



Canada - Newfoundland
Flood
Damage
Reduction
Program

Water Resources Division
Hydrological Modelling
Section

Hydrotechnical Study of the Stephenville Area

MAIN REPORT

Volume 2 of 2





Canada-Newfoundland
Flood Damage Reduction Program



Hydrotechnical Study of the Stephenville Area

Volume 2 of 2

Physical Surveys and Field Program

Corner Brook

Gander

STEPHENVILLE

Port-aux-Basques

St. John's

February , 1984

Grand Bank

Nolan Davis & Associates Limited

in association with

Cumming-Cockburn & Associates Limited

Table of Contents

	<u>Page No.</u>
VOLUME 2: SUPPLEMENTARY REPORT	
Physical Surveys and Field Program	
LIST OF TABLES & DRAWINGS	
LIST OF FIGURES	
1.0 INTRODUCTION	1-1
1.1 General	1-1
2.0 FIELD PROGRAM	2-1
2.1 General	2-1
2.2 Gauging Stations	2-1
2.3 Physical Surveys	2-2
2.3.1 Structures	2-3
2.3.2 Cross-Sections	2-4
2.4 Discharge Measurements	2-5
2.5 Factors Affecting Stream Flow and Groundwater Movement	2-7
2.5.1 Causitive Agents for Basement Flooding	2-7
2.5.1.1 Perched Water Tables	2-8
2.5.1.2 Water Table Gradients	2-10
2.5.2 Impact of River Regime on Flooding	2-11
2.5.2.1 Fluctuations in Independent Parameters	2-11
2.5.2.2 Impacts Regarding Flooding	2-13
2.5.2.3 Groundwater Component of Streamflow	2-17

Table of Contents (continued)

	<u>Page No.</u>
2.5.3 Additional Factors Influencing Flooding	2-19
2.5.4 Potential for Acquiring High Flow Data in Spring 1983	2-19
APPENDIX A: Tables and Drawings	
APPENDIX B: Structures and Photographs	
APPENDIX C: Water Level and Discharge Measurements	
APPENDIX D: Meteorological Records	
APPENDIX E: Channel Cross Sections	

List of Tables & Drawings

TABLE 1: Crest Gauge Locations

TABLE 2: List of Geodetic Monuments Used for Survey Control

DRAWING 1: Location Map

List of Figures

FIGURE 1: Groundwater Related Basement Flooding

FIGURE 2: Changes in Channel Morphology From Man

Introduction

1.0

Introduction

1.0

1.1 General

The objectives of the hydrotechnical studies on the Blanche Brook and Warm Creek watersheds as defined in the Technical Committee's Terms of Reference included 1) development of hydrologic models suitable for estimating 1:20 and 1:100 year flood hydrographs in the study area and 2) development of hydraulic models suitable for calculating water surface profiles throughout both watersheds for these two return frequencies. The methodology and hydraulic modelling components used to attain these objectives are described in the main report text (Vol. 1). Volume 2 summarizes the field data acquired for the modelling team during the period September 1982 - June 1983.

The field program was undertaken by staff members of Nolan, Davis & Associates Limited and Cumming-Cockburn & Associates Limited. Arrangements were made with a local resident, Mr. I. Wiseman, to take crest gauge readings and stream flow velocities. As well, two individuals from the area were engaged to assist with the surveying activities. The following sections describe the field program which primarily comprised stream flow measurements, physical surveys and related reconnaissance activities.

Field Program

2.0

Field Program

2.0

2.1 General

Physical aspects of the field program included installation of crest gauges and subsequent collection of stream discharge data and water level measurements during peak runoff conditions. In addition, all structures along both Blanche Brook and Warm Creek were identified and physical dimensions obtained. Cross-sections of the channel and flood plain at various locations along both watercourses were surveyed as part of the initial field program. To supplement the physical aspects of the field program a hydrogeological reconnaissance survey of both watercourses was carried out in an effort to identify the groundwater component of stream flow.

2.2 Gauging Stations

An initial review of existing mapping for the area suggested that seven crest gauges would likely be adequate for obtaining the required water level measurements. The criteria for locating the gauges was that they be positioned in the main stream channel and at the same time located where structural constraints (culvert and bridge openings) were such as to impede heavy flow discharge and hence result in backwater build-up.

A total of eleven 2.5-metre long crest gauges were manufactured; seven for the originally proposed locations, with remaining units for backup in case of vandalism or as replacements for units

destroyed by ice or debris. The crest gauges were installed by the field personnel on September 21 and 22, 1982.

Subsequent to installation of the crest gauge on Blanche Brook at the old bridge structure on the Hansen Highway Crossing, field personnel were informed that the structure was going to be demolished. This unit was therefore removed and repositioned on the new bridge. Prior to completion of the field work, an eighth crest gauge was installed on Warm Creek at the Hansen Highway bridge structure on Route 460. Relocation of the Blanche Brook gauge and installation of the above noted eighth gauge was carried out October 6, 1982.

Elevations for all crest gauges were established relative to Geodetic Datum as part of the overall field survey program. The various level circuits for the cross sections and gauge elevations were tied into Geodetic Benchmark 432-K set in concrete at the base of the flagpole in front of the old Harmon Airforce Headquarters.

The location and geodetic elevation of the crest gauges are listed in Appendix A of this Summary Report.

2.3 Physical Surveys

Physical surveys carried out as part of the field program included defining structure types and sizes along both watercourses, obtaining representative cross-sections of both stream channels and flood plains and referencing these sections to Geodetic Datum and existing large scale topographic mapping of the area. Details respecting these field measurements are described in the following sub-sections.

2.3.1 Structures:

Each of the structures along Blanche Brook and Warm Creek represents a potential flow constriction which can and in many instances does have a pronounced effect on surface water profiles during peak flow periods. Accordingly, physical dimensions and critical elevations, as noted below, were obtained for these structures.

For Bridges

- clear span opening between piers
- height of bridge deck above the channel bottom
both in the upstream and downstream sides
- intermediate pier dimensions
- deck surface elevation
- depth of flow at centre of span or channel

For Weirs

- structure span
- top and bottom profile at centreline
- top and bottom profile at upstream and downstream structure extremities
- location, spacing and dimension of control gates
- location and width of spillway sections

The data sheets and photographs for each of the structures along Warm Creek and Blanche Brook are included in Appendix B of this volume. Photographs taken by field personnel on the 4th of October, 1982 generally show the types of structures along the

watercourse and crest gauges secured to these structures.

2.3.2 Cross-Sections:

Before initiating a start on the physical surveys, field staff from Nolan, Davis/Cumming-Cockburn traversed Blanche Brook and Warm Creek watercourses to ensure selection of representative section locations. Sections were then noted on 1:2500 mapping and reviewed with the survey party chief prior to layout. Field locations of section lines was determined by angle and distance measurements from existing landforms and structures. Since many of the sections required considerable line cutting, this aspect of the survey was carried out during bad weather when instrument work was considered impractical.

A total ~~(fo)~~ sixty-five cross-sections were surveyed, thirty-nine along Warm Creek and twenty-six along Blanche Brook. Sections along Blanche Brook started 137 m downstream of Kin Place Bridge - Sta 0+000 (in close proximity to the seashore on St. Georges Bay) and terminated 430 metres upstream of the new bridge on the Hansen Highway - Sta 36+10.

Cross-sections along Warm Creek beginning at the confluence with Blanche Brook - Sta 0+000 were obtained through to Noels Pond, thence from the upstream end of the pond to a point 1030 metres beyond the Hansen Highway bridge structure - Sta 81+85. The thirty-nine cross-sections obtained on Warm Creek varied in length from 40 metres to a maximum of 360 metres.

Elevations for sections on Blanche Brook and those on Warm Creek downstream of Noels Pond were referenced to Geodetic Datum relative to Benchmark 432-K located at the base of the flagpole in front

of the old Harmon Base Headquarters - El. 21.596 metres. The thirteen sections surveyed upstream of Noels Pond were tied into Geodetic Benchmark No. 76F885 located on the Hansen Highway Bridge over Warm Creek (brass plug set in the bridge abutment - El. 26.646 metres). Following establishment of temporary benchmarks at section locations, a series of level circuits were run to tie each section to Geodetic Datum. At the same time, temporary benchmarks used for crest gauge data were picked up and reduced to Geodetic.

Level work for the field program was carried out using a spirit level and conventional surveying techniques. Elevation closure for the entire survey, utilizing Geodetic Benchmark 432-K and 76F885 was 886 mm. For the circuit distance involved (19 km) this is somewhat less than the 105 mm maximum allowable error for third order levelling.

2.4 Discharge Measurements

Four stations, two on each of the watercourses, were established to facilitate stream discharge measurements as part of the field monitoring program. The stations on Blanche Brook were located coincident with bridge structures B2 and B3 to accommodate uniform flow measurements while Warm Creek measurements were taken at bridge structures B6 and B7. As noted from Table 1, Appendix A, crest gauges were also positioned on these same structures.

In order to obtain low flow data for the rating curves, discharge and stage data were measured on March 11, 1983. Table D-2, Appendix D indicates that only an insignificant amount of precipitation fell

on the watershed during the ten days prior to the low flow sampling.

Flow measurements were taken by Mr. I. Wiseman of Stephenville using a Teledyne Gurley Type 622 current meter and wading rod. Measurements were taken in accordance with Water Survey of Canada guidelines. As the readings were taken using the standard meter head rather than a pigmy meter, some degree of error was experienced because of the shallow water and rough channel bed conditions prevalent at the time. However, based on a detailed review of computed discharge, it was found that this error was not significant.

The resultant discharge calculations are included in Appendix C.

Discussions with Water Survey of Canada personnel at Corner Brook indicated that provisional data from their station below the Blanche Brook-Warm Creek confluence showed a relatively constant stage height of 1.70 m throughout March 11, 1983. Utilizing the December 1982 rating curves, the resultant calculated discharge is $0.586 \text{ m}^3/\text{s}$.

Comparison of recorded flows at the WSC gauge with combined calculated flows for Blanche Brook and Warm Creek (March 1983) indicates a difference of $0.5 \text{ m}^3/\text{sec}$ in the discharge data which may be due to any one of the following:

- 1) inaccuracy of discharge measurements at Stations 3 and 6
- 2) alterations and/or inaccuracies in the low flow portion of the rating curve at the WSC gauge
- 3) an influent reach of stream between Stations 3 and 6, and the WSC gauge

The monitoring program continued for nine months, terminating the end of June, 1983. During this period data was obtained on three rainfall/snowmelt events and one low flow period. One further event was also assessed in July, 1983. A summary of these events is provided in Appendix C.

Two main problems were encountered during the field program over which little or no control could be exercised, as discussed below.

- 1) No significant storms effected the Stephenville area during the monitoring period. Even though very large precipitation events occurred in the interior during the study, the Stephenville area was either bypassed entirely or received only minimal precipitation.

Further, the snowfall received during the 1983 winter months was lower than the mean records in all months as recorded at AES Station 71815 (Stephenville Airport), as noted in Appendix D. This, in combination with very moderate temperatures, minimized accumulation of snow on the ground and therefore eliminated large spring floods. As a result, there were no flooding events by overbank flow or rising groundwater table experienced during the monitoring period.

- 2) Vandalism of the crest gauge recorders proved impossible to deal with even though they were checked frequently and repaired and/or replaced on a number of occasions. As a result, when stage elevations did rise in the river most of the recorders were inoperative. Where gauge readings could not be obtained because of inoperative gauges, high water levels were marked on the adjacent structures and referenced to Geodetic at a later date.

2.5 Factors Affecting Stream Flow and Groundwater Movement

2.5.1 Causitive Agents for Basement Flooding:

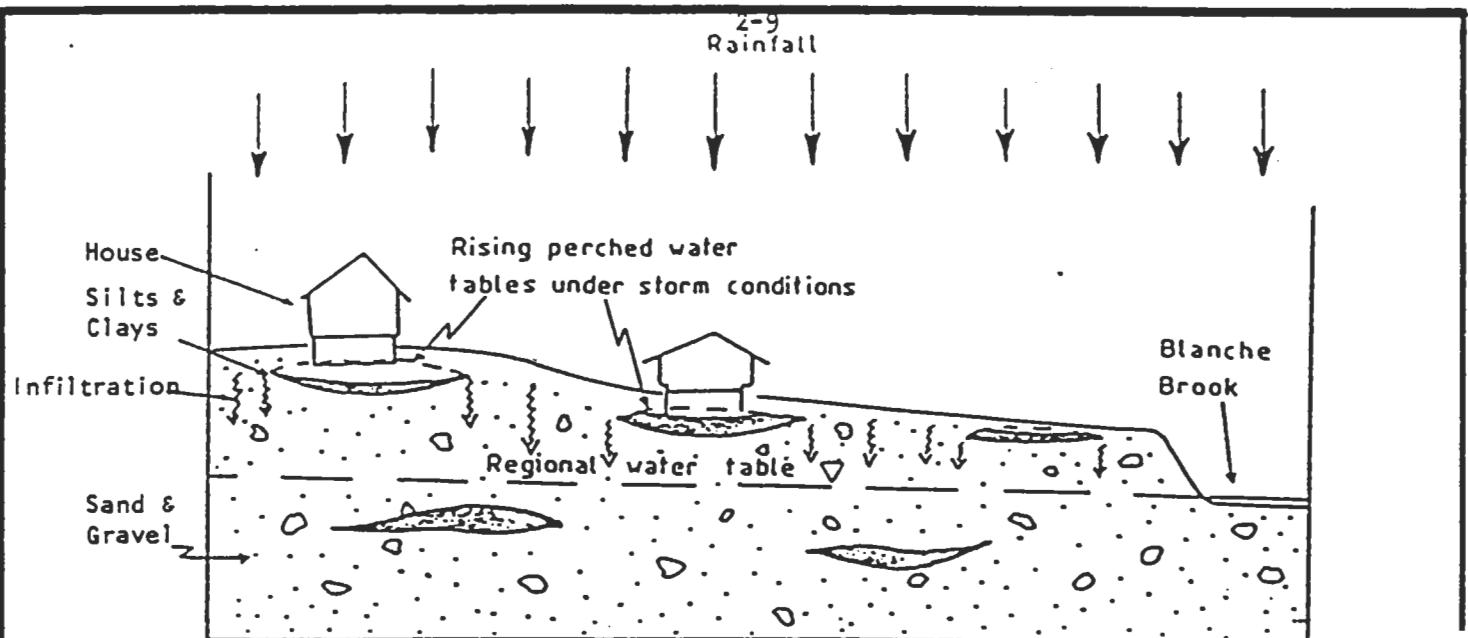
Information gathered to date on the flooding of basements indicates:

- 1) Groundwater levels rise into the basements of some homes prior to an appreciable rise in stage in the study channels,
- 2) While groundwater surcharge is not encountered in all homes along the study channels, it appears most prevalent along the west side of Blanche Brook between Main Street and St. Clair Avenue (see Stations 3 and 4 respectively on Drawing 1, Appendix A). Visual assessment of the area between Main Street and St. Clair Avenue suggests perched water tables and water table gradient as two possible causes of this phenomenon.

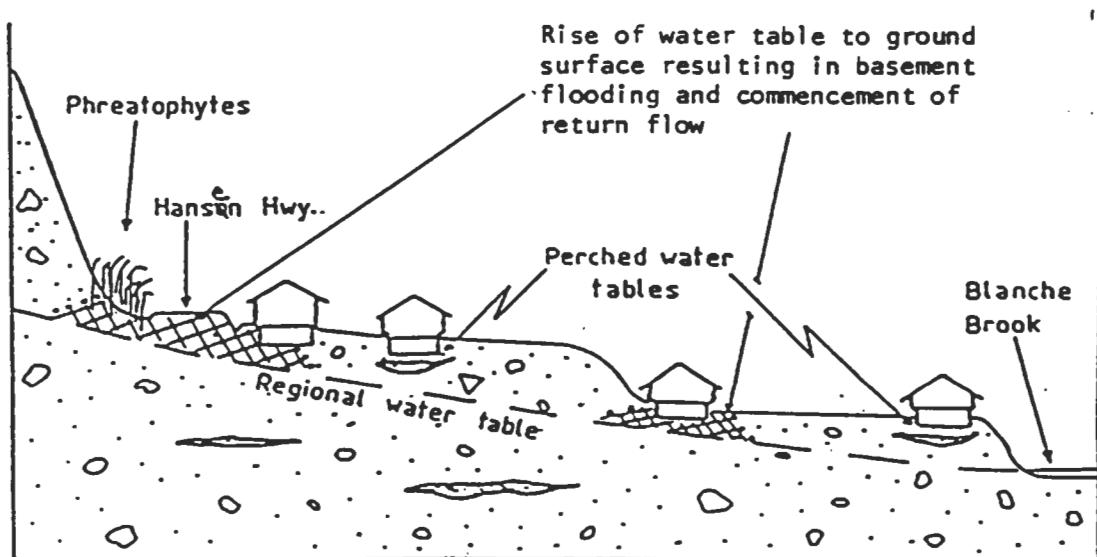
2.5.1.1 Perched Water Tables:

In the past there appears to have been significant lateral activity in the channel as evidenced by the ridge and swale topography in the flood plain. As a result, the lithology of the outwash gravel deposits underlying the flood plain is expected to include pods and lenses of fine grained deposits. These silts and clays would result from overbank deposition in the remnants of former channels.

These fine grained deposits can be expected to exhibit much lower permeability than the surrounding coarse grained material. The resultant major decline in vertically downward permeability will create a perched water table which could lie at a higher elevation than the water level in the channel. With a rainfall event, this shallow perched water table could be expected to respond rapidly; thereby quickly rising to near the surface and entering any basements which would be vulnerable (see Figure 1). At least one residence recently constructed over a filled-in swale, has been affected by groundwater surcharge of this nature.



SKETCH - EFFECT OF PERCHED WATER TABLES ON BASEMENT FLOODING



SKETCH - EFFECT OF WATER TABLE GRADIENT ON BASEMENT FLOODING

FIGURE 1

CANADA-NEWFOUNDLAND
FLOOD DAMAGE REDUCTION PROGRAM

GROUNDWATER RELATED
BASEMENT FLOODING

2.5.1.2 Water Table Gradient:

The valley morphology and surficial geology are indicative of a near-surface water table in at least two locations (as noted schematically in Figure 1) and having a significant gradient. One near surface location is at the base of the western valley wall and the other is located at the base of a small terrace. Homes built at these locations would tend to notice a quick water table response with basement flooding prior to storm flow conditions in the channel.

The proximity of the water table to the surface is exemplified, where natural vegetation exists, by dense phreatophyte (alders) growth at the base of the valley wall. According to Mr. Wiseman, some of the homes immediately to the east of the Hansen Highway experience flooding in their basements.

In both of the above described situations, the water table lies relatively close to ground surface under non-storm flow conditions. As such, under storm conditions, the processes associated with the variable source area-overland flow concept of stream flow generation apply. In this concept, near-stream and near-steep hydraulic gradient increases develop soon after the beginning of the storm event. The speed of this rise is independent of the upland area response and is augmented by the height of the capillary zone and its close proximity to the ground surface. Infiltration quickly converts the tension saturated capillary fringe into a pressure saturated zone and the water table rises almost instantaneously to the ground surface. At this point, water emerges from the ground and runs downslope toward the channel as overland flow. If runoff occurs in sufficient volume, the capacity of existing highway drains in the area could be exceeded, resulting in local flooding within the flood plain prior to a rise in stage in the channel.

2.5.2 Impact of River Regime on Flooding:

The processes affecting the attitude and form of a channel include principally: geology, climate, vegetation, regional topographic slope, discharge rate, water temperature and sediment (suspended, bedload, and dissolved) load. The channel slope and geometry are the predominantly dependent variables on which a river maintains a steady stage equilibrium.

It is therefore apparent that changes, whether natural or man-made, in any of the above independent variables could alter existing channel morphology; thereby affecting flooding.

Based on the field visits and previous experience elsewhere in the Atlantic Provinces, the following points are considered relevant:

2.5.2.1 Fluctuations in Independent Parameters:

A) Natural

- a) Thomas (1975) indicated "a slow fairly uniform trend toward more precipitation in the Atlantic Region over the past 35 years".

At Sydney, Nova Scotia, an analysis of total annual precipitation has been carried out utilizing moving decadal means (Baechler, 1983). The analysis indicated a significant, constant increase in total annual precipitation such that decadal means centered in the mid 70's were greater than 15 cm higher than those centered in the mid 50's. Further analysis indicated the increased precipitation was occurring predominantly in October, November and December.

If a similar trend is occurring in the Stephenville area there are important ramifications with respect to potential flooding. Not only would larger amounts of precipitation and runoff be experienced within the watershed; but such conditions would exist at a time of year when evapotranspiration losses would be minimal. As a result, the runoff coefficients would be higher, thereby generating a greater volume of water in the channel.

However, the approximate extent and effect of these trends on the area is sketchy as little analysis of the trends and their intensity-duration patterns for fall storms has been undertaken in recent years.

- b) Coupled with this increased volume of precipitation is the drop in pH (acid rain) due to industrial emissions. Although research indicates an associated potential increase in dissolved sediment loadings in streams and later a potential reduction in forest cover, nothing definite is available to date. If such changes did occur, the affect on channel morphology and timing of the peak runoff characteristics of the basin could be significant.
- c) There is a present rise in sea level of approximately 0.3 m/century. This rise in base level, to which the channel is trying to achieve an equilibrium profile, will tend to cause instability in the channel. This effect and the related impacts would be expected to be localized near the mouth and as such is not expected to be significant with regard to the potential flood problems.
- d) The basins in question are too small to be affected differentially by isostatic uplift rates.

B) Man-Induced

Superimposed upon the above natural short and long term fluctuations are the changes induced by man through alterations in land use.

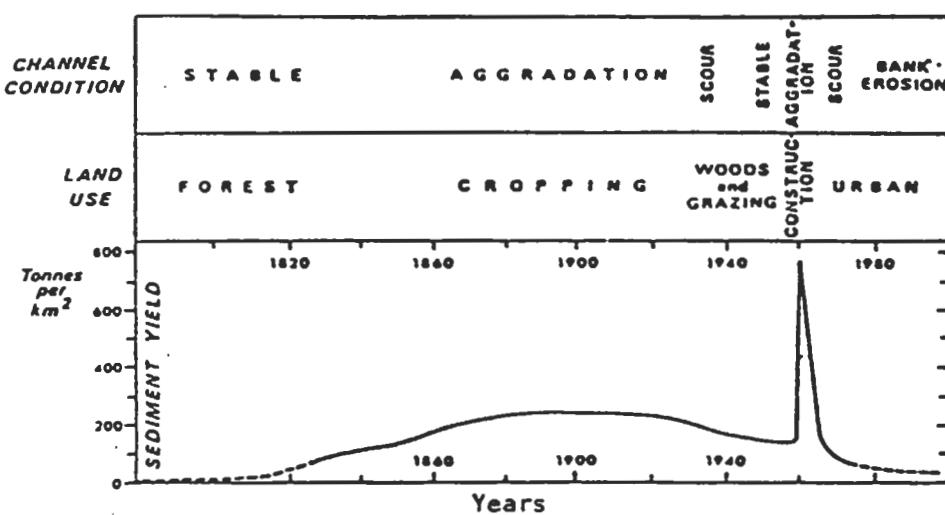
These changes and the resultant effects on channel morphology are partly summarized in Figure 2. Of particular note for further discussion are:

- the peaking sediment loads during construction
- the decline in sediment loading and, although not shown, an increased volume of runoff and peakedness of storm hydrographs associated with urbanization
- the scour and bank erosion associated with urban storm flows

Given the history of development in the watersheds in question, the reaches under investigation primarily receive tributary inflow from the urban area indicated to the far right of Figure 2. The upper portions of the watershed exhibit some "cropping and grazing" although it is predominantly a natural forested area with minimal cutting activity. Although washing of debris during high runoff events contributes somewhat to these changes. Therefore, there are temporal and spatial fluctuations in land use which have and are effecting channel morphology.

2.5.2.2 Impacts Regarding Flooding:

Acknowledging the above fluctuations in parameters which directly effect the dynamic equilibrium in the channel, it is necessary to determine their effect on channel morphology and the resultant impact on flooding.



Source: Gregory and Walling (1973)

FIGURE 2

CANADA-NEWFOUNDLAND
FLOOD DAMAGE REDUCTION PROGRAM

CHANGES IN CHANNEL MORPHOLOGY
FROM MAN-INDUCED ALTERATIONS
IN LAND USE

Present knowledge of channel regime is limited in accurately predicting the resultant changes in channel morphology. However, some qualitative statements may be made using an empirical relation set out by Schumm (1969):

$$Q_w = \frac{w \cdot d \cdot ML}{S}$$

where:

w	=	channel width
d	=	channel depth
ML	=	meander wave length
S	=	stream slope

From the previous discussion it is apparent that the more significant, relatively short-term fluctuations concern the increase in water volume to be handled by both streams as a result of increased precipitation and urbanization. Schumm indicates that for an increase in discharge:

$$Q_w = \frac{w^+ \cdot d^+ \cdot ML^+}{S^-}$$

+ = increase
- = decrease

The main question then becomes: are there restrictions placed upon the channel that will prohibit it from altering some or all of these parameters? If there is, and the channel cannot expand to the necessary dimensions to handle the flow, then the impact will be to increase the frequency and extent of flooding.

Visual inspection of the channels at various reaches within the study area indicates the potential existence of three such restrictions as discussed below:

A) Lag Pavement:

It appears that the winnowing action of channel flow over time has created a lag pavement wherein the finer-grained material has been removed from the coarse-grained stream or river deposit resulting in a residual relatively uniform channel bed. This is more apparent along Blanche

Brook between Main Street and the Hansen Highway. This would serve to restrict any increase in channel depth and decline in slope. This is a self governing process since, as the channel depth cannot increase naturally, then the maximum effective bed shear stress at bankful flow cannot increase and erode the lag pavement.

This restriction may be augmented by:

- a) the presence of bedrock forming the channel bed in at least two places along Blanche Brook
- b) man-made channel modifications carried out 5 - 10 years ago on Blanche Brook. This comprised placement of some of the channel bed material along both banks to curtail erosion, thus restricting any increase in channel width in this area.

B) Rip Rap:

As suggested by the equation, meander length should tend to increase. Such lateral movement in the channel is in evidence between Main Street and the Hansen Highway on Blanche Brook. However, in order to protect nearby homes, rip rap has been placed along the concave banks at the apex of two meanders. This action restricts any alterations in meander wave length.

C) Bridges:

The construction of numerous bridges across the channels throughout the study reaches restricts channel expansion and alteration in meander length.

Due to the present restrictions imposed upon the necessary alterations in channel morphology, it can be suggested that

the frequency and magnitude of flooding may increase with time. Unfortunately, the response time scales are unknown.

2.5.2.3 Groundwater Component of Streamflow:

In an effort to describe the effect of bank storage on moderating flood waves within the study reaches in question on an "order of magnitude" level, it was decided to determine a bulk hydraulic conductivity (K) for the outwash gravels underlying the flood plain. This was estimated by two methods:

- 1) visual inspection of gravel within stream banks
- 2) stream discharge measurements at low flow over a specified reach to determine inflow from groundwater.

Visual inspection of channel banks about the study watercourses indicated predominant materials were comprised of sands and gravels. The matrix comprised principally of medium to coarse sand. The clasts were found to be well rounded with an average "B" axis in the pebble size range (approximately 10 percent were in the cobble or greater size). Values of K reported for this type of material range from 10^{-2} to 1 cm/sec (Freeze and Cherry, 1979).

Stream discharge measurements were made two hours apart on March 11, 1983 on Blanche Brook at Main Street (Station 3) and at a point 1140 m upstream. The respective discharges were 0.81 and $0.91 \text{ m}^3/\text{s}$, indicating a loss in stream flow of $0.1 \text{ m}^3/\text{s}$. This loss could be attributed to an influent reach of stream channel or a reduction in accuracy of the discharge measurement as previously discussed.

Based on the above, there appears to be very little groundwater

inflow to the channel. This is further supported by the low water temperatures in the stream which remained at 1°C throughout the reach and down to the confluence of Blanche Brook and Warm Creek.

The possibility of the channel being influent in this area is supported by the discrepancy with even further flow reduction at the WSC gauge.

Stream discharge measurements were also made on Warm Creek at Mississippi Drive (Station 6) and at a point 420 m downstream within one hour of each other on March 11, 1983. The respective discharges were 0.32 and 0.39 m^3/s , indicating a gain of 0.07 m^3/s . Given the low volume of water and accuracy of any discharge measurement, the apparent rise in flow is not considered significant.

Based on evaluation of the discharge data shown in Appendix C, it would appear that the hydrogeological flow system and its interconnection to Blanche Brook and Warm Creek cannot be correlated directly. It is thus concluded that the data collected to date was insufficient to attempt any reasonable identification of the contribution of groundwater to stream flow at low and high flow events.

The complexity in assessing bank storage effects for the study reaches is further complicated by the probability of the formation of mud seal along the banks. This situation is relevant to inflowing waters travelling at high velocities and carrying heavy concentrations of suspended sediment. This would have been more prevalent during construction stages along the reaches (Drawing 1). The formation of such a seal would significantly reduce permeabilities in the channel's banks, thereby reducing stream flow modification by bank storage.

2.5.3 Additional Factors Influencing Flooding:

Two further factors were noted that are effecting flooding:

- 1) At least two bridges located near Main Street on Blanche Brook and at Route 460 on Warm Creek, have abutments which are skewed to the direction of flow at moderate and high discharges. Eddying behind these piers has resulted in cessation of bedload transport and bar formation. The resultant loss in channel capacity may locally enhance flooding. Bar formation is most pronounced near Main Street where it occurs along the concave bank near the apex of a meander. The location of the bar at Main Street may further augment the backwater effect on the water surface profile near the meander.
- 2) The location of Route 460 (Hansen Highway) and CNR Line at right angles to the flood plain on Warm Creek may enhance flooding in the community of Noels Pond area. Since the road and rail-bed are built-up above the flood plain with no underdrains, it prohibits overbank flows from flowing straight down the valley floor. Instead, the overbank flood wave is confined and directed back toward the channel in order to bypass the obstruction.

2.5.4 Potential for Acquiring High Flow Data in Spring 1983

There was essentially no snow cover in Stephenville by the end of March, 1983. A brief visit to Cold Brook indicated minimal snow cover in the headwaters. It was therefore anticipated that there would not be high flow events due to snow melt accompanying the spring freshet during the 1983 year. This was subsequently verified during the coarse of investigations on the study area.

