ENVIRONMENTAL IMPACT STUDY

TRANS - CANADA HIGHWAY MILES 0 - 7.8 BANFF NATIONAL PARK

EPARTMENT OF PUBLIC WORKS WESTERN REGION

OMBARD NORTH PLANNING LTD. CALGARY WINNIPEG VANCOUVER

Lombard North Planning Ltd.
RESOURCE DEVELOPMENT CONSULTANTS

21 July 1972

Mr. A. L. Perley, P. Eng.
Calgary District Director
Federal Department of Public Works
400 Customs Building
Calgary 21, Alberta

Dear Mr. Perley:

We are pleased to present our findings to date on the Phase I portion (mile 1 - 7.8) of the environmental impact study related to the proposed Trans-Canada twinning through Banff National Park, Alberta. The information is contained in two volumes in order to facilitate illustration of both the study program and results.

The study was a joint undertaking between the consultants, Department of Public Works, National and Historic Parks Branch, and the Canadian Wildlife Service. To the many individuals who devoted their talents and energy to this multiple disciplinary study we owe our thanks and are confident the information herein will stand as a measure of success for this team effort.

Public concern for the environment has been growing as more and more of the deleterious side effects of man's development become evident. Unfortunately there are, at the present time, few precedents to serve as guidelines for carrying out a study of this nature. This study, therefore, in many ways represents a milestone in Canadian highway development in providing comprehensive resource and planning information to assist in the discussion making process for corridor selection.

Respectfully submitted,

LOMBARD NORTH PLANNING LTD.

james Taylor.

James R. Taylor,
Vice-President and General Manager
Calgary Office

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INTRODUCTION

EVENTS LEADING TO THE STUDY

Traffic growth on the Trans-Canada Highway has traditionally been a major concern to the National and Historic Parks Branch and the Department of Public Works. The problem stems largely from the fact that the highway serves two important functions, namely: (1) access to one of Canada's most famous National Parks, and (2) linkage as part of Canada's national transportation system. With both commercial and recreation demands on the highway increasing at a rapid rate, it was not difficult to predict as early as the beginning of the "sixties" that the traffic volumes would soon reach the designed capacity level. Indeed, traffic surveys conducted in 1967 revealed that volumes were exceeding the maximum capacity levels on 50% of the weekdays and on 100% of weekends based on average hourly volumes throughout the daylight hours. These conditions prevail throughout most of the tourist season. More recent surveys indicate the continued growth in the use of the highway and therefore the need for two additional lanes is becomming more and more imminent.

Budgetary constraints and planning complications have delayed implementation of the twinning program but construction on the first four miles west of the east gate is now scheduled for 1973. As part of a relatively new policy which reflects a greater public concern for the environment, the National and Historic Parks Branch requested the Department of Public Works to conduct an environmental impact study of the proposed first phase of the program (7.8 miles) and incorporate the results into the final engineering locational and design considerations.

Thus in the fall of 1971 the Department of Public Works approached the Calgary office of Lombard North Planning Ltd. which is a consulting firm specializing in environmental planning and resource development. The ensuing discussions between the consultants and officials of both the Department of Public Works and the National and Historic Parks Branch resulted in Lombard North Planning being retained to conduct the study over the fall and winter. It was hoped that the study would, in addition to satisfying the environmental concerns, provide valuable information for the in-progress planning study of traffic within the Park and facilitate meeting the schedule for beginning the twinning program.

ORGANIZATION & PARTICIPANTS

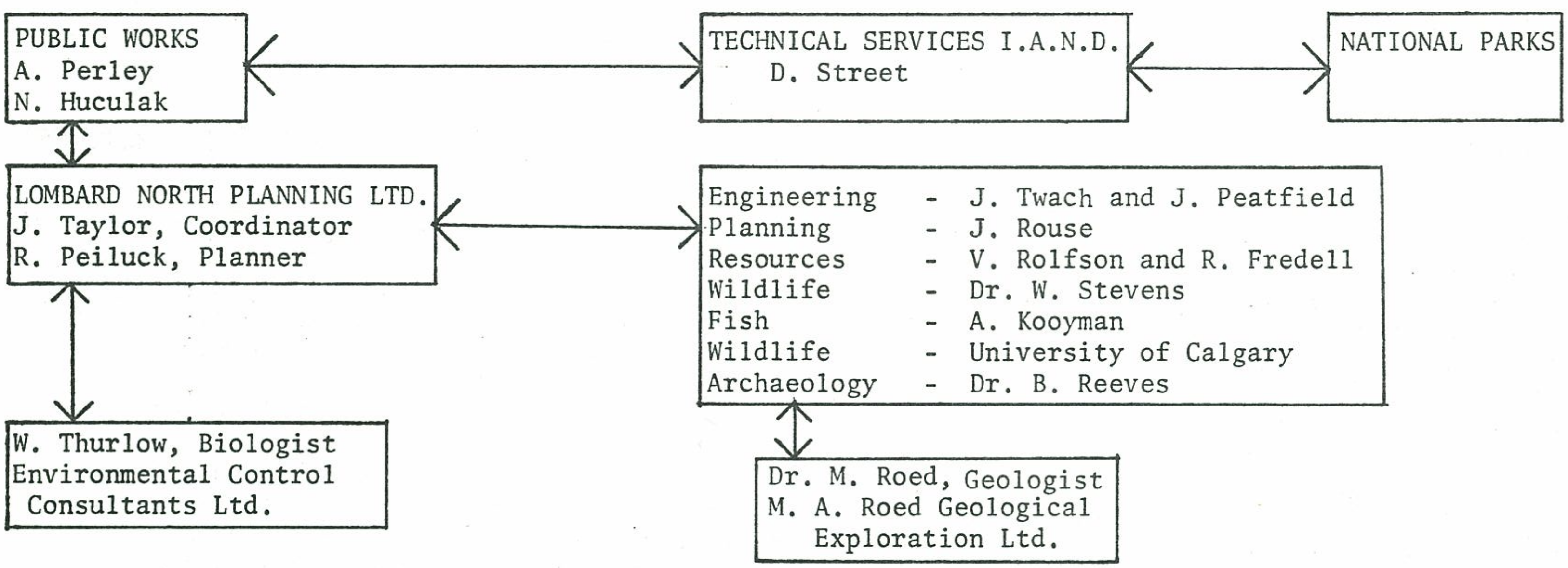
The formal organization for the study was evolved with Lombard North Planning reporting directly to the Department of Public Works. The concerns of the National and Historic Parks were represented by the Technical Services Division of the Department of Indian Affairs and Northern Development.

On a more informal level, Lombard North Planning was responsible for soliciting, analyzing and co-ordinating information obtained from the appropriate planners and resource specialists employed by the National and Historic Parks Branch, and the biologists and ecologists working for the Canadian Wildlife Service, Department of the Environment.

Because of the complex nature of the study and the number and variety of governmental agencies involved, it was necessary to hold regular progress meetings between the consultants and designated government representatives. In addition there were numerous supplementary meetings with sub-committees which were derived from the basic study team. The resulting discussions served as the basis for reviewing the work in progress, analyzing the results and presenting the conclusions. These meetings also served as a further communications medium since government personnel outside the study team were often invited as observers. The individuals and respective agencies who participated in the study team are listed in alphabetical order. The organization and flow chart is exhibited in the accompanying chart (Illustration 1).

R. FREDELL	National Parks
N. HUCULUK	Public Works
A. KOOYMAN	Canadian Wildlife Service
J. PEATFIELD	Public Works
R. PEILUCK	Lombard North Planning
A. PERLEY	Public Works
M. ROED	Consultant to Lombard North Planning
V. ROLFSON	National Parks
J. ROUSE	National Parks
W. STEVENS	Canadian Wildlife Service
D. STREET	Technical Services
J. TAYLOR	Lombard North Planning
W. THURLOW	Consultant to Lombard North Planning
J. TWACH	Public Works

ILLUSTRATION 1



SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Over the past 9 months, a multiple disciplinary team including resource specialists, engineers and planners have studied the proposal to twin the first 7.8 miles of the Trans-Canada Highway located west of the east gate inside Banff National Park. The results of the inventory and analysis of all the relevant and available data revealed that there are three possible alternative locations for the two new lanes.

The first alternative designated CORRIDOR "A" parallels the existing route up to Carrot Creek fan where it swings north and takes a course along the top of the upper bench or terrace. This alignment remains on the terrace until a point immediately north of the traffic circle. The second alternative designated as CORRIDOR "B" parallels the CPR railway right-of-way throughout the course of the 7.8 mile proposed development. This corridor involves the relocation of approximately 3 miles of railway line. The third alternative designated as CORRIDOR "B-1" involves building the new lanes immediately adjacent to the existing highway. The railway relocation scheme may also be applied to this latter alternative.

1. ENVIRONMENTAL IMPACT

In relative terms the three alternatives may be rated as to the anticipated levels of environmental impact. Corridor B appears to be by far the least damaging. It parallels an already existing corridor and skirts areas of significant ecological importance. Corridor B-1 appears to be the least desirable. In addition to traversing certain ecological units and causing damage to others, Corridor B-1 raises a major biological objection on the basis of side by side twinning. Scientific evidence reveals that the number of highway kills more than double as the result of this type of four lane design. Corridor A appears to rate somewhere between the other two alternatives. However there are two important "unknowns" which further support the selection of Corridor B. First, Corridor A represents a major transportation artery through a relatively undisturbed area, and secondly, it is difficult to predict the total impact in terms of noise pollution.

The 1968 DPW Proposal was evaluated and ranked for comparative purposes. The results of this analysis indicate that this proposal will incur the second highest environmental impact levels or somewhere between the levels attached to Corridor A and B-1.

