



Public Works  
Canada

Travaux publics  
Canada

Western Region

Région de l'Ouest



MACKENZIE HIGHWAY, N.W.T.  
MILE 495 TO MILE 521  
PRELIMINARY DESIGN DATA

MEMORANDUM

NOTE DE SERVICE

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Western Region

SECURITY CLASSIFICATION DE SECURITE

OUR FILE - N. REFERENCE

9305-52-300

YOUR FILE - V. REFERENCE

DATE

December 13, 1973

SUBJECT  
OBJET

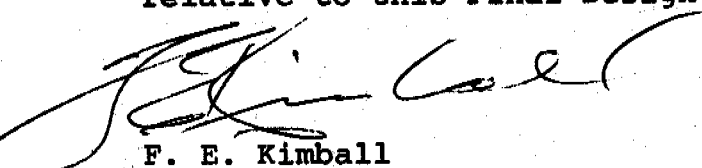
PRELIMINARY DESIGN SUBMISSION - MILE 495 TO MILE 521  
MACKENZIE HIGHWAY

Enclosed are 24 copies of the narrative portion of the above-noted Design Submission. Two sepia copies of the plans have been forwarded under separate cover.

Six copies of the narrative and a sepia of the plans have been forwarded to Mr. J. Hamilton of D.I.N.A. in Yellowknife. Single copies of the narrative and a single set of prints have been forwarded to D.O.E. in Edmonton and Winnipeg and E.M.R. in Calgary.

No bridge plans or data has been submitted, however, tentative gradelines are shown on the plans. Final gradelines for the dashed sections will be submitted with the bridge consultant's drawings.

Every attempt has been made to answer all questions and provide all information requested by various reviewing agencies. It would be appreciated if you could obtain an early response identifying any omissions or additional information requirements relative to this Final Design Submission.



F. E. Kimball  
Project Manager NWT Roads  
Western Region

Encl.

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## INTRODUCTION

The design of the Mackenzie Highway from Mile 495 - Mile 521 is in accordance with the General Design Data Report published on August 20, 1973 by Public Works of Canada, Western Region.

The narratives contained in this Report, Detailed Design Data for Mile 495 - Mile 521 of the Mackenzie Highway, supplement the General Design Data Report of August 20, 1973 by providing full consideration to specific concerns as identified in the Mackenzie Highway Environmental Working Group's Consolidated Comments relevant to this Design Submission.

Submissions requested in the Information Deficiency Report of January 18, 1972 are also contained, based on Public Works understanding of I.N.A. requirements. The M.H.P.M. has not directed Public Works on the exact submission requirements relative to E.W.G. requests.

The reader should note that this Report forms part of a total Design Submission, the major portion of which is contained in separate plan form.

Attention is also drawn to the fact that the drawings contain complete notes of design and impact assessment for hydrology, culverts and environmental impact.

CHAPTER 1REFERENCE: Consolidated Comment - Blackwater ISUBJECT: R.O.W. Location Alternatives(a) Consolidated Comment - Blackwater I - Addendum -  
Problem 7

An N.W.T. Agency Assessment Report recorded the possible presence of a subterranean creek at Mile 499.7. If, indeed present, special engineering precautions may be required, or an alternative location may have to be considered.

- Evidence of a subterranean creek at Mile 499.7 is not apparent to the designer. It is requested that a copy of the Agency Assessment Report suggesting the presence of a subterranean creek be made available to D.P.W. for further assessment of this area.

CHAPTER 2

REFERENCE: Consolidated Comment Blackwater II

SUBJECT: Ditching in Areas With High Ice Content  
Permafrost.

(a) Consolidated Comment - Blackwater II - Recommendation 3

*Regarding segments Mile 473.5 - Mile 478.5 and Mile 493 - Mile 500 it is recommended that extensive test drilling be undertaken to determine the distribution of high ice content permafrost, and that ditching should only be considered where entirely unavoidable in terms of the recommendations of Consolidated Comment III (463 - 500P).*

The geotechnical information shown on the Plan Profile Mile Sheets generally indicate visible ice from Mile 495 - 500. With an overlay fill type cross-section being proposed by the design throughout this area, minimum implications are anticipated throughout this section.



CHAPTER 3REFERENCE: Consolidated Comment Blackwater VSUBJECT: Culverts, hydrologic and hydrotechnic design.(a) Consolidated Comment - Blackwater V - Recommendation 7

*It is recommended that at Mile 498.6 a large culvert be installed and an effective protection against beaver activity be used in the streambed near the intake of this culvert.*

A 104' clear span bridge was recommended by the Hydrology Consultant at the above location.

Lack of response by the Client to the preliminary Bridge Design Submission prevents further comments to the above recommendation.

**CHAPTER 4**

**REFERENCE:** Consolidated Comment - Saline I  
**SUBJECT:** Location of R.O.W., Timing of Construction Activities; Associated Resource Use.

(a) Consolidated Comment - Saline I - Recommendation 1

*For Miles 500 - 509 in particular, the Final Design Submission should provide that information as requested in points 5c and f, 6a (iii), and 8f of the January 18, 1973 "Report Regarding Information Deficiencies in the D.P.W. Design Submissions for the Mackenzie Highway."*

(i) R.R.I.D. 5(c)

"Overland drainage and minor gullies:

*the Submission should be accompanied by a general statement outlining which drainage problems were recognized and how it is intended to handle these."*

A general statement outlining drainage problems is contained in Chapter 1 of the Mackenzie Highway General Design Data, Mile 297 - 543 of August 20, 1973. Specific statements on drainage for this Design Submission are contained in Chapter 18 of this Narrative Report.

(ii) R.R.I.D. 5(f)

Plan: *The mile by mile plan at the scale of 200 ft./inch (ca. 1:2400) should indicate the*

outline of every body of flowing or standing water and wetland areas occurring within ca. 1,000 feet of the centreline of the right-of-way to the extent that is practicable for the map scale used.

- Recommendation No. 16 of E.W.G. Report, July 27, 1973, on R.R.I.D. accepted the 1"=1000' Mosaics which are included in the Plans.

(iii) R.R.I.D. 6(a) (iii)

The location of every roadside or off-take ditch.

- As requested in Recommendations 20 and 21 of E.W.G. Report July 27, 1973 on R.R.I.D., the Plan Profile Mile Sheets show the ditch locations by the designated section type. Additional ditches may be required during construction. These cannot be identified at this time because of the lack of detailed topographic information which generally becomes available during the pre-construction survey.

(iv) R.R.I.D. 8(f)

A document to be prepared by the Department of Public Works, with the Canadian Wildlife Service (D.O.E.) and the Fisheries Service

(D.O.E.) stating the consensus of opinion regarding the most desirable timing of construction operations for areas where undesirable impact on terrestrial and aquatic wildlife and fish populations are anticipated to occur during parts of the yearly cycle of migration, reproduction, etc.

- The Environmental Impact Plans highlight possible locations of undesirable impact and state the time of year for that concern. This information will be contained in the Construction Contract Documents limiting construction activities during periods of undesirable impact to the extent considered practical.

(b) Consolidated Comment - Saline I - Recommendation 2

On the basis of information provided in Recommendation No. 1 above, the Environmental Working Group will provide D.P.W. with further recommendations regarding remedial measures required to minimize the long-term impact on these wetland units.

- No comment is required from D.P.W.

(c) Consolidated Comment - Saline I - Recommendation 3

Recommendation L, C, A 6, Consolidated Comment VIII (Miles 463 - 500 P) regarding beaver-culvert interactions, also applies to the present comment.

Recommendation L, C, A6

For streams which can be identified as being of known importance to beaver and for which culverts are proposed (for example stream crossing at Mile 498 (380+00 to 382+00) it is suggested that D.P.W. consultants confer with specialists from the Hydraulic Design Assessment Committee and the Canadian Wildlife Service, with the objective of developing possible design solutions for minimizing the potential and long-term interactions between beavers and culverts.

- Statements on beaver activity are contained in Chapter 13 of the M. H. General Design Data, Mile 297 - 543.

CHAPTER 5REFERENCE: Consolidated Comment Saline IISUBJECT: Aesthetics, Landscape Value, and  
Recreational Assessment.(a) Consolidated Comment - Saline II - Recommendation I

*Consideration should be given to using curves which are longer than 2112' and flatter than 3° so that some sort of continuity is established between the highway and surrounding terrain. These changes should be reviewed in association with the soils conditions (See Problem 1).*

Problem 1

*The continuous adherence to the Roads and Transportation Association of Canada recommendation to keep curves between 1584' - 2112' in length (i.e. .3 to .4 minutes long in driving time at 60 M.P.H.) creates a road alignment which is often incongruent with the surrounding terrain.*

<i>i.e. Mile 504</i>	<i>(STA. 668 - 760±)</i>
<i>Mile 507</i>	<i>(STA. 830 - 880±)</i>
<i>Mile 509</i>	<i>(STA. 910 - 943±)</i>
<i>Mile 531</i>	<i>(STA. 650 - 620±)</i>
<i>Mile 533</i>	<i>(STA. 550 - 490±)</i>
<i>Mile 537</i>	<i>(STA. 340 - 310±)</i>

**General statements on Horizontal Alignment are contained in Chapter 17 of the M. H. General Design Data, Mile 297 - 543.**

Alignment revisions with surrounding terrain considerations have been proposed on all the locations listed in the above problem. The alignment revisions are shown on the 1"=1000' Mosaics included in the Design Submission.

(b) Consolidated Comment - Saline II - Recommendation 2

*The vertical alignment could be improved by the use of longer L.V.C.'s which should be reviewed in conjunction with the horizontal form and the soil conditions. (See Problem 2).*

Problem 2

*Similarly the rigid maintenance to the Roads and Transportation Association recommendation that the minimum L.V.C.'s used are 5 times the driving speed, i.e.  $5 \times 60 = 300'$ . This creates a choppy vertical alignment which is visually distracting.*

General statements on vertical alignment are contained in Chapter 22 of the M. H. General Design Data, Mile 297 - 543. Longer vertical curves have been employed in the Design Submission.

(c) Consolidated Comment - Saline II - Recommendation 3

*Recommend that transition between ditch types be implemented during construction (See Problem 3).*

Problem 3

*The occurrence of short sections of typical ditch types A, B, and C, closely spaced requires transition*

*between ditch types for integration with the surrounding terrain.*

<i>i.e. Mile 506</i>	<i>(STA. 768 - 800±)</i>
<i>Mile 509</i>	<i>(STA. 974 - 990±)</i>
<i>Mile 515</i>	<i>(STA. 1247 - 1266±)</i>

Contour grading at the junction of cuts and fill slopes are normal practice in the construction of the Highway as stated in Chapter 9 of the M. H. General Design Data, Mile 297 - 543.

