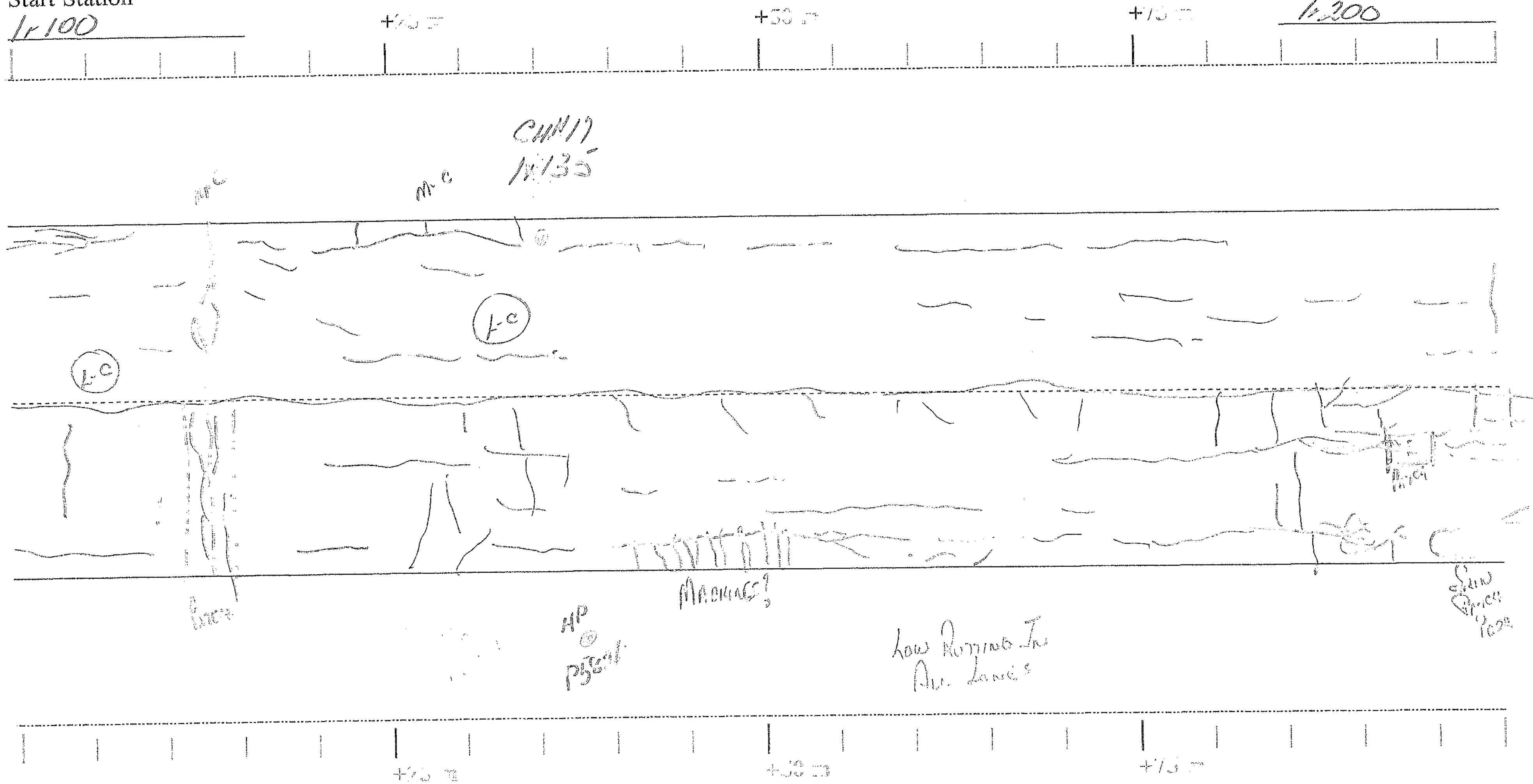
ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

Highway Guzman Drive Direction Dearborn to Lerros From Station 0+000 To Station 3+429

Surveyed By Walter Lupton Date Surveyed March 14-07 Conditions Cool & Cloudy

Start Station 1+100 End Station 1+200



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 12820

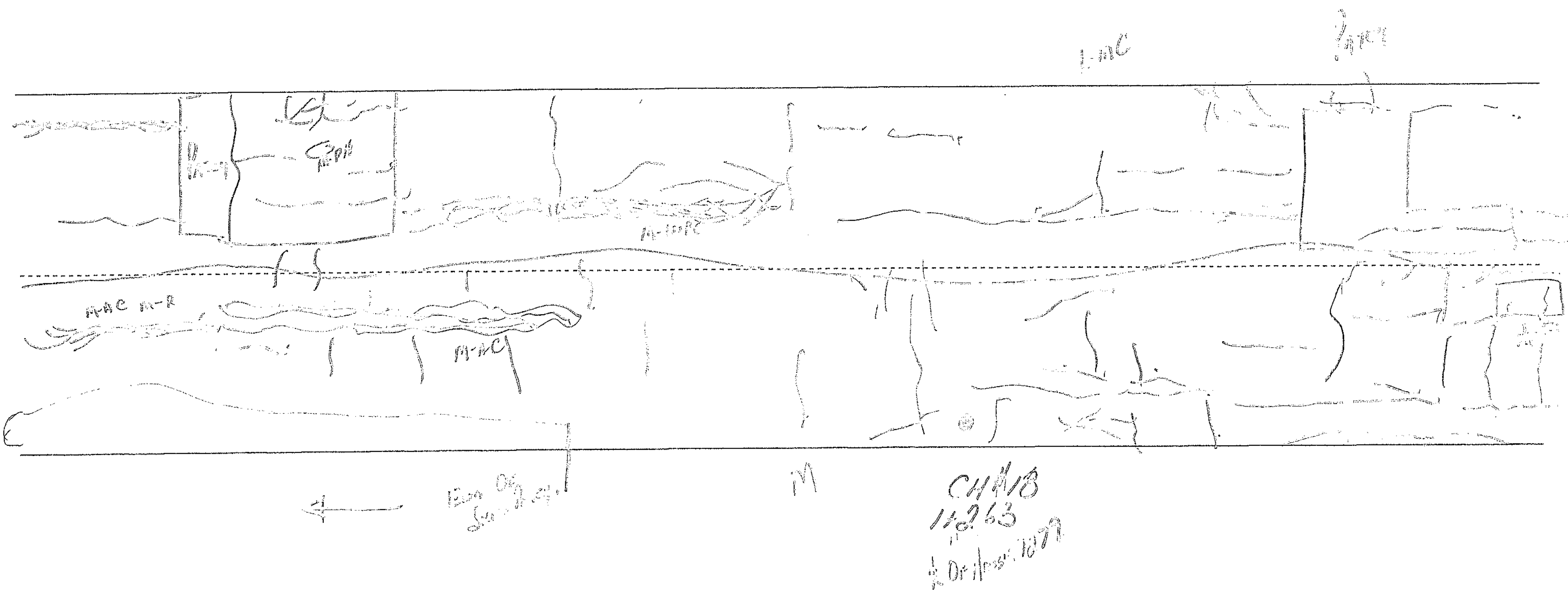
PAVEMENT DISTRESS MAPPING SURVEY

Highway ______ Direction ______ From Station 0+000 To Station 3+429

Surveyed By ______ Date Surveyed ______ Conditions ______

Start Station 1+200 End Station 1+300

+25 +50 +75



+25 +50 +75

APPLIED RESEARCH ASSOCIATES, INC.

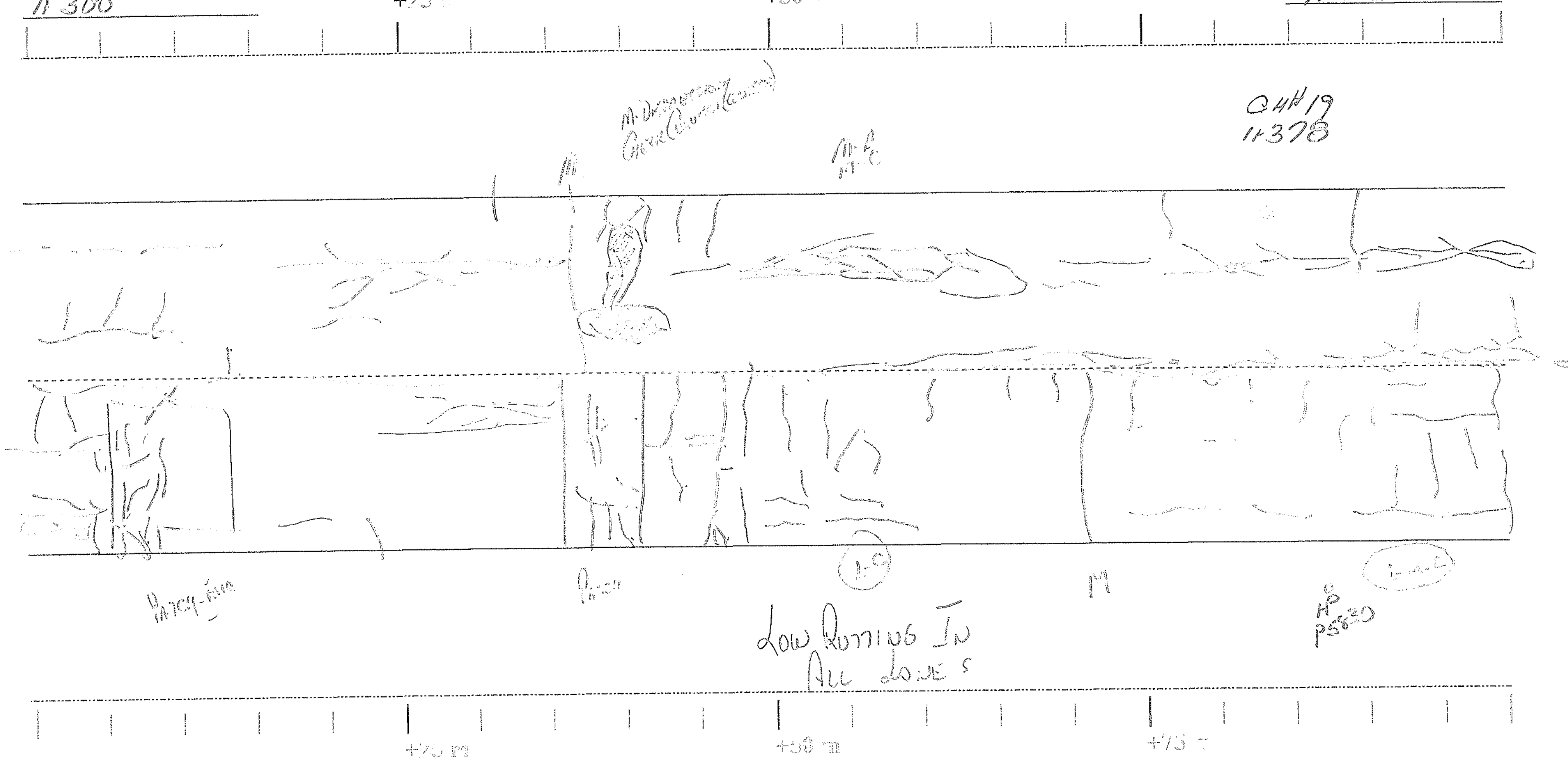
ARA Project No 17826

PAVEMENT DISTRESS MAPPING SURVEY

Highway Cowan Lake [illegible] Direction Jones to Harris From Station 0+000 To Station 3+427

Surveyed By Wagner Lawson Date Surveyed March 15-07 Conditions Cool Sunny

Start Station 11+300 End Station 11+400



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 12890

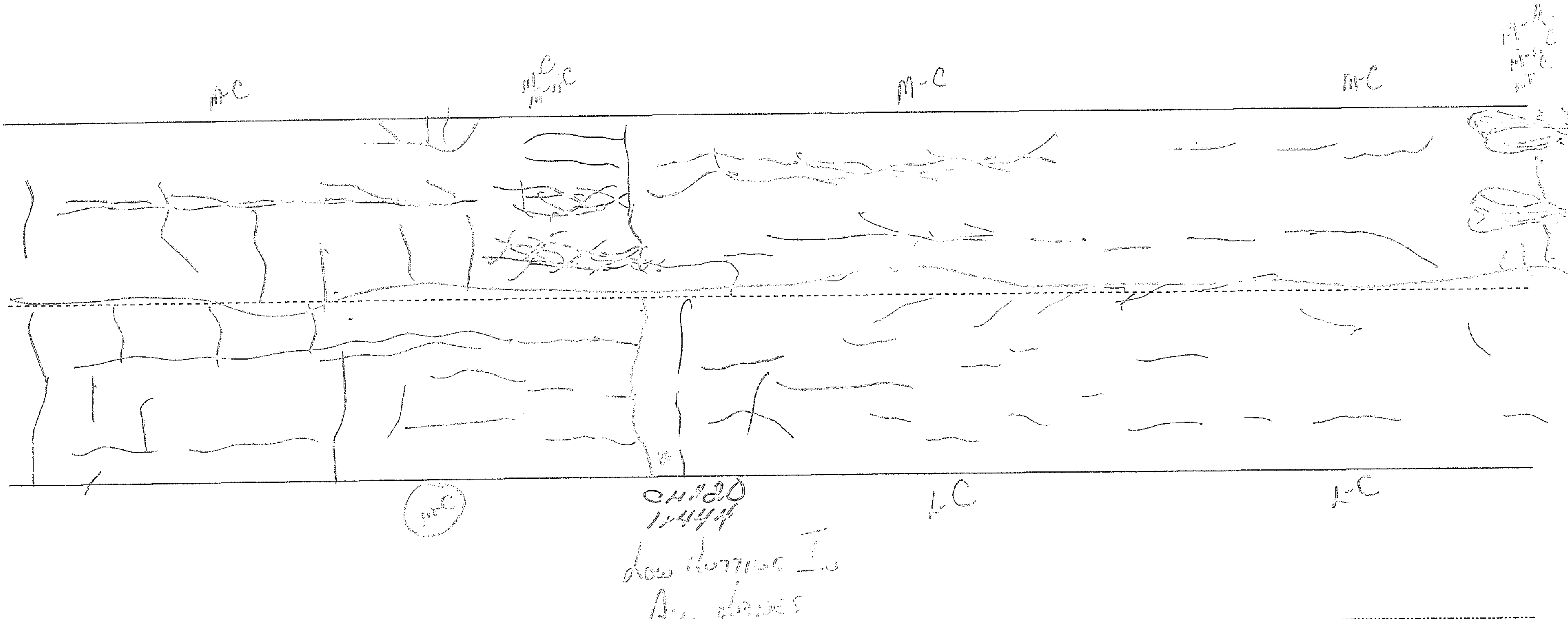
PAVEMENT DISTRESS MAPPING SURVEY

Highway Grover Lane Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 15-07 Conditions Cool & Sunny

