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HIGHWAY 29
HUDSON HOPE TO CHARLIE LAKE

ENVIRONMENTAL IMPACT AND ENGINEERING STUDY OF HIGHWAY 29 RELOCATION

SECTION 1.

PRELIMINARY

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HIGHWAY #29 - HUDSON HOPE TO CHARLIE LAKE

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SECTION 1

Prepared on behalf of

THE MINISTRY OF TRANSPORTATION & HIGHWAYS

Prepared by:

September 1981

Graeme & Murray Consultants Ltd.

SYNOPSIS

This study has investigated feasible alternative relocation alignments of Highway #29 at Attachie and Bear Flats in the Peace River valley. These relocations will be necessitated by the building of Site C dam on the Peace River and the raising of the river level.

The alternative alignments considered have been aligned to minimize the effects on the agriculture and land use capability of the valley.

Engineering and construction costs of the proposed alignments have been considered, together with all relevant environmental impacts and an overall comparison and ranking of the routes determined.

The conclusion and recommendation of the study are that Alignment C is preferable on the Attachie Section, subject to the findings of the hydraulic model study on potential wave action on that alignment, and that Alignment E2 is preferable on the Bear Flats section.

TABLE OF CONTENTS

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

FIGURES (located at end of report)

1. INTRODUCTION

1.1 Background
(refer to Figure 1)

For some years, B.C. Hydro and Power Authority have been investigating the feasibility of designing and constructing power generation plants on the Peace River in northeastern British Columbia.

Power generation has already commenced for Phase 1 at the W.A.C. Bennett Dam, by the impoundment and forming of Lake Williston. Phase 2 dam and power plant are currently under construction at Peace Canyon Site 1 west of Hudson Hope. The third possible phase is for the construction of an earth-fill dam and generating capability at Site C, south of Fort St. John.

This proposed impoundment would raise the level of the existing Peace River by up to 36m (120').

This flooding would inundate and cover parts of Highway 29 as it runs between Fort St. John and Hudson Hope in the Peace River valley. B.C. Hydro & Power Authority are currently seeking a water licence and approvals to carry out these works.

This report is a record of the detailed study carried out by Graeme & Murray in order to determine the preferred alignment for the relocation of the highway at two of the affected sections - Attachie and Bear Flats (see Figure 1).

1.2 Terms of Reference

The terms of reference call for an environmental and engineering investigation into the alignment and a recommendation to be made of a preferred alignment for the relocation of the highway, the findings of the study are to be documented in report form.

A copy of the terms of reference or details of services required are given in Appendix 1.

1.3 Methodology and Study Procedure

The Peace River valley and area have been the subject of numerous intensive investigatory studies over the years associated with the Site C dam project. These studies have covered a wide range of subjects, from the collection and documentation of physical data, such as geotechnic and hydrological information, through to environmental issues, such as those of a social nature.

Much information is, therefore, available on the area, but to date this has been assembled and considered from the impacts or effects the dam construction and impoundment would have.

This study acknowledges that this information is available and has used it in this separate assessment of alternative realignments of Highway #29.

The past studies have been carried out by both B.C. Hydro & Power Authority personnel and consultants. Reference has been made to the same personnel during this study, and they have been asked to review and consider alternative highway alignments which have been investigated and identified as feasible from the engineering viewpoint.

The engineering study has been based on 1"=400' (1:4800) aerial mapping of the area carried out in 1968, which has contours to a 3m (10') interval.

Numerous alternative horizontal alignments were developed to the required Ministry of Transportation & Highways standards (see Section 3.1.2) in consultation with the soils consultants. These numerous alignments were developed with the aim of minimizing loss of agricultural land and were then reviewed with the environmental consultants. Alignments with the worst environmental impacts were discarded at this stage, and the remaining alignments were further refined and construction costs estimated following site inspection and study of the detailed aerial photography by engineering and geotechnic personnel.

These alignments were then submitted to the environmental subconsultants to assess the relative environmental impacts and to recommend mitigation measures where possible and to state a preference for any alignment.

This information on environmental impacts, mitigation measures, construction costs, and schedules was all reviewed and evaluated, conclusions were drawn up, and the recommendation of the preferred alignment was made.

1.4 Report Structure

The report has been prepared as a self-contained report and contains the complete findings regarding Highway #29 relocation.

The structure of the report closely follows the methodology used in the study. The first sections within the report detail existing conditions in the area, covering the physical aspects of topography, geology, and geotechnic information, mineral resources, drainage, climate, and hydrology. These existing conditions are followed by a description of the settlement features, agriculture and forestry aspects, and fish and wildlife of the area.

The engineering aspects of highway alignment, design standards, and route descriptions follow. River crossings, which are the major feature of the alignments, have been considered in detail. Methods of construction and staging the projects have been investigated and are reported on. Finally, under the engineering aspects, construction costs are detailed.

Impact assessments have been carried out for each alignment under the environmental considerations, and mitigation or enhancement measures have been detailed for each alignment.

Finally, the alignments are discussed and compared. A recommendation is made of the preferred alignments on the Attachie and Bear Flats sections.

The plan scale which preliminary design has been carried out for this study is 1-4800 (1"-400'). This design is shown on plans within the report to a 1:10,000 scale.

2. EXISTING CONDITIONS

2.1 OVERVIEW

2.1.1 Location
(refer to Figs. 2, 3 & 4)

The Peace River is one of the major rivers in western Canada. It originates in northeast British Columbia, in the Rocky Mountain Trench, by the confluence of the Finlay and Parsnip Rivers. The Peace River then flows eastwards, past Hudson Hope and Fort St. John, into northwestern Alberta.

Site C dam is proposed on the Peace River, close to the British Columbia/Alberta border such that Highway #29 between Hudson Hope and Fort St. John would require relocation.

2.1.2 General Description of the Area

The proposed reservoir site is located on the western edge of the Interior Plains. This relatively flat to slightly rolling plain (Alberta plateau) has been carved by the Peace River into a valley 2-3 kilometres wide and 180-250m (600'-800') deep.

This valley lies in a general west-east direction and has tributaries coming into the valley at right angles. The valley is steep sided and has a lower floor composed of relatively level river terraces.

The climate is that of the "Interior Plains," with high summer temperatures and low winter temperatures. These high temperatures in the summer, coupled with the longer days, concentration of rainfall during the summer, and good soils, give an area ideally suited to the cereal growing which predominates in the area.

The trading and commercial centre of this rural area is Fort St. John (pop. 15,000*), at the eastern end of the area. Hudson Hope (pop. 1,200*) is located some 75 km. upstream. The early means of communication and travel into the area via the rivers and by track have given way to those of road, rail, and aircraft.

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*B.C. Government Statistics, 1980.

2.1.2 General Description of the Area (cont.)

Highway #97 continues northwestwards from Dawson Creek up through Fort Nelson to the Yukon and Alaska as the Alaska Highway.

Highway #29 runs from Fort St. John along the north bank of the Peace River via Hudson Hope to Chetwynd on Highway 97. It is this section of Highway #29 that would be flooded by the new reservoir formed by the proposed Site C dam.

The British Columbia Railway has a spur line from Prince George to Fort St. John and up to Fort Nelson, and it is used as the area's grain outlet to the coast.

The recent proposed development to extract coal from Tumbler Ridge to the southwest will require additional new railway and highway spurs and will generate further growth in the general area.

Fort St. John has a modern airport capable of handling Boeing 737's, which provide a regular service to major cities in western Canada.

Many of the larger ranches have their own aircraft which they operate locally from airstrips on their own property.

2.1.3 Brief History and Background

As evidenced by the numerous artifacts found in this area of the Peace River, this valley was an important feature in the lives of the native Indians who hunted, camped, and lived along the river's banks.

The first EuroCanadian known to have travelled the Peace River was Alexander Mackenzie (1793). On his recommendation a fort, known as Rocky Mountain Fort, was established on the west bank of the Moberly River, east of the area under consideration. Continued development of the fur trade in the area thereafter resulted in the establishment of further forts in the area, one on the opposite bank to present-day Hudson Hope. This latter fort was established by Simon Fraser in 1805 and was called Rocky Mountain Portage House.

During this period of exploration and fur trade (1793-1900), independent trappers established themselves in the area. Transient gold miners also stayed in the valley, prospecting and trapping.

Agricultural settlement of the valley took place from 1910 to the present day, where land clearing is still proceeding.

Initially all communications and contact with the area were with Alberta, since there were no road or rail connections with southern British Columbia. The building and opening of the Alaska Highway in 1946 and the building of the highway between Prince George and Dawson Creek have encouraged further settlement and contact with the rest of British Columbia..

Latterly the growth of the area has been associated with expansion and development of non-agricultural industries, principally forestry, oil, and gas.

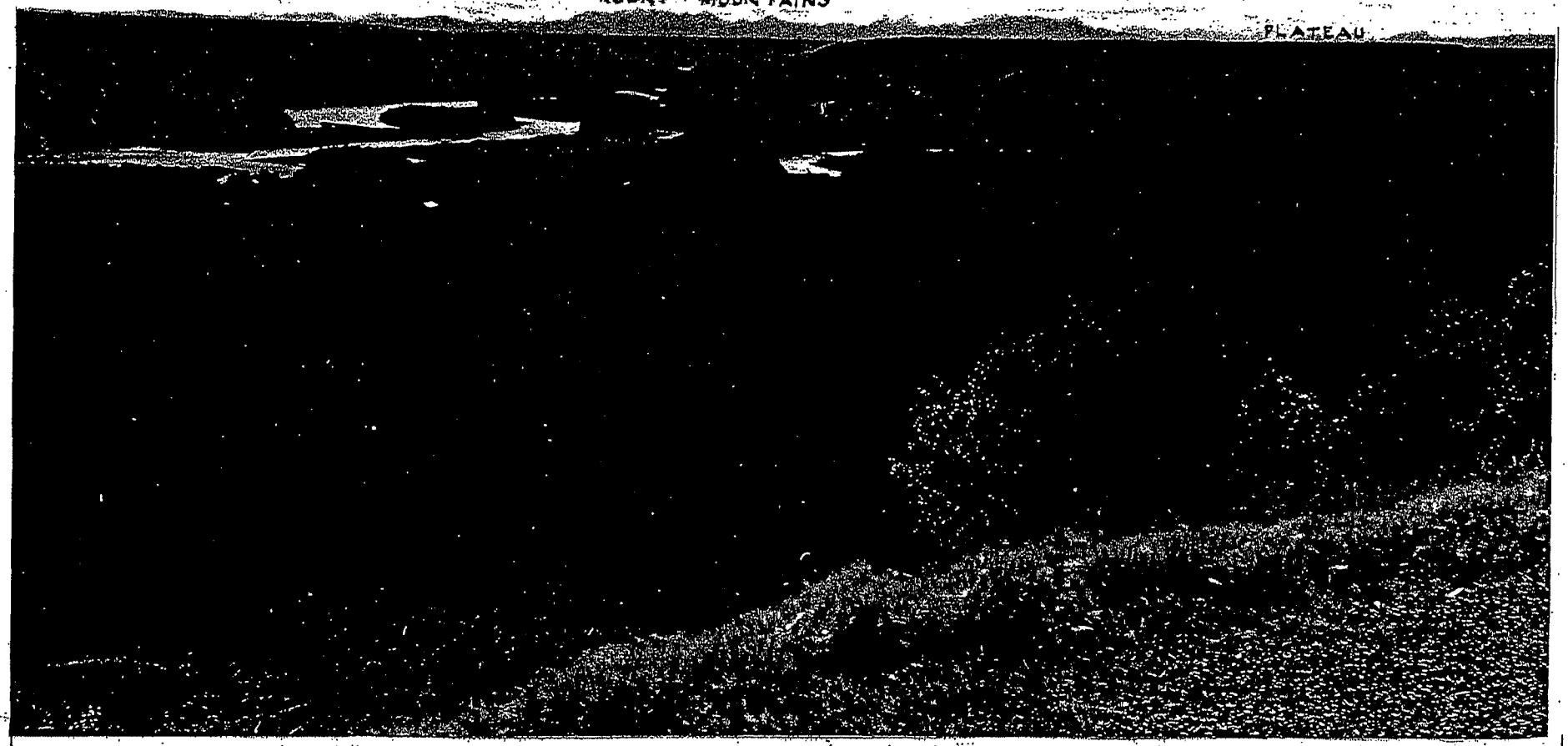
2.2 PHYSICAL CHARACTERISTICS

2.2.1 Topography
(see Figures 2, 3, 4, and Photographs 2.2.1.a and 2.2.1.b)

The slightly rolling land of the Albertan plateau has been deeply incised in an east-west direction by the Peace River, leaving a valley 2-3 kilometres wide and up to 250m (800') deep. North of the valley this land is extensively cleared and cultivated, with grain, rape seed, and cattle fodder being the main crops. South of the river valley little true clearing has taken place, and the area is designated as a wildlife reserve.

Within the river bottom there are two river terraces which, because of their gentle slope towards the river (approx. 5%) and their covering of good workable soil (see Section 2.4.2), have been cleared and cropped. The best soil cover lies on the higher parts of the upper and lower terraces, with the lower slopes of the terraces covered by trees at some locations where clearing has not taken place. The edge of the valley has a steep-sided slope (varying from 10^{o}-30^{o}) up onto the plateau. Only along the toe of this slope does the upper terrace show any noticeable change in topography. This occurs at numerous gully locations where washout of the softer slope material has been deposited in a fan shape (see photographs overleaf).

The Attachie Section is the most westerly section of Section 1 and includes the Halfway River. Halfway River is the major tributory entering the Peace River over Section 1 and enters through high, 40m (130'), near vertical cliffs cutting through the terrace. The Halfway river valley bottom is wide (up to 1.5 km.) and level with past evidence of many different river courses. A narrow projection of high land runs from the west bank towards the east bank. This projection will remain above water if the reservoir is formed (see Photograph 2.2.1.a overleaf).


ROCKY MOUNTAINS
PLATEAU

2.2.1 Topography (cont.)

The second river (Cache Creek) lies on the Bear Flats section, but this is not a major river. It nevertheless exhibits similar features with the steep, near-vertical banks (40m) and the level valley bottom. Cache Creek valley bottom has a fairly consistent width of 0.5 km. approx. and is covered in mature coniferous trees for most of its length. Tree cover on the terraces consists of copses of poplar and lodgepole, with larger areas of continual cover along the upper/lower terrace and lower terrace/river interface. Occasional copses of trees exist along the toe of the steep slope at the back of the upper terrace. However, the steep slopes themselves are, in general, free of trees and are covered in grass and low shrubs (see Photograph 2.2.1.b overleaf).

VIEW OF BEAR FLAT FROM EAST LOOKING WEST

2.2.2 GEOLOGY AND GEOTECHNICAL INFORMATION*

2.2.2.1 Bedrock Geology
(refer to Figs. 5, 6 & 7)

The only rock formation which is exposed along the banks of the Peace River within the study area (roughly between the Halfway River and Cache Creek) is shale of the Cretaceous Fort St. John Group (Shaftsbury Formation). In sequence, it is overlain by Dunvegan Sandstone, which is exposed in upland areas well away from the river.

The shale formation is generally flat lying, dark grey in colour, and very fissile. It contains occasional interbeds of siltstone.

On the Halfway River (within the Attachie Section of new road), bedrock is exposed to between elev. 1,550 (472 m) and elev. 1,520 (464 m) on the banks and is believed to underlie the terrace areas on both sides of the river at similar elevations.

At Cache Creek, within the Bear Flat realignment section, bedrock is exposed to about elev. 1,550 (472 m) on both banks. It is believed that the bedrock surface underlies the terraces on both sides of the creek within the realignment area at about this elevation, except at the east end, where bedrock rapidly rises to elev. 2,850 (870 m) within the Cache Creek Slide Area.

*This section is a summary of information presented in Thurber Consultants' report to B.C. Hydro, "Site C Reservoir Shoreline Stability Assessment," dated April 1978.

2.2.2.2 Surficial Geology
(refer to Figures 5, 6, & 7)

The stratigraphy of the overburden overlying bedrock in the Peace River valley is complex in detail but generally adheres to the following sequence:

- Post-glacial river (and terrace) gravels, alluvial fans, slide debris, etc.

- Late glacial clays and silts up to 40m (140') thick. These materials were deposited in "Lake Peace" up to the elev. 2,250 (686 m) level. Commonly plastic, occasionally gravelly.

- Glacial till (Wisconsin) up to 25m (80') thick. Deposited during the last major advance of ice from the Canadian Shield.

- Interglacial river and lake deposits consisting typically of 120m (400') or more silt, clay (sometimes stony), and minor sands.

- Glacial till (Laurentide), rarely exposed and commonly missing in the reservoir area.

- Interglacial or preglacial basal river gravel deposits, typically not more than 30m (100') thick. This material was deposited by a large river flowing through a bedrock channel.

The terraces on the slopes of the Peace River portray the history of downcutting. Throughout the reservoir area there is a marked upper terrace, about 45-60m (150-200') above river level, designating a period when widening of the valley predominated over vertical downcutting. The proposed road alignments are mainly located on this feature.

Surficial geology of the study areas is shown on Figures 5, 6, and 7, based on analysis of existing air photographs and field inspection.

2.2.2.3 Terrain Sensitive to Highway Construction

The only soil unit encountered by the proposed road alignments which is at all sensitive to highway construction is the slope formed in clay and silt along the back of the terrace. This slope has been subject to past failures and is expected to suffer instability in the future.

2.2.3 MINERAL RESOURCES

2.2.3.1 Natural Gas Reserves
(refer to Figures 2, 3, & 4)

The Wilder Gas Field lies at a depth of about 2,135m (7,000') below the ground surface on both sides of the Peace River. Eight wells have been drilled in the Peace River valley area, and three of these lie in the area of Bear Flats (see Figure 4).

At present these wells are not "on stream" and have no pipeline connections to them. Such connection may be made in the future when the economic return improves.

The extraction and collection of the natural gas will be able to proceed in the future and will not be affected by a new reservoir or relocated highway.

2.2.3.2 Coal

Coal does exist in the area in the Gethin formation which has been identified as lying within 700'-800' (210-240m) of the ground surface.

The records of the Department of Mines & Petroleum resources indicate that there was interest in coal licences in the Hudson Hope area, but these applications have lapsed and have been dropped. Coal extraction will not be prevented by any of the alignments.

2.2.3.3 Oil

Oil exploration has taken place in the past and licences for oil and gas exploration and extraction have been taken over most of the Peace River area.

It appears that, at the moment, gas is the only produce from these shallow wells. Deeper wells may be drilled in the future.

2.2.3.4 Sand and Gravel

The lower and upper terraces on the north bank of the Peace River contain substantial quantities of gravel deposits. This gravel varies in quality from a clean well-graded sand and gravel to a silty sand. The gravel in the valley bottom of Halfway River contains medium-sized (0.3m dia.) boulders.

The gravel resource has only been worked at three locations on the two sections and these are small pits. It has been estimated* that some 760 million m^3 of granular material will remain above the reservoir elevation, 461.77m (1,515'). The proposed alignments could take advantage of the use of gravel materials as import, 2-3 million m^3, for fill construction (see Section 3.2) and there would still be large reserves of gravel remaining.

2.2.3.5 Other Minerals

There are no existing mineral claims in the area, and placer leases are not permitted since this is not a designated area. The two reserves that are in effect under the B.C. Numerical and Placer Acts* cover the Peace River and tributaries below the 464.82m (1,525') contour and along a transmission line route on the north side of the Peace River between Hudson Hope and Fort St. John. These reserves protect these areas from staking without recourse and release by the parties involved.

*B.C. Hydro Report HE C790.

2.2.4 DRAINAGE

2.2.4.1 Surface Drainage
(refer to Figures 2, 3, & 4)

The Peace River is the major water collector with the two main rivers, Halfway River and Cache Creek, joining it at right angles at Attachie and Bear Flats respectively.

Reference to Section 2.2.5 indicates that, whilst rainfall is low overall for the year, 450mm (17.71"), heavy rainfall - max. 80.3mm (3.2") in 24 hours - does occur over a short period.

Due to the soft nature of the surface materials of the area, well-defined gullies and creeks have developed which carry these heavy rainfalls and snow melt waters to the Peace River. These gullies and valleys are typically at right angles to the Peace River.

During the summer, these creeks and gullies are generally dry and, because the soils of the upper terrace overly gravels, the smaller of these creeks disappear entirely as the water flow diminishes and eventually ceases altogether as it percolates into the gravel.

The land in the area is generally cultivated on a rotation system with land left to summer fallow every third year. During this fallow period, the land is cultivated throughout the summer, but no crops are allowed to grow. As a result, heavy summer rainfall causes limited washout of topsoil off these fields. This factor must be kept in mind when the highway drainage outfalls and design are determined so that this washout problem is not worsened (see Section 3.1.7).

*Confirmed on September 3, 1981, at the Department of Mines & Petroleum Resources.

2.2.4.2 Subsurface Drainage

The silts and clays of the upper plateau are relatively impervious as evidenced by the wet and swampy areas along the plateau. The only presence of subsurface water, which is evident in the area, appears as springs at the lower edge of the upper terrace at the gravel/rock (shale) interface. One notable spring exists adjacent to the highway on the road to the Watson and Haig ranches. Users come from as far as 20 miles to collect this water for drinking purposes. This spring is obviously fed by the gravel layer which lies under the upper terrace.

2.2.4.3 Drainage Structures
(refer to Figures 2, 3, & 4)

The two future major drainage structures at Halfway River and Cache Creek are dealt with in Section 3.1.6.

The present structure at Halfway River consists of two major, approx. 61m (200'), spans plus a westerly side span of approx. 15m (50'). The structure is a new one, constructed in 1975, and is of composite deck construction with the reinforced concrete deck cast onto steel girders. Piers are constructed in reinforced concrete. Consideration should be given to dismantling and reusing the deck beams elsewhere in the area. Once the reservoir waters commence rising, these would easily be floated off, loaded onto highway transport, and taken to a new bridge site or storage.

The present Cache Creek bridge on Highway #29 is an old timber truss structure and would not be suitable for reuse.

There are no other streams or creeks in the Attachie section.

There is a 900mm (3'0") diameter culvert at chainage 1+800 on Alignment E. There is evidence at this culvert of considerable silting during run-off; this has been overcome by providing a separate inlet into the culvert at a higher elevation. Such a feature will be incorporated into new culverts where deemed necessary on this project.

Other drainage structures and culverts existing in the area lie on the lower terrace, where they are dealing with much slower flows of water. These areas and structures would all be flooded, so it is the structures on the upper terrace and at the toe of the slope to the plateau that are significant.

2.2.4.3 Drainage Structures (cont.)

At the series of switchbacks on the climb to the plateau level, east of Bear Flats, the existing highway crosses numerous gullies which have been culverted and the water flow directed away from the fill slope. Half-open channel sections have also been used in the area, again to control water erosion. Any new design must include similar preventive measures.

2.2.5 Climate

The climate of the area can be classified as "Canadian Prairie," indicating low annual precipitation with a large range in annual temperature.

Results from the nearest continuous weather station at Fort St. John are summarised below:

Fort St. John - Elevation 693.5m (2,275')

Average Air Temperature °C (°F)	Jan.	-17.22° (1.0°)
	July	15.9° (60.6°)
Average Annual Precipitation		450mm (17.71")
Mean Rainfall		255mm (10")
Mean Snowfall		2,062mm (81.2")
Average total days with frost		193
Greatest rainfall in 24 hours		80mm (3.2")

The four months with greatest rainfall are May-June-July-August.

These records are based on 29 years of continuous records and apply in general to the valley of the Peace River, although summer extremes of temperature are moderated somewhat by the presence of the body of water of the Peace River. In the winter, pockets of frost lie in the valley on occasions, giving lower temperatures than on the plateau.

Whilst the growing season is short, as indicated by the large number of days with frost, the summer days are long and give good growing conditions, particularly as most of the precipitation falls during these growing months. During the winter the temperature remains below freezing continually, and the snow which falls remains throughout the winter.

Two main wind directions prevail in the area, from the north in the winter and the southwest in the summer months. Wind velocities tend to be lower in the valley, 7km/hr (4 mph), during the winter, due to the decoupling effect from winds at the upper plateau level, but they are higher in the summer due to convective effects. The valley winds tend to orient themselves with the valley direction and are apparent as gusting convective winds. These should be considered from their effects on traffic in the cases of high fills or sudden exposure at a cut/fill location.

2.2.5 Climate (cont.)

The maximum winds recorded at any instant during the period 1976-1977 in the valley on the Attachie and Bear Flats sections was 29 km/hr (18 mph), a relatively low wind speed.

Fog frequently forms in the valley in the late summer and early fall and is worst on the lower terraces, closer to the river, but does fill the valley to the plateau level on occasion. Records indicate that the amount of fog formation is limited only, however, and does not therefore pose a major problem to route location considerations.

2.2.6 Hydrology

Monthly discharges and annual mean discharges, maximum instantaneous and maximum daily discharges in m^3/sec. have been recorded for the Halfway River over the period 1962 to the present day. Drainage area for this river is 9,400 km^2.

These figures are summarized below:

Station 07FA001
Halfway River near Farrell Creek
(Flows in Cubic Metres/Second)

Mean Annual Flow 1962-1979	77.0					
Mean Monthly Flows 1962-1979	Jan.	Feb.	Mar.	Apr.	May	June
	12.5	10.7	10.4	35.9	158	239
	July	Aug.	Sep.	Oct.	Nov.	Dec.
	191	123	75.6	57.1	29.4	17.5
Maximum Instantaneous Flow	1,320* (June 27, 1962)					
Maximum Daily Flow	1,980 (June 29, 1965 and August 14, 1976)					

*It is understood that this flow is lower than that for the maximum daily flow due to lack of continuous recording.

Only the mean monthly and annual average flows are available for Cache Creek at this time, since this creek has not had a major recording station.

Cache Creek
Flows in Cubic Metres/Second

Mean Monthly Flows 1962-1979	Jan.	Feb.	Mar.	Apr.	May	June
	1.13	1.53	1.75	7.39	23.05	11.1
	July	Aug.	Sep.	Oct.	Nov.	Dec.
	8.5	6.25	4.90	4.67	3.14	1.87
Average Annual Flow	6.27					

What is significant to note is that the maximum flows occur during the summer months, May, June, and July, and that these are caused by the combination of high rainfall and snow melt.

2.2.7 Visual Resources
(refer to Photographs 2.2.1.a and 2.2.1.b)

The Peace River Valley is a major rich source of visual experience in the Province. The present Highway #29 alignment is such that the views of the valley are optimized as it descends, runs through, and climbs out of the valley and ascends again between Bear Flats and Attachie.

As one descends into the valley, the pastoral scene, with the cultivated and cropped fields in the valley, appears below. This is framed by the Rocky Mountain Range in the distance and bounded immediately by the winding Peace River and its high forested south bank (see Photographs 2.2.1.a and 2.2.1.b).

During the summer, the cultivated areas and different crops grown in the valley stand out and give pattern to the land. Tree cover occurs more heavily towards the River and it is generally deciduous in nature. Other than the regularity of the fields, there are few signs of man and the resultant feeling on viewing the valley is one of tranquility.

Travelling through the valley itself, this feeling of tranquility is further heightened by the glimpses of fields of cereal, occasional old farm buildings, wooded areas, and the sun-dappled waters of the Peace River as it meanders through the valley.

Stopping places are available along the highway for the traveller to take advantage of these views.

Off the highway there is an abundance of wildlife with wild flowers carpeting the open spaces. Occasionally an old homesteader's log cabin can be found.

Given that a scale of 0 to 10 applies to scenic values and that these range from a heavily industrialized scene at Scale 0 to one of the utmost scenic beauty respectively at Scale 10, this area would receive a rating of 9.

2.3 SETTLEMENT FEATURES
(see Figs. 2, 3, & 4)

2.3.1 Settlement Pattern

Settlement within the area is limited to isolated ranches apart from Attachie where there is a collection of five homes, all adjacent to the farm buildings at Tompkins Ranch. There is a small school set to the east of the highway in the same area (see Figure 2).

At present there is a farm at the western end of the Bear Flats Section between the foot of the steep (10%) highway descent from the plateau and Peace River. Further to the east and well north of the highway, there are the Watson and Haig homes and farm buildings. The Bently's house and farm building are immediately east of the Cache Creek. At the present time the house is not occupied. There are two new homes east of the realigned highway at the eastern end of Bear Flats.

2.3.2 Heritage Resources and Archaeology
(refer to Figs. 8, 9, & 10)

Heritage resources include prehistoric, historic, and paleontological sites and the objects contained therein. These resources are irreproducible, finite in number, and form a vulnerable and fragile part of the modern cultural and natural environment. Heritage resources represent the only means of understanding past cultural systems and their interaction with the natural environment in the absence of documentary evidence.

The areas in which the proposed relocations of Section 1 of Highway #29 would occur are located on the high intermediate terraces of Bear and Attachie Flats. Heritage resource impact assessments conducted between 1974 and 1978* included parts of these terraces. These studies have shown both to contain a variety of archaeological and historical sites.

The previous studies were oriented to ascertaining the effects the construction of the Site C hydroelectric facility would have on heritage resources. As both terraces are above the level of the proposed reservoir, the study team's focus was on areas which would sustain impact from slope failure and wave erosion, i.e., the terrace edges and valley walls of Cache Creek and the Halfway River. Highway relocation was recognized as an indirect effect of the Site C development**; however, this aspect of the project did not receive specific investigation.

To augment existing information, a 3-day overview assessment was conducted of the proposed relocation routes in August 1981. This study was, of necessity, cursory and constrained by observational difficulties caused by crop and native vegetational cover.

A total of 4 known archaeological sites occur in the relocation corridors in the Attachie Flats section,

The proposed relocation routes across Bear Flats impinge upon 14 located heritage resources,

(see Figs. 9 & 10).

*Fladmark 1974; Spurling, Finlay and Fladmark 1976; Spurling 1978; Spurling 1980a, 1980b.

**e.g., Spurling 1980a: 103-5.

2.3.2 Heritage Resources and Archaeology (cont.)

The settlement history revealed by artifactual materials recovered from some of these (and associated sites), as well as through a documentary search and interviews with local informants*, may be sketched as follows. Be it noted, however, that the settlement scenario advanced for the prehistoric period is not supported by scientific excavations on either terrace and, therefore, must be regarded as speculative.

The earliest aboriginal occupations discovered to date within the upper Peace River valley are evidenced on the high intermediate terrace in the Bear Flats region, west of Cache Creek. At several locations [redacted] basally ground projectile points have been found by local landowners. These points are stylistically attributable to the Agate Basin, Cody, and Lusk/Frederick/Angostura complexes of the middle to late PaleoIndian period (ca. 10,000-7,000 years B.P.) of the Plains culture area.*** A large and extremely well made biface of an exotic material also recovered from this terrace may indicate that even earlier cultural complexes (*viz*. Clovis/Folsom) are present.

Unfortunately, all these apparently early finds have been made from agriculturally disturbed contexts, and limited test excavations at the site in 1974 disclosed no discernable stratigraphy. Therefore, dating of these complexes, at least in the disturbed parts of these sites, may not be possible. As this terrace is one of the highest above present river level (i.e., 67m) to contain archaeological resources and would have been one of the first open to human settlement, the presence of early cultural materials is not unexpected, and the possibility exists that older resources may be buried by slopewash deposits at the toe of the valley escarpment where point bars would have formed when the Peace River flowed at this elevation.

Materials relating to the Middle Prehistoric period have also been recovered from the high intermediate terrace at Bear Flats. Oxbow complex (ca. 5,000-2,500 years B.P.) items are known from the site; artifacts diagnostic of the McKean Complex (4,500-3,000 years B.P.) have been recovered from and a Pelican Lake projectile point (ca. 3,000-1,750 years B.P.) has come from the site; and Besant complex (ca. 1,500-1,600 years B.P.) items have been found at the site.

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*See Finlay 1978.

**All archaeological sites in Canada are assigned an alphanumeric label known as a Borden number which corresponds to their latitude and longitude.

***See Spurling 1980b: 353-95.

2.3.2 Heritage Resources and Archaeology (cont.)

As regards the initiation of settlement of the high intermediate terrace of Attachie Flats, the earliest materials recognized thus far appear to be McKean Complex (ca. 4,500-3,000 years B.P.). The "front" of this terrace is ca. 40m above present river level, suggesting a later abandonment by the Peace River than was the case for the Bear Flats terrace. Consequently, the Attachie Flats terrace would have been available for settlement subsequent to Bear Flats. At present, the archaeological evidence is consistent with this interpretation. However, like Bear Flats, older cultural occupations may also be buried by slopewash deposits at the bottom of the main valley escarpment (i.e., at the back of the terrace).

The Late Prehistoric period is represented by a single, Avonlea-like projectile point recovered from the [redacted] in Bear Flats. Late prehistoric complexes, however, should be widespread in both the Bear and Attachie Flats areas. The Late Prehistoric period generally extends from ca. 1,500 B.P. to the period of EuroCanadian contact.

The first known EuroCanadian to penetrate the upper Peace River was Alexander Mackenzie, who passed through the study area in 1793 during his well-known voyage of discovery to the Pacific Ocean. His account of either Bear Flats or Jim Rose Prairie, made on May 16, 1793, merits citation:

> As for the other animals, they are in evident abundance as in every direction the elk and the buffalo are seen in possession of the hills and plains ... Mr. Mackay, and one of the young men, killed two elks, and mortally wounded a buffalo, but we only took part of the flesh of the former ... The country is so crowded with animals as to have the appearance, in some places, of a stallyard, from the state of the ground, and the quantity of dung which is scattered over it.*

At the time of contact, the upper Peace was populated by the Beaver, Sekani (and possibly Rocky Mountain Indians) of the Athapaskan linguistic group. These populations had undergone several decades of territorial displacement due to the fur trade. The economic base of these groups involved hunting, fishing, and the collection of vegetal items. The social organization consisted of small, largely kin-related groups whose movements were scheduled by resource procurement opportunities.**

*Mackenzie 1971: 163-4.
**See Spurling 1980b: 51-73.

2.3.2 Heritage Resources and Archaeology (cont.)

The year following Mackenzie's exploration, the Northwest Company established the first of several fur trade houses at the mouth of the Moberly River. Other posts were built opposite the village of Hudson Hope and at the mouth of the Beatton River. The posts of the upper Peace River served as important fur trade centres, as well as provisioning and staging locations for New Caledonia (as the area was then known) for 30 years. However, a declining subsistence base and the murder of several traders by a local native group led to the abandonment of the area by the Hudson Bay Company in 1824.*

Except for short sorties through the upper Peace valley by fur trade personnel and explorers, the EuroCanadian vacancy of the region was total until the 1860s. At this time the Hudson Bay Company reopened trading outlets at Fort St. John on the banks of the Peace and opposite the modern village of Hudson Hope. Other companies later established posts in the area and several gold rushes (in the Peace River headwaters, the Ominica, and Klondike) attracted independent traders, miners, and adventurers to the region.

The ensuing 40 years saw the arrival of missionaries, fledgling attempts at agriculture, and systematic geological and railroad surveys.

Agricultural development of the region began in earnest immediately prior to World War I with the lifting of a federal land reserve. Several historical resources which stand on the east side of Cache Creek on the high intermediate terrace relate to this period.

The site of comprises two 1-2 storey log cabins, a long, rectangular barn, and a hexagonal barn. Finlay (1978) attributes their construction to the Christians, Freers, and Robinsons. The Robinsons arrived in the area in 1921.** A second site - - consists of farm buildings and machinery and the original Bear Flats school house built in 1921. The earliest structures at this site were built by the Dopp family who settled here in 1917. Agricultural activities have removed other structures built during this period on both Bear and Attachie Flats.

Modern agricultural development, the discovery of fossil fuel resources, the construction of the Alaska Highway, and the harnessing of the hydroelectric resources of the Peace have rounded out the contemporary social and economic organization of the region.