Appendix A

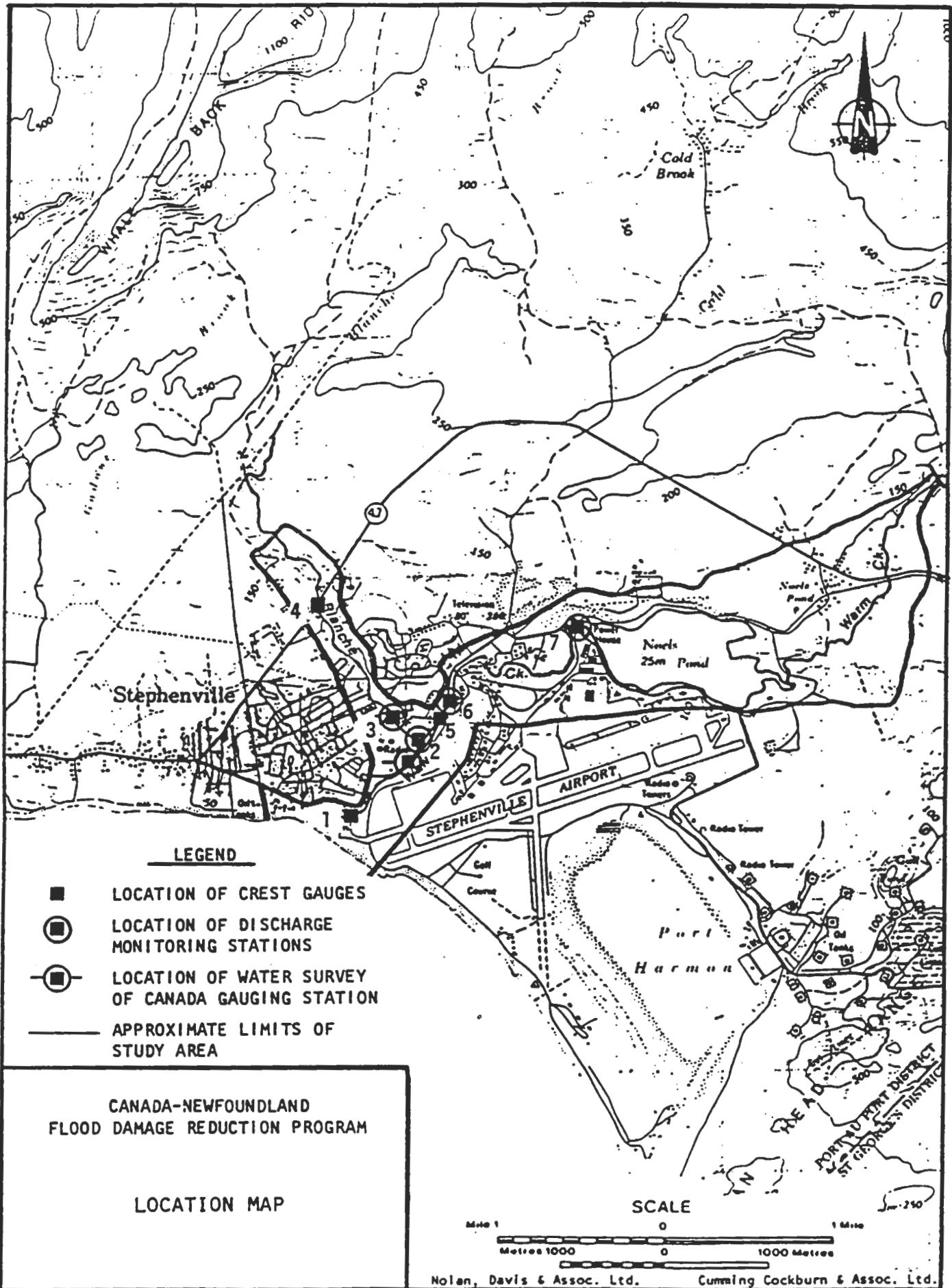
Tables and Drawings

TABLE 1
 CREST GAUGE LOCATIONS
 FOR
STEPHENVILLE HYDROTECHNICAL STUDY

<u>Gauge No.</u>	<u>Type</u>	<u>Bottom Elev. (m)</u>	<u>Location</u>
1	crest	2.358	Blanche Brook - on abutment upstream side of Kin Place bridge
2	crest	6.092	Blanche Brook - on abutment upstream side of Minnesota Drive bridge
3	crest	8.806	Blanche Brook - on abutment upstream side of Main Street bridge
4	crest	27.378	Blanche Brook - on abutment upstream side of Hansen Highway bridge
5	crest	7.374	Warm Creek - on abutment upstream side of Carolina Avenue bridge
6	crest	8.783	Warm Creek - on abutment upstream side of Mississippi Drive bridge
7	crest	21.903	Warm Creek - on abutment upstream side of C.N. Railway trestle
8	crest	24.686	Warm Creek - on abutment upstream side of Hansen Highway bridge

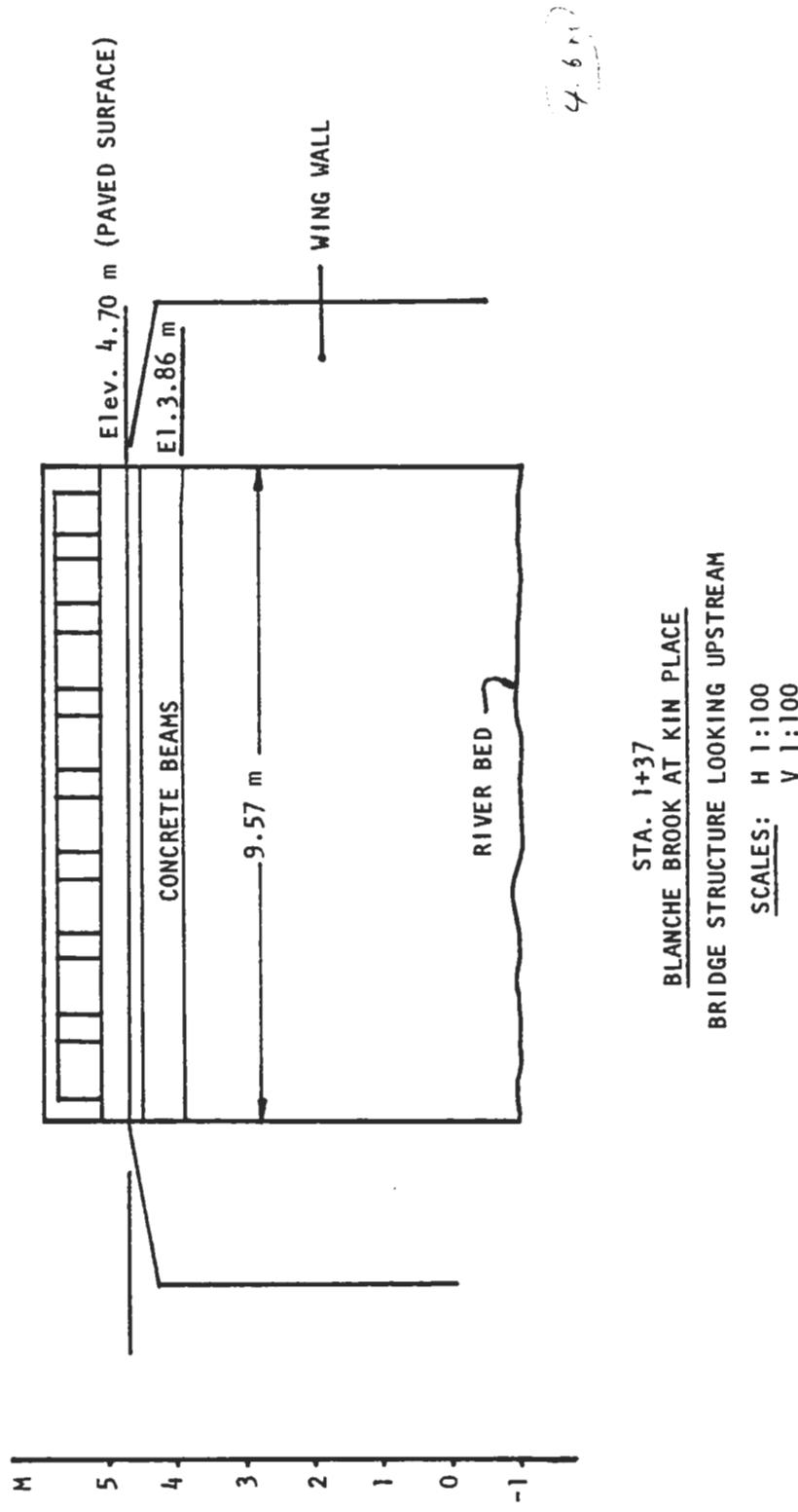
TABLE 2
LIST OF GEODETIC BENCHMARKS
USED FOR SURVEY CONTROL
STEPHENVILLE HYDROTECHNICAL STUDY

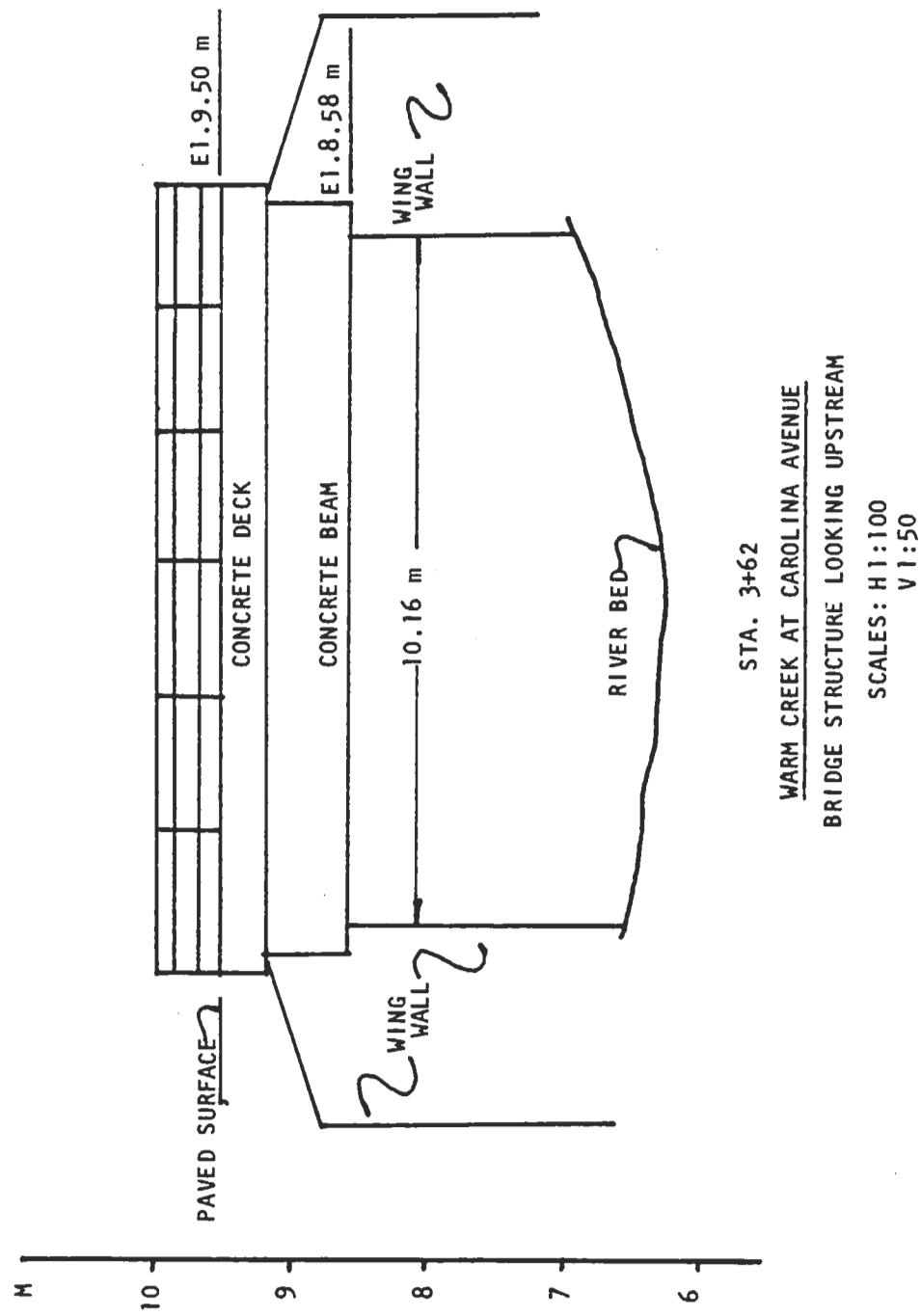
<u>Benchmark No.</u>	<u>Elevation (m)</u>
432-K	21.596
76F885	26.646

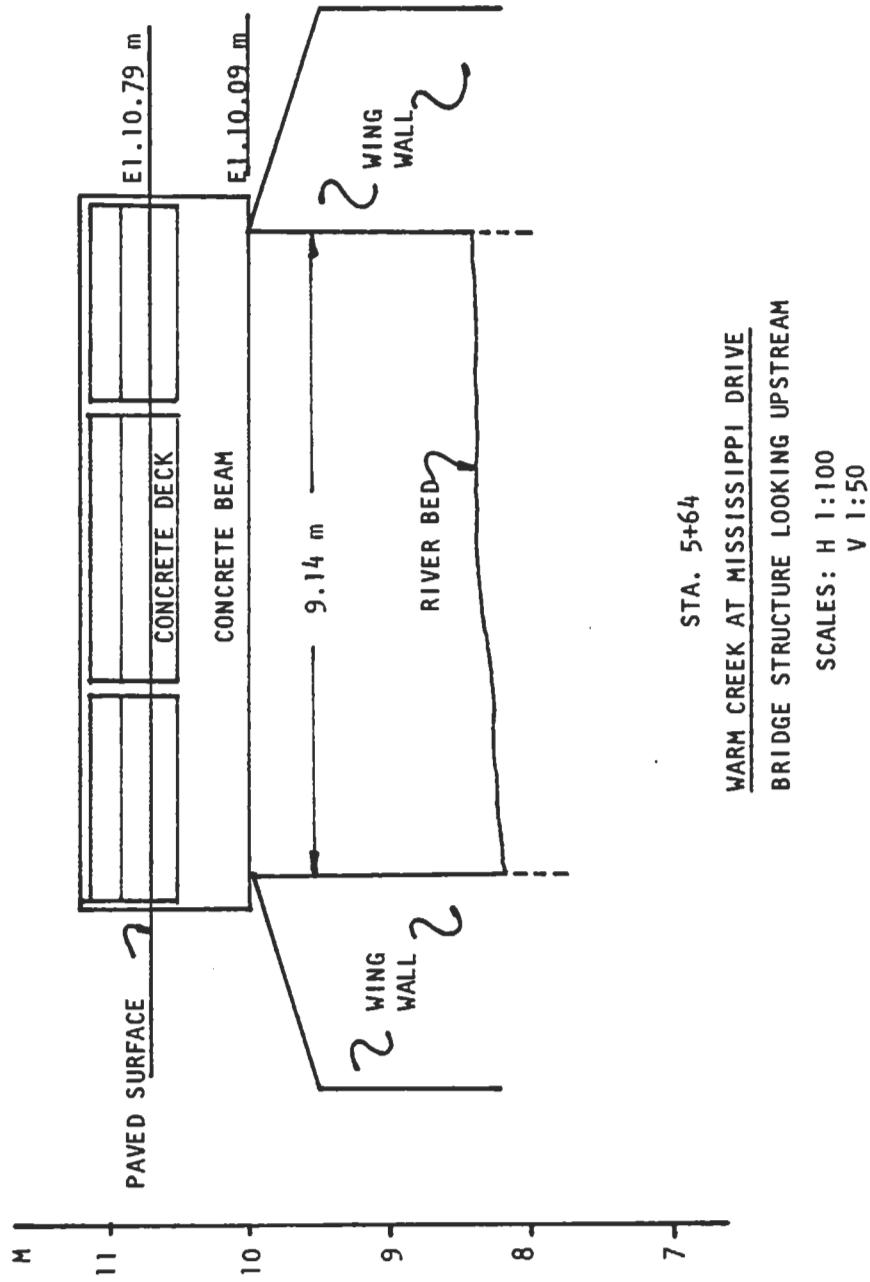


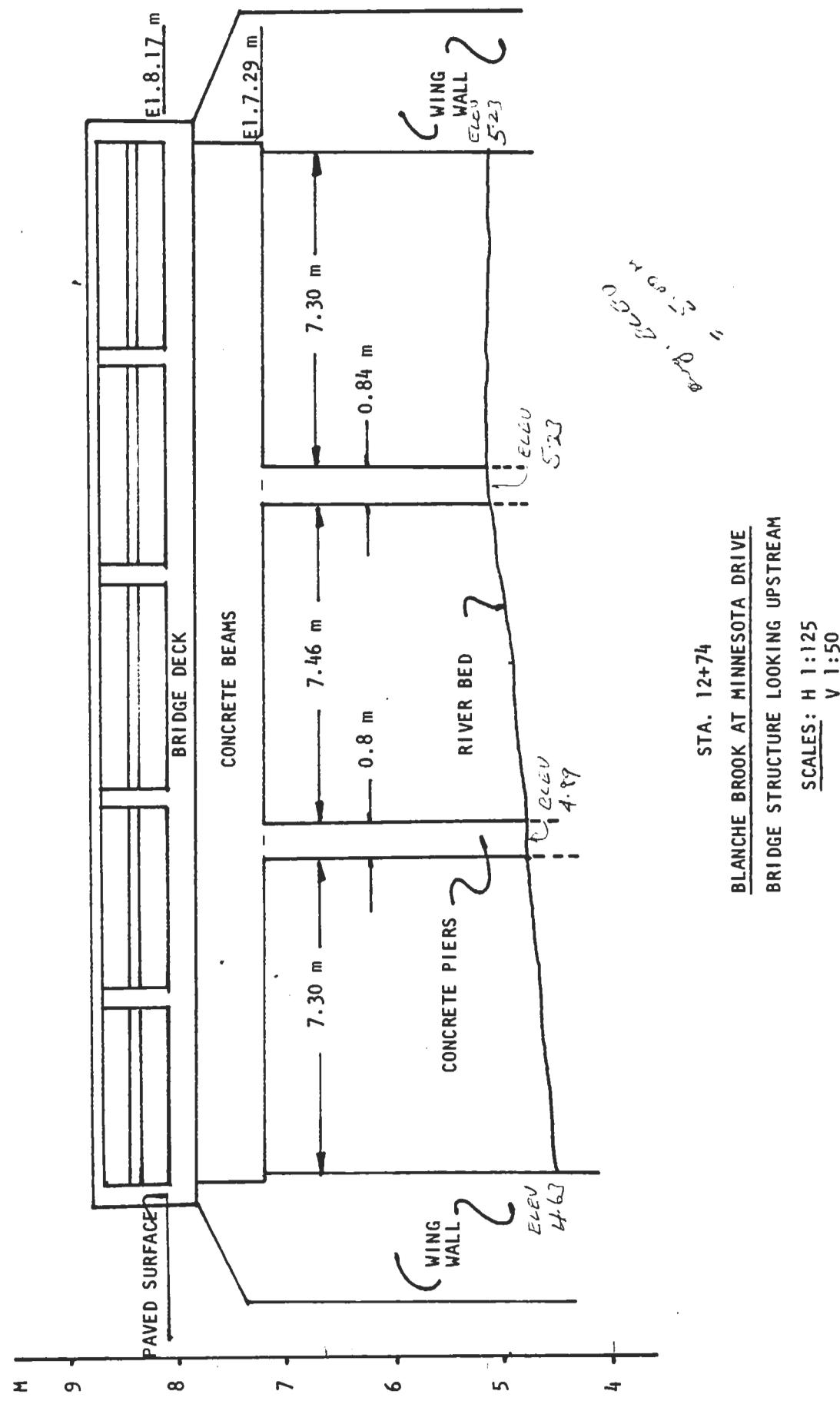
Appendix B

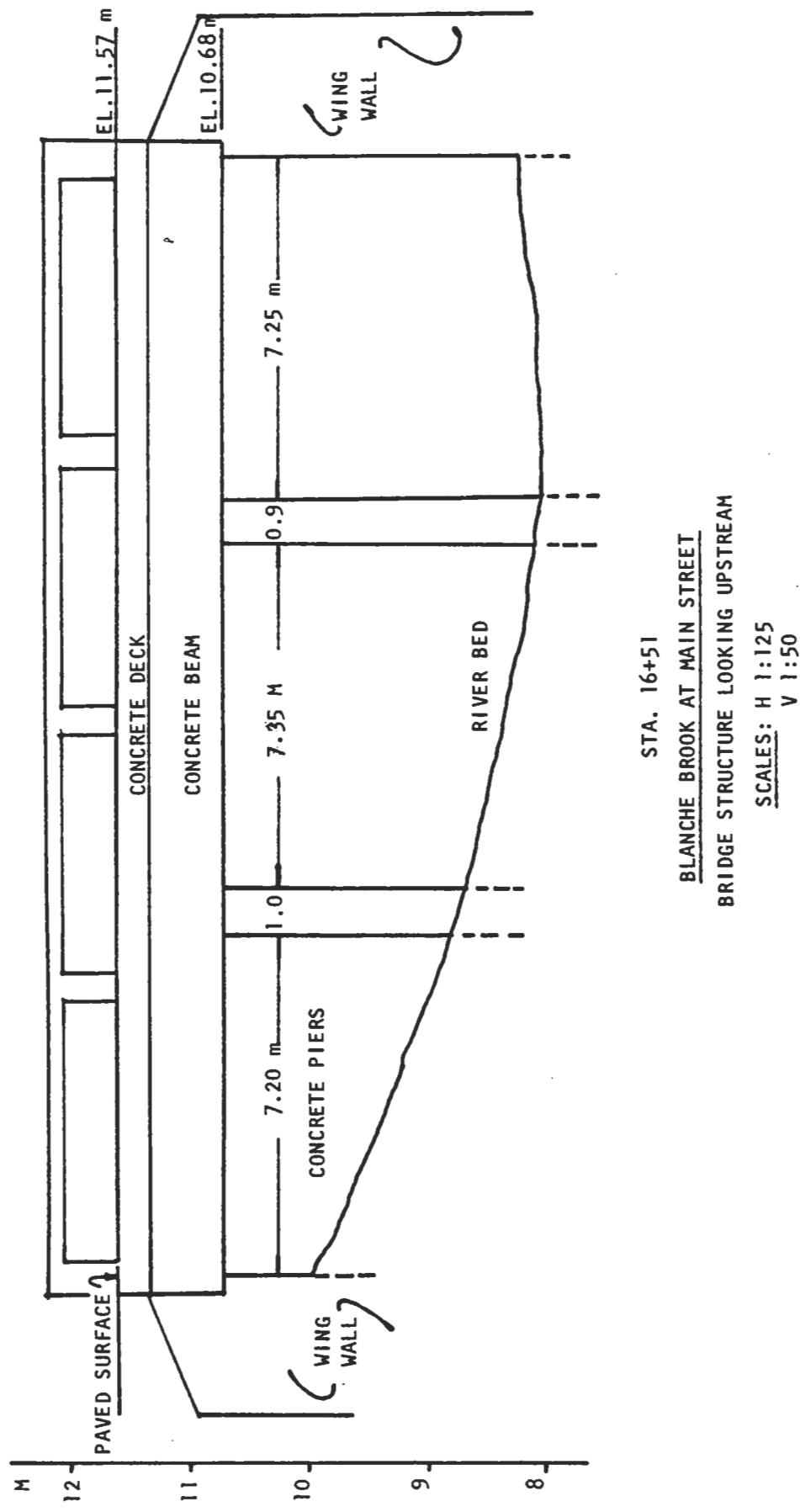
Structures and Photographs

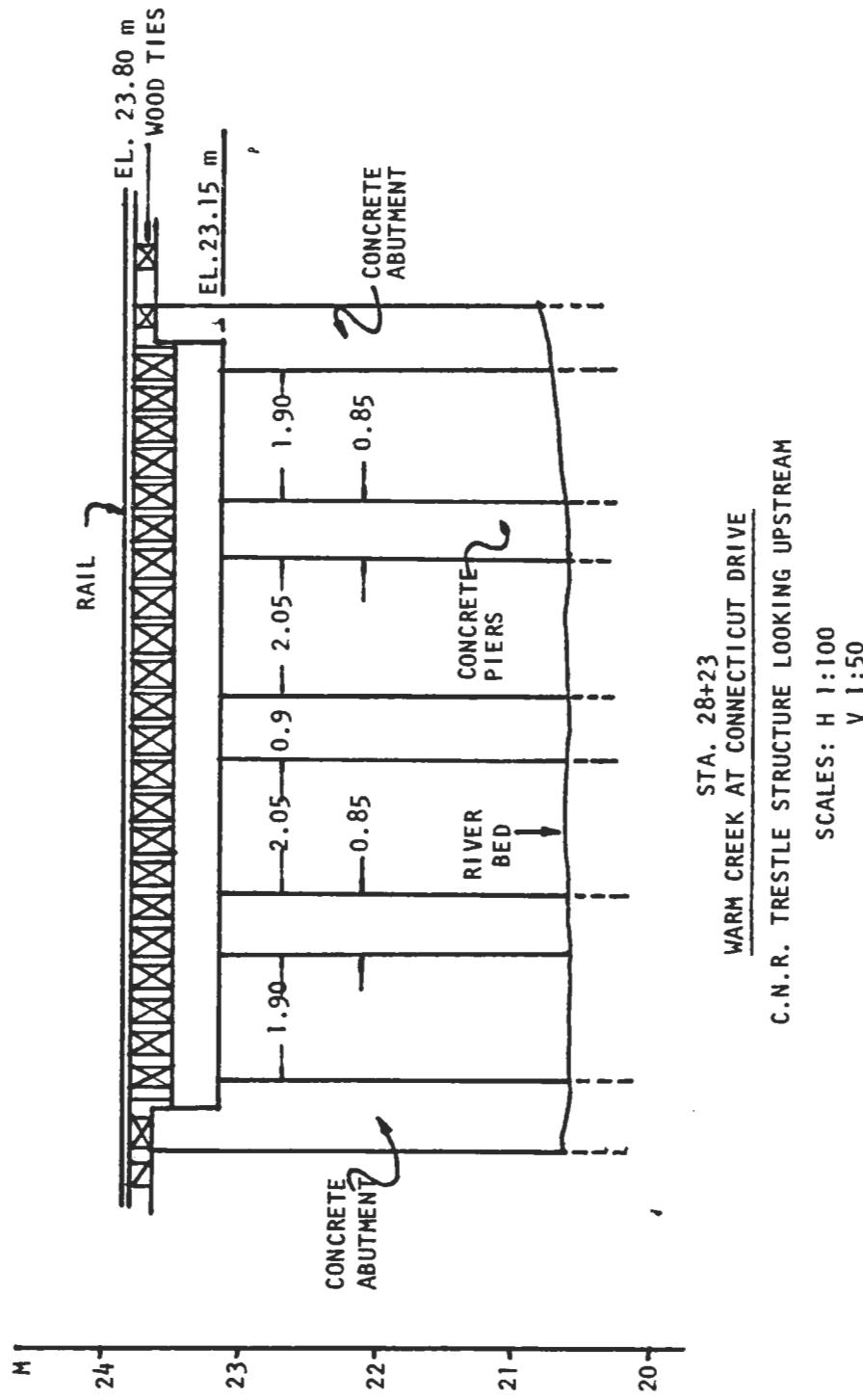


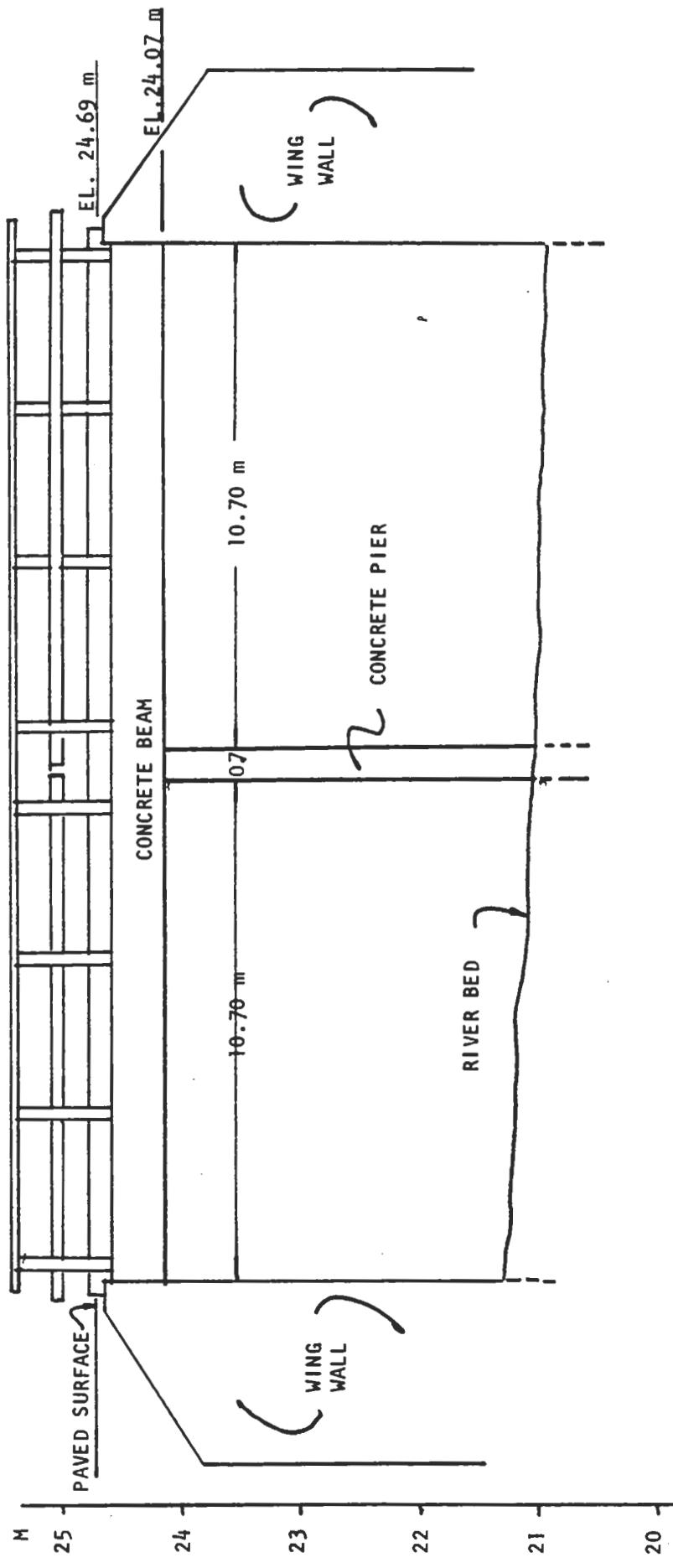








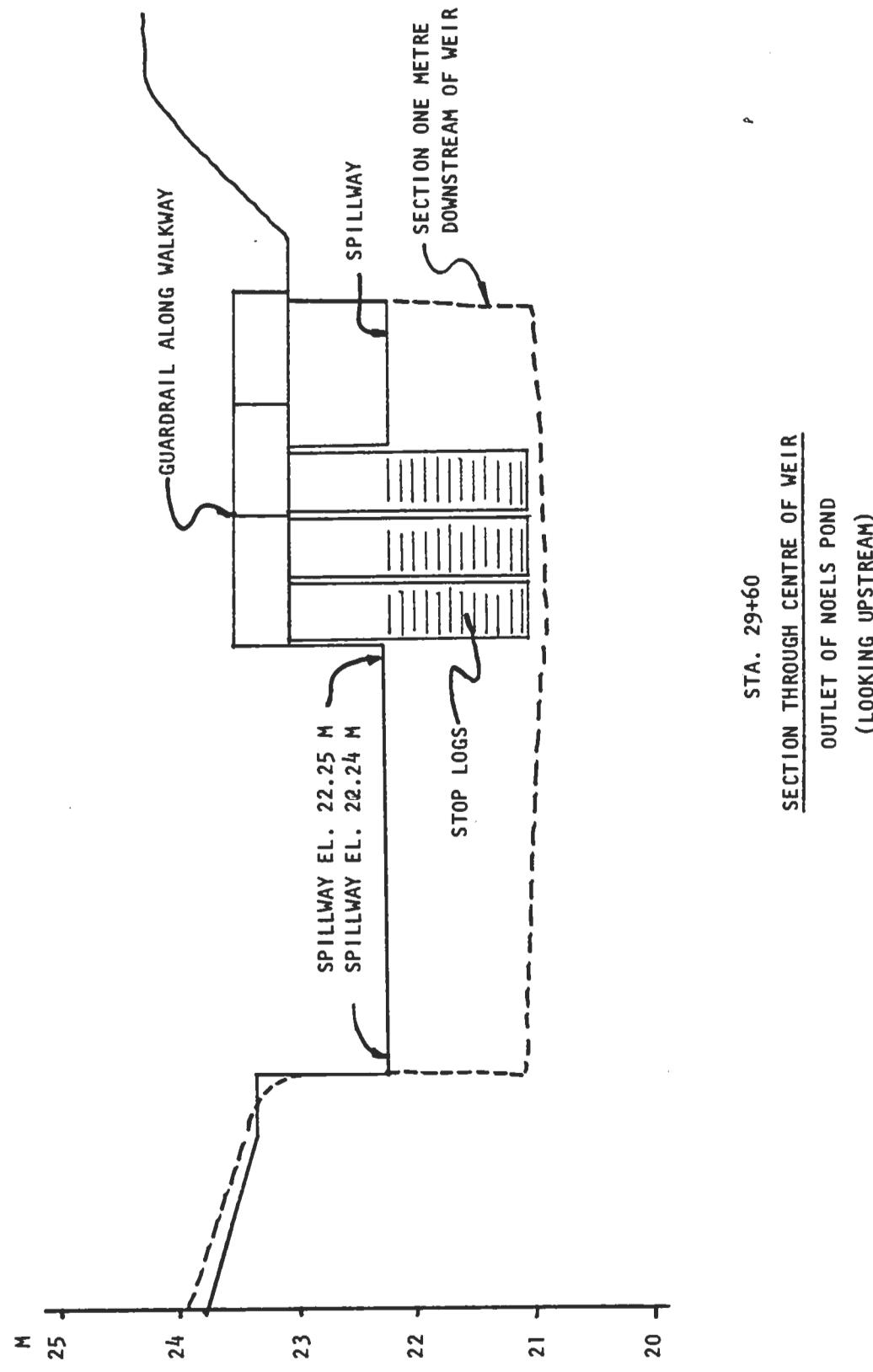


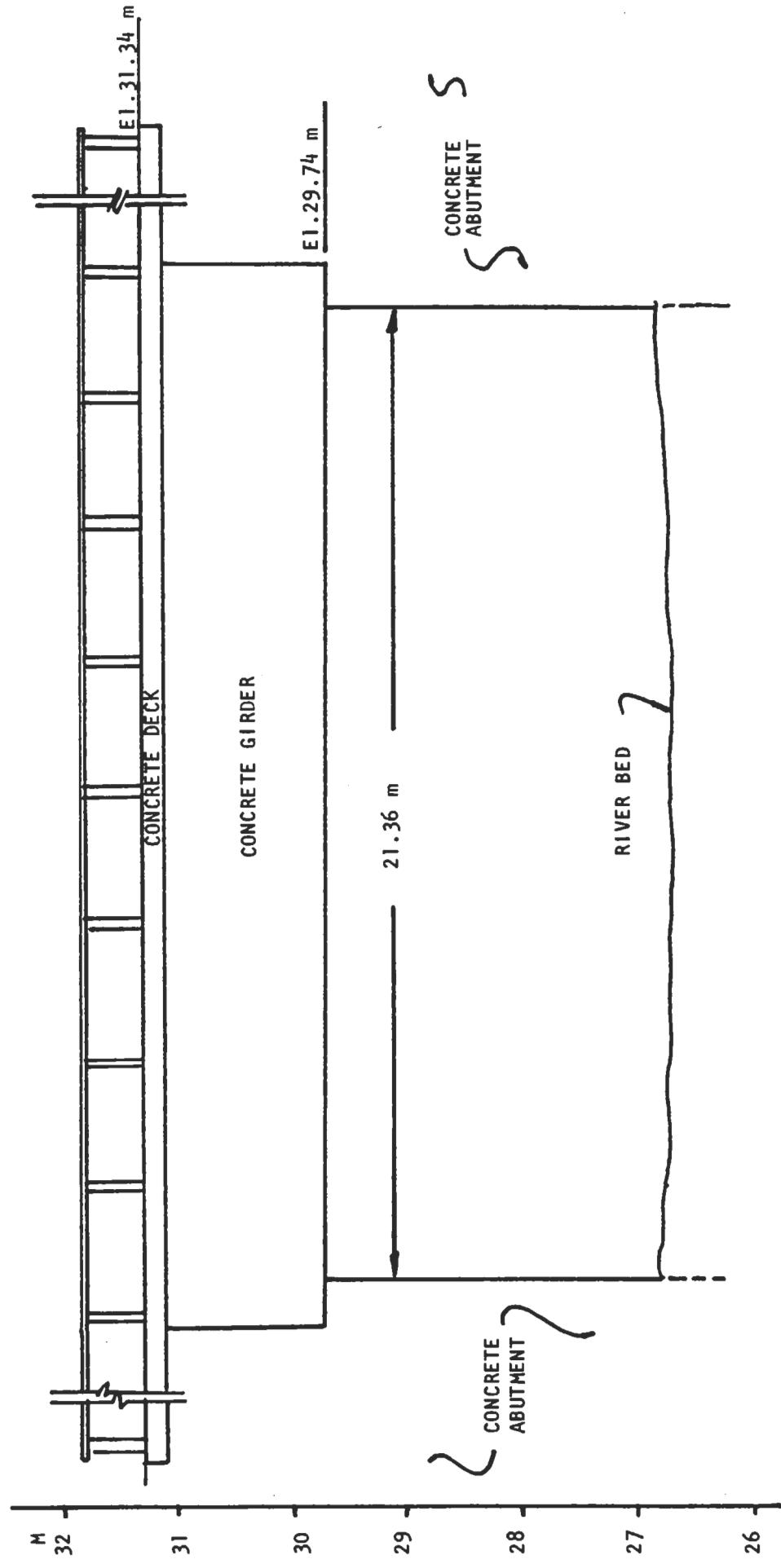


STA. 29+11

WARM CREEK AT CONNECTICUT DRIVE
BRIDGE STRUCTURE LOOKING UPSTREAM

SCALES: H 1:125
V 1:50

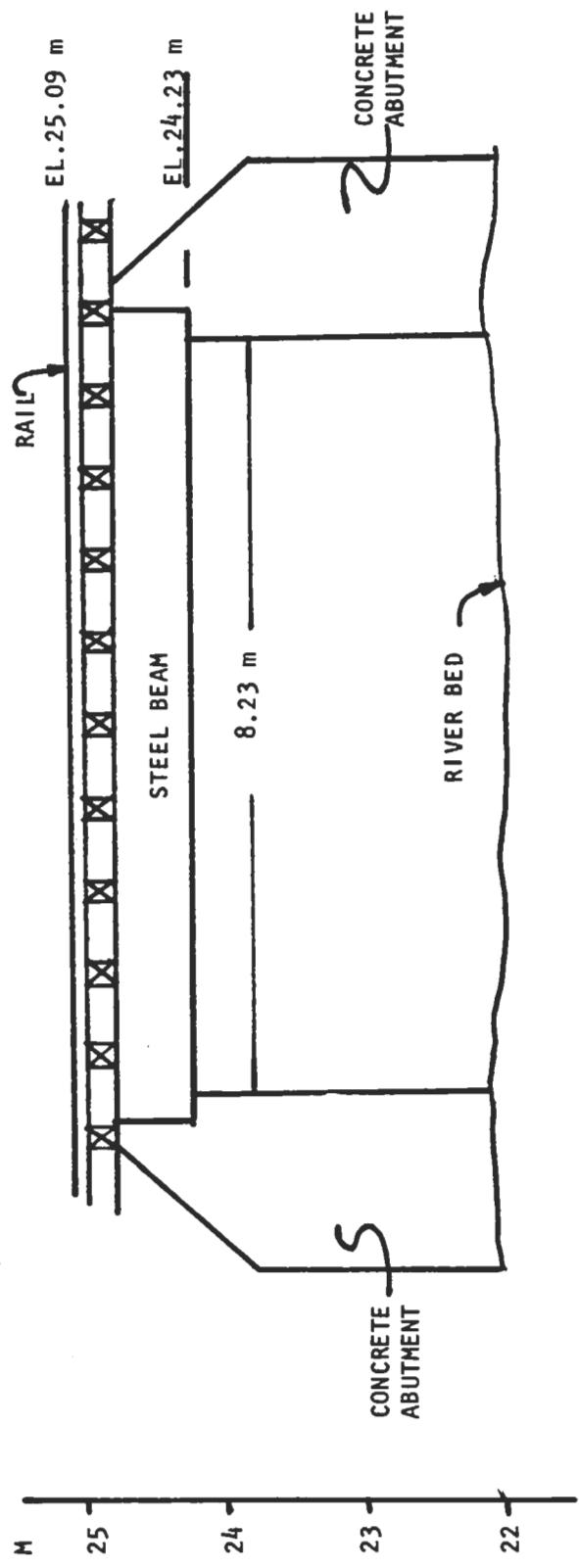




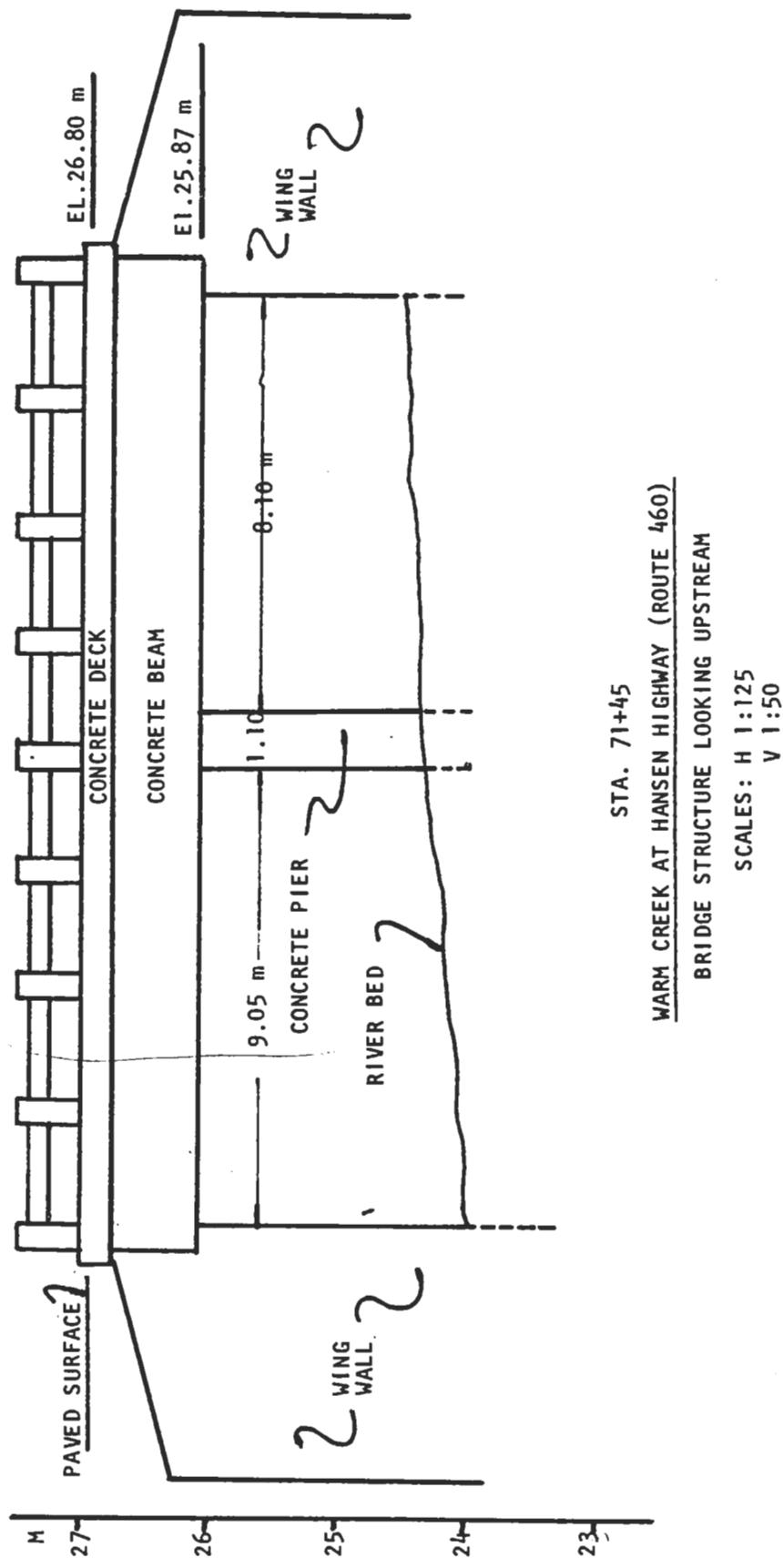
STA. 31+71
BLANCHE BROOK AT HANSEN HIGHWAY (ROUTE 460)