Start Station 1+400 End Station 1+500

+25 m +50 m +75 m



+25 m +50 m +75 m

ARA Project No 17820

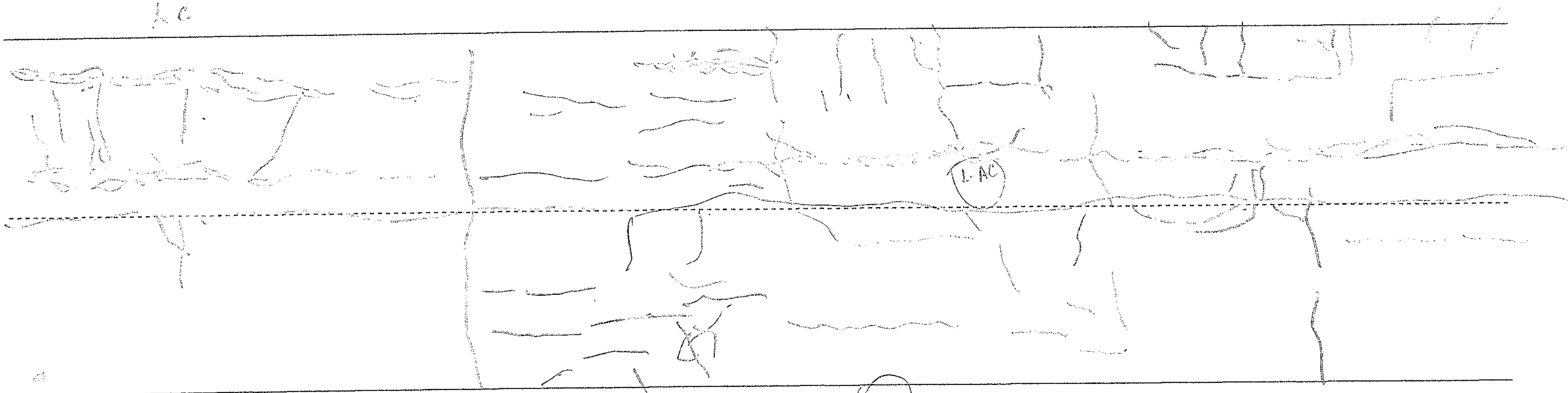
PAVEMENT DISTRESS MAPPING SURVEY

Highway Cuban Line Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 18-07 Conditions [illegible]

Start Station 11500 +25 m +50 m +75 m End Station 11600

L-AC
LC



L-AC

LC

CH#21
11502

M
NP
P5873

+25 m +50 m +75 m

ARA Project No 12890

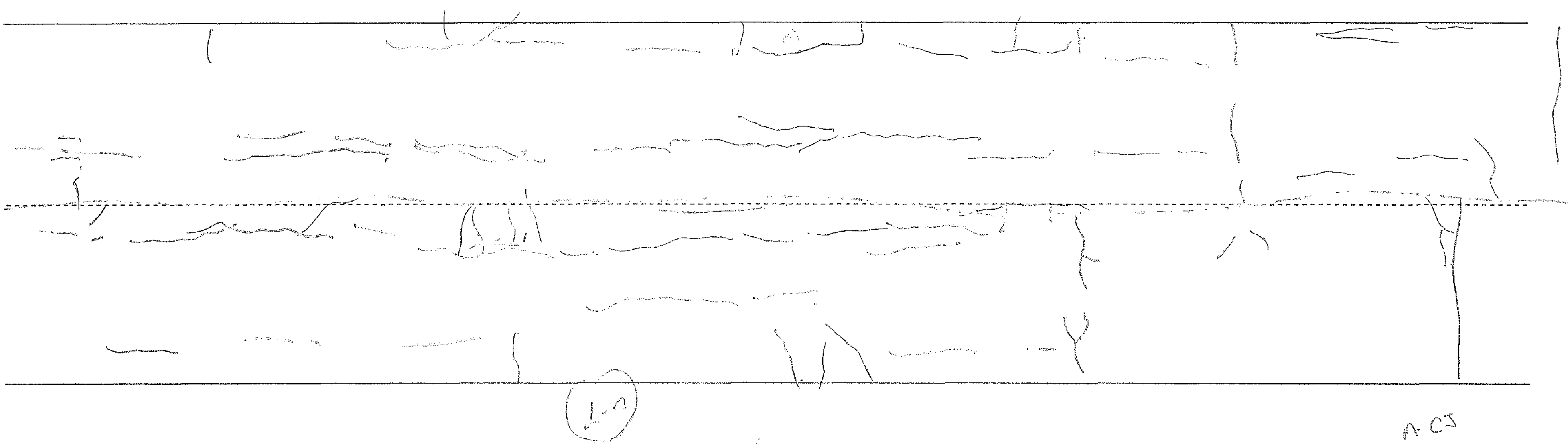
PAVEMENT DISTRESS MAPPING SURVEY

Highway Cuzzon Line Direction Dunn To Lorenzo From Station 0+000 To Station 3+429

Surveyed By Walter Lupton Date Surveyed March 13-07 Conditions Cool & Sunny

Start Station 11600 +25 m +50 m +75 m End Station 11700

CK #22
11652



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

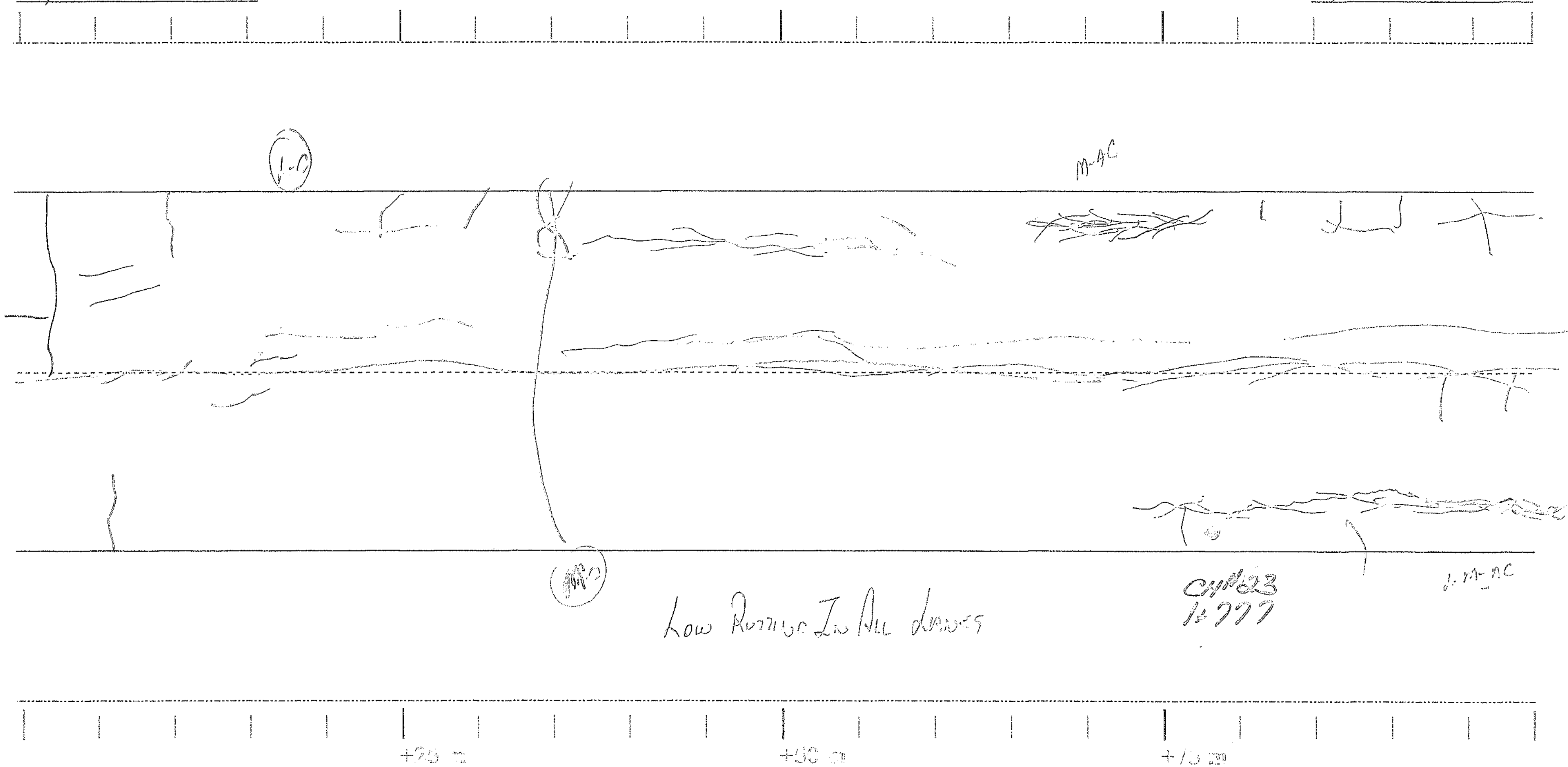
ARA Project No 12820

PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed [illegible] Conditions Cool + Sunny

Start Station 1+700 +25 m +50 m +75 m End Station 1+800



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 12820

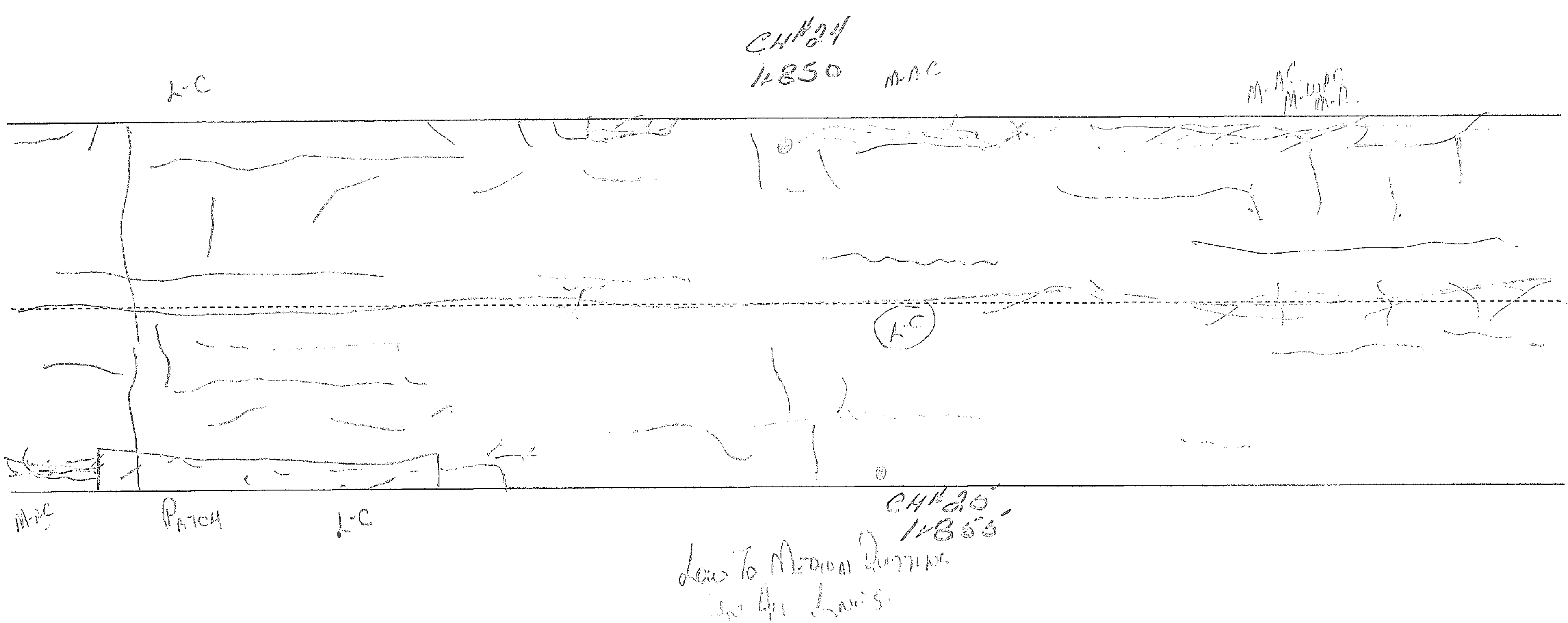
PAVEMENT DISTRESS MAPPING SURVEY

Highway Canon Lane Direction Durant To Brewer From Station 0+000 To Station 3+429