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*See Spurling 1980b: 51-73.
**Ventress *et al.* 1973: 57.

2.3.3 Highway and Access Roads

Highway #29 is the main highway in the area, connecting with Highway #97 to the northwest of Fort St. John and running along the Peace River Valley westwards to Hudson Hope and then southwards to Chetwynd on Highway #97.

This highway descends from the plateau area to Bear Flats in a series of severely sub-standard switchbacks at 8%-10% gradient down the steep valley slope.

Once in the valley, the alignment runs along the level lower terrace, crossing Cache Creek before climbing again at 10% on a good horizontal alignment up onto the plateau.

Highway #29 runs at this high level for a short way before descending steeply (10%) down a good standard of alignment to the valley floor and the lower terrace. The highway crosses the Halfway River, a major tributary of the Peace River in this area, by means of a new highway bridge before climbing gently up onto the upper river terrace beyond Attachie.

Two secondary roads take off from Highway #97 in the Bear Flats area, one up onto the upper terrace serving the Watson and Haig ranches and the second following the Peace River downstream of Bear Flats to serve existing farms in that area.

Farm track and access roads exist in the area, which connect the valley level lands with those on the plateau. These occur on the Tompkins and Haig ranches. Other lesser used access tracks exist throughout the cultivated and wooded areas.

2.3.4 Boundaries and Land Ownerships
(refer to Figs. 2, 3 & 4)

Boundaries and land ownership for the Attachie and Bear Flats areas are shown on Figures 2, 3, and 4. To the west and east of Halfway River, land below the safe line and potential reservoir level is owned by either the Crown or B.C. Hydro. Above this level the land is generally privately owned. The same applies in the Bear Flats area, although one area below this elevation is still privately owned.

There are five private land owners in the two areas, one at Attachie with a large ranch (approx. 10,000 acres) and four others of varying size from 100 acres to 10,000 acres in the Bear Flats area.

2.3.5 Utilities and Services
(refer to Figs. 2, 3, & 4)

There are few major utilities in the area. A major power line is located along the edge of the plateau, but there are no major utilities in the valley; however, most of the homesteads are complete with power and telephone connections from the power and telephone lines along the highway.

2.3.6 Water Supply System

There is no water supply system in the area; water is collected either from springs or wells into the gravel. Water quality is good, as evidenced by the distances (20 miles) people are prepared to travel to take water from the springs.

2.4 AGRICULTURE

2.4.1 General

The agriculture of the Peace River region is similar to that found in the Canadian prairies, with grain, oilseeds, and forage being the principal crops. In the Peace River valley, similar types of agricultural activities are found, with a number of the production units having associated cattle operations. Fort St. John is the major service centre for agricultural operations in the region and in the Peace River valley. Highway #29 is used by the farming operations within the Peace River valley to transport goods and services. The highway is also used to transport farm equipment and farm produce within individual farm units within the valley.

2.4.2 Agricultural Soils and Land Capability
(refer to Figs. 11, 12, & 13)

The Peace River region is located partly in the foothills of the Rocky Mountains and partly in the Great Plains area of North America. The region is characterized by rolling and hilly land near the foothills and broad, relatively flat land in the plains area. The Peace River and its tributaries are dominant physiographic features of the region. The land forms are principally broad plateaus interspersed by the deep valleys of the various rivers.

These valleys can be further described by three basic landforms:

1. Steep erodable slopes extending from the river's edge up to the plateau. Such lands contain no agricultural value.

2. Undulating topography with slopes ranging between 25 and 50 per cent but containing no flat arable benches. Such areas may provide only grazing opportunities for agriculture.

3. Alluvial riverside terraces and upper benches interspersed by steeper banks. The terraces and benches provide opportunities for agricultural development.

In addition, there are a number of islands, particularly within the Peace River, which range in size and in agricultural value.

2.4.2 Agricultural Soils and Land Capability (cont.)

The soils of the Peace River region were surveyed and classified in 1965.* A more detailed examination of the alluvial soils of the Peace River valley was made as part of the B.C. Hydro & Power Authority's Peace River Site C Hydroelectric Development Agriculture Studies to more clearly define the agricultural capability of the alluvial soils. A description of the agricultural soils found within the Peace River valley is included in Appendix 2.

The climate of the Peace River region is defined as a moderate continental climate characterized by short moderately warm summers and long cold winters. Within the region there is considerable variation in climate as the result of differences in elevation and other climate-influencing factors. These differences in climate and their effect on agricultural production are referred to as the climate capability for agriculture. The climate capability is rated using seven classes, with the particular classification rating depending upon the range of crops that can be grown. The wider the range of crops, the higher the class, with Class 1 representing the highest agricultural climate capability and Class 7 having no significant agricultural capability.

The major farming areas of the Peace River region have a Class 2 climate, with agricultural areas at higher elevations possessing climates with capabilities as low as Class 5. The climate capability of the Peace River valley is broadly defined as Class 1.

The agricultural land capability is the recognized classification system for assessing the range of crops that can be produced on particular land parcels. Under this system, the land is rated in one of seven classes, depending on their potential and limitations for agricultural use. The basic criteria used for this rating are the inherent soil, climate, and landform characteristics.

Classes 1 through 3 are considered capable of producing a wide range of cultivated crops, with the range of crops decreasing from Class 1 to Class 3. Class 4 lands are considered capable of producing only a narrow range of crops and are marginal for sustained arable culture. Class 5 land is capable of producing only permanent forages, and Class 6 lands are capable of use for natural grazing. Lands rated as Class 7 are considered to have no agricultural use. A general description of the seven agricultural capability classes is included in Appendix 3.

Table 2.4.2, which follows, shows the aerial extent of the various capability classes of the lands in the Province, the Peace River region, and the Peace River valley.

*Soil Survey of the Peace River Area, Report N.8 of the British Columbia Soil Survey.

TABLE 2.4.2

Land Area by Agricultural Capability Classification
Province,* Peace River Region,* and the Peace River Valley**

Capability Class	Province*		Peace River-Liard Region*		Peace River Valley**	
	Hectares	Acres	Hectares	Acres	Hectares	Acres
1	69,136	172,840	3,789	9,472	2,464	6,161
2	393,069	982,673	119,609	299,023	12,502	31,255
3	988,167	2,470,418	370,246	925,615	1,765	4,412
4	2,107,109	5,267,772	529,335	1,323,338	2,116	5,291
5	6,067,007	15,167,517	1,973,818	4,934,545	932	2,330
6	5,267,007	13,239,190	565,150	1,412,875	3,212	8,030
7	14,727,524	36,818,812	1,148,128	2,870,321	2,656	6,639
Total Area	29,647,688	74,119,222	4,710,075	11,775,189	25,647	64,118

[1]*Source: Agriculture Land Capability in British Columbia.
**Includes 6,444 hectares (15,922 ac.) of eroded steep and broken land located between the river and the 1,515 foot contour. This land would be Class 6 and Class 7. Eroded, steep, and broken land located between the 1,515 foot contour and the brink of the trench is not included.

2.4.3 Agricultural Land Reserves
(refer to Figs. 11, 12, & 13)

The Agricultural Land Reserves (A.L.R.) have been established to preserve lands with the capability for agricultural production. Within the Province, there are approximately 4.6 million hectares (11.6 million acres) of land in the A.L.R. Of this total, approximately 1.5 million hectares (3.7 million acres) are located within the Peace River region. Within the Peace River valley, virtually all of the land with capability for agricultural production is located within the A.L.R.

2.4.4 Forestry*
(refer to Photographs 2.2.1.a & 2.2.1.b)

Timberlands which lie within the Site C reservoir and could be affected by the proposed road realignments are located in the Boreal Spruce Zone and are made up of white spruce, balsam poplar, lodgepole pine, and aspen. The spruce, pine, and conifers of minor occurrence have a commercial value and are harvested. Deciduous species are normally left because there is not a market of sufficiently high demand to justify their harvest.

Most of the terrace areas on the north bank have been cleared for agricultural use, while the vegetation on the steeper slopes is typically open grassland with scattered aspen copses.

The proposed road alignments at Bear Flats and Attachie traverse no stands which could be considered as potentially merchantable.

*This section summarizes information in Reid, Collins, and Associates' report to B.C. Hydro, "Site C Forest Resource Assessment," dated May 1978.

2.5 FISH AND WILDLIFE

2.5.1 Fish*
(refer to Figs. 2, 3, & 4)

Development of the Site C reservoir would have, as its main effect, the alteration of the present riverine system into the reservoir and the blockage of upstream movements of fish by the dam. The impoundment would greatly increase the amount of habitat available to aquatic organisms and fish.

Cache Creek, in the reaches near to and above the impoundment level, presently provides poor to moderate habitat for mountain whitefish and suckers but good habitat for lake chub.

The Halfway River, as would be expected from its popularity as a fishing area, would provide good habitat for mountain whitefish, burbot, and suckers in the reaches near and upstream of the finished reservoir level. Arctic grayling habitat is classified as moderate.

2.5.2 Wildlife**
(refer to Figs 2, 3, & 4)

The Peace River region has a diverse wildlife environment, due to its varied topography and vegetation. The region is particularly important for moose, wolves, and grouse, and it contains the only significant deer herds in the northern half of British Columbia.

The proposed road alignments at Bear Flats and Attachie traverse an area of generally poor wildlife habitat, except on the west bank of the Halfway River, where the terrace provides good moose and fur-bearer habitat and moderate deer and upland game bird habitat.

Personal communication with local residents indicates that some traffic collisions with wildlife occur, but exact documentation of species and numbers is lacking. The proposed new alignments do not pass through more densely populated game ranges than does the existing road.

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*This section summarizes information in Renewable Resources Consulting Services' report to B.C. Hydro, "Site C Fish and Aquatic Environment," dated February 1978.

**This section summarizes information in Donald A. Blood & Associates' report to B.C. Hydro, "Site C Wildlife sub-report," dated April 1978.

2.5.3 RECREATION*
(refer to Figs. 2, 3, & 4 and Photographs 2.2.1.a & 2.2.1.b)

2.5.3.1 Recreation Opportunities*

Bear Flats provide the first practicable locations for the development of recreational facilities west of the Site C dam site with the reservoir in operation. It is the first point at which the reservoir would be visible and accessible to motorists travelling on Highway #29 from Fort St. John. It has been suggested that the existing highway (which would be inundated by the reservoir) could become a boat launching ramp. No other shoreline recreational development is suggested for the east bank of Cache Creek, since it is under cultivation and would not be a particularly attractive site.

The forested terrace area above the proposed reservoir level on the west bank of Cache Creek is an attractive area for camping and picnic area development. This block of land, measuring about 40 ha., contains mature lodgepole pine and is surrounded by cleared agricultural land. Road access into the area could be developed easily. A development scheme comprising a 100-unit campground and 20-unit picnic area has been proposed.

Between Cache Creek and the Halfway River, there will be no features of major recreational value on the northern shoreline of the Site C reservoir.

A second major view of the reservoir will unfold for westbound travellers on Highway #29 on the descent to the Halfway River at Attachie. Traditionally, the Halfway River has been one of the most popular recreational sites within the Site C area. However, due to potential wave hazards resulting from slides on the south bank of the reservoir, no boat launching or docking facilities were recommended (see Section 4.6.4).

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*This section is a summary of information presented in Edwin, Reid & Associates' report to B.C. Hydro, "Site C Recreation Impact Assessment," dated April 1978.

2.5.3.2 Fishing

Fishing use of the Site C area is expected to increase slightly with development of the reservoir, due to increases in local population, in boating on the reservoir, and in fish population. A major constraint on the sports fishery will be the harvest available on a sustained basis, estimated to be 14,000 fish per year.

2.5.3.3 Hunting

Hunting use of the Site C reservoir area after impoundment is expected to change little from that at present. The increase in area population is expected to be balanced by a reduction in attractiveness of hunting caused by the loss in wildlife due to flooding by the reservoir.

2.5.4 Traffic

Traffic flows between Fort St. John and Hudson Hope are relatively light and of the order of 1,000-2,000 vehicles per day (August 1980).

However, with the growing development and population in the area and the increasing potential of Williston Lake as a recreation area, this seasonal flow can be expected to continue to increase at a steady rate. Apart from heavy agricultural traffic, the composition of the traffic is mainly light trucks, recreational vehicles, and passenger vehicles.

3. PROJECT DESIGN ALTERNATIVES

3.1 ALTERNATIVE ROUTES
(refer to Figs. 1, 2, 3 & 4)

3.1.1 General

Section 1 encompasses an area some 4 km west of Halfway River to a point 5 km east of Cache Creek on Highway #29.

Highway relocation is shown to be necessary on the north bank of the Peace River for a 5 km length at the Attachie section and 10 km at Cache Creek on the 1:50,000 plan accompanying the invitation to submit a proposal.

Two predicted slide areas are shown on that plan, one to the west of Halfway River (Area B) and the other between Halfway River and Cache Creek (Area C).

The existing highway has been relocated outside Areas B and C, since the 1:50,000 mapping was prepared, so further relocation is not necessary. This has been confirmed by Thurber Consultants in a brief letter report entitled "Site C Development – Highway #29" in which the summary states, "No protective works are considered to be required in Area B."

As can be seen from the figures, the proposed reservoir would inundate and cover some 15 km. of Highway #29 at the Attachie and Bear Flats areas. Relocation of the highway would, therefore, be necessary, since Highway #29 forms an essential highway link between the community of Hudson Hope and valley area, the dam sites upstream, Williston Lake, and Fort St. John.

Two basic strategies are possible with the highway relocation. The first is to consider the review of the whole of the highway alignment. The second strategy is to consider relocation of the highway only over the lengths that could be flooded.

3.1.1 General (cont.)

Consideration was given to the former, and the best alignment from Bear Flats through to Hudson Hope was developed along the plateau. This alignment would cross the Halfway River and Cache Creek valleys at their deepest locations, 200m (650'), traverse some good agricultural land and some poor ground with drainage problems. In addition, such a route would not provide access to existing developed land and properties in the valley nor to the proposed new reservoir for recreation purposes. This strategy would involve relocation of some 60 km. (36 mi.) of highway between Hudson Hope and Fort St. John, whereas relocation of the flooded highway only on Sections 1 and 2 amounts to 24 km. (14.4 mi.). Costs/km. would be much higher and, consequently, this strategy was not considered further.

The alternative alignments considered in this brief study, therefore, relate to those in the valley bottom only.

Prior to this study, preliminary investigation had identified two possible general alignments on both the Attachie and Bear Flats areas. These were at the toe of the steep plateau slope or, alternatively, adjacent to the proposed reservoir.

During this study, these alignments have been investigated in detail, and alignments which are feasible from an engineering standpoint and sympathetic to the terrain have been designed. An additional route has been introduced at Halfway Creek, since it has the advantage of lower cost.

Essentially, however, the routes considered run along the edges of the upper valley terrace so that the agricultural land is affected as little as possible.

The two sections, Attachie and Bear Flats, comprise the whole of Section 1, and the alternative routes have been considered in a west-to-east direction, covering Attachie first with Alternative Alignments A, B, and C and with D1, D2, D3, E1, E2, and E on Bear Flats.

3.1.2 Design Standards

The Ministry of Transportation & Highways called for the following design standards:

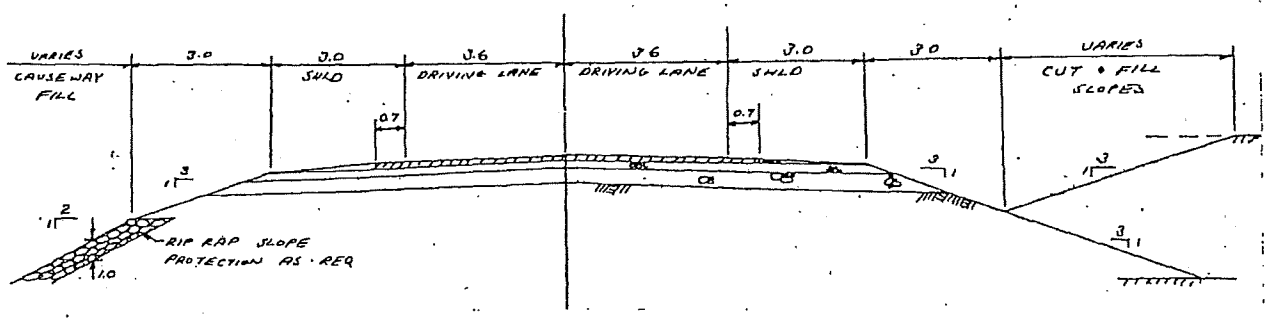
Design speed - 90 km/hr.
Paved lane width - 3.6m
Width of top, including shoulders - 10m
Maximum grades - 7%
Maximum curvature - 230m
Lanes - 2 lanes with truck lanes where warrants indicate.

Subsequent discussion has also confirmed that, where the above standards are not being met on the present highway, any new works could tie into this sub-standard length only if the potential exists for eventual improvement to the required standard. The exception to this is the case of the long grades (1.5 km.) out of the valley which have good horizontal alignment but have grades up to 10%. This acceptable situation occurs at the east end of the Attachie area and the west end of Bear Flats, where recent improvements have been carried out to the existing highway.

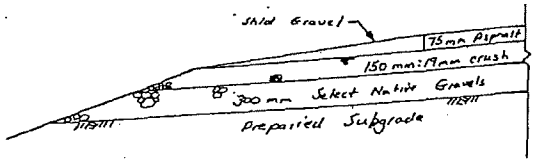
Thurber Consultants have identified the design side slopes necessary at the river crossings as 2:1 and any cutting slope in the silts to be 3:1 (see SK 3.1.2 overleaf).

The highway would have an open gravel shoulder with drainage run-off collected by means of parallel drainage ditches where necessary.

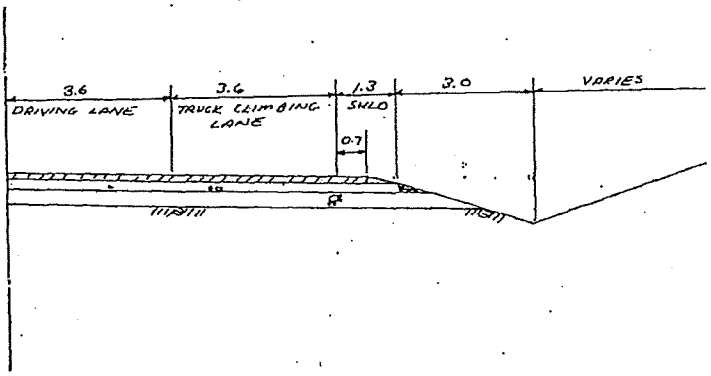
In view of the low traffic flows (see Section 2.5.4), all intersections would be at grade.



TYPICAL CROSS SECTION.



PAVEMENT CONSTRUCTION



TRUCK CLIMBING LANE.

TYPICAL CROSS SECTIONS

GRAEME & MURRAY CONSULTANTS LTD.
CONSULTING ENGINEERS

SCALE Not to scale	DATE Sept 20 1981.		
DESIGNED H.T.J.	CHECKED H.T.J.	SK. 3.1.2.	REV. –
DRAWN H.T.J.	APPROVED		

3.1.3 Engineering Constraints or Features

Engineering constraints are given both by the topography and the nature of the soils in the area. Both of these present themselves at the ends of each of the sections as the highway climbs out of the valley up onto the plateau level. In order to achieve the necessary standards (see Section 3.1.2), high fills and deep cuts are inevitable. However, alignments and grades have been designed such that deep cuts in the steep silty slopes have been minimized or occur when the alignment is at right angles to the contours. This is in accordance with the recommendations of the soils consultant. Gradients up onto the plateau exceed or are at the maximum specified value (see Figs. 14 & 15 and Section 3.1.5).

Apart from the climb to the plateau level, the other significant topographical features are the river crossings.

Halfway River and Cache Creek valley bottoms have been cut some 40m (130ft) below the upper terrace level. A high fill, 30m (approx. 100'), is required to carry the highway across these valleys above the projected flood level. In the case of the Halfway River, the quantities of fill required to achieve this crossing are significant, 2.7 million m^3 (3.5 million cu.yds.), and it was for this reason that the shorter valley crossings (Alignments B & C), with the reduced quantities and costs, were investigated.

3.1.4 Identification of Sensitive Areas

The potential soils problems along the toe of the steep slope up onto the plateau identify the sensitive areas (see Section 2.2.2.3). However, the problems are neither insurmountable nor can the area be avoided by alternative alignments, as there is need to climb up onto the plateau.

The location of the good cultivated agricultural land on both the Attachie and Bear Flats sections has created a large sensitive area from the toe of the steep slope almost to the proposed reservoir edge (see Sections 2.4.1-3 inclusive).

In terms of archaeology, the sensitive areas generally occur along the Halfway River and Cache Creek banks and through the wooded area above the spring line (immediately west of Bear Flats) (see Section 2.3.2).

The introduction of the river crossing fills and structures at Halfway River and Cache Creek will have little effect on the fish regime compared with the major change in the ecology of the water system from river to reservoir. Nevertheless, the crossings will be designed and constructed with care to minimize the effects and to allow fish movements at all depths.

From a visual aspect, the whole of the valley can be considered sensitive. There is a highway at present through the area, and this blends into and forms part of the landscape as it parallels the meandering Peace River (see Photographs 2.2.1.a & 2.2.1.b).

Any new alignment should blend equally well and should reflect the change of character of the valley from river to reservoir, allowing for viewing points and access to the reservoir.

Although there is a small residential community (10 houses) on the Attachie and Bear Flats sections, the community is a close-knit social one, since the farmsteads are relatively isolated. Any new highway which is located closer to residences could, therefore, be seen as a sensitive issue. On the other hand, access to the highway will be quicker and easier, in winter in particular, so that there is not seen to be a sensitive issue socially.

3.1.5 DESCRIPTION OF ALTERNATIVE ROUTES

3.1.5.1 Attachie Section
(refer to Figs. 2 and 14, and Photograph 2.2.1.a)

Alignment A

This alignment was the original one considered for this section. It runs from the higher ground west of the Halfway River to the east bank at the toe of the slope. The Halfway River valley would be crossed by means of a high fill, 30m (100'), and the river bridged with a tall viaduct-type structure (see Section 3.1.6.2) allowing the passage of water. From the east bank the alignment would closely follow the toe of the plateau slope before tying into the existing highway at Chainage 3+750. From this chainage, the existing highway climbs out of the valley at a gradient of 10% on a good horizontal alignment (see Fig. 2 plan and Fig. 14 profile).

Apart from cut sections on the immediate approaches to the river bank and the high fill above the proposed flood level, the alignment closely follows the existing ground.

A major volume of fill, 2.7 million m^3 is required in the fill across the valley.

A small amount of agricultural land is alienated to the north of the proposed alignment between chainages 2+700 and 3+750. Maximum gradient on the new alignment would be 3% with up to 7% at the tie-ins into an existing 10% gradient.

3.1.5.1 Attachie Section (cont.)

Alignment B

This alignment takes advantage of the prominent outcrop of shale which would be left on the west side of Halfway River when impoundment takes place. The quantity of fill is reduced to 1.9 million m^3 and more of the existing highway is used at the eastern end of the alignment. Alignment B follows the edge of reservoir as closely as possible, crossing Halfway River at a location more exposed to the reservoir (and the possible wave damage caused if a slide occurred on the east side of the present Attachie slide) than Alignment A (see Section 4.6.4). The alignment follows an existing ranch road from the school to the residences and farm buildings.

Again, apart from the cut on the approaches to the river and the high fill required across the valley to keep above proposed flood level, the alignment follows the existing ground level closely. Maximum gradient on the alignment is 3%.

Alignment C

Alignment C effects a reduction in earthworks down to 2.1 million m^3 compared with Alignment A by adopting a different crossing point on the Halfway River. The alignment is shorter and is less exposed to possible slide-induced wave damage than Alignment B. Once onto the east bank, it is identical horizontally and vertically with Alignment A.

3.1.5.2 Bear Flats Section
(refer to Figs. 3, 4 & 15 and
Photograph 2.2.1.b)

Over this section there are two general alignments with variations at the ends (see Figs. 3 & 4 plan and Fig. 15 profile).

Alignment D

Alignment D descends from the plateau level to the toe of the steep slope by means of either a 7% (D2) or 10% (D1 & D3) gradient. The 10% gradient would utilize a newly improved section of highway, and the 7% would require a difficult cut-fill traverse up slopes composed of silts and clays which at present are exhibiting signs of instability on the edges of the new highway. Alignment D would continue along the open toe of the slope, skirting the edge of the cultivated land, and through some wooded areas to Cache Creek, where it would cut down through the bank to cross the deep valley by means of a high fill, approx. 25m (82'), and high bridge.

From this point onwards, three alternative alignments D1, D2, and D3 are possible:

D1 would climb directly up onto the plateau level at a 10% gradient with heavy earthworks in the poor material. This alignment uses the topography to little advantage. Soil problems on this alignment are probable and will require detailed investigation. Fills up to 40m (130') and cuts of 20m (66') would occur on D1.

D2 makes use of the topography and is able to provide a maximum 7% gradient up onto the plateau level. However, a 100m radius (50 km/h standard) is required on the alignment to avoid excessive depths of cut. A 4% gradient is maintained on this substandard radius. Whilst most of the construction up the steep slope is on fill, inevitably cut occurs with the consequent problems of slope stability. Maximum fills on D2 would be 30m (100') with a maximum cut of 35m (115'). Again, soil problems are probable on this alignment and will require detailed investigation.

D3 makes very good use of the natural topography, following a gully up onto the plateau level. The earthworks would be relatively light compared with D1 and D2 and would consist of fill benched onto the side slope on the 10% gradient up onto the plateau. Maximum fill would be 20m (66') and maximum cut would be 10m (33') on Alignment D3. It is felt that sufficient is known about the soils in this area without resorting to further soils investigation.

3.1.5.2 Bear Flats Section (cont.)

Alignment E

Alignment E attempts to make as much use of the existing highway as possible by connecting into the foot of the recently improved 10% gradient at the western end of this section. The alignment would then climb up onto the lower edge of the upper terrace, above and parallel to the proposed reservoir level before continuing eastwards, skirting the edge of cultivated areas and through heavily wooded areas, to Cache Creek. The alignment would follow the ground profile closely over this length, except for one gully crossing where a fill of 10m (33') would be required.

At Cache Creek the highway would descend in cut to the fill-and-structure crossing of the creek before climbing up to ground level again and tying into the existing highway at chainage 9+300. This tie-in location could be the end of Stage I of the project (see Section 3.2.2). The alignment would pass through the farm building complex located on the east bank of Cache Creek. Maximum cut on this element of Alignment E would be 9m (30') with a maximum fill of 34m (110') at the creek crossing.

Two alignments to extend Alignment E up onto the top of the plateau have been considered. These are E1 and E2.

E1 uses the existing highway from chainage 9+300 to 10+000 as it climbs at 10% before bearing to the left and descending at a 2% gradient to chainage 10+500 and then climbing again at a 10% gradient up onto the upper plateau level, using the topography and existence of a gully to best advantage. A maximum cut of 10m (33') and fill of 17m (56') would occur on Alignment E1.

E2 climbs from chainage 9+300 approx. up onto the upper pleateau level at a maximum gradient of 7%. Maximum cut and fill are similar to those for E1.

3.1.6 RIVER CROSSINGS
(refer to Figs. 2-4, 14 & 15)

3.1.6.1 General

The two major rivers to be crossed by the new alignment are Halfway River and Cache Creek, located on the Attachie and Bear Flats sections, respectively. Both rivers flow through wide, deep, steep-sided valleys (see figures) before discharging into the Peace River.

Water impoundment level for the reservoir is to be 461.8m (1,515 ft.) with a Project flood elevation of 463.3m (1,520 ft.). A highway grade elevation of 466.3m (1,530 ft.) has therefore been selected for the river valley crossing locations on the two sections. This elevation is approximately 30m (100 ft.) above the valley floor.

Halfway River and Cache Creek are two of the major inflows into the Peace River over this area with mean annual flows of 77 m^3/sec. and 6.3 m^3/sec. respectively (see Section 2.2.6 for peak flows).

Both before and after impoundment, peak flows from these rivers must be free to discharge into the Peace River.

Impoundment is scheduled to take place during the snow melt and will take an estimated 20-60 days. Due to this short period, the highway and bridge construction must be completed before impoundment commences.

Various possible river valley crossing modes have been investigated and are discussed below.

3.1.6.2 Alternative Bridging Methods
(see SK 3.1.6.2 overleaf)

1. Structure Plus Fill

This valley crossing solution is the conventional approach and would require a large quantity of fill material, 2.7 million m^3 for Halfway River on Alignment A and 0.5 million m^3 for Cache Creek, plus a costly structure, [redacted] and [redacted] respectively. Rip-rap protection of the fill would be required to prevent erosion at the impoundment level and at the bridge training slopes.

The structure would have to be sized such that there would be sufficient waterway area to carry flood flows at the valley floor elevation prior to commencement of impoundment.

As impoundment proceeded, so the waterway area of the structure would increase, so that, on completion of impoundment, the available waterway area would eventually be approximately ten times that required. In the event of reservoir draw-down, such a structure would allow water from the Halfway River impoundment to be discharged back down to the river bed level, if necessary.

Estimated costs for this crossing mode, including fill requirements, are given in Table 3.1.6.2.

Both the fill and the oversize structure are costly items, and the following considerations were investigated with a view to reducing these costs.

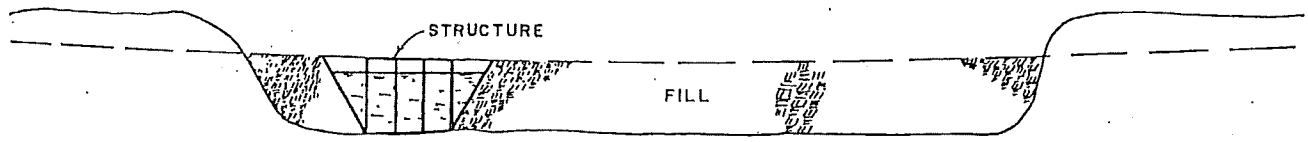
2. Floating Bridge

Once impoundment is complete, there would be little change in water level, and the whole valley cross-section would be available for the passage of river water, resulting in a negligible current. Such situation would be ideal for a floating bridge crossing.

However, the only practical way to install the floating units would be to float these out and position them once impoundment was complete. This would require closure of Highway #29 for the 20-60 days it took to raise the reservoir level.

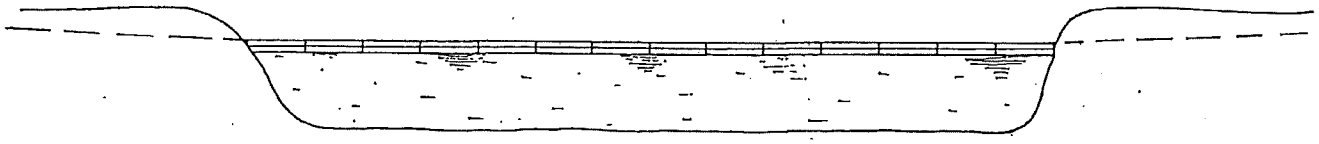
Traffic between Hudson Hope and Fort St. John would need to divert round Highway #97, and local movements would be badly disrupted.

1



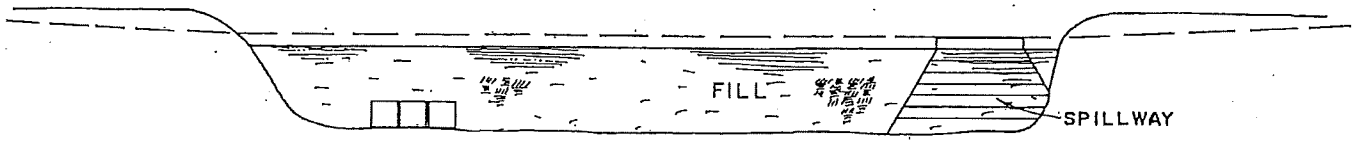
FILL & STRUCTURE

2



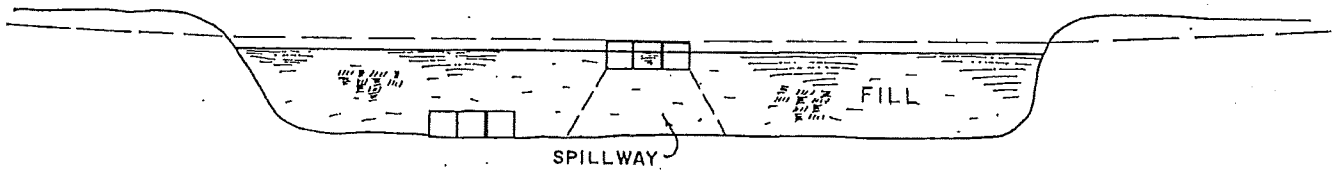
FLOATING BRIDGE

3



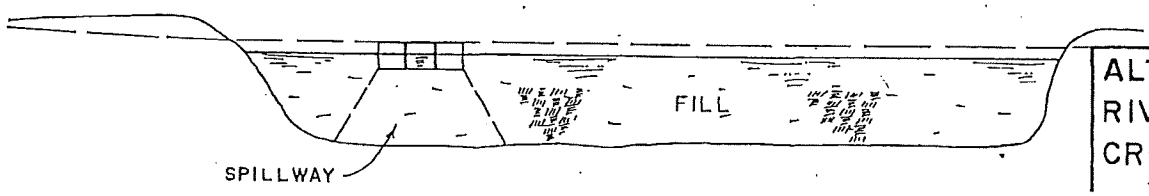
LOWER LEVEL BRIDGE

4



LOWER & UPPER LEVEL BRIDGE

5



ALTERNATIVE RIVER CROSSINGS

3.1.6.2 Alternative Bridging Methods (cont.)

Anchors for the units could be established prior to flooding. Any severe draw-down of the reservoir could create problems with conventional anchoring systems, and this event would need to be allowed for in design.

The question of ice build-up against the structure would need to be considered and allowed for in the anchoring detail, since ice build-up on the slow-flowing reservoir system will be greater than with the present river system.

A clear span should be included in the floating system to allow for the passage of ice and flood debris and to allow for recreational boating use.

Estimated construction costs for a floating structure are given in Table 3.1.6.2.

This solution does investigate the merits of eliminating the fill and the costly permanent structure but, as the table of costs shows, it does not give any cost benefit and incurs inconvenience to the public.

The next alternative considers reduction of conventional structure size and costs.

3. Low-Level Bridge

In this consideration, the flood flow waterway area would be provided at valley bottom level by the construction of a culvert-type structure. This structure would need to be very long, 250m, but would provide the maximum waterway area required for flood flow. Fill would be placed over this culvert structure.

It is noted from previous reports* that the rivers entering Peace River carry large amounts of sediment and that Halfway River would be heavily silted within 50 years. This large amount of silting would throw doubts on the merits of having the only waterway area for the river at a lower level in a zone that is subject to silting. In the case of high river flows with partial silting having taken place, the resultant high water velocities could cause scour, possible damage to the submerged structure, and possible fill failure or, alternatively, complete or partial blockage of the culvert could lead to breaching of the fill by the river run-off topping the earth fill, unless a spillway is included as control for this water.

*Environmental Impact Statement, B.C. Hydro & Power Authority, July 1980, Section 5-3.

3.1.6.2 Alternative Bridging Methods (cont.)

Should a major reservoir draw-down be required with the culvert wholly or partially blocked, the fill section would need to retain Halfway River and function as a dam. The fill section should, therefore, be designed with that need in mind. The design should include the spillway to control the discharge from the retained level of the river to the draw-down level of the reservoir should blockage of the culvert occur. This spillway is included as part of an upper-level structure in the next alternative.

Costs for this alternative are given in Table 3.1.6.2.