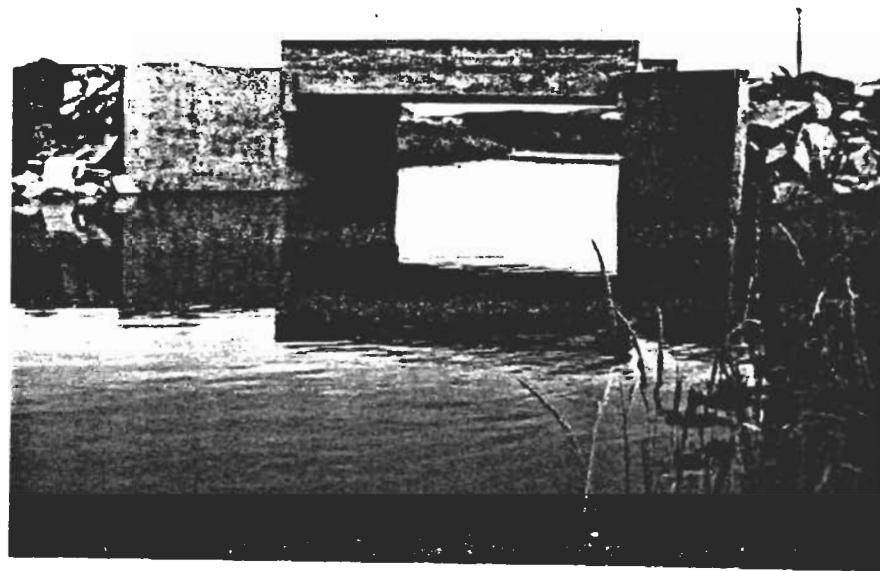
BRIDGE STRUCTURE LOOKING UPSTREAM

SCALES: H 1:125
V 1:50

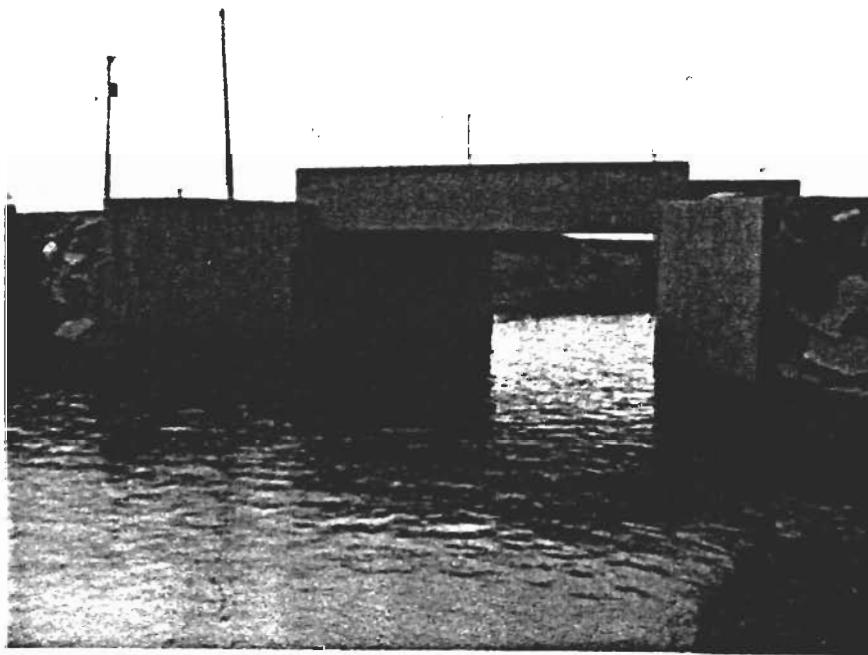


STA. 59+68
WARM CREEK
C.N.R. TRESTLE STRUCTURE TO LINERBOARD MILL
SCALE: H 1:75 V 1:50



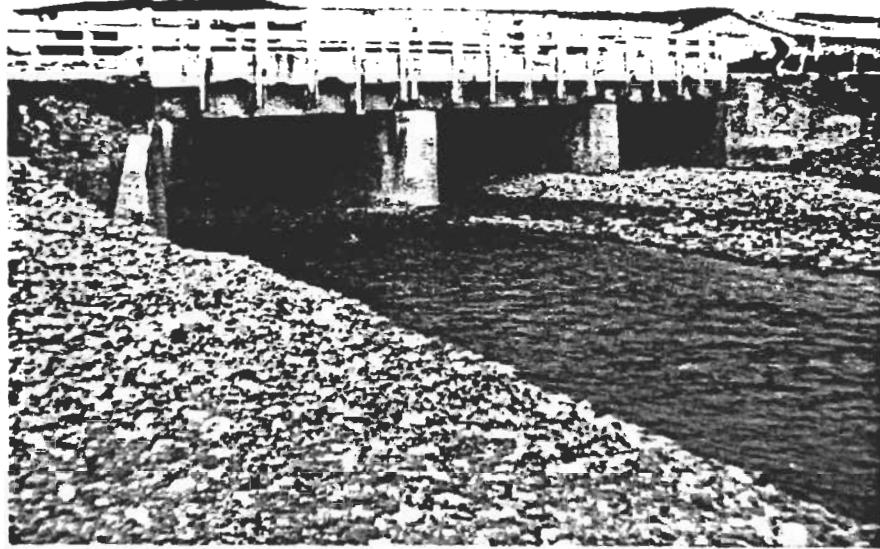


BLANCHE BROOK AT KIN PLACE LOOKING UPSTREAM
STRUCTURE B1 STA. 1+37
PHOTOGRAPH 1

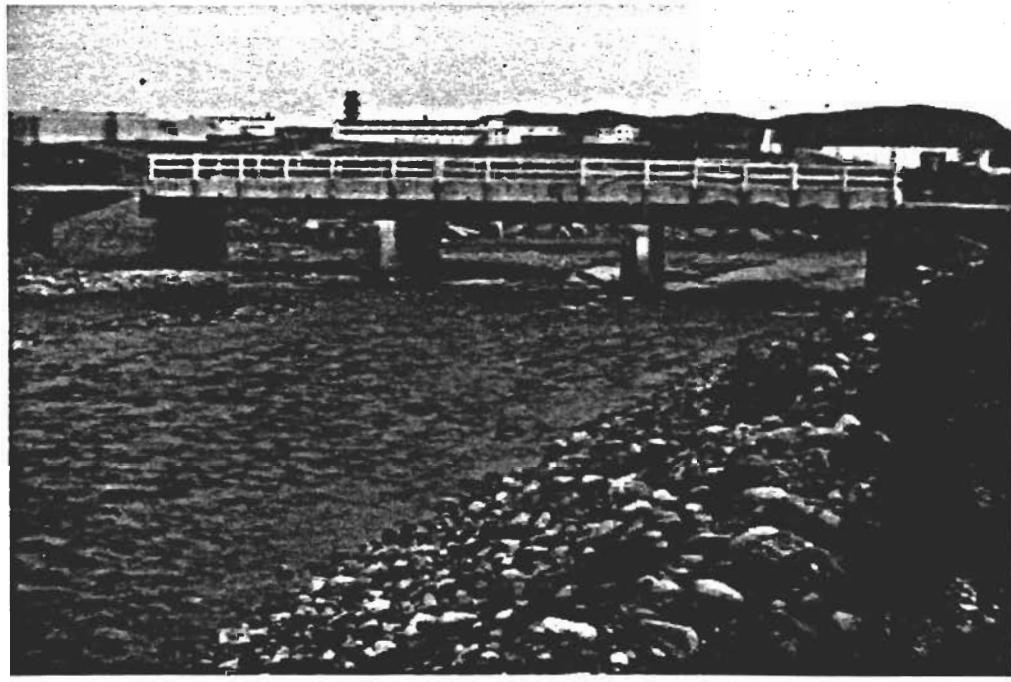


BLANCHE BROOK AT KIN PLACE LOOKING DOWNSTREAM
STRUCTURE B1 STA. 1+37
PHOTOGRAPH 2

~~Blanche Brook looking upstream~~
~~Structure B2 STA. 12+74~~



BLANCHE BROOK AT MINNESOTA DRIVE LOOKING UPSTREAM
STRUCTURE B2 STA. 12+74
PHOTOGRAPH 3



BLANCHE BROOK AT MINNESOTA DRIVE LOOKING DOWNSTREAM
STRUCTURE B2 STA. 12+74
PHOTOGRAPH 4



BLANCHE BROOK AT MAIN STREET LOOKING UPSTREAM
STRUCTURE B3 STA. 16+51
PHOTOGRAPH 5



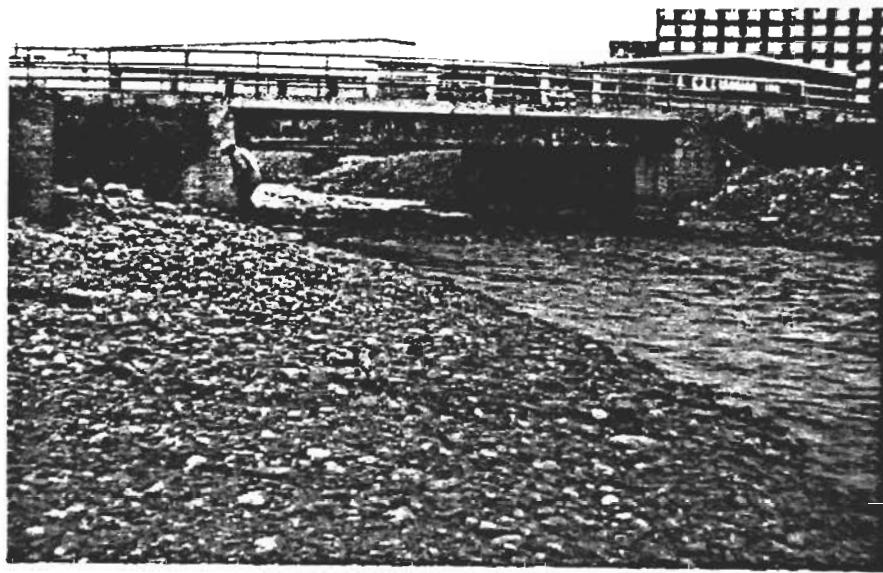
BLANCHE BROOK AT MAIN STREET LOOKING DOWNSTREAM
STRUCTURE B3 STA. 16+51
PHOTOGRAPH 6



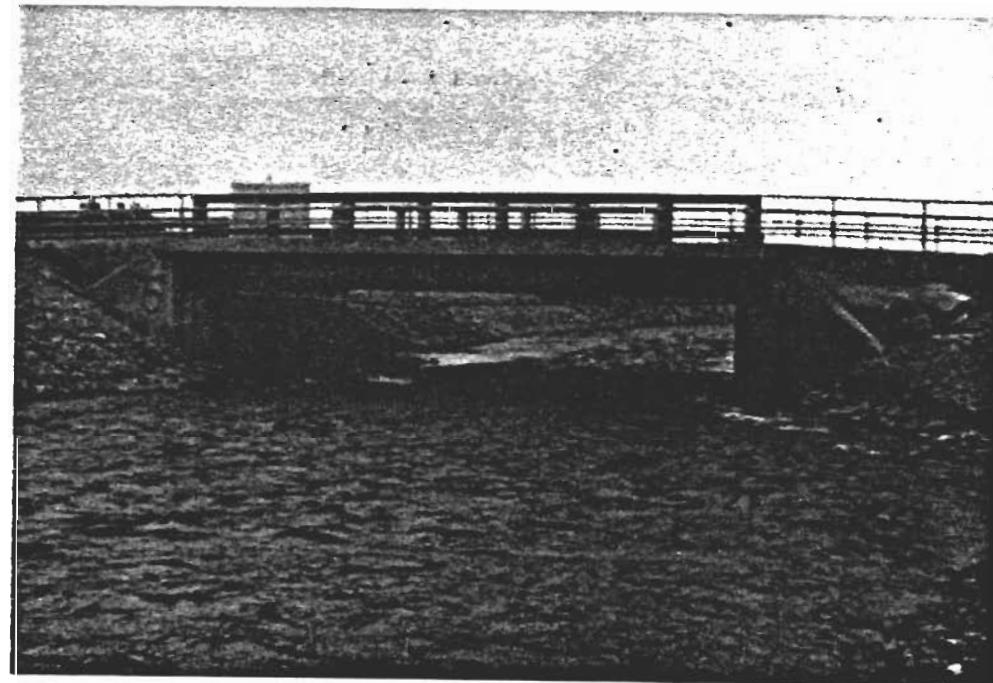
BLANCHE BROOK AT HANSEN HIGHWAY LOOKING UPSTREAM
STRUCTURE B4 STA. 31+71
PHOTOGRAPH 7



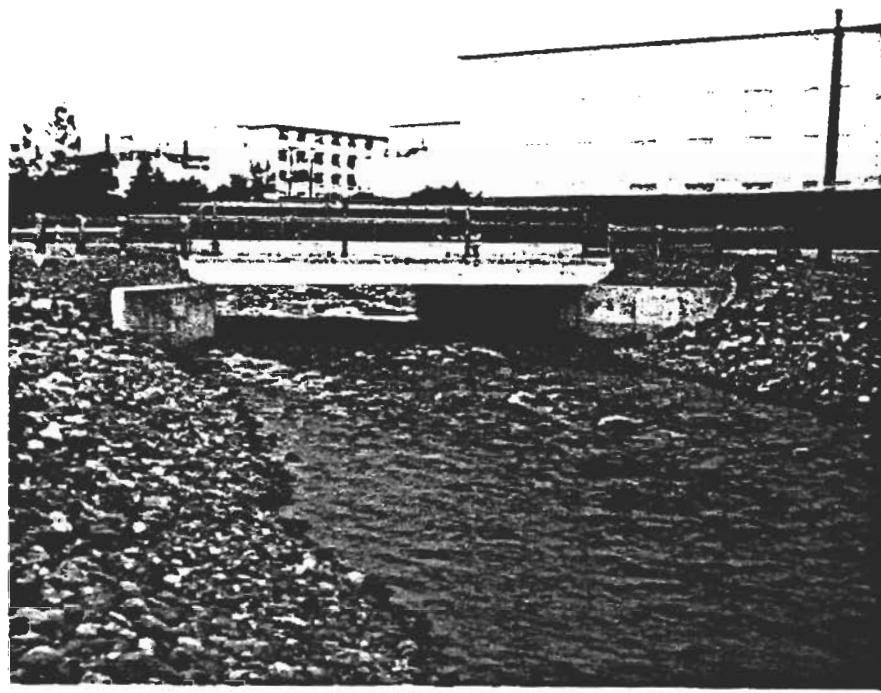
BLANCHE BROOK AT HANSEN HIGHWAY LOOKING DOWNSTREAM
STRUCTURE B4 STA. 31+71
PHOTOGRAPH 8



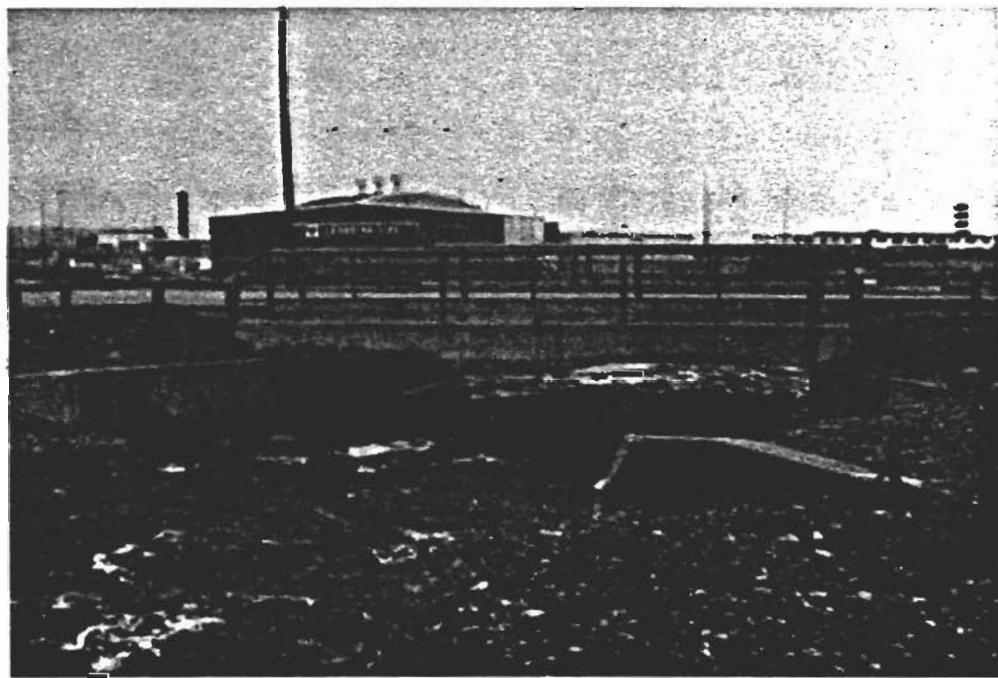
WARM CREEK AT CAROLINA AVENUE LOOKING UPSTREAM
STRUCTURE B5 STA. 3+62
PHOTOGRAPH 9



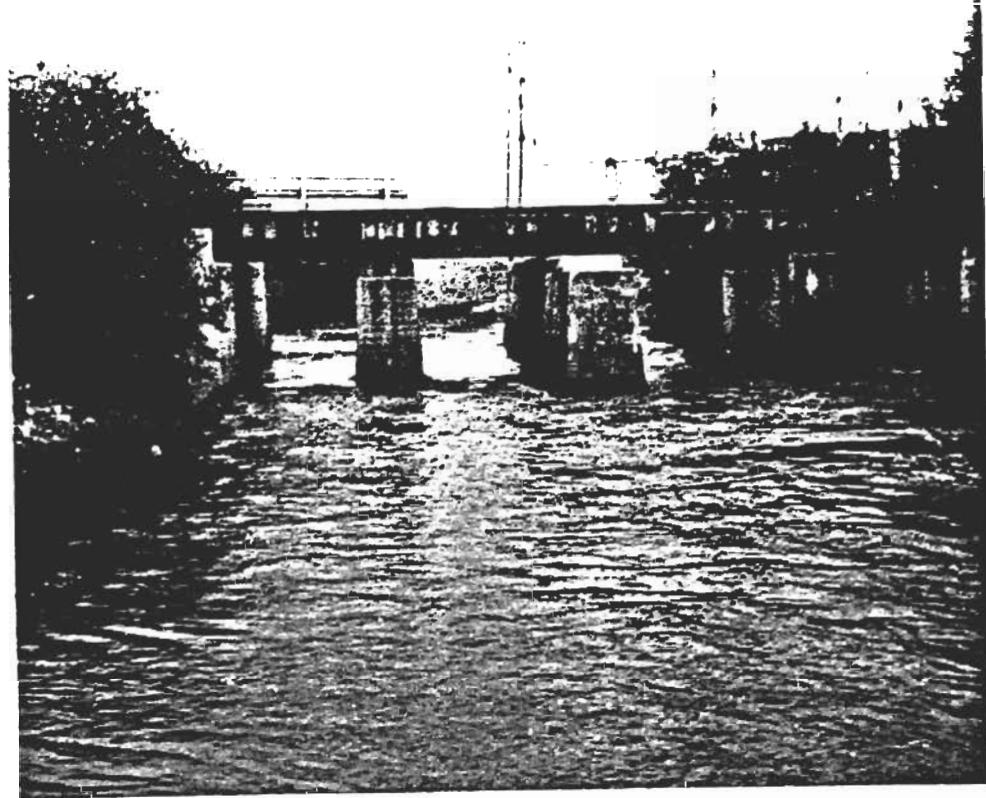
WARM CREEK AT CAROLINA AVENUE LOOKING DOWNSTREAM
STRUCTURE B5 STA. 3+62
PHOTOGRAPH 10.



WARM CREEK AT MISSISSIPPI DRIVE LOOKING UPSTREAM
STRUCTURE B6 STA. 5+64
PHOTOGRAPH 11



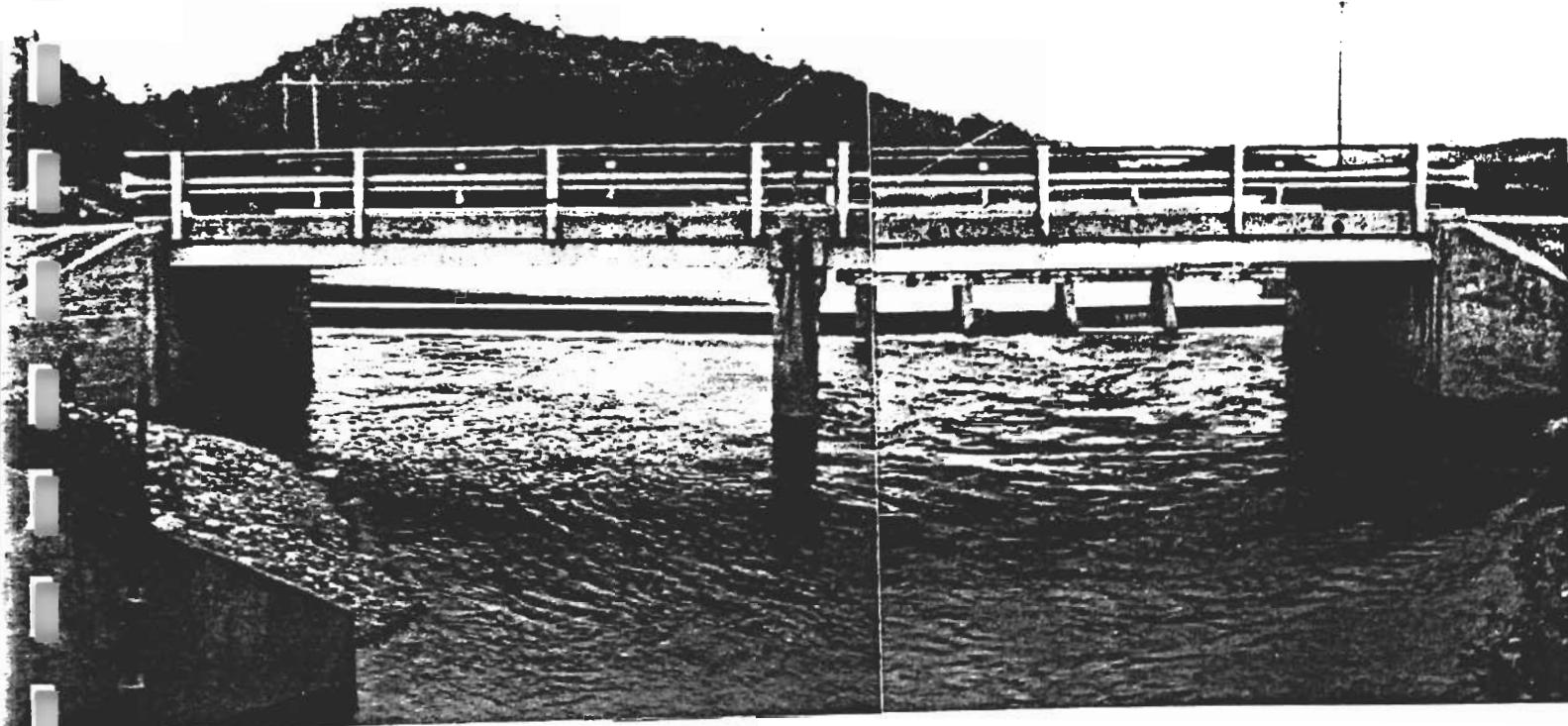
WARM CREEK AT MISSISSIPPI DRIVE LOOKING DOWNSTREAM
STRUCTURE B6 STA. 5+64
PHOTOGRAPH 12



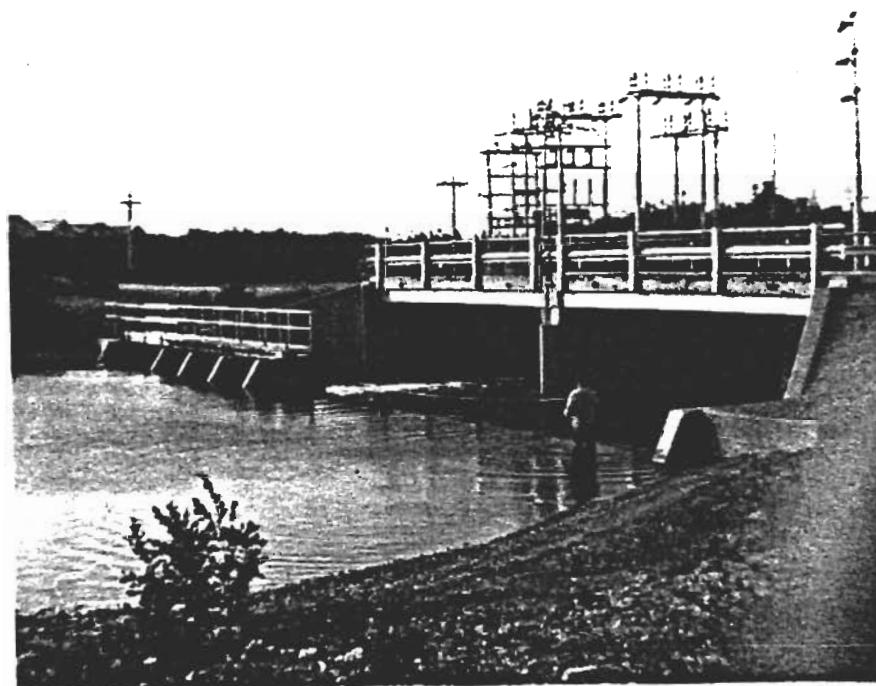
C.N.R. TRESTLE ON WARM CREEK AT CONNECTICUT DRIVE LOOKING UPSTREAM
STRUCTURE B7a STA. 28+23
PHOTOGRAPH 13



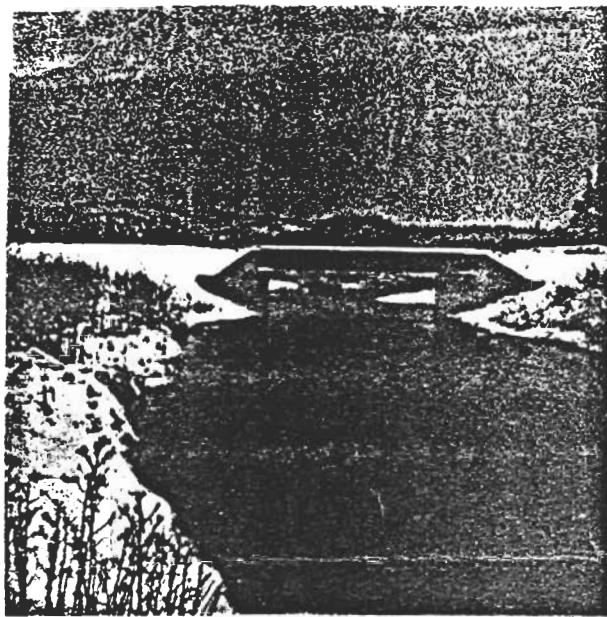
C.N.R. TRESTLE ON WARM CREEK AT CONNECTICUT DRIVE LOOKING DOWNSTREAM
STRUCTURE B7a STA. 28+23
PHOTOGRAPH 14



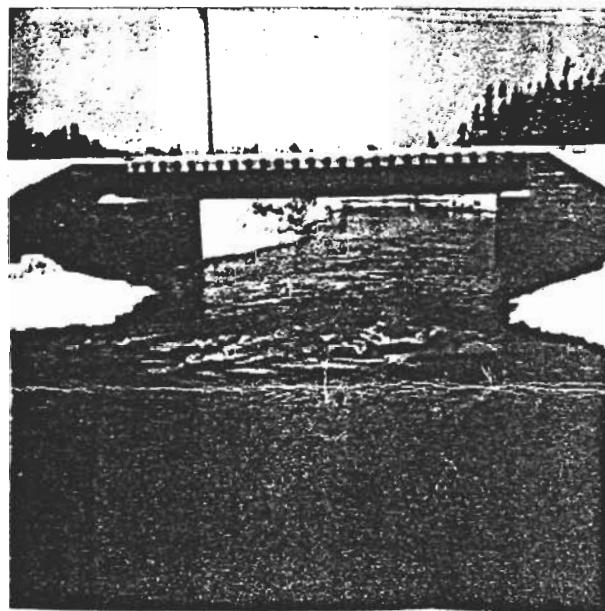
WARM CREEK AT CONNECTICUT DRIVE LOOKING UPSTREAM
STRUCTURE B7 STA. 29+11
PHOTOGRAPH 15



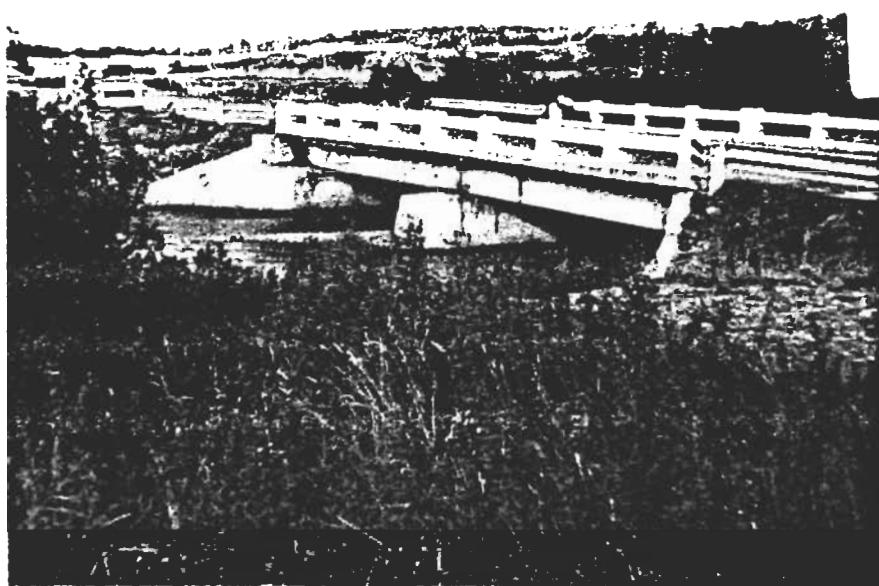
WEIR STRUCTURE ON WARM CREEK AT OUTLET END OF NOEL'S POND
LOOKING DOWNSTREAM TOWARDS BRIDGE ON CONNECTICUT DRIVE
STRUCTURE B7b STA. 29+60
PHOTOGRAPH 16



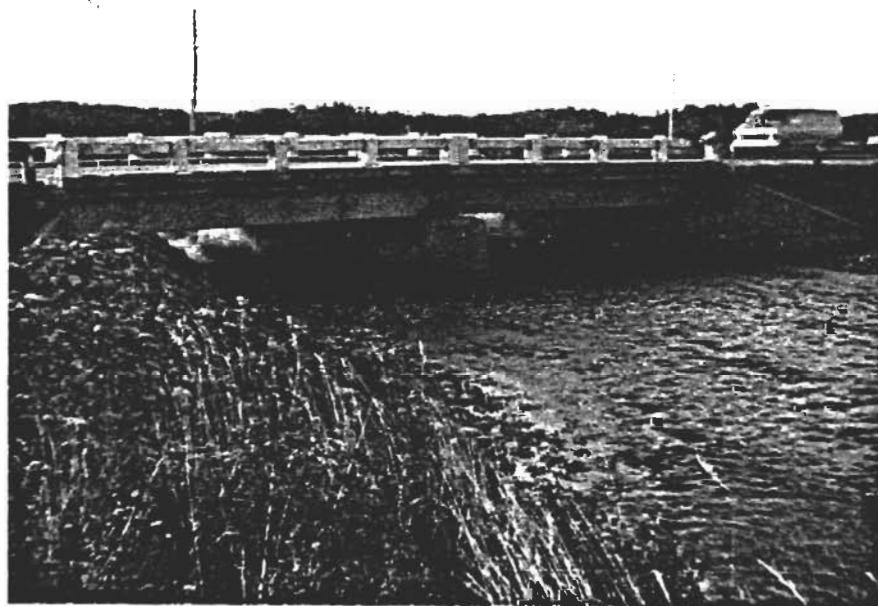
C.N.R. TRESTLE OVER WARM CREEK ON SPUR-LINE
TO LINERBOARD MILL LOOKING UPSTREAM
STRUCTURE B8a STA. 59+63
PHOTOGRAPH 17



C.N.R. TRESTLE OVER WARM CREEK ON SPUR-LINE
TO LINERBOARD MILL LOOKING DOWNSTREAM
STRUCTURE B8a STA. 59+63
PHOTOGRAPH 18



WARM CREEK AT HANSEN HIGHWAY (R. R. 460) LOOKING UPSTREAM
STRUCTURE B8 STA. 71+45
PHOTOGRAPH 19



WARM CREEK AT HANSEN HIGHWAY (R. R. 460) LOOKING DOWNSTREAM
STRUCTURE B8 STA. 71+45
PHOTOGRAPH 20

Appendix C

Water Level and

Discharge Measurements

SUMMARY OF MONITORED EVENTS

Monitored Events

January 11 - 13, 1983

Comments

- A total of 59.4 mm rain fell (at times intermittently) between 2220 hr. 11/01/83 and 1830 hr. 13/01/83; peaking on 13/01/83 with 34 mm.
- during this period an 11 cm snow cover was reduced to <1 cm.
- crest gauge readings were taken between 1330 - 1530 hr. on 13/01/83 at 1.5 - 3.5 hr. prior to peak stage at the WSC gauge. Six stations had been vandalized and hence water levels were marked on structures and surveyed at a later date.
- no flooding problems were encountered.