Surveyed By Warren Loomis Date Surveyed March 13 '97 Conditions Clear Sunny

Start Station 1+800 End Station 1+900

+25 m +50 m +75 m



+25 m +50 m +75 m

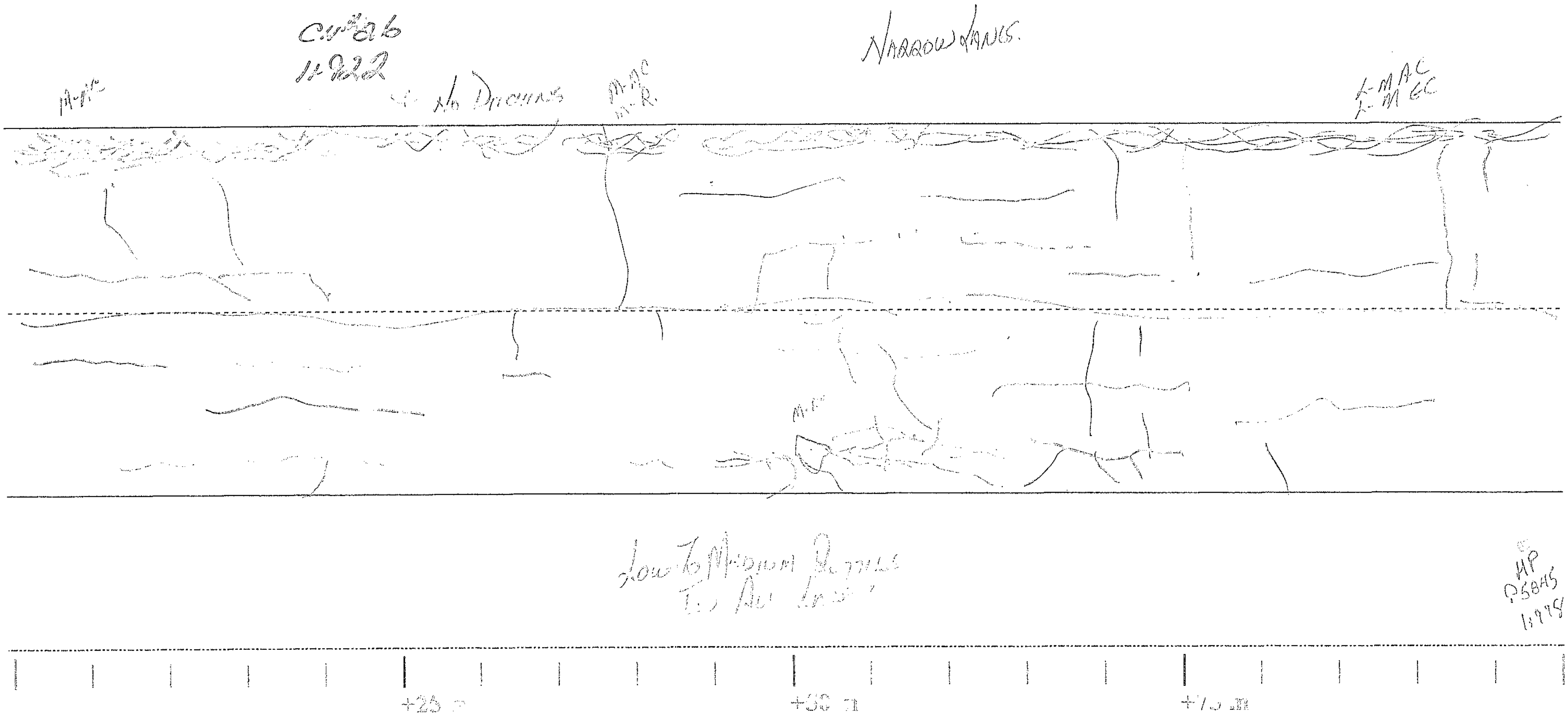
ARA Project No 12890

PAVEMENT DISTRESS MAPPING SURVEY

Highway Greenway Lane Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 13 '99 Conditions Cool [illegible]

Start Station 1+900 +25 m +50 m +75 m End Station 2+000



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

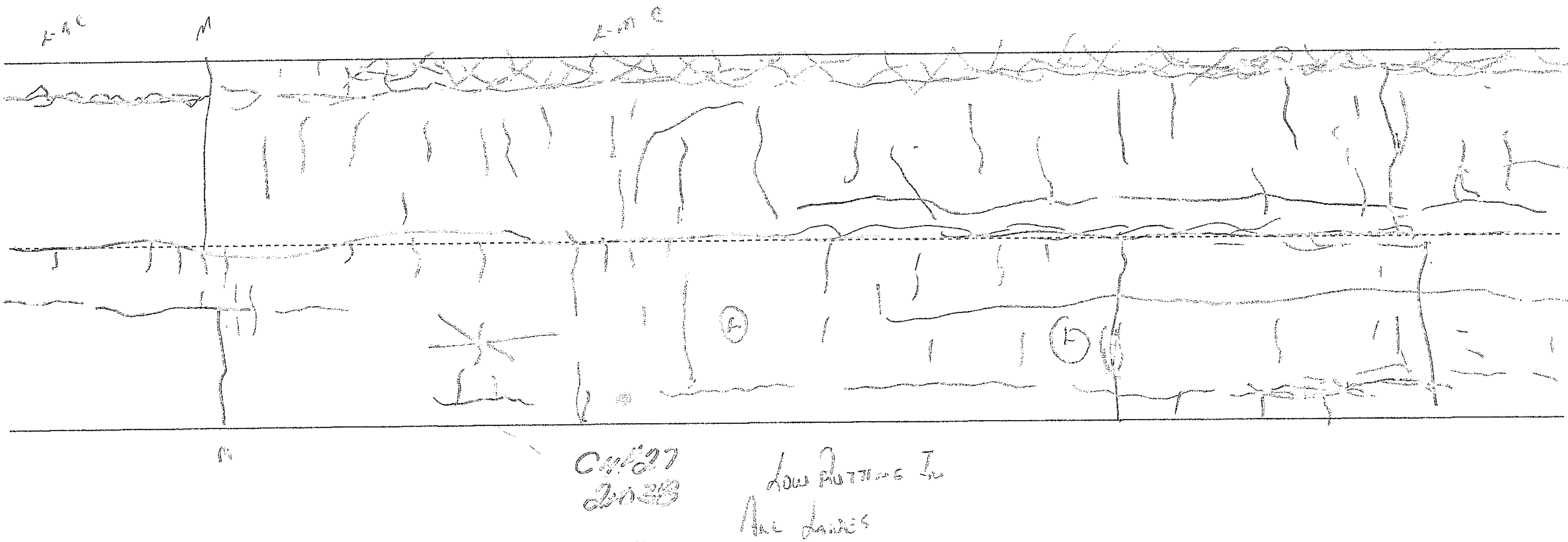
PAVEMENT DISTRESS MAPPING SURVEY

Highway Gunn Lane Direction [illegible] From Station [illegible] To Station [illegible]

Surveyed By Warren Jordan Date Surveyed [illegible] Conditions Cool & Sunny

Start Station 2+000 End Station 2+100

+25 m +50 m +75 m



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

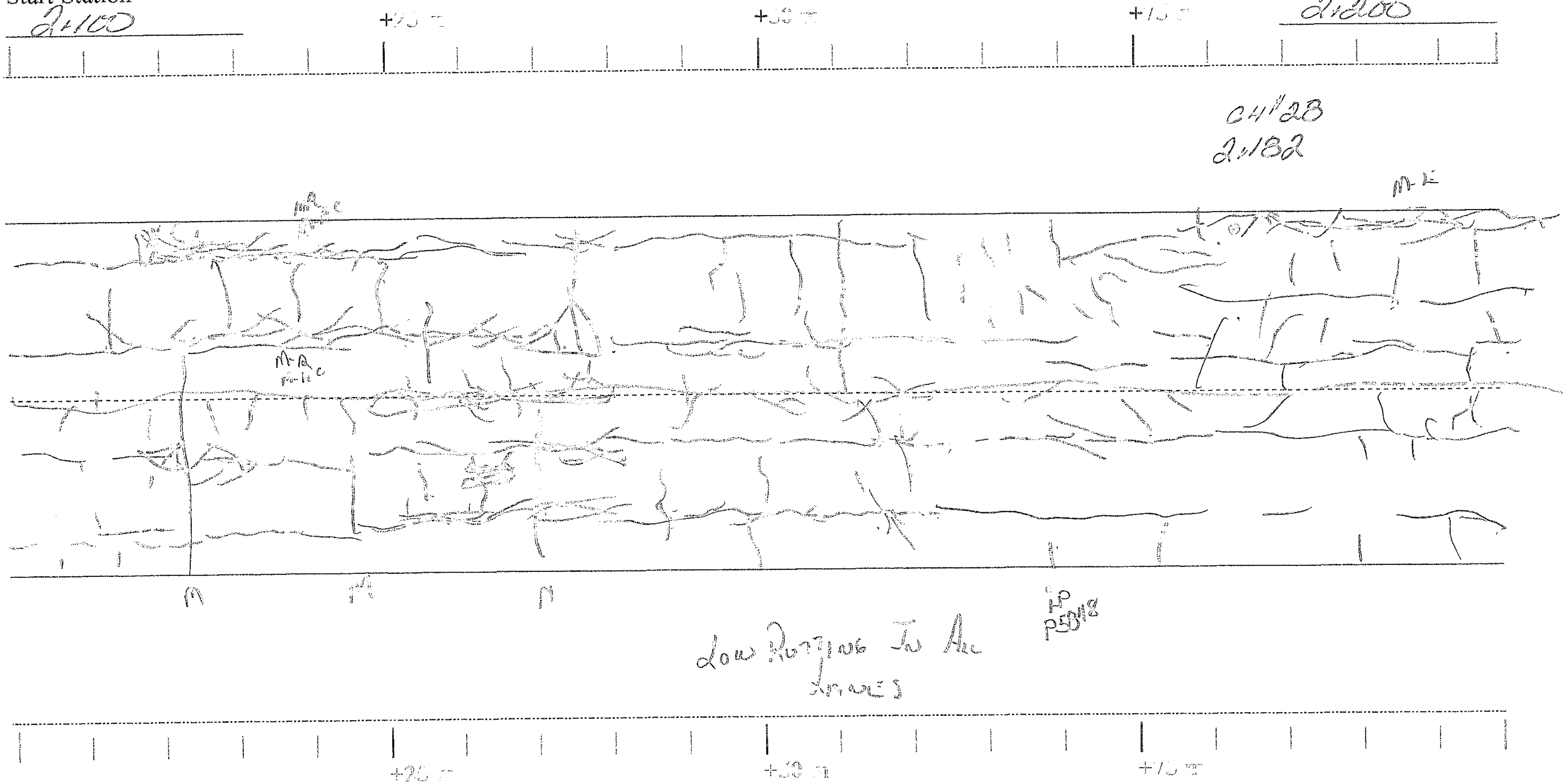
ARA Project No 17820

PAVEMENT DISTRESS MAPPING SURVEY

Highway Overton Lane Direction Denver to Kansas From Station 0+000 To Station 3+480

Surveyed By [illegible] Date Surveyed May 18 '0? Conditions Cool & Sunny

Start Station 2+100 End Station 2+200



APPLIED RESEARCH ASSOCIATES, INC.

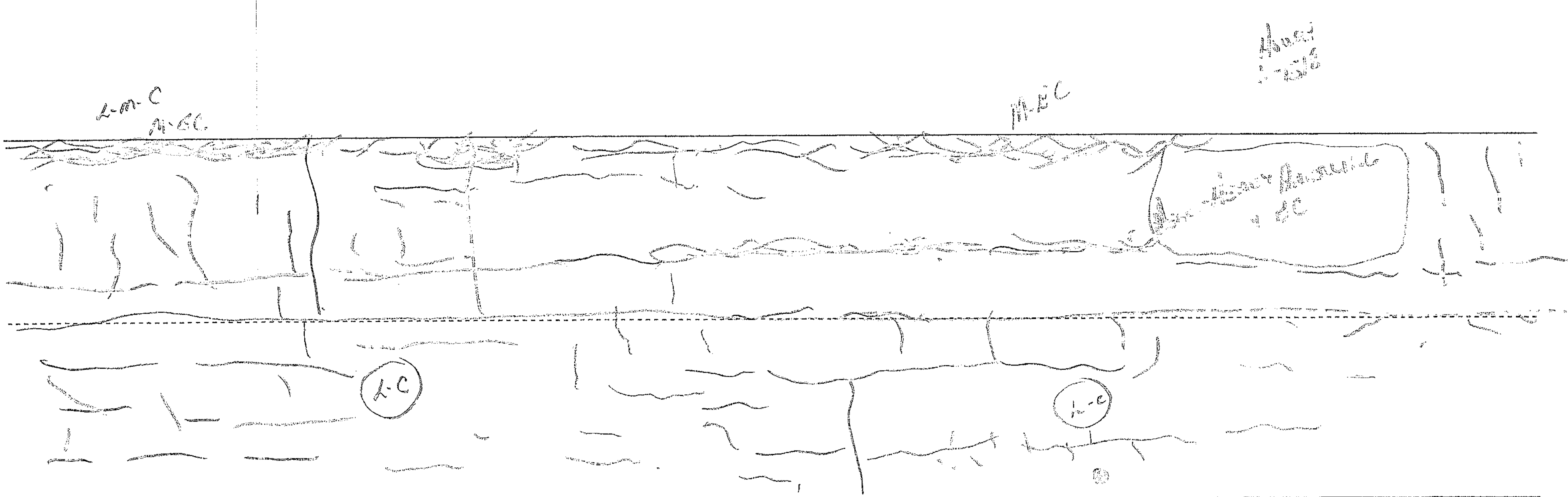
ARA Project No 17890

PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 16-07 Conditions [illegible]