- (d) Consolidated Comment - Saline II - Recommendation 4  
*Recommend D.P.W. employ selective clearing guidelines.*

*Guidelines for selective clearing are being prepared by D.P.W. environmental consultants, F. F. Slaney and Company and will be ready before implementation is required.*

- (e) Consolidated Comment - Saline II - Recommendation 5  
*Recommend reforestation methods be employed at Mile 528 to reduce the areas damaged by construction and at Mile 533 to integrate the air strip with the Highway. (See Problem 5).*

- (i) *Mile 528 referred to by this recommendation is now on a revised alignment as shown on the 1"=1000' Mosaic included in the design package.*



- (ii) Reforestation of cut lines visually adverse is being studied by D.P.W. and will, where necessary, be implemented after construction.

(f) Consolidated Comment - Saline II - Recommendation 6

Recommend that D.P.W. provide E.W.G. with the following information:

1. Typical cross-section of highway and pipeline intersection.
2. Right-of-way clearing width for pipeline (120' R.O.W.).
3. Ancillary facilities associated with crossings - no other ancillary other than markers.

This information is required before an adequate visual assessment can be made (See Problem 6).

Problem 6

The proposed gasline routing which intersects the Highway at Mile 513.7 and Mile 518.7 could be visually adverse to the driver.

- (i) Typical cross-section of highway and pipeline intersection is contained in the preliminary draft submitted on March 30, 1972 by Canadian Arctic Gas Study Ltd.

- (ii) The right-of-way clearing width for the pipeline is proposed to be 120 feet.
  - (iii) No ancillary facilities other than markers will be required along the pipeline R.O.W.
- (g) Consolidated Comment - Saline II - Recommendation 7
- The E.W.G. requires from D.P.W. the recreational document referred to in previous consolidated comments Mile 448 - 463 before an adequate evaluation can be made (See Problem 7).

Problem 7

The following areas have recreational potential:

- Mile 502 - 503 (STA. 563- 615±) - terrain is suitable for a campsite.
- Mile 502.7 (STA. 595±) - archaeological site on southeast corner of the lake - interpretive potential.
- Mile 505.3 (STA. 740±) - archaeological site - interpretive potential.
- Mile 506.5 (STA. 800±) - archaeological site - interpretive potential.
- Mile 511 (STA. 1080-1090±) - site - interpretive potential.
- Mile 513 (STA. 1170±) - archaeological site at lake - interpretive recreational potential.
- Mile 520 (STA. 1247-1220±) - Saline River and archaeological site - recreational and interpretive potential.

The Environmental Consultant's assessment of recreational potential on the Mackenzie Highway is contained in the Environmental Data Sheets of the design package.

CHAPTER 6

REFERENCE: Consolidated Comment Saline III

SUBJECT: Passage of Cross-Drainage, Ponding of  
Overland Flow.

(a) Consolidated Comment - Saline III - Recommendation 1

*The final design package should include a contour strip map at scale of ca. 1:2400, covering the detailed topography extending circa 1000 ft. on either side of the R.O.W. The contour interval should be no more than five feet.*

Orthophoto mapping of 1:2400 with a contour interval of 5 feet is now being prepared for later insertion.

(b) Consolidated Comment - Saline III - Recommendation 2

*Adequate geotechnical information should be supplied with the final design package, specifically regarding soil type and ice content. Test drill holes should be made at least down to 20 ft. below the lowest portions of the terrain.*

The geotechnical information included on the Plan Profile Mile Sheets is in accordance with the promise outlined in Recommendation No. 25 of the E.W.G. Report of July 27, 1973.

The Unified Soil Classification System for soil type and the Standard N.R.C. denotation for ice content are used for descriptions.

Miles 504 - 509 and 514 - 521 are on revised alignment. It is intended to obtain detailed geotechnical information in the revised segments at a later date.

(c) Consolidated Comment - Saline III - Recommendation 3

*Volume and rate of surface drainage should be investigated, particularly for maximized rainstorm and spring freshet conditions.*

(i) Volume and rate of surface drainage for all areas requiring culverts larger than 60" diameter were assessed by the Hydrology Consultant.

(ii) Volume and rate of surface drainage for areas requiring culverts smaller than 60" diameter were considered as described in Chapter 36 of the M. H. General Design Data, Mile 297 - 543.

(d) Consolidated Comment - Saline III - Recommendation 4

*Regarding the passage of overland flow under the road, the MHEWG recommends:*

a) *that no ditched connection whatever should be*

made between adjoining ponding areas parallel to, and upslope from the Highway. Every natural ponding area located upslope from the R.O.W. should, instead, be provided with its own drainage passage structure under the roadbed;

- b) that off-take ditches should not be constructed in areas where high ice content permafrost is found to be present in silt, silty clay or clay;
- c) that wherever possible, drainage from culverts should be allowed to find its own way across the terrain downslope from the R.O.W. This recommendation applies to: i) cases where terrain conditions downslope from the Highway would encourage natural dispersal; ii) cases where drainage upslope from the R.O.W. is not concentrated in gullies or in any other minor line of concentrated run-off to be crossed by the R.O.W.
- d) that if construction of off-take ditches in areas described in paragraph (b) above is absolutely necessary, special anti-erosion and thermal protection measures should be incorporated in the Final Design Submission.

D.P.W. accepts the above recommendations. The designer has generally followed these recommendations in areas of overland flow characteristics.

(e) Consolidated Comment - Saline III - Recommendation 5

Regarding the distributary channels on fan aprons, the MHEWG recommends that it be considered:

- a) that berms be constructed upslope from the R.O.W. to prevent natural diversion.
- b) that two or more discrete distributaries occurring on a single fan shall not be confined to a single channel.
- c) that ample culverts be installed in the designated section to accommodate overland flow between discrete distributaries.

This recommendation refers to Problems 5 and 6 of this Consolidated Comment.

Problem 5

Between Mile 504 and 505 (680+00 - 720+00), at Mile 508 (880+00 - 908+00), and between Mile 531 and 532 (621+00 - 670+00), wet fans drain by means of slow seepage through the vegetation mat. Ponding of water against the road could initiate irreversible thermokarst development in the underlying silts, which are ice rich.

Problem 6

Between Mile 507 and 508 (860+00 - 878+00), and between Mile 530 and 531, the road traverses an apron formed by coalescent fans. Natural diversions during the spring freshet or a heavy rainstorm may result in natural relocation of channels which presents an EE hazard to the Highway. Combination of individual distributary channels would lead to gullying, whereas individual channels are more or less in equilibrium at the present time.

- (i) The alignment from Mile 507 - 508 has been relocated off the scarp toward the Mackenzie River. The re-alignment is shown on the 1"=1000' Mosaics included in the design package.
  - (ii) The segment from Mile 530 - 531 is not included in this Submission.
- (f) Consolidated Comment - Saline III - Recommendation 6  
 The MHEWG recommends that careful consideration be given to the alternative R.O.W. location described in Consolidated Comment VIII (500 - 540P); the cross-drainage problems presented by the presently selected R.O.W. location would be substantially reduced by major relocations of the alignment.



Statements and rationale of D.P.W.'s acceptance or rejection of the proposed alternative R.O.W. locations recommended by the above are contained in the Alignment Update Report of November 5, 1973.

CHAPTER 7REFERENCE: Consolidated Comment Saline IV.SUBJECT: Ditching in High Ice Content Permafrost.(a) Consolidated Comment - Saline IV - Recommendation 1

*The recommendations made regarding the accommodation of overland flow, contained in Consolidated Comment III (500-540) also apply to the present comment.*

As stated in the previous chapter of this Report the designer generally accommodated overland flow as recommended in Consolidated Comment III (500-540).

(b) Consolidated Comment - Saline IV - Recommendation 2

*The Environmental Working Group wishes to receive from the Department of Public Works the document described in paragraph 8 (c) of the Information Deficiency Report d.d. January 18th, 1973.*

R.R.I.D. 8(c)

*A document outlining how the D.P.W. design teams intend to cope with the problems posed by ditching in permafrost areas containing high ice contents in the subsoil.*

The proposed methods of coping with this problem are outlined in Chapter 14 of M. H. General Design Data Mile 297 - 543.

(c) Consolidated Comment - Saline IV - Recommendation 3

*It is recommended that extensive test drilling be undertaken to determine the distribution of high ice content permafrost, and that ditching should only be considered where entirely unavoidable in terms of the recommendations of Consolidated Comment III (500 - 540P).*

Generally the high ice content permafrost has been delineated by the geotechnical surveys of 1972-73. This information is shown on the Plan Profile Mile Sheets. It is intended to obtain the detailed geotechnical data on the revised locations at a later date.

Ditching recommendations of the above reference were generally followed in the Design Submission.

(d) Consolidated Comment - Saline IV - Recommendation 4

*It is recommended that type A and B construction, presently proposed for the segments designated below will be replaced with type C overlay construction when adequate test drilling would confirm the presence of high ice content permafrost below the proposed R.O.W.*

This applies to segments:

615+50 - 639+50	1265+80 - 1283+25
742+00 - 767+50*	1288+80 - 1301+80*
769+00 - 774+00*	1312+00 - 1306+00*
775+50 - 781+50	1295+00 - 1288+00*
788+50 - 792+70*	560+00 - 537+00
793+50 - 799+50	499+00 - 486+00*
910+00 - 932+30*	486+00 - 475+00*
1221+80 - 1232+00	376+00 - 371+00*
1235+35 - 1244+00	329+00 - 322+00*
1260+00 - 1264+40*	

The segments above, Stations 615+00 to 932+30 are on revised alignment (Mile 504.1 to Mile 508.9). Overlay construction has been designed for this entire alignment revision except for two short stretches, Stations 697+80 to 704+80 and Stations 915+80 to 920+80. The soils information in these segments as provided by the hand-dug test pits, indicated ditching was permissible providing an economical gradeline.

Stations 1221+80 to 1306+00 are also on revised alignment. Overlay construction was also the method proposed in the Design Submission for this segment.

Stations 560+00 to 322+00 (Mile 533.2 - Mile 537.4) listed above are not included in this Design Submission.

(e) Consolidated Comment - Saline IV - Recommendation 5

*Wherever ditching in high ice content permafrost areas is absolutely unavoidable, ditches should be*

placed as far away from the roadbed as is practical. All proposed ditching included in the final design for this section should be accompanied by specific proposals regarding the prevention of mechanical or thermal erosion; topics such as vegetation, insulation with peat, chips or tree tops and limbs, use of rock or coarse gravel, use of netting, etc. could be commented upon.