March 10 - 11, 1983

- discharge measurements were made during low flow conditions (no significant precipitation over the previous 10 days), two on Blanche Brook at and just above Station 3 and Warm Creek and just above Station 6
- observations and calculations were made respecting the groundwater component to streamflow and the impact of groundwater on flooding, in particular the flooding of basements prior to overbank flow

June 1 - 3, 1983

- a total of 86.2 mm fell intermittently between 0700 hr. 01/06/83 and 0730 hr. 03/06/83.
- discharge measurements were made on Blanche Brook at Station 2 at 1510 hr. 03/06/83 and on Warm Creek at Station 7 between 1630 - 1723 hr.
- six crest gauges had been vandalized and were inoperative; two were read
- no flooding was associated with this event

July 17 - 18, 1983

- a total of 37.2 mm was received between 0700 hr. 17/07/83 and 0330 hr. 18/07/83
- all crest gauges were checked but water levels did not rise sufficiently (maximum rise 0.30 m) to give flow and/or gauge readings.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cochrane & Assoc. Ltd.
Holen, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. _____
Type: Crest gauge
Location: Blanche Brook at Kin Place
(i) Survey Data Table

Gauge Date: GEOEDETIC

Measured by: I. Wiseman

(ii) General Comments on Condition of Watercourse

Date: June 2, 1983

Date	Stage In ft. Out in.	Gauge Reading	Photograph Number	Ice Conditions Upstream Downstream	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge	
							Teeming	Leaking
83								
June 2	1300	-	2	X	-			

crest gauge



(iii) General Comments on Condition of Watercourse

Date:

June 2, 1983

Comments:

Water crested at normal for time of year,
no immediate danger of flood damage.

Elev. 2.358 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cochrane & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 2

Gauge Datum: GEODETIC

Type: Crest gauge

Location: Blanche Brook at Minnesota Drive

I) Survey Data Table

Date	In In Out	Gauge Reading	Photograph Number Looking Upstream Downstream	Ice Condition Test	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge		Condition of Culvert/Bridge Plugged Open Flow
							Operational	Non- Operational	
83									
June 2	1315	-	4	X	-		X		X

crest gauge



II) General Comments on Condition of Watercourse

Date: _____

June 2, 1983

Comments: _____

Water gauge at normal for time of year,
no immediate danger of flood damage.

Elev. 6.092 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cochrane & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 3
Type: Crest gauge

Location: Blanche Brook at Main Street

1) Survey Data Table

Gauge Datum: GEOGRAPHIC

Measured by: J. Wiseman

Date	Flood		Photograph Number Looking Upstream	Ice Conditions Yes	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Non- Operational	
	In	Out					Plugged	Open Flow
June 2	1325	-	6	X	-		X	
								X

crest gauge



II) General Comments on Condition of Watercourse

Date: _____

Comments: _____

June 2, 1983

Water gauge at normal for time of year,
no immediate danger of flood damage.

Elev. 8.806 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 4
Type: Crest gauge

Gauge Datum: GEOSTATIC
Location: Blanche Brook at Hansen Highway

(i) Survey Data Table

Date	Ice In Out	Gauge Reading	Photograph Number Loring Upstream Downstream	Ice Condition Yes No	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Non- Operational	Condition of Culvert/Bridge Plugged Open flow
June 2	1345		8	X	-		X	
								X

crest gauge



(ii) General Comments on Condition of Watercourse

Date: June 2, 1983

Comments:

Water gauge at normal for time of year,
no immediate danger of flood damage

Elev. 27.378 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cochrane & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 5
Type: Crest gauge
Location: Warm Creek at Carolina Avenue

i) Survey Data Table

Date	Time In Out	Gauge Reading	Photograph Number Looking Upstream Or Stream	Ice Condition Yes	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Non- Operational	Condition of Culvert/Bridge Plugged	Open If Dry
1983									
June 2	1400	-	10	X	-		-		-

Gauge Datum: GEODETIC

Measured by: I. Wiseman

Date	Time In Out	Gauge Reading	Photograph Number Looking Upstream Or Stream	Ice Condition Yes	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Non- Operational	Condition of Culvert/Bridge Plugged	Open If Dry
1983									
June 2	1400	-	10	X	-		-		-

crest gauge



ii) General Comments on Condition of Watercourse

Date: June 2, 1983

Comments:

Water gauge at normal for time of year,
no immediate danger of flood damage.

Elev. 7.374 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 6

Gauge Date: GEODETIC

Type: Crest gauge

Location: Warm Creek at Mississippi Drive

(1) Survey Data Table

Date	Tide In Out	Gauge Reading	Photograph Number Upstream Downstream	Ice Conditions Yes	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge		Condition of Culvert/Bridge Plugged Open flow
							Operational	Non- Operational	
June 1	1410	-	X	X	-			X	
June 2									X

crest gauge



(11) General Comments on Condition of Watercourse

Date:

June 2, 1983

Comments:

Water gauge at normal for time of year,
no immediate danger of flood damage.

Elev. 8.783 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolen, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 7

Type: Crest gauge

Location: Railway trestle at downstream end of Noels Pond

I) Survey Data Table

Date	Flow		Gauge Reading	Photograph Number	Ice Conditions Looking Upstream	Ice Thickness (in.)	Condition of Watercourse (Description)	Condition of Gauge		Condition of Culvert/Bridge Plugged	Open / f_{Dw}
	In	Out						Non- Operational	Operational		
183											
June 2	1425	0.720		14	x	-		x		x	

crest gauge



II) General Comments on Condition of Watercourse

Date:

June 2, 1983

Comments:

Stage El. - 22.623 m

Elev. 21.903 m

Measured by: L. Wiseman

STEPHENVILLE FLOOD MONITORING
/ PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 8
Type: Crest gauge

Location: Warm Creek at Route 460

I) Survey Data Table

Date	In In 1983	Gauge Reading	Photograph Number Looking Upstream Downstream	Ice Conditions Test No	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Operational	Non- Operational	Condition of Culvert/Bridge Plugged	Condition of Culvert/Bridge Open flow
June 2	1445	0.610		X	-		X			
									X	

crest gauge



II) General Comments on Condition of Watercourse

Date: June 2, 1983

Comments: Stage E1. - 25.296 m

Elev. 24.686 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 1

Gauge Datum: GEOGRAPHIC

Type: Crest gauge

Location: Blanche Brook at Kin Place

I) Survey Data Table

Date	In Time	Out Time	Gauge Reading	Photograph Number Looking Upstream	Ice Condition Looking Downstream	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Operational	Non- Operational	Condition of Culvert/Bridge Plugged	Condition of Culvert/Bridge Open Flow
83											
Jan 13	1330	-	*	2	X	-	-	X			

* water level below gauge, noted on structure and surveyed later El. 1.939 m

crest gauge



Elev. 2.358 m.

II) General Comments on Condition of Watercourse

Date: _____

Comments: _____

Measured by: I. Wiseman

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cochrane & Assoc., Ltd.
Nolan, Devlis & Assoc., Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 2
Type: Crest gauge
Location: Blanche Brook at Minnesota Drive

I) Survey Data Table

Date	Tide		Gauge Reading	Photograph Number	Ice Conditions	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge		Condition of Culvert/bridge Plugged	Condition of Culvert/bridge Open flow
	In	Out						Upstream	Downstream		
83											
Jan 13	1340	*		4	x	-			x		x

* gauge missing

crest gauge



Elev. 6.092 m.

II) General Comments on Condition of Watercourse

Date:

Comments:

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Holen, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 3
Type: Crest gauge
Location: Blanche Brook at Main Street
(i) Survey Data Table

Gauge Datum: GEODETIC

Measured by: J. Wiseman

Date	In Tide	Out Tide	Gauge Reading	Photograph Number	Ice Conditions Looking Upstream Or Stream Bed	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Operational Non- Operational	Condition of Culvert/Bridge Plugged Open flow
Jan 13	1400	*	6	*	X	-		X	X

* Gauge non-operational - water level marked on bridge structure and
and surveyed in at later date - El. 9.040 m.

crest gauge



(ii) General Comments on Condition of Watercourse

Date: _____

Comments: _____

Elev. 8.806 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 4
Type: Crest gauge
Location: Blanche Brook at Hansen Highway

I) Survey Data Table

Gauge Datum: GEOGRAPHIC

Measured by: J. Wiseman

Date 183	In Out	Gauge Reading	Photograph Number Looking Upstream	Ice Conditions No Yes	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge	
							Operational	Non- Operational
Jan 13	1415	*	8	X	-		X	

* Gauge out of position - water level noted on bridge structure
and surveyed in at later date - El. 28.090 m.

crest gauge



II) General Comments on Condition of Watercourse

Date: _____

Comments: _____

Elev. 27.378 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Sacchini & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 5

Type: Crest gauge

Location: Warm Creek at Carolina Avenue

1) Survey Data Table

Gauge Datum: GEODETIC

Measured by: I. Wiseman

Date	In Out	Gauge Reading	Photograph Number Looking Upstream	Ice Conditions Ties No.	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge	
							Operational	Non- Operational
183								
Jan 13	1430	*		10	x	-	x	

* Water level didn't reach bottom of gauge.

crest gauge



II) General Comments on Condition of Watercourse

Date: _____

Comments: _____

Elev. 7.374 m.

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Holen, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 6 Gauge Datum: GEODETIC

Type: Crest gauge

Location: Warm Creek at Mississippi Drive

i) Survey Data Table

Date	Tide In	Tide Out	Gauge Reading	Photograph Number Looking Upstream D/Stream	Ice Condition Ties	Ice Thickness (ft.)	No Description	Condition of Watercourse (Description)	Condition of Gauge Operational	Condition of Culvert/Bridge Plugged	Condition of Culvert/Bridge Open Flow
183									X		
Jan 13	1440	-		12	X	-					X

crest gauge



ii) General Comments on Condition of Watercourse

Date: _____

Comments: _____

Elev. 8.783 m.

Measured by: J. Wiseman

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 7

Type: Crest gauge

Location: Railway trestle at downstream end of Noels Pond

i) Survey Data Table

Date	In Tide	Out Tide	Gauge Reading	Photograph Number Looking Upstream of Stream	Ice Conditions Yes	No	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge Operational	Man- Operational	Condition of Culvert/Bridge Plugged	Condition of Culvert/Bridge Open [or Plugged]
'83												
Jan 13	1505	0.618		14	x	-			x			x

crest gauge



ii) General Comments on Condition of Watercourse

Date:

Comments:

Elev. 21.903 m

STEPHENVILLE FLOOD MONITORING
PROGRAM
Cumming-Cockburn & Assoc. Ltd.
Nolan, Davis & Assoc. Ltd.
for
Canada-Newfoundland
Flood Damage Reduction Program

Gauge No. 8
Type: Crest gauge
Location: Warm Creek at Route 460

1) Survey Data Table

Date	Time In Out	Gauge Reading	Photograph Number Looking Upstream Downstream	Ice Conditions Yes No	Ice Thickness (ft.)	Condition of Watercourse (Description)	Condition of Gauge		Condition of Culvert/Bridge Plugged Open flow
							Operational	Non- Operational	
Jan 13	1525	*		18	X	-		X	X

* Gauge missing - water level noted on bridge structure and surveyed in at later date - El. 25.486.

crest gauge



Elev. 24.686 m.

II) General Comments on Condition of Watercourse

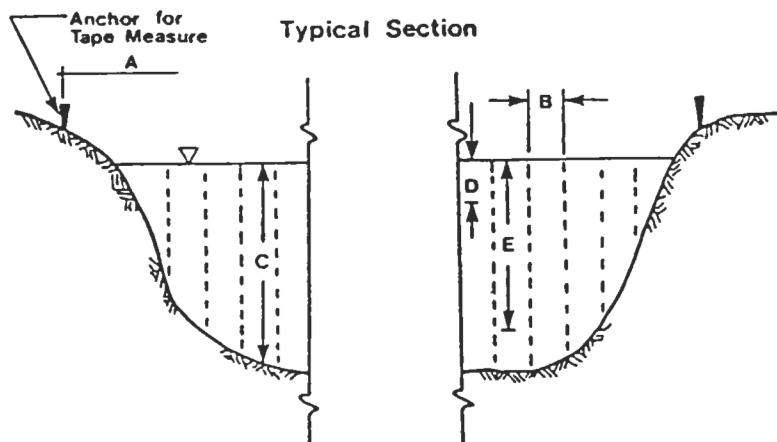
Date: _____

Comments: _____

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel		Depth "d"	Meter "d" 0.5 0.8	Rev.	Time		Velocity "v"	\bar{V}	Area	Discharge "Q" m^2 m^3/s
No.	Dist.				sec.	sec.				
1	1.10	m							.506	0.07
2	1.10	0.46	1.3	10	49		.146		.374	0.06
3	1.10	0.34	1.1	10	42		.171		.441	0.17
4	1.10	0.40	1.2	25	45		.381		.374	0.24
5	1.10	0.34	0.9	40	43		.633		.297	0.19
6	1.10	0.27	0.5	40	42		.649		.297	0.08
7	1.10	0.27	0.5	20	55		.252			
8	1.10									
9	1.10	0.18	0.3	20	45		.307		.198	0.06
10	1.10	0.30	0.5	40	40		.679		.330	0.22
11	1.10	0.40	1.1	50	40		.847		.440	0.37
12	1.10	0.61	1.5	50	41		.826		.670	0.55
13	1.10	0.85	1.1 2.3	60 60	43 43		.947 .947	0.95	.935	0.88
14	1.10	0.91	1.1 2.9	70 60	42 40		1.121.02	1.07	1.00	1.07
15	1.10	0.46	0.8	25	40		.424		.510	0.22
16	1.10	0.67	0.9 1.8	40 55	44 41		.619 .908	0.76	.740	0.56
17	1.10	0.82	1.0 2.2	95 90	42 41		1.53 1.49	1.51	.90	1.36
18	1.10	1.0	1.2 3.1	125 75	41 42		2.06 1.21	1.64	1.100	1.80
19	1.10	1.37	1.4 4.1	125 65	40 41		2.12 1.08	1.60	1.510	2.42
20	1.10	1.62	1.6 4.9	115 75	40 43		1.95 1.17	1.56	1.780	2.78
Total Discharge										$13.10 m^3/s$

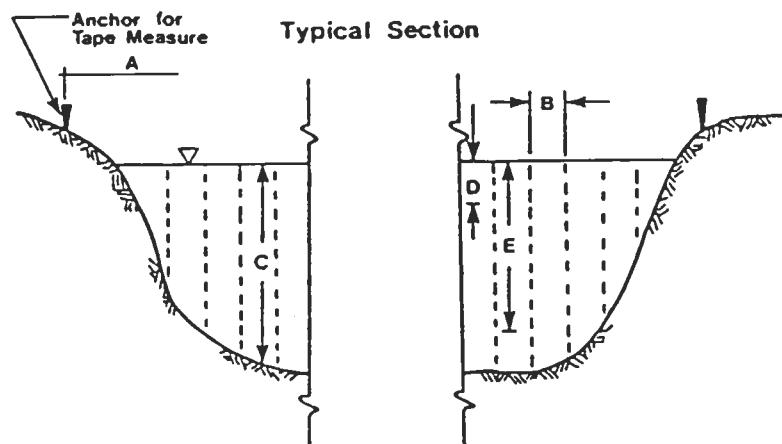


- A Distance to measuring point
- B Panel width ($d/20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel No.	Depth "d" Dist.	Meter "d"		Rev.	Time sec	Velocity "v"	\bar{V}	Area	Discharge "Q"
		0.2	0.6						
1	0.50	.22	m	x	0		40		
2	1.00	.12		x	19		40	.321	.06 m ² .02 m ³ /s
3	1.5	.21		x	28		40	.469	.11 .05
4	2.0	.20		x	28		40	.469	.10 .05
5	2.5	.28		x	18		40	.305	.14 .04
6	3.0	.28		x	27		40	.453	.14 .06
7	3.5	.33		x	18		40	.305	.17 .05
8	4.0	.25		x	30		40	.502	.13 .07
9	4.5	.24		x	34		40	.567	.12 .07
10	5.0	.26		x	32		40	.535	.13 .07
11	5.5	.22		x	22		40	.370	.11 .04
12	6.5	.26		x	31		40	.513	.13 .07
13	7.0	.18		x	20		40	.337	.09 .03
14	7.5	.19		x	16		40	.271	.14 .04
15	8.5	.15		x	16		40	.271	.13 .04
16	9.25	.27		x	36		40	.601	.14 .08
17	9.5	.22		x	22		40	.370	.19 .07
18	11.0	.15		x	22		40	.370	.17 .06
19	11.75	.12		x	11		40	.033	.06 .00
20	12.0	.14		x	11		40	.033	.09 .00
21	12.5	.0						Total Discharge	.91 m ³ /s



- A Distance to measuring point
- B Panel width ($d/20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

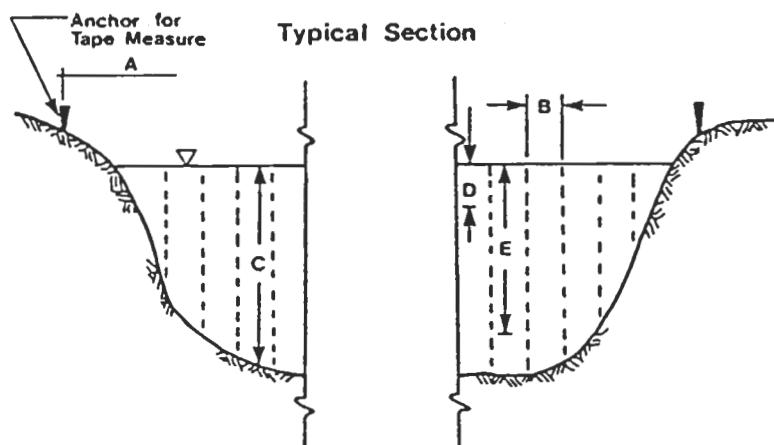
- start measurement at 11:24 am, stop at 11:52 am
- water temperature = 0°C at 11:30 am

Sta. 27+91
Location: Blanche Brook
Date: March 11, 1983
Recorded by: I. Wiseman F. Baechler

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel No.	Depth "d" Dist.	Meter "d"		Rev.	Time sec.	Velocity "v"	\bar{V}	Area	Discharge "Q"
		0.2	0.6						
1	.0	.34	m	x	12		.210	.22	m^2
2	.13	.28		x	22		.375	.22	
3	.38	.23		x	17		.299	.09	
4	.88	.31		x	21		.357	.11	
5	1.13	.26		x	14		.256	.07	
6	1.38	.22		x	12		.210	.06	
7	1.63	.21		x	15		.262	.05	
8	1.88	.23		x	8		.146	.06	
9	2.13	.22		x	.9		.165	.06	
10	2.38	.19		x	12		.210	.05	
11	2.63	.20		x	6		.110	.05	
12	2.88	.19		x	8		.146	.07	
13	3.38	.20		x	10		.174	.07	
14	3.63	.18		x	9		.165	.05	
15	3.98	.15		x	4		.076	.18	
16	5.00	.0		x	-		-	-	
17									
18									
19									
20									
								Total Discharge	$.32 \text{ m}^3/\text{s}$



- A Distance to measuring point
- B Panel width ($d/20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

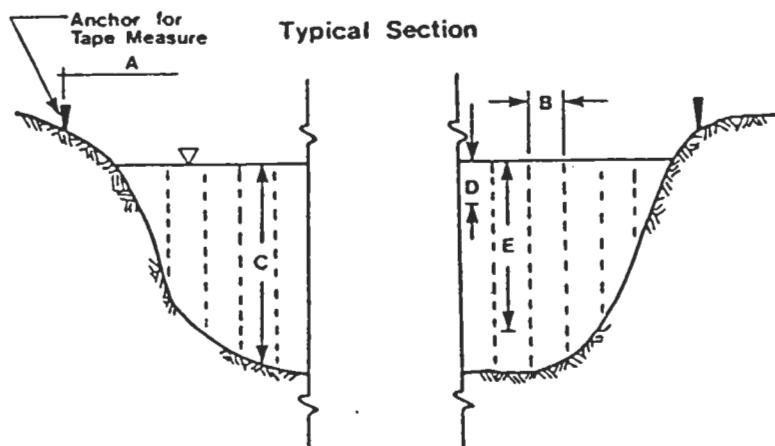
- measurements taken between 12:13 pm - 12:36 pm
- stage = 8.390 m
- water temperature = 3°C at 12:20 pm

Structure B6
Location: Warm Creek
Date: March 11, 1983
Recorded by: I. Wiseman F. Baechler

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel No.	Depth "d" Dist.	Depth "d"	Meter "d"		Rev.	Time sec.	Velocity "v"	\bar{V}	Area	Discharge "Q"
			0.2	0.6						
1	0.5	.13 m		x	25		40	.421	.08 m ²	.03 m ³ /s
2	0.75	.13		x	25		40	.421	.03	.01
3	1.0	.18		x	33		40	.552	.05	.03
4	1.25	.16		x	20		40	.338	.04	.01
5	1.5	.20		x	45		40	.747	.07	.05
6	2.0	.24		x	25		40	.421	.09	.04
7	2.25	.25		x	35		40	.585	.06	.04
8	2.25	.16		x	50		40	.829	.06	.05
9	3.0	.25		x	60		40	1.00	.09	.09
10	3.25	.27		x	60		40	1.00	.07	.07
11	3.25	.29		x	40		40	.668	.07	.05
12	3.75	.30		x	45		40	.747	.08	.06
13	4.0	.28		x	25		40	.421	.10	.04
14	4.5	.20		x	45		40	.747	.07	.05
15	4.75	.22		x	45		40	.747	.06	.04
16	5.0	.21		x	20		40	.338	.12	.04
17	5.9	.12		x	40		40	.668	.09	.06
18	6.5	.10		x	15		40	.256	.06	.02
19	7.0	.11		x	13		40	.223	.14	.03
20	8.0	.00		x	-		-			
										Total Discharge .81 m ³ /s



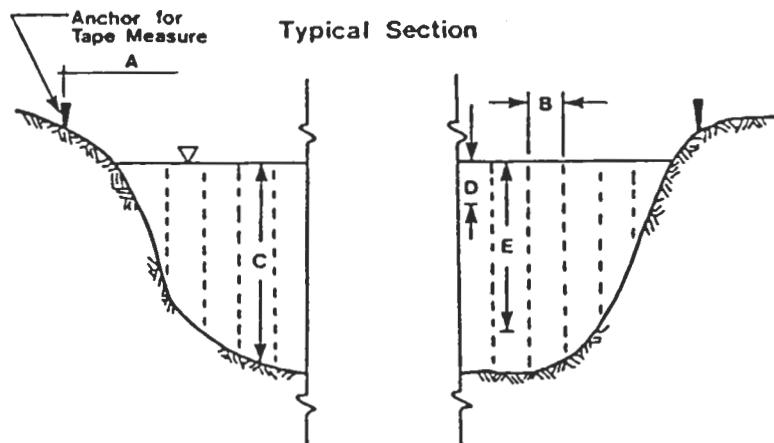
- A Distance to measuring point
- B Panel width ($d/20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

- start measurement at 9:40 am, stop at 10:15 am
- stage elevation 9.116 m

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel No.	Depth "d" Dist.	Meter "d"		Rev.	Time Sec	Velocity "v"	\bar{V}	Area	Discharge "Q"
		0.2	0.6						
1	2.25	.09	m	x	19		40	.320	
2	2.50	.10		x	13		40	.226	
3	2.75	.10		x	14		40	.244	
4	3.0	.15		x	8		40	.146	
5	3.25	.14		x	23		40	.390	
6	3.50	.16		x	17		40	.300	
7	3.75	.17		x	40		40	.668	
8	4.00	.15		x	10		40	.174	
9	4.25	.09		x	15		40	.262	
10	4.75	.15		x	22		40	.375	
11	5.00	.15		x	7		40	.128	
12	5.25	.09		x	15		40	.262	
13	5.75	.08		x	22		40	.375	
14	6.00	.10		x	13		40	.226	
15	6.25	.10		x	14		40	.244	
16	6.50	.14		x	26		40	.445	
17	6.75	.14		x	8		40	.146	
18	7.0	.16		x	22		40	.375	
19	7.25	.16		x	19		40	.320	
20	7.75	.17		x	24		40	.408	
	8.5	.0						Total Discharge	.39 m ³ /s



- A Distance to measuring point
- B Panel width ($d=20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

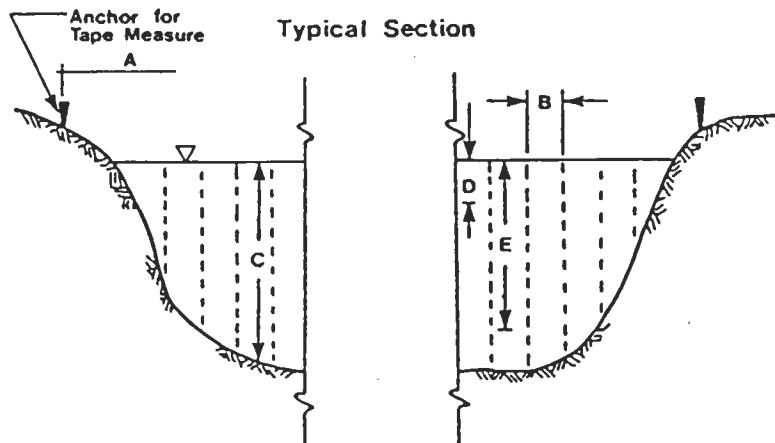
- measurements taken from 1:11 pm to 1:35 pm
- water temperature 3°C at 1:15 pm

Sta 1+44
Location: Warm Creek
Date: March 11, 1983
Recorded by: I. Wiseman F. Baechler

Stephenville Flow Monitoring Program

CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM

Panel No.	Depth "d"	Meter "d"		Rev.		Time		Velocity "v"		\bar{V}	Area	Discharge "Q"
		0.5	0.6	40	40	40	41	.679	.665			
1	1.13	1.4	m	1.4	4.2	40	40	.679	.665	.67	1.58 m ³	1.06 m ³ /s
2	1.13	1.4		1.4	4.2	35	40	.594	.679	.63	1.58	0.99
3	1.13	1.3		1.4	4.1	30	10	.513	.176	.34	1.47	0.50
4	1.13	1.3		1.3	3.8	25	25	.381	.424	.40	1.41	0.56
5	1.13	1.2		1.3	3.7	30	15	.466	.259	.36	1.37	0.50
6	1.13	1.2		1.3	3.7	35	20	.591	.344	.47	1.37	0.64
7	1.13	1.3		1.3	3.8	30	35	.512	.591	.55	1.41	0.78
8	1.13	1.4		1.4	4.2	20	30	.344	.512	.42	1.58	0.66
9	1.13	1.4		1.4	4.2	30	15	.512	.259	.38	1.58	0.60
10	1.13	1.3		1.4	4.1	30	15	.512	.259	.38	1.47	0.56
11	1.13	1.3		1.3	3.9	55	40	.905	.649	.78	1.45	1.10
12	1.13	1.3		1.4	4.1	20	15	.344	.240	.29	1.47	0.43
13	1.13	1.3		1.4	4.1	25	25	.424	.424	.42	1.47	0.61
14	1.13	1.4		1.4	4.2	45	30	.743	.512	.62	1.58	0.98
15	1.13	1.6		1.5	4.7	25	35	.424	.591	.50	1.81	0.91
16	1.13	1.6		1.5	4.7	55	50	.886	.847	.87	1.81	1.60
17	1.13	1.6		1.5	4.7	50	50	.847	.807	.83	1.81	1.50
18	1.13	1.3		1.3	3.9	50	50	.847	.847	.85	1.45	1.23
19	1.13	1.3		1.4	4.1	30	55	.50	.908	.70	1.47	1.03
20	1.13	1.3		1.3	3.8	50	50	.847	.826	.84	1.41	1.18
Total Discharge											17.42 m³/s	



- A Distance to measuring point
- B Panel width ($d/20$)
- C Total depth at metering point
- D Metering Depth ($0.2 \times d$)
- E Metering Depth ($0.8 \times d$)

Structure B7
Location: Warm Creek
Date: June 3, 1983
Recorded by: I. Wiseman

Appendix D

Meteorological Records

TABLE D-1

Meteorologic Records for AES Stn # 71815 (Stephenville)
for Period January 9 - 14, 1983

Date	Comments	Precipitation		Air Temperature C°	
		Rain mm	Snow cm	Max.	Min.
January 9	snow		2.3	-5.2	-11.2
January 10	snow		0.7	-3.0	-12.0
January 11	rain and snow	8.4	0.3	-8.3	- 4.3
January 12	rain	17.0		10.0	- 2.5
January 13	rain	34.1		11.1	- 0.2
January 14	rain and snow	trace	trace	-0.1	- 3.9

TABLE D-2

Meteorologic Records for AES Stn # 71815 (Stephenville)
for Period March 1 - 11, 1983

Date	Comments	Precipitation		Air Temperature C°	
		Rain mm	Snow cm	Max.	Min.
March 1		nil		-3.8	-16.5
March 2	one 40 min. rain period	trace		5.2	- 4.4
March 3	rain showers	2.9		9.4	3.5
March 4	rain & snow	trace	3.0	5.8	- 8.2
March 5	snow showers		3.2	-5.6	- 9.4
March 6	snow showers		5.1	-1.3	-11.8
March 7	snow showers	nil	2.9	-6.4	-10.8
March 8		nil		-2.7	-12.3
March 9		nil		0.0	-13.0
March 10		nil		2.0	- 8.8
March 11	rain	0.8		7.0	0.2

TABLE D-3

Meteorologic Records for AES Stn # 71815 (Stephenville)
for Period June 1 - 6, 1983

Date	Comments	Precipitation		Air Temperature C°	
		Rain mm	Snow cm	Max.	Min.
June 1	rain	67.6		15.7	9.0
June 2	rain	18.6		15.4	7.4
June 3	rain	12.6		9.5	4.4
June 4	rain	2.1		13.5	4.8
June 5	rain	6.8		17.5	8.6
June 6	rain	0.4		18.2	9.0

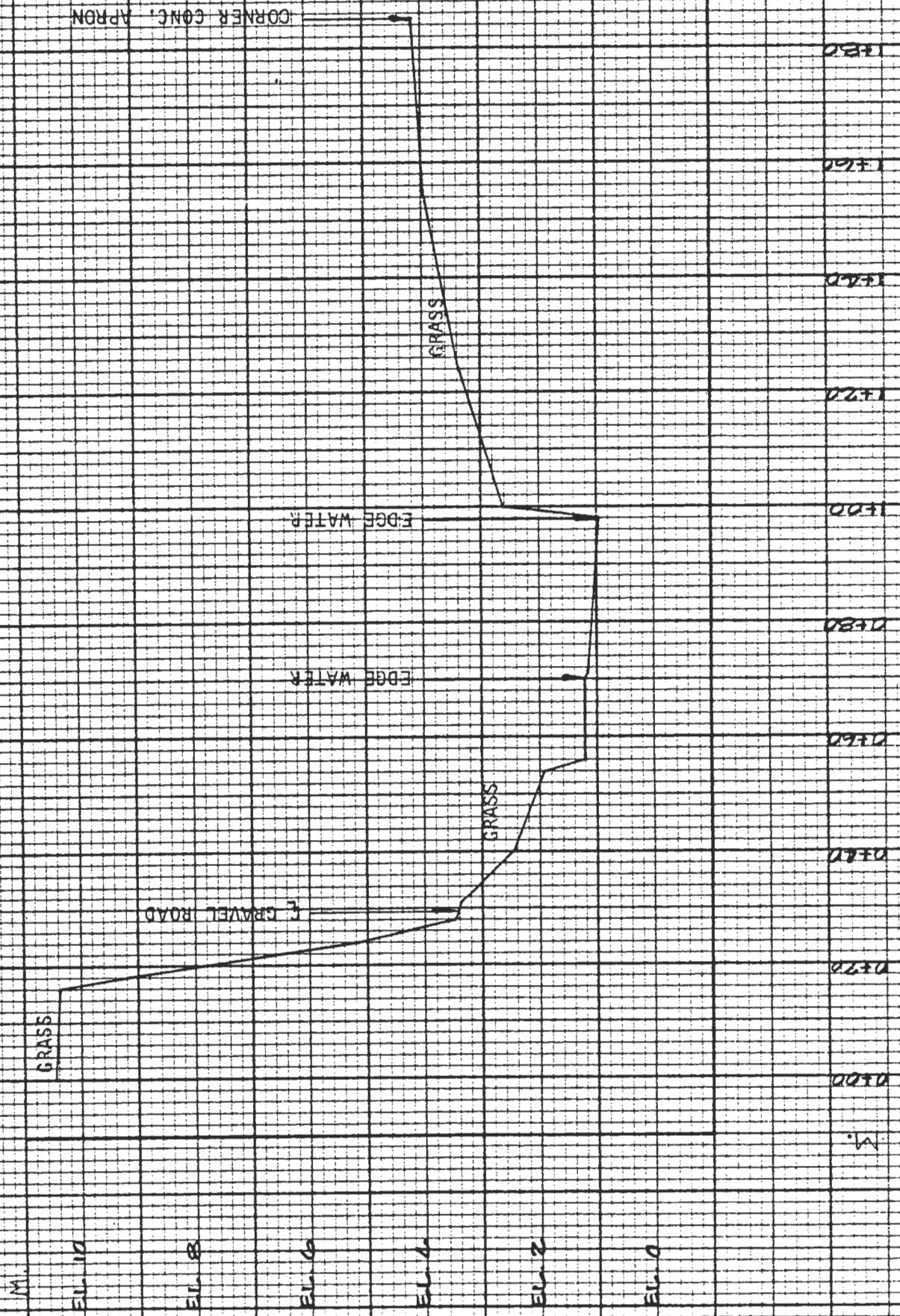
Snowfall Records - AES Station 71815 (Stephenville Airport)
for Winter Months, 1983