Start Station 2+200 +25 m +50 m +75 m End Station 2+300



Low [illegible] CH 29 2+270

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

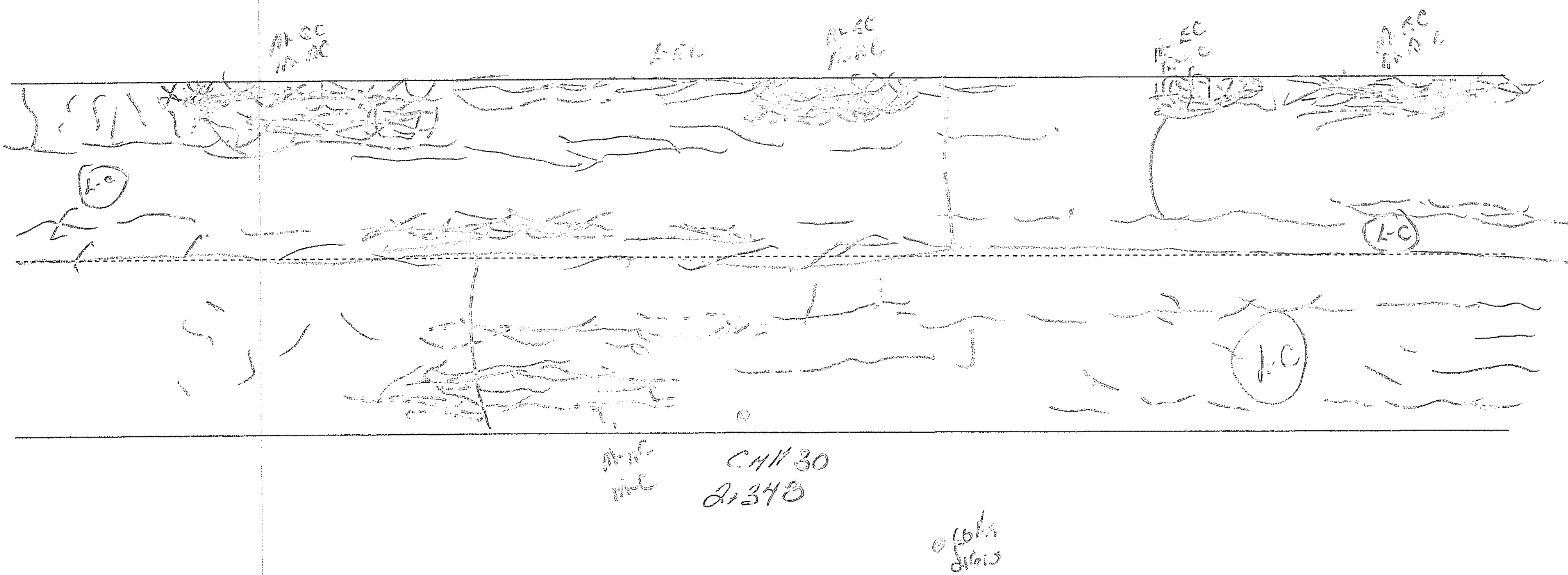
ARA Project No 12870

PAVEMENT DISTRESS MAPPING SURVEY

Highway ______ Direction ______ From Station 0+000 To Station 3+429

Surveyed By ______ Date Surveyed ______ Conditions ______

Start Station 2+300 +25 m +50 m +75 m End Station 2+400



+25 m +50 m +75 m

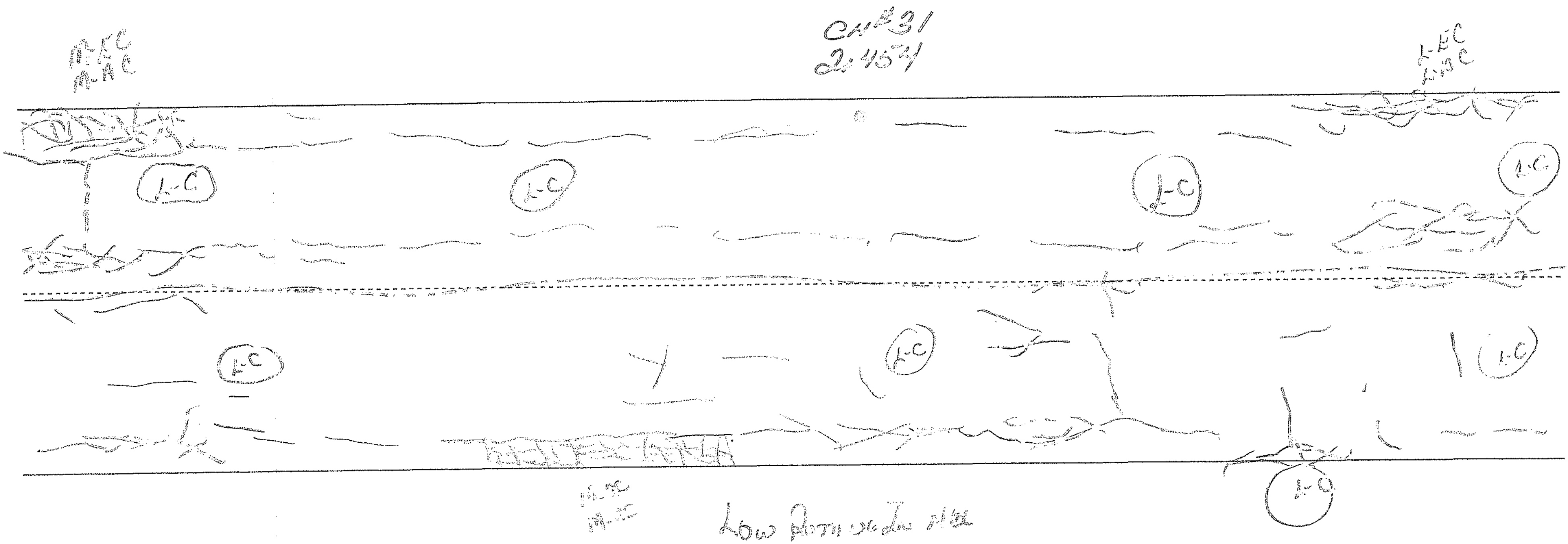
ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

Highway Guelph Line Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By Walter Lupton Date Surveyed March 13-07 Conditions Cool Sunny

Start Station 2+400 +25 m +50 m +75 m End Station 2+500



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

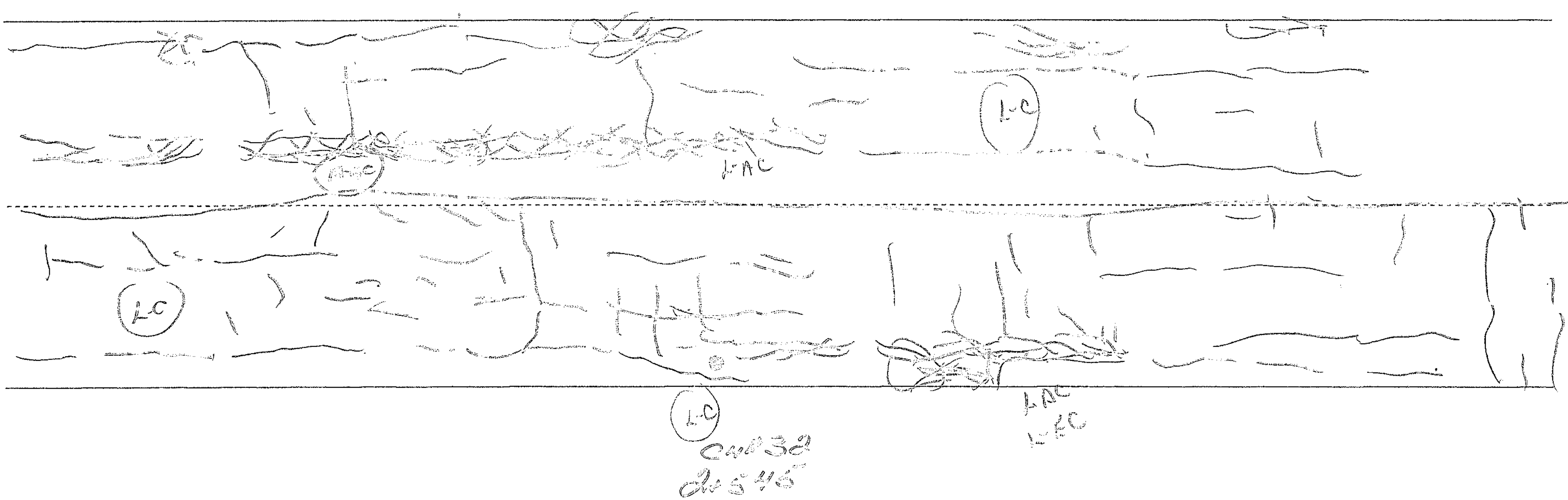
ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

Highway Gulzar Lane Direction Derby To Pierres From Station 0+000 To Station 3+429

Surveyed By Walter Dupton Date Surveyed March 18-07 Conditions Cool & Sunny

Start Station 2+500 +25 m +50 m +75 m End Station 2+600



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

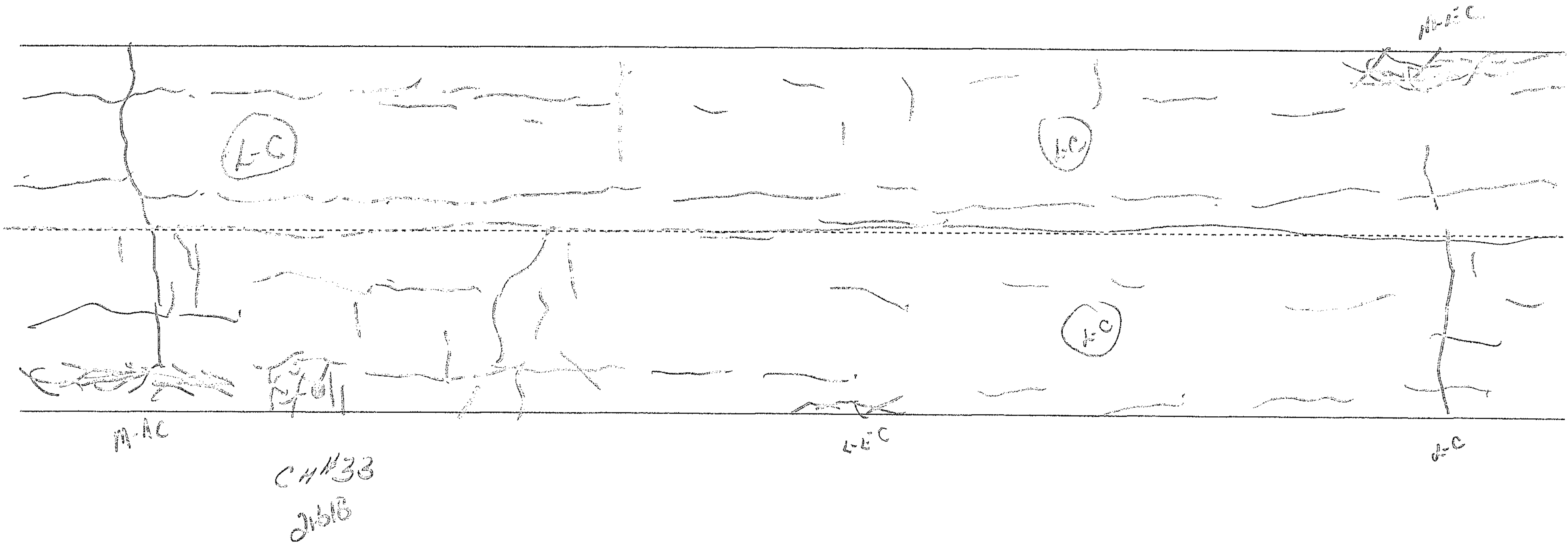
PAVEMENT DISTRESS MAPPING SURVEY

Highway Green Lane Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By Wayne Lowman Date Surveyed March 18-07 Conditions Cool Sunny

Start Station 2+600 End Station 2+900

+25 m +50 m +75 m



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

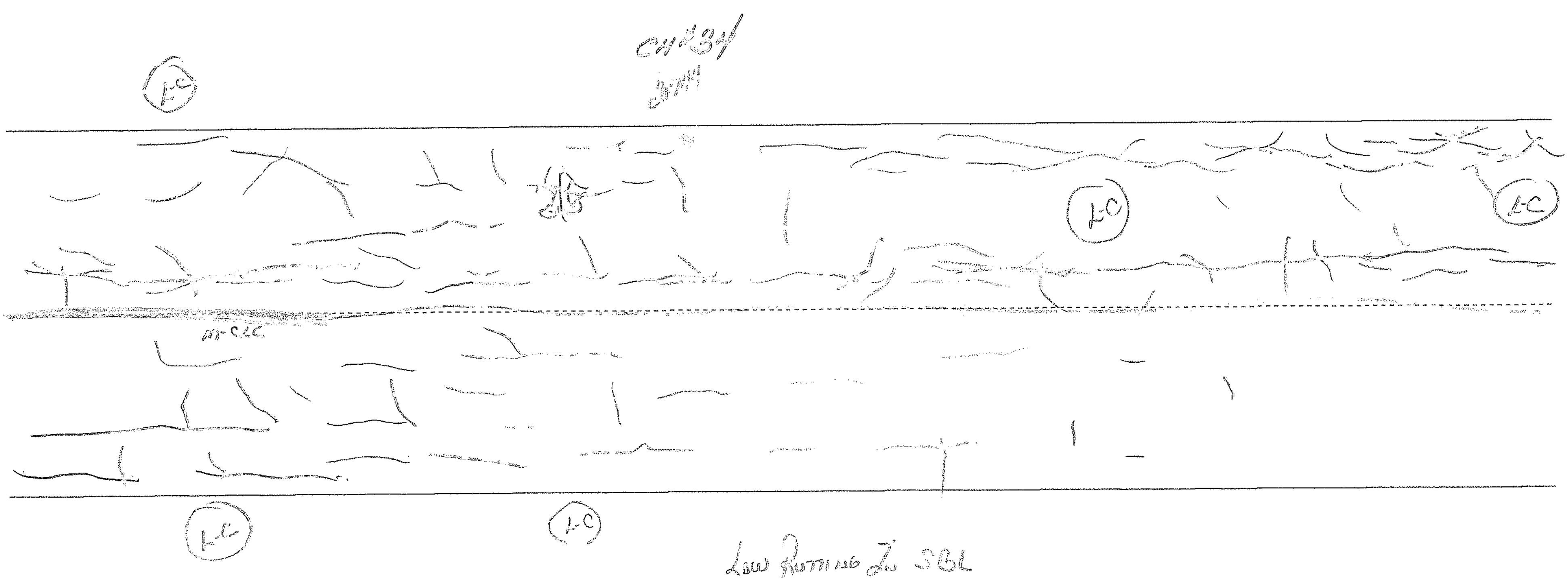
ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 18 '09 Conditions [illegible]