4. Fill with Bridge at Valley and Upper Levels

This option assumes that the lower bridge could become blocked and that there would be need for an upper-level waterway area rather than just a spillway. If draw-down is a real possibility, then the fill would again have to be designed to perform as a gravity dam and would need the spillway and protection of the downstream face.

The inclusion of the spillway and design and construction of the fill in such a manner as to enable it to act as a gravity dam is the correct safe solution. In this case, the lower structure and waterway area become redundant and could be dispensed with as the following alternative considers.

5. Fill with Bridge at Upper Level Only

Upon completion of the fill and structure, the impounded river water would rise and flow through the structure and down the spillway. Upon reservoir impoundment, the spillway will become submerged but will remain available to protect the fill if major draw-down of the reservoir takes place. Costs for this option are given in Table 3.1.6.2.

3.1.6.2 Alternative Bridging Methods (cont.)

6. Discussion of Options

Table 3.1.6.2 indicates that Option 1 is the cheapest solution if both crossings are considered. It is also the most practical solution and has the advantage of catering for draw-down of the main reservoir without resorting to a secondary dam on the Halfway River. All other solutions require additional design consideration to cater for draw-down, and this is reflected in the construction cost estimates.

While the floating bridge solution costs are similar to those for Option 1, there would be a social disadvantage of closing the highway during the period of impoundment and the need for very detailed research of ice and debris loads on the floating structure and anchors. Maintenance costs for a floating structure would be higher than for a conventional system.

Severe draw-down would cause the crossing to be inoperable and cause problems with the design of end spans for possible uncoupling.

7. Conclusion and Recommendation

Option 1 is the preferred option and is recommended for construction.

In the comparison of the options, the structures have been sized to take the flood flow at a velocity of 3m/sec., generally at 3m depth, although the upper structure options 4 and 5 have allowed a depth of flow of 10m.

TABLE 3.1.6.2

RIVER CROSSING CONSTRUCTION COST COMPARISON

FOR HALFWAY RIVER

Crossing Mode	Alt. A	Alt. C
	Costs (x [redacted])	
Option 1	[redacted]	[redacted]
Option 2		
Option 3		
Option 4		
Option 5		

Notes:

1. These estimates of costs include an allowance for engineering and contingencies.
2. These estimates consider only the river crossing from bank to bank and include fill.

3.1.6.3 Halfway River and Cache Creek

1. Structure Type

The selection of the type of structure for bridging Halfway River and Cache Creek is dependent on the location and construction methods possible (see Section 3.2.1.2).

The construction proposed for the new structure would be similar to the existing structure at Halfway River, with a plate girder and concrete deck set on tall piers (see SK 3.1.6.3 overleaf).

It is not known at this stage if piled foundations will be required for the piers. Bore holes to be taken in the near future will determine the parameters for the foundation design at both river crossing locations.

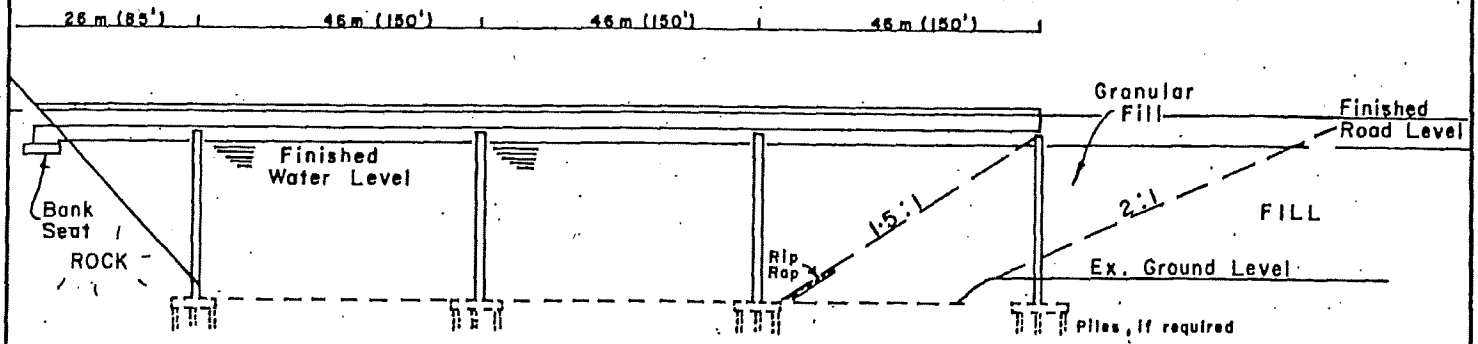
Halfway River is a wide, swift-flowing river carrying large amounts of sediment and flood debris at times of peak flows. Aerial photographs of the area, taken over the years, show evidence of past river channel changes, but the main bed and course have been constant over the past 50 years at least. This is confirmed by the presence of mature trees in the valley bottom. A flood channel does exist on the inside of both bends.

Once impoundment takes place, however, possible changes in the river course cease to be a problem, so the 1-2 year period after the substructure is built is the duration to be considered for the future channel course. Since no changes are apparent over the last 50 years, it can reasonably be assumed that no changes will take place over this 2-year period.

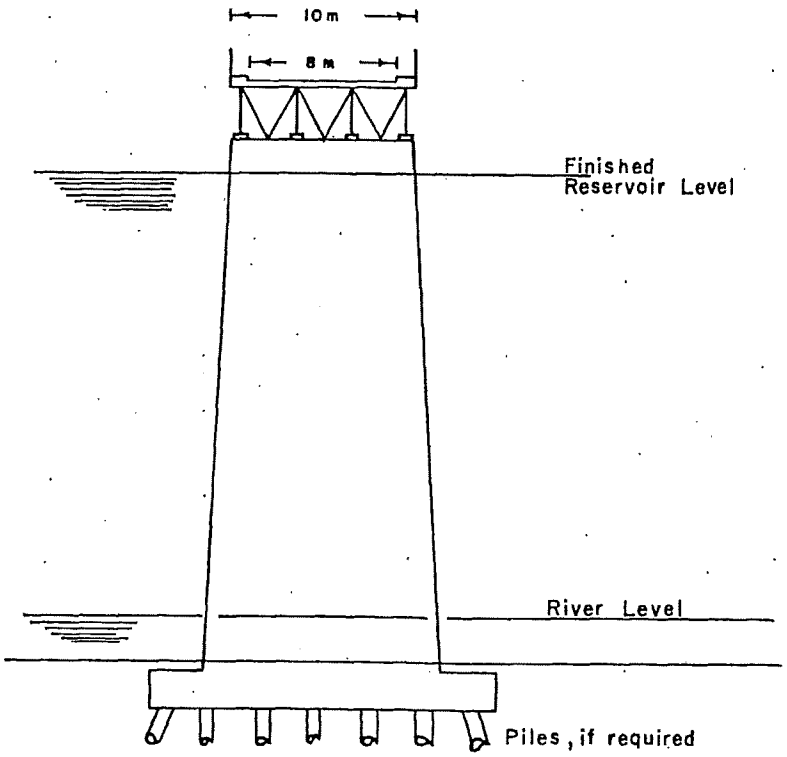
The need for scour protection to the piers will be assessed in the detailed design stage. Again, this will apply to the 1-2 years after the substructure is completed before impoundment.

Channel training works in the form of rip-rap will be required to the toe of the granular fill to protect the bridge approaches. Rip-rap will also be required to the full length of the fill at the finished reservoir level to give erosion protection to the fill against wind-created waves (see Section 4.6.4 for possible waves created by landslides).

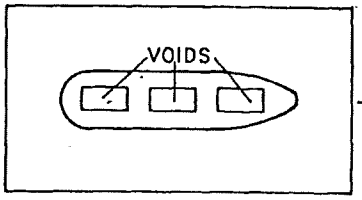
The proposed structure, shown on SK 3.1.6.3, consists of 2 main and 2 side spans.



ELEVATION



CROSS SECTION



PIER BASE

PROPOSED HALFWAY RIVER CROSSING

SK. 3·1·6·3

3.1.6.3. Halfway River and Cache Creek (cont.)

In order to provide the maximum waterway area during the peak flow period in Year 5 (see Table 3.2.3), it is suggested that the fill be taken to the 2:1 slope at the end of Year 4 and, after the peak flow period in Year 5, the granular fill would be placed around the end pier and protected by rip-rap. This method would enable the equivalent waterway area to the present structure to be provided at the required peak flow time without resorting to an additional span and costs.

Once impoundment takes place, river velocities will decrease, since the waterway area provided will be some 7-10 times greater than that required for peak flows.

It is to be noted that, in terms of bridge construction, the bridge on Alignment C (Attachie section) has the advantage of the best construction access and crosses the river at a point where its width is confined. It has no overflow or flood channels to contend with, as do Alignments A and C.

Cache Creek does not present the same problem on structure locations, and Alignments D and E are similar.

2. Piling

Details of piling requirements and foundation design will be established after detailed soils investigation at the bridge sites has been carried out. This should be completed in 1981.

3.1.6.4 Other Creeks and Streams
(refer to Figs. 2-4)

There are no significant creeks or streams on the Attachie section, but a culvert will be required under the highway at chainage 3+750 (see Section 3.1.7).

The only significant creek on the Bear Flats section is the one at chainage 1+800 on Alignments D and E. As described in Section 2.2.4.3, the existing culvert shows past evidence of silting its upstream end, and improvements to this inlet layout are required.

Such culverts will be required throughout on Alignments D and E for highway drainage needs. Two culverts will be required on Alignment E at chainages 3+600 and 4+750 to extend the creeks across the highway.

In view of the large amount of solids evident in the stream beds of the area, it is proposed that asphalt-coated corrugated steel culverts be used. Careful consideration should be given to the entrance and exit details to prevent scour and allow for removal of silt and debris build-up.

3.1.7 Drainage
(refer to Figs. 2, 3 & 4)

Pavement drainage will discharge across the gravel shoulder into the highway ditches as shown on SK 3.1.2. The system of outfalls proposed for each section is discussed below.

Attachie Section

From chainage 0+000 to 2+700, the highway ditches would discharge into Halfway River. The discharge points would be at the cut/fill location at the high river banks. Discharge would be controlled and erosion prevented by ditch lining or piping of the outfall.

The ditches would flow from chainage 2+700 on Alignments A and C and would connect into the existing highway drainage at chainage 3+750.

Drainage for Alignment B would be directly into the reservoir.

Bear Flats Section

Due to the cultivated and loose nature of the soils, it will be most important to control run-off on Alignment D. From chainage 0+000 through to chainage 2+400, the ditches would discharge into the creek at 2+000.

There would be a low point in Alignment D at 2+900, and drainage ditches would fall to this point from 2+400 to 3+500. There is no natural outfall at this location, and either an outfall 750m long will be required across the cultivated land or, alternatively, a detention pond could be built to hold the water. It is suggested that this pond be excavated down to the gravel level so that the ditch discharge is held and allowed to percolate into the gravel strata. With earth-moving equipment available, this alternative would be the least costly and disruptive of the two.

From chainage 3+500 eastward and 4+800 westward, the discharge would be to a low point at 4+300. This discharge would need to be carried down the side of the cultivated land in a ditch to a small creek opposite the ranch at chainage 4+800. This small creek eventually discharges under the existing highway into Peace River.

3.1.7 Drainage (cont.)

From chainage 4+800 eastward and 6+000 westward, the highway discharge would be to a low point at 5+400. This low point is part of the creek system discussed above.

From chainage 6+000, discharge would be to Cache Creek on Alignment A and from chainage 9+000 westward to Cache Creek on Alignments D1, D2, and D3.

East of chainage 9+000, the drainage pattern is more complex and it is most essential in this area of poor soils that both surface and subsurface run-off be well controlled. Each alignment would require a different drainage concept but, in essence, this would involve ditch collection of pavement run-off and discharge into the creeks in the area. Each creek will require culverting under the highway and all discharge points will have protection works to prevent erosion.

At present these gullies discharge into the small ditches on the north edge of the cultivated land, and these, in turn, peter out as they cross the field. An allowance has been included in the estimates for these alignments for collecting and piping the discharge of the area as one major outfall.

Alignment E presents few problems of drainage, since it is close to the reservoir and discharge points throughout its length. Drainage from Alignments E1 and E2 could be drained along the alignment to discharge into the existing highway ditch at 9+300 and thence into the proposed reservoir.

Construction costs for the proposed ditches, culverts, and outfalls have been included in the estimates of cost.

3.1.8 Viewpoints and Rest Stops
(refer to Figs 2-4)

Reference should be made to Section 2.5.3 regarding potential recreation sites.

Present viewpoints and rest stops are shown on Figures 2-4. Due to possible wave action in the Attachie area, no viewpoints or rest stops are recommended on this section adjacent to the reservoir. Whilst this precludes any viewpoints and rest stops on Alignment B, Alignments A and C would be above potential wave action for part of their length. However, this length is located on a cultivated stretch of land and would not be satisfactory as either a viewpoint or rest stop.

It is recommended that the rest stop to the east of the Attachie section be enlarged as demand requires, since this is both a good viewpoint and rest stop area (see Photograph 2.2.1.a taken from this general area).

Two potential viewpoints with one doubling as a rest stop are available on Alignment D. The combined viewpoint/rest stop could be at chainage 4+900, where the alignment departs from the edge of the agricultural land into the toe of the steep slope. The area is well treed and has a level area suitable for parking and provision of picnic tables, etc.

The other viewpoint would be at the edge of the plateau, chainage 9+500 approximately, to replace the viewpoint lost if Alignments D1, D2, or D3 were built. This location has a most impressive view of the valley (see Photograph 2.2.1.b taken from this location).

This same location, but at chainage 10+750, would provide a good vantage point for Alignment E. There are numerous other rest stop and viewpoint possibilities on Alignment E. Chainage 9+100 would make an ideal boat launch location, and the possibility of a rest stop and point of interest adjacent to Cache Creek and the collection of old farmstead buildings* should be considered. The remainder of the section of the highway on Alignment E would pass through treed and open areas adjacent to the reservoir, affording suitable viewing areas but not good access to the reservoir.

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*The older farm buildings are located to the north, on the east side of Cache Creek. The newer existing farm buildings at chainage 8+100 would be affected by Alignment E.

3.1.9 Highway and Access Roads
(refer to Figs. 8, 9, & 10)

Continued access to the existing highway at chainage 3+750 will be required for alignments A and C at the Attachie Section, since the superseded highway would continue to serve land and remaining farm buildings on Tomkins Ranch.

If Alignment B is selected, an access to the buildings and land will be required at chainage 2+500.

On the Bear Flats Section, continued access to the existing highway at chainage 1+500 would be required so that lands at the eastern end of the area could be accessed.

Access to the Watson and Haig farmsteads could be given by improvement of connection to the new highway of the farm track which crosses Alignment D at chainage 5+200. All lands to the west of Cache Creek could continue to be accessed as at present. East of the creek, the existing highway would need to remain open to enable access to be made to the lands on Bear Flats and to serve the farmsteads down the north bank of the Peace River which presently access Highway #29 at chainage 9+200, Alignment E.

Alignment E would require a new access to the secondary road at chainage 4+800 and at 6+500, but no other accesses would be required. Access to lands for Alignment E would remain much as at present.

3.2 CONSTRUCTION

3.2.1 GENERAL

3.2.1.1 Earthworks

The ease of excavation of the materials of the area, the rolling topography, and the fact that the new alignment is a relocation completely away from the present highway make for an efficient earthworks operation. The relatively short hauls and easily won materials are such that rubber-tired scrapers would be suitable for the project. However, at the cut/fill locations by the rivers and, in particular, on the ascent from Bear Flats on Alignments D, initial earthworks would need to be carried out by front-end loader and truck.

The soils consultant has confirmed that the silts and clays will be suitable as fill, if carefully handled and compacted, but, because of the overall shortfall on the various alignments, imported fill is required. This shortfall occurs adjacent to the rivers with a balance of cut/fill achieved on the alignments away from the river so that, on the elements of Alignments D1, D2, and D3 from chainage 0+000 to 7+000 and 8+700 to the run-in, an earthwork balance exists.

It is proposed that additional fill materials be won from the cut approaches to the rivers by reducing the side slopes from the standard 3:1 to 25:1 and returning this borrow area to agricultural use afterwards (see Figs. 16 & 18).

This proposal has the following advantages:

1. The material is a good gravel, 1m-3m below ground level, and the upper silts (1m-3m) could be incorporated with the gravels as fill in the excavation process.

2. The haul is downhill and could not be located any closer to the fill and would, therefore, be least costly.

3. By stripping and setting aside both topsoil and the upper 1m of overburden and replacing the borrow material after completion and then returning the land for agricultural use, less land would be lost to the highway construction, as it would be possible to return usable land right up to the highway ditch instead of to the top of the cut slope. The particular area of borrow would only miss a season's crop growth.

3.2.1.1 Earthworks (cont.)

4. The more open profile would appear more natural and would not create the same problem of snow drifting and ice formation as would a cut with 3:1 slopes.

Alignments A and C on the Attachie section could borrow 1.2 million m^3 in this manner, and the additional fill required, 1.5 million m^3 for Alignment A and 0.9 million m^3 for Alignment C, would be taken from the gravels in the valley bottom, either by scraper or dragline if the high watertable proved to be a problem.

In the case of Alignment B, the only suitable borrow would be from the Halfway River valley bottom, since it would not be possible to haul from the gravel located on the east bank across the river until the structure was completed.

The different estimated costs of borrow from the terraces and valley bottom have been included in the cost estimates.

Similarly, at Cache Creek on the Bear Flats section, it is proposed to borrow from the upper terrace area. This quantity would be sufficient for the crossing, and there would be no need to borrow elsewhere.

It is anticipated that the earthworks operation could be completed during one summer construction period. Dust control by watering will be necessary to minimize the effects on crops and nuisance to people.

3.2.1.2 Structures

The two major structures at Halfway River and cache Creek could both be built "in the dry" by temporarily diverting the river away from the bridge site, giving sheet pile protection to the foundation and pier construction and then rediverting. In the cost estimate, it has been assumed that piles will be required for both structures, but the confirmation and detailed requirements will not be known until a detailed soils survey has been carried out.

Access to both sites is good, and materials and deck beams will easily be taken to the site from the existing highway.

As with the highway alignment, the proposed structure locations are such that there will be no conflict with existing traffic and structures, so that optimum-sized equipment and construction methods can be employed.

Since a total construction period of 18-24 months is anticipated for the structures, the bridge construction site will experience both a winter and a maximum run-off period, so that the construction site protection works will need special attention and observation for possible damage due to the elements during winter lay-off and snow melt.

3.2.2 Staging

No staged construction is possible on the Attachie section; complete construction of the alignment selected must be carried out.

On the Bear Flats section, Alignments D1, D2, and D3 do not lend themselves to staged construction, although a temporary connection to the existing highway, by means of a very substandard curve in the area of chainage 9+500, would be possible during construction, giving an initial usable length from chainage 1+000 to 9+500.

Alignment E, on the other hand, lends itself to staged construction. The length from 1+000 to 9+300 must be completed as the first stage, with E1 or E2 constructed at a later date when traffic flows or maintenance costs justify the improvement of grade and alignment up onto the plateau.

3.2.3 Construction Programme Timing

B.C. Hydro's preliminary design study allowed for a six-year design and construction programme from "Authorization to Proceed" to the first generating unit coming into service in the fall following impoundment during the snow melt period of June-July.

Given that the six-year programme will still apply, a proposed highway construction programme is drawn up below relative to the years 0-6 from "Authorization to Proceed."

It has been assumed that the two sections will go out to tender at the same time but be let as separate contracts. Whilst the Fort St. John area would not normally support two major highway contracts of this size, it is felt that, with construction proceeding on a much larger scale in both structural and earthworks at Site C, there should be a sufficient influx of workers in the area to support the total works.

See Section 3.1.6.3 for discussion of bridge construction.

TABLE 3.2.3

PROPOSED CONSTRUCTION PROGRAMME

ACTIVITY	YEAR 4												YEAR 5												YEAR 6												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
ROADWORKS																																						
1. Site clearance & fencing					X	X																															
2. Topsoil strip					X	X																															
3. Earthworks					X	X	X	X	X	X	–	–																									
4. River protection works										X	X	–				X	X	X	X																		
5. Drainage works						X	X	X	X	X	–					X	X																				
6. Reinstating borrow areas										X																											
7. Access roads																–	–	–	–	–	X	X	X														
8. Gravel & crushed																X	X	X	X																		
9. Asphalt																					X	X	X														
10. Finishing works																					–	–	–				X					X	X				
11. Connection to existing highway and opening																–																					
STRUCTURES																																					
12. Site clearance					X																																
13. River diversion and temporary protection works					X	X																															
14. Piling					X	X	X																														
15. Foundations						X	X	X																													
16. Piers							X	X	X	X	–																										
17. Fill around piers									X	X																											
18. Protection works									X	X	–																										
19. Re-divert river										X	–																										
20. Superstructure construction																X	X	X	X	X																	
21. Finishing works																					X	X	–	–			–	–	X	X							

Impoundment and opening of highway

Power generation commences

X X X = Work proceeding

– – – = Work proceeding dependent on weather

3.3 Maintenance

The question of maintenance of Highway #29 has been briefly discussed with the Ministry staff responsible for this task.

The two main items of maintenance, other than regular paving, etc., are soil stability and snow clearance.

Slope stability problems are presently apparent on the highway and side slopes on the 10% grade at the east end of the Attachie section. At this location, realignment of the highway to a good horizontal alignment has taken place, but there are still signs of sagging and movement in the highway which require maintenance.

On the descent to Bear Flats from the west, the highway has been newly realigned away from the edge of the drop to Peace River. However, there are still signs of local side slope stability above the highway. Above Bear Flats, both the side slopes and the highway have signs of instability, and continued maintenance has been required in the past.

Whichever alignment is selected on the Bear Flats section, there will still continue to be surface slips in the silty material and the need for continued maintenance. However, the 3:1 slopes proposed compared with the present 1:1 and steeper slopes, will need less maintenance.

In the winter, snow and ice create maintenance problems on the highway, particularly on the steeper gradients. Any new alignment to the required standard above Bear Flats will be a definite improvement for snow clearing. If more open profiles are adopted in the cuts (see Sections 3.2, 4.1.2, and 4.4), snow drifting will be less of a problem.

In general, alignments located on the lower edge of the upper terrace will require least pavement maintenance, since they will be founded directly on gravels, whereas alignments at the toe of the plateau slopes will be founded in more silty material, with more chance of frost damage.

3.4 QUANTITIES AND COST ESTIMATES

3.4.1 General

Construction cost estimates have been prepared for each alternative alignment possible.

These costs are based on the going 1981 rates for items in the Fort St. John area.

Quantities have been calculated in detail for each alignment. Those for the earthworks are from cross-sections and profiles produced by computer to enable the many possible variations of an alignment to be examined before the correct earthwork balance and cross-section profile was achieved.

Structure costs are based on construction cost figures taken for structures constructed throughout B.C.

Allowances have been included for probable additional drainage requirements such as counterfort drains in the side slopes of the poorer soils and for a 0.6m thick granular blanket on the steep side slopes in the poor soils where fill is going to be placed. Allowances have also been included for outfalls where applicable.

The costs include allowance for contingencies and engineering.

Table 3.4.1 below gives these costs.

The major quantities are shown on Table 3.4.2.

If the two tables are considered together, the following is apparent.

TABLE 3.4.1

ESTIMATE OF CONSTRUCTION COSTS FOR ALTERNATIVES (cost x [redacted])

ITEMS / Alignment	ATTACHIE SECTION			BEAR FLATS SECTION					
	A	B	C	D1	D2	D3	E1	E2	E*
1. Site clearing and fencing	[redacted]								
2. Topsoil strip	[redacted]								
3. Allowance for unknown soils problems				[redacted]					
4. Earthworks Cut/Fill/Tip Include borrow in alignment Import	[redacted]								
5. Reinstatement	[redacted]								
6. Grade gravel crushed & asphalt									
7. Protection works	[redacted]								
8. Drainage	[redacted]								
9. Miscellaneous access roads, traffic control, etc.	[redacted]								
10. Completion, signs, linings, etc.	[redacted]								
11. Structure	[redacted]								
TOTAL	[redacted]								
plus Engineering & Contingencies ($ million)	[redacted]								

*Alignment E ties into the existing highway at the east end of Bear Flats and does not climb up onto the plateau level

TABLE 3.4.2

COMPARISON OF ALTERNATIVES

ITEMS / Alignment	ATTACHIE SECTION			BEAR FLAT SECTION					
	A	B	C	D1	D2	D3	E1	E2	E
Overall length (km)	3.75	2.9	3.55	9.1	9.75	9.0	10.45	10.4	7.5
Truck lane (km)	---	---	---	2.35	2.0	2.35	2.0	2.8	---
Earthworks (million m^3)									
*Cut/Fill/Tip	1.480	0.135	1.596	1.050	2,031	0.844	1.157	1.470	0.873
**Import	1.2	1.83	0.60	0.605	0.460	0.814	0.191	0.290	0.029
Maximum gradient on design length (%)	6.6	4	6.6	10	7	10	10	7	2
Max. gradient alignment connects to (%)	10	10	10	10	7	10	10	10	10

* Note this figure includes borrow that could be taken from the "on line" borrow areas (see Section 3.2.1).

** This figure is borrow from outside the highway alignment.

3.4.2 Attachie Section

1. Alignments B and C would both cost [redacted] and would be less than Alignment A [redacted]. This difference of cost is due to the heavier earthworks [redacted] on Alignment A compared with costs of [redacted] on Alignments B and C respectively.

2. Alignment B is the shortest route but, because the import quantity is heavier than that for Alignment C, the final total construction estimates are similar.

3. All projects provide the required standard of alignment, and all projects would tie into the existing 10% gradient at the eastern end.

3.4.3 Bear Flats Section

1. Alignment E1 has the least cost, [redacted], when the complete improvement up onto the plateau is considered.

2. Alignments D1, D3, and E1 all have 10% gradients included in their design.

3. Alignment D2 is the most costly alignment of all, [redacted] but eliminates existing 10% gradients at either end of the project and has a maximum design gradient of 7%.

4. Alignments E1 and E2 are the only ones that can be staged, and E2 includes a 7% design on the substandard section of Highway #29 as it climbs up out of Bear Flats.

5. The initial stage for Alignment E is estimated to cost [redacted]

6. Alignment D3 is the shortest alignment, and Alignments E1 and E2 are the longest.

7. Cut/fill quantities vary from M $0.8m^3$ to M $2.03m^3$, and import required varies from M $0.19m^3$ to M $0.814m^3$ on the complete alignments. This large variation is due to different topography crossed and the self-fixing of the vertical and horizontal alignments to meet the standards and soils consideration requirements.

4. IMPACT ASSESSMENT

4.1 PHYSICAL IMPACTS

4.1.1 DRAINAGE

4.1.1.1 Attachie Section

There would be no impacts on the drainage of the area by any of the alignments. Adequate outfalls exist at present for any of the highway alignments selected.

4.1.1.2 Bear Flats Section

Alignment D would have a greater effect on the surface drainage of the area than would alignment E west of Cache Creek (see Section 3.1.7). Both additional outfalls and regrading and widening of existing ditches would be required on Alignment D, and these works would have the effect of collecting and concentrating the run-off from the highway and steep plateau slope. As discussed in Section 3.1.7, a detention pond system may be an acceptable, and indeed useful, mitigation measure, since the impounded water could both charge the groundwater or, alternatively, give a source of irrigation water. (Note: No farmer on the upper terrace irrigates his crops at the present time.)

Alignments east of Cache Creek would have similar effects on the area, again concentrating and collecting surface run-off waters, but discharging them either directly into the river or into the present drainage system.

It is felt that no alignments will affect groundwater of the area. Any major change in groundwater level will be a raising of the level due to the decreased hydraulic level difference when the reservoir is created.

4.1.2 Landscape and Visual Resources
(refer to Photographs 2.2.1.a & 2.2.1.b)

Any new highway or structure is going to have an impact on the landscape in an area such as the Peace River valley. One aim of the design of the highway and structures should be to minimize this impact and to design the alignment to blend into and complement the vista.

At Attachie, the new reservoir bank will be regular and fairly straight. Alignment B, which closely parallels the bank, will reflect this uniformity. Similarly, Alignments A and C, which follow the undulating and irregular plateau toe slope, will have these undulations reflected in their alignment. The bridge structure on Alignments A and C will be visible from a further distance than that on Alignment B, since they would be angled to the valley alignment. This is not necessarily detrimental, as the structure can feature as a visual link across the Halfway River impoundment area and be aesthetically attractive in its own right.

The avoidance of the regularity of side slopes in cut and fill, as is suggested in Sections 3.2.1 and 4.4.3.b (both for different reasons), would do much to blend the alignment visually into the area and give a more natural appearance.

During the construction stage, the new highway will be immediately visible and apparent in the landscape until the side slopes are covered with either crops or natural vegetation.

The vistas available to a highway user at the present time will still be seen on both alignments, albeit in their altered form, with the reservoir instead of the Peace River.

Alignment D will have the greatest impact on the landscape on the Bear Flats section, since the alignment is through more open terrain in an area where there is no road or track at the present time (see Photograph 2.2.1.b). Alignment E, on the other hand, passes through wooded areas for the greater part of its length, essentially along the same corridor as the present highway.

Earthworks are significantly less on Alignment E than on Alignment D. However, side slopes could again be varied from the standard slopes, so that land could be returned to agriculture and additional fill material could be gained, the end effect blending and appearing more natural in the landscape.

4.1.2 Landscape and Visual Resources (cont.)

Alignments D1, D2, D3, E1, and E2 east of Cache Creek will all be apparent in the landscape, but they lie in an area of lower visual quality. Due to heavy earthworks in the climb up onto the plateau, it would not be practical to vary the standard slopes from those recommended by the soils consultant. No blending of the earthworks would therefore be possible. The curved alignments proposed east of Cache Creek are beneficial in that the "notch" effect of the cutting on the skyline is avoided. Only Alignment D1 would give this notch effect, and then only when viewed locally from a southerly direction.

Again, the vistas available to the highway user would still be seen from all of the alignments. Alignment D is more open than Alignment E and would have good vistas throughout, but it would be remote from the reservoir and treed areas as it passed by, whereas Alignment E would pass through the treed area adjacent to the reservoir and would have more changing vistas of the reservoir through the trees and glimpses of the agricultural land on the opposite side.

4.1.3 Heritage Resources and Archaeology

[redacted]

All proposed relocation routes for the Attachie Section of Highway #29 conflict with known, or a high to moderate potential for, heritage resources. Particularly sensitive in this regard are [redacted] For example, each alternative bridging of Cache Creek intercepts heritage resources, and all of the Halfway River crossings entail adverse impact to at least one heritage resource.

[redacted] the number of heritage resources known to be within or in proximity to each alternative highway corridor is presented, along with kilometre values of areas judged to have high, moderate, or low potential for [redacted]. The assessment of potential [redacted] direct experience with the resources of the region, and inferential geological data. The tabulated resources and sensitive areas are graphically presented in [redacted]

Locations evaluated as having a high potential for archaeological sites are either associated with recorded sites or are in areas where sites have been previously encountered, such as [redacted] Given the large deposits of slopewash which have accumulated at the toes of the slope, it is probable that most archaeological resources which may occur [redacted]. Should highway construction involve cut and fill, it is possible that archaeological resources would be disclosed in the course of these activities. Low potential areas are comprised of shallow floodplain deposits and the steep slopes of the main valley escarpment.

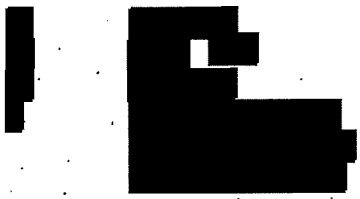
[redacted] Site significance assessments are based upon Spurling's scheme* with the following modifications.

*Spurling 1980a: 126-50.

4.1.3 Heritage Resources and Archaeology (cont.)

TABLE 4.1.3.a

Heritage Resources and Areas Potentially Containing Heritage Resources in Conflict with Section 1 of Highway #29 Alternatives (Attachie and Bear Flats)

Route	Known Resources	Potential		
		High	Moderate	Low
Attachie				
Bear Flats				

4.1.3 Heritage Resources and Archaeology (cont.)

The five original variables comprising scientific significance (*viz.* culture historical data, paleoenvironmental data, socio-economic data, technological data, and methodological and technical advancement opportunities) have been collapsed to a single average value; uniqueness and integrity are omitted; and educational and recreational development opportunities are assessed, assuming that construction of the Site C dam proceeds. The highest significance value awarded in this scheme is 3.

Regardless of which alternatives are selected, heritage resources will be jeopardized. Available information is insufficient to permit recommendations of those alternatives which would have the least cumulative adverse impacts to archaeological and historic sites. And, clearly, decisions regarding the optimum relocation routes must weigh geotechnical engineering and social impact considerations as well.

Recommendations:

The following recommendations are made as a result of the initial overview study findings. Most pertain to more intensive investigations suggested for initiation following the selection of the Section 1 alignments. However, a practical means of augmenting the overview study in the near future entails the inspection of drilling cores acquired during geotechnical studies of the alignments. Buried soils may be in evidence in the upper, unconsolidated sediments of cores taken from those alignments proposed for the toe of the main valley escarpment (i.e., Alignments A, D1, D2, and D3). The presence or absence of paleosols in these areas could assist in assessing the potential for buried archaeological resources.

Subsequent to the selection of the Section 1 alignments, a detailed inventory of heritage resources should be undertaken. This study should involve both pedestrian and subsurface survey techniques. Pedestrian survey of cultivated lands are best conducted before planting in early spring or following harvest in autumn. Wooded areas and pastures should receive systematic test-pitting. At stream crossings where deep accumulations of sediment occur, the use of light earth-moving equipment may be required.

4.1.3 Heritage Resources and Archaeology (cont.)

Simultaneous with the inventory program, site-specific assessments involving test excavation should take place at resources known to be in conflict with the selected rights-of-way. These investigations should be oriented towards ascertaining the volumes, sizes, contents, cultural affiliations, and significances of the resources.

Following the completion of the inventory and site-specific assessments, redesign options should be considered to allow, insofar as is practical, significant resources to be avoided or protected. Where these mitigation options are not feasible, scientific excavation may be necessary.

Should Alignment A and/or D1, D2, D3 be selected, it is recommended that construction activities involving cutting into the slope be monitored for the presence of buried archaeological deposits.

In the event Alignment E is selected, an "as found" documentation of the historic structures and technological items of [redacted] should be undertaken (assuming it will be affected).

Finally, all borrow sources used in the construction of the preferred alignments should be inspected for the presence of archaeological resources.

TABLE 4.1.3.b

Known Heritage Resources in Conflict With
Section 1 of Highway #29 Alternatives (Attachie and Bear Flats)

Site	Description	Significance
Attachie		
[redacted]	Estimated Size: 160,000m^2; Depth: 40 cm; Cultural Items: [redacted] Condition: surface disturbed, subsurface may be intact	scientific: 2.8 education: 1.0 recreation: 2.0
[redacted]	Estimated size: 5,000 m^2; Depth: not observed; Cultural items: [redacted] Condition: mostly intact	scientific: 2.4 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: sample approximation - 2,500 m^2; Depth: not observed; Cultural Items: [redacted] Condition: slightly disturbed	scientific: 1.0 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: 200m^2; Depth: 10-30 cm; Cultural Items: [redacted] Condition: slightly disturbed	scientific: 1.2 education: 0.0 recreation: 0.0
Bear Flats		
[redacted]	Estimated Size: 100m^2; Depth: 3 cm; Cultural Items: [redacted] Condition: slightly disturbed	scientific: 1.2 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: 300,000m^2; Depth: 10-15 cm.; Cultural Items: [redacted] Condition: disturbed by agriculture	scientific: 2.8 education: 1.0 recreation: 1.0

Table 4.1.3.b (cont.)