<u>MONTH</u>	<u>1983 SNOWFALL</u>	<u>MEAN SNOWFALL</u>
January	82.4 cm	95.2 cm
February	58.0 cm	76.0 cm
March	42.5 cm	58.5 cm
April	7.0 cm	22.0 cm
May	0.0 cm	4.2 cm

Appendix E

Channel Cross Sections

SECTION E-E STA. 0+00



SECTION B-B

STA. 1+37

05+2

2+25

00+2

SL+1

05+1

52+1

00+1

SL+0

05+0

52+0

00+0

M

EL - 4

EL - 0

EL - 2

EL - 8

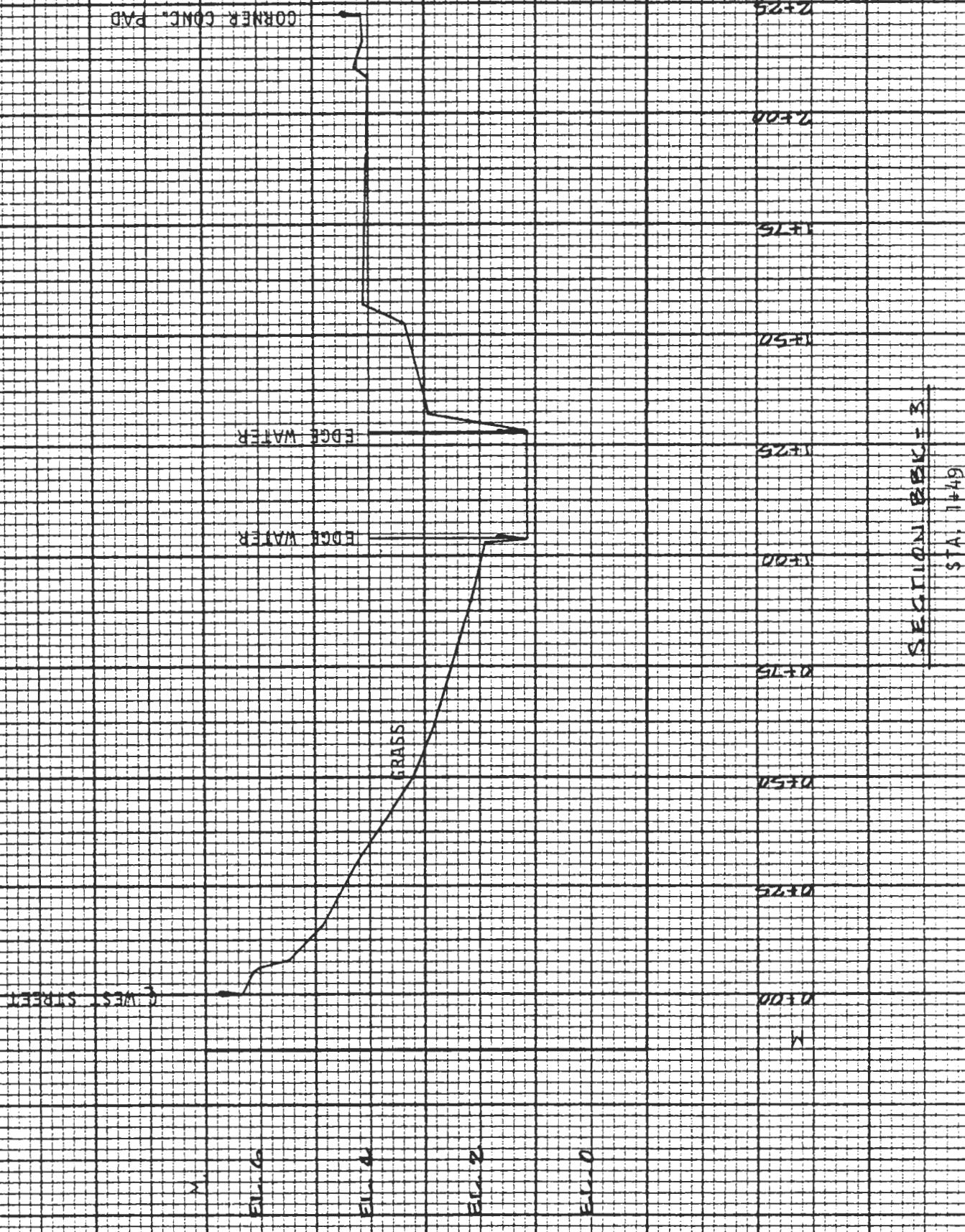
ALONG C-K IN PLACE

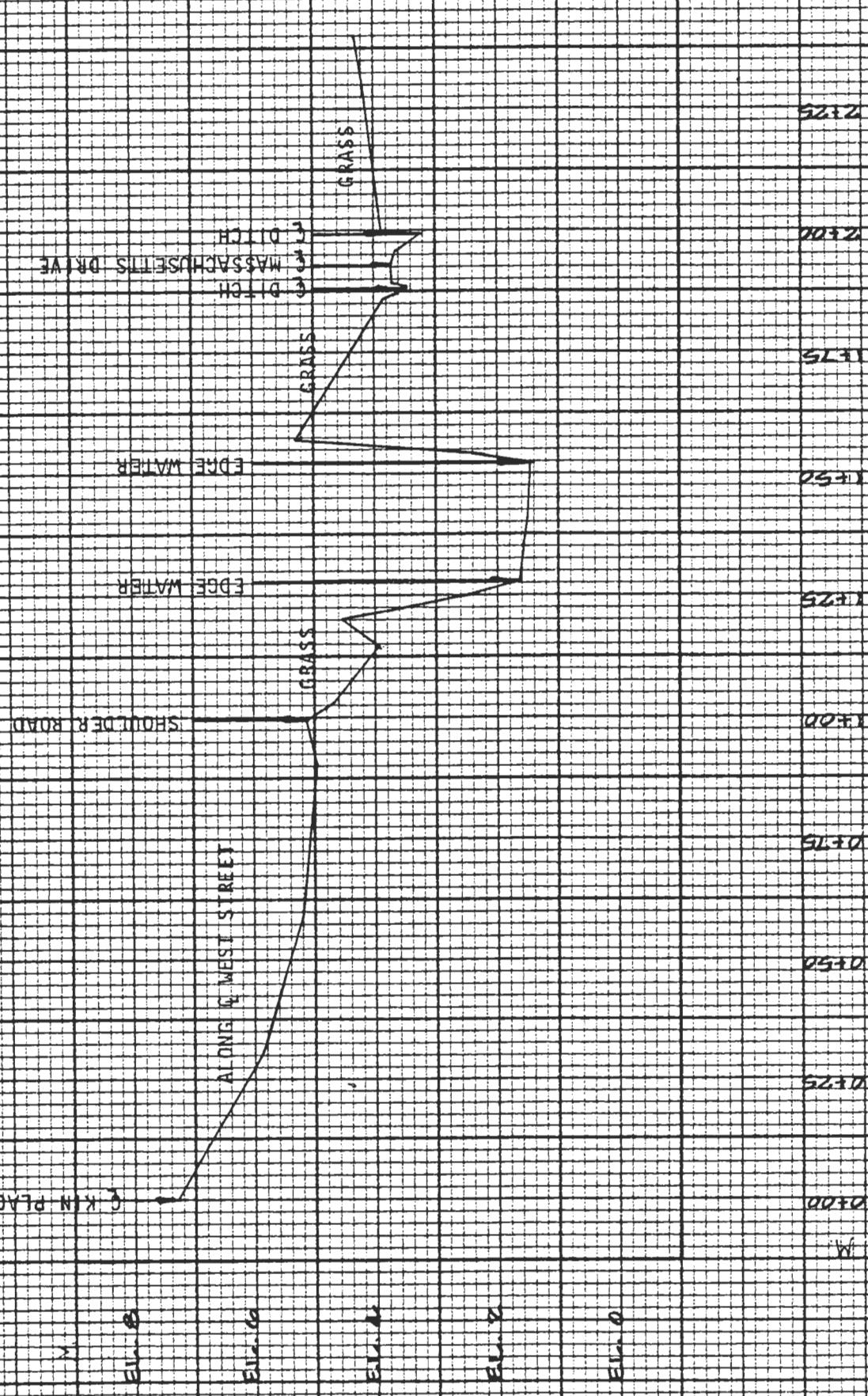
BOTTOM OF DECK BEAM E.I. 3.86 m
CHANNEL

END OF BRIDGE

END OF BRIDGE

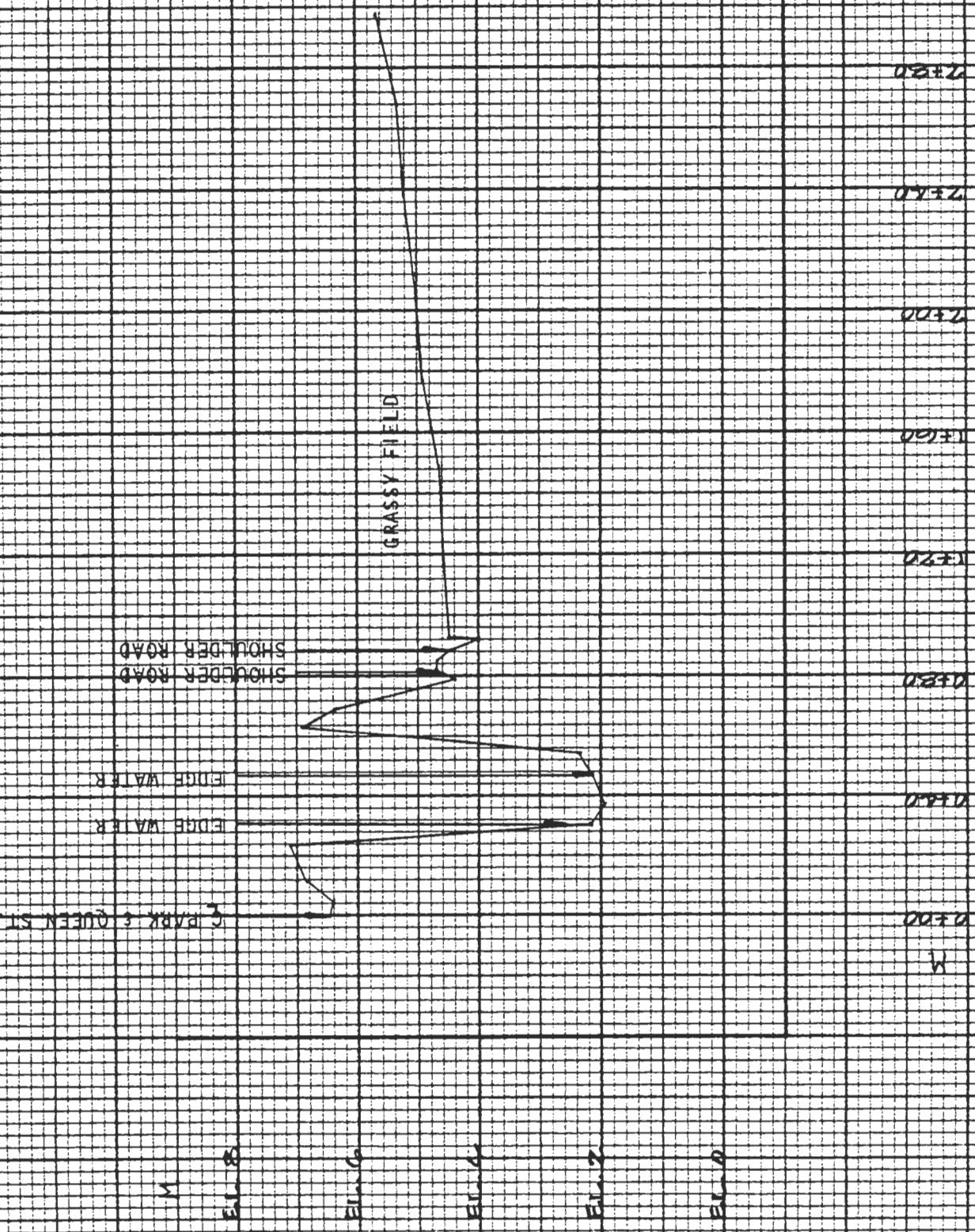
6 KIN PLACE S.W.E.S.