2. ENGINEERING CONSIDERATIONS

The engineering implications of the three alternatives is relatively straight forward. Corridor A is largely a cut and fill operation. Large cut and fill areas are required in association with meltwater channel crossings, and in providing access to and from the terrace. On the other hand, Corridor B which courses along the relatively flat Bow River flood plain involves the use of borrow material to replace poor soils and build the grade. Adding two lanes in close proximity to the existing highway involves a combination of the aforementioned construction techniques.

3. PLANNING AND VISUAL IMPLICATIONS

Corridor B provides the superior alignment with respect to visual experience from the road. The corridor provides access to the Bow River Valley floor with attending visual variety. Corridor A also provides visual access to a new park area but fails to capitalize on potential views from the upper elevations. In addition, negative views such as the transmission line are introduced to the highway user. Twinning the existing T.C.H. alignment (Corridor B-1) will not change the drivers experience other than visual roadside quality that would be subjected to the negative effects of increased cut and fill sections.

The relative visual impact in the context of the total park would be less for Corridor B considering the visability of the more extensive road scars of A and B-1 from various viewpoints. The need for borrow pits required by B could have a negative impact unless properly located and treated.

The implications for planning of each corridor are less obvious. The widely separated alignments proposed by A and in some cases B opens up new areas of the park for roadside use or interpretive development. Corridor A will create a problem for existing uses and access routes in the Johnson Lake area. All proposals necessitate a re-appraisal of existing roadside use areas and secondary road systems and access points.

4. ECONOMICS

In order to rationally compare the costs of each of the alternatives, the 1968 DPW proposal, which is the least cost alternative is used as a base. Corridor B represents the least increase in capital costs or 31 percent involving $482,000. Corridors B and B-1 follow with 34 percent or $536,000, and 59 percent and $923,000 respectively. Although the initial capital cost of Proposal B, when looked at in terms of construction costs only, represents a significant increase over an alignment such as represented by DPW 1968 the impact, when considered relative to the total overall costs of the highway during its anticipated service life becomes a relatively minor item, i.e. assuming a time value for money of 7% shows the relative total cost increase to be only 2.1% (B-1, 6% and A, 15%). It must be kept in mind that in spite of the estimated construction cost increase in proposal B over DPW 1968 Proposal, there is no anticipated increase in road user or maintenance costs.

CONCLUSIONS

1. The anticipated environmental impact of the Corridor B proposal is less than the other alternatives.

2. Corridor B should be compatable with the Park environment and the associated policies and objectives.

3. The increased capital cost of Corridor B over the 1968 DPW engineering alignment is justified on a variety of accounts including an insignificant increase in the total costs of highway over its service life, reduced environmental impact, improved visual characteristics, better highway design and increased driver safety.

RECOMMENDATIONS

AFTER A THOROUGH ANALYSIS OF RESOURCE, ENGINEERING, ECONOMIC, AND AVAILABLE PLANNING DATA PERTAINING TO THE PROPOSED TWINNING OF THE TRANS-CANADA HIGHWAY IN BANFF NATIONAL PARK BETWEEN THE EAST GATE AND THE TRAFFIC CIRCLE, THE CONSULTANTS RECOMMEND CORRIDOR "B" AS THE LOCATION FOR THE REQUIRED ADDITIONAL TWO LANES OF THE HIGHWAY PROVIDED THAT:

1. The Carrot Creek fan - Bow River flood plain ecological complex be left unimpaired and disturbance around its periphery be minimized. *

2. The proposed relocation of the railway be undertaken: a) to preserve the significant ecological resources located immediately north of the existing two lanes, and b) to facilitate the development of a more visually pleasing, safer and better designed highway.

3. A specialized resource and wildlife management program be implemented to facilitate the control of animal movement across the highway and railway and to minimize animal feeding in the proposed alignments. This will necessitate improvement of habitat located outside the alignment and special construction features incorporated into the design.

I'm not so sure about this.

Their suggestions are only some means of animal control - they need to be evaluated - We are unsure about underpasses for large ungulates - habitat improvement must be approached in context of park values.

4. A careful study of borrow requirements and locations be undertaken in conjunction with biologists and planners to minimize the environmental impact and to outline rehabilitation guidelines.

Both fish and terrestrial wildlife values here.

5. A set of implementation guidelines be developed to minimize environmental impact during the construction phase.

C.W.S should provide active input here

6. An archaeologist be invited to inspect the areas under construction from time to time throughout the entire course of the building program.

7. The remains of the original Trans-Canada Highway bordering Chinaman and Duthill Creeks be scarified and reforested. Public vehicular access to these areas should be discontinued.

CONTENTS

TEXT
VOLUME I

MAPS

PART 1 - BACKGROUND

STUDY AREA

The Study Area begins approximately 60 miles west of Calgary at the east gate of Banff National Park and extends a distance of 7.8 miles along the Trans-Canada Highway up to and including the traffic circle or Minnewanka Lake-Banff townsite interchange. While the outside boundaries include the entire Bow Valley corridor, the detailed inventory was limited to the lower slopes and valley floor. In size, the study area represents approximately 25 square miles of Banff National Park (MAP 1).

OBJECTIVES

As per the contract between the Department of Public Works and Lombard North Planning Ltd., the goals of the study are the following:

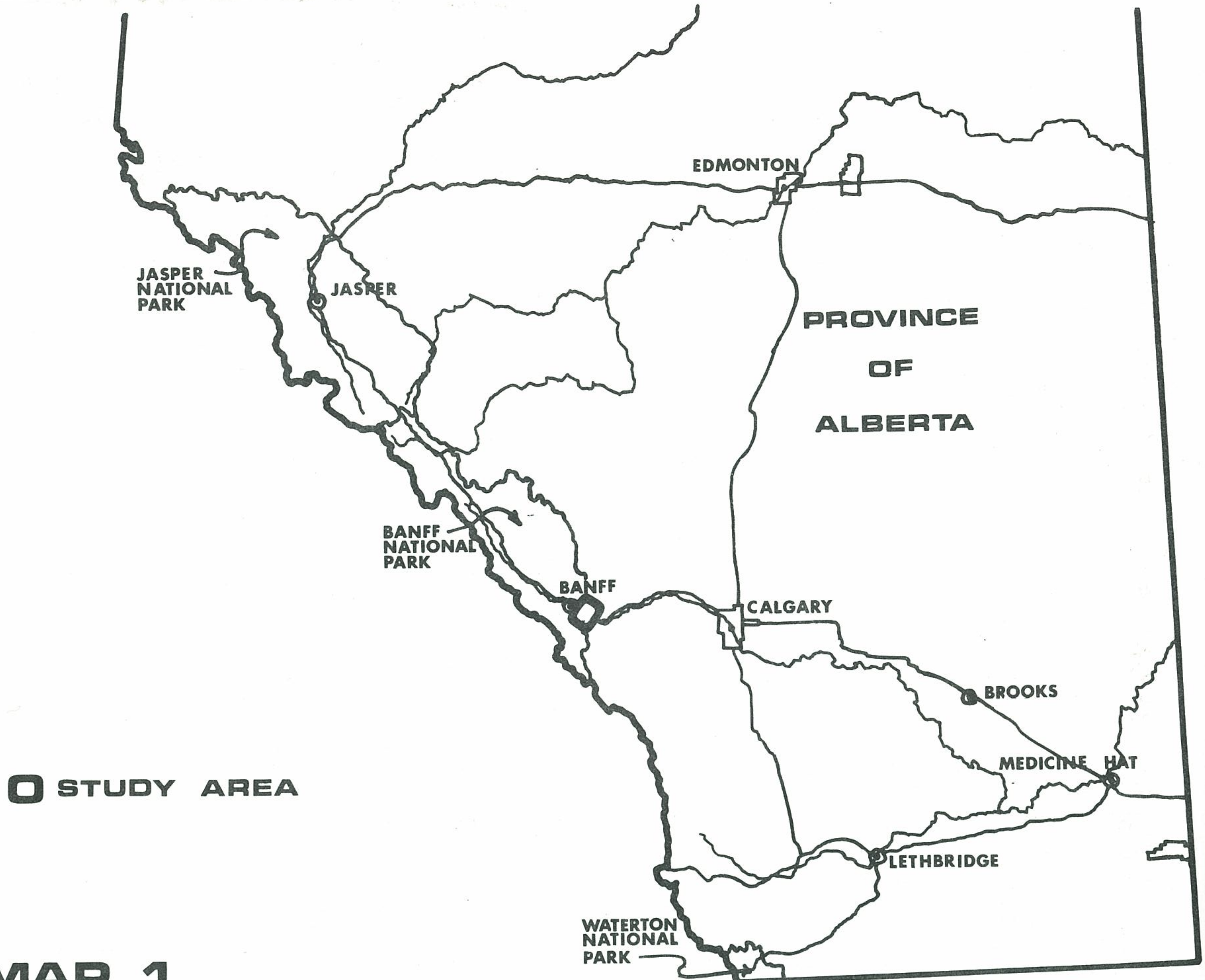
Conduct an ecological and environmental impact study of a transportation corridor in close coordination with the Department of Public Works and the National and Historic Parks Branch of the Department of Indian Affairs and Northern Development to arrive at plans and diagrams that will indicate various restraints for four-laning of the Trans-Canada Highway and related development. Using general goals as set forth by the National and Historic Parks Branch, highway corridors (including an alignment proposal by Department of Public Works) will be evaluated for environmental impact and the most desirable route(s) will be selected. The study in total will consist of a combination of studies in the fields of environmental geology, geography, landscape architecture, limnology, resource planning, wildlife and forest ecology, as well as conventional highway engineering.