Site	Description	Significance
[redacted]	Estimated Size: 2,400 m^2 Depth: 20 cm; Cultural Items: [redacted] Condition: slightly disturbed by clearing	scientific: 1.8 education: 1.0 recreation: 1.0
[redacted]	Estimated Size: 5,000 m^2; Depth: 10-15 cm; Cultural Items: [redacted] Condition: disturbed by road, aggregate borrowing	scientific: 1.8 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: 20,000 m^2; Depth: 20 cm minimally; Cultural Items: [redacted] Condition: some disturbance from cultivation	scientific: 2.2 education: 1.0 recreation: 1.0
[redacted]	Estimated Size: 200 m^2; Depth: not observed; Cultural Items: [redacted] Condition: road disturbance	scientific: 0.8 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: 7,500 m^2; Depth: not observed; Cultural Items: [redacted] Condition: disturbed by cultivation	scientific: 1.2 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: sample approximation - 2,500 m^2; Depth: 20 cm; Cultural Items: [redacted] Condition: undisturbed	scientific: 1.2 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: sample approximation - 2,500 m^2; Depth: 4 cm; Cultural Items: [redacted] Condition: undisturbed	scientific: 1.2 education: 0.0 recreation: 0.0

Table 4.1.3.b (cont.)

[redacted]	Description	Significance
[redacted]	Estimated Size: undetermined; Cultural Items: [redacted] Condition: fair, prehistoric component may be partially disturbed	scientific: 2.4* education: 2.0 recreation: 3.0
[redacted]	Estimated Size: 7,500 m^2; Depth: 4-22 cm; Cultural Items: [redacted]; Condition: undisturbed	scientific: 1.8 education: 0.0 recreation: 1.0
[redacted]	Estimated Size: sample approximation - 2,500 m^2; Depth: 20 cm; Cultural Items: [redacted]; Condition: undisturbed	scientific: 2.0 education: 0.0 recreation: 1.0
[redacted]	Estimated Size: sample approximation - 2,500 m^2; Depth: not observed; Cultural Items: [redacted]; Condition: undisturbed	scientific: 1.6 education: 0.0 recreation: 0.0
[redacted]	Estimated Size: sample approximation - 17,500 m^2; Depth: not observed; Cultural Items: [redacted] Condition: disturbed by cultivation	scientific: 1.8 education: 0.0 recreation: 0.0

*Revised from Spurling (1980a: 147) due to discovery of prehistoric item (grey chert retouched flake) during 1981 overview.

4.2 IMPACT ON FISH
(refer to Figs. 2, 3 & 4)

4.2.1 General

No significant impact of road construction on fish habitat or resource is anticipated. Fish habitat affected by construction of approach fills and foundations for bridges across the Halfway River and Cache Creek is 15m to 30m below finished reservoir level and, therefore, is unlikely to be a spawning and rearing area once the reservoir is in operation.

4.2.2 Mitigation Measures

The effects of construction on the present fish resource and habitat, prior to reservoir filling, would be minimized by:

- Limiting construction activities such as excavation, fill placement, and pile driving in the river bottom to the period from April to September each year.
- Providing a channel between the approach fills of sufficient width to carry the freshet river flow with similar velocities to those experienced at present. By this means, upstream migration of young fish will not be prevented.
- Minimizing erosion of cleared and grubbed slopes adjacent to the river and consequent input of sediment into the river.

4.3 IMPACT ON WILDLIFE
(refer to Figs. 2, 3 & 4)

4.3.1 General

None of the proposed alignments crosses or would disturb any unique or exceptional habitat, and no endangered wildlife species would be affected. The wildlife impact is therefore small.

4.3.2 Attachie Section

From the point of view of wildlife impact, Alignment B along the front of the terrace is preferred because:

- The right-of-way passes through or at the edge of cultivated land with little wildlife habitat capability.
- There is little or no wildlife habitat between the highway and reservoir, and few or no large mammals would have seasonal home range with habitat on both sides of the highway. Thus there would be little or no incentive for any animals to cross the highway and wildlife collisions should be negligible.

Alignments A and C have the disadvantage that on the east bank of the Halfway River there is wildlife habitat between the road alignment and the reservoir. Thus, some animals may cross. In addition, the route is along the toe of important wintering slopes for deer and moose, and some ungulates would graze along the right-of-way. Thus, the number of wildlife collisions would probably be higher than on Alignment B. The loss of uncultivated land, providing potential wildlife habitat, would also be slightly greater for Alignments A and C than for Alignment B.

4.3.3 Bear Flats Section

Alignment E, along the front of the terrace adjacent to the water's edge, is preferred for this section for the same reasons as described above for Alignment B on the Attachie section.

Alignment D has similar impact considerations as for Alignments A and C on the Attachie section. More valuable wildlife habitat would be lost, however, due to the longer road involved.

4.4 IMPACTS ON AGRICULTURE
(refer to Figs. 11, 12, & 13)

4.4.1 General Impacts

The impacts on agriculture of the proposed relocation of Highway #29 from the Halfway River to Cache Creek can be categorized under the following headings:

a. Loss of Agricultural Land - This land varies in capability and value to agriculture depending upon the section of the highway examined. In most instances, the land with agricultural value is located within the Agricultural Land Reserve. The rough and broken land associated with the steep slopes of valley sides provides some agricultural value in terms of cattle grazing. However, the proposed routes would have minimal effect on this resource use.

b. Alienation - Where the proposed highway cuts off land with agricultural value, this results in most instances in land being alienated for agricultural use. The extent and location of these alienated areas are discussed in further detail in the following section.

c. Disturbance - Where the proposed highway is constructed of cut-and-fill materials, areas beyond the right-of-way can be disturbed. The extent and location of these areas is discussed in further detail in the following section. Borrow pits used in the highway construction would also be considered as areas that are disturbed. Specific mitigation measures can be employed to reduce the agricultural loss associated with this activity.

d. Farmstead Disturbance - The proposed highway could affect two existing farmsteads, depending upon which alternative is selected. However, in both instances the farmstead would have already been affected by the construction of the proposed reservoir and the resulting safe line for residential homes.

4.4.2 Impact Evaluation

The following information provides a detailed evaluation of the impacts of the various alternate routes for the proposed highway. To identify the various impacts, the alternate routes have been divided into a number of sections and the various impacts on agriculture have been identified.

FIGURE 11

SECTION - West of Halfway River

Alignment A

- Soils - Branham Clayhurst complex
- Agricultural Land Capability - Class 6 3M 4 5T M
- A.L.R. - all land in the A.L.R.
- Land Use - presently wooded
- Highway - length - approximately 350 meters (1,150 feet)
  - area - approximately 0.95 hectares (2.0 acres)

Alignment B
(that portion that is not part of the existing highway)

- Soils - Branham Clayhurst complex
- Agricultural Land Capability - Class 6 3M 4 5T M
- A.L.R. - all land in the A.L.R.
- Land Use - presently wooded
- Highway - length - approximately 875 meters (2,880 feet)
  - area - approximately 2.4 hectares (6.0 acres)

4.4.2 Impact Evaluation (cont.)

SECTION - East of Halfway River

Alignments A and C

- Soils - Taylor Branham complex
- Agricultural Land Capability - Class 1 6 4 2X
- A.L.R. - majority of land within the A.L.R.
- Land Use - grain production
- Highway - length - approximately 1,815 meters (5,960 feet)
  - area - approximately 4.9 hectares (12.3 acres)
- Alienation - two parcels Cc and Cd are isolated from the main farming operation. Area of these two parcels is 1.0 Ha (2.4 ac.) and 2.6 Ha (6.4 ac.) respectively.
- Borrow Pit - borrow pit Cb of area 6.3 Ha (15 ac.) occurs within the main field but could be rehabilitated for agricultural use.
- Land Disturbance - parcel Ca, 4.4 Ha (10.8 ac.), will be disturbed during construction but could be rehabilitated for agricultural use.

Alignment B

- Soils - Taylor Branham complex
- Agricultural Land Capability - Class 1 6 4 2X
- A.L.R. - all land within the A.L.R.
- Land Use - edge of field used for grain production and area used as farm road.
- Highway - length - approximately 1,200 meters (3,960 feet)
  - area - approximately 3.2 hectares (8 acres)
- Alienation - parcel Bb between proposed highway and proposed reservoir, of approximately 3.9 Ha (9.6 ac.). This parcel has limited agricultural value since it has already been largely disturbed.
- Land Disturbance - parcel Ba will be disturbed but could be rehabilitated for agricultural use. Approximate area is 2.9 Ha (7.2 ac.).
- Farmstead Disturbance - parcels Ba and Bb currently have a number of farm houses, but these will not remain if the Site C project proceeds, as they are located below the safe line. The property owner also farms land on the plateau above this field and plans to locate the farm residence at that location.

4.4.2 Impact Evaluation (cont.)

FIGURE 12

SECTION - Chainage 2+000 - Alignment D

Alignment D (North and South Routes)

- No agricultural impact as route passes through rough and broken land with limited or no agricultural capability.

SECTION - Chainage 2+000 to 2+900 - Alignment D

Alignment D

- Soils - Branham Clayhurst Complex
- Agricultural Land Capability - Class 6 3M 4 5T M
- A.L.R. - all land in the A.L.R.
- Land Use - grain production
- Highway - length - approximately 870 meters (2,860 feet)
  - area - approximately 2.4 hectares (5.9 acres)
- Alienation - minimal if line kept close to toe of slope

SECTION - Chainage 2+900 - Alignment D

Alignment D

- Soils - Toad Farrell complex
- Agricultural Land Capability - Class 1
- A.L.R. - all land in the A.L.R.
- Land Use - grain production
- Highway - length - approximately 1,460 meters (4,800 feet)
  - area - approximately 4.0 hectares (10 acres)
- Alienation - minimal if line kept close to toe of slope

4.4.2 Impact Evaluation (cont.)

SECTION - Chainage 1+900 to 2+500 - Alignment E

Alignment E

- No agricultural impact as route passes through rough and broken land with limited or no agricultural capability.

SECTION - East of Chainage 2+500 - Alignment E

Alignment E

- Soils - Branham Clayhurst complex
- Agricultural Land Capability - Class $\frac{6}{3M}$ $\frac{4}{5T}$ M
- A.L.R. - all land in the A.L.R.
- Land Use - wooded and not developed for agriculture.
- Highway - length - approximately 1,925 meters (6,320 feet)
  - area - approximately 5.2 hectares (13 acres)
- Alienation - isolates parcel Ea, 6.2 Ha (15 ac.), which is not developed for agriculture and has relatively low capability.

4.4.2 Impact Evaluation (cont.)

FIGURE 13

SECTION - West of Cache Creek

Alignment D

- Soils - rough and broken
- Agricultural Land Capability - Class 6T 7T 6 4 R
- A.L.R. - no land in A.L.R. if route kept to toe of slope
- Disturbance - a proposed borrow pit (Parcel Da) would disturb approximately 2.8 hectares (7 acres) of Toad Farrell soils with an agricultural land capability rating of Class 1, all located within the A.L.R. This could be reclaimed for agriculture.

Alignment E

- Soils - mainly Branham Clayhurst with some Toad Farrell for part of the middle of the route.
- Agricultural Land Capability - mainly Class 3M 5T 6 4 M
- A.L.R. - all land in the A.L.R.
- Land Use - majority of the land wooded and not in agricultural production. Section in middle of route is cultivated and is in grain production, but the alignment skirts this.
- Highway - length - approximately 3,270 meters (10,720 feet)
  - area - approximately 8.8 hectares (22 acres)
- Alienation - parcel Eb, 17.7 Ha (43 ac.), would be isolated between the proposed highway and the proposed reservoir. The majority of this parcel is not presently used for agriculture and has relatively low capability.

4.4.2 Impact Evaluation (cont.)

SECTION - East of Cache Creek (Bear Flats) - Chainage 8+300 to 9+000

Alignment D2

- Soils - Taylor
- Agricultural Land Capability - Class 1
- A.L.R. - all land in A.L.R. or adjacent to A.L.R. boundary
- Land Use - grain production
- Highway - length - approximately 700 meters (2,300 feet)
  - area - approximately 1.9 hectares (4.7 acres)
- Alienation - parcel D2a will be isolated from the main field by the proposed highway. This involves approximately 2.8 hectares (7 acres) of land that could be reclaimed for agricultural use.

SECTION - East of Cache Creek (Bear Flats)

Alignment E

- Soils - Taylor
- Agricultural Land Capability - Class 1
- A.L.R. - all land in the A.L.R.
- Land Use - grain production
- Highway - length - approximately 1,100 meters (3,600 feet)
  - area - approximately 3.0 hectares (7.5 acres)
- Alienation - parcel Ec would be separated from the main field by the proposed highway and represents approximately 6.8 hectares (16 acres) of Class 1 land. The extent of the alienation would be dependent upon the actual placement of the highway in relation to the proposed reservoir. A width of anything less than approximately 150 meters (500 feet) would probably not be feasible to farm.
- Farmstead Disturbance - at the western end of this route an existing farmstead is located. However, these facilities are not used at present since the lands are now farmed on a farmstead located on the plateau outside of the valley. The farm dwelling is located within the safe line and would have to be relocated if the reservoir was constructed.

4.4.2 Impact Evaluation (cont.)

SECTION - East of Cache Creek (Outside of Bear Flats)

Alignment D1, D2, D3 and E

- Soils - rough and broken
- Agricultural Land Capability - Class 6T 7T 6 4 R
- A.L.R. - no land in A.L.R.
- Land Use - wooded or steep slopes - not in agricultural use
- Highway - no agricultural impact

4.4.2.1 Comparison of Alternatives – Halfway River Section

None of the alternatives west of the Halfway River have a major impact on agriculture, since the soils traversed are of relatively low capability. East of the Halfway River, both routes impact on high capability agricultural land. If Alternative B is placed as close as possible to the proposed reservoir, the impact from this route would be less than for Alternative C.

4.4.2.2 Comparison of Alternatives – Cache Creek Section

West of Cache Creek, Alternative D would not traverse high capability land if it is kept close to the toe of the slope. However, this alignment would require extensive cut and fill, causing disturbance to adjacent agricultural land. Therefore, even though Alternative E traverses land in the Agricultural Land Reserve, the capability of this land is relatively low, and this alignment is preferred over Alternative D.

East of Cache Creek, Alternatives D1 and D3 are the preferred routes, since they have little direct effect on agriculture. The impact on agriculture of Alternatives D2 and E are fairly similar, since both will alienate some agricultural land.

On balance, the selection of the southern route would be preferred in terms of having the least potential for impact on agriculture. If the southern route is selected, the route should be placed as close to the reservoir as possible to reduce the amount of agricultural land alienated. In the Bear Flats area, the amount of land alienated should be kept to a minimum or, alternatively, a parcel size should be maintained that would still be of a farmable size.

4.4.3 Mitigation

Where the proposed highway is located on agricultural land, there is no mitigation for the land actually lost. However, impact of the highway can be mitigated as follows:

a. Placement of Right-of-Way - Where the right-of-way borders agricultural land and the rough broken land associated with the valley sides, the placement of the right-of-way as close as possible to these steep inclines will lessen the impact on agriculture by reducing the amount of good agricultural land lost. A similar situation exists in regards to the placing of the right-of-way next to the proposed reservoir. The exception to this is where the placement of the right-of-way would result in a field of a size that could still be farmed. Particular reference should be made to the placement of the right-of-way for Alternative E in the Bear Flats area.

b. The grading of disturbance areas to a slope of not more than a 7% slope adjacent to the right-of-way and the replacement of a minimum of 0.5 to 0.75 meters (1.5 to 2 feet) of topsoil will allow agricultural activities to continue in these areas.

c. Rehabilitation of borrow pits using the same standards as outlined in b) above would also allow these areas to be continued to be used for agricultural use.

d. Drainage areas should be preserved or improved to ensure that there is no detrimental change in the drainage patterns across agricultural land.

e. Fencing of the right-of-way should be undertaken in consultation with the affected landowners to ensure that existing or proposed management practices can be implemented.

4.5 Impact on Forestry

The impact would be negligible. None of the proposed alignments crosses stands of merchantable timber.

4.6 IMPACT ON RECREATION

4.6.1 Attachie Section

Despite the potential wave hazard on the Halfway River (see Section 4.6.4), recreational use of the area is expected to continue after creation of the reservoir because of fishing opportunities and scenic attractions of the upper reaches. It is expected that further consideration may have to be given to development of a boat-launching ramp in a relatively safe location on the river, but access for this will be difficult.

Alignment B is preferred from a recreational point of view, since it provides the best long-term opportunities for recreational access to the reservoir. On Alignments A and C, in contrast, private land would exist between the road and the reservoir on the east bank of the river, causing potential access difficulties.

4.6.2 Bear Flats Section

Impact of the road alignment on the proposed recreational development on the west bank of Cache Creek is the major consideration for the Bear Flats section. If the development area is to extend to the water's edge, Alignment E is the preferred route, so as to avoid bisecting the campground and picnic area. If, on the other hand, there is to be private land between the water's edge and the southern limit of the campground/picnic area, cutting off access to the reservoir, then Alignment D would be preferred. A boat-launching ramp is expected to be provided as part of the development on the west bank of Cache Creek. The location of this should be downstream of the structure to overcome problems with overhead clearance. The access will need careful consideration.

It is further suggested that, at chainage 1+800 on Alignment E, an existing parking area should be maintained and even enlarged to provide a day-use picnic area adjacent to the water's edge.

4.7 ENVIRONMENTAL HAZARDS

4.7.1 Fire

The hot dry summers give rise to extreme fire hazard conditions in northeastern B.C. Tree cover is not heavy on the north side of the valley, and there is an abundance of cleared land and natural breaks to enable fire to be controlled and prevented from spreading.

The reservoir would provide even more water for fire-fighting needs than there exists at present.

There are numerous existing tracks through the wooded areas, providing good access to all treed areas, particularly from Alignment E. Alignment D would be least affected by a fire in the area.

4.7.2 Flood

It is understood that the reservoir's water surface would never rise above 463.29m (1,520') and that the normal elevation would be 461.77m (1,515'). This water level would be controled by the Site C dam, so that there would be no danger of flooding from the Peace River.

The waterway area to be provided at the bridges at Halfway River and Cache Creek is more than adequate, so again there would be no danger from flooding. However, at times of flood, these rivers (Halfway River, in particular) carry a large amount of debris, tree roots, trunks, etc. The clearance of bridge soffit to water level will need to be considered carefully at the detailed design stage.

Culverts for the creeks should all have an end detail designed to prevent silting and blockage of the entrance.

During the rainfall periods in the summer, occasional washout from the summer fallow land can occur, and this could lead to local flooding on Alignments B and E respectively. This is not considered to be a significant problem, so all routes would figure equally well.

4.7.3 Snow and Ice

With the present grades of 10%, combined with the switchbacks, snow is hazardous to traffic movements. All new horizontal alignments would greatly improve a vehicle's ability to negotiate the 10% slopes in times of snow and ice, and most preferable of all would be to have the gradients reduced to a 7% maximum.

The routes are not sufficiently different in location to experience different amounts of snow.

Ice formation on the reservoir is expected to be greater than on the river at present, due to reduced velocities. The effects of ice on the bridges will need to be considered carefully in pier design and soffit clearances.

4.7.4 Landslides

Northeastern British Columbia has a history of major landslides associated with the principal rivers. Peace River is no exception, and two major landslides are documented in the area.

The first is the Cache Creek slide, which occurred at the turn of the century, immediately to the east of Bear Flats. No further movement is anticipated on this slide, which is outside the area of highway relocation.

The second, the Attachie slide, occurred in 1972 and is located opposite Attachie on the south bank of the river. This major slide blocked the Peace River for some 10 hours and involved some 6-9 million m^3. It is reported that the sections immediately to either side of the slide area are "in a condition of incipient failure."*

Preliminary study has shown that such a slide could have the effect of locally producing an induced wave (20m high**). The safe line in the Attachie area takes account of such a wave, however this wave would have an effect on the present design concept, since it would overtop the highway and bridge elevations by 15.5m (50').

*Report dated March 1979, "Physical Environment Impact Statement," Thurber Consultants.

**B.C. Hydro report, "Preliminary Design Study, Phase 1," Dec. 1978.

4.7.4 Landslides (cont.)

Constructing the highway and bridge above the potential wave elevation would cost an additional [redacted] approx., which could not be justified since the cost of remedial works, such as the repair of a broached fill would be minimal in comparison. However, if major repair were required to the structure, then the relative costs could be similar, so that detailed design of the bridge must take into consideration the possibility of such a wave, and the structure should be capable of withstanding its effects.

At the present time, a hydraulic model of the area is being completed, and the effects and magnitudes of the possible wave are being assessed. The outcome of the investigation may be the determining factor in selection of alignment at this location.

As stated, surface slides are possible on alignments located in the silty materials, but the effects of these are not considered significant and will only be a maintenance problem.

4.7.5 Seismic Activity

The Fort St. John area lies within a Zone 1 seismic zone, which means that it is in a low area of seismic activity. Victoria and Vancouver, for instance, lie in Zone 3, which is considered to be a high seismic activity area.

4.7.6 Wind

Wind records, as given in Section 2.2.5, indicate low wind strengths, however the transition from a cut onto a fill could warrant signing to warn drivers of a possible cross wind, since the winds tend to align themselves with the valleys.

4.7.7 Fog

Inversion fog is a problem in the fall within the valley, and visibility becomes poor. However the fog occurs throughout the valley and no alignment would have advantage over the other in this respect. In general, the fog is burned off by early or mid-morning.

4.7.8 Wildlife

Wildlife movements will take place across the highway, and the danger of collision will, therefore, exist.

Any alignment close to the reservoir will have least likelihood of collision and, in this respect, Alignments B and E are favoured (see Section 4.3.2).

Reflectors set alongside the highway in the wooded areas elsewhere in the province have proven effective in reducing the incidence of collisions. This mitigation measure should be carried out.

5. DISCUSSION AND COMPARATIVE SUMMARY OF ALTERNATIVE ROUTES

5.1 General

All alignments, A, B, and C on the Attachie section and D1, D2, D3, E1, and E2 on the Bear Flats section, have been compared. It is to be noted that Alignment D is a common route to Cache Creek from the west, and Alignments D1, D2, and D3 take off this Alignment D from the west end of the Bear Flats section to the run-in with the existing highway. Similarly, Alignment E is the common route of Alignments E1 and E2 from the west end to east of Cache Creek. Neither Alignment D nor E have been included in the comparison table, since the overall alignment is the one being considered.

Table 5.1 is the summary and comparison of the alignments. A rating system has been adopted from * (one) to **... (no. of alignments considered). The more stars, the higher the expected impact or the lower the desirability of that alignment.

TABLE 5.1

COMPARISON OF ALIGNMENTS

	Attachie Section			Bear Flats Section				
	Alignments							
Comparison Items	A	B	C	D1	D2	D3	E1	E2
Construction Cost ($ million)								
Length (kilometres)								
Structure Cost ($ million) including contingencies								
Cost/Kilometre excluding structure								
Construction Maintenance	***	**	*	*****	****	***	*	*
Standard of Alignment	*	*	*	****	*	****	***	**
Drainage	**	*	**	**	**	**	*	*
Landscape & Visual Resources	*	*	*	*****	****	***	*	*
Heritage & Archaeology	*	**	***	*	***	**	****	****
Fish & Wildlife	**	*	**	**	**	**	*	*
Agriculture	**	*	**	****	****	***	**	*
Forestry	*	*	*	*	*	*	*	*
Environmental Hazards	Test data awaited*			****	*	****	***	**
Economic Rate of Return	***	**	*	***	**	***	****	*
Overall Ranking**	***	*	*	*****	***	****	**	*

*Model test data awaited may have significant effect on alignment chosen.
**Overall ranking based on equal weighting to all comparison items.

5.2 Explanation of Headings

The following is a brief description of the headings used and how the rating has been determined. Headings have been included for comparison where there is a difference between alignments under that consideration.

Construction Cost, Length, Structure Cost, and Cost/Km (including structure cost) are self-explanatory. This latter item (Cost/Km) is an indication of the construction economics of that alignment or rate, and a rating based strictly on this rate has been given to each alignment. This rating reflects the overall cost exactly.

Construction and Maintenance considers the ease of construction for each alignment, the relative effects and possible delays to traffic on the old highway, and the eventual relative maintenance costs.

Alignment C would be the most straightforward construction of the three alignments on the Attachie section, since the major item of fill in the valley has the fill source conveniently placed. All three alignments would have little, if any, effect on the existing highway and traffic. Apart from major maintenance possible, due to slide-induced waves (see Section 4.6.4), the assessment of which depends on the outcome of the model performance, Alignment A would have least maintenance, since it would be located on gravels.

Construction of Alignments E1 and E2 would be more straightforward on the Bear Flats section. Alignments D1 and D2 would present the most construction problems and would have the greatest effect on existing traffic. Maintenance costs on Alignment E would be less per kilometre than those on Alignment D.

Standard of Alignment details are given in Table 3.4.2, and Alignments have been rated according to whether a 7% gradient has been included in the design or not and what gradients remain at the run-in points.

Alignments on the Attachie section offer the same standard, and all tie with the 10% gradient of the eastern end.

Alignment D2 offers the highest standard overall, with a maximum 7% gradient at both ends of the section, albeit with a substandard horizontal curve at 4% longitudinal gradient at the eastern end. The lowest standard is given by Alignments D1 and D3, since the 10% gradients are longer.

5.2 Explanation of Headings (cont.)

Drainage comparison was based on the extent of drainage works required, residual maintenance, and impact on the land.

On the Attachie section, Alignment B would be most preferred because of its proximity to the reservoir and a drainage outfall. Whilst there are good outfalls on Alignments A and C, slightly more maintenance would be required to drainage courses.

For similar reasons, Alignment E on the Bear Flat section would be the best.

Landscape and Visual Resource consideration of the Attachie section indicates that all alignments will occupy land of the same landscape value and will be visible to the same extent.

On the Bear Flats section, Alignment E will be hidden most of all and will provide a more varied scenic journey. On the climb up onto the plateau, Alignments E1 and E2 would rank better than D3, D2, and D1, in that order, because of the exposure of the alignment in the landscape. Alignment D1 would feature worst because of the "notch" effect.

Heritage and Architecture comparisons are covered in Section 4.1.3 and Table 4.1.3.a, giving Alignment A as having the least overall rating on this resource, with Alignments B and C following in that order.

On the Bear Flats section, Alignment E would be the worst alignment. Alignment D1 would involve the resource least, followed by Alignments D3 and D2 respectively.

One point worth noting regarding the Heritage and Archaeological resource is that, with the correct mitigation measure taken where required before highway construction (as is suggested in Section 4.1.3) and detailed investigation and digs are carried out, the resource would be saved and would "come to light" much earlier, since no detailed work could be carried out in the area in the foreseeable future.

Fish and Wildlife have been compared and ranked on the potential impacts of wildlife for each alignment, since all alignments on each section have similar effects on the fish regime.

Those routes adjacent to the reservoir, Alignments B and E, feature best in terms of wildlife.

5.2 Explanation of Headings (cont.)

Agriculture favours Alignment B on the Attachie section, since it involves loss of least agricultural land and alienates the least land.

On Bear Flat, the soils adjacent to the new reservoir on the lower edge of the upper terrace are poorer than at the back of the terrace. This alignment involves the least cut and fill and, therefore, the least land loss, giving Alignments E the best ranking. Alignment D3 requires less good agricultural land than Alignments D2 or D1.

Forestry is not affected, so all alignments are ranked the same.

Environmental Hazards have many potential impacts, so a separate table has been drawn up, as seen below:

TABLE 5.2.a

	Attachie Section			Bear Flats Section				
	Alignment							
	A	B	C	D1	D2	D3	E1	E2
Fire	*	*	*	*	*	*	**	**
Flood	*	*	*	*	*	*	*	*
Snow & Ice	*	*	*	****	*	****	***	**
Landslides*				*	*	*	*	*
Seismic Activity	*	*	*	*	*	*	*	*
Wind	*	*	*	*	*	*	*	*
Fog	*	*	*	*	*	*	*	*
Wildlife	**	*	**	**	**	**	*	*
Overall Ranking*	**	*	**	****	*	****	***	**

* Model test data awaited may have significant effect on alignment choice for environmental hazards.

Key:

* - most preferred
***** - least preferred

This table gives an overall ranking, but note that the results for the Attachie Section are held back from Table 5.1.

Economic Comparison has been assessed on the consideration of the length of route between common points, time of travel, gradients encountered, fuel used, accident potential, and all construction cost or investment cost. Relevant details are given in Table 5.2.b overleaf.

TABLE 5.2.b

ECONOMIC COMPARISON FOR ALIGNMENTS

	Attachie Section			Bear Flats Section			
	Alignment						
	A	B	C	D1	D2	D3	E1	E2
1. Length (km) – common point to common point	3.75	4.55	4.00	9.5	9.75	9.4	11.6	11.6
2. Lengths of 7% gradient	—	—	—		2.0			2.8
Lengths of 10% gradient	—	—	—	2.35		2.35	2.0	
3. Travelling time (min.)	3.8	4.6	4.00	10.7	9.9	10.6	12.7	11.9
4. Fuel used (litres)	0.45	0.55	0.48	1.37	1.26	1.35	1.59	1.58
5. Running costs ($ million/year)								
6. Relative difference ($ million/year)	—				—			
7. Compounded difference ($ million/year)					—			
8. Estimated construction cost								
9. Cost + running costs over 25 years ($ million)								
Ranking	***	**	*	**		*	*****	****
10. Ranking including accidents and land cost considerations	***	**	*	***		***	****	*

KEY: Indicates alignment with maximum 7% gradient.

* – indicates most preferable.
***** – indicates least preferable.

Note:

1. Description of method of calculation of figures in lines 1. – 10. are given below.
2. All costs are to a September 1981 base.

5.2 Explanation of Headings (cont.)

1. These lines are self-explanatory and use data already collected
2. on overall lengths and gradient lengths.

3. This assumes the following:

   Level terrain speed = 60 km/h
   7% terrain speed = 55 km/h
   10% terrain speed = 40 km/h

4. This assumes fuel usage at 12 litres/100 km on level.

   Increase in fuel on 7% gradient = 40%
   Increase in fuel on 10% gradient = 80%*

5. This assumes 1,000 vehicles/day on the highway and travel time to cost [redacted]/hr. This figure aggregates travel time costs and fuel costs (fuel cost = [redacted]/litre). Other running and depreciation costs are ignored as being common to all alignments.

6. This is the relative difference between the lowest cost/year in Line 5 for that section.

7. This assumes a 25 year design and investment life for cost difference/year in Line 6 over 25 years, assuming a total of 10% increase in cost/year to cover marketing and traffic increase per year.

   The figure given in Line 7, therefore is the relative cost for that section.

8. This is the actual cost estimate for construction.

9. This includes the relative running cost with estimated construction cost (7 + 8), so that a comparison of alignment to include an economic return can be made.

   Whilst approach to this assessment is basic, the picture emerges as one would expect.

   The shorter length of Alignment C and its lowest construction cost combine to make it most favourable on the Attachie section, with Alignment B second. The high costs of Alignment A are sufficient to negate the effects of the shortest length to make Alignment A third and last.

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*Figures from R.R.L. Report LR 226.

5.2 Explanation of Headings (cont.)

On the Cache Creek section, the greater travel distance for Alignment E makes it feature slightly worse than those on Alignment D. The schemes with the lowest cost and length are sufficient to overcome the increased running costs on the 10% gradient to make D3 feature best, followed by D1 and D2, in that order.

Even though E2 would be more costly to construct than E1, its 7% gradient results in reduced running costs so that it features better than Alignment E1.

It is to be noted that there has been no inclusion in this assessment for different accident rates or for different maintenance costs.

If all alignments were to the same standard - maximum 7% gradient, design speed 90 km/hr - the accident rate and maintenance cost rate would be the same. However, Alignments D1, D2, and E1 have gradients of 10%, and Alignment D2 has a horizontal curve included of 50 km/hr. Alignment E2 would have the best accident record and the lowest maintenance cost therefore. If costs for these were assessed and included in the above analyses, they would bring the construction costs + running costs (Line 9 above) for Alignments D1, D2, and D3 up to a value similar to that for Alignment E2. Alignment E1 would increase even further beyond E2.

One other aspect of cost that has not been included in the estimates of cost is that of land. Cost of land on Alignment E would be much lower than on Alignment D, so that Alignments D1, D2, and D3 would feature worse than the alignment on E.

10. This line shows an overall ranking based on consideration of these last two items.

6. CONCLUSIONS

The following conclusions can be drawn from the study of alternative alignments.

1. The soils of the areas will give local slope stability problems, but generally normal construction procedures can be adopted on the alignments. Those alignments away from the toe slopes are preferable.

2. Further soils investigation are required at bridge sites and at the east end of Bear Flats section on the toe slopes.

3. Coal, gas, possibly oil, and gravel exist in the area, but the extraction of these would not affect any of the alignments.

4. Drainage of the area and alternative alignments is good, and the alignments adjacent to the proposed reservoir are preferred, since drainage requirements would be minimal. Special end treatments to culverts to allow for secondary inflow at times of silting or ice build-up will be advisable.

5. The climate of the area is such that winter close-down on construction would take place.

6. Ice formation on the new reservoir will be greater than in the present river systems. This effect will need to be considered on bridge structures.

7. A conventional viaduct-type structure with high approach fills is the most economic and satisfactory means of crossing the major rivers at Halfway River and Cache Creek.

   On the Halfway River section, Alignments B and C offer reductions in fill requirements.

8. A large margin of safety on the waterway area will be provided by the viaduct-type structure, but the soffit elevation should take account of floating debris, ice, and possible recreational use.

9. The area has great scenic value, and the proposed alignments will not be intrusive. Alignments located in treed areas would have the least impact. Use of non-standard slopes is favoured in order that lands could be returned to agriculture and would look "natural."

6. CONCLUSIONS (cont.)

10. There are seven land owners on both sections, including Crown land and land already purchased by B.C. Hydro.

11. About 50% of the land is cleared, principally for cereal production.

12. The soils and geographic location are such that the area has an agricultural capability Class 1, and the lands lie within the A.L.R.

13. Alignments along the edge of the proposed reservoir would have the least impact on agriculture.

14. The area is rich in archaeological artifacts, and all alignments would have an impact on archaeology. Alignments along the toe of the plateau would have the least impact. Inspection of the selected alignment both before and during construction will be most beneficial.

15. Within the study area, forestry is not a major activity, and there would be no impact by the alignments.

16. Certain precautions at construction stage on placement of fill would ensure that the impacts of all alignments on fish regimes would be minimal.

17. Impacts on wildlife would be low, with the alignments adjacent to the proposed reservoir being favoured from this aspect.

18. Apart from wave action due to a potential landslide at Attachie, all environmental hazards on the alignments are similar and normal for the area. Further study on the effects of such a wave is required in the final selection of the alignment on the Attachie section and the detailed design of the structure to withstand this wave.

19. Construction of the highway should be relatively straightforward, in two separate contracts, but it may stretch labour resources of the area.

20. It would be beneficial in terms of the project and agriculture to borrow from the gravels of the upper terrace at Halfway River and Cache Creek and to return the land to agriculture.

21. Alignment C is preferred on the Attachie section, subject to the results of the hydraulic tests.

22. Alignment E/E2 is preferred on the Bear Flats section, since it can be staged, has a 7% maximum gradient on the new alignment, and features best in an overall comparison.

7. RECOMMENDATIONS

The following recommendations are made:

1. Detailed soils investigation should be carried out at the bridge sites to enable the need for piling to be established and foundation design to proceed.

2. Detailed soils investigations should be carried out on the east end of Bear Flat on the climb up onto the plateau.

3. Alternate inlets to culverts should be included in the design to allow for silting and ice blockage.

4. Further information regarding ice formation on the new reservoir should be determined and the data used in determination of the bridge pier design and soffit clearance.