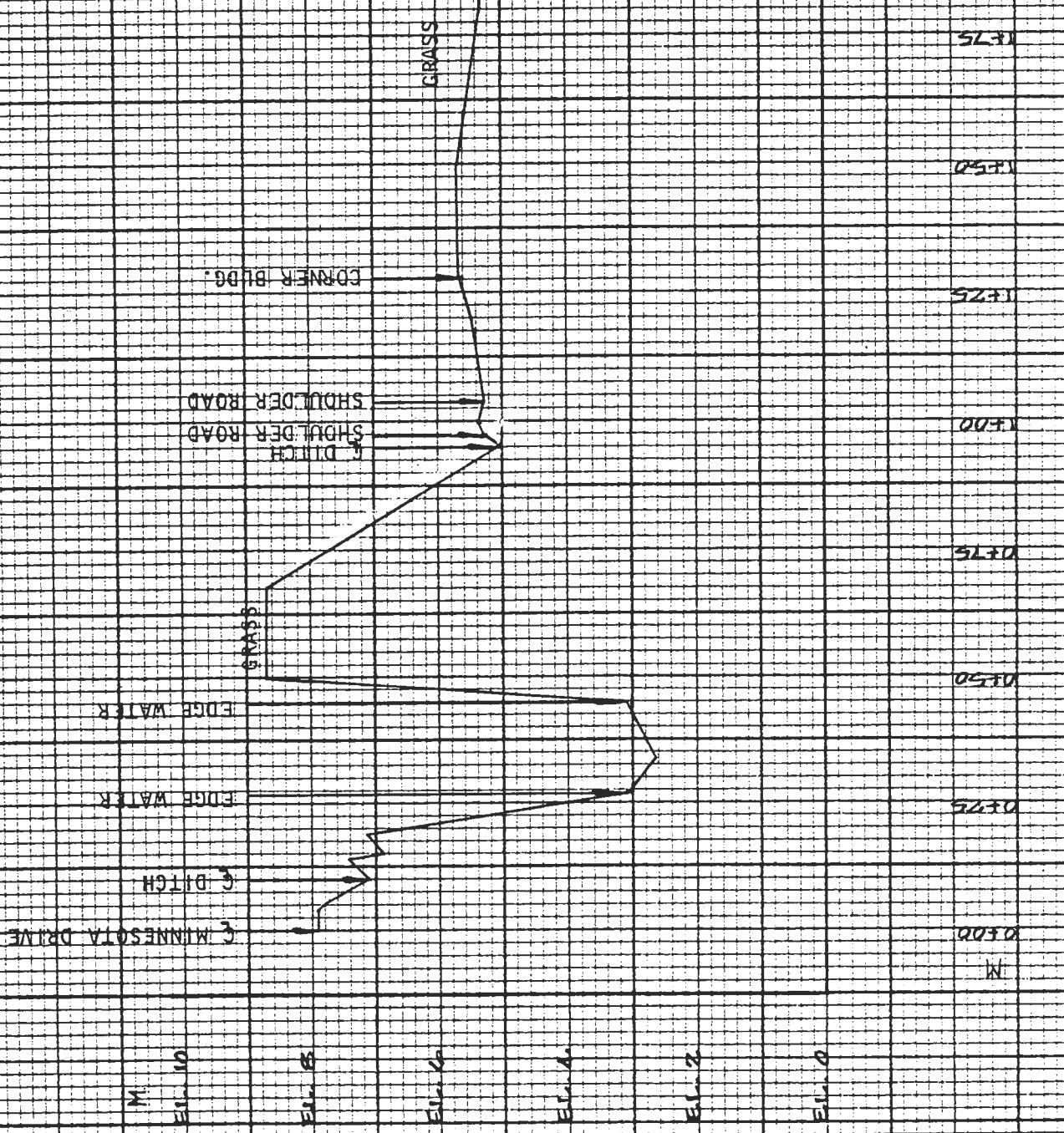


SECTION B&C = 4
SIA 3+03

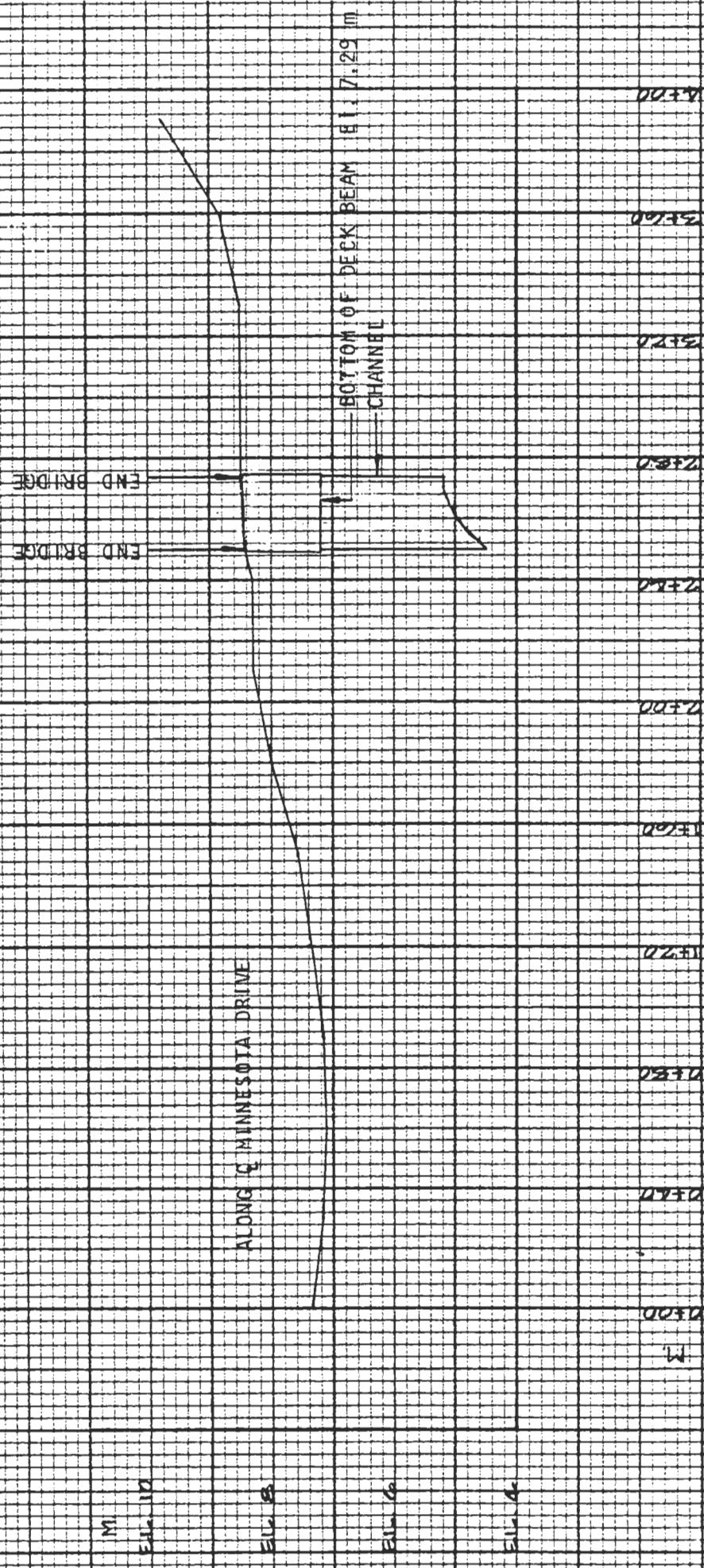
SECTION 2N ELEV - 5
STA: 1+18



SECTION B-BX-1c
SIN 7+25

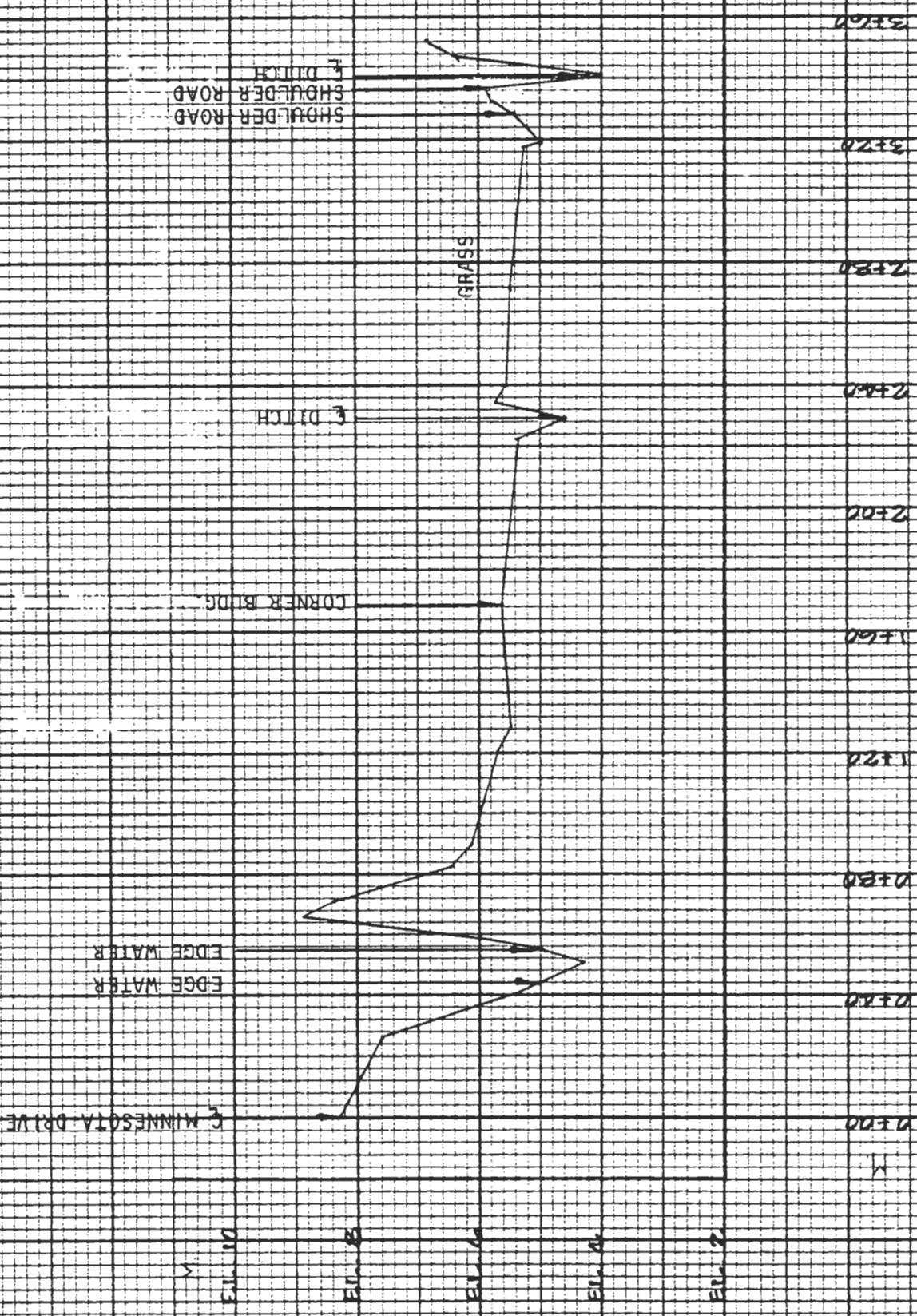


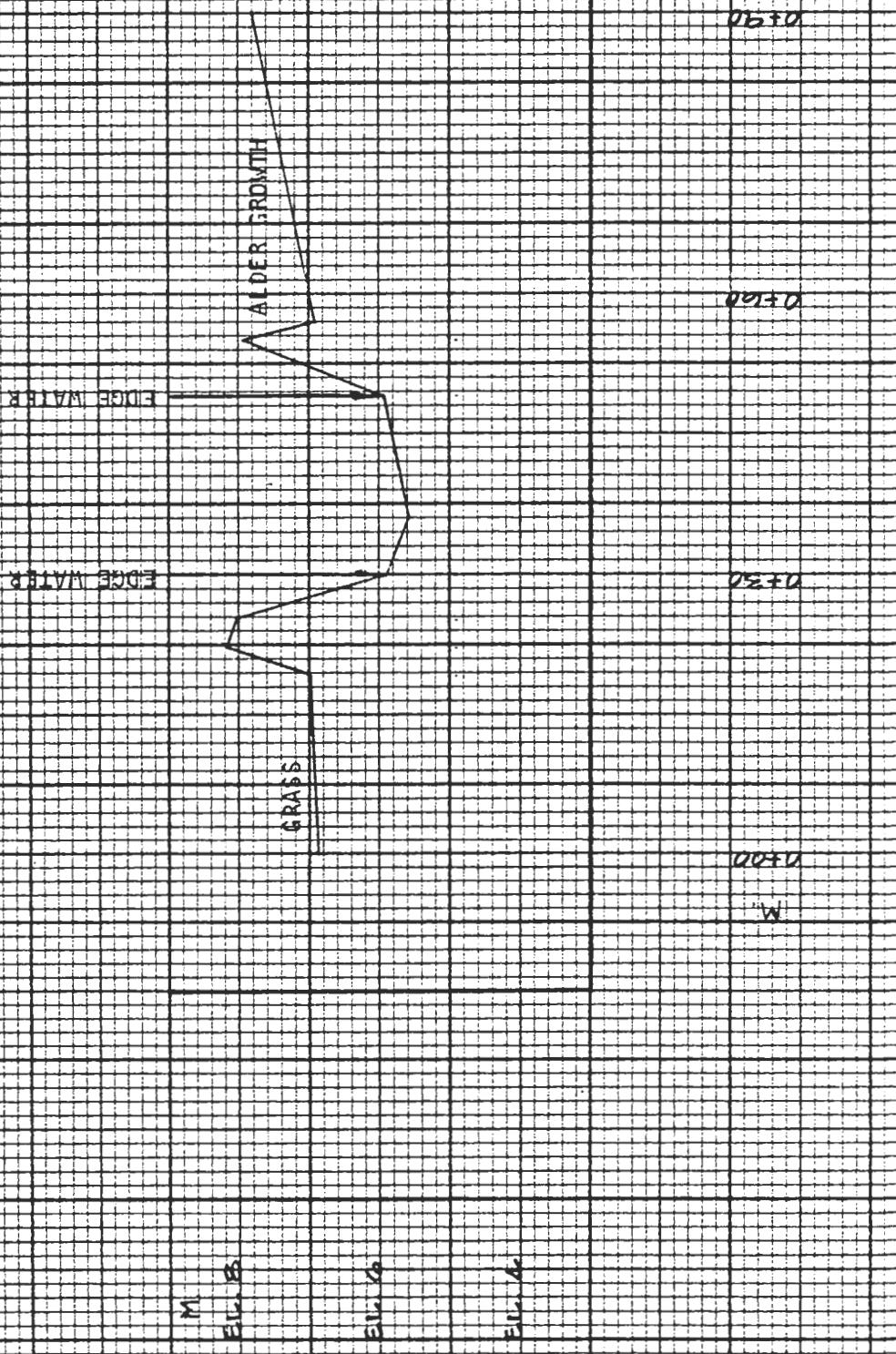
SECTION BACK = 7
STA. 12474



SECTION BACK = 3

STA. 1+00





SECTION BREAK = 9

STA. 13+21

STA. 114+41

SECTION BACK 10

0+00

2+00

3+20

4+80

5+40

11+60

12+50

0+20

0+00

0+00

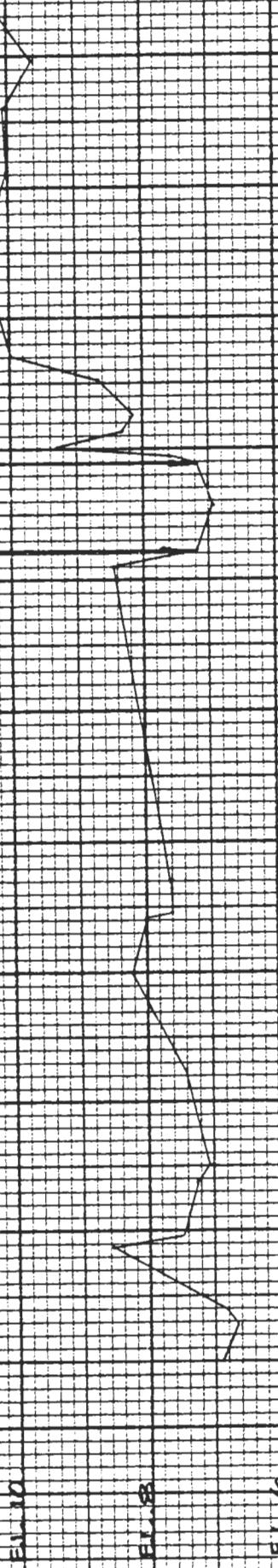
M

EL. 10

EL. 10

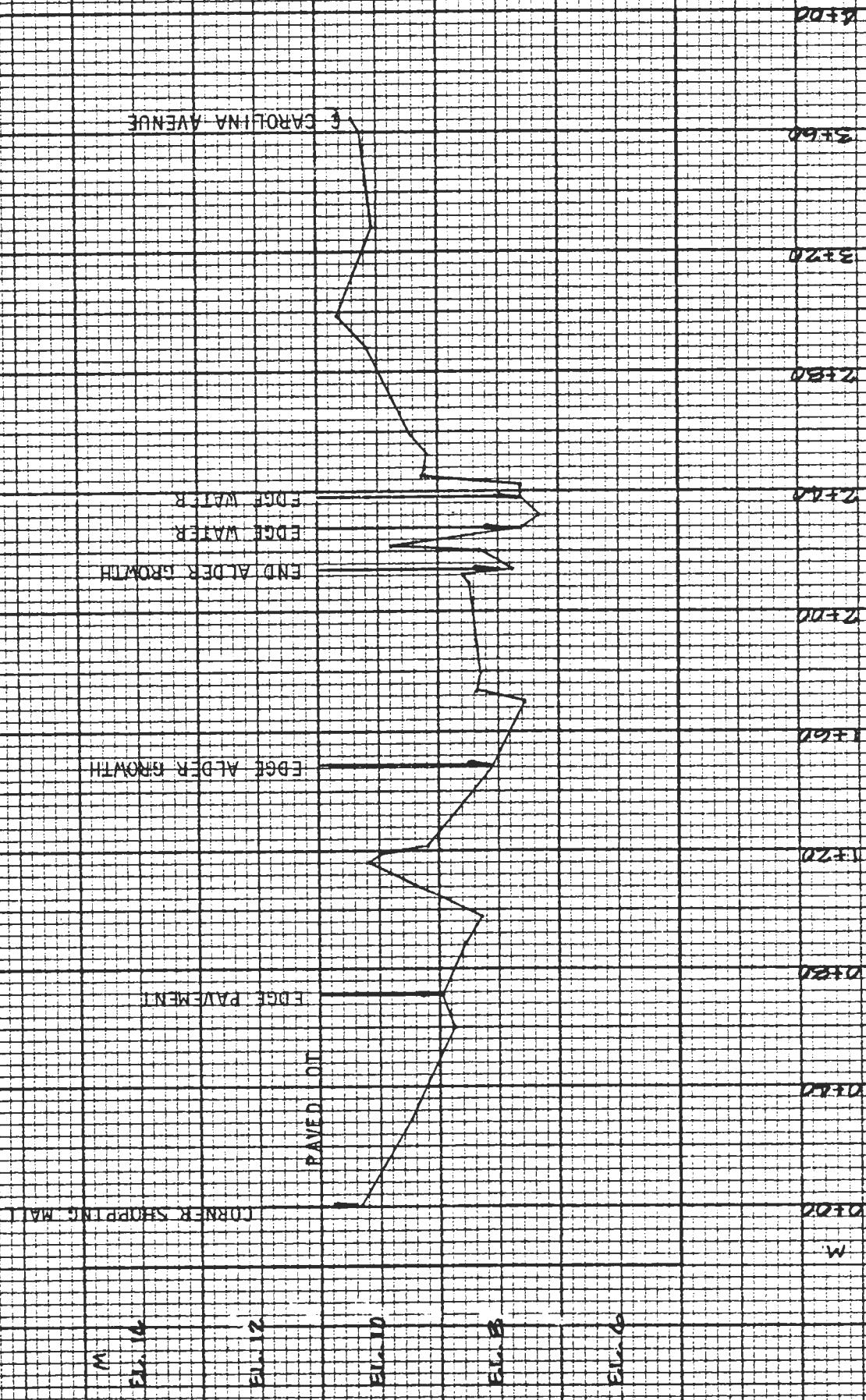
EL. 10

CAROLINA AVENUE

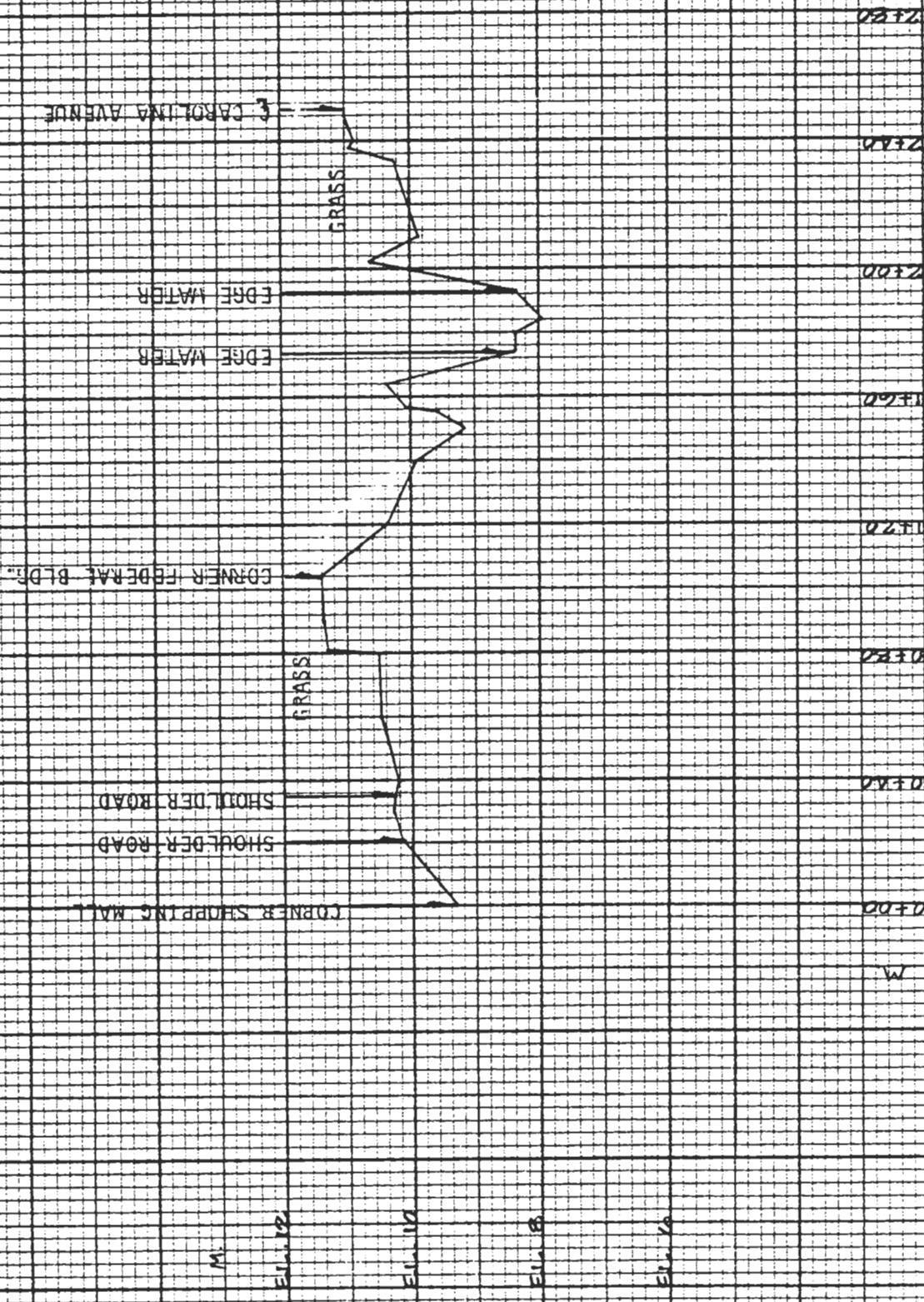


$$\underline{5} + \underline{2} =$$

SECTION ONE EASY-II

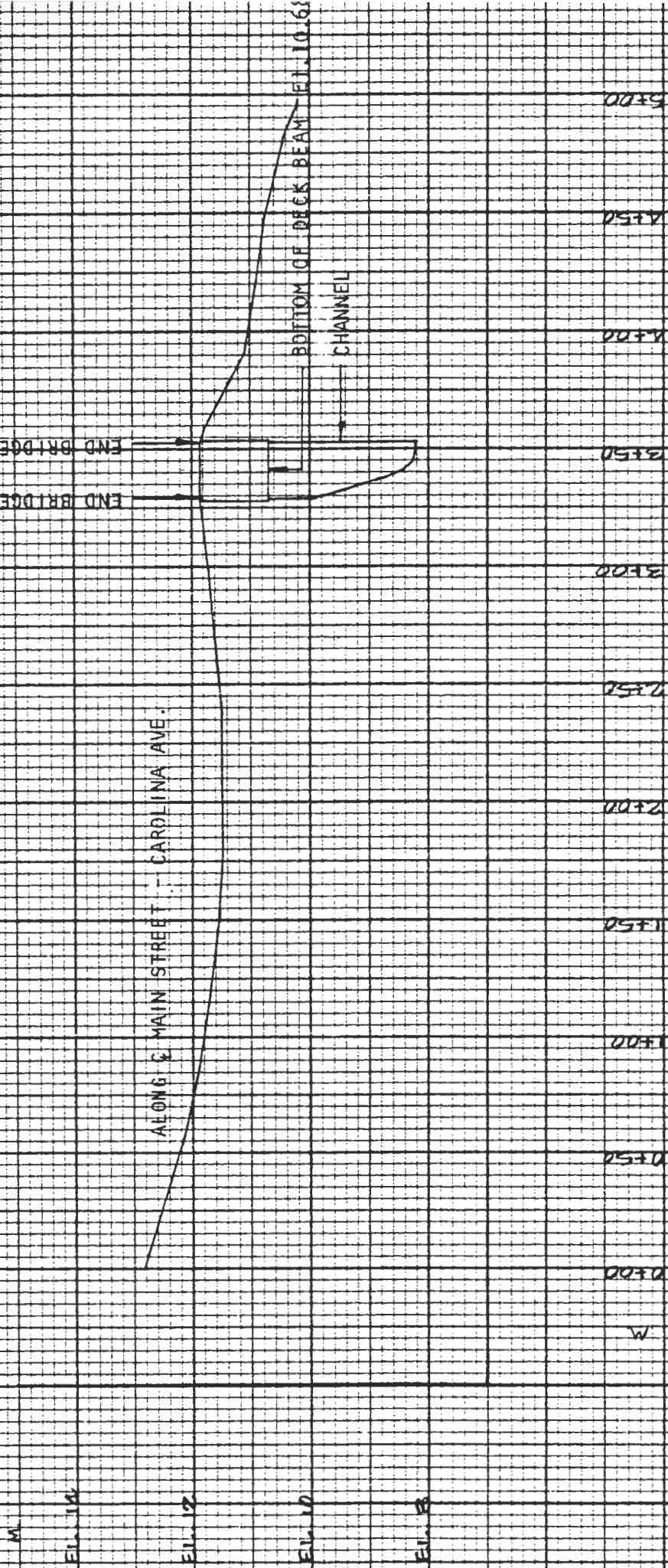


S.ECTION 888-212
S.A. 1616



SECTION B-B'-13

STA 16+51



SECTION 24 BBK = 12 A

STA. 16+66

00+00

11+80

11+60

11+40

11+20

00+00

00+80

00+00

00+00

00+00

00+00

W

AUDON E CARDINA AVENUE

ELL 12

ELL 10

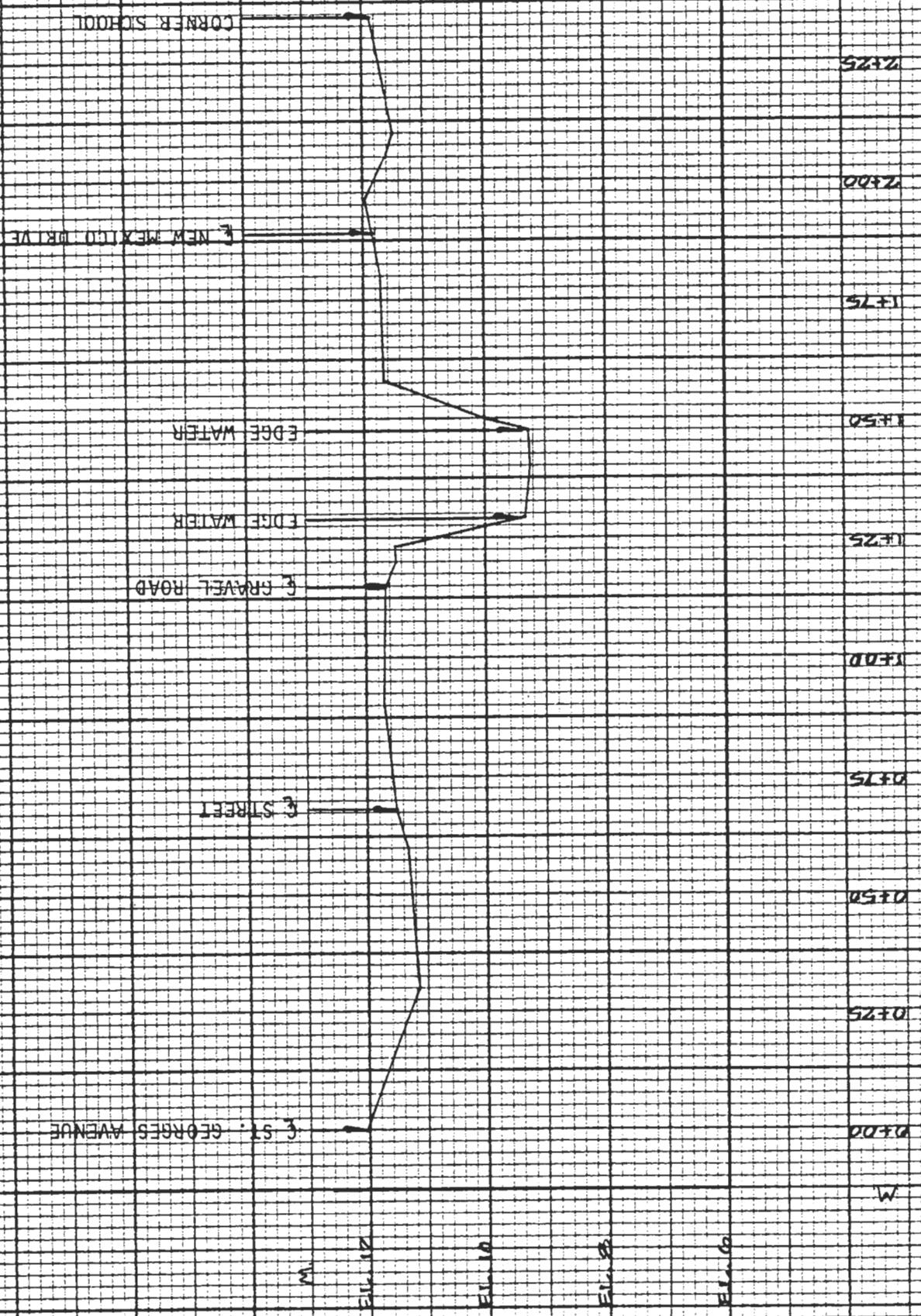
ELL 8

NOTE: STA. 4+95 ON
SECTION BBK = 12 A
STA 0+00 ON BBK - 12 A

a.

ELL 6

SECTION EBB = 14
STA. 17+13



SECTION BBB - 12

STA: 8+53

8+80

8+80

8+80

8+80

8+80

8+80

8+80

8+80

8+80

M

EL. 12

EL. 12

EL. 12

EL. 12

ALONG C. WILLOWDALE

END C. WILLOWDALE

N

EL. 12

SHOULD. BLAMCRE ST.
EDGE MATER

SHOULD. BLAMCRE ST.
EDGE MATER

SHOULD. BLAMCRE ST.
EDGE MATER

CORNER BLDG.

STA 20+48

SECTION BACK = 16

52+25

52+00

51+75

51+50

51+25

50+00

50+75

50+50

50+25

50+00

W

EL 12

EL 11

EL 10

EL 9

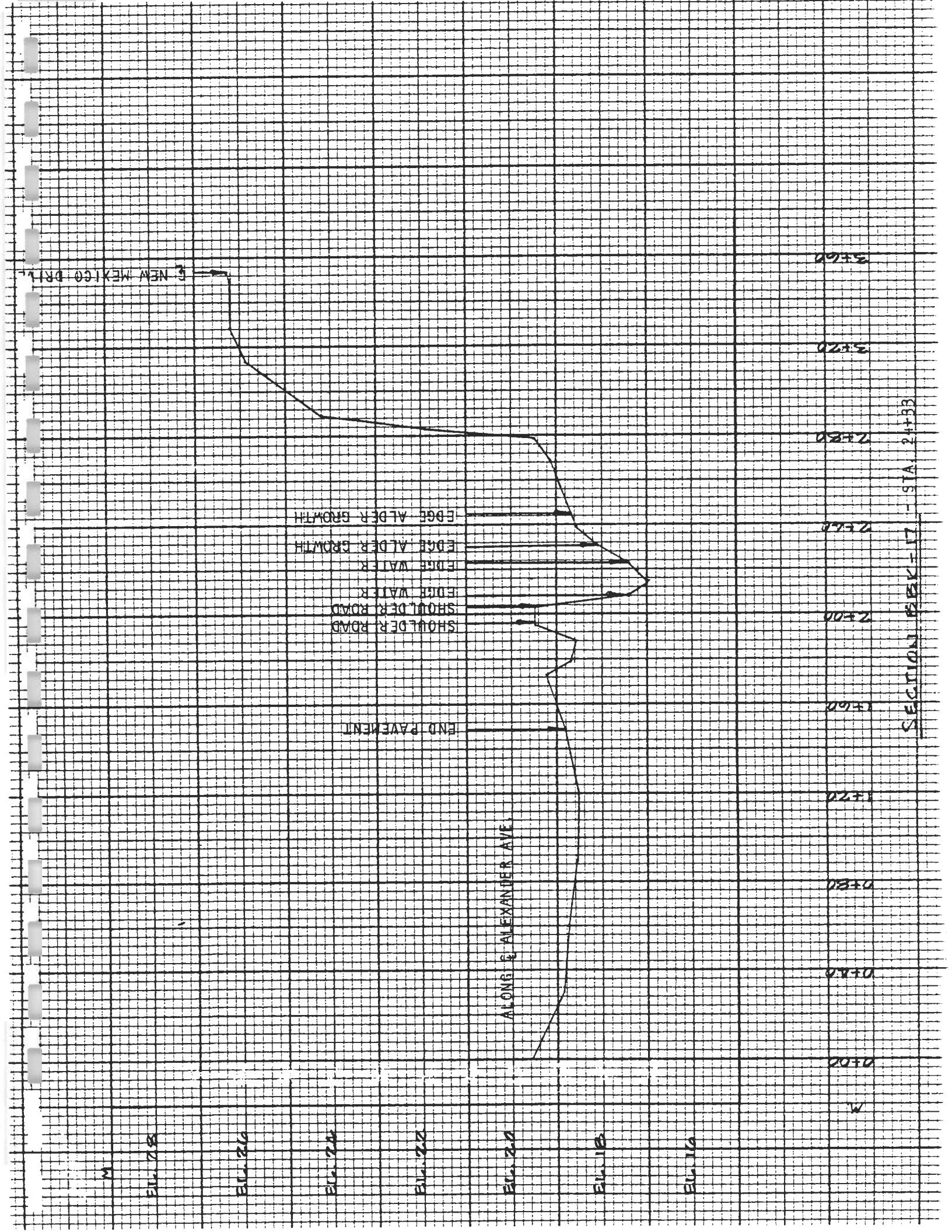
EL 8

W

ALONG E MAXWELL AVE.

E NEW MEXICO DRIVE
EDGE ALDER GROWTH
EDGE ALDER GROWTH
EDGE WATER
EDGE WATER
E BLANCHET STREET
END PAVEMENT

SECTION FIFTEEN - STA 2+33



SECTION 23 - STA. 25+91

25+90

25+90

25+90

25+90

25+91

25+91

25+90

25+90

25+90

M

EL-13
EL-20

ALONG C.M. PLACE

C. QUEEN STREET

EL-22
EL-22

SHOULDER ROAD

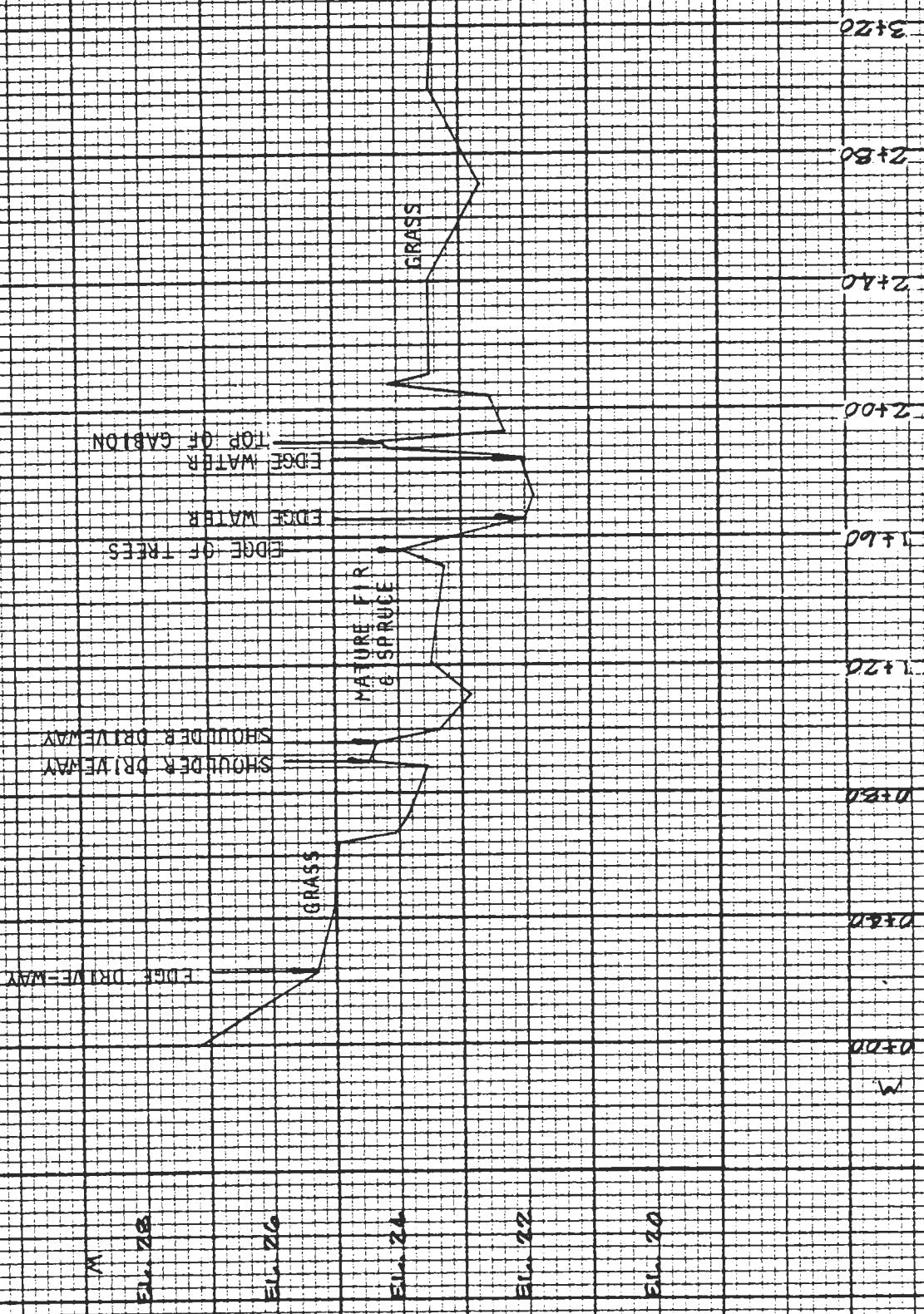
EDGE WATER

EDGE WATER & ALDER GROWTH

END ALDER GROWTH

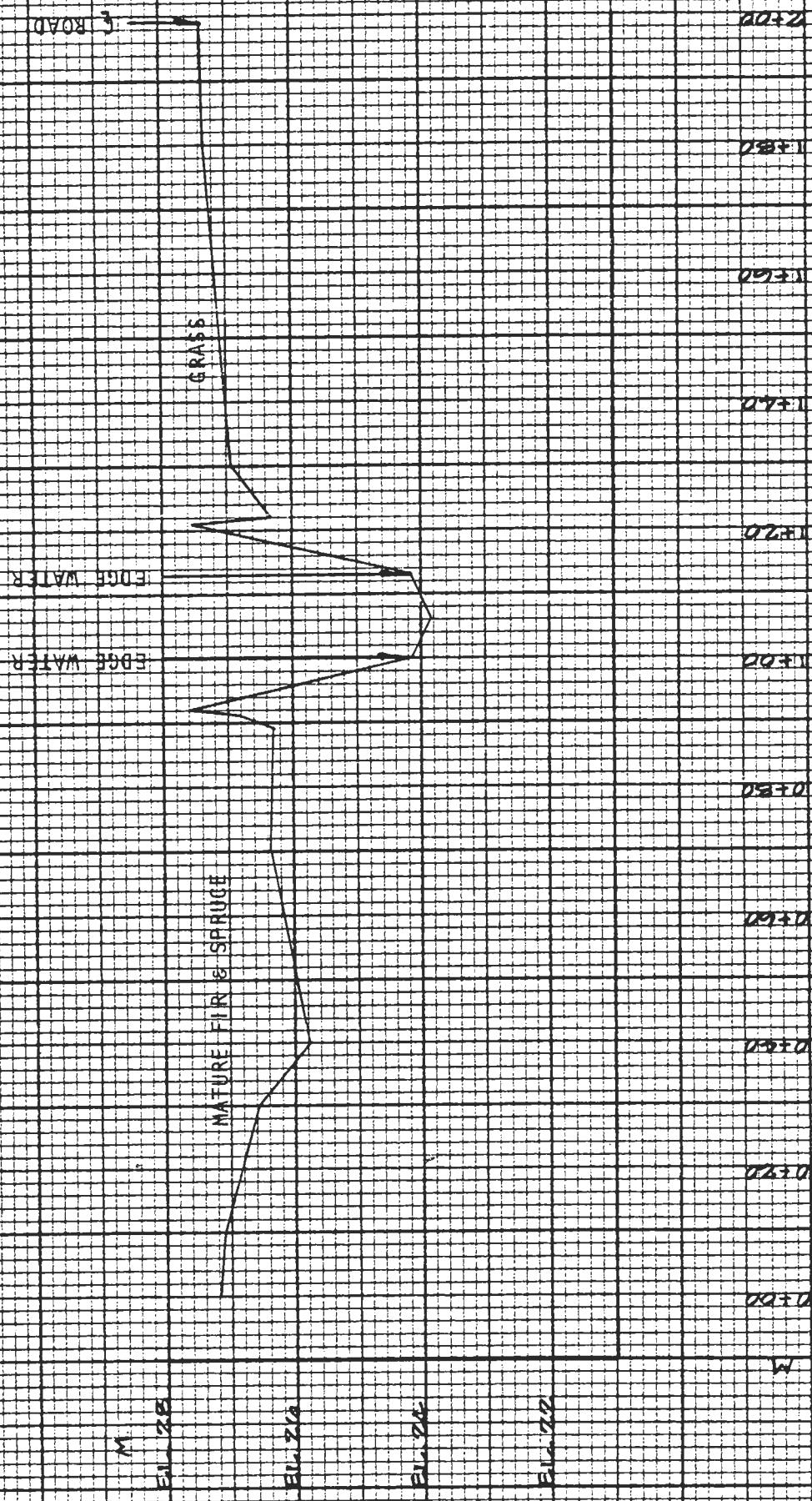
SECTION EER-19

STA. 28-11



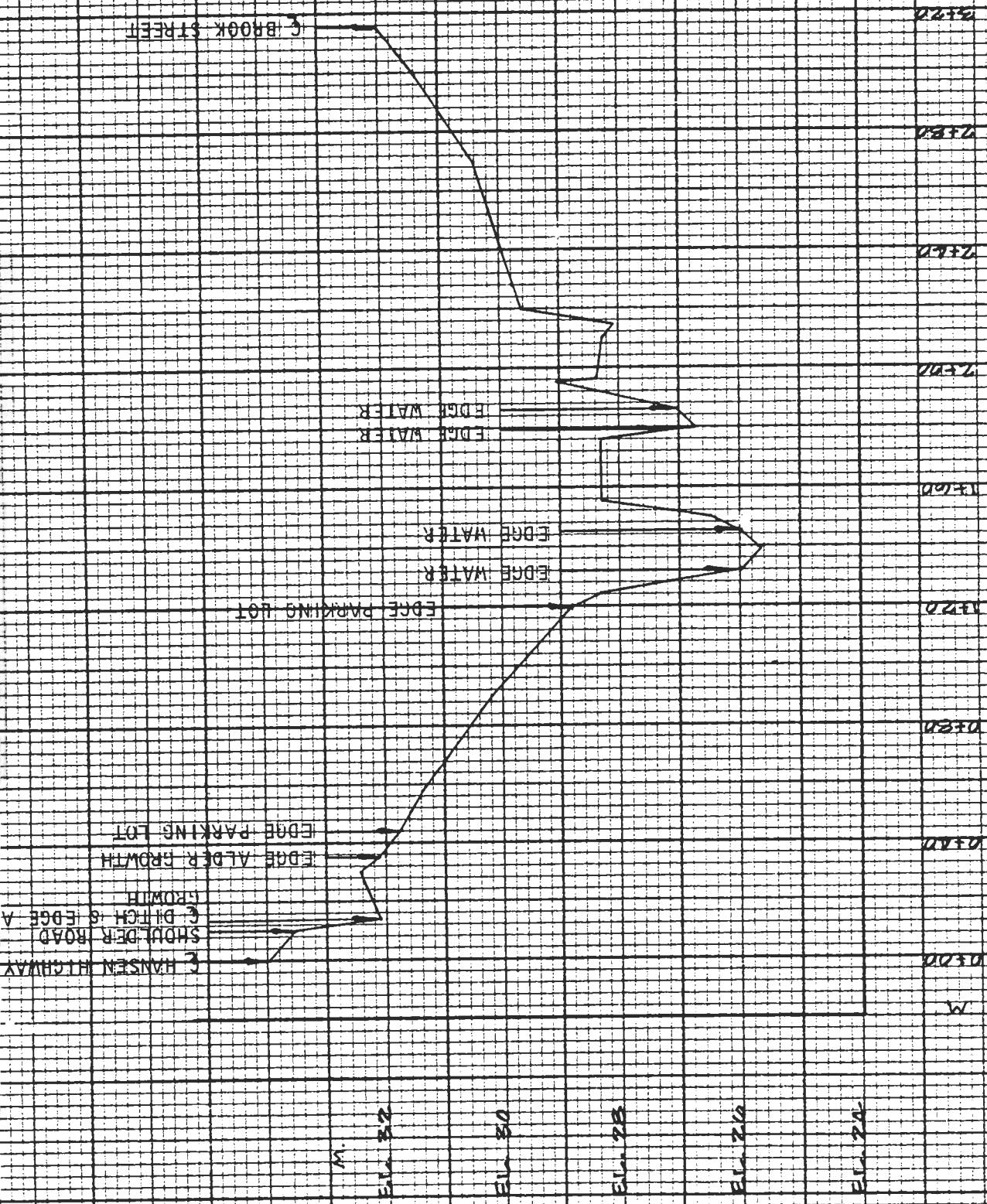
SECTION B-B' - 20

STA 29+61



SECTION BBB-21

STA. 30+71



C. QUEEN STREET

EL. 34

EL. 30

EL. 28

EL. 26

EL. 24

ALONG C. HANSEN HIGHWAY

END BFT DATE

BOTTOM OF DEEK BEAM EL. 29.74 m

CHANNEL

NOT

347

02+0

03+7

04+2

04+7

05+7

06+1

06+0

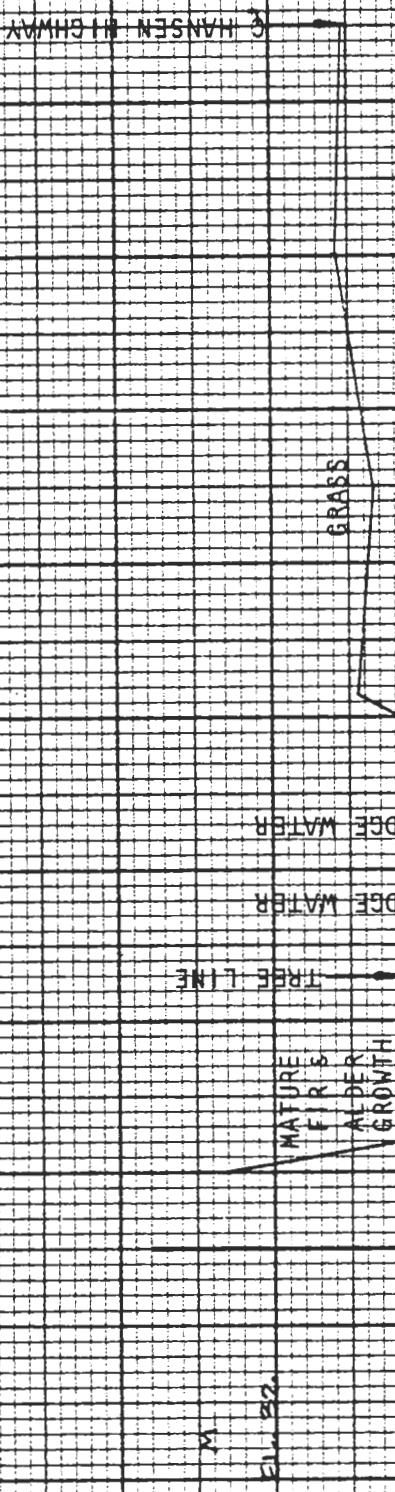
07+0

08+0

SECTION E9C - 22
STA. 31+71

SECTION BBB-23

STA. 3 + 95



13/02

15/02

02/03

04/03

05/03

07/03

11/02

02/03

03/03

M

SECTION MC - 30

S+A 69+33

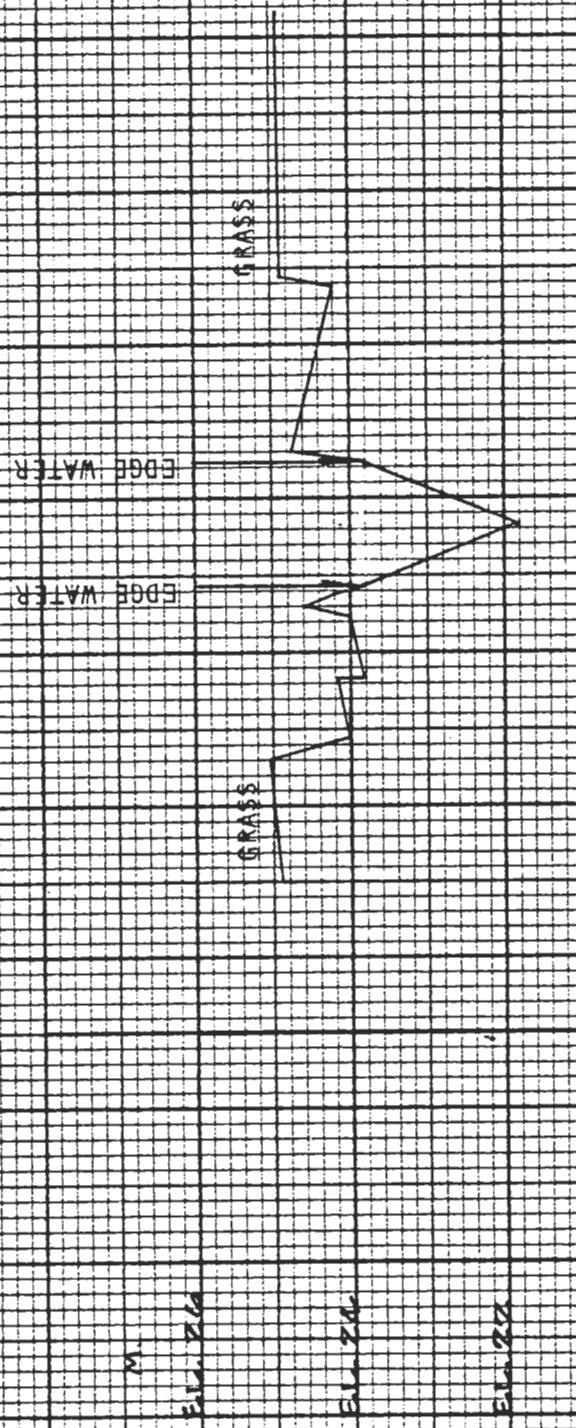
16+0

09+0

0+30

00+0

W



SECTIONAL VIEW - 31

S.T.A. 71+03

02+00

06+00

07+00

08+00

09+00

M

A

EL. 26

EL. 24

EL. 22

ALDERS

GRASS

EDGE WATER

EDGE WATER

SECTION STA. 7+65 W.C. = 32.