TERMS OF REFERENCE

The study format includes five distinct phases. It is important to note that this report pertains to the completion of phase three, namely: Recommendations related to the selection of the corridor which satisfies as best as possible environmental, engineering and planning considerations. Upon approval of the recommended corridor, which is approximately 300 to 400 feet wide, the remaining phases involving detailed alignment and guidelines, and implementation will be executed. As per the contract, the following is the account of the study outline:

The study format for the work will be in five distinct phases:

1 Inventory of Selected Resources;
2 Analysis;
3 Corridor Identification and Recommendations;
4 Detailed Route Selection and Standards;
5 Implementation.


EDMONTON
JASPER NATIONAL PARK
JASPER
PROVINCE OF ALBERTA
BANFF NATIONAL PARK
BANFF
CALGARY
BROOKS
MEDICINE HAT
LETHBRIDGE
WATERTON NATIONAL PARK
STUDY AREA

MAP 1

1 INVENTORY OF SELECTED RESOURCES

This will include all or some of the factors listed below plus other applicable factors identified during the initial research and planning period. Each of the following factors will be inventoried and mapped where applicable.

(1) Geology
- Bedrock
- Surficial Deposits
- Land Forms

(2) Ground Water

(3) Soils

(4) Vegetation
- Tree Cover
- Shrubs
- Ground Cover

(5) Climate
- Temperature and Precipitation
- Exposure

(6) Water
- Drainage Pattern and Flow
- Drainage Conditions
- Quality

(7) Topography
- Relative Relief
- Local Relief
- Slopes

(8) Wildlife
- Reptiles
- Amphibians
- Mammals

(9) Birds
- Waterfowl
- Others

(10) Fish

(11) Riverbank Shoreline Survey
- Physical
- Biological

2 ANALYSIS

All gathered information and data will be analyzed in detail generally within the following areas of interest:

(1) Resource Sensitivity:

Vegetation
Wildlife Habitat and Movement
Land and Water
Pollution - Air, Noise, Water - (related to construction activity and borrow pits)

(2) Engineering Implications:

Building Materials
Stability
Bearing Capacity
Topography
Drainage
Maintenance

(3) Visual Resources:

Topography - Relief, Slope
Vegetation and Edges
Geology
Wildlife, etc.
Drainage and Ponds, Lakes, etc.
Other Interesting Features -
Landscape Types

(4) Recreation Resources:

Activity Oriented
Resource Oriented

This will involve identifying lands which can support recreation facilities (camp ground, picnic site, viewing, etc.) and major bio-physical resources which can support interpretive activities (trail interpretive centres, etc.)

3 CORRIDOR IDENTIFICATION

Corridor alternatives will be considered and evaluated as follows:

(1) Identification

(2) Evaluation in terms of

a. existing
b. proposed

(3) Four overlays will be developed as follows using the above information in composite form:

a. Resource Sensitivity
b. Engineering Capabilities
c. Visual Capabilities
d. Recreation Capabilities

(4) Composite: Corridor alternatives will be analyzed by reviewing factors a, b, c and d above.

(5) Review and Recommendations:

a. At this point in the study all the findings will be presented to the Departmental representative for review and presentation of comments and/or constructive criticism as considered necessary by the Departmental representative.
b. Resulting new data or information will be included and a submission outlining a final corridor recommendation will be made.

4 DETAILED ROUTE SELECTION AND STANDARDS

Upon approval of corridor by the Departmental representative, assistance will be provided to the Department of Public Works in establishing the exact alignment by advising on and/or taking part in:

(1) Cross-section Studies

(2) Median Width and treatment
(3) Associated Structures
(4) Detailed Ecological Considerations
(5) Related Land Use
(6) Views and Driver Experience

5 IMPLEMENTATION

During the design and construction phases consulting services in landscape architecture will be provided to Department of Public Works including:

(1) Landscape Design

a. Slope Treatment
b. Grading Refinement
c. Visual Aspects of Structures
d. Planting

(2) Site Observations

a. Review of possible unnecessary environmental damage
b. Planting, etc.

APPROACH

The study was approached on a project team basis using the talents and resources of a variety of government agencies. Lombard North Planning in addition to supplying professional and technical expertise, provided the necessary project coordination and direction.

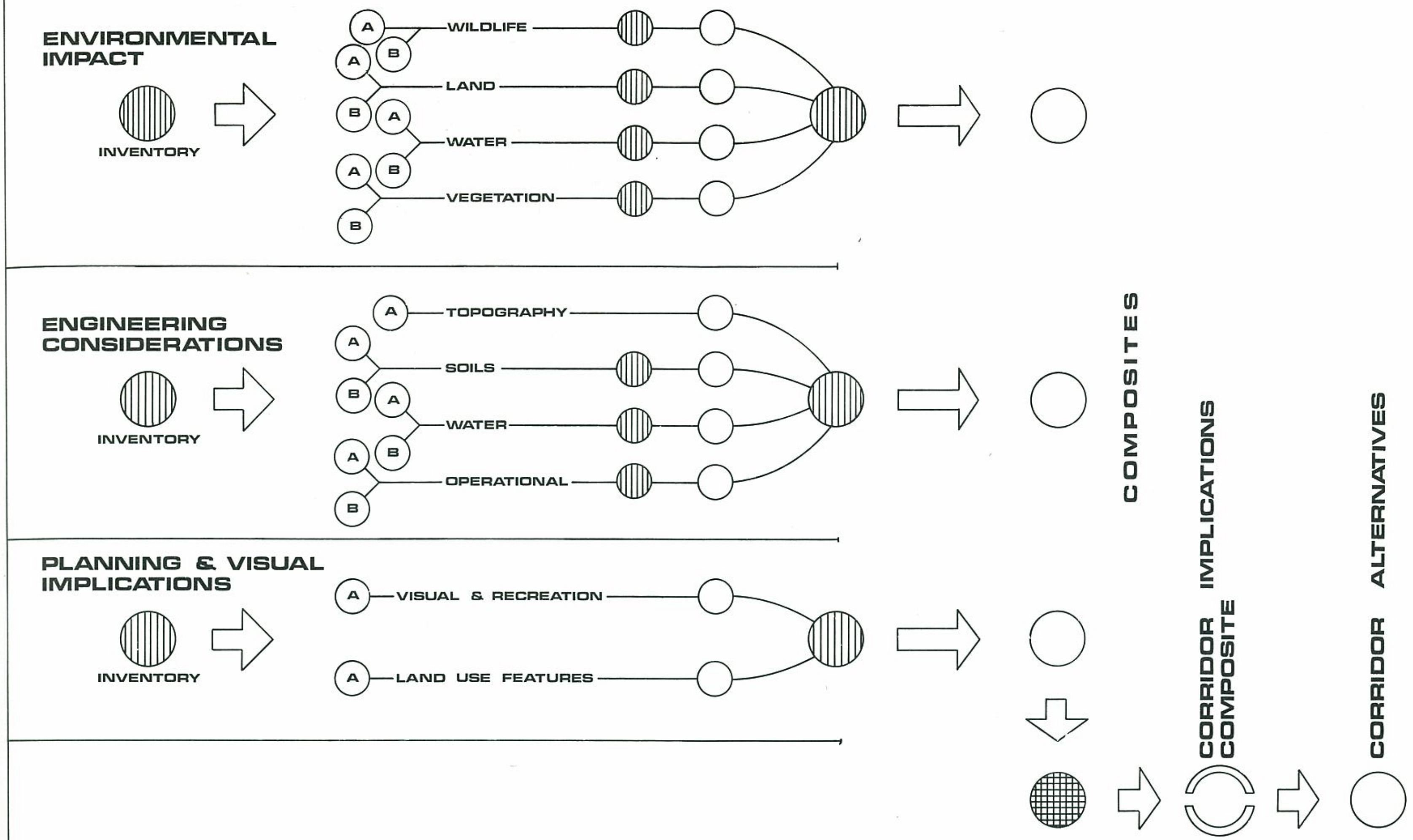
The initial efforts in the study program involved a search and analysis of existing reports. Interviews with experts who are familiar with the region also provided much valuable information. Before entering the field, both large and small scale black and white aerial photography was examined by the various disciplines. Colour infrared photography also provided an important insight into the resource characteristics. Following this operation, a team consisting of a geologist, biologist and resource planner conducted an extensive field study. Because of the lateness of the season, the field program continued well after the first snowfall. All information pertaining to geology, drainage, vegetation, terrain, wildlife, etc. was plotted on 1320 scale photography and later transferred to a mosaic of the same scale. This data together with other information provided the basis for the completion of a series of inventory maps. These maps were presented at a formal meeting. Comments identified the need for some revisions and further study.

Analysis of the data required dividing the study team into three sub-committees, namely: (1) Resources, (2) Engineering, and (3) Visual and Planning. Each group analyzed the inventory information and recorded the results on a series of overlays. The objective of the groups was the same and involved developing a suitability index map for each of the three considerations. For example, resources such as land, water, wildlife and vegetation were rated to identify relative levels of environmental impact as a result of the highway twinning program. Topography, surficial materials, drainage, and exposure characteristics were used as a basis for developing an engineering suitability map. Similar procedures were used to establish a map which considered visual and planning implications.

An overlay of the three index maps produced a final map which could be used to identify possible alternative routes. After each committee had examined the alternative corridors in detail it was possible to affix a preference rating to each of the alternatives. The basis for the rating in terms of costs, management and planning implications was also documented and is included as part of the analysis section of this report (Part IV).

As it was impossible to practically illustrate the documented analysis and identification of alternative corridors on a reduced scale of mapping, a second package involving the appropriate maps at the original scale was produced to accompany this report.

A small-scale version of the analysis procedure or flow chart which introduces the information contained in Volume II is provided in this section in order to aid the reader in understanding the approach to the study before proceeding to the main body of the report (Illustration 2).