5. Agreements to and approval of the method of borrow and return to agriculture should be made.

6. Reflectors to frighten animals off the highway should be erected.

7. Once the alignments have been selected, the route should be flagged and a detailed heritage resource inventory should be undertaken by pedestrian and subsurface survey techniques. Known areas of heritage resources should be test-excavated and scientifically excavated if justified.

8. The three alternative alignments on the Attachie section should be considered in the hydraulic model testing of the Peace River, so that the effects of a further possible slide at Attachie determined on these alignments. The data collected should be used in the design of the structure to enable the structure to withstand the wave action.

   A separate hydraulic model test of the design wave's impact on the proposed structure would provide the design parameters.

9. Alignment C should be adopted as the preferred route on the Attachie section, subject to findings of the hydraulic study.

7. RECOMMENDATIONS (cont.)

10. Alignment E/E2 should be adopted as the preferred route on the Bear Flats section.

11. Alignment E should be built initially as Stage 1 until such time as traffic flows and maintenance costs warrant construction of the remainder of E2 as Stage 2.

Figures 14-18 show the recommended alignments, complete with earthworks.

8. REFERENCES CITED

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APPENDIX 1

Section 1

The Consultant Will:-

1. Engineering

(a) Review the Ministry's projected alignment, cost estimates and information compiled by B. C. Hydro for the project area and submit changes, if any, for the consideration and approval of the Ministry before proceeding with further work.

The review shall include a compilation of all pertinent geotechnical and other investegatory data available.

For information other than that enclosed herein on B. C. Hydro studies contact [redacted] Development Coordinator, Hydroelectric Generation Projects Division, B. C. Hydro, EG 21, Box 12121, 555 West Hastings, Vancouver, British Columbia, V6B 4T6, Telephone 663-3679.

(b) Contact owners for permission to enter properties for detailed examination of the proposed highway route. This work to be coordinated with B. C. Hydro's Properties Division.

(c) Provide 1:500 controlled metric mapping with 2 m contour intervals to this Ministry's specifications which will include test profiles. B. C. Hydro will be doing the necessary photography.

(d) Provide the ground control survey for the mapping in (c) above if suitable information is not available from B. C. Hydro's existing control.

(e) Produce a projected plan and profile on the 1:500 mapping for the relocated sections of Highway 29.

(f) Produce a ground survey along the projected line to include:-

(i) A layout of the final design line ("L"-line) on the ground.

(ii) Reference points for the "L"-line hubs outside the proposed right-of-way boundaries.

(iii) Run a profile on the "L"-line and place bench marks outside the right-of-way.

(iv) Cross section the existing ground along the "L"-line.

Appendix 1 (cont.)

(g) Conduct a general soils investigation producing reports on bank stability and protective measures required with at least one drill hole at depth near each bridge abutment. The soils investigation should locate and specify sources to be used for each type of grading, structural backfill material and riprap bank protection.

(h) Prepare a detailed roadway design and general arrangement drawings for the bridges up to the contract documentation stage. Contract documents are not part of this assignment.

(i) Consult with local highway department personnel in respect to maintenance and operation procedures, problems, etc., with existing facilities and the inclusion of necessary maintenance, emergency and traffic operation features as may be necessary.

(j) Prepare detailed quantity and cost estimates including engineering and contingency amounts and costs of materials and services to be provided by the Ministry and by others to arrive at an accurate overall estimate of cost of the project, including estimated utility relocation costs but not including right-of-way costs.

The Ministry Will:-

1. Critically review the work as it proceeds and will advise on matters regarding policy as these are reached.

2. Take part in and arbitrate all matters between the Consultant and other parties in respect to the preparation of right-of-way, road connections, utilities, etc., when required.

3. Provide all computer services, programming and operation and output necessary to arrive at economical profiles and alignments, earthwork and select material quantities, etc., for balanced and economical design, if the consultant recommends this as the most convenient procedure.

4. Provide As-Constructed plans and drawings of existing highways and structures under Ministry jurisdiction which will be affected or will affect the proposed works. Provide general and specific highway department specificatifons and standards.

APPENDIX 1

Section 2

Biophysical and Land Use Environmental Impact Study

1. Introduction

The relocation of Highway 29 requires a study on the biophysical impact of the revised alignment(s) in order to ensure that mitigation and enhancement techniques are included in the design.

The study will be site-specific to the proposed relocation alignment(s). Appended is the list of the numerous environmental impact studies carried out for B. C. Hydro on the Site "C" project. These will serve as reference material for this study. Futhermore, B. C. Hydro consultants will be available to assist in assessing the impacts based upon their extensive experience in the area.

2. Study Terms-of-Reference

(a) Surficial Materials

In general the surficial materials along the Peace River are prone to slumping. The Consultant should examine the terrain such that the relocated sections of highway will not traverse or be situated beneath areas of known or potential slide conditions. The consultant is to utilize the work carried out, and ongoing, by Thurber Consultants for B. C. Hydro.

(b) Hydrology - Surface Flow

All creeks and rivers must be assessed as to flow characteristics especially flood frequency for design of structures. In addition, surface flow should be assessed in conjunction with the surficial materials study for alleviation of potential slump problems. B. C. Hydro has a considerable amount of data on hydrologic conditions of the major creeks and rivers.

(c) Vegetation and Wildlife

Work should concentrate on identifying habitat utilization through vegetation studies. Also, migration routes of ungulates should be assessed. Wildlife studies undertaken by B. C. Hydro's consultant should be utilized. The study should identify mitigation proposals for alleviating wildlife/vehicle collisions and avoidance of any unique habitat conditions.

Appendix 1 (cont.)

(d) Fisheries

In conjunction with the hydrologist, creek and river crossings will be assessed, leading to the design of optimum structures and training works to relieve adverse impacts on fisheries and erosion problems.

3. Land Use

A few components will require some study in order to assess the relocation alignment(s): Principally,

(a) Outdoor Recreation

Outdoor recreation values and potential sites are to be identified and assessed. Also, proposed recreational sites are available from B. C. Hydro's studies.

(b) Agriculture

The relocation alignment(s) may have impact upon farming operations or on potential capability of agricultural land. Assessment will concentrate on how the alignment(s) will have the least adverse impact on farm operations.

(c) Archaeology and Heritage Resources

The Heritage Conservation Branch and B. C. Hydro consultants have carried out extensive field surveys. The Consultant should provide a statement and map of the resources and if any are potentially affected by the relocation(s).

(d) Social-Economic Concerns

At this time there are no concerns requiring studies of socio-economic factors. The existing reports should provide necessary data in these areas.

(e) Reporting

The Consultant will provide a draft report six weeks from the commencement of the project. A final report should be presented, following review and editing, after 10 weeks from submission date of the draft report.

Progress meetings will be required every two weeks prior to the submission of the draft report.

Appendix 1 (cont.)

ADDENDUM

Terms-of-Reference for
Hudson Hope to Charlie Lake
Relocation - Section I

The required design standards are as follows:-

1.	Design Speed	90 km/h
2.	Paved Lane Width	3.6 m
3.	Width of Top	10 m
4.	Maximum Grades	7 percent
5.	Maximum Curvature	230 m radius
6.	Lanes	Two lane design with truck lanes added when warrants indicate.

Appendix 1 (cont.)

LIST OF BACKGROUND DOCUMENTS

B.C. HYDRO AND POWER AUTHORITY: PEACE SITE C GENERATION/TRANSMISSION PROJECT

*B.C. Hydro and Power Authority, October, 1980. Peace River Site C Benefit/Cost Analysis. System Engineering Division, Report No. SE 7911.

*B.C. Hydro and Power Authority, July, 1980. Peace River Site C Environmental Impact Statement. Report No. SE 7910.

B.C. Hydro and Power Authority, February, 1980. Peace River Site C Mitigation and Compensation. Report No. 8006.

Blood, Donald A., 1979. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Wildlife Sub-Report.

Canadian Bio Resources Consultants Ltd., 1979. Peace River Site C Hydroelectric Development, Agriculture Assessment.

Canadian Bio Resources Consultants Ltd., 1979. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Water Quality and Use.

Canadian Resourcecon Ltd., 1979. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Resource Evaluation Study.

Canadian Resourcecon Ltd., Suzanne Viet and Associates Inc., Urban Programme Planners and Sigma Engineering Ltd., 1979. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Socio-Economic Impact Study.

Canadian Resourcecon Ltd., 1980. Peace River Site C Hydroelectric Development: Vegetable Industry Study.

Canadian Resourcecon Ltd., 1980. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Tourism Impact Study.

*Canadian Resourcecon Ltd., Urban Programme Planners, Sigma Engineering Ltd., December, 1980. Peace River Site C Hydroelectric Development, Environmental and Socio-Economic Assessment: Regional Economics Update, Final Report.

Edwin, Reid and Associates, 1979. Peace River Site C Hydroelectric Development, Recreation Impact Assessment.

*C. Lattey and Associates, 1980. Peace River Site C Hydroelectric Development, Social Assessment Update.

Appendix 1 (cont.)

Reid, Collins and Associates Ltd., 1979. Peace River Site C Hydroelectric Development Environmental and Socio-Economic Assessment: Forest Resource Assessment.

*Renewable Resources Consulting Services Ltd., 1979. Peace River Site C Hydroelectric Development, Fish and Aquatic Environment.

Spurling, Brian E., 1980. The Site C Heritage Resource Inventory and Assessment. Final Report, Impact and Mitigations.

Thurber Consultants Ltd., May, 1978. Site 1 - Site C - Fort St. John Transmission Development Environmental Impact Assessment.

Thurber Consultants Ltd., 1979. Peace River Site C Hydroelectric Development, General Land Use Studies.

Thurber Consultants Ltd., 1979. Peace River Site C Hydroelectric Development, Physical Environment Impact Assessment.

MAP

*Peace River Site C Project Reservoir Area, 1:50,000. Prepared by B.C. Hydro and Power Authority.

NOTE: This is a list of documents prepared to date by the Applicant regarding the Peace Site C Project. An "*" identifies documents submitted by the Applicant for Government review with the Energy Project Certificate Application document, as transmitted to Utilities Commission.

For copies of Application documents, please contact:

[redacted],
Senior Community Relations Officer,
B.C. Hydro and Power Authority,
970 Burrard Street,
VANCOUVER, B.C.
V6Z 1Y3 663-2405

APPENDIX 2

DESCRIPTION OF AGRICULTURAL SOILS

PEACE RIVER VALLEY

The following are descriptions of the soils found in the Peace River Valley with information on their agricultural use and value:

Alluvial Soils

These are derived from recent deposits of the Peace River floodplain and can be broken into two general groupings. Firstly, there are those which comprise the gravel bars, beaches, and major rivers' scars. These areas have little or no topsoil capping and are excessively stony. They generally occur 0-8 ft. above the river level and have no agricultural value. The second grouping includes deep loamy sands to sandy loams ranging from 4-8 feet in depth that are regosolic in nature. They have favourable nutrient and water-holding capacities and a textural class which make them highly suited to intensive cultivation. While presently moderately calcareous with a pH between 7.5-8.0, this would not appear a major limitation to crop use. These soils generally exist 6-20 ft. (1.8m-6.1m) above present water levels and are very well suited to vegetable production.

Taylor Soil Series

This is primarily located on the intermediate benches along the north bank of the Peace River Valley. Soil development is characteristic of a Rego Black Chernozem and the soils are generally of a clay loam texture. These soils are highly productive, but their extremely fine texture may limit their use for various root crops and necessitate special management practices to reduce erosion and ensure damage does not result from excessive compaction or puddling. The depth of these soils can very considerably within the unit but are generally greater than two feet. They Taylor series were mainly mapped independently but, in some limited areas, exist in a soil complex with the Branham series. The Taylor series are presently mainly developed for grain or alfalfa production, but they do have the potential for production of certain vegetable crops.

Appendix 2 (cont.)

Branham Soil Series

This is located on the intermediate benches of the Peace River Valley, primarily along the north bank. These soils are of an Orthic Brunisolic development and have a sandy loam to fine sandy loam texture. They are moderately to excessively drained and have moderately low water and nutrient-holding capacity. Where mapped independently or in a complex with the Taylor, Farrell, or Alluvial series, these soils have fair agricultural value, but when associated with the Clayhurst series, they hold only marginal agricultural values. Most of the present agricultural development associated with this soil series is either grain or pasture production. When the soils are of sufficient depth, they could be considered for other uses, such as vegetable production, but would usually require irrigation and heavy fertilizer applications.

Farrell Soil Series

This also exists along the intermediate benches of the Peace River Valley. These soils are Regosolic in nature and are derived mainly from alluvial fan deposits eroded from the lacustrine clays of the upper plateau. The texture varies from silt loam to silty clay loam. Due to their very fine textures, these soils are extremely erodible and require special management practices to reduce soil compaction and puddling. They are highly productive with good water and nutrient-holding capacity. However, the restrictive moisture range over which these soils can be cultivated reduces their use for intensively cultivated crops. Present agricultural development of these lands is associated primarily with grain and forage or forage seed production.

Pingel Soil Series

This occurs on the intermediate benches of the Peace River Valley, mainly along the river bank. Soil development is characteristic of a degraded Eutric Brunisol. The surface soil texture is generally clay or clay loam but is often underlain by coarse gravelly deposits in the subsoil. These soils, while fairly productive, are very subject to compaction, puddling, and erosion and therefore are not particularly well suited to crops requiring intensive cultivation. At present, most developed areas are used for alfalfa production or pasture crops. Where associated with the Twidwell series, the Pingel series has marginal agricultural value and would not be considered for extensive agricultural development.

Appendix 2 (cont.)

Toad Soil Series

This occupies a limited area on the intermediate terraces of the Peace River Valley. Soil development is characteristic of a Bisequa Gray Luvisol with soil texture of a sandy loam to silt loam. The Toad series occurs as a complex with the Farrell series and, in this complex, possesses favourable properties for agricultural use. At present, most of the area is under grain production, but this complex has potential for intensive forms of agricultural crop production.

Judah Soil Series

This is also found on the intermediate terraces of the Peace River Valley, but only as a soil complex with the Clayhurst series. The Judah soil series are Dark Gray Luvisols with a silty clay loam to silty clay texture. These soils are generally highly productive, but their association with the Clayhurst series considerably reduces their suitability for intensive agricultural development. At present, limited agricultural development exists within this soil unit with the majority of the areas in pasture.

The remaining soil series found in the Peace River Valley include the Grouard, Clayhurst, Twidwell, and Groundbirch series, and these have low agricultural value being mainly used only for pasture production.

APPENDIX 3

AGRICULTURE LAND CAPABILITY CLASSES

A general description of the capability of each class is summarized below:*

Class 1 - Land is capable of producing the very widest range of vegetables, cereal grains, forges, berry fruits, and numerous specialty crops. Soil and climate combinations are optimum.

Class 2 - Land is capable of producing a wide range of regional crops as above, with some differences in variety due to minor restrictions of soils or climate.

Class 3 - Land is capable of producing a fairly wide range of regional crops under good management practices. Soil and/or climate limitations are somewhat restrictive.

Class 4 - Land is capable of a restricted range of regional crops such as hardy cereal grains, hardy vegetables, and forages. Soil and climate limitations demand special management considerations.

Class 5 - Land is capable of production of perennial forage crops only. Soil and/or climate restrictions severely limit the land's capability.

Class 6 - Land is natural rangeland. Soil and/or climate limitations preclude cultivation, but the land may be important in its natural state as grazing land.

Class 7 - Land has no agricultural capability whatsoever.

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*B.C. Environment and Land Use Committee Secretariat, "Agriculture Land Capability in British Columbia," ARDA Project No. 89077, September 1976.

Appendix 3 (cont.)

Interpretation of Symbols on CLI and BCLI Agricultural Capability Maps

$5^{6}_{F\,M} - 4^{4}_{F\,M}$

Soil unit is 60% class 5 with limitations of low fertility and soil moisture deficiency and 40% class 4 with the same limitations.

$\left(4^{6}_{F} - 3^{4}_{F\,P}\right)$

The capability of the soil unit under an irrigated condition which improves the capability by eliminating the soil moisture deficiency limitation.

Subclasses (limitations) - CLI

C ..... Adverse climate characteristics.

D ..... Undesirable soil structure and/or low permeability which restricts rooting depth.

E ..... Unstable land subject to erosion or slumping.

F ..... Low fertility.

I ..... Inundation by streams or lakes for long periods.

M ..... Soil moisture deficiency attributable to soil and land characteristics.

N ..... Salinity.

P ..... Stoniness.

R ..... Consolidated bedrock which restricts rooting depth.

S ..... General adverse soil characteristics (sometimes used in place of D, R, M, & N, individually or collectively).

T ..... Topography.

W ..... Excess of soil moisture other than that caused by inundation.

X ..... Cumulative minor adverse characteristics which singly are not serious enough to affect the class rating.

Appendix 3 (cont.)

B.C. MODIFICATIONS TO NATIONAL GUIDELINES

Organic Soils

05W	(02X)
Soil unit is organic and class 5 due to excess soil moisture.	The capability of the soil under a drained condition which improves the capability by eliminating the excess soil moisture.

Subclasses (limitations - B.C.L.I.)

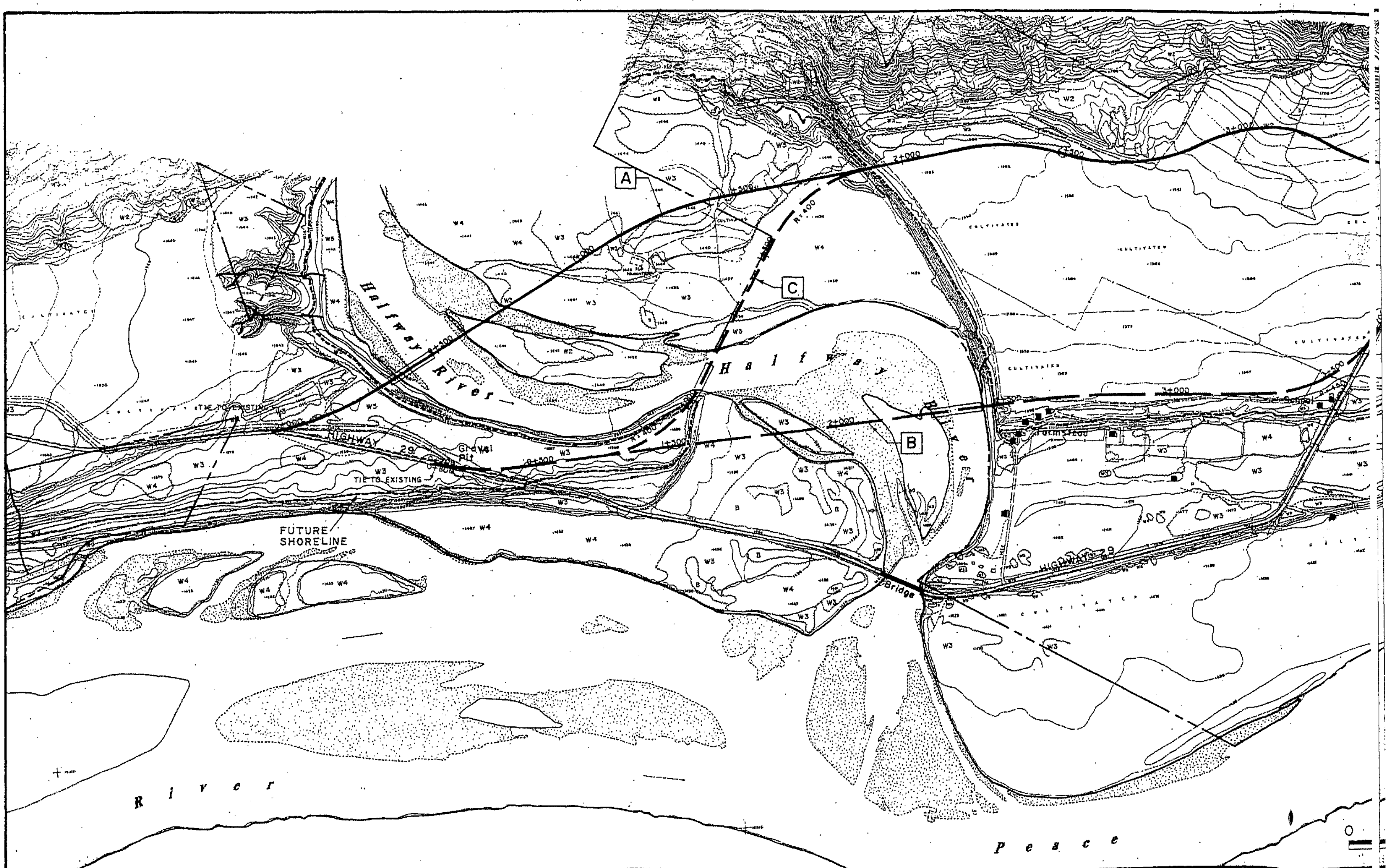
In addition to limitations for mineral soils above, the limitations following are used for organic soils.

B ..... presence of wood (trunks & stumps) that would affect reclamation.

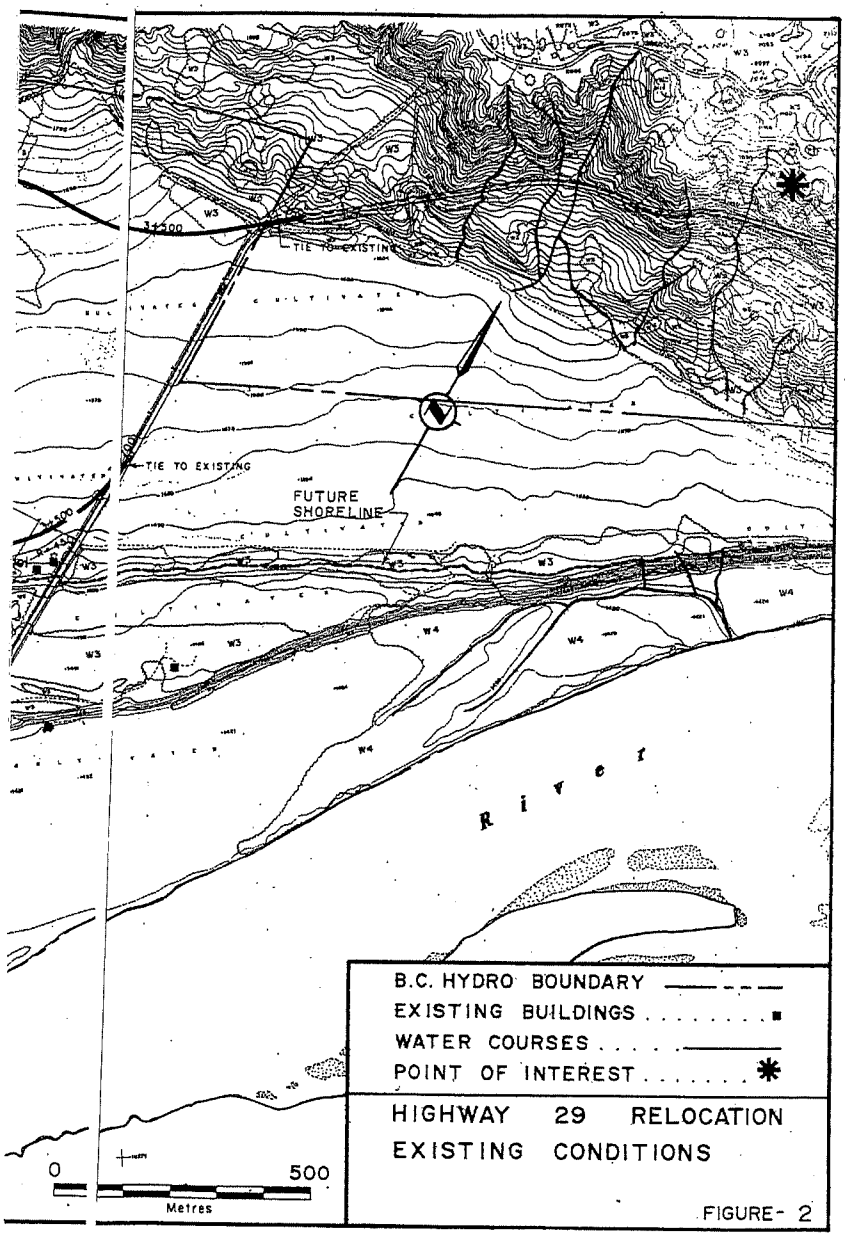
L ..... poorly decomposed soils.

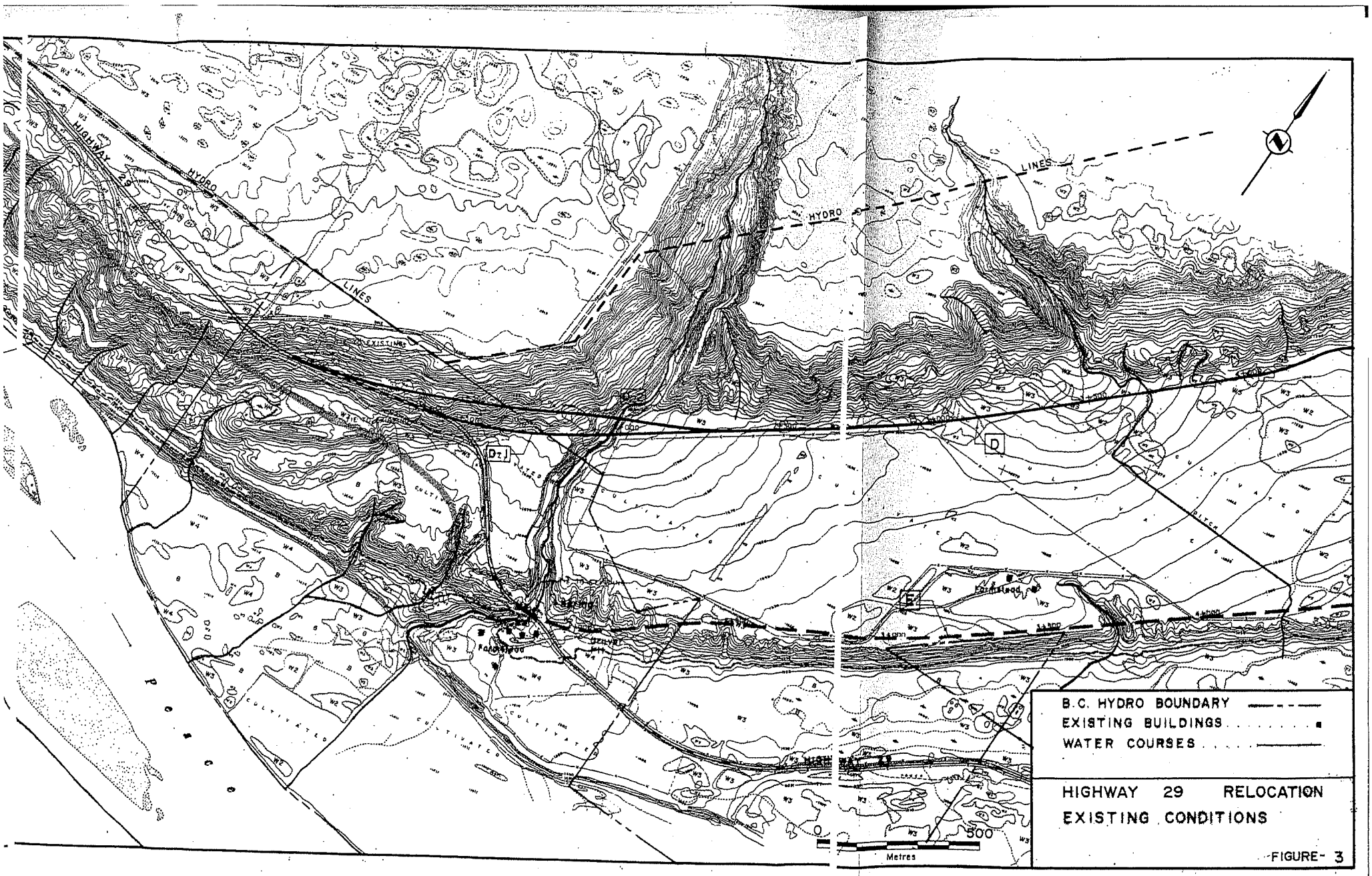
Z ..... permafrost.

NOTE: Improved rating as the result of drainage can be applied to mineral as well as organic soils.



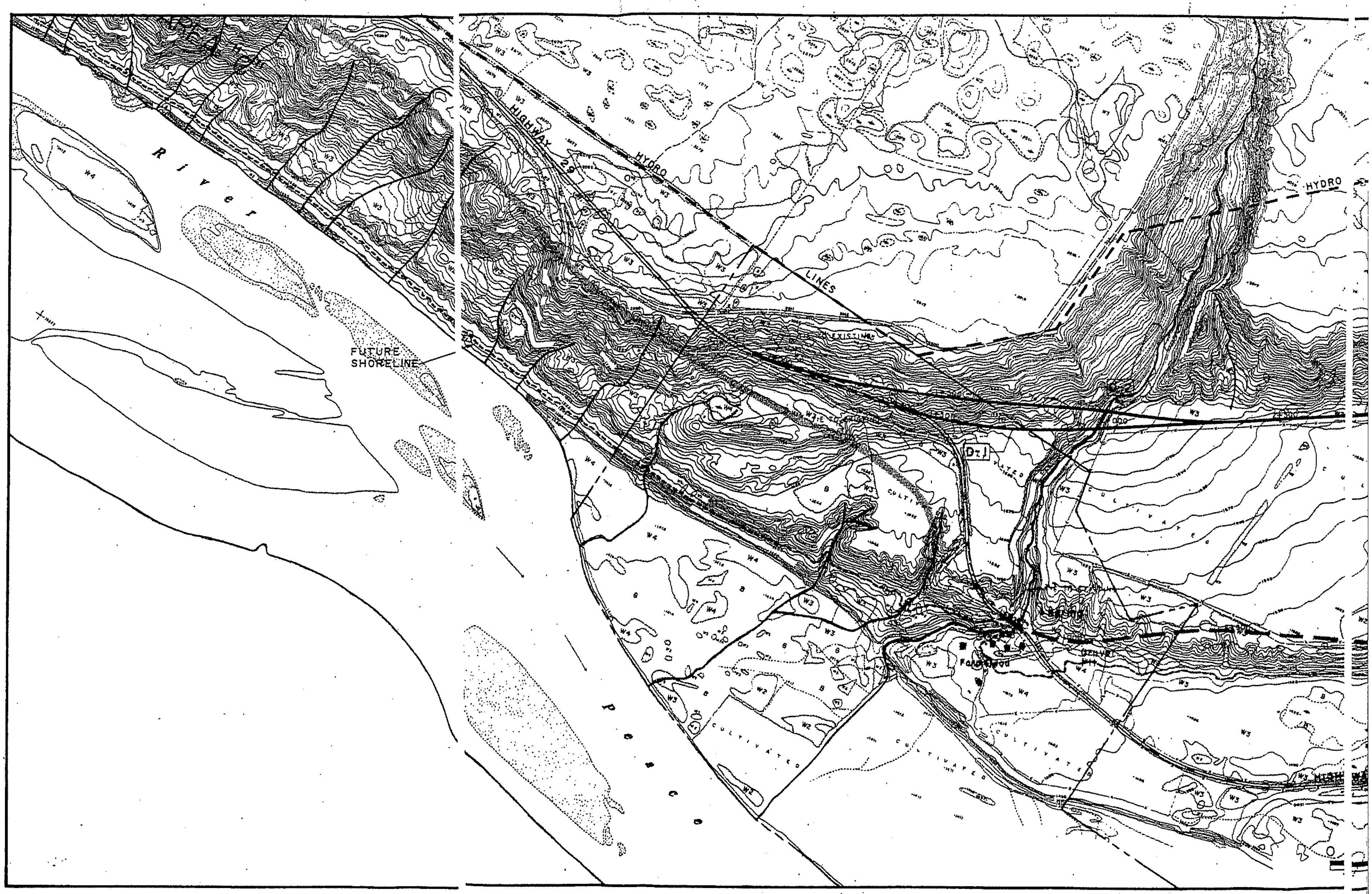
A
B
C
Halfway River
Halfway River
HIGHWAY 29
HIGHWAY 29
Gravel Pit
TIE TO EXISTING
FUTURE SHORELINE
Bridge
Farmstead
School
Peace River
CULTIVATED
R=400
0+500
1+000
1+500
2+000
2+500
3+000


TIE TO EXISTING
TIE TO EXISTING
FUTURE
SHORELINE
River
B.C. HYDRO BOUNDARY
EXISTING BUILDINGS
WATER COURSES
POINT OF INTEREST
HIGHWAY 29 RELOCATION
EXISTING CONDITIONS
0
500
Metres
FIGURE- 2

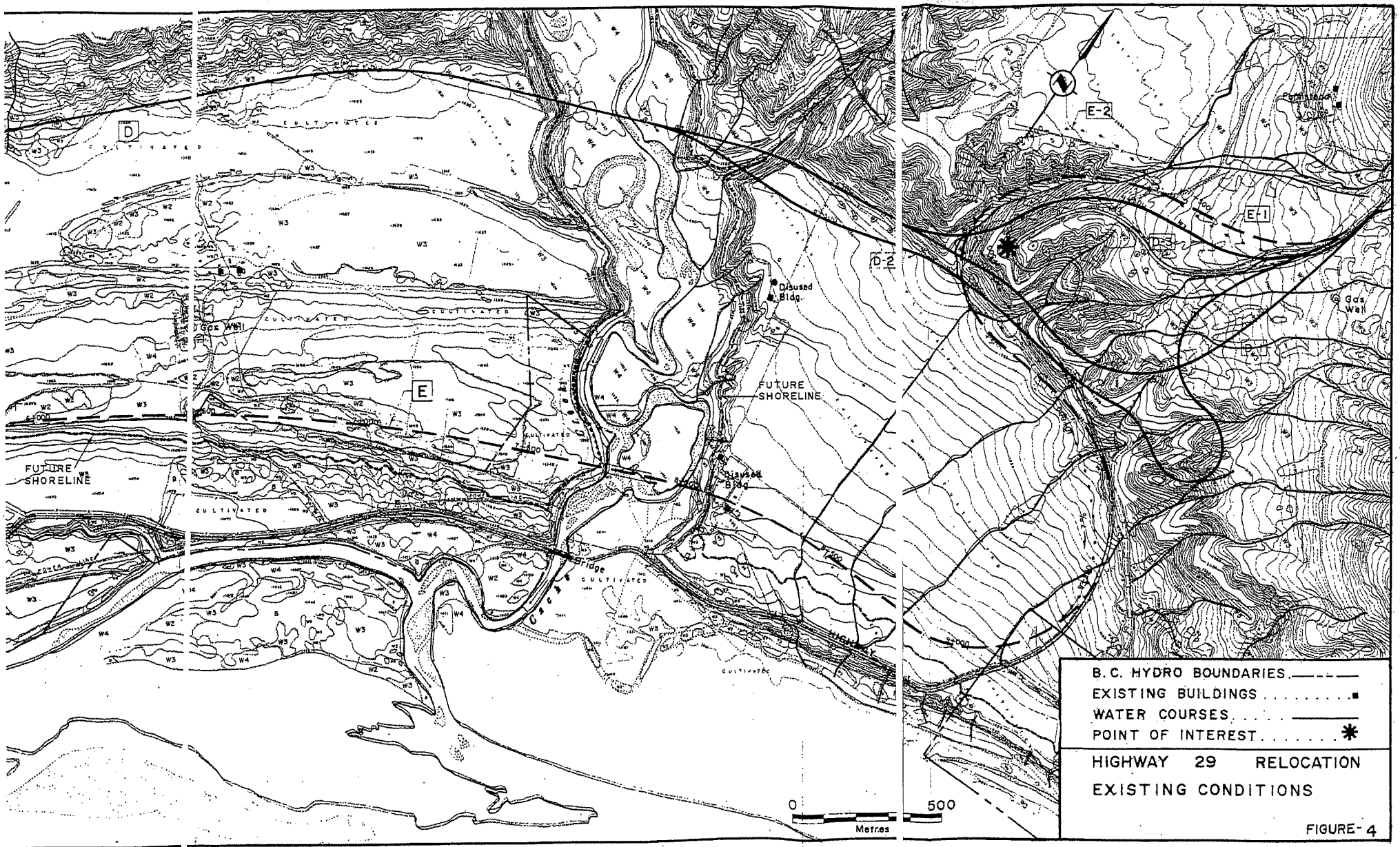


HIGHWAY 29 RELOCATION
EXISTING CONDITIONS

FIGURE- 3


HIGHWAY 29
HYDRO LINES
HYDRO
River
Peace
FUTURE SHORELINE
CULTIVATED
EXISTING
D-1


D
E
D-2
CULTIVATED
W1
W2
W3
W4
B
Fortinstead
Gas Well
FUTURE
SHORELINE
B.C. Highways
Gravel Pit
Disused
Bldg.
Bridge
Creek
HIGHWAY
0
Metres



HIGHWAY 29 RELOCATION

EXISTING CONDITIONS

FIGURE-4

TEXTURE DESCRIPTOR

(Particle sizes based upon Unified Soil Classification System and N.R.C. Field Description)

Specific Clastic Terms:

b	bouldery	203 mm plus
k	cobbly	76 – 203 mm
p	gravelly	5 – 76 mm
s	sandy	.075 – 5 mm
$	silty	.002 – .075 mm
c	clayey	minus .002 mm

Common (Grouped) Classes:

a	blocky	angular boulders
r	rubbly	angular gravel and cobbles
g	mixture of gravel and coarser	
-s-	silt and sand	mixture $ and s
f	fines	mixture $ and c

Organic Soils:

e fibric m mesic h humic

Well-sorted materials are described by the use of a single textural term; less well-sorted and poorly sorted materials are described using two textural terms with the subordinate textural term given first.