EDGE ALDER GROWTH

C TRACK

EL 220

EL 200

EL 180

EL 160

EL 140

EL 120

EL 100

EL 80

EL 60

M

SHOULDER ROAD

C BITCHI

HANGEN HIGHWAY

C SHOULDER ROAD

C BITCHI

EDGE WATER

C WATER

EDGE ALDER GROWTH

C WATER

EL 220

EL 200

EL 180

EL 160

EL 140

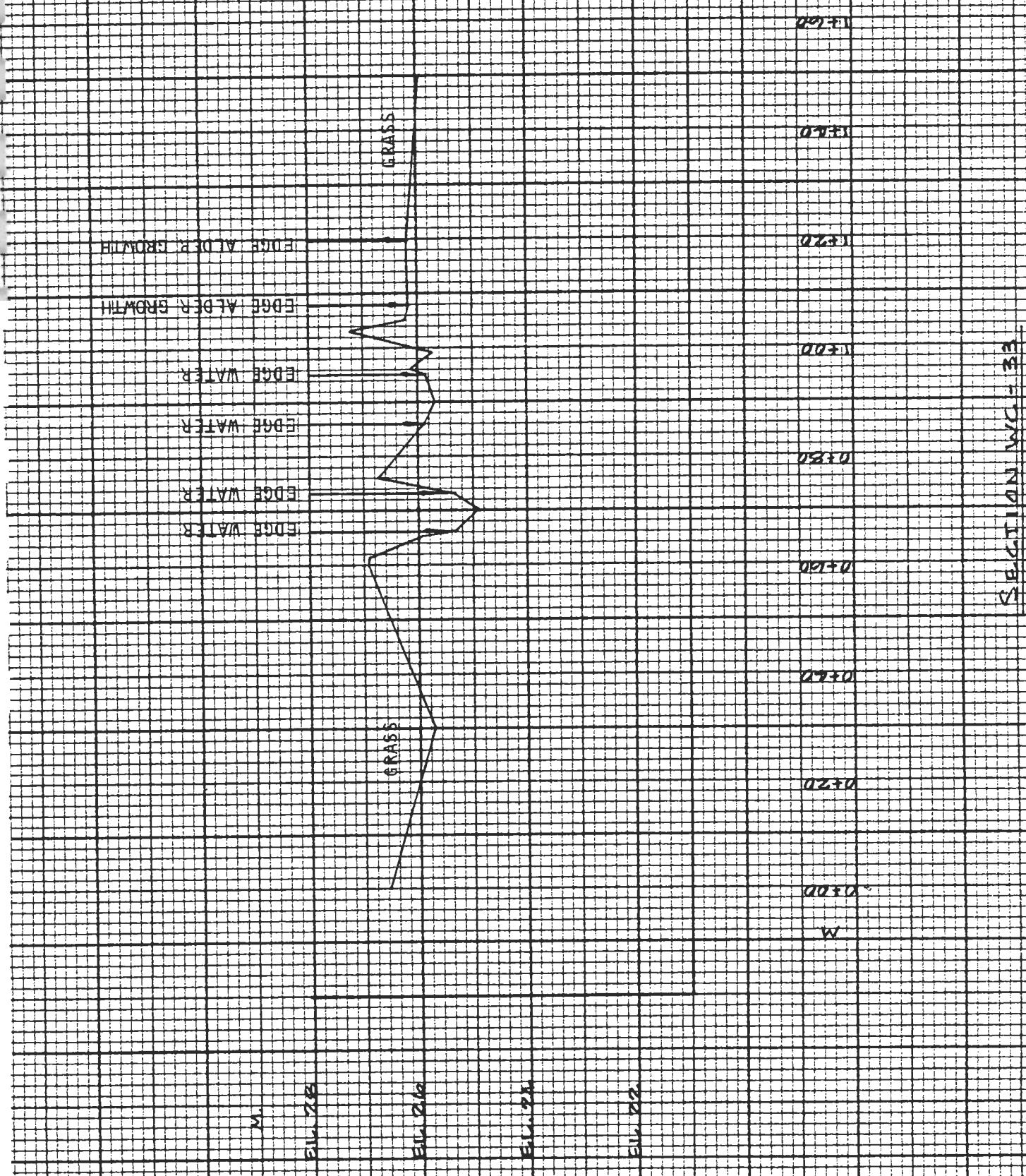
EL 120

EL 100

EL 80

EL 60

M



STA 73425

EL. 3.2

MATURE
TREE
GROWTH

EL. 3.2

EDGE WATER
EDGE WATER
EDGE WATER
EDGE WATER

EL. 2.8

GRASS

EL. 2.6

ALONG EDGE OF STREAM

EL. 2.4

00+00

2

00+00

00+00

00+00

00+00

SECTION 2 N. V/C = 3.4
STA 75+85

C-SKI TRAIL

EL 34

EL 36

EL 32

EL 32

EL 30

EL 28

TRAIL LINE
EDGE WATER
EDGE WATER

MATURE POPULAR
3 FIR TREE
1 BIRCH

GRASS

0582

0440

0072

0071

0220

0580

0440

0070

M

SECTION MC = 35

STA 78+35

SECTION LINE 30



SECTION B-B' - STA. 33+69

06+00

04+00

02+00

00+00

M

EL. 78

EL. 80

EL. 82

EL. 84

EL. 86

EL. 88

EL. 90

M

EDGE WATER

SPADE J.E. R. X MAP E

CORNER OF HOUSE

SECTION B-E = 2.5
STA. 36+10

02+1

02+1

02+1

02+1

02+0

02+0

02+0

02+0

02+0

02+0

M

MATURE FIR & SPRUCE

MATURE FIR & SPRUCE

ST. 36

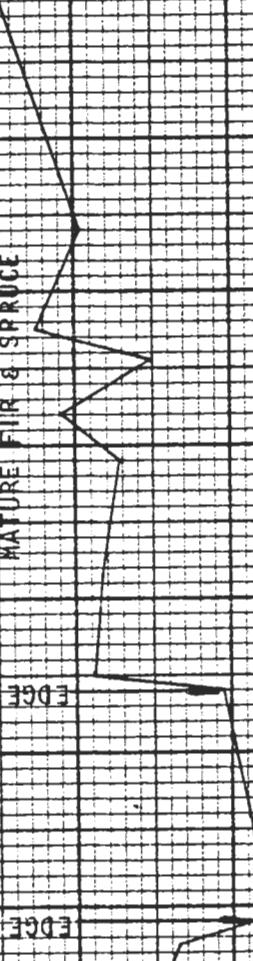
ST. 32

ST. 32

ST. 30

M

ST. 38



SECTION 24 NYC = 1
S.F. 1105

C MINNESOTA DRIVE
EDGE WADER
EDGE MATTER
GRASSY FIELD
C MASSACHUSETTS DRIVE

EL-10

EL-11

EL-12

EL-13

D-20

D-21

D-22

D-23

D-24

D-25

D-26

D-27

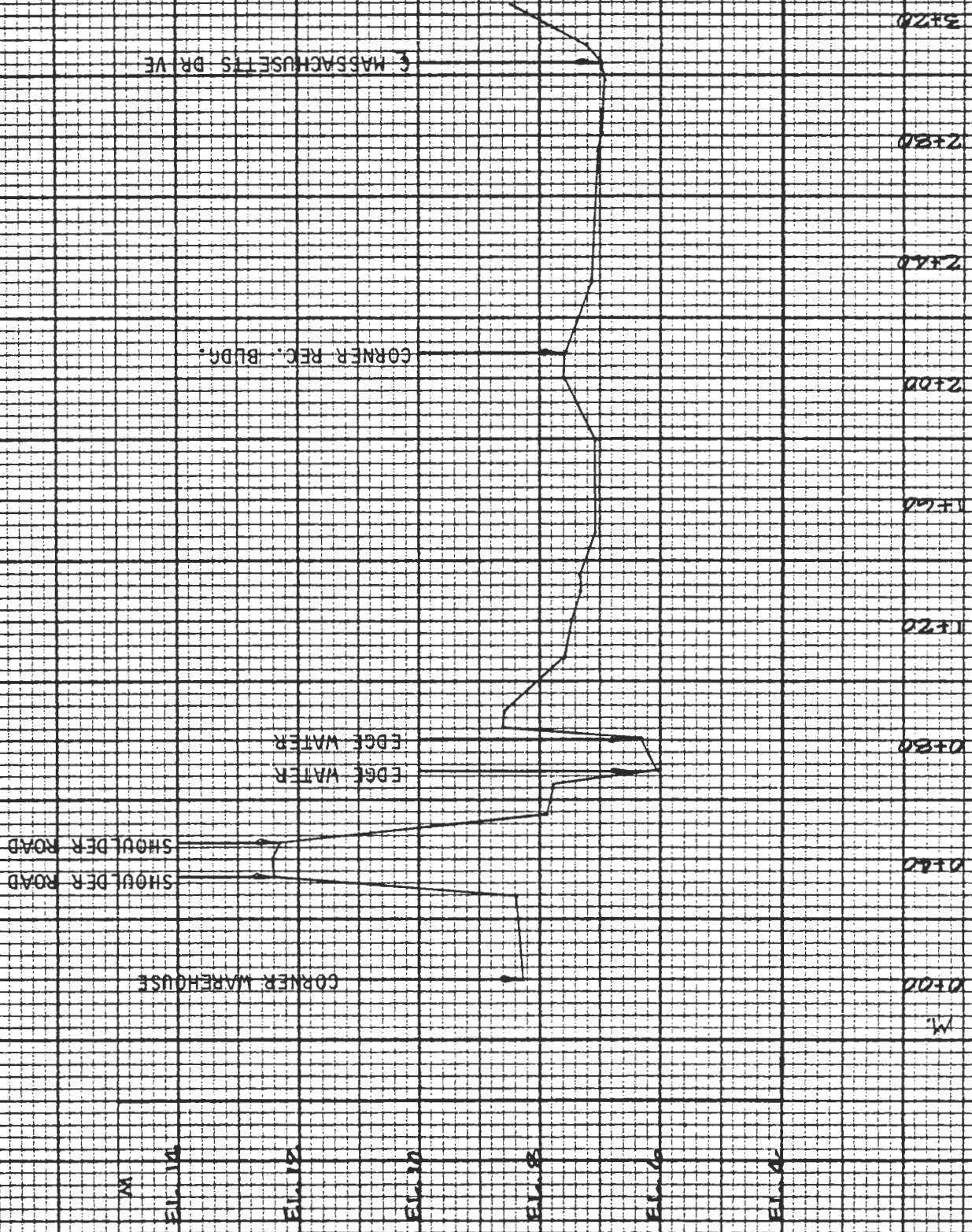
D-28

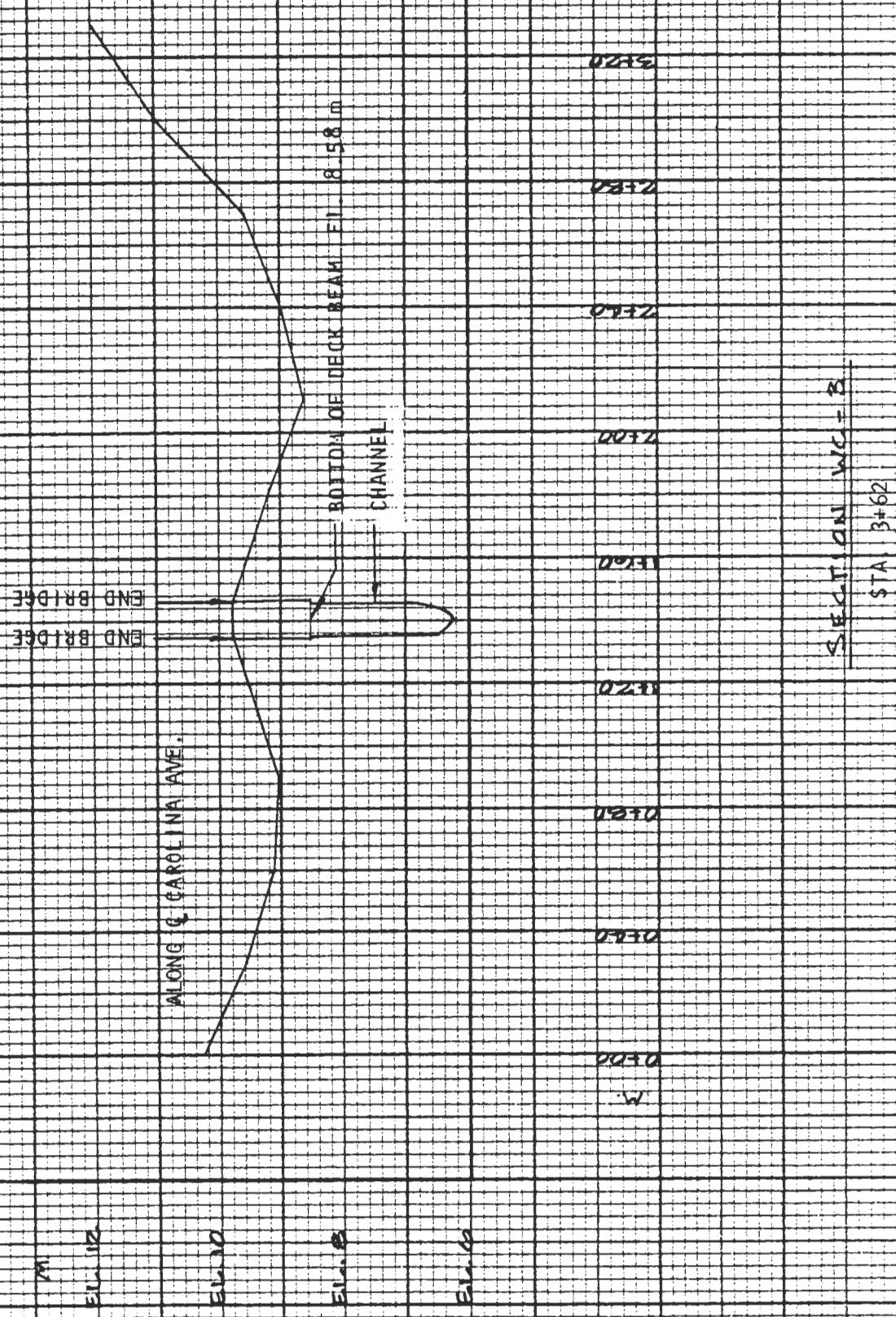
D-29

M

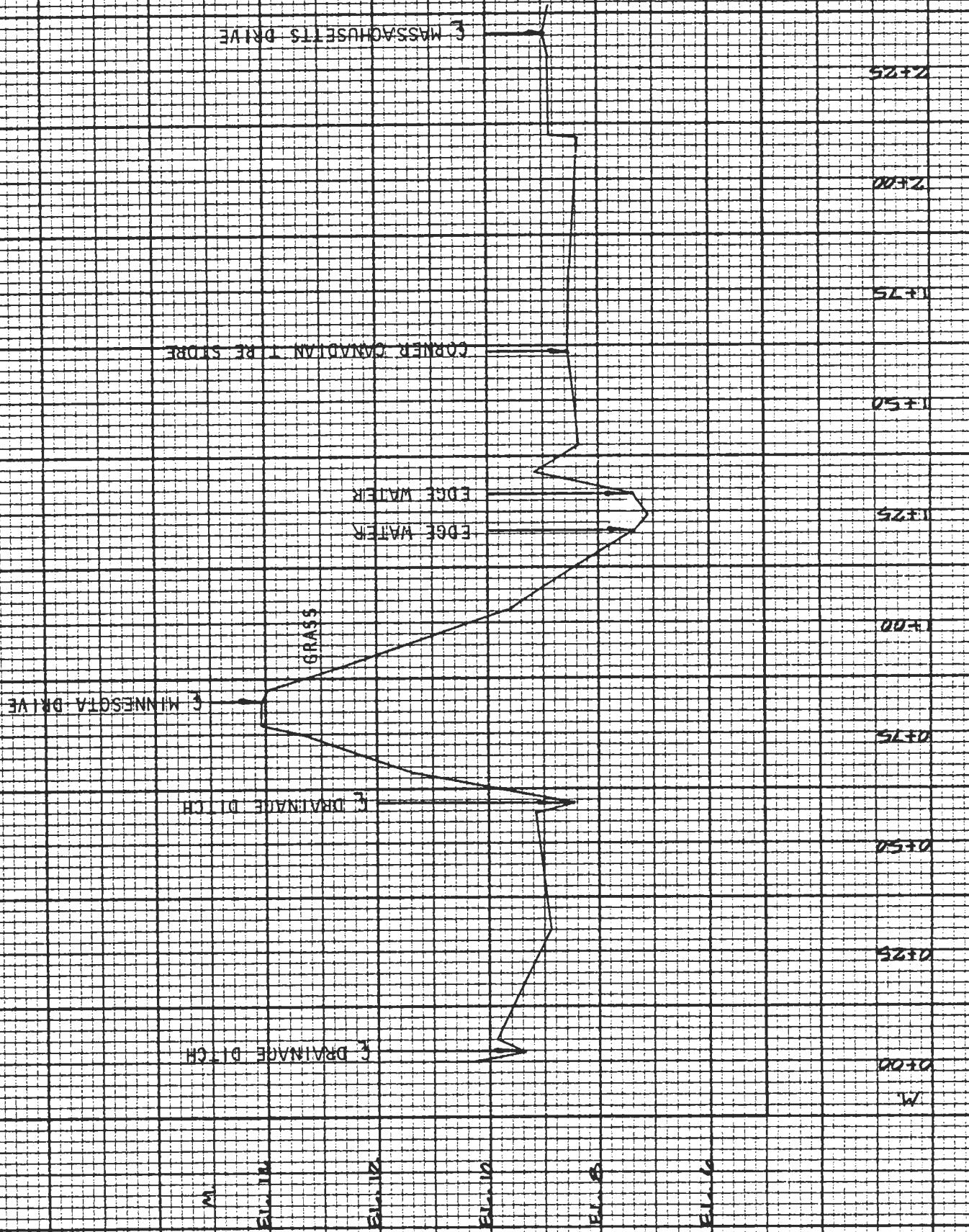
STA. 2+35

SECTION 4AC - 2





SECTION MC-4 - STA. 4+00



SECTION NO. - 5

STA. 4+73

MASSACHUSETTS DRIVE

ELL-10

ELL-12

ELL-8

ELL-6

ELL-10

W

SHOULDER ROAD
SHOULDER ROAD

EDGE WATER
EDGE WATER

ELL-10

ELL-10

ELL-10

ELL-10

ELL-10

W

ELECTRICAL WIRE - C
STA: 5+64

C MASSACHUSETTS DRIVE

CENTER OF BRIDGE

DITCH

GRASS

R.

EL. 1A

EL. 1B

EL. 2

EL. 3

11+80

11+60

11+40

11+20

10+80

10+60

10+40

10+20

10+00

9+80

M

SECTION W.C.-7
STA. 5+69

C MASSACHUSETTS DRIVE

0+40

0+70

1+00

0+80

0+60

0+40

0+20

0+00

M.

EDGE WATER

EDGE WATER

C MINNESOTA DRIVE

DITCH

M.

EL. 12

EL. 12

EL. 12

EL. 12

EL. 12

SECTION A-C - B

STA. 6+03

102±1

0+96

0+100

0+36

0+00

W

CORNER R. BLDG.

EDGE WATER

EDGE WATER

GRASS

C. MINNESOTA DRIVE

C. DITCH

GRASS

SW

SE

EL. 112

EL. 114

W

SECTION A-A
STL. 7+13

D+90

D+60

D+30

D+00

M

D-33

D-13

D-14

D-12

D-13

A

E DITCH
E MINNESOTA DRIVE

E DITCH

GRASS

EDGE WATER
EDGE WATER

C MINNESOTA RIVER

A

EL. 13

EL. 12

EL. 11

EL. 10

EL. 9

N

GRASS

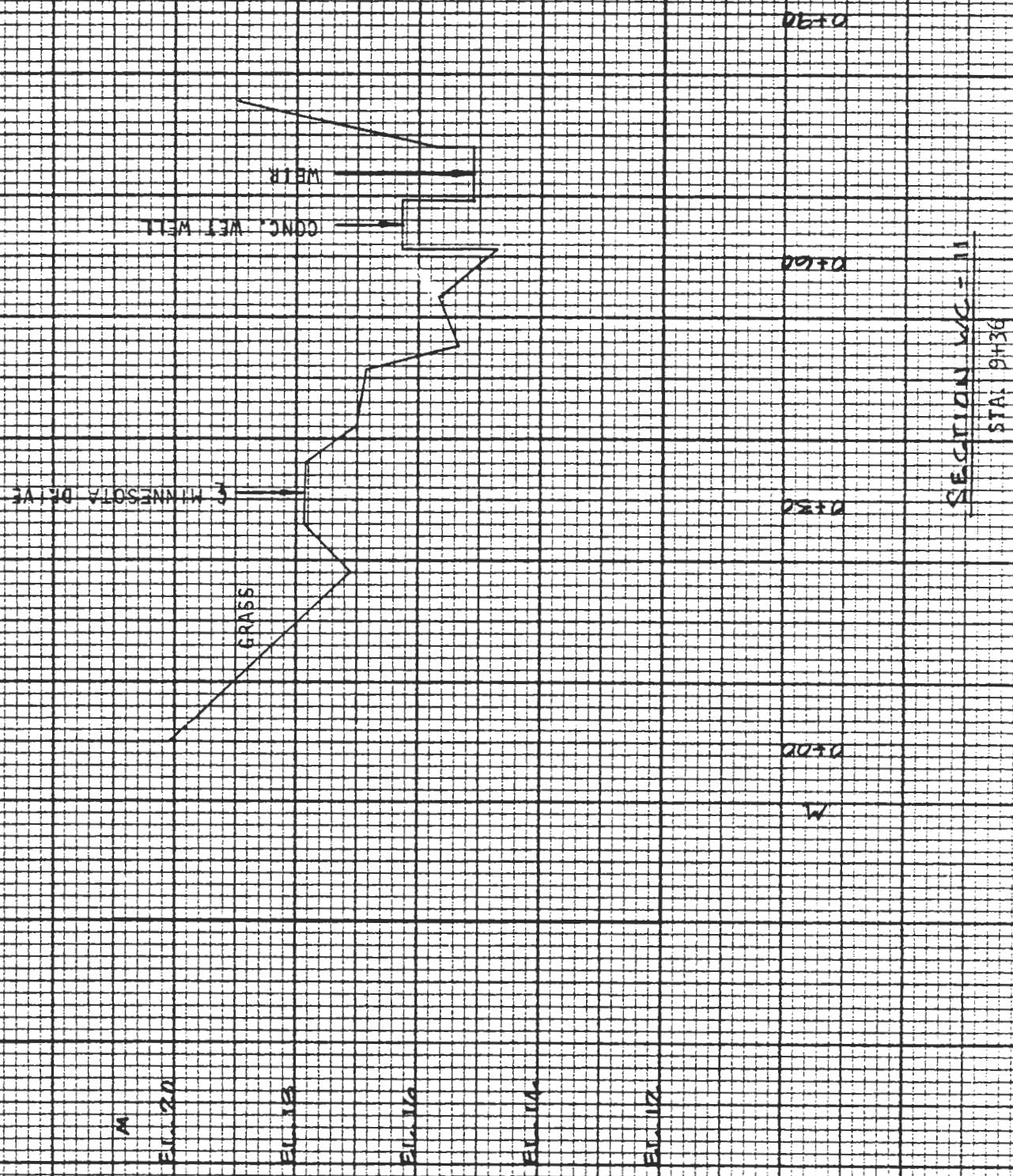
EDGE WATER

D+60

D+50

D+40

SECTION WC-10
STA. B+83



(3.0 m. DOWNSTREAM FROM LINE II)

STN. 9+33

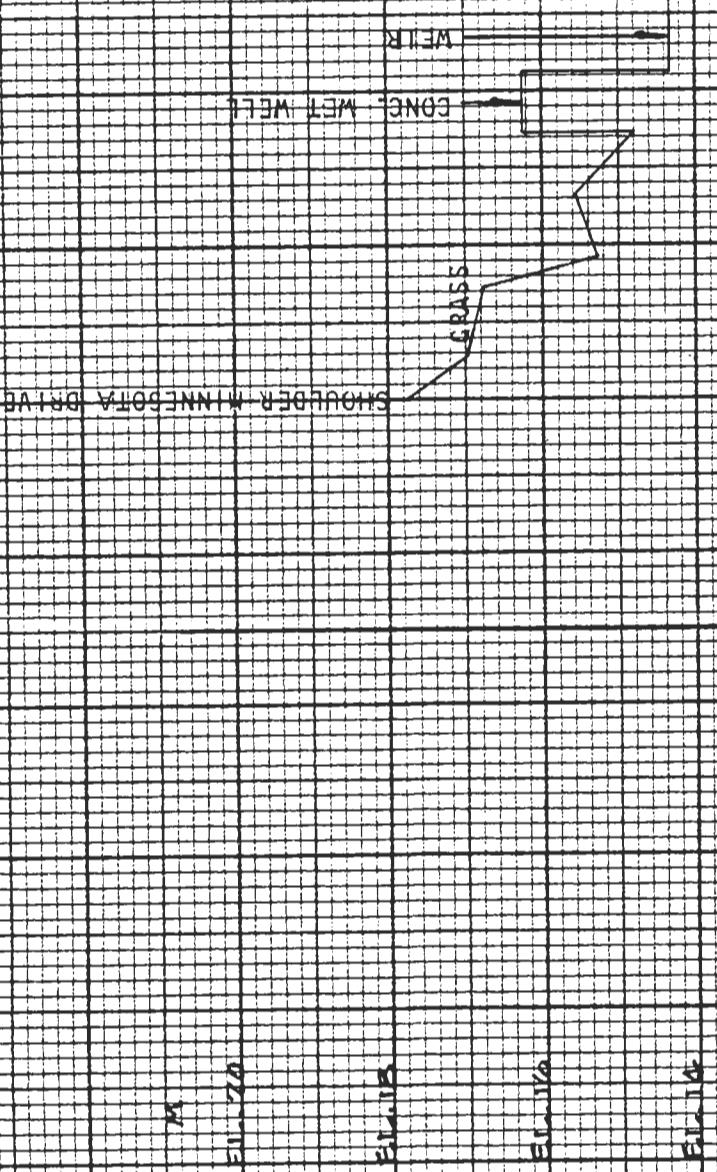
SECTION LINE = A

0+60

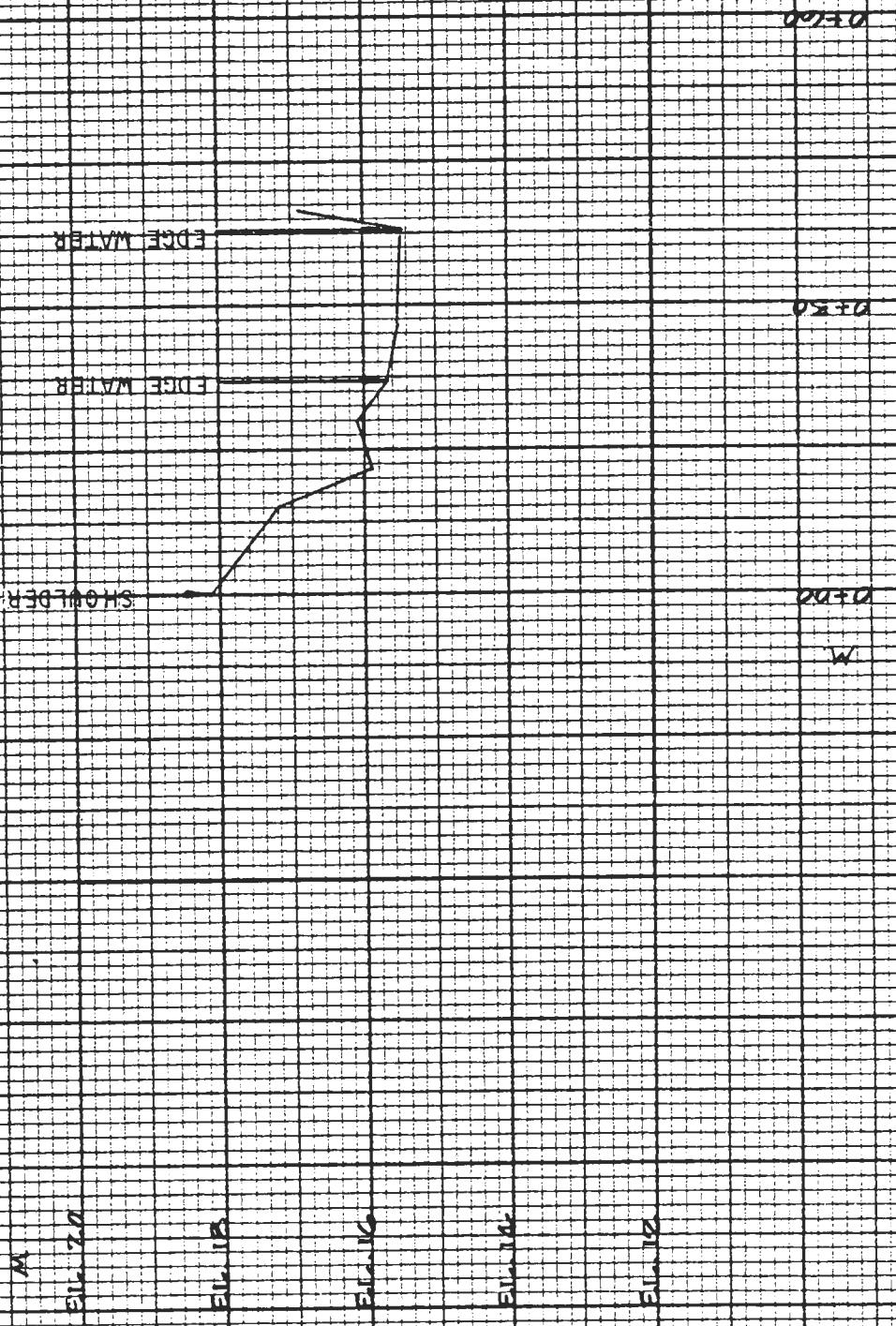
0+70

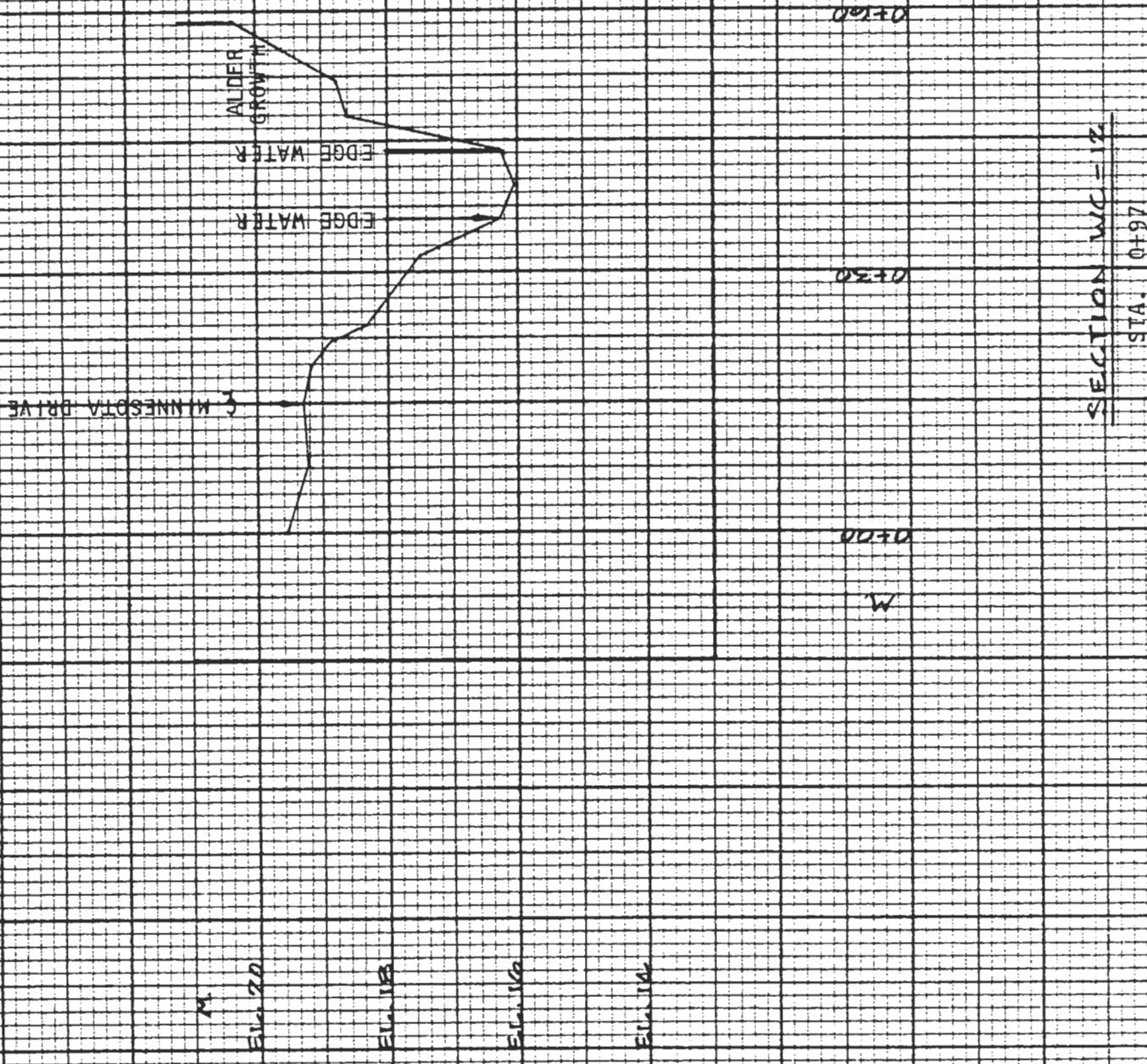
0+80

M.



SECTION W-C-W
(300M UPSTREAM FROM LINE 1)
STA 9+67





a

EL-22

EDGE WATER

A L D E R G R O W T H

EL-18

EL-16

w

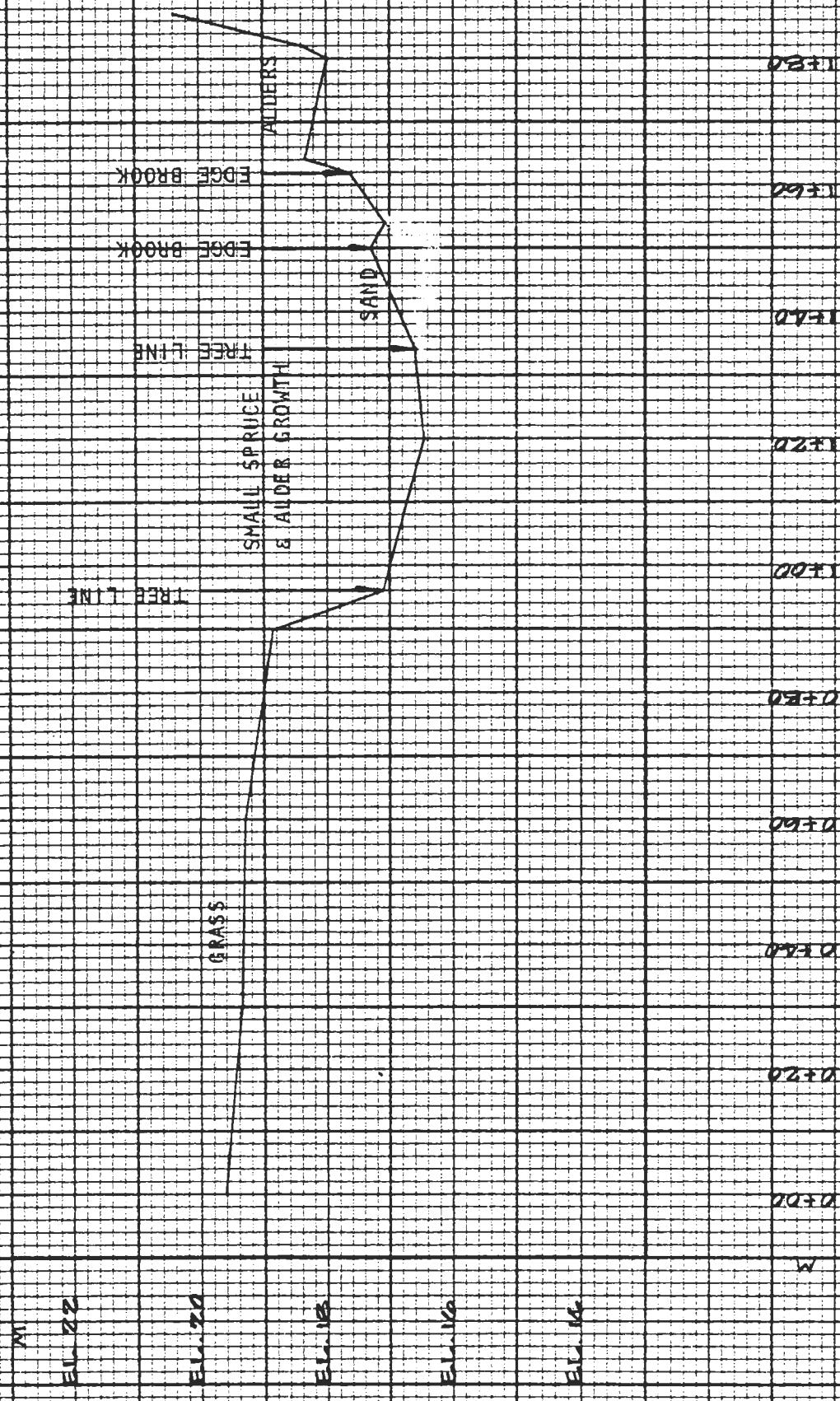
05+0

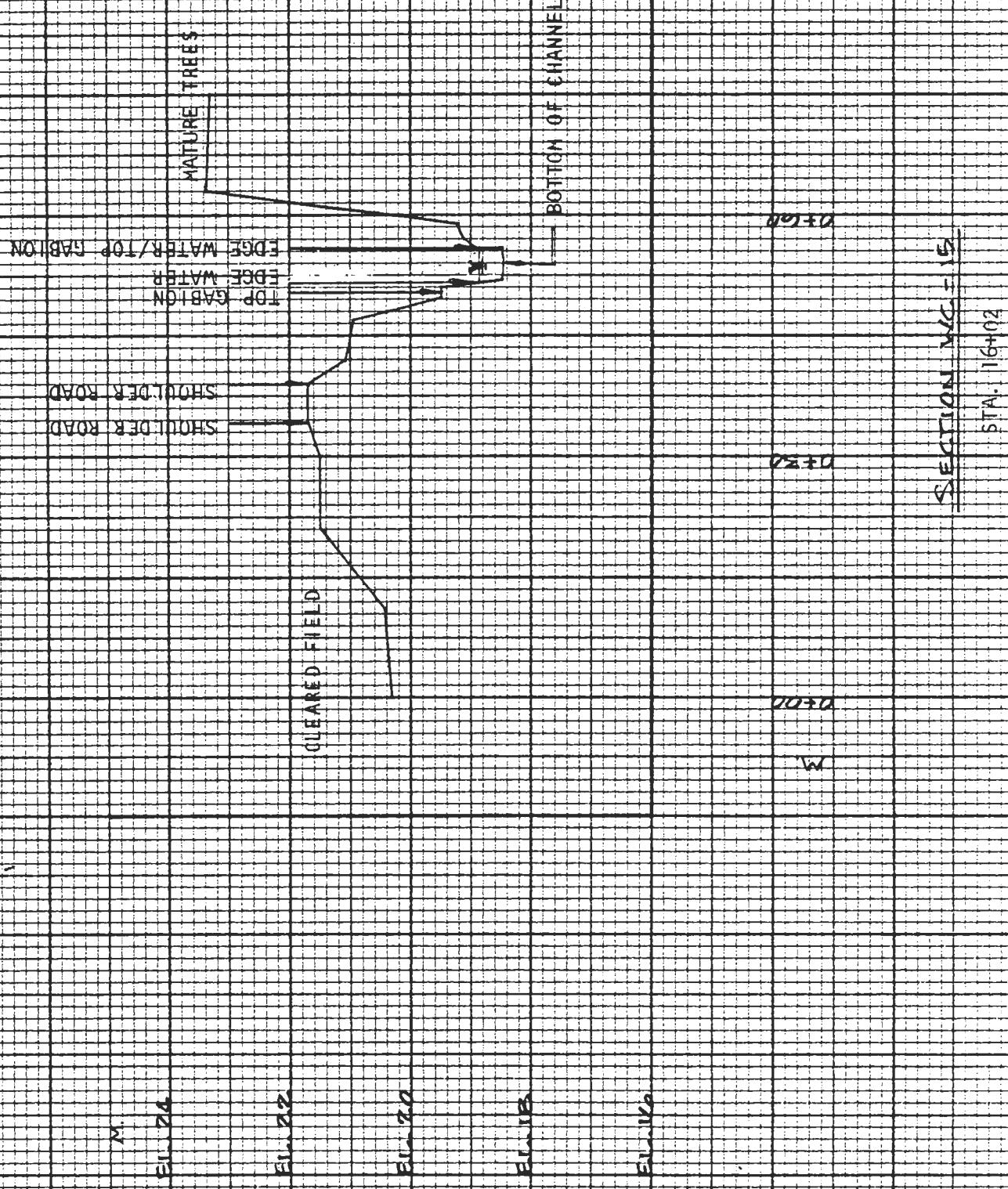
05+0

05+0

SECTION WC = 13
STA. 11+82

SECTION LINE STA. 4+32





SECTION WC-1
STA. 16+34

NATURE
SPRUCE

TOP SABION
TOP CABION

CLEARING AREA

FREE LINE

P.