Start Station 2+700 +25 m +50 m +75 m End Station 2+800



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

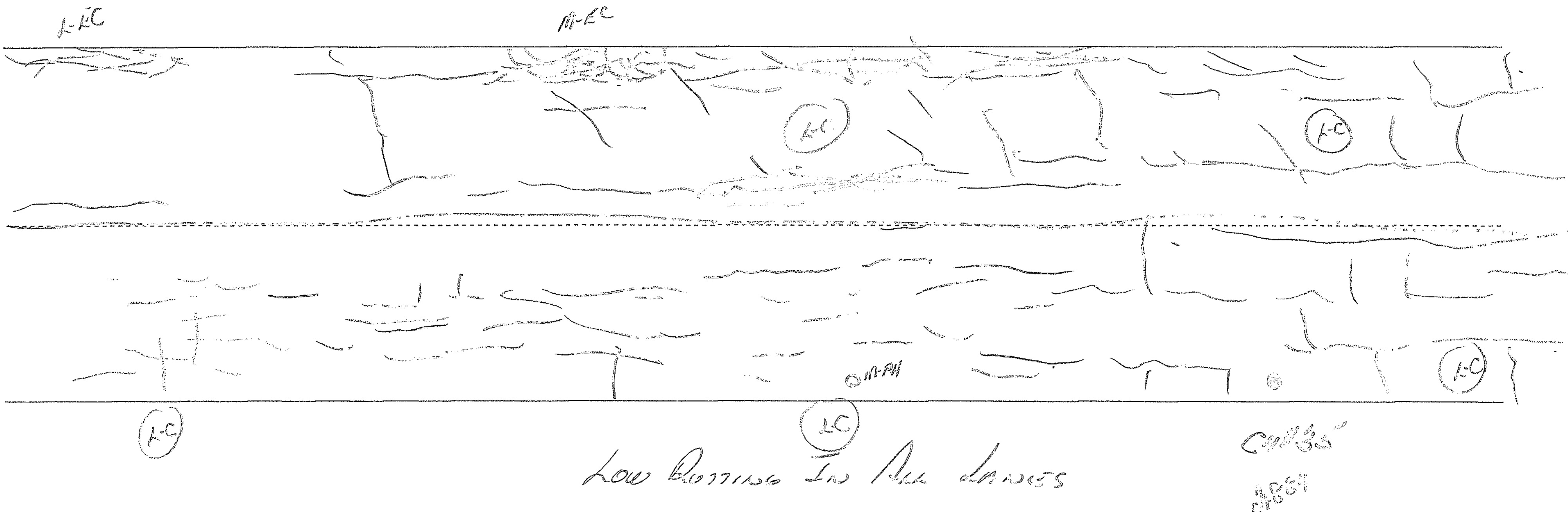
ARA Project No 17830

PAVEMENT DISTRESS MAPPING SURVEY

Highway Golden Line Direction [illegible] From Station 0+000 To Station 3+449

Surveyed By [illegible] Date Surveyed March 13, 07 Conditions Cool & Sunny

Start Station 2+800 +25 m +50 m +75 m End Station 2+900



+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17836

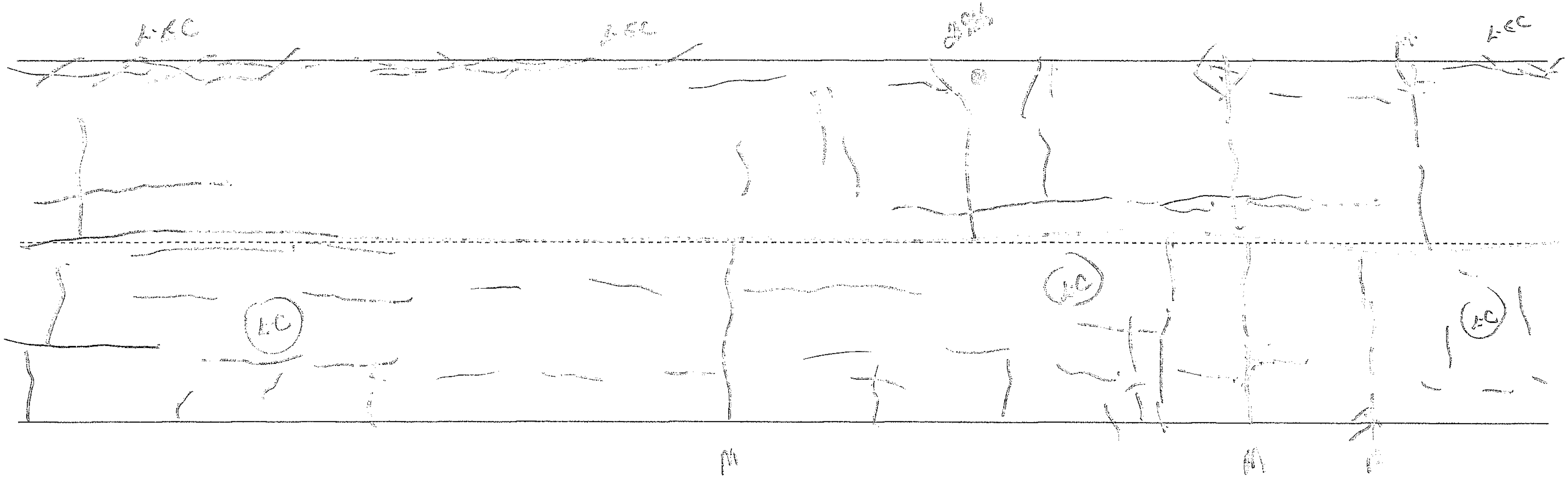
PAVEMENT DISTRESS MAPPING SURVEY

Highway Green Line Direction Denver To Boulder From Station 0+000 To Station 3+462?

Surveyed By Walter Lupton Date Surveyed March 18-07 Conditions Clear Sunny

Start Station 2+900 +25 m +50 m +75 m End Station 3+000

CH#36



Low Rutting In SBL

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

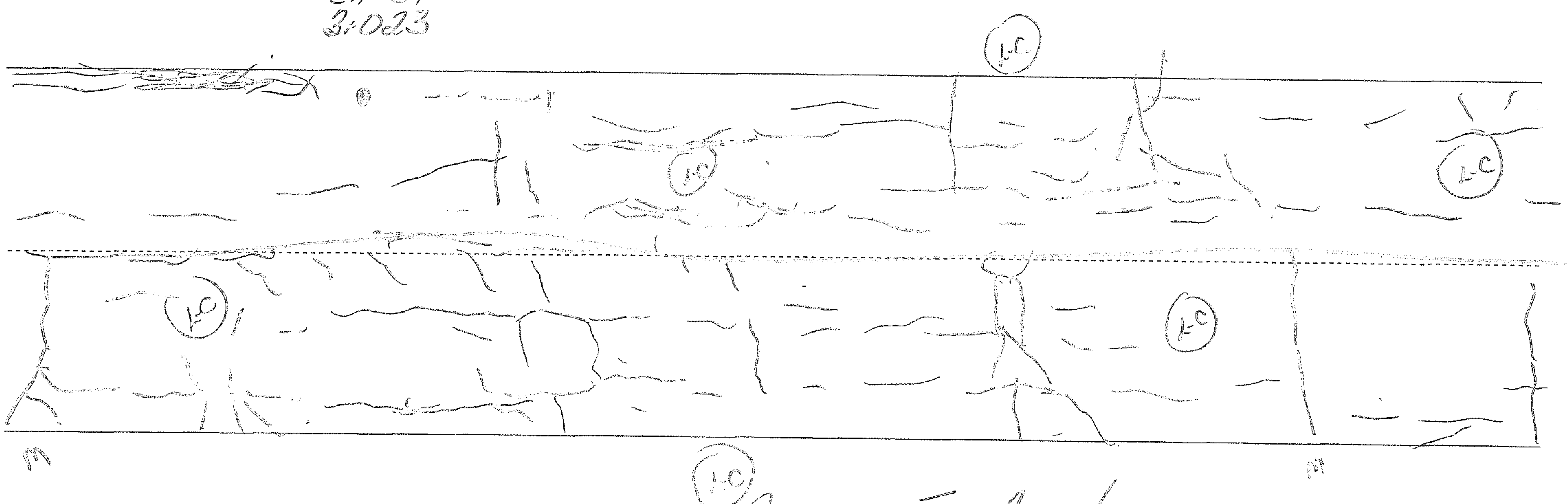
Highway Country Lane Direction [illegible] From Station 3+000 To Station 3+[illegible]

Surveyed By Walter [illegible] Date Surveyed [illegible] 18-07 Conditions [illegible]

Start Station 3+000 End Station 3+100

+25 m +50 m +75 m

CH #37
3+023



Low Running In the Lanes

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

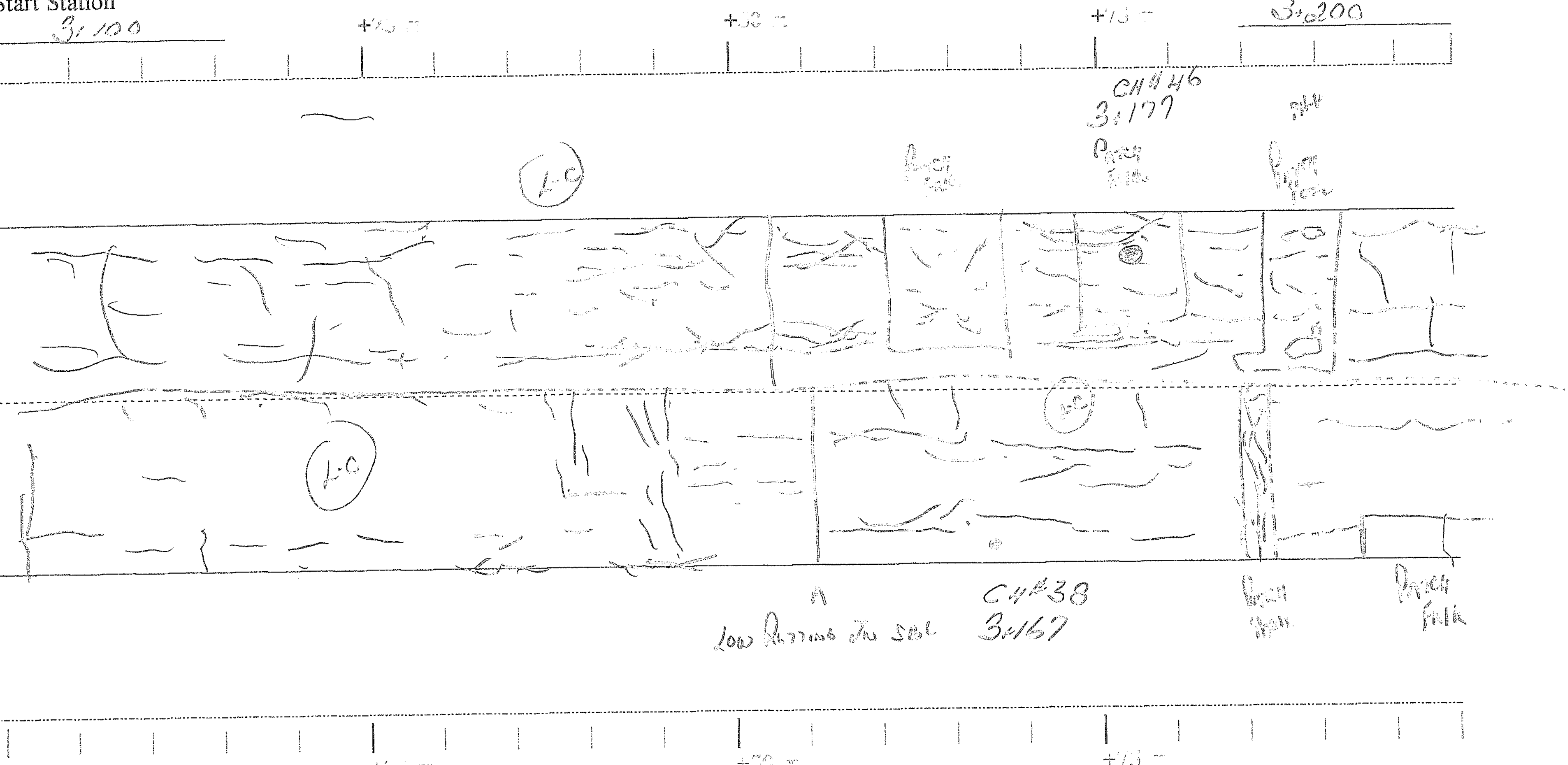
ARA Project No 17870

PAVEMENT DISTRESS MAPPING SURVEY

Highway [illegible] Direction [illegible] From Station 0+000 To Station 3+429

Surveyed By [illegible] Date Surveyed March 15-07 Conditions [illegible]

Start Station 3+100 End Station 3+200



APPLIED RESEARCH ASSOCIATES, INC.

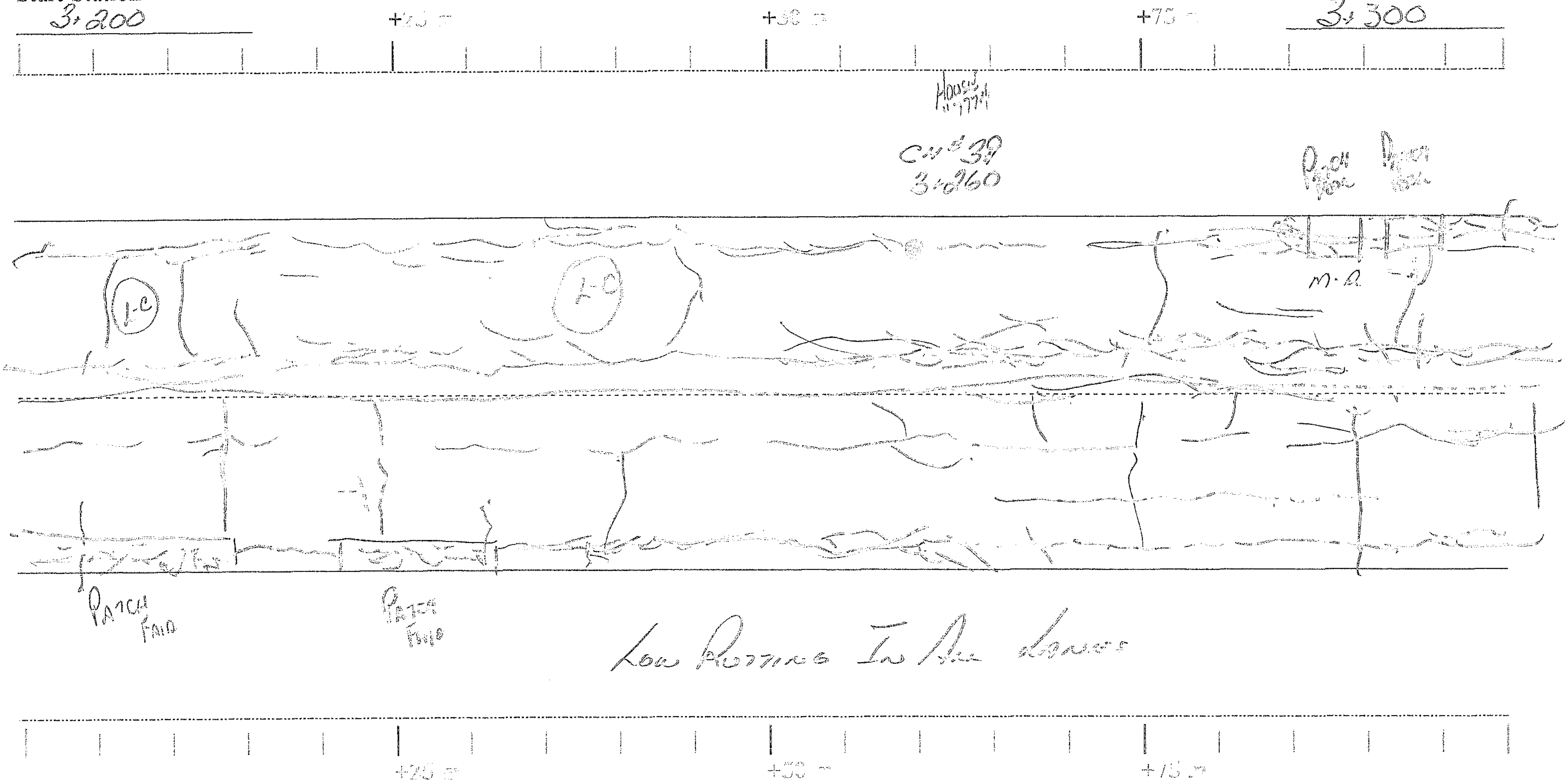
ARA Project No 17370

PAVEMENT DISTRESS MAPPING SURVEY

Highway Coleman Lane Direction Dunn To Lowans From Station 0+000 To Station 3+429