GENETIC MATERIALS

A	Anthropogenic*		
C	Colluvial*	O	Organic*
E	Eolian	R	Bedrock
F	Fluvial (Alluvial)	S	Saprolite*
I	Glacier Ice*	V	Volcanic
L	Lacustrine	W	Marine
M	Morainal (Till)		

U Undifferentiated

* (Marks materials for which formative processes are assumed active; others are assumed inactive).

In areas of air photo interpretation without field checking, textures of genetic materials are commonly not shown. Textures are then assumed to lie within a range which is defined for the Genetic Material within the E.L.U.C. publication.

SURFACE EXPRESSION DESCRIPTOR

a	apron	m	subdued
b	blanket	r	ridged
f	fan	s	steep
h	hummocky	t	terraced
l	level	v	veneer

The use of two (or rarely three) surface expressions together implies there is a mixing of discrete forms and not a combination of intermediate forms. Blanket indicates deposits greater than 1 metre thick; veneer indicates deposits less than 1 metre thick. The use of s is reserved for erosional slopes generally greater than 35° on both consolidated and unconsolidated materials.

QUALIFYING DESCRIPTOR

Qualifies genetic materials or modifying processes always as superscript following the term so qualified.

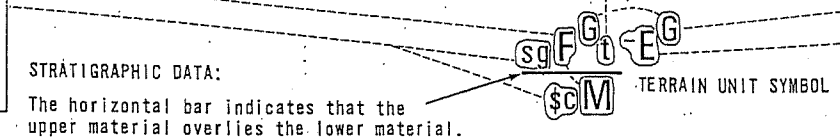
G	Glacial	
B	Bog	Reserved for organic Genetic Materials
F	Fen	
S	Swamp	
A	Active Process	
I	Inactive Process	

Active processes are those which give evidence for being recurrent or contemporary; inactive processes are those which are not recurrent and which have ceased. Modifying Processes and formative processes for Genetic Materials are assumed to be either active or inactive. A superscript modifier is shown only where a process state is contrary to the common assumption.

MODIFYING PROCESSES

-A	Avalanched*
-B	Bevelled
-C	Cryoturbated*
-D	Deflated
-E	Channelled
-F	Failing*
-H	Kettled
-K	Karst Modified*
-N	Nivated*
-P	Piping*
-R	Rapid Mass Wasting*
-S	Soliflucted*
-V	Gullied
-W	Washed
-X	Permafrost*

* Marks processes assumed to be active; others are assumed inactive.



TERRAIN UNIT SYMBOL

STRATIGRAPHIC DATA:

The horizontal bar indicates that the upper material overlies the lower material.

EXAMPLE SHOWN:

Sandy gravelly and coarser fluvioglacial terrace deposits with channels eroded by glacial meltwater; the whole unit overlying silty clay till.

ON-SITE SYMBOLS:

These and other symbols may be used to show features of special interest or limited areal extent.

- Drumlin, crag-and-tail drumlinoid ridge.
- Fluting.
- Glacial striae. Ice flow direction known.
- Glacial striae. Ice flow direction unknown.
- Moraine ridge.
- Esker. Direction of depositional flow known.
- Esker. Direction of depositional flow unknown.
- Large glacial meltwater channel.
- Small glacial meltwater channel.
- Cirque.
- Avalanche track.
- Observation of frozen ground.
- Landslide escarpment.
- Rock slide or earth flow
- Escarpment. Often steep erosional terrace slopes.
- Mine or quarry.
- Borrow pit.

SPECIAL STRATIGRAPHIC INFORMATION:

Brackets tied to point locations show stratigraphic detail at significant exposures. Other units may not be exposed and brackets may therefore only give a portion of a complete stratigraphic column. Locations typically consist of isolated exposures on steep erosional slopes or slide escarpments. Asterisk (*) shows waterbearing units. Materials may be texturally and/or genetically indentifiable. Thickness of units not given or implied.

$$\left(\begin{array}{c} g \\ \hline \$L \\ \hline M \\ \hline sg^* \end{array}\right)$$

Example: Gravelly unit (texturally identifiable) overlying silty lacustrine deposits (texturally and genetically identifiable) overlying till (genetically identifiable) overlying water-bearing sandy-gravelly unit.

COMPOSITE UNITS:

= components on either side of this symbol are approximately equal in area.

/ the component in front of the symbol is more abundant (55 to 70%) than the one that follows.

// the component in front of the symbol is considerably more abundant (70 to 90%) than the component that follows.

example 1:

Mb=R, Moraine blanket area roughly equals the exposed bedrock area.

example 2:

Mb/R, Moraine blanket area is more than the area of exposed bedrock

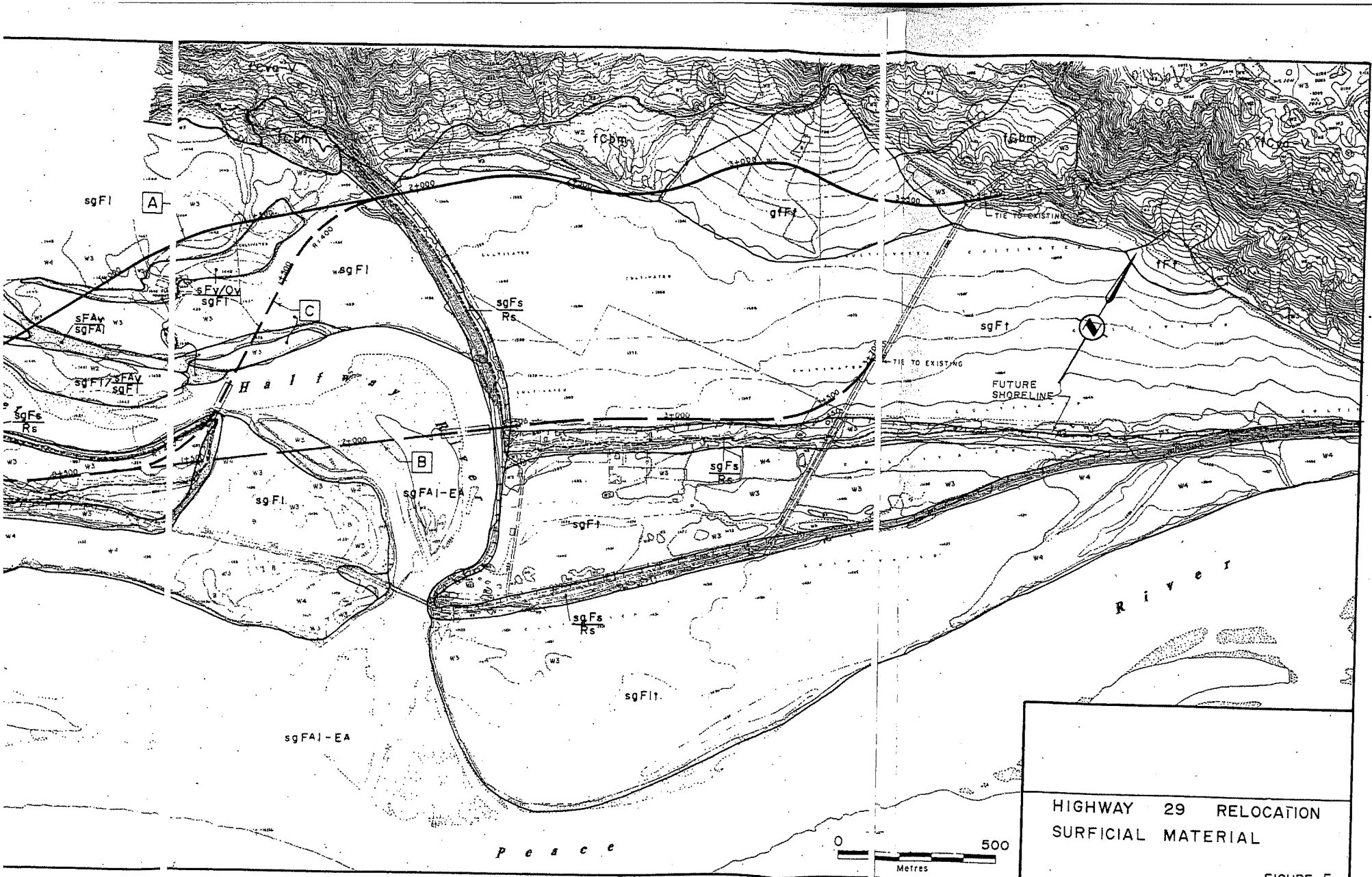
example 3:

Mb//R, Moraine blanket area is considerably more than the area of exposed bedrock.

Modified by Thurber Consultants Ltd. from "Terrain Classification System". British Columbia E.L.U.C. Secretariat, 1978. Refer to this publication, available from the Terrestrial Studies Branch, B.C. Ministry of Environment for important descriptive details of terrain mapping legend.

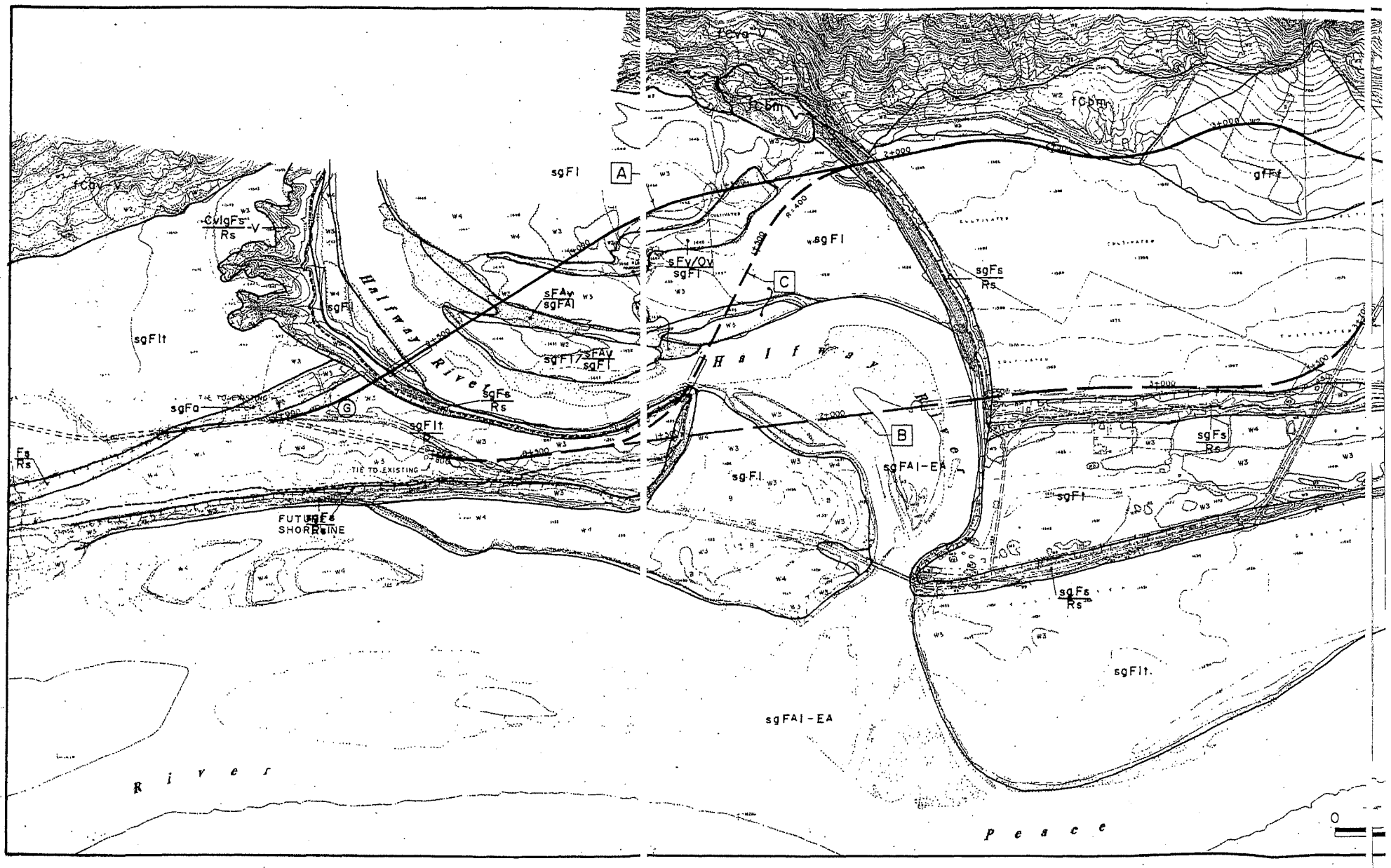
THURBER CONSULTANTS LTD.
VICTORIA VANCOUVER EDMONTON

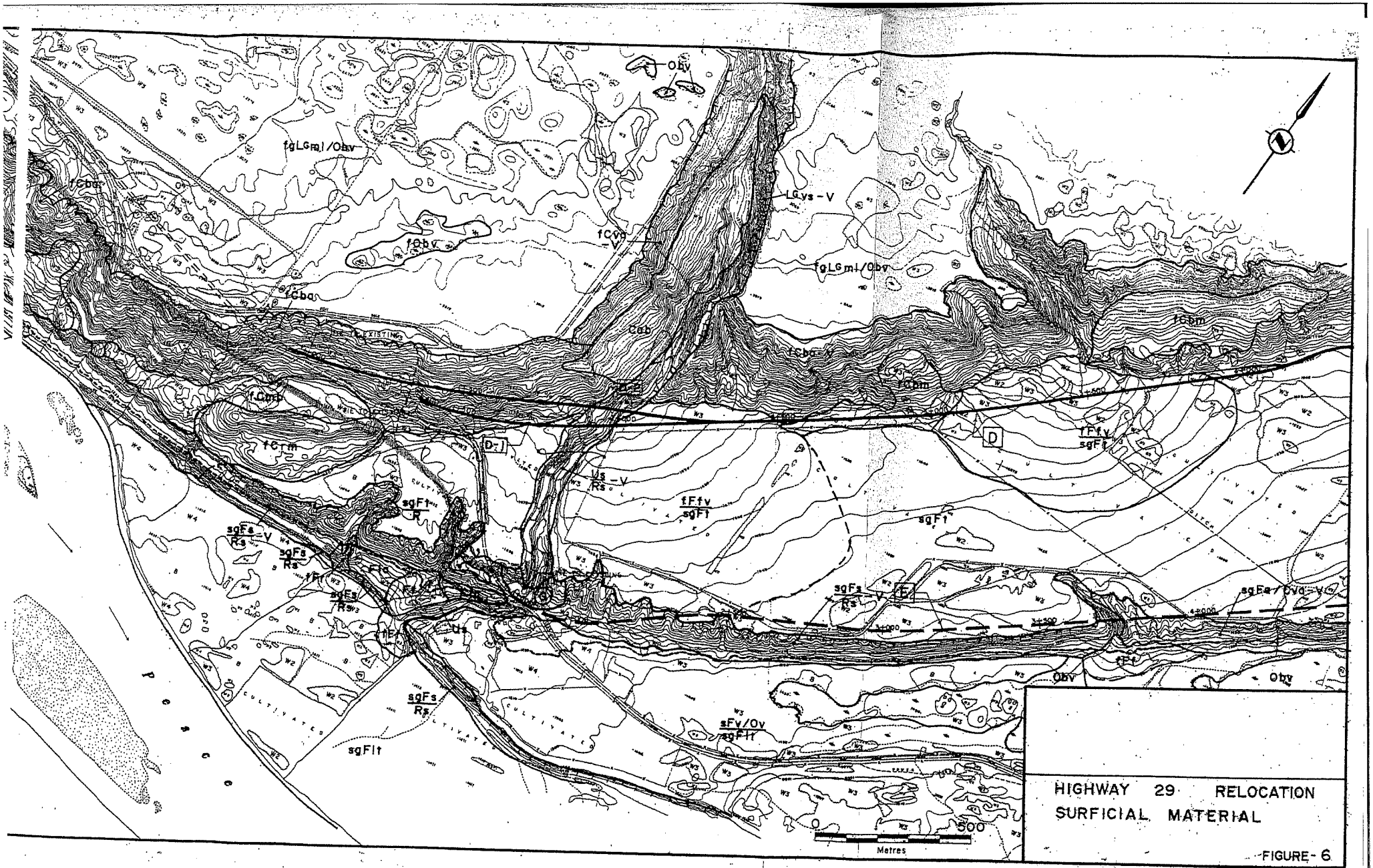
TERRAIN MAPPING LEGEND



HIGHWAY 29 RELOCATION
SURFICIAL MATERIAL

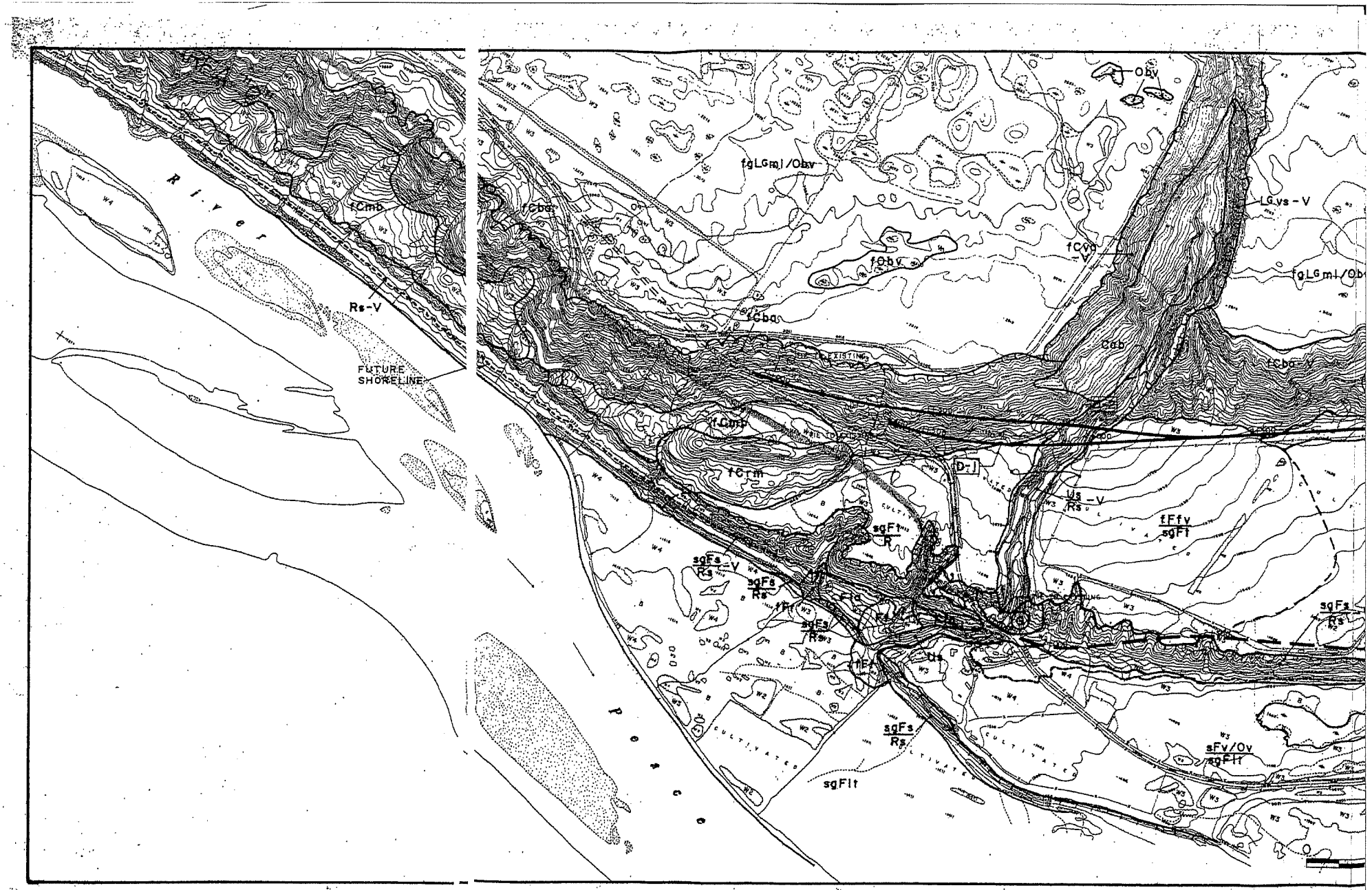
FIGURE-5

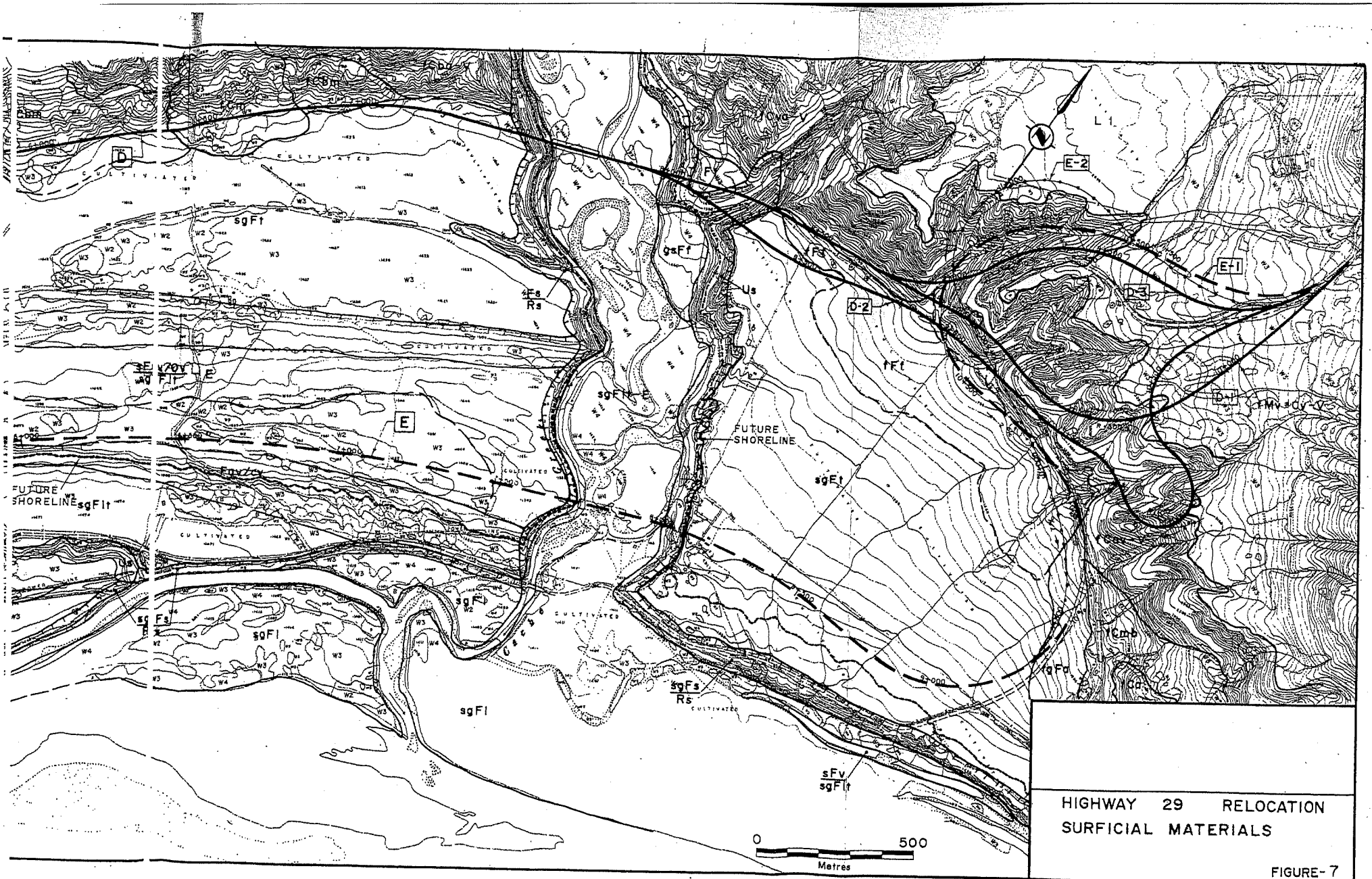

fcvg-V
fcbm
fcpm
sgFl
A
CvlgFs
Rs
-V
sgFl
sFAv
sgFAl
sgFlt
sgFl/sFAv
sgFl
Halfway River
sgFs
Rs
sgFa
TIE TO EXISTING
G
sgFlt
Fs
Rs
TIE TO EXISTING
FUTURE
SHORELINE
sgFs
sFv/Ov
sgFl
C
sgFl
sgFs
Rs
B
sgFAl-EA
sgFl
sgFs
Rs
sgFlt
sgFAl-EA
River
Peace
0



HIGHWAY 29 RELOCATION
SURFICIAL MATERIAL

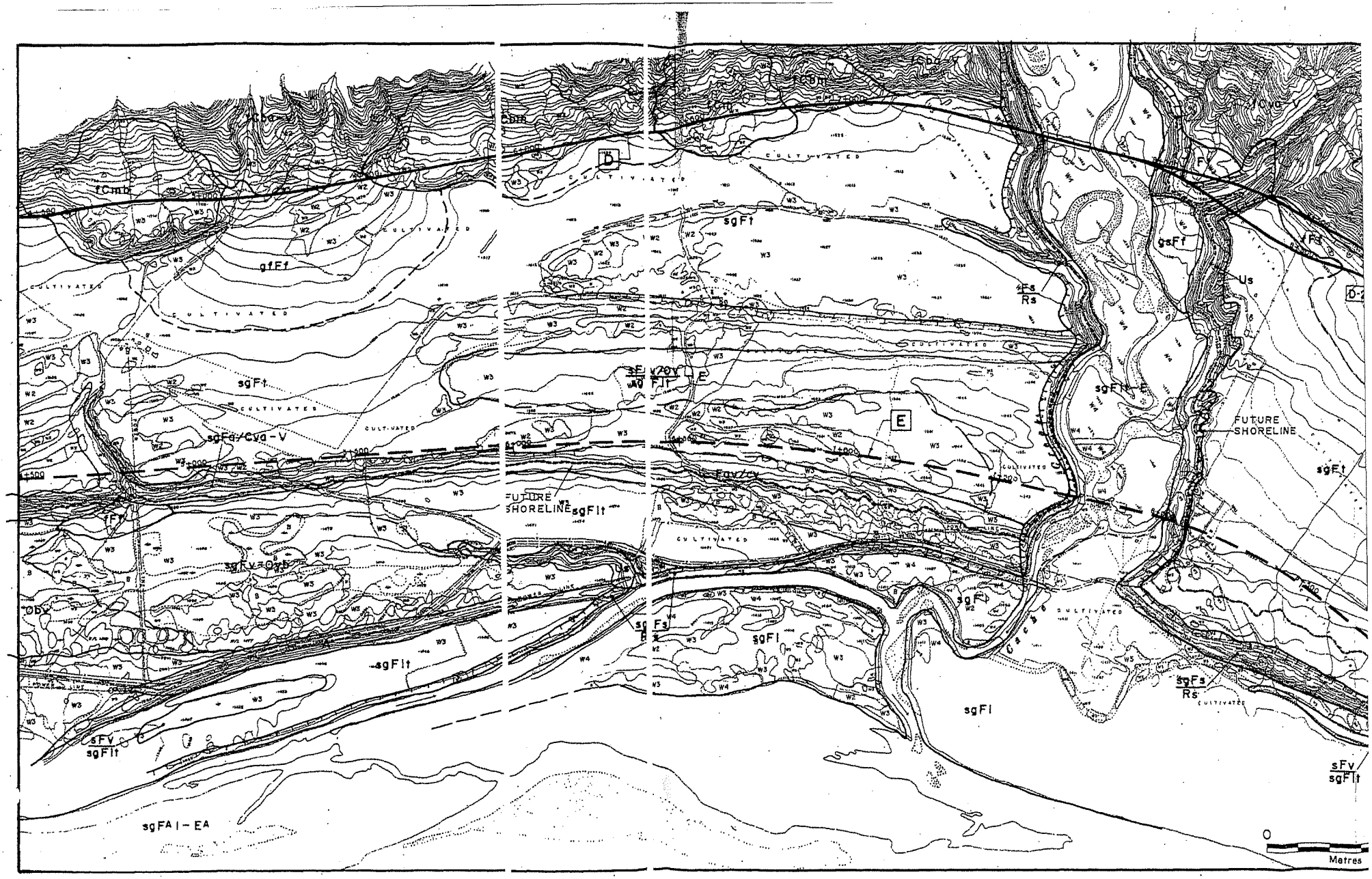
FIGURE- 6

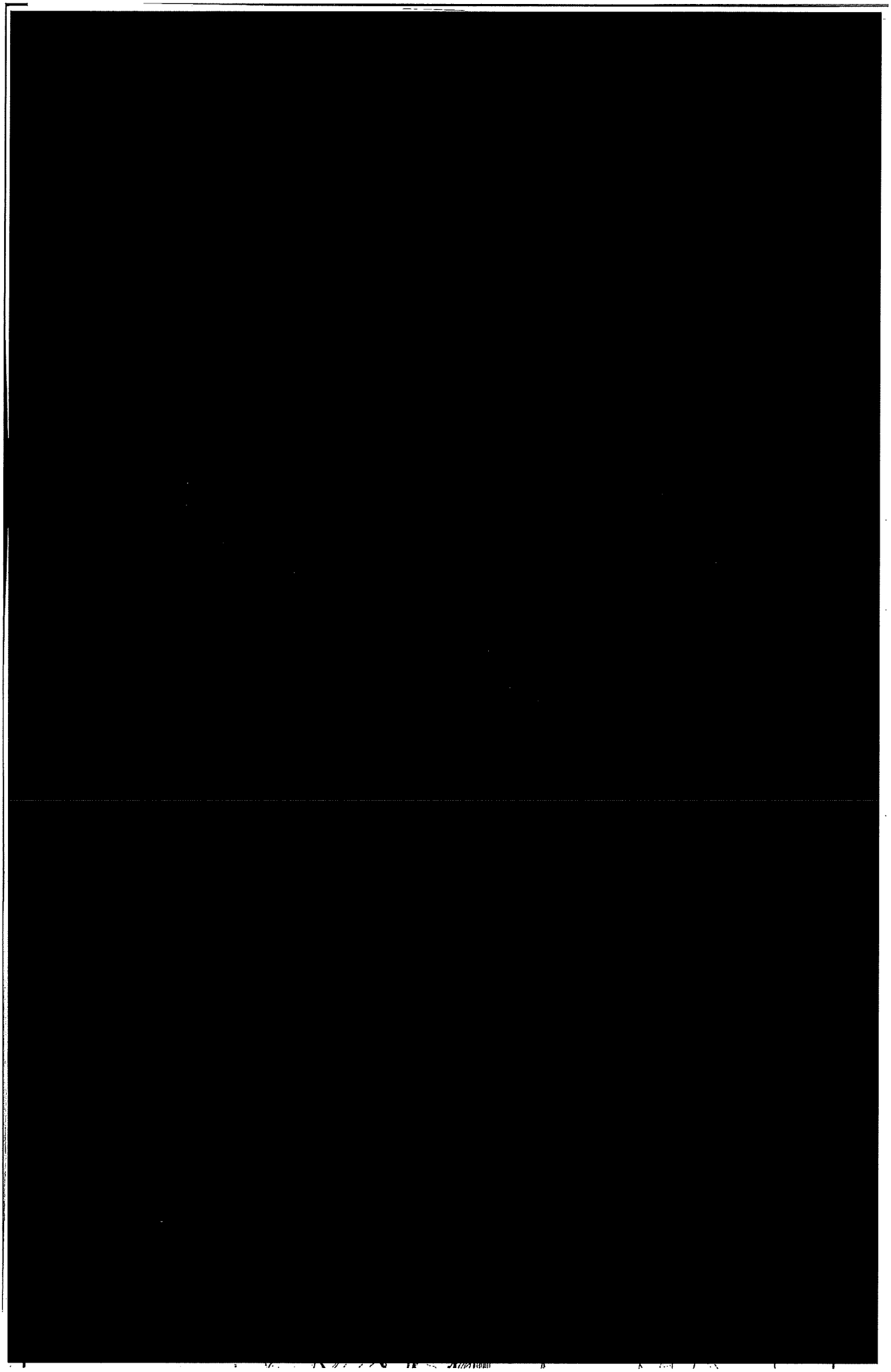

River
fCmb
Rs-V
FUTURE SHORELINE
fgLGmI/Obv
fCba
Obv
LGvs-V
fCvs V
fgLGmI/Ob
fCba-V
fCmb
fCrm
Us Rs -V
fFfv sgFt
sgFs Rs -V
sgFs Rs
sgFt R
sgFs Rs
sgFlt
sFv/Ov sgFlt
Peace