Methods of handling ditching in permafrost are dealt with in Chapter 14 of M. H. General Design Data, Mile 297 - Mile 543. The problems of erosion prevention and control including comments on vegetation, seeding and use of gravel are contained in Chapter 19 of M. H. General Design Data, Mile 297 - Mile 543.

Appendix "A" and Chapter 16 of this narrative presents specific proposals for prevention of mechanical erosion.

CHAPTER 8REFERENCE: Consolidated Comment Saline VSUBJECT: Cuts in Permafrost Areas. Cuts in Erodible Materials.(a) Consolidated Comment - Saline V - Recommendation 1

For the segments described in paragraphs 2 (a) and 2 (c) of the problem statement, it is recommended that closely spaced drilling be carried out to determine the extent of permafrost below the proposed R.O.W. and the content of segregated ice, if present; test holes should extend to at least 20 ft. below the grade to which the cut is to be made. The presence of intra- or sub-permafrost water should be investigated and its hydraulic head recorded.

Major Cuts

2. (a) Major cuts in silt, sandy silt or silty clay are proposed for:

ca.	M. 512.5	1121+40-1129+00	(15 ft. sandy silt)**
	M. 513.6	1172+50-1178+90	(15 ft. sandy silt)**
	M. 513.8	1180+60-1195+50	(15 ft. clayey silt)**
	M. 514.1	1200+50-1207+30	(35 ft. sandy silt)
	M. 519.8	1257+00-1255+00	(20 ft. silt (?))
	M. 521.3	1182+30-1173+20	(40 ft. silt)
	M. 528.0-	528.7 823+00-789+00	(50 ft. sandy silt)***
	M. 533.4	548+00- 539+50	(15 ft. silt and rocks (?))
	M. 533.9	516+00- 511+00	(15 ft. no soils info.)**
	M. 534.3	489+60- 498+00	(15 ft. silt)**

## (i) Mile 512.5 - Stations 1115+30 to 1132+50

A major cut is proposed in this segment. The low moisture content and the characteristics of the

sandy gravel and clay as indicated by the geotechnical data would allow the material from this cut section to be used for construction.

- (ii) Mile 513.6 - Stations 1171+60 to 1196+20  
The moisture contents in this major cut section as indicated by the geotechnical data are generally below the plastic limit. The unfrozen clay will provide suitable construction material.
- (iii) Mile 514.1 - Stations 1199+60 to 1209+30  
No problems are anticipated in cutting the ridge constituting this segment, for the moisture contents are low and the material being clayey silt to pebbles and gravel will provide suitable construction material.
- (iv) Mile 519.8 and Mile 521.3 are on revised alignment, therefore, comments do not apply.
- (v) Miles 528.0 - Mile 534.3 are not included in this Design Submission.

#### Minor Cuts

2. (c) *Minor cuts are proposed in silt, silty clay or sandy silt deposits for:*

ca.	M. 505.4	733+00- 740+00	(10 ft. silt)*
	M. 516.9	1307+00-1310+00	(12 ft. clayey silt)
	M. 517.7	1390+00-1397+50	(12 ft. sandy silt)
	M. 519.4	1285+00-1275+50	(14 ft. silt)
	M. 519.7	1265+50-1264+20	(10 ft. silt)

(i) These segments are all on revised locations and comments do not apply.

(b) Consolidated Comment - Saline V - Recommendation 2

For the segments described in paragraph 2 (b) of the problem statement, it is recommended that closely spaced test drilling be carried out to investigate the thickness of silt cover over sand and gravel as well as the depth of the permafrost in relation to the proposed depth of the cuts, and to determine whether artesian aquifers occur below, or perhaps in, the permafrost. If the silt cover is thicker than a few feet, high ice contents are expected to be found.

Paragraph 2(b)

Major cuts in gravel and sand with a thin veneer of silt deposits are proposed for:

ca.	M. 509.8	961+00- 974+20	(15 ft. sand/gravel)
	M. 510.8	1023+50-1034+80	(40 ft. gravelly sand)**
	M. 520.7	1209+30-1204+00	(20 ft. gravel)

(i) Mile 509.8 - Stations 958+00 to 974+50  
The low moisture content sandy material in this major cut segment provides good construction material. The relatively low moisture content recorded in the geotechnical data indicates artesian aquifers are not likely.



(ii) Mile 510.8 - Stations 1020+50 to 1037+30  
The gravelly till material in this major cut segment provides good construction material. From the geotechnical data, no artesian augifers are expected in this segment.

(iii) Mile 520.7 is on revised alignment.

(c) Consolidated Comments - Saline V - Recommendation 3

*For the segments described in paragraph 2 (d) of the problem statement, it is recommended that exploratory drilling be carried out to determine the thickness of silt and the probable attendant content of segregated ice. Groundwater discharge is not anticipated in these cuts.*

Paragraph 2(d)

Minor cuts are proposed in sand or gravel for:

ca.	M.	509.9	978+00- 979+70	(10 ft. sand/gravel)
	M.	510.0	983+20- 990+80	(10 ft. clayey sand)
	M.	523.7	1059+00-1051+50	(10 ft. sand/gravel)
	M.	531.9	618+50- 615+50	(10 ft. silty sand)

(i) Mile 509.9 - Stations 976+90 to 999+90  
The geotechnical data indicates the material in this cut segment to be of low moisture content sandy gravelly till providing for good construction material.

(ii) Miles 523.7 and 531.9 are not included in this Design Submission.

(d) Consolidated Comment - Saline V - Recommendation 4

*If groundwater and/or high ice content is encountered, consideration should be given to:*

- (a) local relocation of cuts;*
- (b) elevation of the gradeline, requiring larger fills;*
- (c) submission of specific design proposals for those designated locations (above) where options (a) or (b) are not adopted.*

Cuts in groundwater and/or high ice content areas were avoided. Visible ice is indicated in the geotechnical data for a major cut at Mile 514.1, Stations 1199+60 - 1209+40. However, with the low recorded moisture content of the silt to pebbles to gravel and till comprising this cut section it is expected no construction or maintenance problems will be encountered. The designed gradeline provides reduced fills and suitable construction material reducing the borrow requirements.

It is intended to expand this cut section to accommodate additional borrow, if required, by developing contour grading of the ridge to blend the cut into the natural terrain. The large area disturbed by the clearing operation will require a planned revegetation program.

(e) Consolidated Comment - Saline V - Recommendation 5

*In the segments designated in paragraph 1 of the problem statement, no clearing of the R.O.W. should be undertaken until design details have been approved, other than to*

accommodate the movement of survey crews and test drilling equipment.

No clearing will be undertaken without prior approval of the Client.

(f) Consolidated Comment - Saline V- Recommendation 6

The Environmental Working Group wishes to receive from the Department of Public Works a document outlining the general principles employed by D.P.W. design teams in coping with the terrain, climatic, hydrologic, and permafrost problems raised by present or future proposals for cuts into terrain where permafrost is either known or is quite likely to occur, as stated in paragraph 8 (a) of the Information Deficiencies Report, d.d. January 18, 1973.

Paragraph 8 (a) of the R.R.I.D.

A document outlining the general principles employed by D.P.W. design teams in coping with the terrain, climatic, hydrologic and permafrost-related problems raised by proposals for cuts into terrain where permafrost is either known or is likely to occur.

General statements outlining the principles employed by D.P.W. design teams in coping with terrain, climatic, hydrologic and permafrost-related problems, are contained in Chapters 7, 14, 19 and 31 of the M. H. General Design Data, Mile 297 - 543 of August 20, 1973.

(g) Consolidated Comment - Saline V - Recommendation 7

*The MHEWG recommends that very careful consideration be given to the location alternatives recorded in Consolidated Comment VIII (500-540P). In the first analysis, it would appear that far less cuts into permafrost, and to lesser depths, would be required if these alternatives were found to be technically feasible.*

Revised alignment has been staked in the field from Mile 504.1 - Mile 508.9 and from Mile 514.2 - Mile 520.9 and is shown on the 1"=1000' Mosaics included in this Design Submission. Rationale for these revised alignments is contained in the Alignment Update Report Mile 500 - Mile 725 d.d. November 5, 1973.

The designed grade in these areas is of the overlay fill type cross-section eliminating ditch cutting unless unavoidable for the purpose of maintaining an economical gradeline.

**CHAPTER 9****REFERENCE:** Consolidated Comment Saline VI**SUBJECT:** Thickness of Fill, Suitability of Fill Material.**(a) Consolidated Comment - Saline VI - Recommendation 1**

*The MHEWG wishes to be provided with information regarding the expected performance of clay, silt and sand (and mixtures thereof) under the climatic and terrain conditions prevailing along the R.O.W., and pertaining to the natural frozen or thawed state in which they are intended to be taken from lateral ditches and from other borrow areas. It is recommended that this information will be described in paragraph 6 (c) of the Report regarding Information Deficiencies in D.P.W. Design Submissions for the Mackenzie Highway.*

Statements on the expected performance of clay, silt and sand (and mixtures thereof) under the above conditions are contained in Chapter 3, M. H. General Design Data, Mile 297 - Mile 543.

The Borrow Pit Report for this Design Submission is contained in Chapter 15 of this Narrative Report.

**(b) Consolidated Comment - Saline VI - Recommendation 2**

*It is recommended that the proposed fill thickness be increased to minimally five feet.\* This recommendation*

applied to segments:

767+50- 769+00	1283+80-1288+80	1173+50-1081+00**
799+50- 910+00**	1301+80-1307+00	1050+00- 619+00**
1035+00-1111+50**	1310+00-1313+75***	508+50- 499+00**
1177+50-1180+50***	1330+00-1389+50	475+00- 376+00**
1232+00-1235+35	1398+00-1449+00	371+00- 329+00**
1244+00-1250+00	1306+00-1301+50***	322+00- 191+80**
1255+60-1260+00***	1263+00-1258+20***	
1264+40-1265+80***	1254+00-1211+00	

- \* Assuming that the current 5 ft. standard fill thickness adopted by D.P.W. provides adequate insulation for frozen ground conditions.
- \*\* Many short stretches in this segment have inadequate fill.
- \*\*\* Absence of adequate geotechnical information warrants the assumption of the presence of permafrost.