Surveyed By Walter Lawson Date Surveyed March 18-09 Conditions Good + Sunny

Start Station 3+200 End Station 3+300



APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

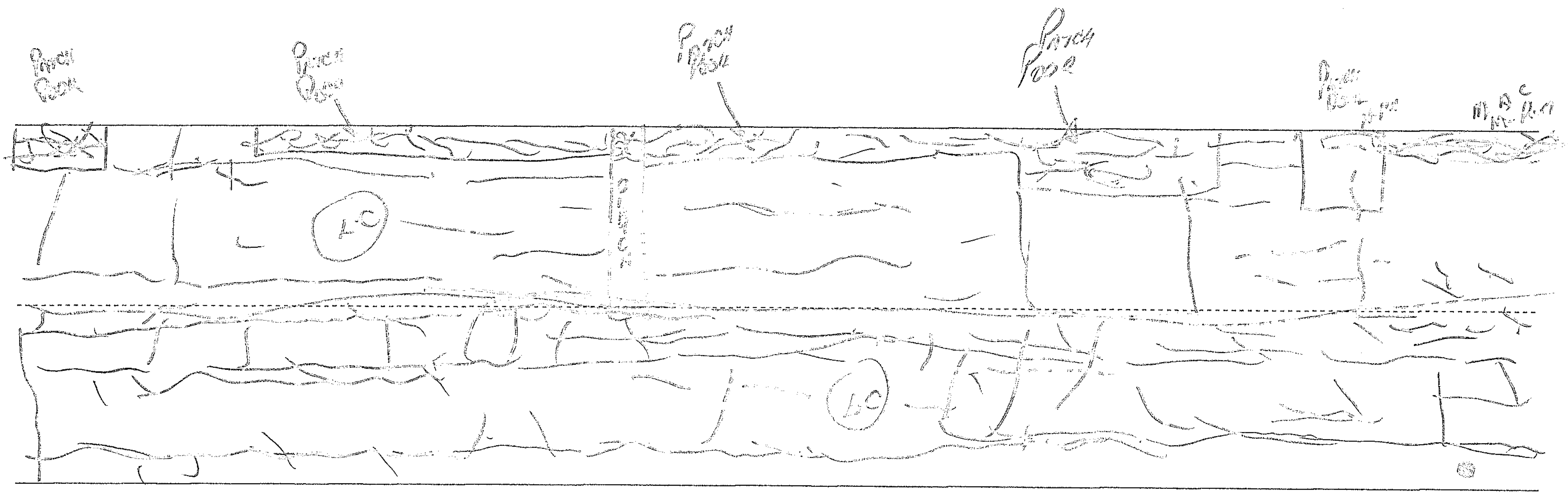
PAVEMENT DISTRESS MAPPING SURVEY

Highway Gunny Line Direction Towards [illegible] From Station 0+000 To Station 3+429

Surveyed By Walter Lupton Date Surveyed March 13-07 Conditions Cool & Sunny

Start Station 3+300 End Station 3+400

+25 m +50 m +75 m



Low To Medium Raveling In All Lanes

HP 2557

CH 4416

3+385

+25 m +50 m +75 m

APPLIED RESEARCH ASSOCIATES, INC.

ARA Project No 17870

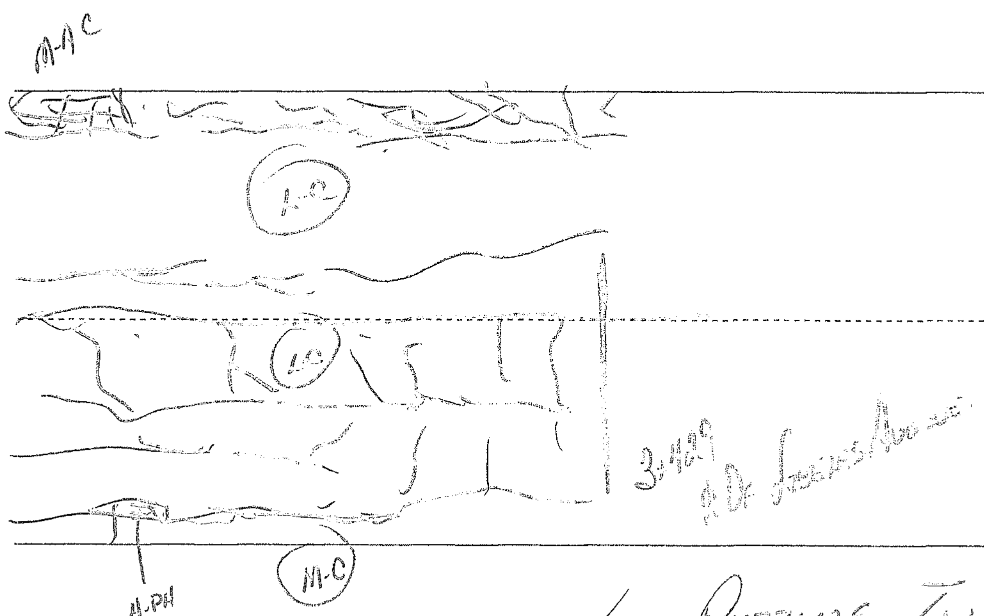
PAVEMENT DISTRESS MAPPING SURVEY

Highway Conroy Lane Direction Dunn To Brooks From Station 0+000 To Station 3+429

Surveyed By William Sootor Date Surveyed March 18-07 Conditions Cool + Sunny

Start Station 3+400 End Station 3+500

+25 m +50 m +75 m



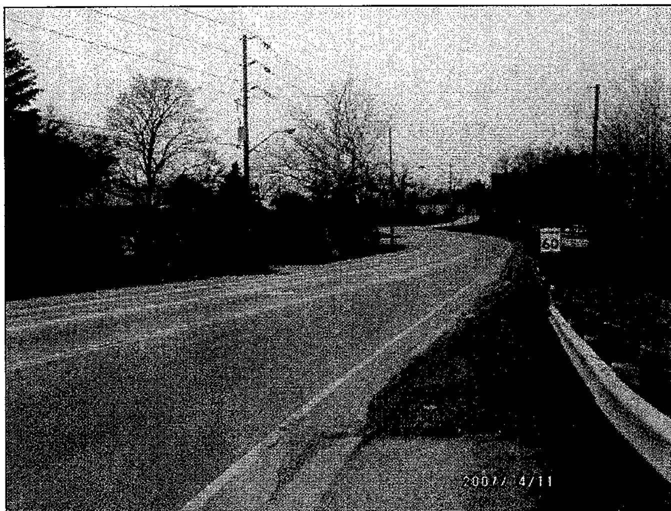
Low Ruttings In All Lanes.

+25 m +50 m +75 m

APPENDIX B

PHOTOGRAPHS OF TYPICAL PAVEMENT AND ASSOCIATED FEATURES

APPENDIX B
Guelph Line
Derry Road to Steeles Avenue
Photographs of Typical Pavement and Associated Features

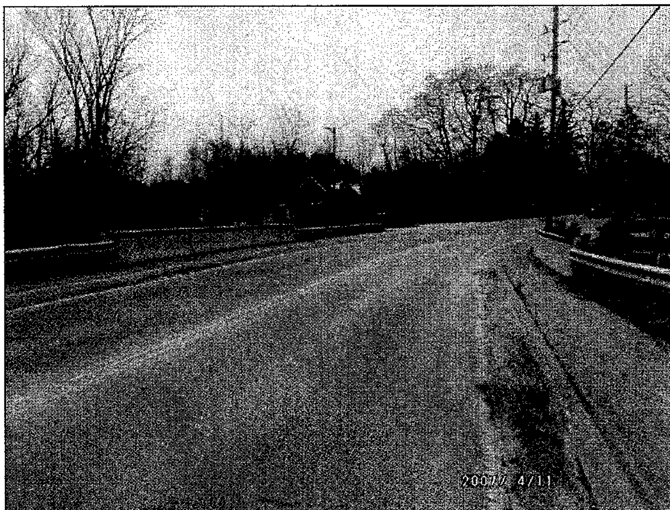


Looking north from intersection with Derry Road.

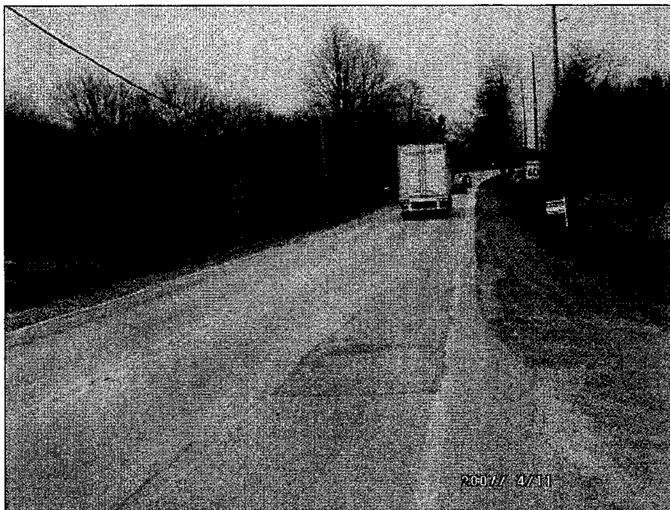
Typical longitudinal cracking.

Distress area in northbound lane. Note delamination of overlay in upper right corner of patch.

APPENDIX B
Guelph Line
Derry Road to Steeles Avenue
Photographs of Typical Pavement and Associated Features

	Facing north toward structure on south section of project.
	Areas of alligator cracking and patching in southbound lane
	Cracking and rutting in both lanes.

APPENDIX B
Guelph Line
Derry Road to Steeles Avenue
Photographs of Typical Pavement and Associated Features

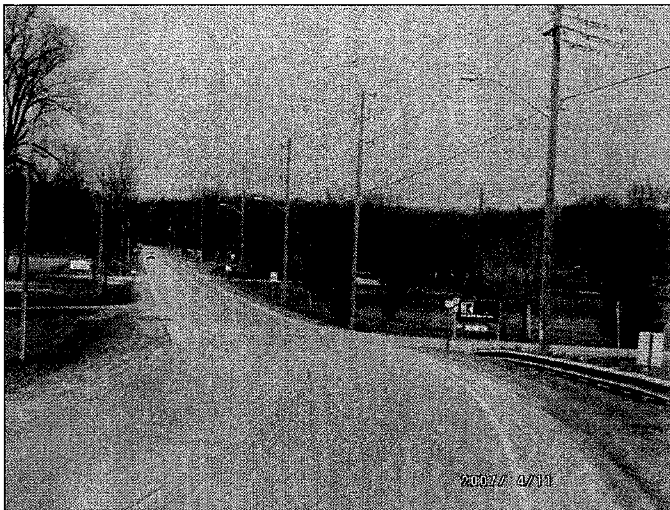


Typical patches in centre section of project.

Typical patches and cracking in centre section of project.

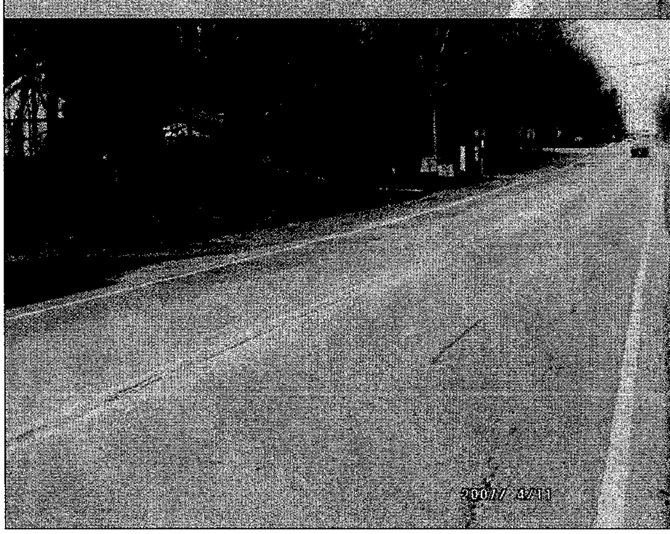
Distresses in southbound lane.

APPENDIX B
Guelph Line
Derry Road to Steeles Avenue
Photographs of Typical Pavement and Associated Features



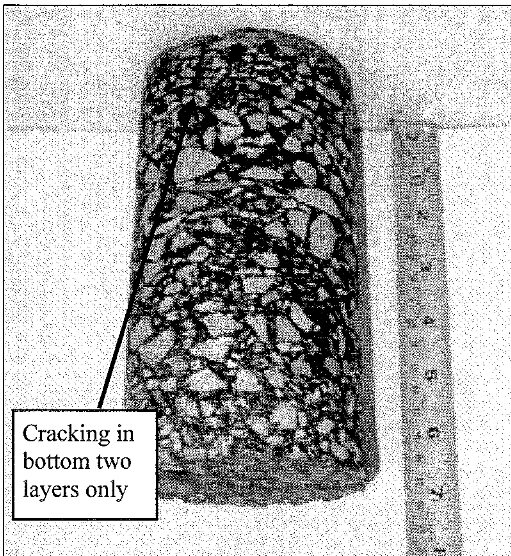
Looking northward in central section of project.

Typical longitudinal and transverse cracking in northern section of project.