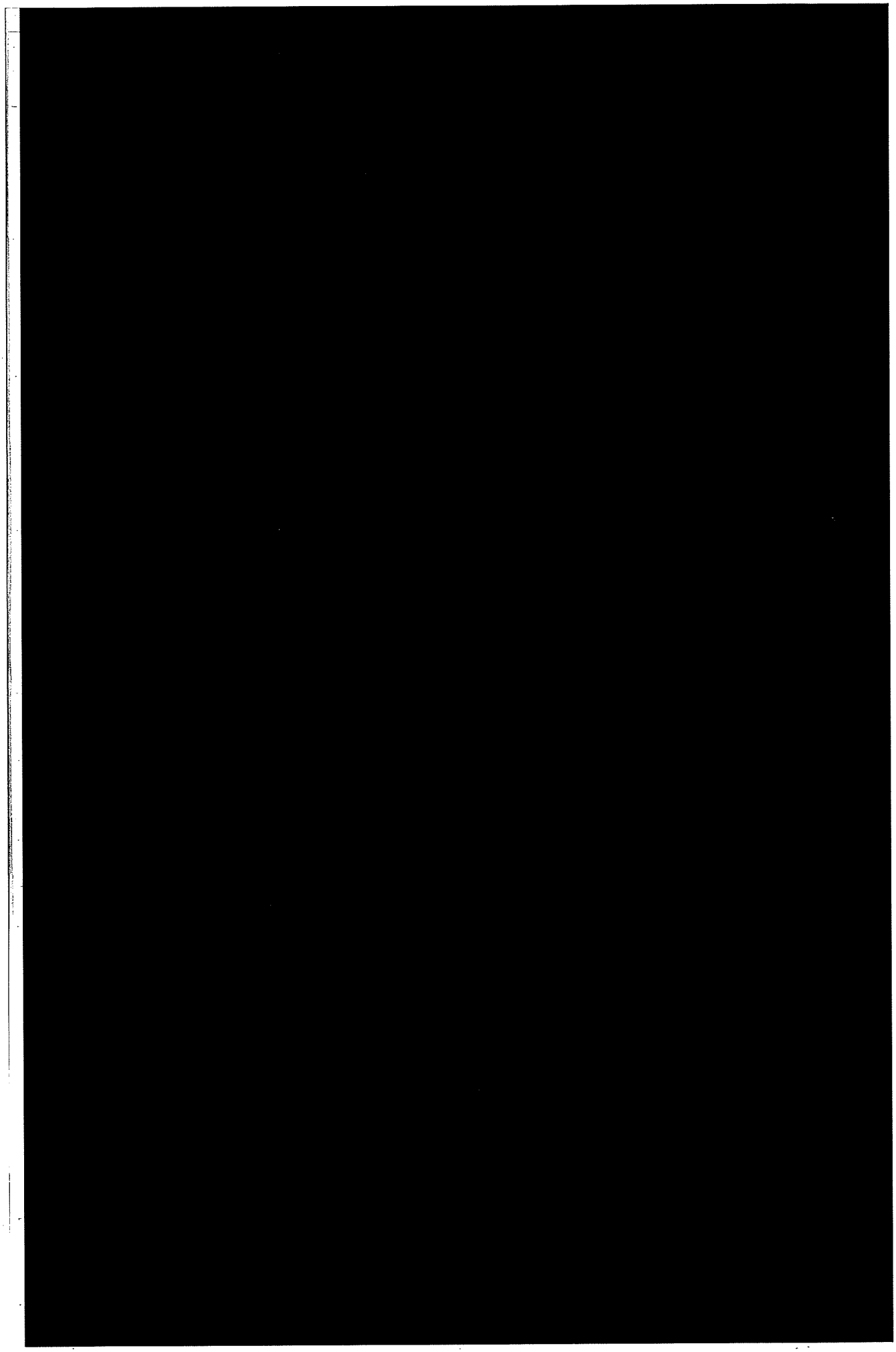


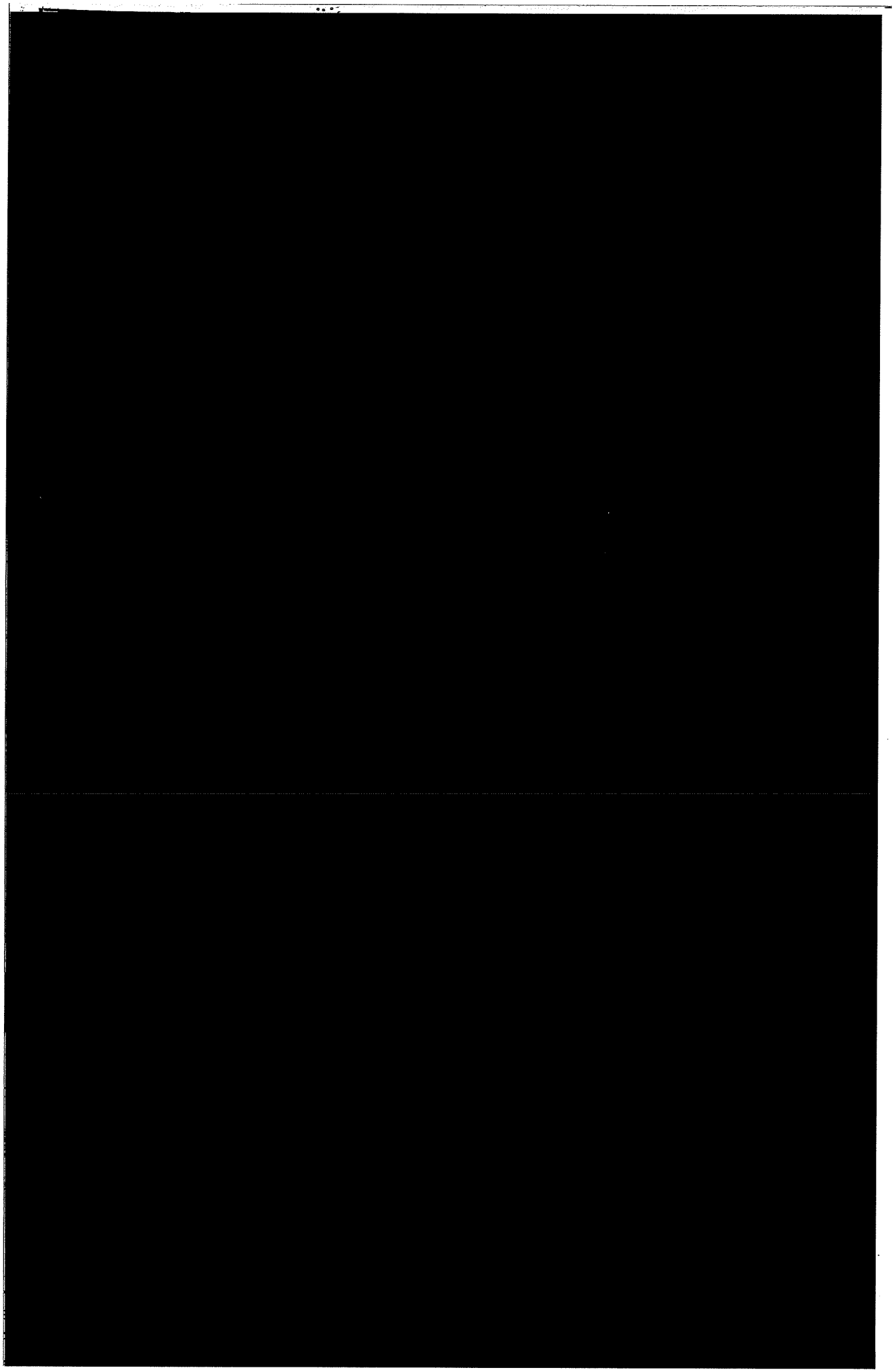
HIGHWAY 29 RELOCATION
SURFICIAL MATERIALS

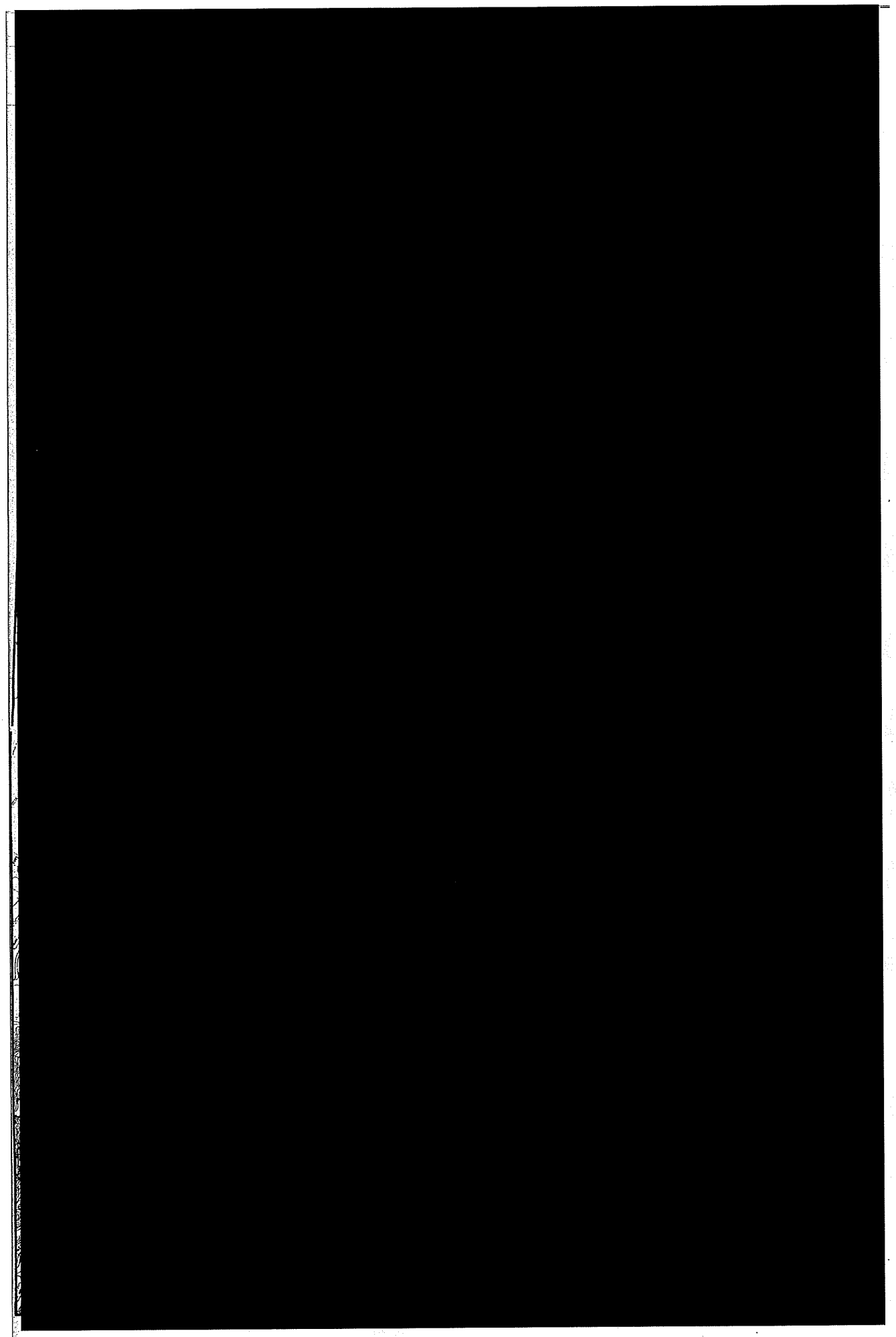
FIGURE- 7

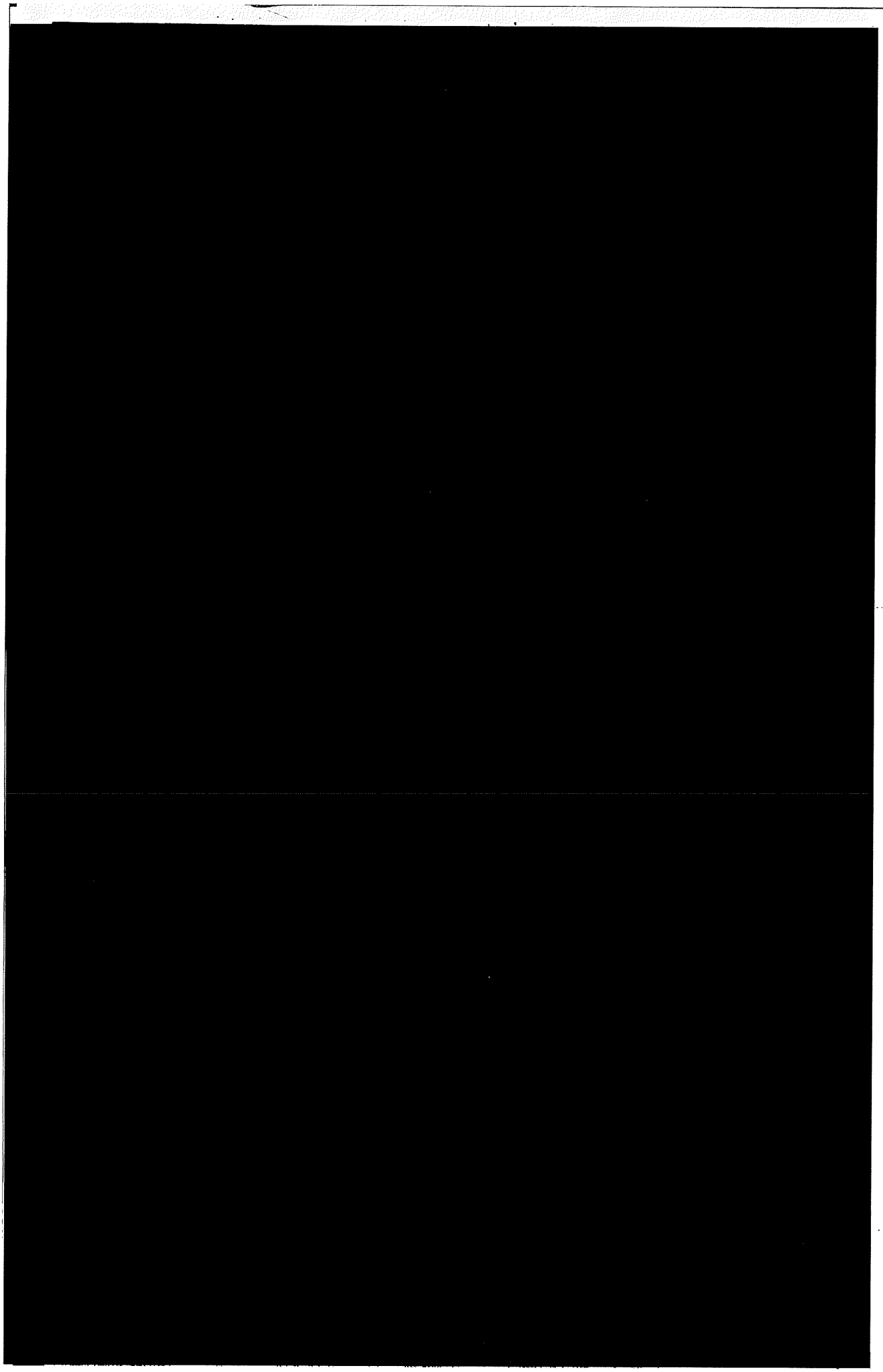

fCmb
gfEf
sgFf
sgFd/Cvg-V
fFf
sgFv=Orb
Obv
sgFlt
sFv
sgFlt
sgFA I - EA
fCbn
fCvg-V
gsFf
Us
sFs
Rs
sgFf
FUTURE
SHORELINE
sgFf
Fav/cv
sgFlt
sgFl
sgFs
Rs
sFv
sgFlt
D
E
0
Metres

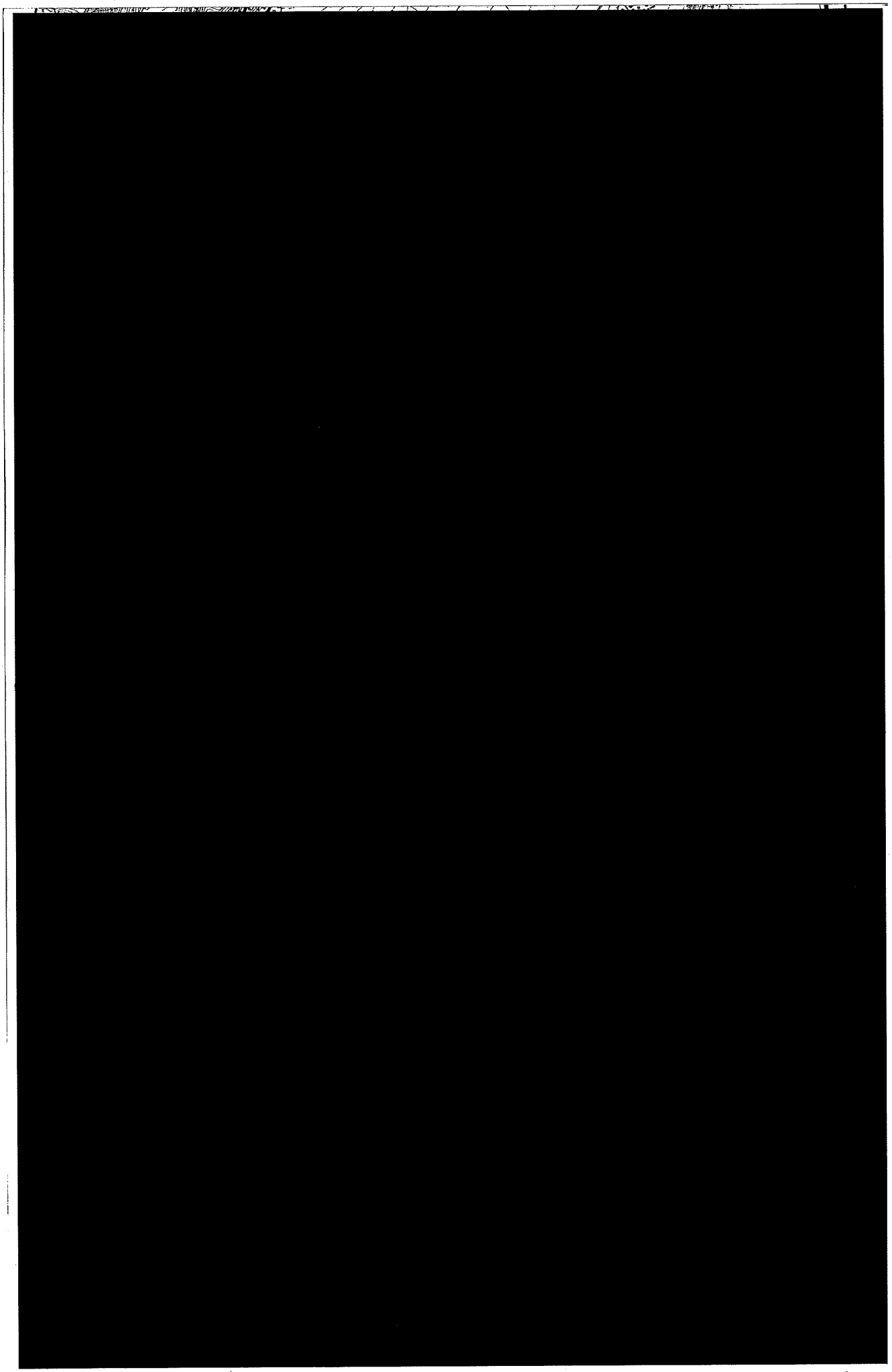












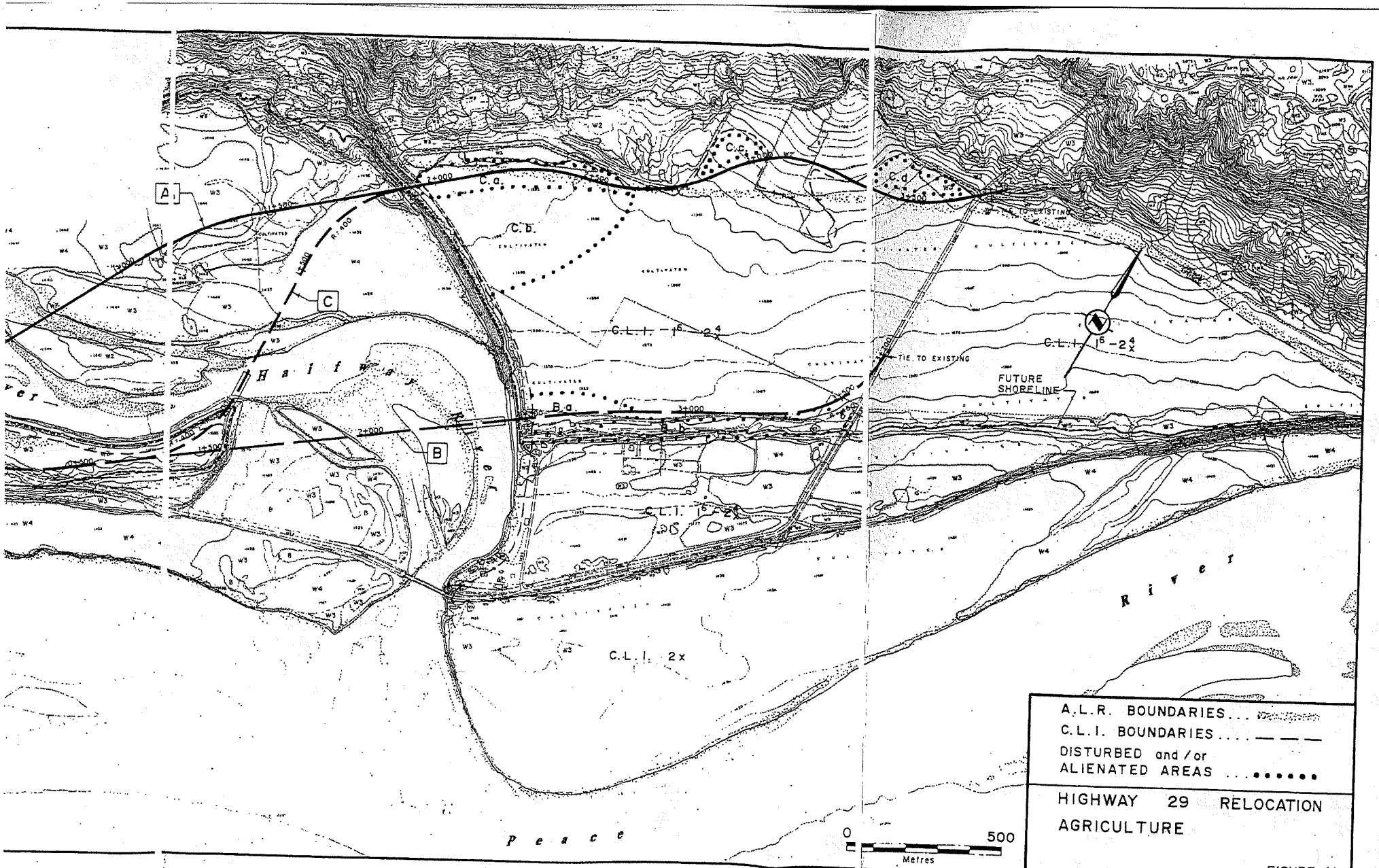
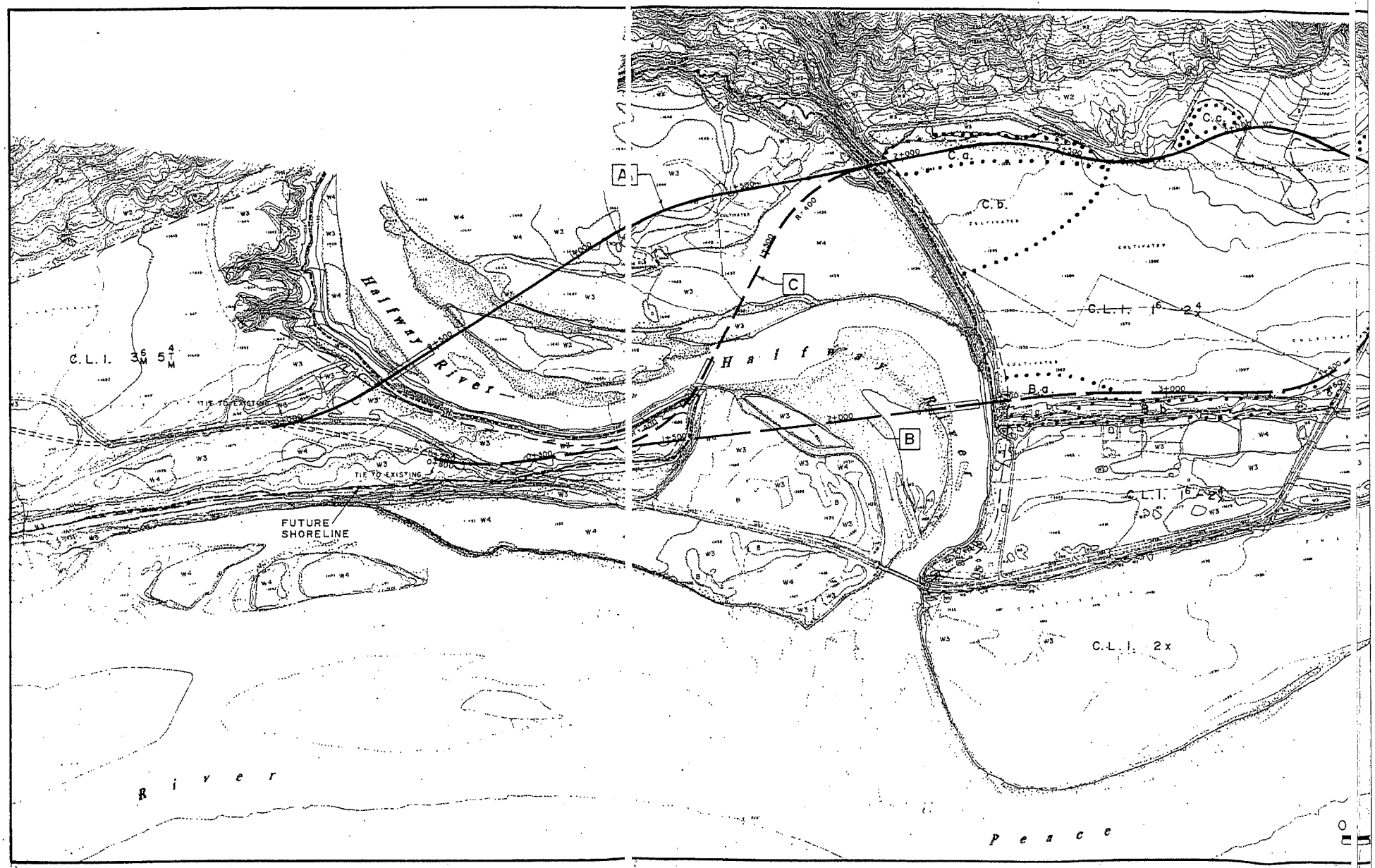
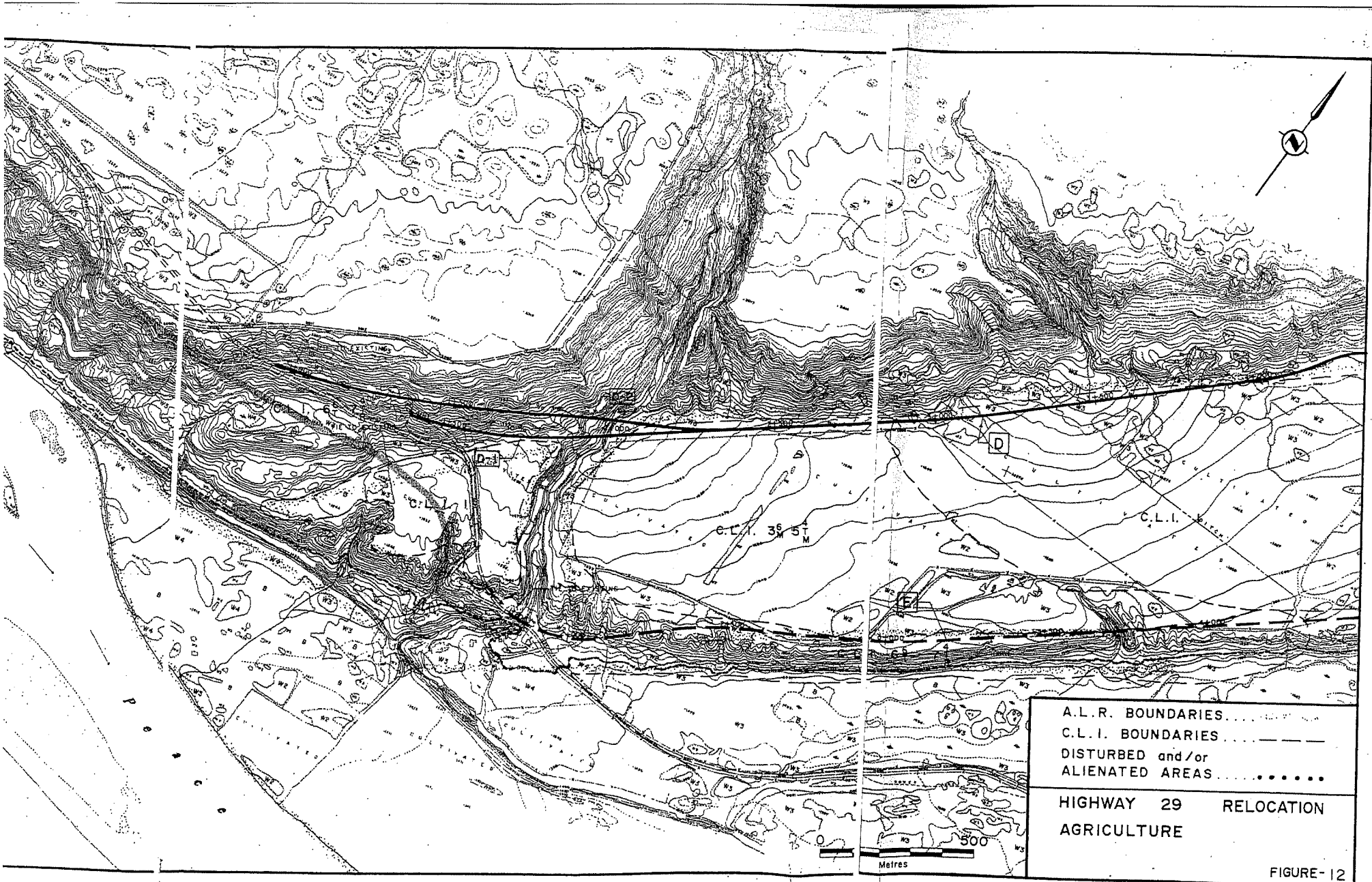
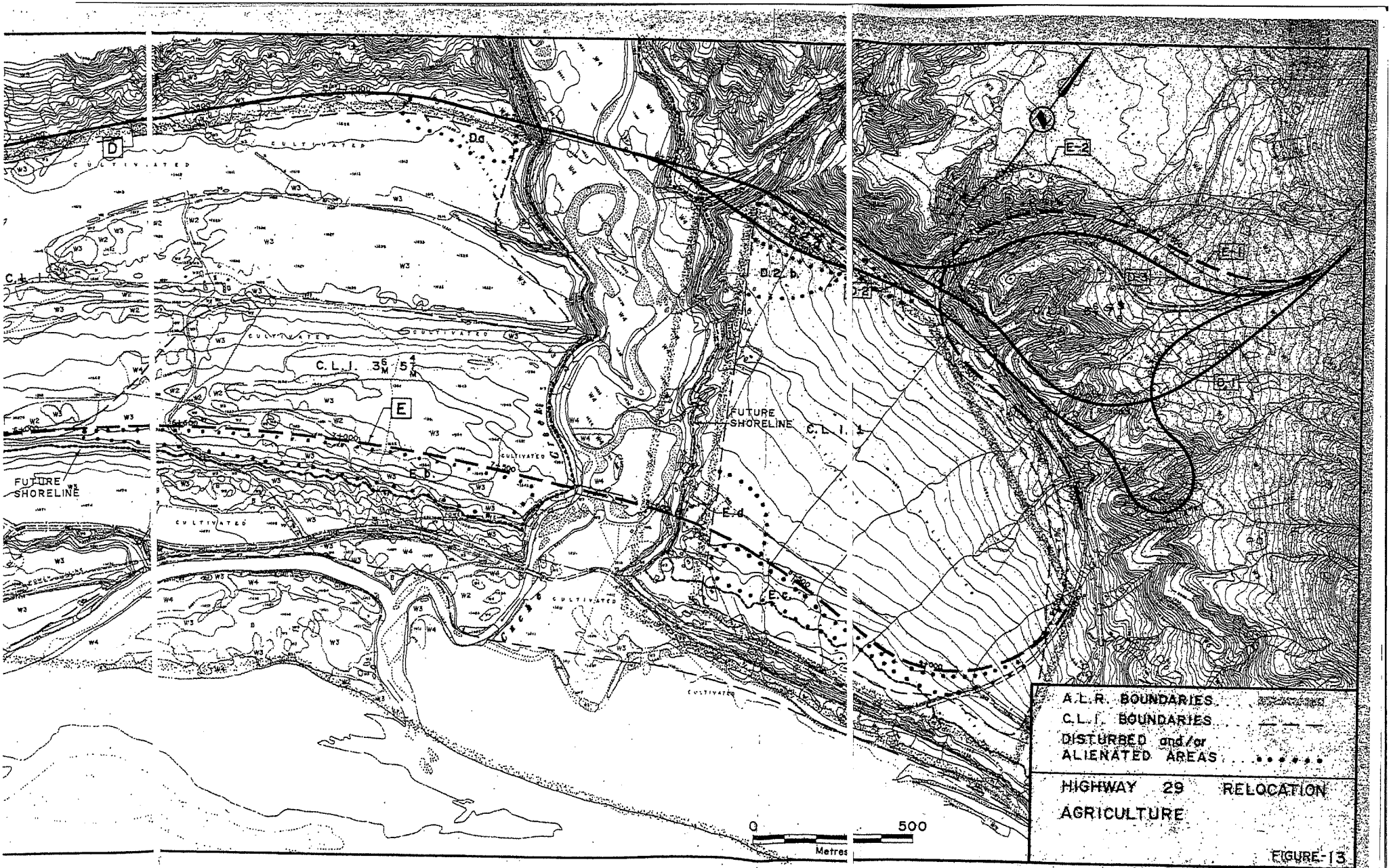

A
B
C
C.a
C.b
C.c
C.d
B.a
B.b
R=400
R=500
TIE TO EXISTING
FUTURE SHORELINE
C.L.I. 1^6 - 2^4
C.L.I. 1^6 - 2^4_x
C.L.I. 2x
Halfway River
Peace River
A.L.R. BOUNDARIES
C.L.I. BOUNDARIES
DISTURBED and/or ALIENATED AREAS
HIGHWAY 29 RELOCATION
AGRICULTURE
0
500
Metres