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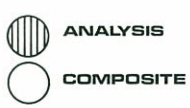

STUDY PROGRAM - FLOW CHART

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SCALE: 1" = 1320'

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T.C.H. BANFF PARK FOUR LANING MILE 0 - 7.8	
drawing title	titre du dessin
designed by	conçu par
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drawn by	dessiné par
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reviewed by	examiné par
date	
approved by	approuvé par
date	
Tender	Soumission
D.P.W. Project Manager	Administrateur de projets M.T.P.
project number	no. du projet
85854	
drawing no.	dessin no.
ILLUSTRATION 2	

PART 2 - INVENTORY

BEDROCK GEOLOGY

The dominating landforms, consisting of mountains and valleys, are made up of a thick sequence of sedimentary rocks which range from Paleozoic to Mesozoic in age. Rocks belonging to the Paleozoic Era consist of layers of carbonate rocks (limestone and dolomite) separated by units of hard sandstone and shale. Younger Mesozoic strata in contrast are made up of sandstone, siltstone, coal and shale. The resistant carbonates which form the ledges and peaks of mountains, and the softer shaley rocks in which valleys have been formed, all exhibit features that illustrate the early geologic and paleontologic development of the area.

The most striking manifestation of the magnitude of the earth forces which uplifted the Rockies is provided by structural complexities displayed in Paleozoic and Mesozoic rock outcrops. The Bow and Cascade River Valleys in the study area mark the loci of one of the major thrust faults which have been so instrumental in determining the architecture of the Rockies. This fault is called the Rundle Thrust Fault (MAP 2). A brief summary of the geologic history of the region is included as Appendix 1. It includes a description of the three major divisions of geologic time, namely: Paleozoic, Mesozoic and Cenozoic Eras.

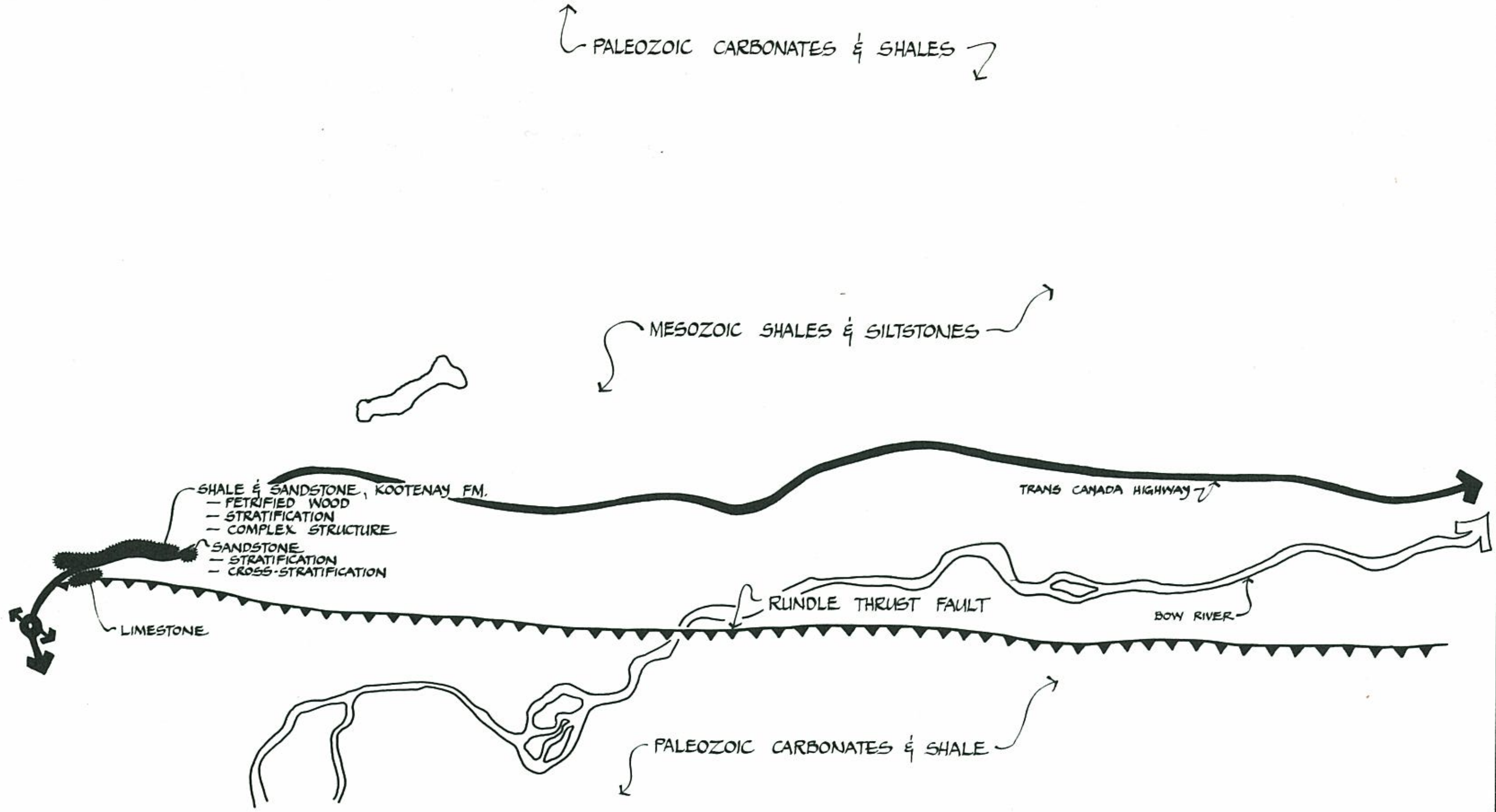
SURFICIAL GEOLOGICAL LANDFORMS

Surficial deposits are the most widespread geologic material in the study area. The deposits range from till and outwash sediments deposited in glacial time, to deposits formed since the disappearance of ice. Specifically the study area includes spectacular terrace landforms which record the disappearance of ice and alluvial features which portray the evolution of the present landscape since glacial time (MAP 3).

(1) Glacial Deposits

Glacial deposits include two distinct tills which record two separate advances of the Bow Valley glacier during the late Pleistocene time. The most widespread till was deposited during the main advance of the Bow Valley glacier and is best exposed in bluffs 4 miles east of Banff townsite. There the till overlies stratified drifts which were deposited by an earlier retreating glacier. Most of the till at the surface in the study area belongs to the Bow Valley glacier but isolated patches of a younger till attest to a re-advance of the Bow Valley glacier after it had receded to the west of Banff townsite.

Most of the till has a matrix of stony clay, is somewhat calcareous, and contains cobbles and boulders derived from bedrock in the Bow River Valley. Some silt, sand and gravel layers occur in the till but without detailed stratigraphic knowledge these lense-shaped units cannot be predicted.



2 BEDROCK GEOLOGY

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SCALE: 1"= 1320'

T.C.H. BANFF PARK
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project number 85854

The geomorphic expression of the till is mainly in the form of ground moraine with a local relief of 10 to 15 feet. In some areas the till is up to 50 feet thick and overlies even thicker glacial deposits but at other localities the till is only one to three feet thick and overlies bedrock.

Scattered patches of aeolian silt and sand occur on top of the till but there has been no systematic attempt to record these occurrences. Post-glacial fluvial activity has dissected the till along all valleys in the area. Some alluvial deposition on till landforms has also taken place. Much of the gravel along the Bow and Cascade Rivers is simply wasted and reworked till, the fine material of the original deposit having been carried away by the rivers during development of the valleys.

(2) Glacio-fluvial Deposits

Glacio-fluvial stratified deposits are the most common surficial material in the study area. At least four distinct periods of intense glacial outwash development are preserved in the series of terraces and meltwater channels that have been outlined. These terraces are related to complex melting phases of the Bow Valley glacier.

The deposits consist mainly of sandy gravel that exhibits parallel stratifications and also cross-stratification. A few lenses of clay, silt and sand can be found within the units although these materials are sporadic in occurrence. The gravels may be in excess of 30 feet thick but some terraces are mantled by only a thin layer of gravel one or two feet thick.

(3) Glacio-lacustrine Deposits

Banded glacio-lacustrine silt and sand occurs in a small area on each side of the Cascade River Valley east of Banff townsite. The thickness was in part glacially dammed during the last deglaciation of the area. Buried soils and a volcanic ash are important features that have been preserved near the top part of the unit.

(4) Aeolian Deposits

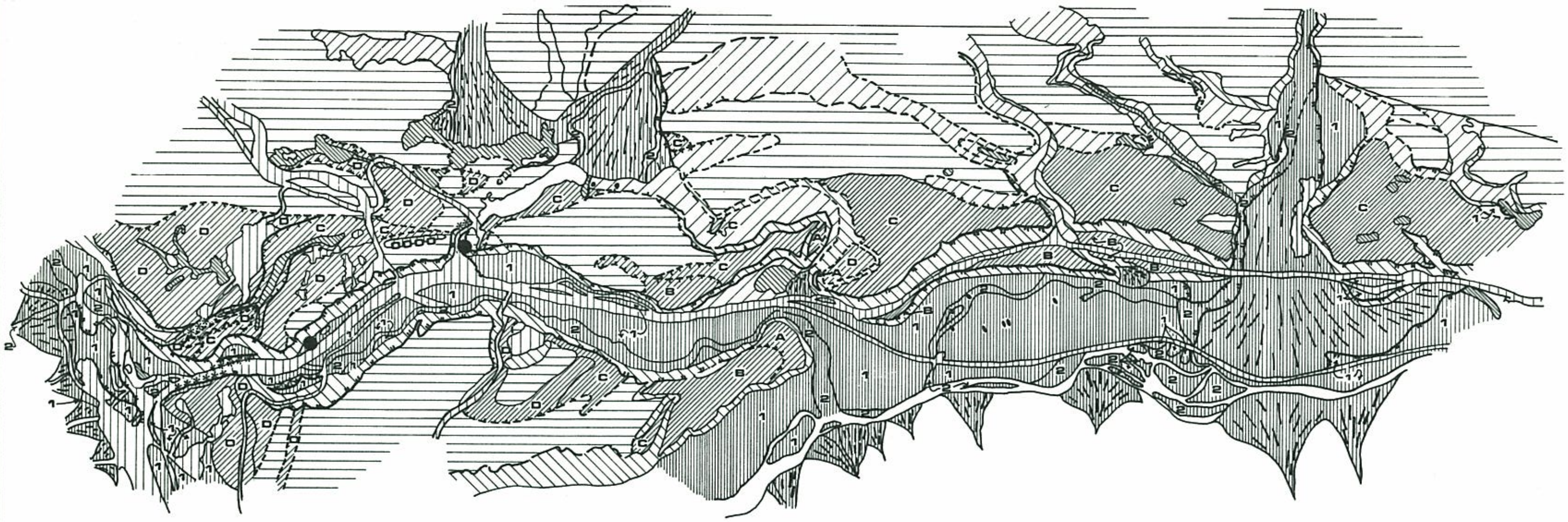
Restricted patches of aeolian silt and sand are common in the study area. In all cases the deposits have been stabilized by vegetation. Most are one or two feet thick but one on a bedrock terrace east of Cascade River is up to six feet thick at least. These deposits are important in that they may contain buried soils and undiscovered archaeological sites.