This recommendation is based upon intuition. The thickness of fill actually required should be designated as that which is adequate to ensure that no thaw will occur below the average summer thaw penetration level prior to the clearing of the R.O.W. and/or the damaging or complete destruction of the insulating organic mat. No hard information is available at this time to facilitate the definition of specific thicknesses for specific materials with specific thermal properties.

Chapter 20 of M. H. General Design Data, Mile 297 - 543 contains statements regarding D.P.W.'s intent to the above recommendation.

(c) Consolidated Comment - Saline VI - Recommendation 3

*Regarding the segment Mile 500 - Mile 505 and the shorter segment 910+00 - 960+00 (at ca. Mile 509), it is recommended that consideration be given to the removal of the organic mat and the silt veneer followed by filling to grade with gravel, provided that adequate test drilling confirms the presence of coarse sand or gravel below a thin (say, less than 2 ft.) veneer of silt.*

The geotechnical data for the above segments indicates generally sandy and poorly graded gravel below the organic mat. No silt was recorded. This type of soils characteristics permitted a "B" type cross-section in some areas providing some stretches of the Highway with a balance earthwork design.

(d) Consolidated Comment - Saline VI - Recommendation 4

*It is recommended that locally derived silt or clay fill shall not be used until more information regarding performance has been provided and utilization of these silts and clays can find support in environmentally sound construction practices.*

D.P.W.'s opinion on the above matter is contained in Chapter 3 of the M. H. General Design Data, Mile 297 - 543.

CHAPTER 10REFERENCE: Consolidated Comment - Saline VIISUBJECT: Design of Fill Over Culverts in Gullies.(a) Consolidated Comment - Saline VII - Recommendation 1

*The Environmental Working Group wishes to receive from the Department of Public Works a document outlining how it intends to cope with the concerns raised in paragraph 3 of the problem statement (above) in particular, as well as describing its engineering and/or maintenance solutions to problems posed by the anticipated icing of culverts in general.*

Paragraph 3

*Particularly for locations where thick fills over culverts are proposed, no information is provided regarding the long-term effects of possible permafrost aggradation in the fill sections and around the culverts on culvert efficiency. Without the benefit of specific applied research regarding ice build-up in culverts covered by thick fills in permafrost areas, it cannot be assumed that culvert efficiency during spring thaw conditions would not deteriorate in time, if and as permafrost aggradation takes place around them.*

- (i) Statements on long-term effects of possible permafrost aggradation in fill sections and around culverts are contained in Chapter 12 of the M. H. General Design Data, Mile 297 - 543.



(ii) Statements outlining engineering and/or maintenance solutions to problems posed by the anticipated icing of culverts in general, are contained in Chapter 30 of the M. H. General Design Data, Mile 297 - 543.

(b) Consolidated Comment - Saline VII - Recommendation 2

*The Environmental Working Group wishes to receive from the Department of Public Works a statement regarding the sideslope angles it has adopted for major fills constructed with silty clay, sandy clay, silty sand, sandy silt, and gravel.*

Statements regarding sideslope angles for fills is contained in Chapter 31 of the M. H. General Design Data, Mile 297 - 543.

(c) Consolidated Comment - Saline VII - Recommendation 3

*The Environmental Working Group wishes to receive from the Department of Public Works statements outlining the protective measures to be utilized to prevent sloughing of the upstream toe of all fill bodies exposed to wetting up to the design flood level adopted for various culverts draining areas larger than one square mile.*

Using the Method of Slices for Stability for both rising of flood water and rapid drawdown for the material

generally found in this design section, it was determined that the use of a berm five feet below the design flood level was adequate to prevent sloughing.

During construction, the Resident Engineer will ensure that a berm on the upstream slope five feet below the design flood level will be constructed on fills over culverts draining areas larger than one square mile.

(d) Consolidated Comment - Saline VII - Recommendation 4

*The MHEWG recommends that careful consideration be given to the R.O.W. location alternatives described in Consolidated Comment # VIII (500-540P); it would appear that the number and the height of major fills could be substantially reduced if the alternative alignments were found to be technically feasible.*

The alignment revisions from Mile 504.1 - Mile 508.9 and from Mile 514.2 - Mile 520.9 have substantially reduced the number and heights of major fills as proposed in the Preliminary Design Submission of 1972.

CHAPTER 11

REFERENCE: Consolidated Comment - Saline VIII.

SUBJECT: R.O.W. Location Alternatives.

(a) Consolidated Comment - Saline VIII - Recommendation 1

*It is recommended that the Department of Public Works investigate the validity of the proposed relocations and report their findings together with the Final Design Submission for this section.*

D.P.W.'s reports on the investigations of the validity of the proposed relocations are contained in the Alignment Report, Mile 500 - 725 d.d. November 5, 1973.

(b) Consolidated Comment - Saline VIII - Recommendation 2

*Some of these relocation proposals may be in conflict with recreational land use potential and aesthetic priorities. It is recommended that this aspect be taken into account in the Report requested in Recommendation L 1.*

Land use potential and aesthetic priorities were considered in investigating of suggested realignments.

(c) Consolidated Comment - Saline VIII - Recommendation 3

*No clearing or cutting of the R.O.W. should be undertaken in the segments described in the problem statement paragraphs 2 - 6 until decisions regarding location have been made.*

No clearing of the R.O.W. will be undertaken without prior approval of the Client.

(d) Consolidated Comment - Saline VIII - Recommendation 4

*The final design package should include adequate geotechnical information as described in paragraph 6b i)-iv) of the Information Deficiency Report, d.d. January 18, 1973.*

The above geotechnical information, where available as requested above, is included on the Plan Profile Mile Sheets.

(e) Consolidated Comment - Saline VIII - Recommendation 5

*It is recommended that in considering location alternatives ample attention should be given to smooth horizontal continuity, to the extent that terrain conditions allow.*

D.P.W. accepts this recommendation.

**CHAPTER 12****REFERENCE:** Consolidated Comment Saline IX**SUBJECT:** Comments on Culverts**(a) Consolidated Comment - Saline IX - Recommendation 1**

*It is recommended that the stream flow volume and velocity be monitored during the spring freshet and the summer of 1973 at the intersection of the stream and the proposed R.O.W. alignment at Mile 504.5.*

**This recommendation makes reference to Problem 1**

*The level of the stream draining a lake to the east of Mile 504.5 is regulated by this lake. Flow volume in the channel is not known. There is a concern that culvert sizing and design of entrance and exit channels may affect the lake level if design were to proceed on the basis of insufficient hydrological information.*

**The sizing of the drainage structure at Mile 504.5 which, due to alignment revisions, has been changed to Mile 504.9 on this Preliminary Design Submission, was determined by the Hydrology Consultant based on drainage area.**

**(b) Consolidated Comment - Saline IX - Recommendation 2**

*The MHEWG wishes to be provided with the rationale for*

*the choice of culverts rather than bridges for the stream crossings at Mile 519.7 and Mile 528.4.*

- (i) Mile 519.7 is on a revised alignment. The location of this stream on the revised alignment as shown on the 1"=1000' Mosaics included in this Submission is now at Mile 519.3.
  - (ii) The Hydrology Consultant's choice of a culvert rather than a bridge was one of economics considering the gradeline circumstances at the crossing.
  - (iii) Mile 528.4 is not included in this Submission.
- (c) Consolidated Comment - Saline IX - Recommendation 3
- The MHEWG wishes to be advised as to the measures proposed to be taken to ensure the passage of fish through culverts of the length as are apparently intended to be used at Mile 519.7 and Mile 528.4.*

*This recommendation is concerned by the following:*

*Problem 1*

*The stream at Mile 519.7 is proposed to be crossed with a fill ca. 100 ft. high. Assuming a side slope angle of 2:1 on the fill, the culvert would probably have a minimum length of 450 ft. It may prove very difficult to provide for fish passage in a culvert of such length.*

Problem 2

The stream at Mile 528.4 is proposed to be crossed with a fill ca. 140 ft. high. Assuming a side slope angle of 2:1 on the fill, the culvert would probably have a minimum length of 600 ft. It may prove difficult to provide for fish passage in a culvert of such length.

- (i) The revised alignment provided a better crossing of the stream referred to as Mile 519.7. The revised mileage for this crossing is 519.3 and the revised length of the culvert, 236 feet, should reduce the concern expressed in Problem 1.
- (ii) Mile 528.4 is not included in this Design Submission.

**CHAPTER 13****REFERENCE:** Consolidated Comment Saline X**SUBJECT:** Stream Crossings, Bridges.**(a) Consolidated Comment - Saline X - Recommendation 1**

*The MHEWG recommends that all bridge design proposals for the Mackenzie Highway shall take as primary criterium that the mean velocities at design discharge shall not be increased.*

**(b) Consolidated Comment - Saline X - Recommendation 2**

*The MHEWG recommends that all bridge designs using fills across vegetated flood-plains shall be equipped with ample culverts, permitting flow of water on the flood plain during spate conditions. So-called "old flood channels," which are frequently utilized during spate conditions should be accommodated with culverts large enough to handle the water volumes in these channels; fish passage, however, does not have to be provided for.*

**(c) Consolidated Comment - Saline X - Recommendation 3**

*The MHEWG recommends that all bridge design proposals for the Mackenzie Highway for cases involving braiding streams, will in no way reduce the natural channel width, and will add to the natural channel width a space equal to 1.5 times the width of piers; wherever possible piers should be preferably located where colonizing vegetation indicates a measure of stability within or at the margins of the natural channel.*



The Hydrologist Consultant feels other considerations regarding Recommendations 1, 2 and 3 require further clarification. Further discussion will be forthcoming in these regards.

(d) Consolidated Comment - Saline X - Recommendation 4

*Since the assumptions on which the design of bridges for this segment of the Mackenzie Highway is based, appear to imply severe EP and EE hazards, and relocation to sites requiring lesser spans may have to be considered, the MHEWG recommends that no clearing of the R.O.W. other than to accommodate survey and test drilling crews, be undertaken between Mile 504 and 540, until the concerns raised in this Consolidated Comment have been closely investigated and their implications assessed in relation to the proposed R.O.W. location alternatives contained in Consolidated Comment #VIII (500-540P).*

No clearing will be undertaken without prior approval from the Client.

**CHAPTER 14****REFERENCE:** Consolidated Comment Saline XI**SUBJECT:** Sources of Granular Material**(a) Consolidated Comment - Saline XI - Recommendation 1**

The MHEWG wishes to receive a borrow pit report with the Final Design Submission for this Section of the Mackenzie Highway. The nature of this Report is described in the "Report Regarding Information Deficiencies in D.P.W. Design Submissions for the Mackenzie Highway," January, 1973, item 6C.