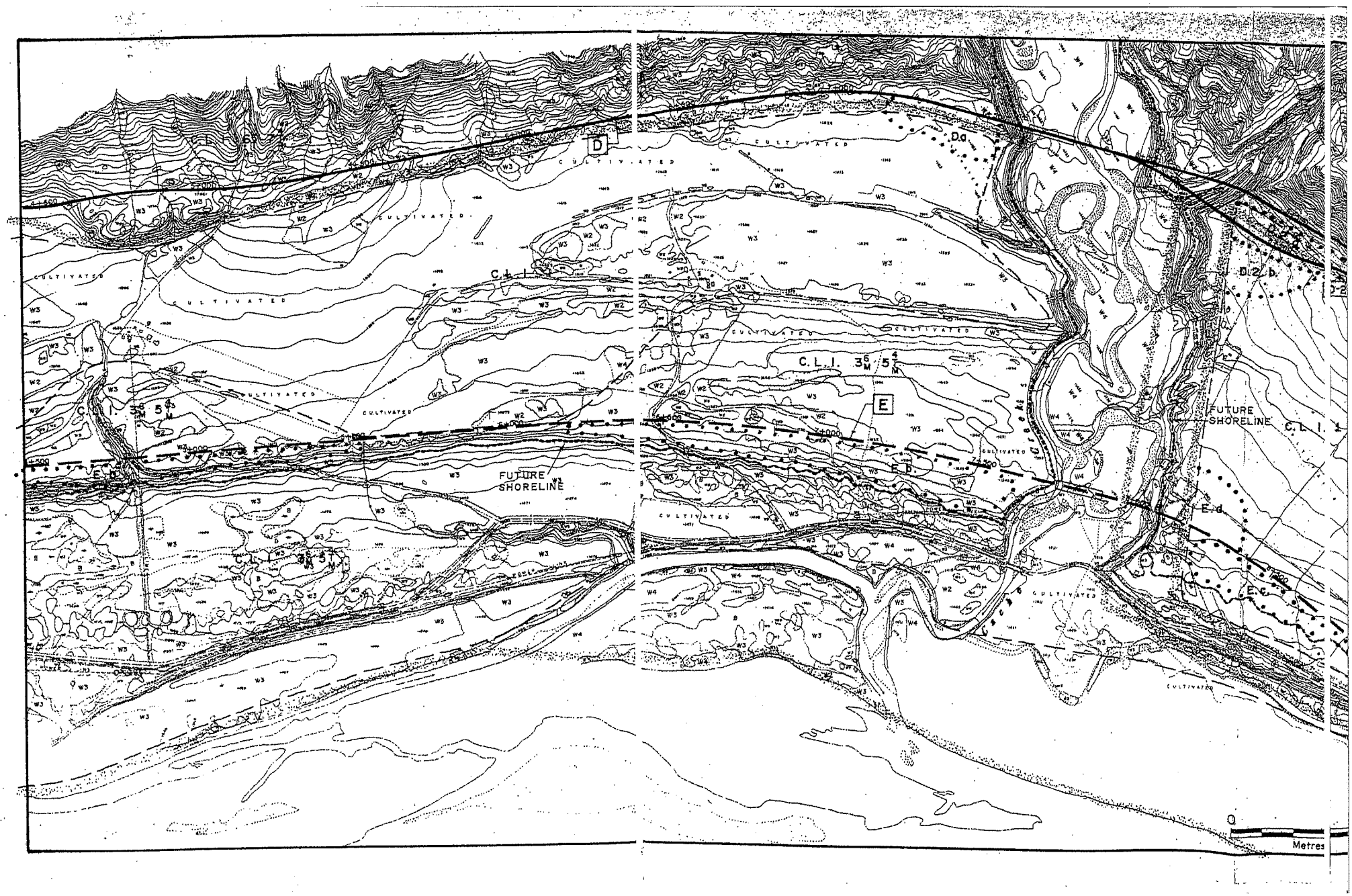
FIGURE-11

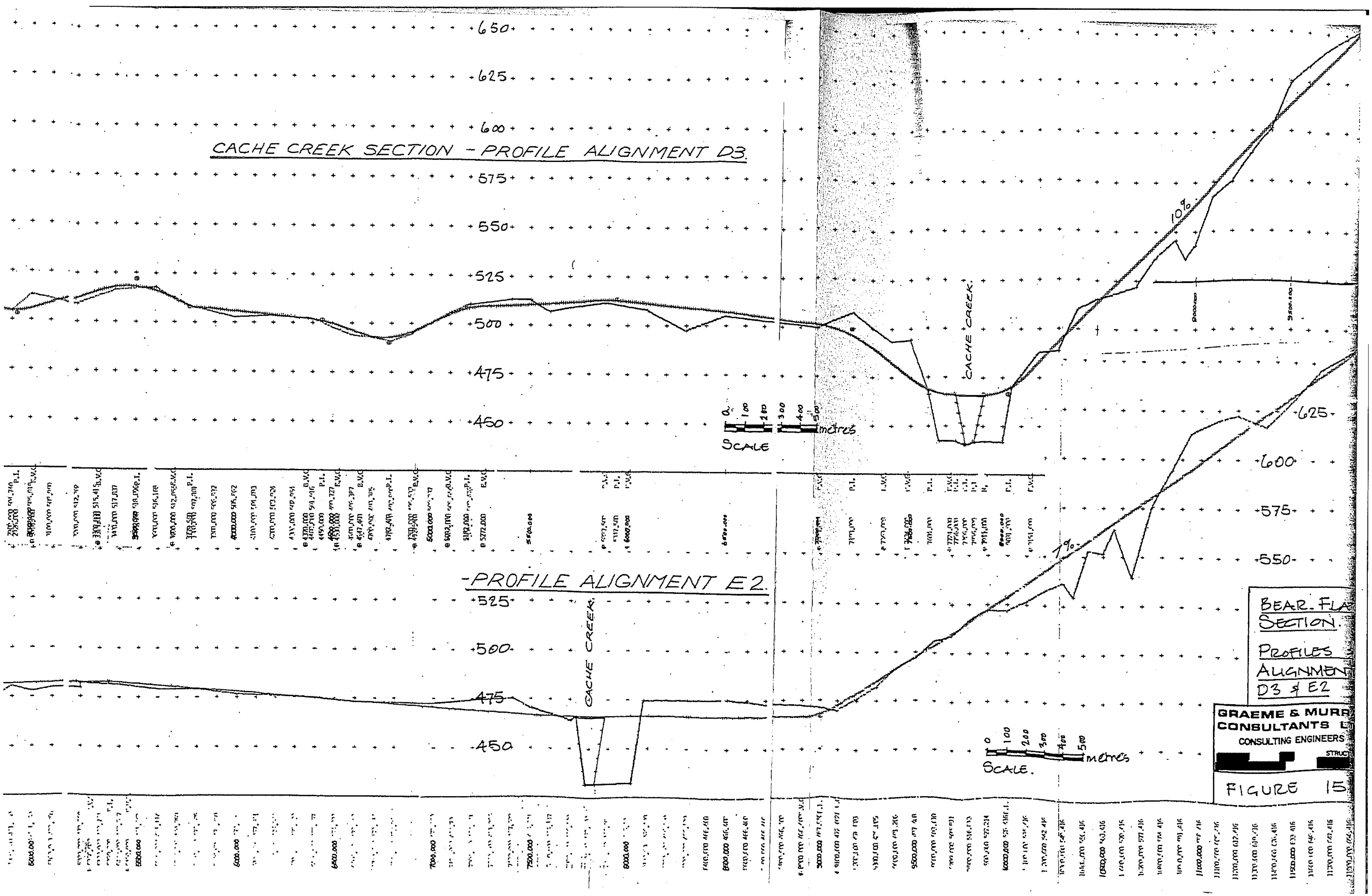

A
B
C
C.L.I. 3M 5M
C.L.I. 1 2x
C.L.I. 2x
C.a.
C.b.
C.c.
B.a.
B.b.
R=400
R=300
Halfway River
Peace River
TIE TO EXISTING
FUTURE SHORELINE
CULTIVATED
0+000
1+000
2+000
3+000
4+000
5+000
6+000
7+000
0+500
1+500
2+500
3+500
4+500
5+500
6+500
7+500

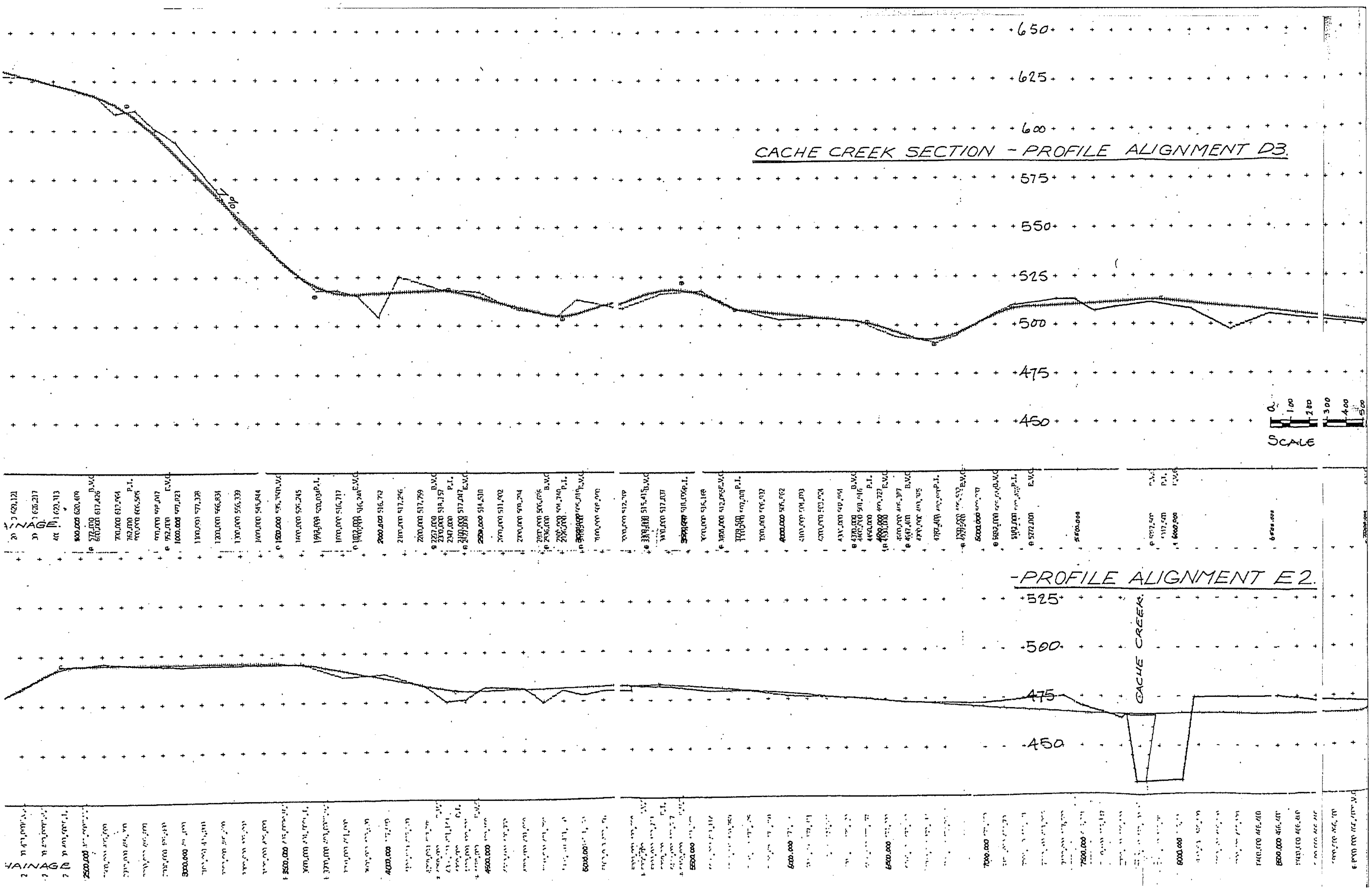

A.L.R. BOUNDARIES
C.L.I. BOUNDARIES
DISTURBED and/or ALIENATED AREAS
HIGHWAY 29 RELOCATION
AGRICULTURE
FIGURE-12
0
500
Metres
C.L.I. 6
C.L.I. 3M 5T M
C.L.I.
D
D-1
E
E-1
peace

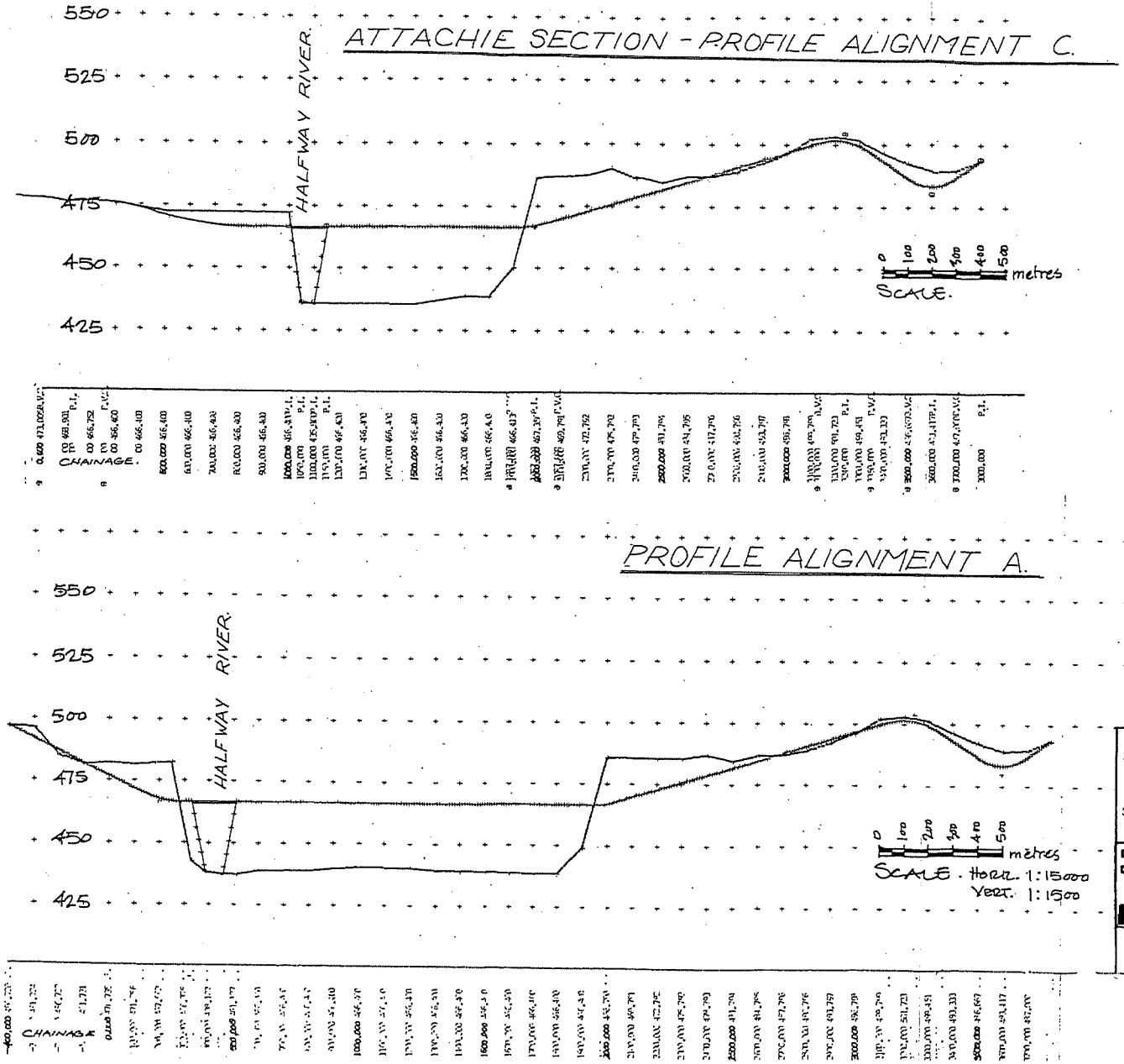

River
FUTURE
SHORELINE
C.L.I.
C.L.I. 36 M 5 M
D-1
D-2
W1
W2
W3
W4
W5
CULTIVATED


A.L.R. BOUNDARIES
C.L.I. BOUNDARIES
DISTURBED and/or ALIENATED AREAS
HIGHWAY 29 RELOCATION
AGRICULTURE
FIGURE-13
FUTURE SHORELINE
C.L.I. 3 6/M 5 4/M
CULTIVATED
0
Metres
500


D
E
C.L.I.
FUTURE SHORELINE
Creeks
CULTIVATED
Metres


CACHE CREEK SECTION - PROFILE ALIGNMENT D3.
650
625
600
575
550
525
500
475
450
CACHE CREEK.
10%
SCALE
0 100 200 300 400 500 metres
-PROFILE ALIGNMENT E2.
525
500
475
450
CACHE CREEK.
7%
625
600
575
550
SCALE.
0 100 200 300 400 500 metres
BEAR. FLA
SECTION.
PROFILES
ALIGNMENT
D3 & E2
GRAEME & MURR
CONSULTANTS L
CONSULTING ENGINEERS
FIGURE 15


CACHE CREEK SECTION - PROFILE ALIGNMENT D3.
650
625
600
575
550
525
500
475
450
7%
SCALE
0
100
200
300
400
500
CHAINAGE
PROFILE ALIGNMENT E2.
525
500
475
450
CACHE CREEK.



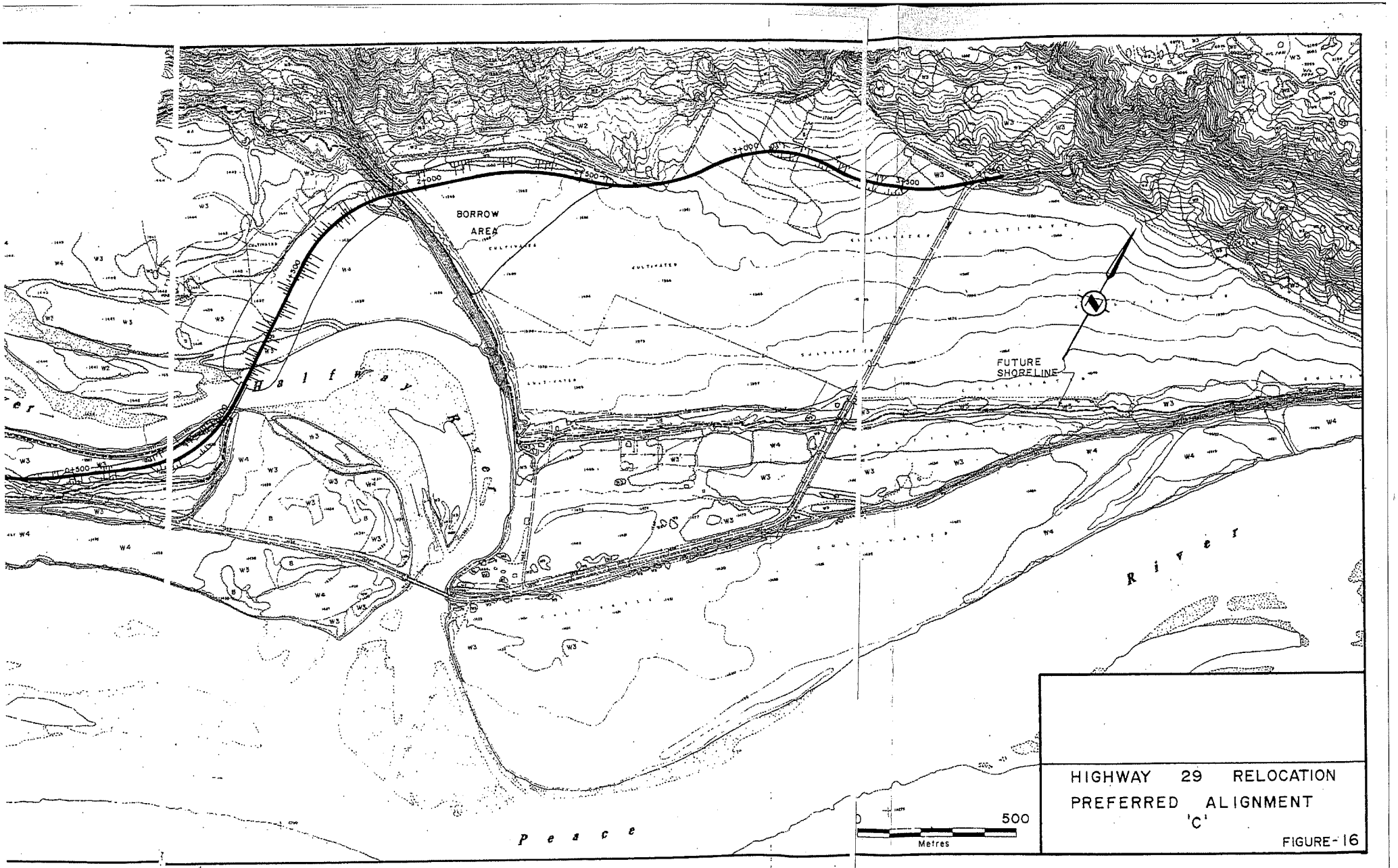
ATTACHIE SECTION PROFILES

ALIGNMENTS C & A

GRAEME & MURRAY CONSULTANTS LTD.
CONSULTING ENGINEERS

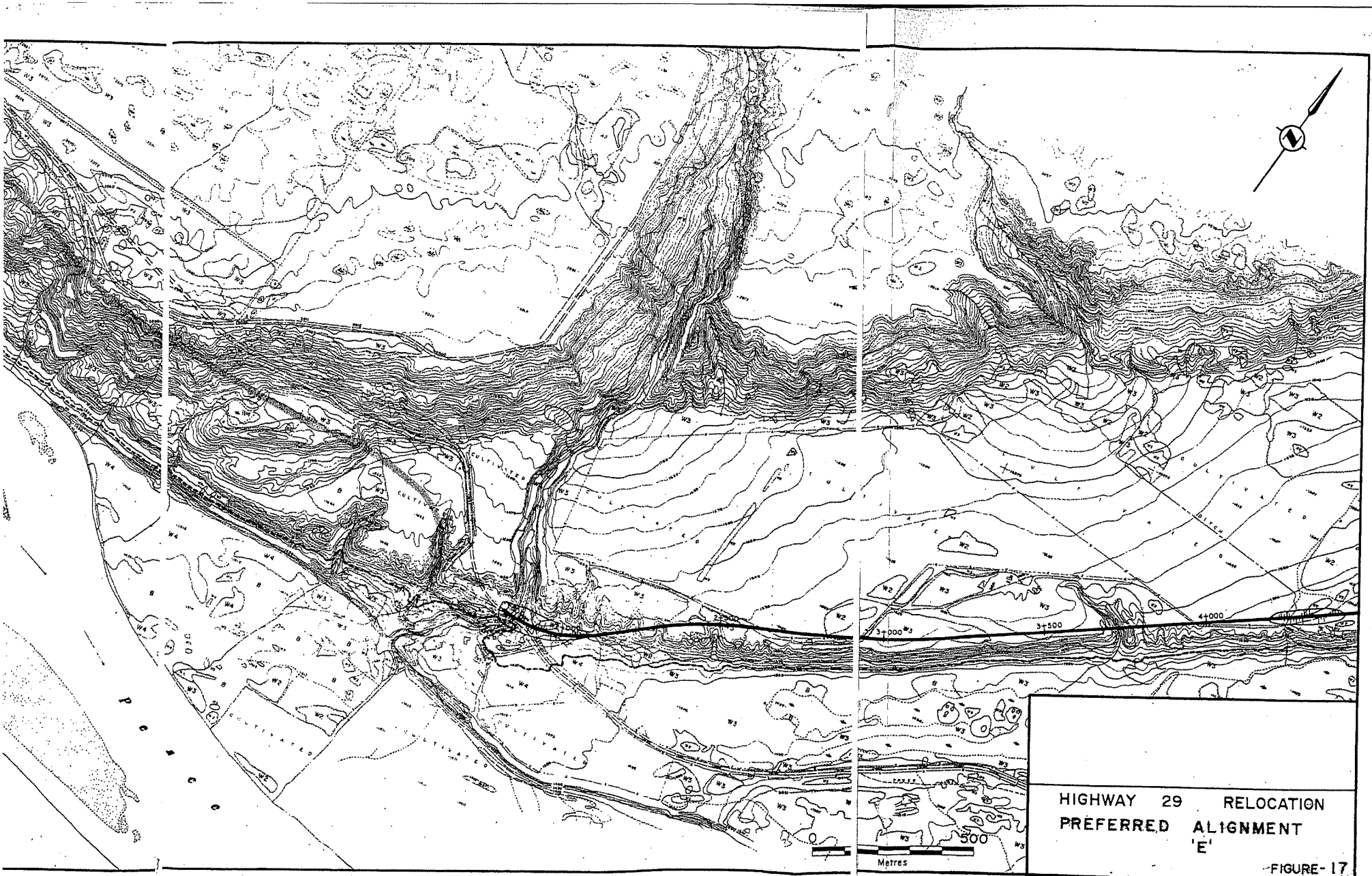
[redacted]

FIGURE 14



HIGHWAY 29 RELOCATION
PREFERRED ALIGNMENT
'C'

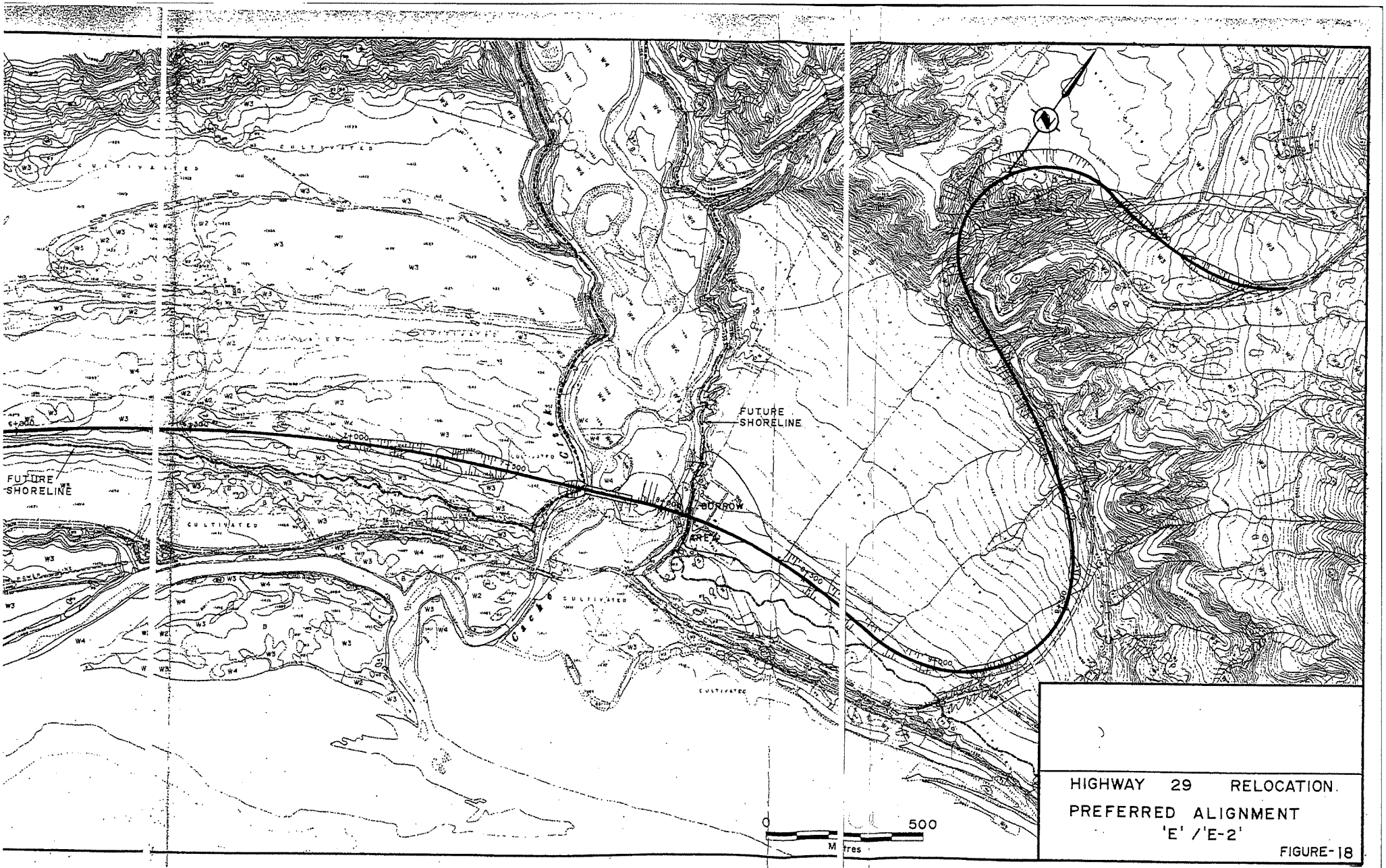
FIGURE-16



HIGHWAY 29 RELOCATION
PREFERRED ALIGNMENT
'E'

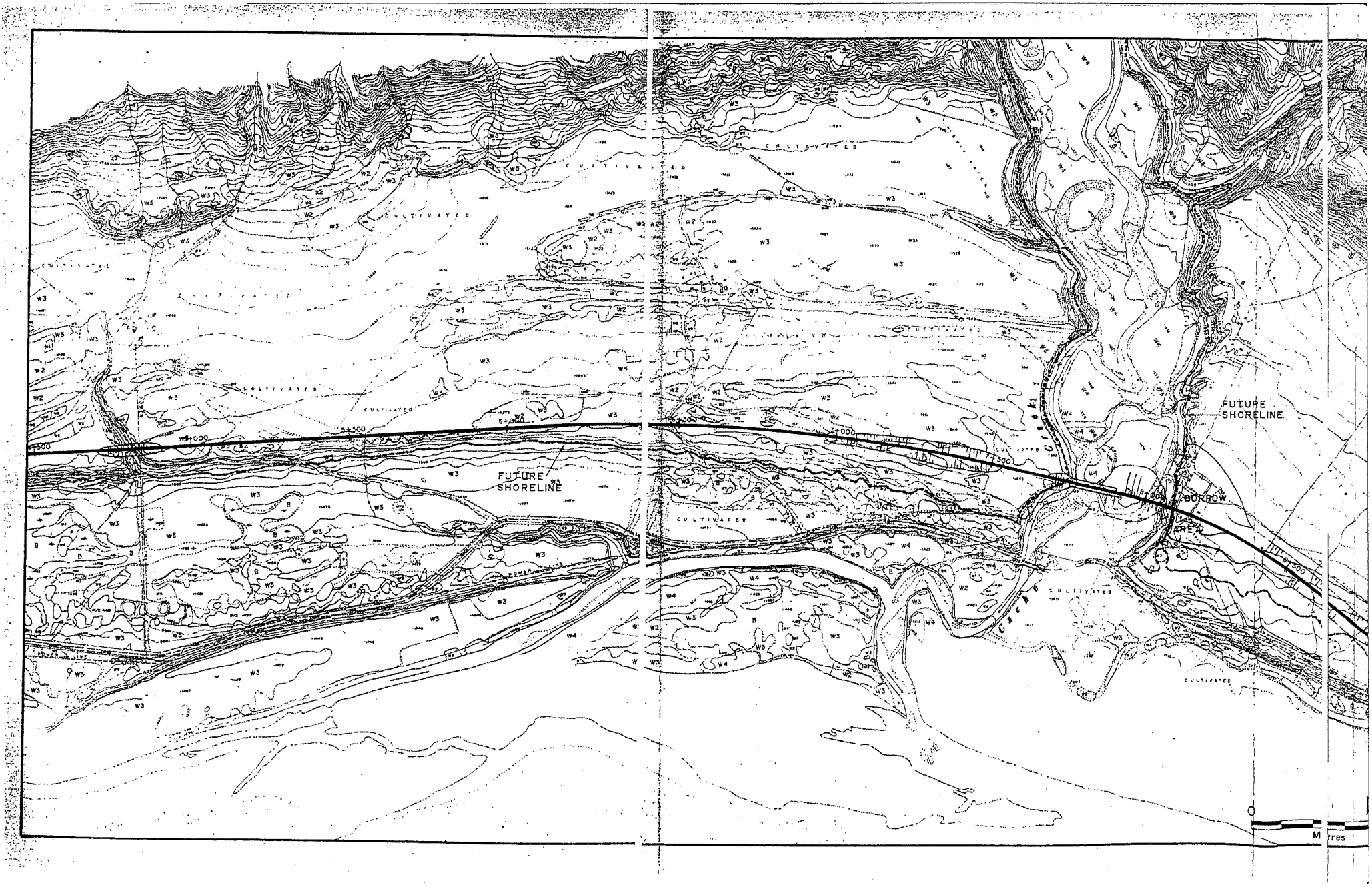
FIGURE- 17

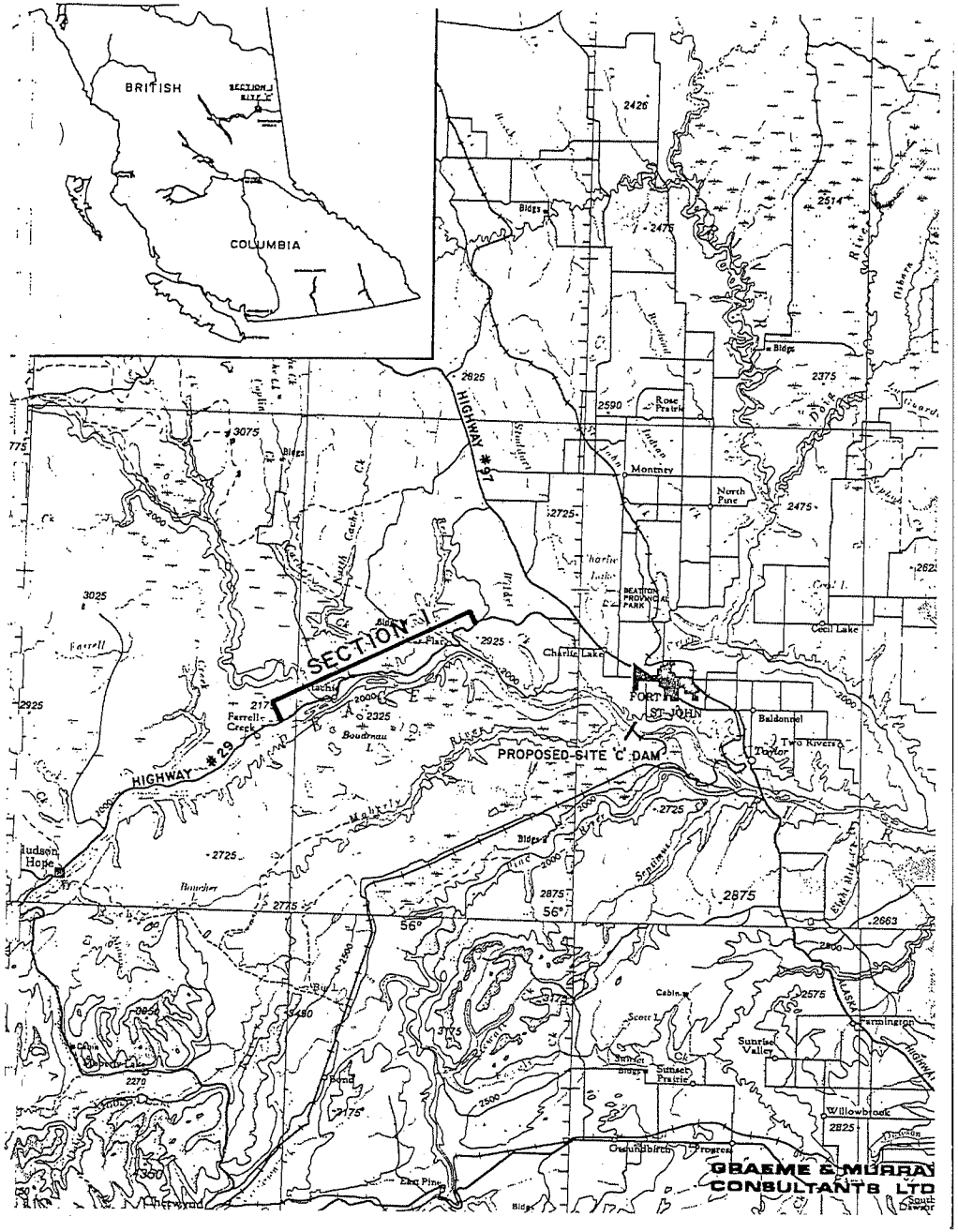

R i v e r
FUTURE
SHORELINE
P e a c e
CULTIVATED



HIGHWAY 29 RELOCATION.
PREFERRED ALIGNMENT
'E' /'E-2'

FIGURE-18


FUTURE SHORELINE
FUTURE SHORELINE
OXBOW
CREEK
CULTIVATED
W1
W2
W3
W4
W5
B
0+500
1+000
1+500
2+000
2+500
3+000
Metres


BRITISH
COLUMBIA
SECTION J
HIGHWAY #97
HIGHWAY #29
SECTION
PROPOSED SITE 'C' DAM
FORT ST. JOHN
Hudson Hope
Charlie Lake
Montney
Rose Prairie
North Pine
Baldonnel
Two Rivers
Sunrise Valley
Willowbrook
Farmington
Sunset Prairie
Ocean Mountain
Progress
Bear Flat
Clear Hills
Boundary L.
Boucher
Farrell Creek
Beatton Provincial Park
GRAEME & MURRAY CONSULTANTS LTD