(5) Nonglacial Deposits

Nonglacial deposits present a wide range of materials formed under a variety of processes since the cessation of glacial activity in the area. These include pond and organic deposits, channel and flood plain alluvium, alluvial terraces, alluvial fans, landslide and colluvial deposits, and features related to man's habitation.

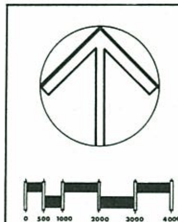
a. Pond and Organic Deposits

These materials occur in poorly drained depressions. Some pond deposits are due mainly to silting caused by periodic beaver occupation of some valleys; others appear to have resulted from a slope-wash deposition over a long period of time. Organic



3 SURFICIAL GEOLOGY & LANDFORM

- MAN MADE
- MUSKEG
- ALLUVIUM (ACTIVE STREAM CHANNEL)
- ALLUVIUM
- ALLUVIUM (FLOOD PLAINS & ALLUVIAL TERRACE
- LACUSTRINE (LOWLAND)
- COLLUVIUM
- OUTWASH (A-YOUNGEST, B-NEXT YOUNGEST, C-NEXT-YOUNGEST, D-OLDEST
- TILL
- GEOLOGIC CONTACT APPROXIMATE, INFERRED
- MAJOR SCARP
- MINOR SCARP
- *** BEDROCK OUTCROP
- COAL MINE
- OLD BEAVER DAMS
- ooo SUBSIDENCO PITS.



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A detail no. — détail no.
B location drawing no. — sur dessin no.
C drawing no. — dessin no.
revisions — date

SCALE: 1" = 1320'

project title — titre du projet
T.C.H. BANFF PARK
FOUR LANING
MILE 0 - 7.8

drawing title — titre du dessin

designed by — conçu par
date
drawn by — dessiné par
date
reviewed by — examiné par
date
approved by — approuvé par
date
Tender — Soumission
D.P.W. Project Manager — Administrateur de projets M.T.P.
project number — no. du projet
85854
drawing no. — dessin no.

deposits vary greatly in thickness. Some are only one or two feet thick whereas others are in excess of six feet thick. A considerable amount of silt, clay and muck are contained within organic accumulations.

b. Channel Alluvium and Flood Plain Deposits

The Bow and Cascade Rivers and Carrot Creek contain most of the alluvium in the area. Silty sand and gravel are the most common materials. Over 200 feet of alluvium has been drilled in the Bow River just to the west of Banff. Flood plain deposits are composed mainly of sandy-clayey silt.

c. Alluvial Fans

Carrot Creek has a well developed active alluvial fan but except for floods of catastrophic consequence it does not exhibit a rapid rate of sedimentation. The railroad has served to considerably retard the growth of the fan. The abandoned alluvial fan of Carrot Creek is a far more spectacular feature; it is a classic example of an alluvial fan that was formed some time ago since it now forms an extensive terrace. This landform attests to an interval of time which witnessed considerably more run off than has been documented in recent years.

Several alluvial terraces occur adjacent to the Bow River also; these do not have a prominent geomorphic expression but through detailed airphoto analysis they reveal an interesting phase of development of the valley floor.

d. Landslide and Colluvial Deposits

Landslide deposits in the area are minor in extent consisting of the odd small-scale slump or earth flow along a steep scarp. Probably the unit most susceptible to mass movement is the glácio-lacustrine silt and sand located to the east of the Cascade River near the flow control structure.

Colluvial deposits occur on all but the steepest slopes. A layer of soil creep material composed of clay, sand and gravel six feet thick is not uncommon on most slopes of the area. This layer exhibits marked stratification with a downhill inclination.

e. Features due to Man's Habitation

Man's activity is clearly recorded by road and railroad construction, excavations, alluvial fan control structures, and subsurface mining. Perhaps the most important feature is the area of subsidence pits located above the old workings of the Anthracite Coal Mine which was developed in the early part of the century.

DRAINAGE

(1) Surface Water

The drainage pattern within the study area is relatively simple and is largely related to the glacial and post-glacial history. More recent modifications by man also contribute to the existing drainage characteristics. The Bow River, which is the only major drainage system in the study area, flows in a meandering fashion through the lower valley floor. Its propensity for horizontal changes in course has largely been restricted since the building of the Canadian Pacific Railway around the turn of the century. However, evidence of the magnitude of this former movement is illustrated in the abandoned meander scarred floodplain between the Trans-Canada Highway and railway lines west of Carrot Creek.

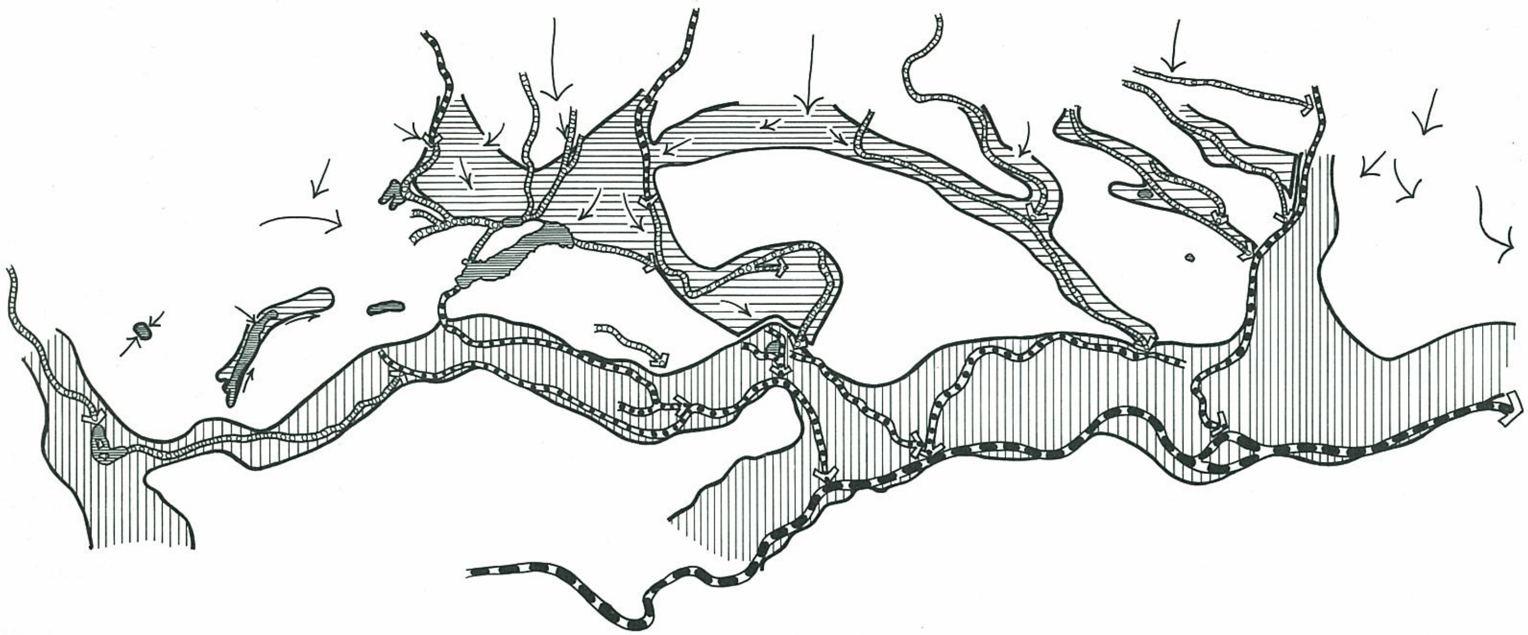
The largest tributary of the Bow River within the study area is the Cascade River. Its flow has been largely modified as part of a Calgary Power development and may be divided into two sections. The lower portion is characterized by strong flows which originate from Minnewanka Lake and out flow at the Calgary Power Station adjacent to the Trans-Canada Highway. The upper portion has been largely modified as a result of the construction of the railway and Trans-Canada Highway. The channel is normally dry except during the summer period when holding ponds immediately north of the traffic circle are filled as part of the summer fire prevention program. Overflows from these ponds, however, quickly disappear into the gravels which form the base of the channel.

The major source of water for Johnson's Lake is derived from two large mountain streams. During the early spring there is surface flow through a variety of channels into the Johnson's Lake area. However, throughout most of the year, these channels which course through large alluvial fans, become subsurface. They reappear in the form of springs and creeks in the vicinity of the edge of the Bow River flood plain in the Duthill area and south of Johnson's Lake. The flow in Chinaman's Creek is regulated by a control structure at the west end of Johnson's Lake. Flows are adequate to provide a scenic winding stream in close proximity to the Trans-Canada Highway.