**R.R.I.D. 6(c)**

**Borrow pits:** Each Final Design Submission should be accompanied by a borrow pit report, stating:

- the rationale for the choice of certain borrow areas;
- the thickness of permafrost, if present, and if such a permanently frozen zone extends less than 20 feet below the elevation of the lowest point to which it is proposed, planned, or intended to excavate the borrow area, and/or if such a permanently frozen zone extends less than 20 feet below the elevation of that part of the pit floor from above which the greatest thickness of material is proposed, planned or intended to be removed.

- (i) Rationale for choice of certain borrow areas is contained in Chapter 15 of this Submission.
- (ii) Permafrost depth, etc. for borrow areas will be determined for the Final Design Submission and will be more accurately delineated during pre-construction prior to opening of the borrow pit.

(b) Consolidated Comment - Saline XI - Recommendation 2

*Agency assessment officers have drawn attention to the occurrence of potential sources of good granular materials to the east of Mile 504.5, to the south of Mile 504 (glaciofluvial plain) and to the west of Mile 508 - 509.*

In September, 1972 the Department of Indian Affairs and Northern Development engaged PEMCAN Services "72" to conduct Stage 1 of the Territorial Granular Materials Inventory. Stage 1 is defined as the areas from Fort Simpson to Fort Good Hope, N.W.T.

- (i) PEMCAN test hole #198 was taken in the vicinity of "east of Mile 504.5" - the analysis was silty sand, unsuitable material.
- (ii) PEMCAN test hole #197, to the south of Mile 504 indicated gravel and sand. The material was recommended for various construction aggregates. This area warrants further investigation.

- (iii) PEMCAN test holes #208 and #209, west of Mile 508 - 509 were unsuitable as granular material for the sandy silty gravel was recommended as general fill to very marginal fill.

CHAPTER 15SUBJECT: Special ditch treatment to prevent erosion.

- (i) Special treatment for planned ditches has been identified in accordance with Appendix "A" of this Report for the following locations.

<u>Mile</u>	<u>Station</u>	<u>Average % Slope</u>	<u>Estimated Discharge in c.f.s.</u>	<u>Ditch Protection or Ditch Check Spacing</u>
509-510	955- 975	1.9	5	60'
510-511	1020-1037	6.7	2	Coarse Gravel
512-513	1115-1121	7.4	10	Cobbles
512-513	1121-1132	5.0	25	Cobbles
513-514	1170-1182	2.9	5	60'
513-514	1189-1196	3.7	5	50'
514-515	1200-1209	3.7	3	60'
514-515	1225-1234	6.5	20	Cobbles
519-520	1308-1315	2.4	8	***
519-520	1294-1304	2.4	5	***
520-521	1214-1225	7.9	10	Cobbles

\*\*\* Specific method of ditch protection to be determined as geotechnical information is made available.

**CHAPTER 16**

**REFERENCE:** Report Regarding Information Deficiencies  
d.d. January 18, 1973 (5) (a) Preliminary  
Design Submissions.

**SUBJECT:** Preliminary Design Submission - Stream  
Crossings.

Stream crossings: the submissions should state clearly  
whether crossings with culverts or with bridges are intended:  
ortho-photo topographic maps at a scale of ca. 1:2400 with  
5 feet contours should be included with the submission for  
each section that contains one or more crossing sites, for  
which special design proposals are to be submitted to the  
E.W.G. at later dates.

- (i) The Plan Profile Mile Sheets contained in the Design Submission clearly indicate the intended drainage structures proposed at all stream crossings.
- (ii) The special ortho-photo mapping required whenever bridge crossings are intended will be provided in the Preliminary Bridge Designs.

**CHAPTER 17**

**REFERENCE:** Report Regarding Information Deficiencies  
d.d. January 18, 1973 (5) (b) Preliminary  
Design Submission.

**SUBJECT:** Preliminary Design Submission - Stream  
Crossings involving flood plains.

Stream crossing involving flood plains: the preliminary submissions should state clearly how the flood plains adjacent to bridge sites are intended to be traversed, such as with low fills permitting flow over the fill body, or with high fills with culverts to permit flood flow passage or with elevated causeways permitting free flow of flood water on the flood plains.

The Highway gradeline through sections containing bridge crossings have been approximated for this Preliminary Design Submission due to the lack of response by the Client to crossing concepts previously submitted. In general, however, the approach taken will be to use fills with culverts in order to eliminate any flood plain ponding.

**CHAPTER 18**

**REFERENCE:** Report Regarding Information Deficiencies  
d.d. January 18, 1973 (5) (c) Preliminary  
Design Submission.

**SUBJECT:** Preliminary Design Submission - Overland  
drainage and minor gullies.

Overland drainage and minor gullies: the submissions should be accompanied by a general statement outlining which drainage problems were recognized and how it is intended to handle these.

The length of Highway from Mile 495 to Mile 521 encounters significant variations in terrain conditions and encumbent drainage characteristics. This has resulted in many variations of the requirement for drainage facilities in and along the Highway.

From Mile 495.0 to Mile 498.5 the alignments cross a glacio-lacustrine plain consisting mostly of silty to clayey deposits and overlaying glacial tills. The nature of the materials and generally flat relief may give rise to ponding of overland flow and additional culverts have been included in the Preliminary Design Submission for this sector to accommodate this potential problem.

From Mile 498.5 to Mile 504.0 the alignment crosses a glacio-fluvial plain consisting of the remnants of deltaic, outwash and eskerine deposits which are composed of fine to coarse sands,



gravels and boulders. The area is generally well-drained and few if any drainage problems are anticipated.

At Mile 504.7 the R.O.W. crosses a marshy area with a poorly defined drainage channel. The Hydrology Consultant has proposed a bridge for this crossing in order to minimize environmental and drainage problems. From Mile 505 to 507.2 the Highway follows a slightly raised platform of glaciolacustrine silts and clays, which tend to be moderately drained. Additional culverts are included in this preliminary design package to account for any potential ponding of overland flow.

From Mile 507.2 to 509.8 the alignment crosses predominantly glaciofluvial deposits consisting mainly of sands and gravels. The presence of these coarse grained materials has reduced overland flow by subsurface drainage and ponding problems are not anticipated. However, this section as well the sector from 509.8 to Steep Creek, is crossed by areas of glaciolacustrine silts and clays, often indicated by peat plateaus. Although subsurface drainage varies from fair to moderate, the potential for overland flow in these areas has been recognized and additional culverts have been included in the preliminary design to accommodate this.

The R.O.W. from Steep Creek to Mile 514 ascends a gradual terrace of silts and clays overlain by peat. Drainage tends to be moderate in nature and varies with the hummocky relief.

The thickness of the silts and clays overlaying the glacial till is often in excess of ten feet. Subsurface drainage is minimal due to the fine grained nature of the soils, however, well-defined natural drainage channels have been formed due to the general relief of the area. From Mile 514.0 to Mile 521 (excluding the Saline River) the Highway alignment crosses a glaciolacustrine plain of silts and clays, intersected by many well-defined drainage channels. Occasional poorly drained areas of muskeg occur on the R.O.W. and the problem of overland flow has been dealt with by the inclusion of additional culverts.

**CHAPTER 19**

**REFERENCE:** Report Regarding Information Deficiencies  
d.d. January 18, 1973 (5) (d) Preliminary  
Design Submission.

**SUBJECT:** Preliminary Design Submission - Source of  
borrow.

Sources of borrow: the Submission should include a statement outlining the types and quantities of borrow material proposed to be used and the anticipated ice content of those materials; the approximate number of borrow pits and the approximate locations and proposed access routes should be determined in a general way.

- (i) The proposed borrow pit locations with proposed quantities as determined from a quantity take-off based on the preliminary design gradeline and the proposed access routes, are shown on the 1"=1000' Mosaics contained in the Design Submission.
- (ii) The types of borrow material and anticipated ice content where the geotechnical information was available is also shown on the 1"=1000' Mosaics. In areas of alignment revisions, borrow area locations were determined from aerial photo interpretation and will require geotechnical information prior to the Final Design Submission to more accurately assess the suitability of the material.

CHAPTER 20

REFERENCE: Report Regarding Information Deficiencies  
d.d. January 18, 1973 (5) (e) Preliminary  
Design Submission.

SUBJECT: Preliminary Design Submission - Temporary  
Stream Crossings.

Temporary stream crossings: the preliminary design submissions should be accompanied by a statement outlining the nature and location of temporary stream crossings, the approximate time at which they are proposed to be installed and the approximate time at which they are proposed to be removed and replaced with permanent structures, for each drainage line traversed by the R.O.W.

For major stream crossings the bridge consultants have been asked to provide a design for a temporary crossing in their Bridge Design Submission.

For minor stream crossings in which culverts are proposed, the available knowledge at this time of the requirements and timing of construction activities limits the design team in presenting a firm statement outlining the nature and location of temporary stream crossings.

CHAPTER 21

REFERENCE: Report Regarding Information Deficiencies  
d.d. January 18, 1973 5 (f) Preliminary  
Design Submission.

SUBJECT: Preliminary Design Submission - Plan

Plan: The mile by mile plan at the scale of 200 ft./inch  
(ca. 1:2400) should indicate the outline of every body of  
flowing or standing water and wetland areas occurring with-  
in ca. 1,000 feet of the centreline of the right-of-way  
to the extent that is practicable for the map scale used.

Recommendation No. 16 of E.W.G. Report, July 27, 1973, on  
R.R.I.D. accepted the 1"=1000' Mosaics for this purpose  
which are included in the Plans.

APPENDIX "A"

SUBJECT: SPECIAL TREATMENT FOR DITCHES

Construction of the Highway will invariably result in some re-arrangement of the natural drainage pattern with the channelling of runoff into roadway ditches and offtake ditches.

In a normal stream channel the bed of the stream adjusts to the rate of flow with scour or deposition of material occurring until a balance is established.

In new channels such as the roadway ditches, an equilibrium will not have been established hence the potential for scour erosion exists with the possible transportation of materials into natural streams.

It is, therefore, desirable that the flow velocities of the anticipated runoff in the new channels, be controlled to prevent scouring of the exposed channel material and, failing this, that the runoff be channelled into areas where sedimentation may occur with minimal damage to the natural surroundings.

The determination of maximum allowable flow velocities at which scour will occur depends on numerous factors, including sediment in the water, soil characteristics, such

as grain-size density, organic binder, cementation, ice content and other natural factors.

General limits from Seelye, E. E., 1956: Foundations, Design and Practice, have been recognized as acceptable velocities for non-scour non-silt conditions.