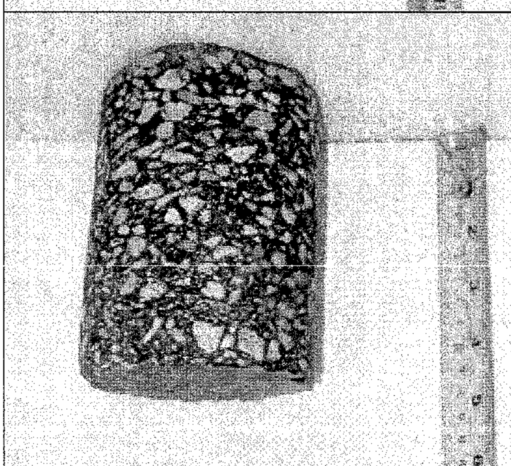
Looking northward at intersection with Steeles Avenue.

APPENDIX B
Guelph Line
Derry Road to Steeles Avenue
Photographs of Typical Pavement and Associated Features



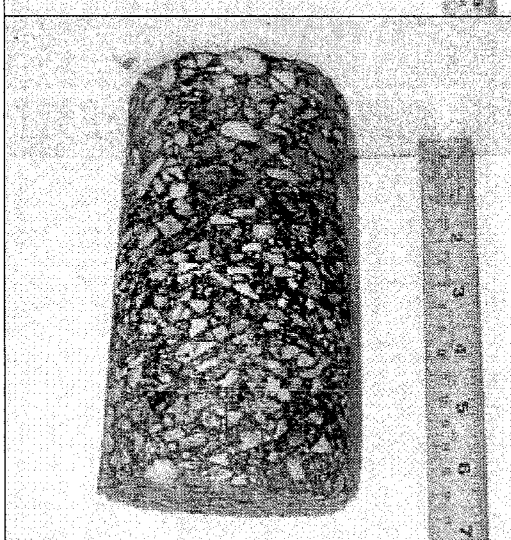
Core Photo 1
Sta. 1+012, Northbound Lane
2 m Lt CL

Type	Core (mm)
Surface Course	30
Binder Course	40
Binder Course	50
Surface Course	30
Surface Course	30
Total	**180**



Core Photo 2
Sta. 1+855, Northbound Lane
2.0m Lt CL

Type	Core (mm)
Surface Course	30
Surface Course	30
Surface Course	30
Surface Course	30
Total	**120**



Core Photo 3
Sta. 3+167, Northbound Lane
2.0m Lt CL

Type	Core (mm)
Surface Course	30
Surface Course	40
Surface Course	40
Binder Course	60
Total	**170**

APPENDIX C

RUT DEPTH AND CROSS FALL MEASUREMENTS

APPENDIX C
Guelph Line
Derry Road to Steeles Avenue
Rut Depth and Cross Fall Measurements

Station	Lane	Road Cross Fall *		Rut Depth (mm)	
		Measured (mm)	Grade (%)	Left Wheelpath	Right Wheelpath
0+057	NBL	0	0.0	0	0
0+166	SBL	140	5.7	10	7
0+270	NBL	-90	-3.7	0	5
0+383	SBL	-150	-6.1	0	10
0+457	NBL	70	2.9	5	10
0+525	NBL	25	1.0	5	7
0+630	SBL	-150	-6.1	0	3
0+761	NBL	30	1.2	0	15
0+869	SBL	45	1.8	0	12
0+934	SBL	20	0.8	3	5
1+012	NBL	50	2.0	12	7
1+135	SBL	50	2.0	5	5
1+263	NBL	70	2.9	7	10
1+378	SBL	20	0.8	12	7
1+444	NBL	90	3.7	15	20
1+502	NBL	60	2.5	20	15
1+652	SBL	170	7.0	12	0
1+777	NBL	30	1.2	7	20
1+850	SBL	70	2.9	15	20
1+855	NBL	70	2.9	0	10
1+922	SBL	80	3.3	17	20
2+038	NBL	80	3.3	10	15
2+182	SBL	80	3.3	70	20
2+270	NBL	40	1.6	3	7
2+348	NBL	60	2.5	0	5
2+454	SBL	0	0.0	3	0
2+545	NBL	40	1.6	3	20
2+618	NBL	80	3.3	5	15
2+744	SBL	70	2.9	12	10
2+884	NBL	0	0.0	0	7
2+966	SBL	0	0.0	10	0
3+023	SBL	20	0.8	7	3
3+167	NBL	30	1.2	3	7
3+260	SBL	60	2.5	5	5
3+325	SBL	50	2.0	10	10
3+395	NBL	50	2.0	3	17

* - Cross Falls were measured across the lane from left to right, in the direction of travel.

APPENDIX D

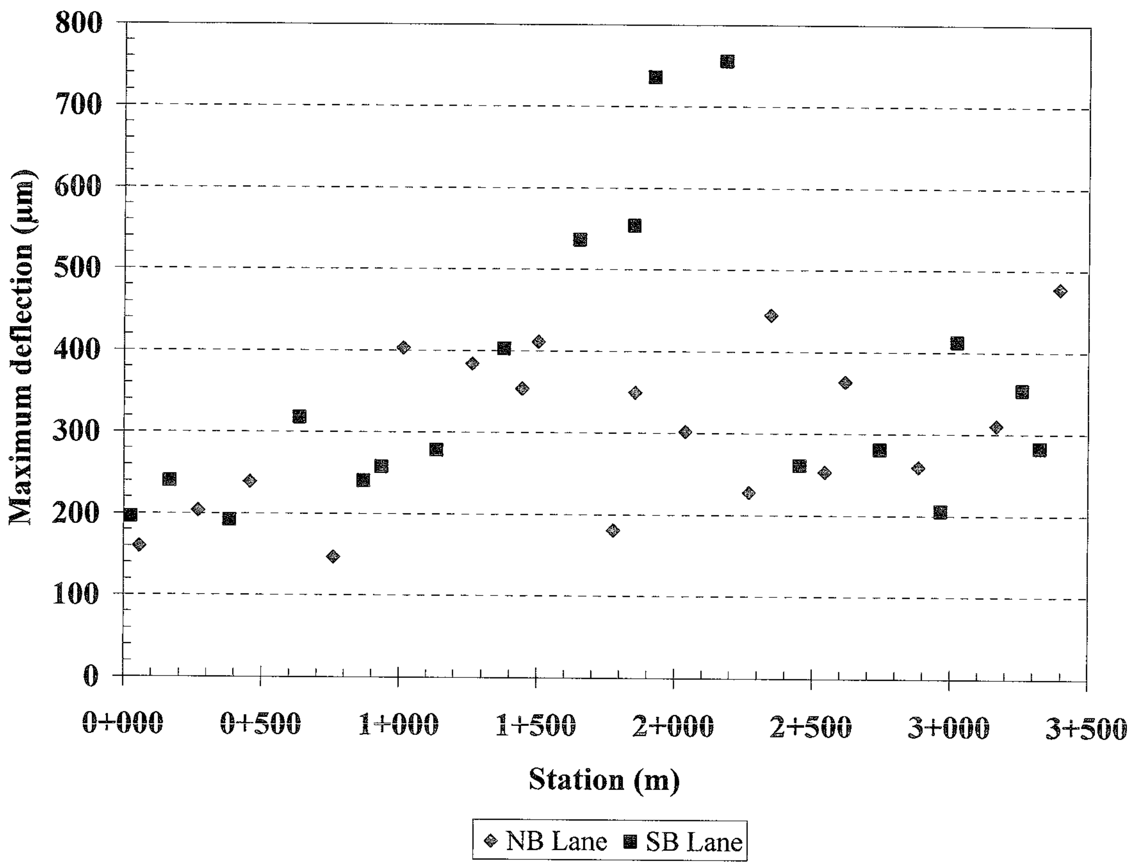
FALLING WEIGHT DEFLECTOMETER TEST RESULTS

APPENDIX D
Guelph Line
Derry Road to Steeles Avenue
Falling Weight Deflectometer Test Results

Station	D_0 (µm)	M_R (MPa)	E_P (MPa)	SN_{eff} (cm)	SN_{des} (cm)	SN Deficiency (cm)
Northbound Lane						
0+057	160	70	1,063	20.8	9.8	0.0
0+270	204	73	765	18.7	9.8	0.0
0+457	239	52	690	18.0	9.8	0.0
0+761	147	58	1,284	22.2	9.8	0.0
1+012	403	30	411	15.2	9.8	0.0
1+263	384	27	454	15.7	9.8	0.0
1+444	354	30	489	16.1	9.8	0.0
1+502	411	24	434	15.5	9.8	0.0
1+777	181	42	1,092	21.0	9.8	0.0
1+855	349	38	460	15.8	9.8	0.0
2+038	302	33	587	17.1	9.8	0.0
2+270	228	40	808	19.0	9.8	0.0
2+348	445	23	394	15.0	9.8	0.0
2+545	253	73	583	17.1	9.8	0.0
2+618	363	57	395	15.0	9.8	0.0
2+884	259	45	648	17.7	9.8	0.0
3+167	310	38	538	16.6	9.8	0.0
3+395	477	31	328	14.1	9.8	0.0
Average	304	44	635	17.2	9.8	--
Southbound Lane						
0+025	196	50	912	19.8	9.8	0.0
0+166	240	55	673	17.9	9.8	0.0
0+383	192	79	806	19.0	9.8	0.0
0+637	318	48	488	16.1	9.8	0.0
0+869	240	58	661	17.8	9.8	0.0
0+934	258	39	687	18.0	9.8	0.0
1+135	278	31	676	17.9	9.8	0.0
1+378	403	38	384	14.8	9.8	0.0
1+652	537	26	296	13.6	9.8	0.0
1+850	554	30	274	13.3	9.8	0.0
1+922	736	20	213	12.2	9.8	0.0
2+182	756	28	189	11.7	9.8	0.0
2+454	261	44	647	17.7	9.8	0.0
2+744	281	37	623	17.4	9.8	0.0
2+966	206	54	830	19.2	9.8	0.0
3+023	413	35	383	14.8	9.8	0.0
3+260	354	31	485	16.0	9.8	0.0
3+325	283	60	532	16.5	9.8	0.0
Average	361	42	542	16.3	9.8	--

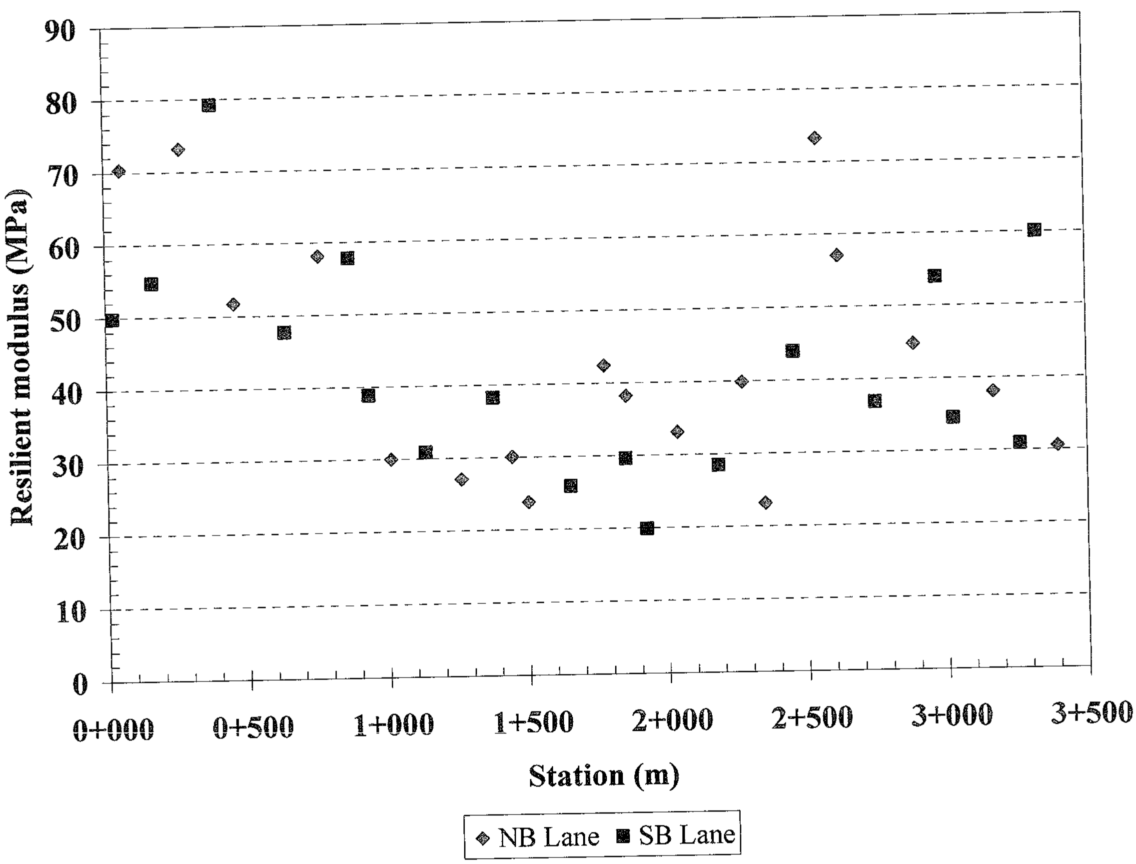
APPENDIX D
Guelph Line
Derry Road to Steeles Avenue
Falling Weight Deflectometer Test Results