The watershed for the Carrot Creek is far larger and consequently this creek has an active surface flow throughout the year. Centuries of flow have resulted in the formation of a large alluvial fan which, in the past, competed for area with the Bow River. The potential power of these streams is illustrated by the deposit of coarse materials located adjacent to the western portion of the fan, which was deposited suddenly towards the turn of the century and wiped out the then existing highway and railway. Other drainage channels are related to relatively small meltwater channels which pick up water from the adjacent mountain sides and eventually course through the Bow River Floodplain. The channels contain surface water for only a brief period during the spring.

(2) Groundwater

Several major groundwater aquifers and numerous minor aquifers have been delineated during this work (MAP 4). The Bow and Cascade Rivers represent the largest potential aquifers in the region and act as major discharge reservoirs for the flanking mountains. The aquifers in the meltwater channel of Johnson's Lake Valley and Carrot Creek are next in importance. Other aquifers include the alluvial fans of the area and all outwash terraces underlain by stratified drift.



- MAJOR STREAM
- MINOR STREAM
- INTERMITTENT STREAM
- SURFACE PONDS, LAKES, ETC.
- MAJOR ACQUIFER
- OTHER MAIN ACQUIFER
- → GENERAL MOVEMENT

4 DRAINAGE

SURFACE WATER
GROUND WATER

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A detail no. — detail no.
B location drawing no. — sur dessin no.
C drawing no. — dessin no.

revisions — date

SCALE: 1" = 1320'

project title — titre du projet

T.C.H. BANFF PARK
FOUR LANING
MILE 0 - 7.8

drawing title — titre du dessin

designed by — conçu par
date
drawn by — dessiné par
date
reviewed by — examiné par
date
approved by — approuvé par
date
Tender — Soumission
D.P.W. Project Manager — Administrateur de projets M.T.P.
project number — no. du projet
85864
drawing no. — dessin no.

A superb example of groundwater discharge and dependent geological conditions occurs at the large spring just below Duthill (MAP 4). This spring is probably recharged initially by the two large alluvial fans east of Johnson's Lake. The groundwater moves within the subsurface perpendicular to the slope and where it meets a barrier it is either trapped or else it finds another subterranean permeable path. At Duthill the permeable path may be formed by a subsurface bedrock valley filled with outwash gravel or stratified bedrock valley filled with outwash gravel or stratified drift commonly referred to as a buried valley. Where the present surface intersects such a valley, springs as exemplified at Duthill are common phenomena.

VEGETATION & SOILS

The description of vegetation and soils is based on designated broad homogenous units (MAP 5). In general these units are related to surficial deposits and therefore the vegetation map conforms closely with the map of surficial geology and landforms. The most complex vegetation occurs on flood plains and alluvial fans where drainage becomes an important factor. The simplest vegetation is found on dryer sites where there has been a history of fires.

(1) Lodgepole Pine

Trees consist of pure even-aged stands of dense lodgepole pine, which are usually not older than 70 to 80 years. Shrubs are very sparse and consist of buffalo berry, ground juniper, bearberry and some young spruce. The herb layer is sparse to moderately dense. Important species include hairy wild rye, pine grass, asters, arnica and creeping juniper.

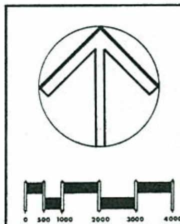
Luvisolic (Orthic Grey Wooded) soils dominate under this type of cover. There is one to two inches of raw humus over mineral soil with the upper part of mineral soil being leached. These soils are strongly to moderately acid and have moderate to poor fertility. Drainage is very good and soils may become extremely dry towards the end of the summer.

(2) Lodgepole Pine - Spruce

This unit is characterized by stands of mature trees (90 years +) which consist of lodgepole pine and varying amounts of spruce. Lodgepole pine predominates except on the moist sites where spruce is more common. Very limited amounts of trembling aspen and balsam poplar are also found on moist sites. Most stands are dense to moderately dense. Lodgepole and spruce may be of the same age or lodgepole may form the overstory with spruce beneath. Douglas Fir occurs with lodgepole on the lower terraces and on those parts of the upper terrace which are closest to the valley bottom. These stands are generally more open than the average for this type. The shrub layer is very sparse. Common species are buffalo berry, ground juniper, white meadowsweet and blueberries. The herb layer is sparse to moderately dense. Species are similar to those in the lodgepole pine type.

5 VEGETATIVE COVER

- LODGEPOLE PINE
- LODGEPOLE PINE - SPRUCE
  - A. UPLAND TERRACE
  - B. LOWER TERRACE SLOPES
- ASPEN-POPLAR, POPLAR SPRUCE
- SPRUCE
- PARKLAND
  - A. ALLUVIAL FANS
  - B. TERRACES & UPLAND AREAS
  - C. FLOODPLAIN
  - D. MELTWATER CHANNEL
- WET MEADOW
- DRY SOUTHWEST FACING SLOPES
- ACTIVE FLOOD PLAIN
- MOUNTAIN SLOPES



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Luvisolic (Orthic Grey Wooded) is the most common soil type. Brunisolic soils are found on dryer sites while Podsols occur on more moist sites. Most soils have a one to two inch raw humus layer over a leached mineral horizon. Soils are moderately to strongly acid and have low fertility. Soils are well-drained and moist to slightly xeric.

(3) Aspen-Poplar, Poplar-Spruce

Trees consist of either open to closed stands of trembling aspen and balsam poplar. Scattered spruce occur in the more open stands but are absent from the closed stands. Closed stands are young and healthy and, in many cases, are increasing in size by sending up suckers around their margins. Most of the open stands are overmature and many individuals have died. Shrubs are moderately dense to sparse. Young suckers of aspen and balsam poplar are dominant. Other species include prickly rose, snowberry, white meadowsweet, Saskatoon berry, and wild gooseberry. The herb layer is dense, consisting of a mixture of grasses and forbs. Common species include Canada wild rye, pine grass, timothy, brome grass, pea vine, showy aster, fireweed, bedstraw, wild geranium and wild vetch.

(4) Spruce

This type can best be considered as two subtypes: 1) moderately closed to dense stands, and 2) stands which are more open. Trees of subtype 1 are pure spruce while subtype 2 are spruce with small amounts of aspen and spruce. The shrub layer is almost completely lacking in subtype 1. In subtype 2 there is a sparse to moderately dense cover of buffalo berry, ground juniper, bearberry, silverberry, shrubby cinquefoil, and snowberry. Subtype 1 has a sparse cover of horsetails, cow parsnip, some grasses and moss. Subtype 2 has a moderately dense cover consisting of wild rye, reed grasses, anemone, aster and yarrow.

Regosols on moist sites and Gleysols on wetter sites are found in subtype 1. Soils consist of a deep layer of fine sand and silt over gravel. Regosols are encountered in subtype 2. Soils are well-drained and consist of a moderately thick sand and silt layer over gravel. The surface layer is a chernozemic humus which varies in thickness from 1/2 to 4 inches. Fertility is fairly good.

(5) Parkland

a. Alluvial Fans

The tree layer consists of open to partially closed stands dominated by aspen. In some places spruce is dominant or occurs in mixture with the aspen. Shrubs are very sparse to absent. Spruce saplings are common in some locations while aspen suckers occur in others. The herb layer is moderate to sparse, dominated by grasses including pine grass, wild rye and june grass, among others.

The major soil types are Luvisols (Grey Wooded) and Dark Grey Chernozems. The surface soil is a chernozemic humus layer which varies in thickness from 1 to 4 inches. Most of the profiles are shallow and range in texture from sandy to gravelly. Temporary seepage may be present in the spring. Soils become quite dry towards the end of the summer. The soils have moderate fertility on most sites.

b. Terraces and Upland Areas

This type is quite variable which makes it difficult to generalize. The cover consists of mixed stands of aspen, spruce, Douglas fir and some lodgepole pine. Stands are open to partially closed. Shrub cover is sparse and consists of small amounts of buffalo berry, ground juniper and spruce saplings. The herb layer is moderate to sparse with some grasses, trailing juniper and bearberry.

Brunisols and Luvisols (Grey Wooded) are the most common soil types. Fertility is moderate to low and soils are dry to moist.

c. Flood Plain

Open stands of spruce occur most frequently. There are large numbers of spruce saplings. Small patches of balsam poplar, willows, silver berry and snowberry also occur. The herb layer is moderate to sparse and consists of a misture of grasses and forbs.

Regosols are most common, followed by Luvisols and Gleysols. Soils consist of gravels and sands which are covered with a thin layer of finer sediments. Soils have moderate to low fertility and are moist to dry. This type is occasionally flooded.

d. Meltwater Channel

Trees include open stands of aspen, spruce, and balsam poplar. There is a good cover of snowberry, wild rose, and aspen suckers. The herb layer consists of a moderate cover of pine grass, hairy wild rye, timothy and various forbs.

The soils are Luvisolic (Grey Wooded) with a chernozemic humus layer. They are fairly deep, fertile, fine-textured soils. Moisture is close to optimal with some seepage occurring in the spring and early summer.

(6) Wet Meadow

This type can best be considered as two subtypes: Subtype 1 - shallow depressions in the upland forest; Subtype 2 - swampy areas on the Bow River flood plain and one large swamp at the base of the north fan near Johnson's Lake.

a. Upland Forest

Trees form a thin ring around the margin of the slough. They are mostly spruce with small numbers of balsam poplar and willow shrubs. The herb layer forms a ring on the inside of the trees. Plants such as cattails, bur reed, pondweed, and various sedges and grasses are common.

Soils are mostly organic. They are very wet but fertile.

b. Flood Plain and Alluvial Fan

A variety of trees form the outside edge of these wetland areas. Scattered open stands of spruce, balsam poplar and trembling aspen may be found within these complexes. The shrub layer is represented by various species of willow, dwarf birch, Labrador tea, blueberry and cranberry. The herb layer includes various sedges and grasses, and horsetails and Sphagnum moss.