EL. 22

EL. 20

EL. 18

EL. 16

EL. 14

M

00+2

00+0

00+1

00+2

00+1

00+1

00+2

00+1

00+0

00+0

00+0

SECTION W/C - 17

STA. 17+58

5232

2030

5131

1150

5231

2031

5131

1150

5230

2030

M

PROFILE ALONG C.N.R. TRACK BED

END OF TRACK

M

E.L. 24

E.L. 22

E.L. 20

E.L. 18

4 - C.M.P. CULVERTS
1.2 M.D.A.

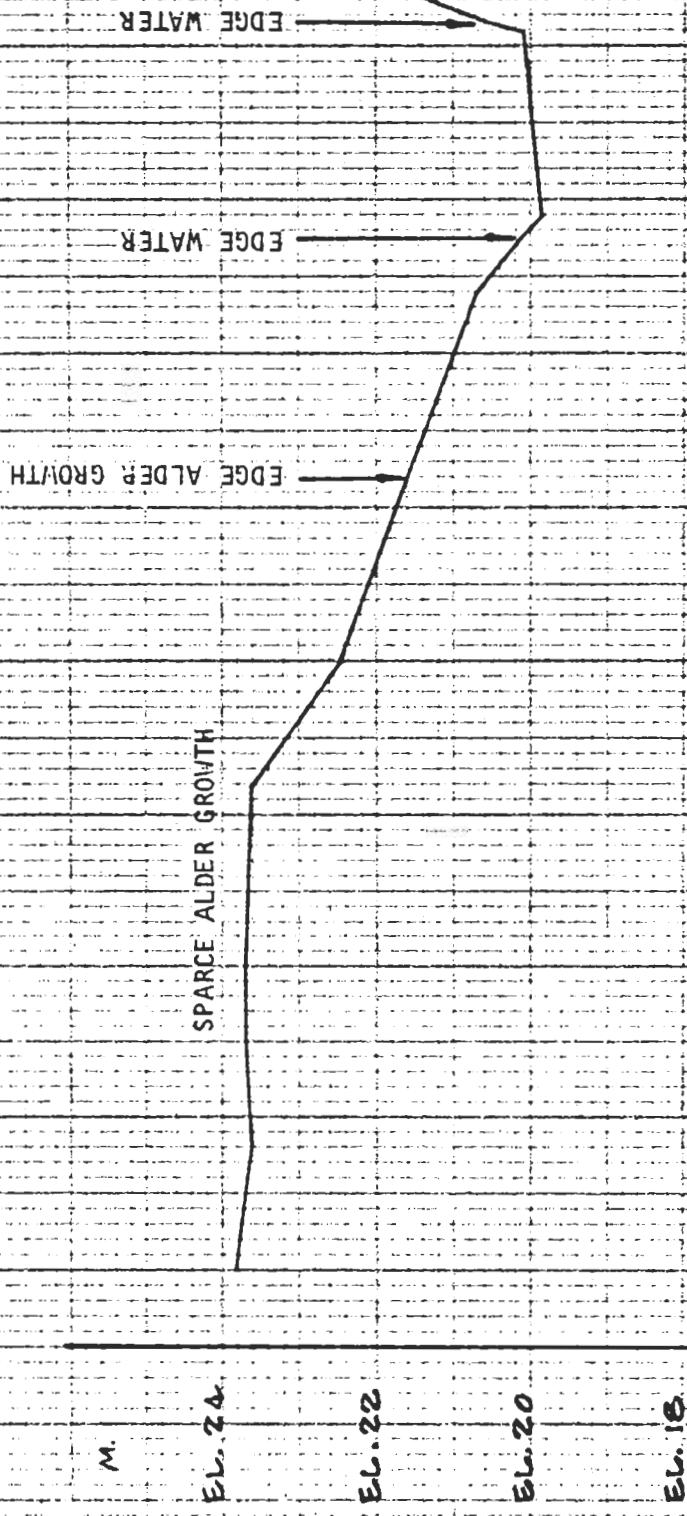
WASHOUT AREA

UPSTREAM N.Y.
DOWNSTREAM N.Y.

CULVERT - MPN 05

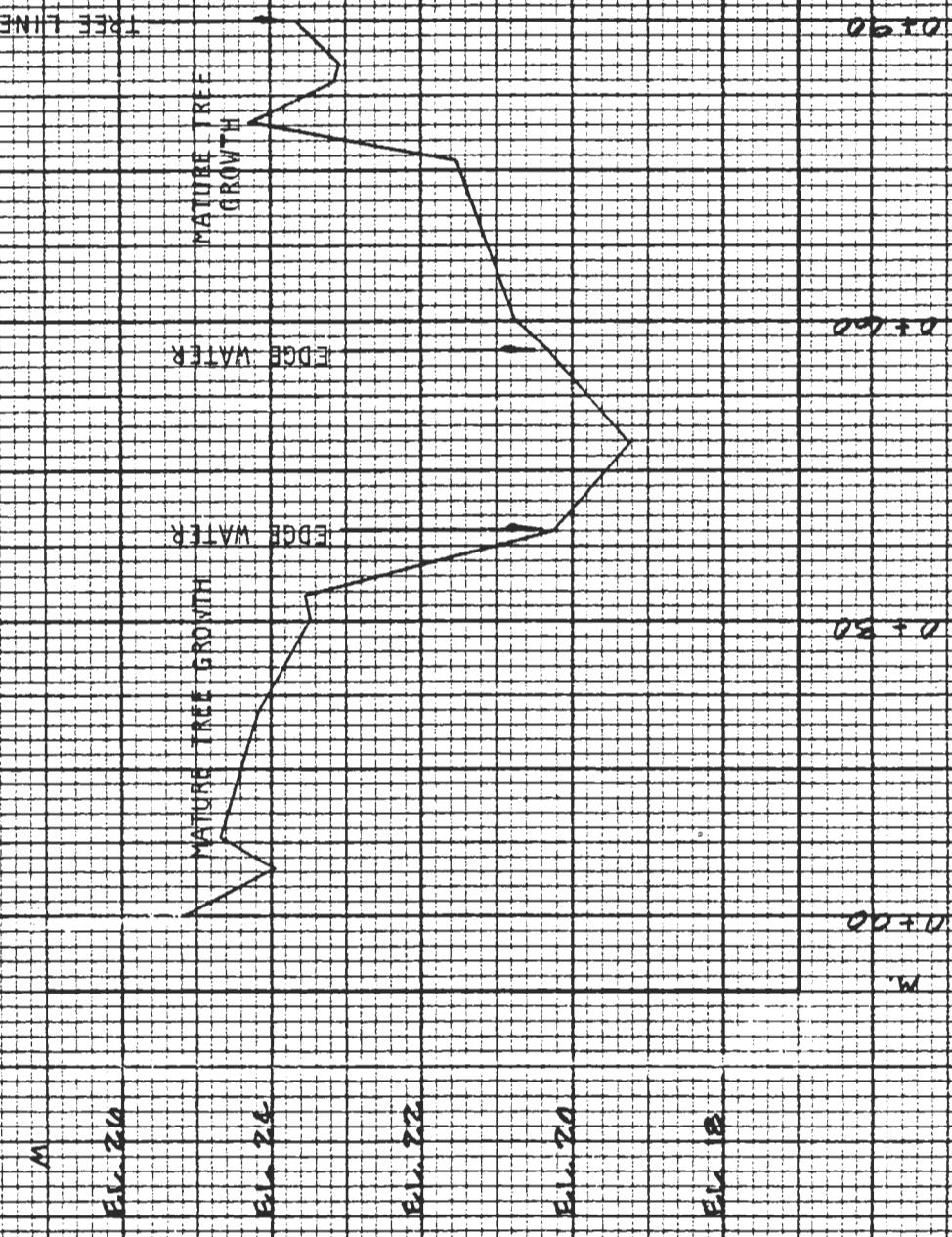
SECTION WC-1B

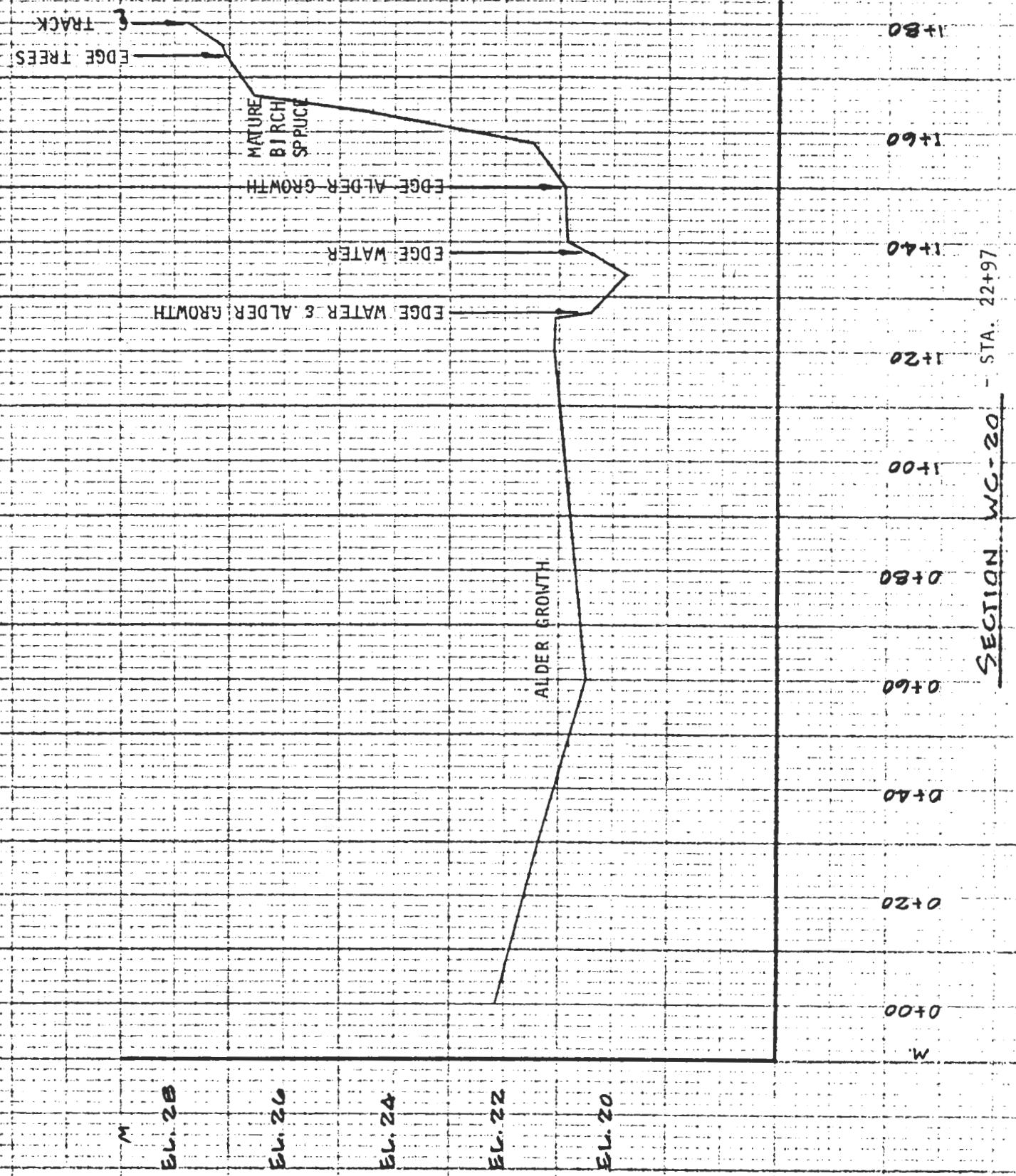
STA. 17+64



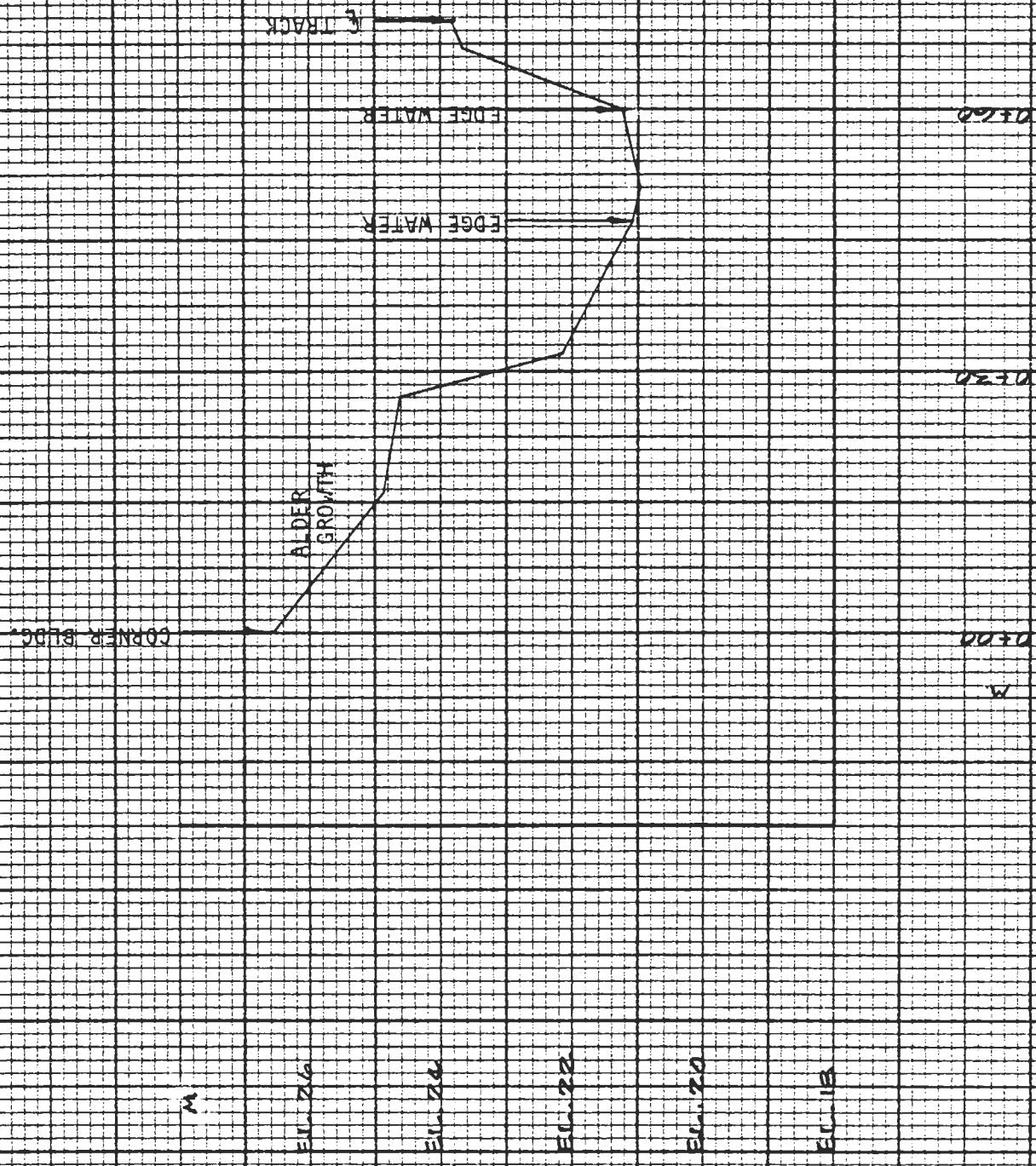
SECTION MC-9

STA. 8+37

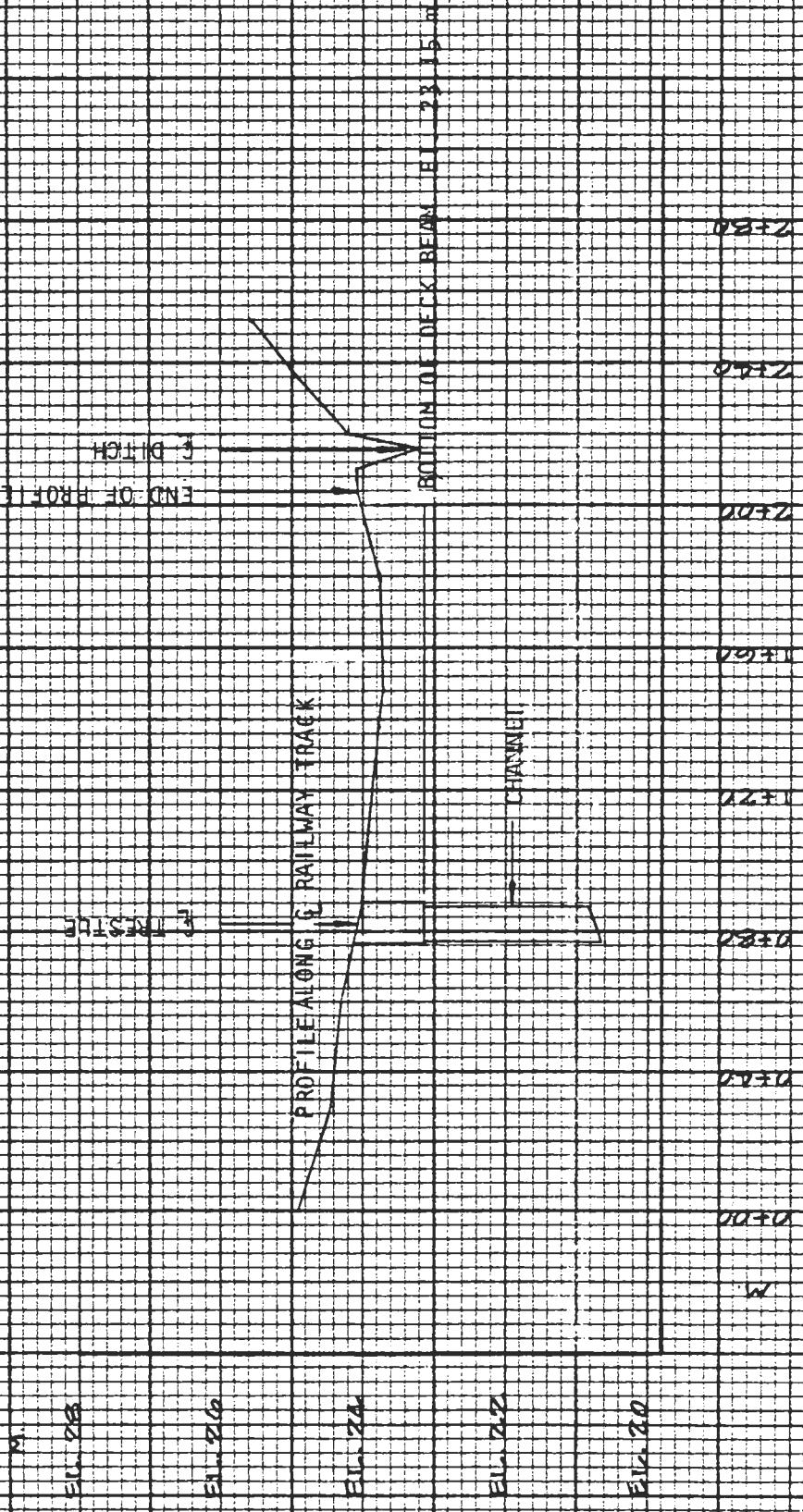




SECTION MC - 21
STA. 27+12

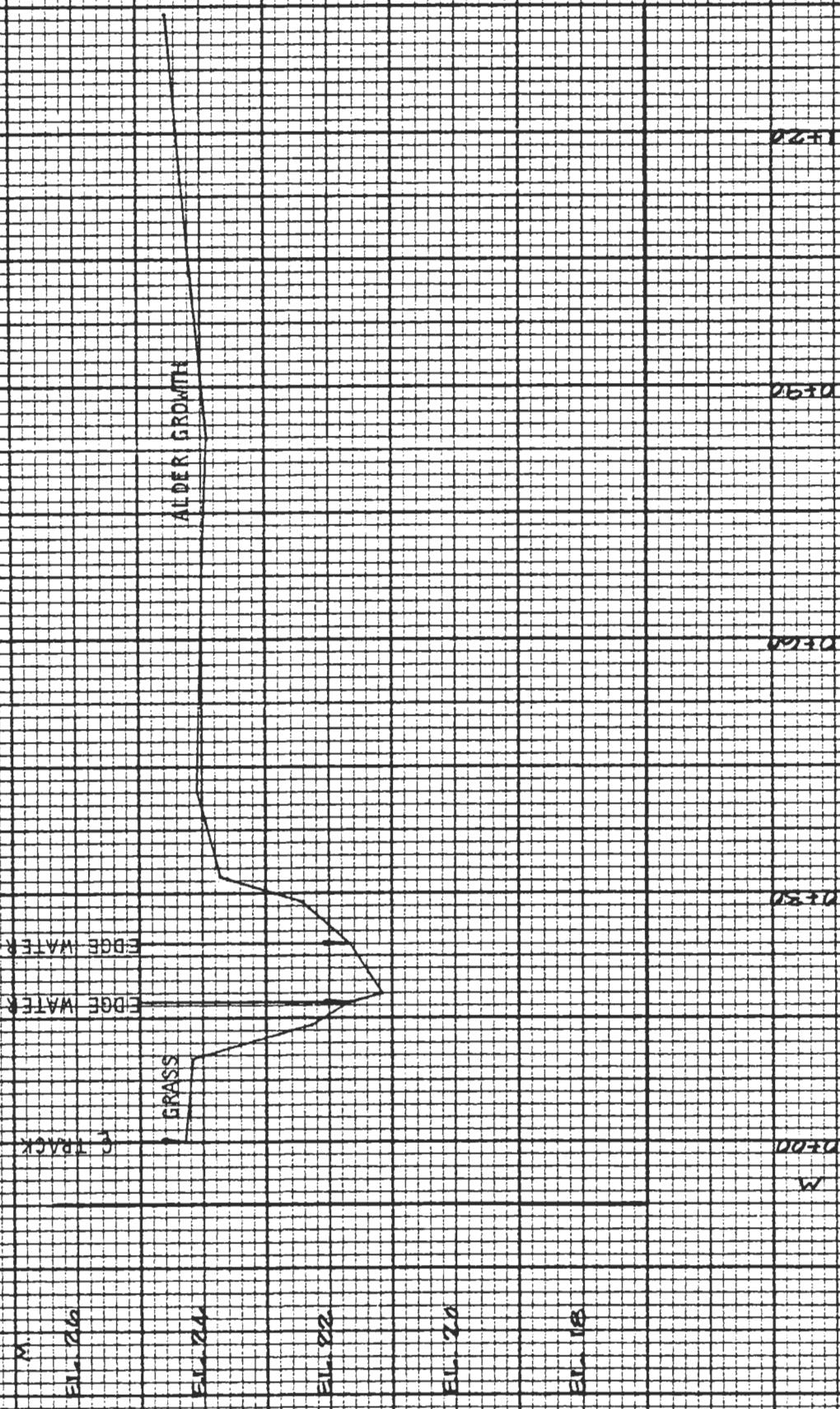


SECTION W/C - 22
STA. 28-88



SECTION NO. 23

STA. 28+90



SECTION A-A 29+11

SECTION A-A C=24

EL-20

EL-180

EL-170

EL-160

EL-150

EL-140

EL-130

EL-120

EL-110

M

EL-20

EL-19

EL-18

EL-17

ALONG T-E CONNEC'TIVE DRIVE

END BRIDGE

END BRIDGE

C TRACK E G CONNEC'TIVE DRIVE

BOTTOM OF DECK BEAM F-24-07 III

CHAMFER

M

EL-20

EL-19

EL-18

EL-17

STA. 2H+52

SECTION LINE = 25

00+00

02+00

00+00

V

EL. 20

EL. 22

EL. 24

EL. 26

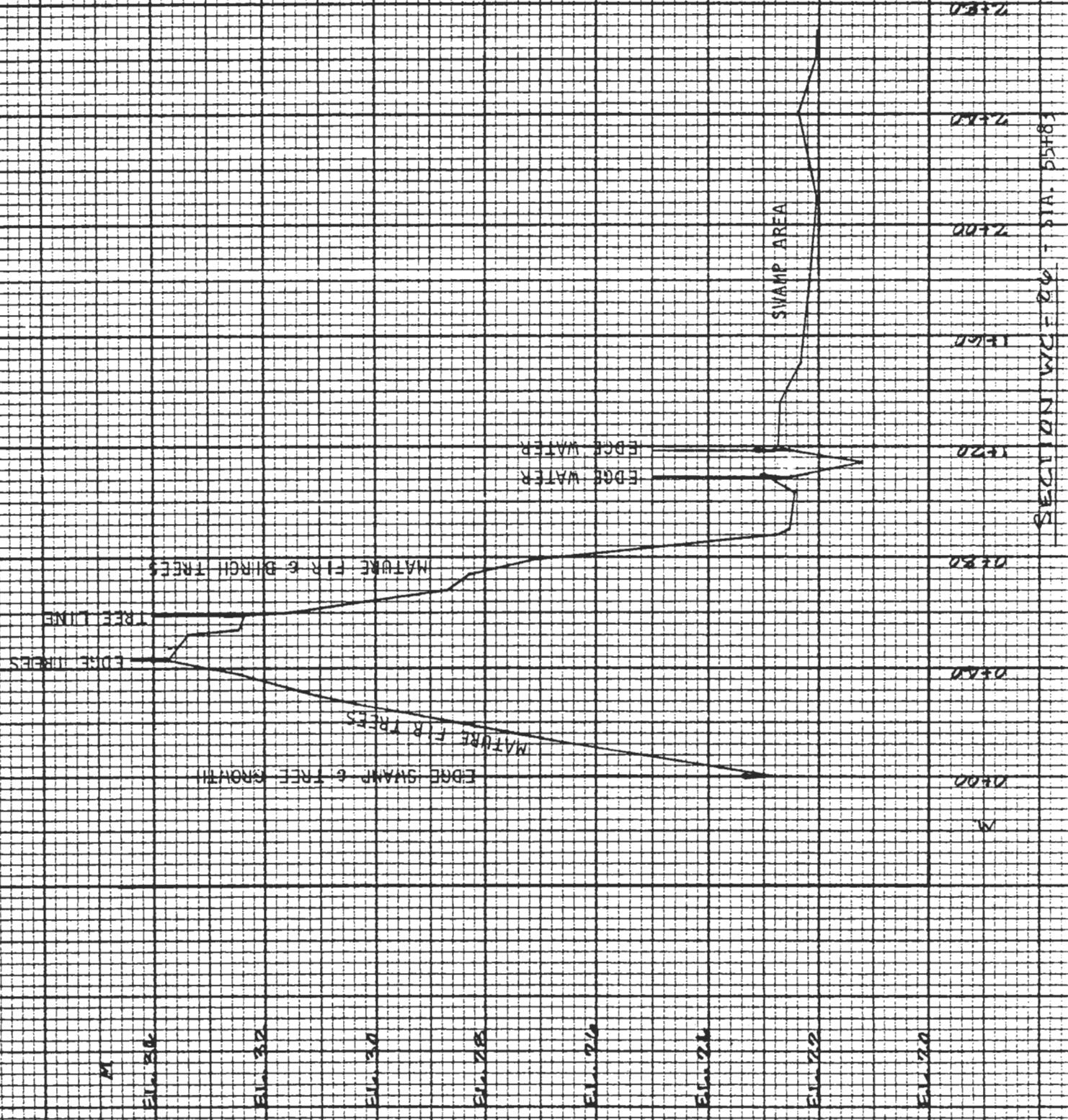
N

DRIVE TO SWAMP

ALDER GROWTH

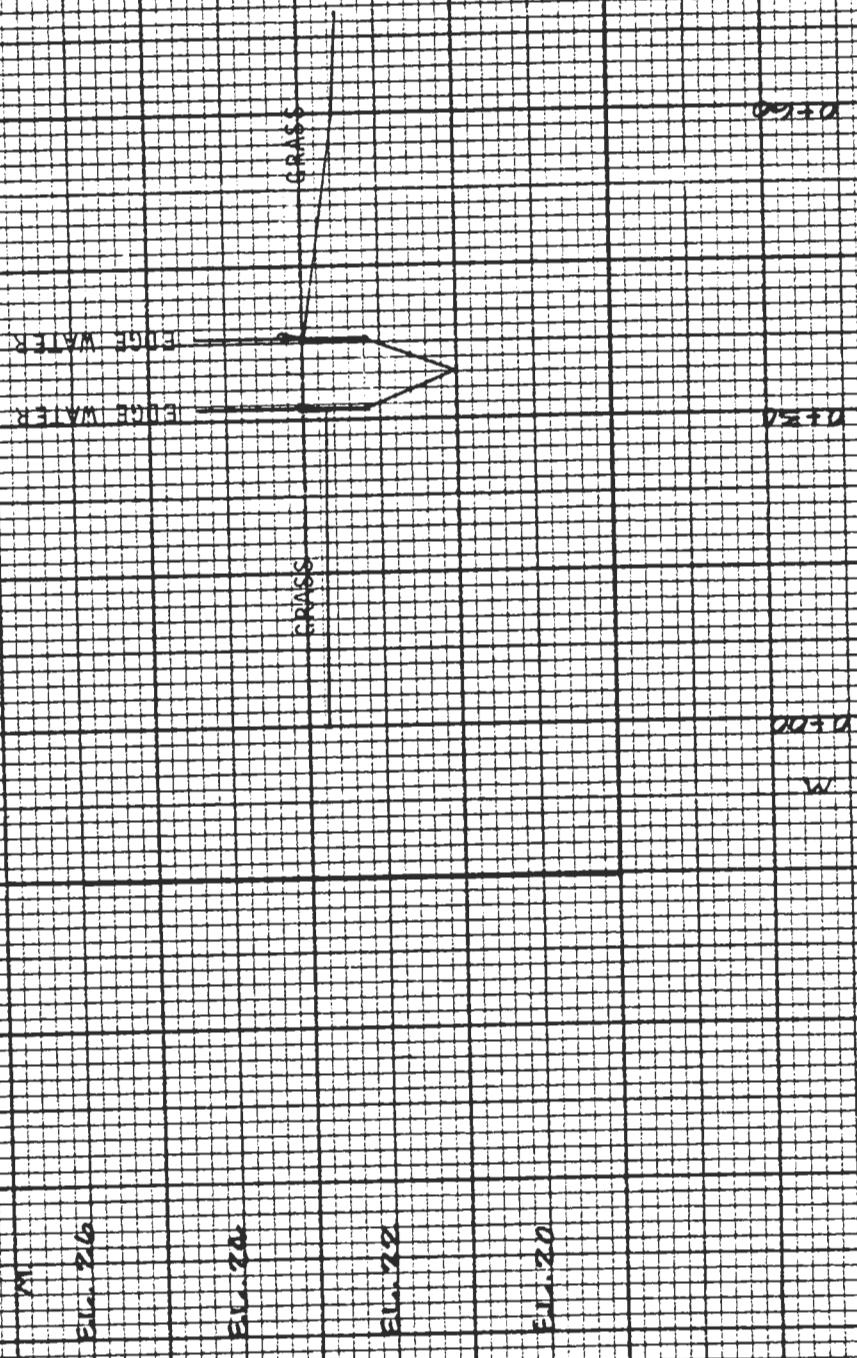
EDGE OF WATER

SWAMP



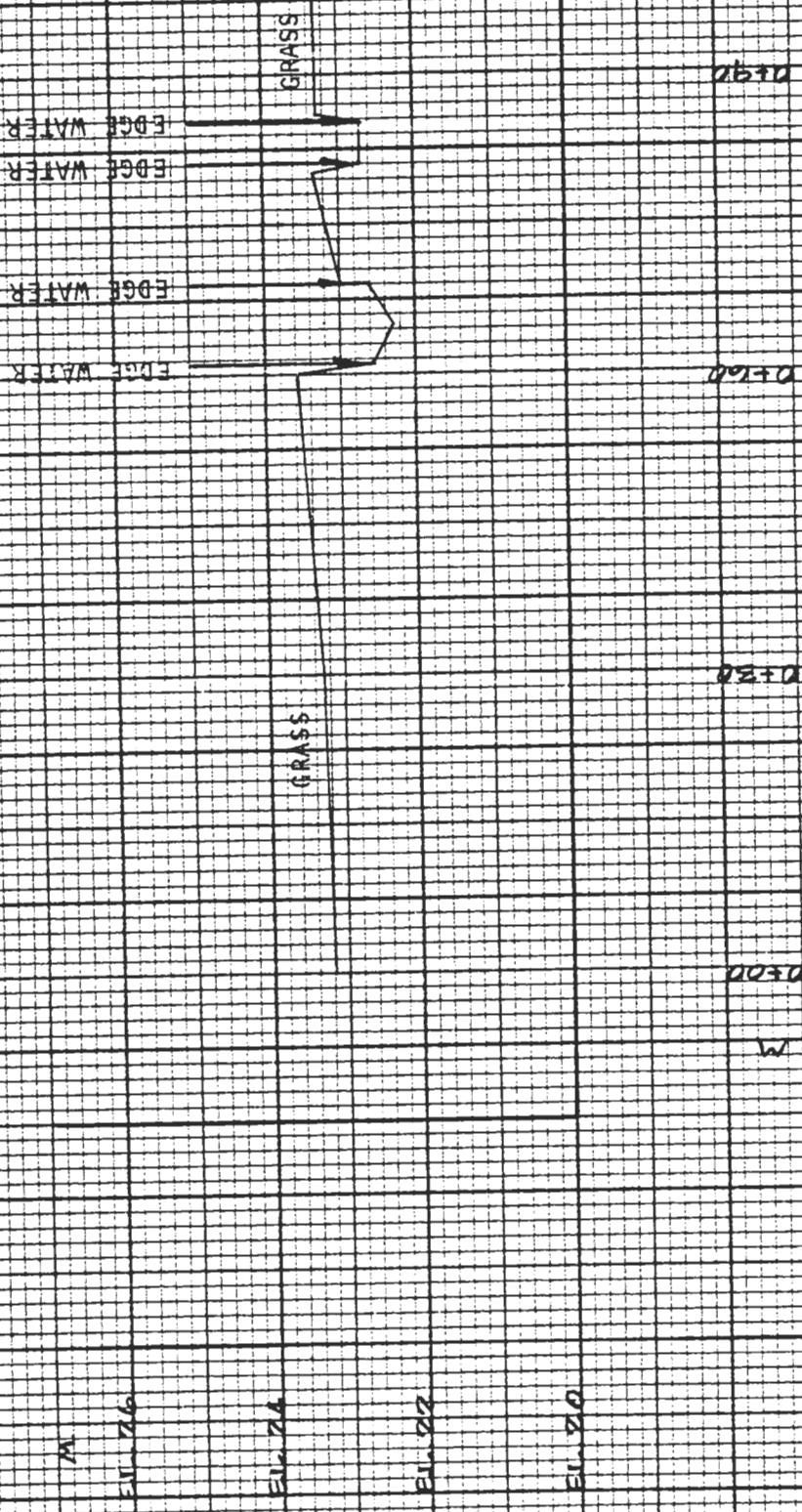
$$57 + 38 = 95$$

L2-2M NOV 1965



SECTION VC - 28

STA. 61+38



SECTION WC-29

STA. 6+08

TREE LINE

GRASS

EDGE WATER

GRASS

M

EL-26

ST-24

EL-22

EL-20

00+55

00+50

00+45

00+40

00+35

00+30

00+25

00+20

00+15

00+10

M