It should, however, be emphasized that these are not necessarily the maximum velocities beyond which scour will definitely occur for a particular soil.

Recommended design velocities for use on the Mackenzie Highway have been tabulated by E. W. Brooker & Associates Ltd., Mackenzie Highway Geotechnical Evaluation, Volume 1, Appendix "C".

Using Manning's Equation and the limiting design velocities from Handbook of Steel Drainage and Highway Construction Products, Highway Task Force, American Iron and Steel Institute, discharge vs. gradient curves, were calculated for the ditch sections and general soil types to be encountered on the Highway. From experience and observation, the limiting velocities are generally applicable.

The calculation of the anticipated runoff i.e. discharge to which the ditches may be subjected, was determined, where possible, by scaling the area of the drainage basin from

aerial photographs and estimating the flow using a modified rational formula adjusted for the area and based on the knowledge of the designer.

The discharge vs gradient curves were then utilized to recognize areas of potential water erosion.

Similarly design discharge vs gradient curves were plotted for the recommended design velocities of Brooker. Based on these velocities, ditch grade vs. check dam spacing curves were developed for various discharges.

An elevation difference of one foot between check dam crests was chosen based on the physical limitations of ditch depth.

Since effects of runoff on the channel are dependant on:

1. Soil type and gradation;
2. Quantity of runoff;
3. Water and soil temperatures;
4. Degree of revegetation;
5. Grade of channel and discharge

the decision as to the type and nature of erosion prevention must reside with the Field Construction Engineer.



**LIMITING WATER VELOCITIES**  
**FOR THE DESIGN OF STABLE CHANNELS**

<b>Material</b>	<b>Manning n</b>	<b>Velocity ft/sec.</b>
Fine sand colloidal.....	0.020	1.50
Sandy loam noncolloidal.....	.020	1.75
Silt loam noncolloidal.....	.020	2.00
Alluvial silts noncolloidal.....	.020	2.00
Ordinary firm loam.....	.020	2.50
Volcanic ash.....	.020	2.50
Stiff clay very colloidal.....	.025	3.75
Alluvial silts colloidal.....	.025	3.75
Shales and hardpans.....	.025	6.00
Fine gravel.....	.020	2.50
Graded loam to cobbles when non- colloidal.....	.030	3.75
Graded silts to cobbles when colloidal.....	.030	4.00
Coarse gravel noncolloidal.....	.025	4.00
Cobbles and shingles.....	.035	5.00

**Reference:**

Handbook of Steel Drainage and Highway Construction  
Products. Highway Task Force, American Iron and Steel  
Institute.

TABLE C\*-1

Manning's 'n' for Natural Stream channels and Design Velocities for Non-Silt, Non-Scour Conditions for use on the Mackenzie Highway.

MATERIAL	MANNING n	RECOMMENDED DESIGN VELOCITIES (fps)
Stiff Clay	0.025	2.00
Colloidal Silt	0.025	1.00
Non-Colloidal Silt	0.020	2.00
Fine Sand	0.020	1.25
Coarse Sand	0.020	1.25
Silty Sand	0.020	1.50
Silt Till	0.025	2.00
Clay Till	0.025	2.00
Fine Gravel	0.020	2.00
Coarse Gravel	0.025	3.00
Well Graded Gravel	0.025	3.00
Cobbles	0.035	5.00
Broken Stone	0.035	3.00
Shale	0.025	4.00
Vegetal-lines	0.033	3.5 maximum

1. Table C-1 is based on channel depths being between 0.5 and 3.0 feet.
2. Aging of channels permits velocities to be increased by 30%.
3. For vegetal-lined channels increase the given values by up to 1.5 (fps) but not exceeding maximum values given.
4. Gradients should not exceed 4 percent for any drainage course.

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\* References:

1. Seelye, E.E., 1956: Foundations, Design and Practice
2. Handbook of Steel Drainage and Highway Construction Products. Highway Task Force, American Iron and Steel Institute.

# SOLUTIONS TO MANNING'S EQUATION FOR CHANNEL GRADES

## MANNING'S EQUATION

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$V$  = mean velocity of flow "fps

$R$  = hydraulic radius in ft =  $\frac{A}{WP}$

$WP$  = wetted perimeter in ft.

$A$  = x-sectional area of flow in sq. ft.

$n$  = coefficient of roughness

$S$  = slope in ft/ft

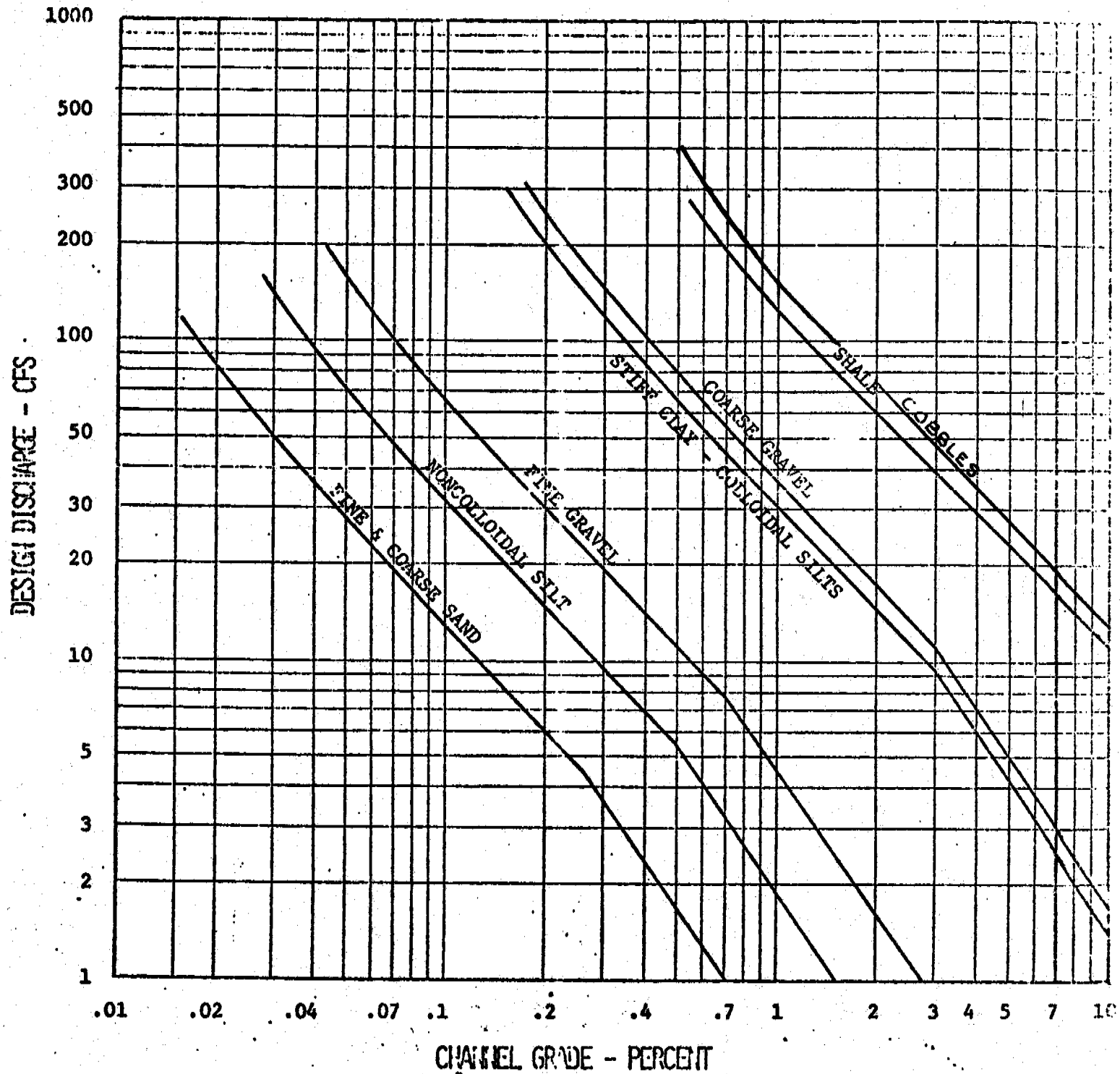
SOLVING for  $S$

$$S = \left( \frac{Vn}{1.486 R^{2/3}} \right)^2$$

The channel grade in percent is:

$$= 100 \left( \frac{Vn}{1.486 R^{2/3}} \right)^2$$

# LIMITING CHANNEL GRADES FOR THE DESIGN OF "B" TYPE DITCHES

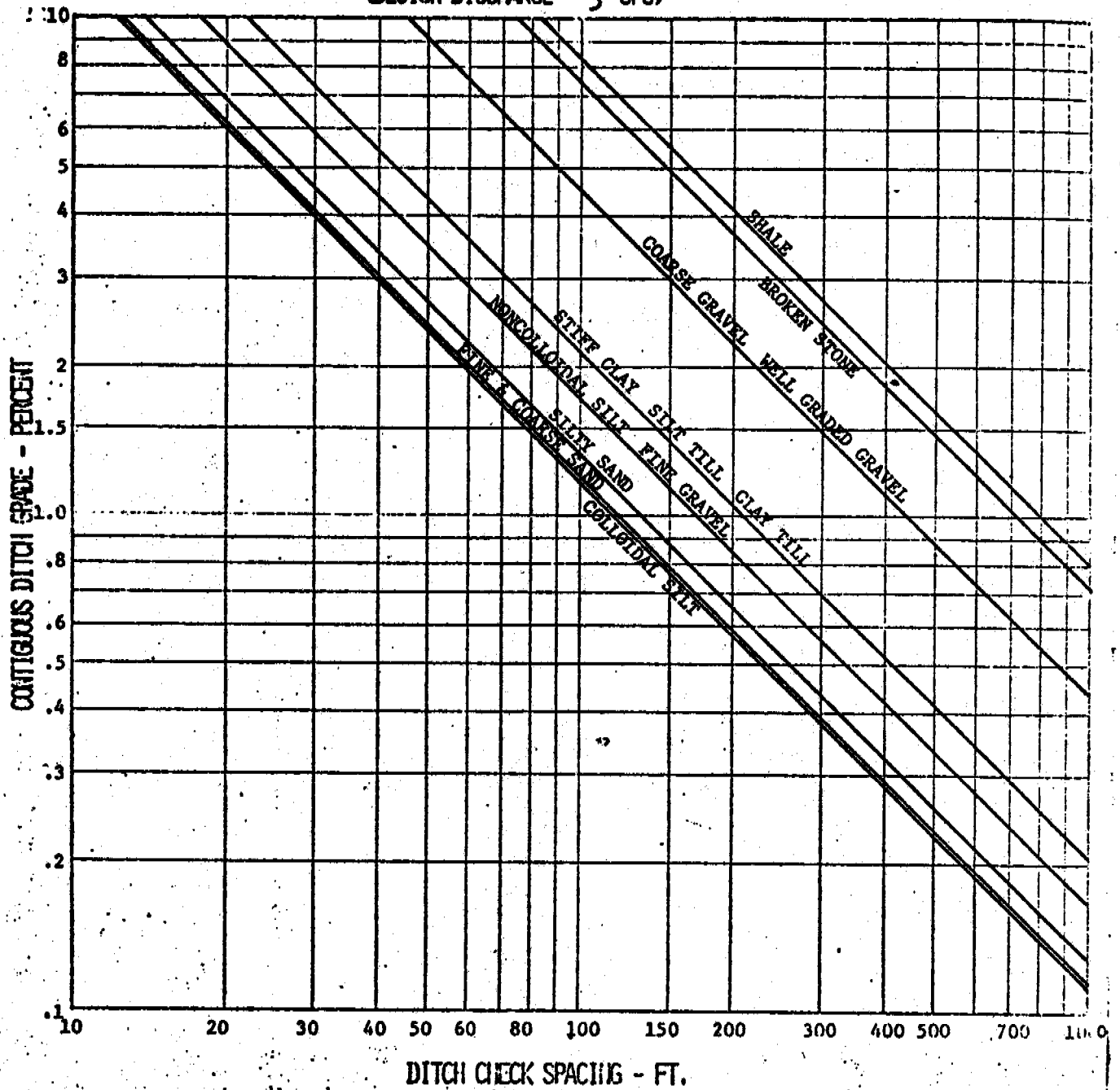


Reference:

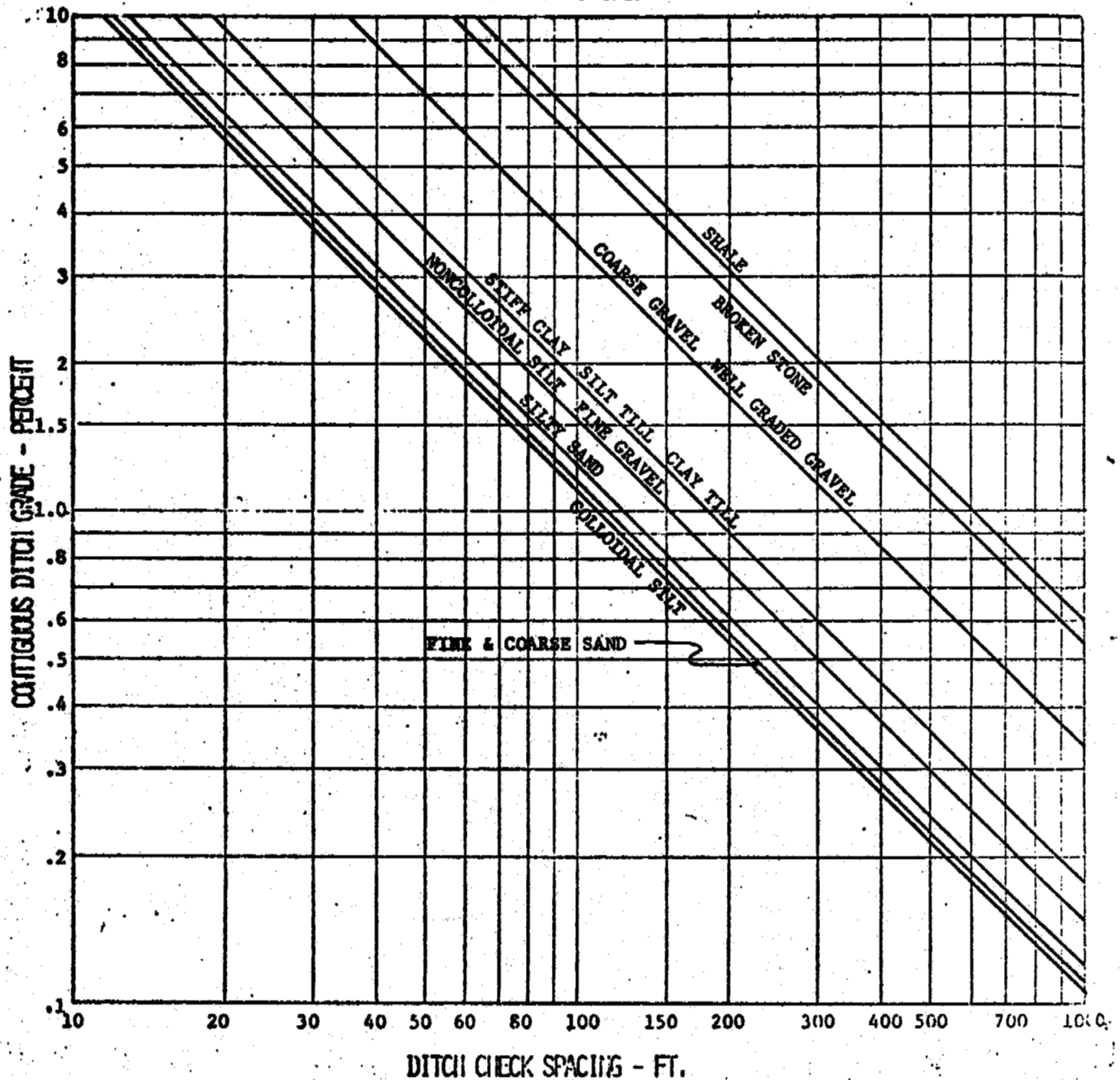
Handbook of Steel Drainage and Highway Construction Products, Highway Task Force,

# DITCH CHECK SPACING

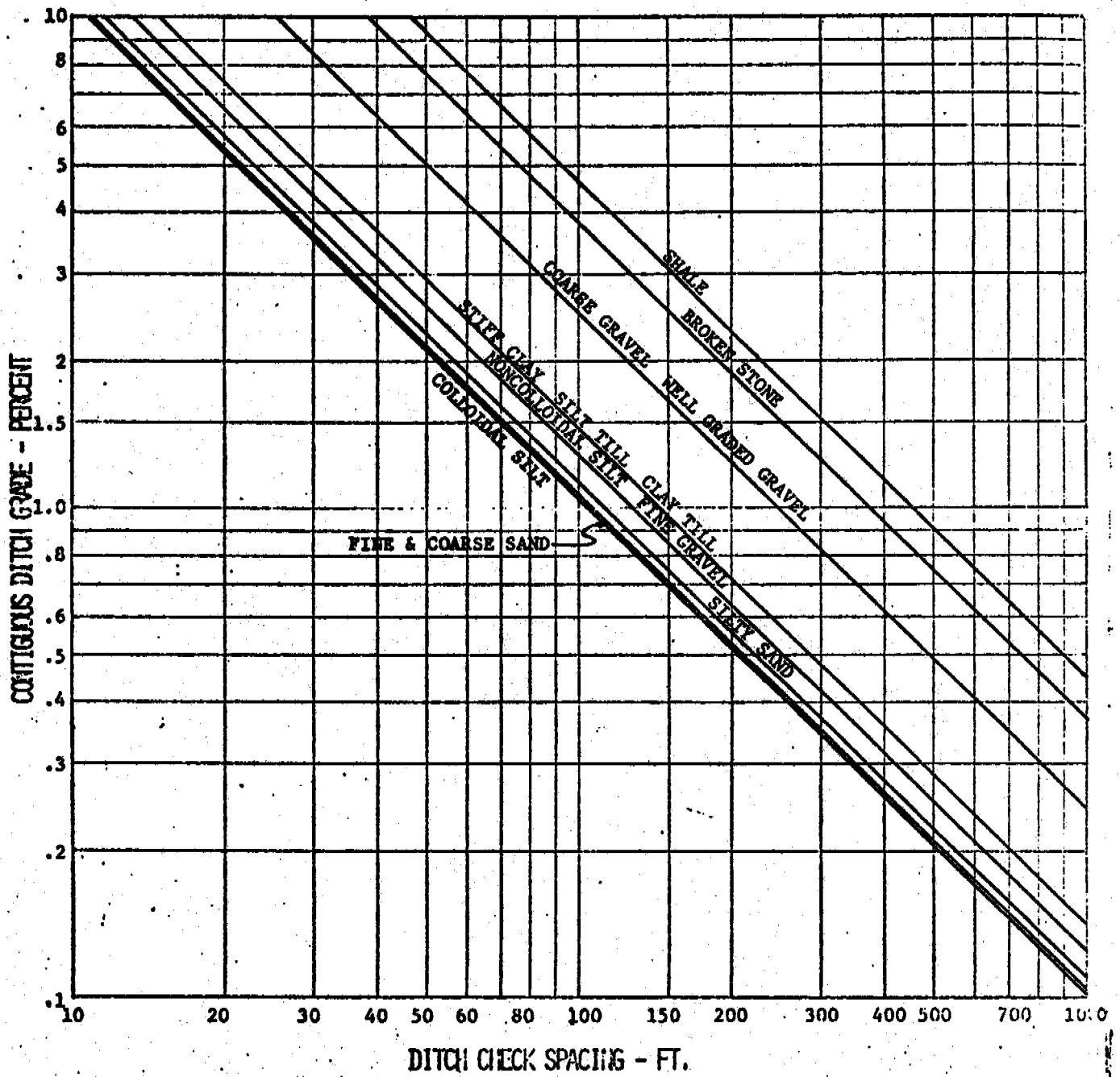
(DESIGN DISCHARGE - 3 CFS)