Soils consist of poorly drained lime sediments and organic material. Soil types include Gleysols and organic soils. The fertility is variable depending on the site.

(7) Dry Southwest Facing Slopes

The trees are mostly Douglas fir, but sometimes they are mixed with lodgepole pine. These are open to savanna-like stands which are uneven-aged. Some trees are up to 400 years old. The shrub layer is very sparse, consisting of Douglas fir saplings, creeping juniper and bearberry. The herb layer is sparse to moderately dense. Common species include pine grass, hairy wild rye, timber milk vetch, wild strawberry and showy aster.

Regosols occur on steep slopes while Brunisols are found on the more gentle slopes. Mineral soils may occur right to the surface or there may be a thin mull humus layer. Profile development is slow and most soils are shallow. Soils are well-drained and become extremely dry during the summer.

(8) Active Flood Plain

The tree cover is limited to edges. Small stands of balsam poplar are found along channels where moisture conditions are best. Spruce occurs in small stands or as scattered individuals in shrub and herb communities. Shrub and herb communities are extensive, covering most of this type. Leading species include shrub-size balsam poplar, silverberry, shrubby cinquefoil and several species of willow. Shrub communities are mostly open, but some dense stands are present. The herb layer varies from very dense to sparse with the latter being by far the most common. Leading species include fireweed, stonecrop, yellow avens and horsetails.

Soils are very immature Regosols. Profile development is completely lacking in most sites. Others have only a thin litter layer which develops between floods. Coarse to fine gravels make up most of the soil material. In places the gravels are covered by a coarse sand layer of varying thickness. Soils become very dry during late summer. This factor along with the floods eliminate many species from this type. Soil fertility is very low, however flooding provides some nutrients.

(9) Mountain Slopes

Tree cover consists of open stands of mixed conifers of variable age. Douglas fir and lodgepole pine are prevalent on lower slopes while spruce, timber pine and alpine fir are more common at higher elevations. There is an open to dense cover of shrubs. A wide variety of species are present including buffalo berry, wild rose, shrubby cinquefoil, and gooseberry. The herb layer is characterized by a wide range of cover and species depending on characteristics of the individual sites.

Soils are predominately shallow Regosols over limestone bedrock. Fertility is fair but drought is a problem in some sites.

FISH & WILDLIFE

For purposes of this inventory, animals are considered in one of two categories. Included within the first group are animals that are common throughout the park and/or do not occur abundantly within the study area although occurring in abundance elsewhere in the park. In the second group are those animals which inhabit the study area for most of their lives, move into the study area as a result of behavioural responses, or are not abundant either in the study area or throughout the park.

The first group is not considered for the purpose of this study since loss of their habitat is not significant in terms of species survival throughout the park, and will not have severe consequences on those species within the park area. It is the second group of animals that must be considered for any direct or indirect impact that road construction might have on them or their environment (MAP 6).

1. Big-Game Animals

Big-game animals that occur in the study area are wapiti, moose, mule deer, white-tail deer, black bear, and grizzly bear. Big-Horn Sheep do not occur within any area amenable to highway site location since they occur on the higher slopes and in the back country of side valleys such as Carrot Creek.

Winter range is usually the weakest link in the provision of food for big-game animals. On this premise, the study area was inventoried and classified into three categories according to an area's importance as winter range for three species -- wapiti, mule deer, and white-tail deer. The classes -- key, good and poor are shaded on the map as black, gray and white respectively.

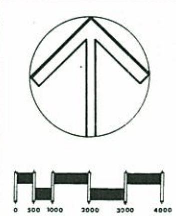
According to Stelfox (1969) all the white-tail deer, two-thirds of the wapiti, and one-third of the mule deer are found below an elevation of 4,500 feet in the Canadian Rocky Mountain National Parks. "General speaking, big-game winter on west and south-facing slopes where grass and shrub forage is greatest and winter sunshine and prevailing westerly winds moderate snow pack and air temperatures." (ibid).

a. Wapiti - North American Elk
(Cervus canadensis Erzleben)

Once absent from Banff National Park completely, subject to a high reproductive potential, very migratory in behaviour, and subject to high highway and rail mortality, these animals are the most sensitive to any disruption in their natural habitat. In the 1940's the wapiti population expanded to such large numbers that they exhausted all forage supplies and nearly became absent from the park area. Only good management practices by the Warden Service acting on the advice of the Canadian Wildlife Service had maintained a healthy, viable population within Banff.

KEY WINTER RANGE FOR UNGULATES
GOOD WINTER RANGE FOR UNGULATES
POOR WINTER RANGE FOR UNGULATES
MAJOR SPAWNING STREAM
CROSSING AREAS - ELK, MULE DEER & BEAR
COYOTE DENING AREA
OSPREY NEST

6 WINTER RANGE



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designed by / conçu par
date
drawn by / dessiné par
date
reviewed by / examiné par
date
approved by / approuvé par
date
Tender / Soumission
D.P.W. Project Manager / Administrateur de projets M.T.P.
project number / no. du projet
85854
drawing no. / dessin no.

There are three distinct herds within Banff National Park with apparently very little mixing among them.

The total number of elk in the Bow Valley herd from the east gate to Lake Louise varies from year to year depending on many factors. For the years 1962 to 1966 inclusive the elk populations were 410, 610, 360, 250 and 260 respectively. It is estimated that less than 150 occur in the study area from the east gate to the Banff interchange.

Two critical factors affecting the elk populations at the present time are limited winter range, and highway and train mortality. Perhaps the most critical link in the ecology of elk is winter range, particularly in the Rocky Mountain Parks.

The records of highway mortality were plotted to identify traditional big-game crossings. There were two such areas - in the regions of Carrot Creek and the Tunnel Mountain road - representing approximately one-tenth of the 7.8 miles within the study area. These are ranked as Class 1 areas because they are critical to Wapiti survival. According to one study (Flook, 1970), Wapiti mortality in the study area due to traffic accidents is a minimum of 20 animals per year.

b. Moose (*Alces alces*)

Moose are not abundant throughout the park but do occur in the study area. They are browsing animals and prefer to feed on bushy twigs, dwarf willow being a favored food. In forested areas balsam fir, white birch, and aspen are the main foods. In the summer, moose utilize lakes to escape the heat and insects and feed on water lilies and pondweeds.

c. Bears

Two species of bear occur in the park, the black bear (*Ursus americanus*) and the grizzly (*Ursus arctos, horribilis*). Both are not abundant in either the park in general or the study area in particular.

The study area includes two garbage dumps (one closed) on either side of the highway which creates to and fro wanderings between the two. Furthermore, there is a considerable roadside area providing lush grass early in the spring which attracts both species of bear.

d. Other Mammals

(1) Beaver

The beaver population in the park is low, since the majority of the area is not good beaver habitat. On the average, one acre of aspen-poplar forest per year is required to sustain a family or colony of beavers. Beaver populations are limited, and are restricted to the area east of Johnson's Lake and the alluvial fan at Carrot Creek.

Beaver generally prefer quiet habitats away from the noise and human activities. However, there are examples of where colonies adapted to adjacent highway traffic.

(2) Coyote (Canis latrans)

Although relatively common throughout the park, these canine predators have a denning area near the interchange which may be considered critical to their survival in the study area.

Coyotes are not particularly important from the point of view of park visitors but serve a useful and valuable function in eating the carcasses of animals killed by trains or cars, or have died of starvation, disease, or old age.

2. Birds

According to Godfrey (pers. comm.) the osprey (Pandion haliaetus) should be considered a rare and endangered species in the mountain parks. Feeding primarily on fish, access to suitable fish populations such as those provided by the Bow River and Johnson's Lake are necessary.

One osprey nest is located in the study area, on a telegraph pole adjacent to the C.P.R. tracks.

3. Fish

The fishery aspect of the study area is mainly concerned with a small creek leading from Johnson's Lake to the Bow River, commonly referred to as Chinaman's Creek. Based on past studies, it appears that this particular creek is the only suitable spawning area in the study area. Both brook trout (Salvelinus fontinalis) and Dolly Varden (Salvelinus malma) spawn the length of the creek and produce fish which subsequently move into the Bow River providing a recreational pastime in the form of sport fishing. Fish were also seen throughout the length of Duthill Creek and therefore this area is also considered as an important potential habitat.