Maximum Deflection Normalized to 40 kN



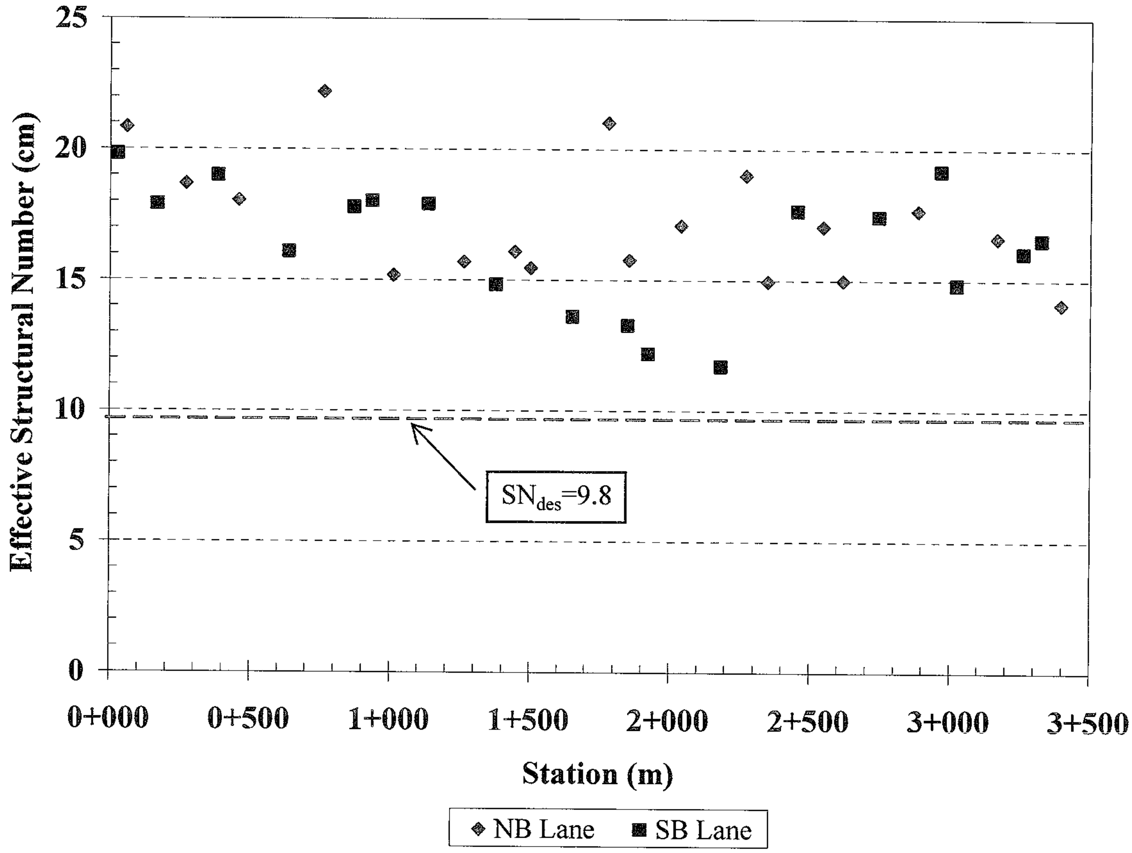
APPENDIX D
Guelph Line
Derry Road to Steeles Avenue
Falling Weight Deflectometer Test Results

Subgrade Resilient Modulus



APPENDIX D
Guelph Line
Derry Road to Steeles Avenue
Falling Weight Deflectometer Test Results

Effective Structural Number



APPENDIX E

COREHOLE LOGS

APPENDIX E
Guelph Line
Derry Road to Steeles Avenue
Coreholes Logs

Station	Lane	Thickness mm									Comments
		Surface	Surface	Surface	Binder	Binder	Binder	Surface	Surface	Total	
25 S	NB	30	40		30	40				140	South of Derry Road
0+025	SB	50			50	60				160	
0+057	NB	40	50		50	70				210	
0+160	SB	40			30	50				120	
0+270	NB	40			50	40				130	
0+383	SB	40			30	50				120	
0+457	NB	40			60	40				140	
0+525	NB	50			40	40				130	
0+630	SB	50			40	40				130	
0+761	NB	60			50	50				160	
0+869	SB	40			40	50				130	
0+934	SB	30			40	50				120	
1+012	NB	30			40	50		30	30	180	Crack in bottom 2 layers only
1+135	SB	30	30	30				40	40	170	
1+263	NB	40	30	40						110	
1+378	SB	30	30	30				10		100	
1+444	NB	40	40	30				20		130	
1+502	NB	40	30	30				40		140	
1+652	SB	40	40	20				20	10	130	
1+777	NB	50	50	30				40		170	
1+850	SB	30	40	20				10		100	
1+855	NB	30	30	30				30		120	
1+922	SB	40			70					110	
2+038	NB	40	40	50				30		160	
2+182	SB	40	40	20				50		150	
2+270	NB	40	40	40	30	60				210	
2+348	NB	50	40	30	60					180	
2+454	SB	20	50		30	40				140	
2+545	NB	30	50	30				20		130	
2+618	NB	30	50	20						100	
2+744	SB	30	40		30	60				160	
2+884	NB	30	60	40				30		160	
2+960	SB	30	30		40	40				140	
3+023	SB	30	30	40				10		110	
3+167	NB	30	40	40	60					170	
3+260	SB	50			40	40				130	
3+325	SB	50			80					130	
3+395	NB	30	50		70					150	
25 N	NB	20	40	30				20		110	N. of Steeles Avenue
25 E	WB	60			30	50				140	Derry Rd.
25 W	EB	50	30		50	40				170	Derry Rd.
25 W	WB	40	40	20						100	Steeles Avenue
25 E	EB	40	50							90	Steeles Avenue

APPENDIX F

BOREHOLE LOGS

APPENDIX F
Guelph Line
Derry Road to Steeles Avenue
Borehole Logs

0+270 NB 2.0 m Rt CL D 0

0 - 130	Asph			
130 - 330	CRL			dry
330 - 1	CRL 50 mm minus			dry
		w @ 700 mm	=	3 %
		4.75 mm	=	39 %
		0.075 mm	=	12 %
1 - 1.5	Br Si(y) Cl Till			moist
		w @ 1.2m	=	12 %
		4.75 mm	=	97 %
		0.075 mm	=	60 %
		5 µm	=	34%

Frost Susceptibility=LSFH
Erodibility=0.18
Unified Classification=CL
Liquid Limit=29.2
Plastic Limit=15.2
Plasticity Index=14.0

0+637 SB 2.0 m Lt CL D 0

0 - 130	Asph	
130 - 680	CRL	dry
680 - 1.5	Br Sa and Gr	dry

1+263 NB 2.0 m Rt CL D 0

0 - 110	Asph			
110 - 700	Br Sa and Gr			dry
		w @ 400 mm	=	5 %
		4.75 mm	=	69 %
		0.075 mm	=	17 %
700 - 1.5	Br Si(y) Cl Till			moist
		w @ 1.1m	=	18.6 %
		4.75 mm	=	100 %
		0.075 mm	=	71 %
		5 µm	=	39%

Frost Susceptibility=LSFH
Erodibility=0.22
Unified Classification=CL
Liquid Limit=32.4
Plastic Limit=17.6
Plasticity Index=14.8

1+652 SB 2.0 m Lt CL D 0

0 - 130	Asph	
130 - 590	Br Sa and Gr	dry
590 - 1.5	Br Si(y) Cl Till	dry

1+922 SB 2.0 m Lt CL D 0

0 - 110	Asph			
110 - 690	Br Sa and Gr			dry
690 - 1.5	Br Si(y) Cl Till			wet
		w @ 1.1m	=	20 %
		4.75 mm	=	98 %
		0.075 mm	=	55 %
		5 µm	=	25%

Frost Susceptibility=LSFH
Erodibility=0.22
Unified Classification=CL
Liquid Limit=32.3
Plastic Limit=17.0
Plasticity Index=15.3

2+270 NB 2.2 m Rt CL D 0

0 - 210	Asph	
210 - 610	Br Sa and Gr	dry
610 - 1.2	Br Si(y) Cl Till	moist
1.2 -	NFP (Blds)	

2+744 SB 2.0 m Lt CL D 0

0 - 160	Asph			
160 - 1.2	Br Sa and Gr			dry
		w @ 700 mm	=	5 %
		4.75 mm	=	53 %
		0.075 mm	=	13 %
1.2 - 1.3	Br Si Sa and Gr			moist
		w @ 1.25m	=	8 %
		4.75 mm	=	48 %
		0.075 mm	=	20 %
		5 µm	=	19%
1.3 -	NFP (Blds)			

APPENDIX F
Guelph Line
Derry Road to Steeles Avenue
Borehole Logs

3+260 SB 2.0 m Lt CL D 0

0 - 130	Asph			
130 - 850	Br Sa and Gr			dry
850 - 910	Blk Si(y) Cl Tr Org			dry
910 -	NFP (Blds)			

3+395 NB 2.0 m Rt CL D 0

0 - 150	Asph			
150 - 640	Br Sa and Gr			dry
		w @ 400 mm	=	4 %
		4.75 mm	=	57 %
		0.075 mm	=	2 %
640 - 1.5	Br Si(y) Cl Till			moist
		w @ 1.1m	=	9 %
		4.75 mm	=	99 %
		0.075 mm	=	57 %

Frost Susceptibility=LSFH
Erodibility=0.29
Unified Classification=CL
Liquid Limit=25.3
Plastic Limit=16.5
Plasticity Index=8.8

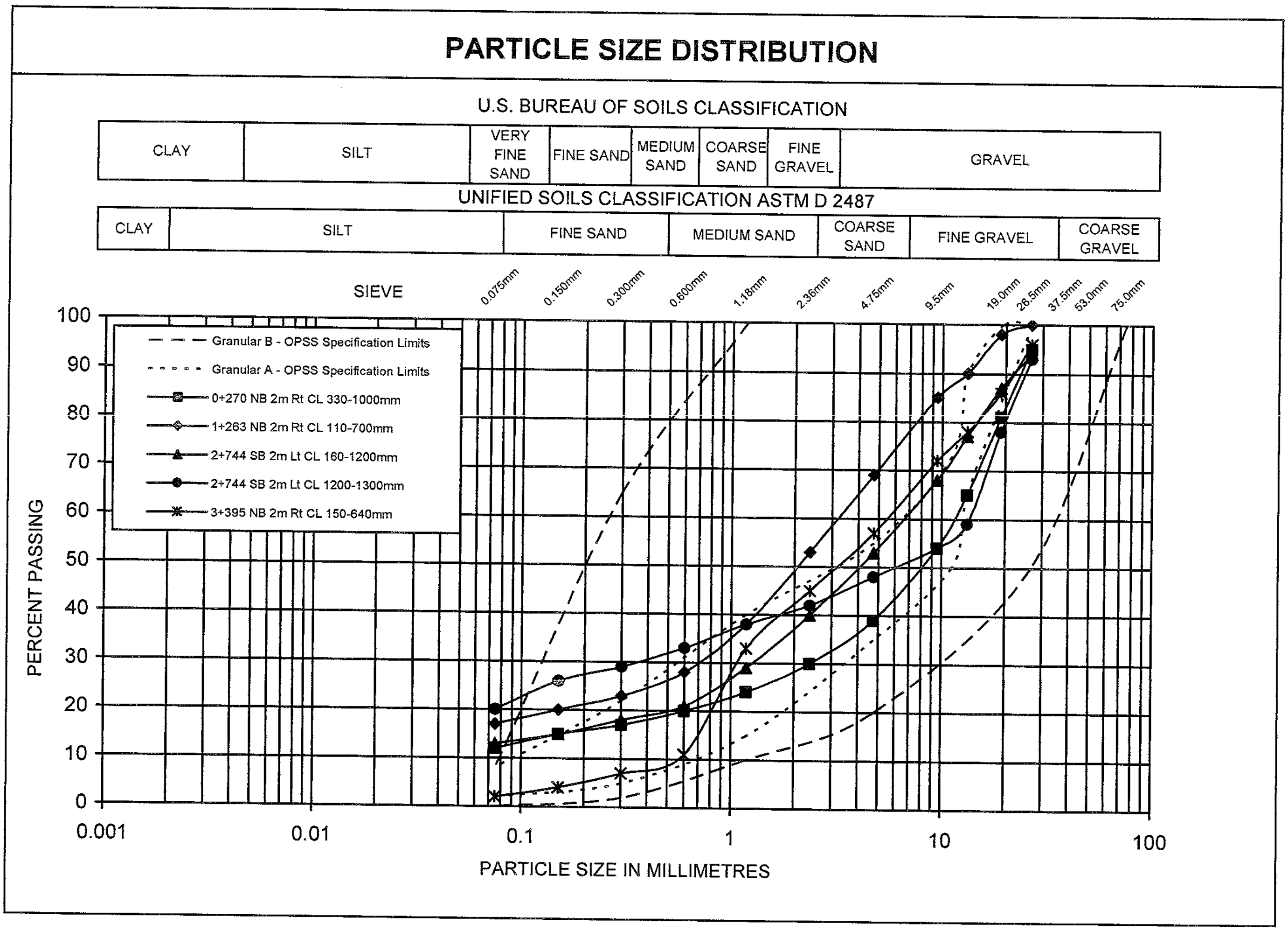
APPENDIX G

LABORATORY TEST RESULTS

APPENDIX G
Guelph Line
Derry Road to Steeles Avenue
Laboratory Test Results

Granular Test Result Summary

Station (km)	Offset (m)	Depth (mm)	Field Classification	Percent Passing (%)		Water Content (%)	Frost Susceptibility
				4.75 mm	75 µm		
0+270 NB	2.0 Rt	330-1000	CRL 50 mm minus	39	12	3.3	LSFH
1+263 NB	2.0 Rt	110-700	Br Sa and Gr	69	17	5.1	LSFH
2+744 SB	2.0 Lt	160-1200	Br Sa and Gr	53	13	4.6	LSFH
2+744 SB	2.0 Lt	1200-1300	Br Si Sa and Gr	48	20	8.0	LSFH
3+395 NB	2.0 Rt	150-640	Br Sa and Gr	57	2	3.7	LSFH



APPENDIX G
Guelph Line
Derry Road to Steeles Avenue
Laboratory Test Results

Subgrade Test Result Summary

Station (km)	Offset (m)	Depth (mm)	Classification	
			Field	ASTM Unified
0+270 NB	2.0 Rt	1000-1500	Br Si(y) Cl Till	CL
1+263 NB	2.0 Rt	700-1500	Br Si(y) Cl Till	CL
1+922 SB	2.0 Lt	690-1500	Br Si(y) Cl Till	CL
3+395 NB	2.0 Rt	640-1500	Br Si(y) Cl Till	CL

Station (km)	Percent Passing (%)				Water Content (%)	Plasticity (%)		Frost Susceptibility	Soil Erodibility Factor, K
	4.75 mm	75 µm	5 µm	Si & VFS		PI	PL		
0+270 NB	97	60	34	26	12.2	14.0	15.2	LSFH	0.18
1+263 NB	100	71	39	32	18.6	14.8	17.6	LSFH	0.22
1+922 SB	98	55	26	29	19.5	15.3	17.0	LSFH	0.22
3+395 NB	99	57	19	38	9.1	8.8	16.5	LSFH	0.29

PARTICLE SIZE DISTRIBUTION