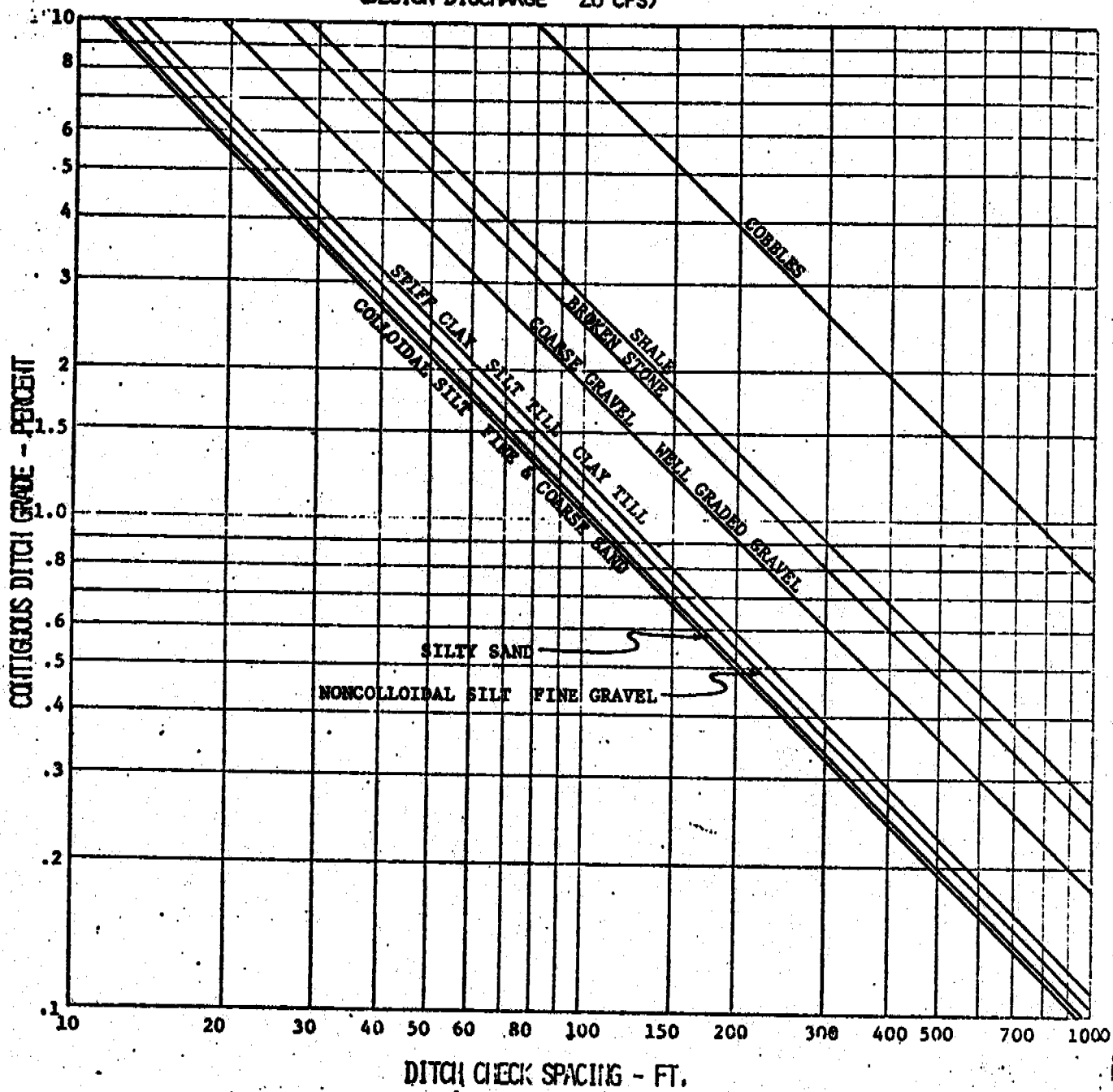
# DITCH CHECK SPACING (DESIGN DISCHARGE - 5 CFS)



**DITCH CHECK SPACING :**  
(DESIGN DISCHARGE - 10 CFS)

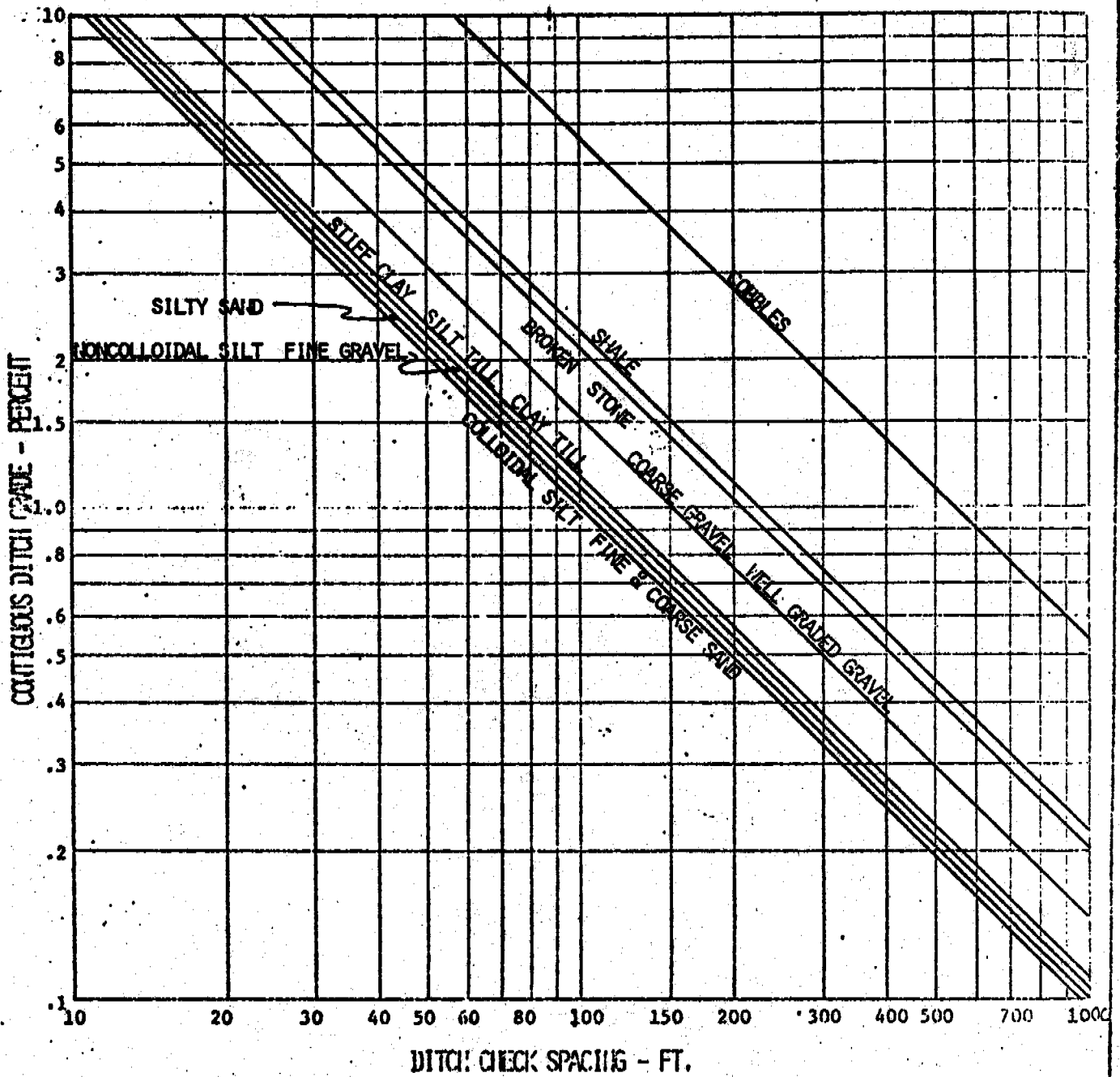


# DITCH CHECK SPACING : (DESIGN DISCHARGE - 20 CFS)





# **DITCH CHECK SPACING** (DESIGN DISCHARGE - 30 CFS)



**APPENDIX "B"**

**SUBJECT:**      **HYDROLOGY DATA FOR CULVERT DESIGN -**  
                 **MILE 495 TO 521**







The formula used by the hydrology consultant, Bolter, Parish, Trimble Ltd. was as developed in their Hydrology Study and Design of Culverts, Mile 297 to Mile 345, November, 1972 and modified as outlined in their subsequent reports on Mile 403.1 and Mile 407.5, June 12, 1973 and in their report on Mile 406.2, September 20, 1973.

The following summary of Data used supplements the Culvert Design Sheets included in the Preliminary Design Submission.

HYDROLOGY SUMMARY

PRELIMINARY - SUBJECT TO REVISION

MILE 490 TO MILE 521

MILE	496.8	504.9	508.3	509.8	511.1	514.3	515.7	516.0	517.9	519.3
Drainage Area (A) TOTAL (sq. miles)	13.7	16.7	6.0	4.8	2.1	4.9	1.2	4.0	1.2	5.4
Qhwm (c.f.s.)	170			364	210	290	 110	 430	 174	 -
Drainage Area (Ae) EFFECTIVE (sq. miles)	2.0	-	-	4.8	2.1	4.9	1.2	4.0	.6	5.4
Relief (feet)	50	-	-	1100	650	1500	1250	1650	550	1600
(100 - L) Water Retained for Runoff	.19	-	-	.24	.22	.26	.25	.27	.22	.26
Rainfall (inches in 24 hours)	3.5	-	-	3.5	3.5	3.5	3.5	3.5	3.5	3.5
M Ratio	4.12	-	-	3.90	4.11	3.89	4.18	3.97	4.40	3.56
Qe (c.f.s.)	146	-	-	430	177	460	117	400	54	467
Drainage Area (A1c) LAKE CONTROL (sq. miles)	11.7	16.7	6.0	-	-	-	-	-	.6	-
Relief (feet)	1400	1550	1100	-	-	-	-	-	550	-
(100 - L)	.26	.26	.24	-	-	-	-	-	.22	-
Rainfall (inches in 24 hours)	3.5	3.5	3.5	-	-	-	-	-	3.5	-
Q1c (c.f.s.)	284	410	135	-	-	-	-	-	12	-
Drainage Area (Am) MUSKEG (sq. miles)	-	-	-	-	-	-	-	-	-	-
Qm (c.f.s.)	-	-	-	-	-	-	-	-	-	-
Q rational (c.f.s.) (Qe + Q1c + Qm)	432	410	135	430	177	460	117	400	66	467
Q design	430	410	135	430	210	460	120	430	175	470



Qhwm not assessed at this crossing, requires field inspection prior to final design.



Qhwm assessed at old alignment. Revised location has negligible change in drainage area.

## Hydrologist Drawings cont'd

Number of  
Sheets

115-3-116 @ Mile 496.8 -----	1
-117 @ Mile 504.9 -----	1
-118 @ Mile 508.3 -----	1
-119 @ Mile 509.8 -----	1
-120 @ Mile 511.1 -----	1
-122 @ Mile 514.3 -----	1
-123 @ Mile 515.7 -----	1
-124 @ Mile 516.0 -----	1
-127 @ Mile 517.9 -----	1
-128 @ Mile 519.3 -----	1

Total

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76

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