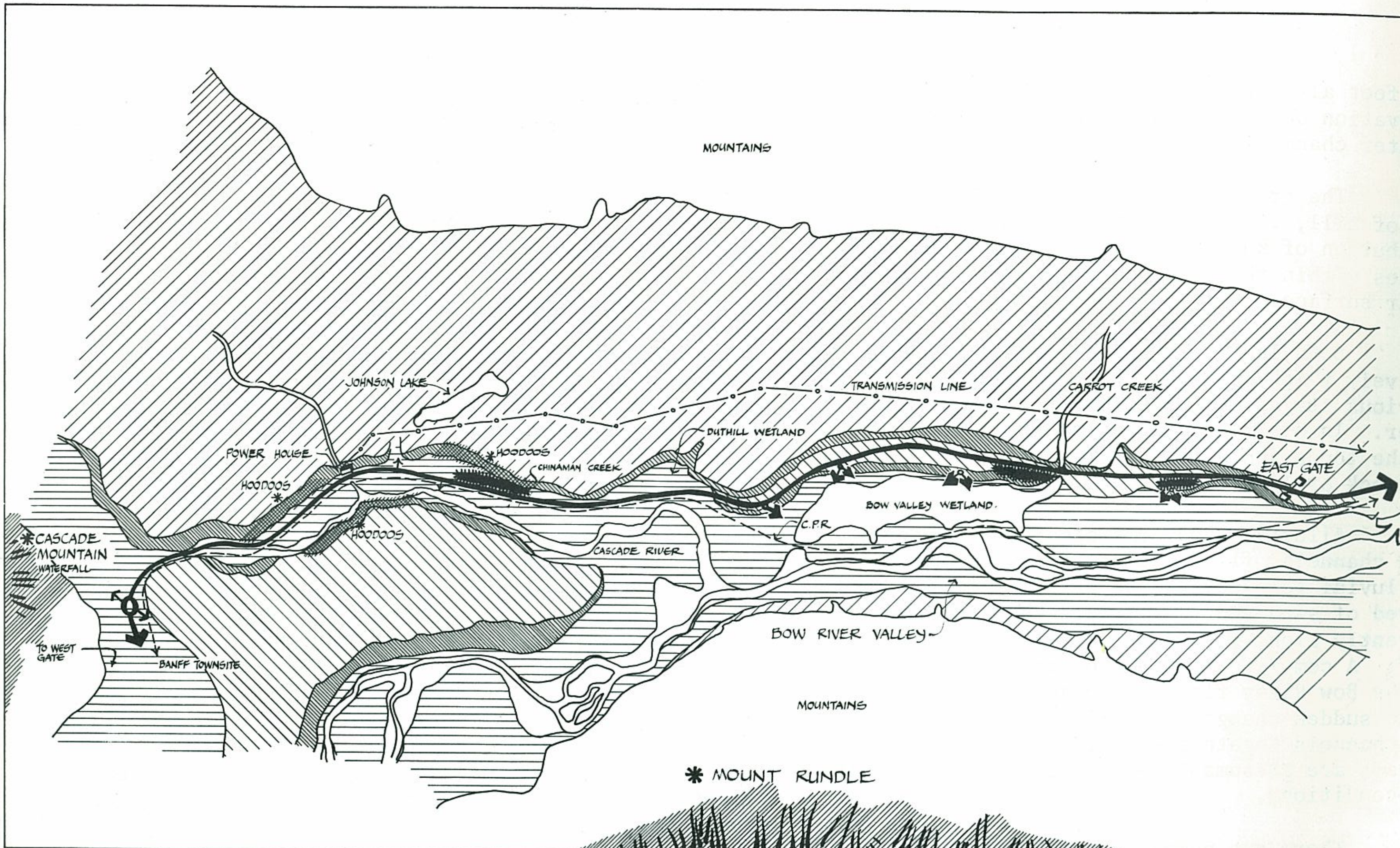
VISUAL RESOURCES

1. Landscape Units

Three principal landscape units occur within the study area: (1) Rugged Mountain Slopes (above 5,000 feet A.S.L.), (2) Glacial Morainic Landforms or Valley Terraces (4,600 to 5,000 feet A.S.L.), and (3) Alluvial Nonglacial Landforms or Flood plains, Alluvial Fans, and Stream Channels (less than 4,600 feet) - (MAP 7).

The mountain slopes are composed almost entirely of bedrock. The topography which includes steep slopes and jagged edges, reflects extensive scouring by valley glaciers. At higher levels, dynamic alpine features have resulted from cirque glaciation. The general trend of the mountains and geomorphic features have been strongly influenced by the northwesterly structural trend of the rocks. Fracture zones and differential weathering influence the detailed geomorphic form of the mountain features.

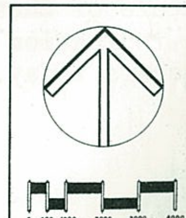
Morainic landforms have undergone very little change since glacial ice disappeared from the valleys over 10,000 years ago. Most of the moraine occurs as a bench-like linear landform on the north side of the Bow River flood plain. This landform has been somewhat loosely referred to as a relatively flat terrace. However, in fact this bench exhibits a hummocky surface and is traversed by numerous melt-water channels. Local relief is in the order of 10



- FLOODPLAIN
- ESCARPMENT
- BOW RIVER VALLEY
- FIRST LEVEL TERRACE
- SECOND LEVEL TERRACE
- PRIME FEATURES
- USE AREAS
- VIEW POINTS

7 VISUAL RESOURCES

LANDSCAPE UNITS
LANDSCAPE FEATURES



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to 15 feet although far more significant differences in elevation occur in association with the larger meltwater channels.

The ground moraine which is largely composed of till, is characterized by an irregular distribution of knolls and depressions. Outwash terraces within the morainic unit have a more regular surface.

Both landforms which are comprised of relatively thick deposits, can be related directly to various stages of recession of the Bow Valley glacier. In other places rock outcrops indicate that the topographic pattern is largely controlled by bedrock or local geology.

Alluvial landforms consist of present stream channels, flood plains, terraces and fans. The alluvial terraces of the Bow River which are composed of sand and gravel, are characterized by dry, gently sloping surfaces with minor local relief. A complex of abandoned channels associated with the Bow River flood plain and Carrot Creek fan provide sudden changes in relief of up to five feet. These channels together with tremendous depths of materials are presumably an indication of periodic flood conditions.

There are numerous other active and abandoned alluvial fans within the study area. They occur at the mouth of major tributary streams and have gently sloping inclines oriented more or less perpendicular to the Bow River. The size and nature of these abandoned fans and terraces are an indication of much greater fluvial activity than occurs today.

2. Landscape Features

Within the landscape units certain categories of landscape features can be identified. These landscape features can either contribute to or detract from landscape quality, and can be either natural or man-made.

The natural features which are a direct result of land form include the most significant natural spaces, valley edges and profiles, and massive mountainous background. These elements are present throughout the study area, and provide the setting and atmosphere for travellers regardless of their means of travel. These landscape features are best exemplified from scenic view points which occur along topographic edges and open spaces.

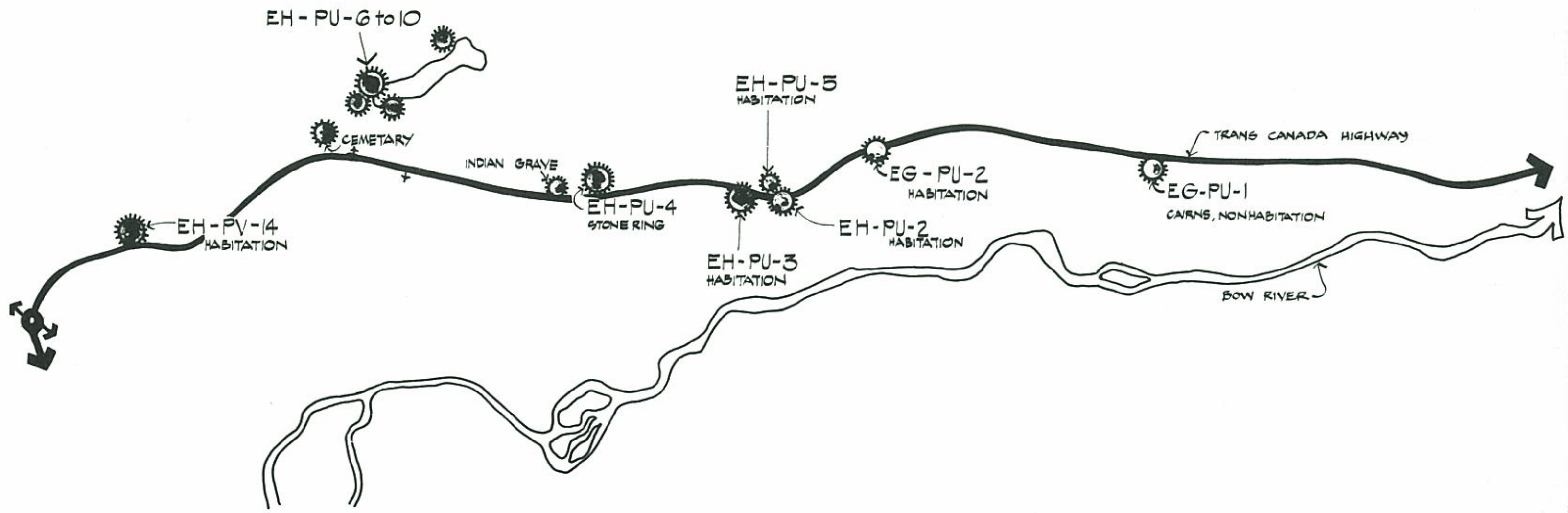
A second category of landscape features are those that are contrasting or unique. While generally smaller in scale than the first category of features, they stand out clearly because they have form, colour, texture or material which contrasts with the general landscape. Thus they account for the variety and diversity within landscape units. They include features such as Carrot Creek, the Bow River, Chinaman's Creek, Johnson's Lake, and Hoodoos. Isolated remnant Douglas fir trees and exposed steeply-sloping terrace edges are other examples.

Man-made features constitute a third category and include those elements which stand out as having special qualities because of their architectural or historic value or because of the way in which the man-made feature compliments the natural landscape. An example of the former is the structures associated with the eastern park gate entrance. Some scenic portions of the existing Trans-Canada Highway and Johnson's Lake Road provide examples of the latter situation.

Unfortunately there are a number of man-made features which are considered as being negative elements in the landscape. Examples of this type of feature include the Calgary Power powerhouse and transmission lines. Slumping exposed roadside scars, garbage disposal areas, and greenhouse junk yard are also considered to be negative landscape features.

ARCHAEOLOGICAL SITES

Information for the development of archaeological site location was supplied by Dr. Brian Reeves of the University of Calgary. It was derived from a study conducted over the past few years, the results of which are contained in a report. It should be noted that the study was of a preliminary nature and much further work needs to be done. However, for the purposes of this study this information provided much needed guidance and the project team is grateful to Dr. Reeves for his cooperation and participation.



EG-PU-1 CAIRNS, NON HABITATION
EG-PU-2 CAMPSITE, MIDDLE PREHISTORIC 3580 B.C. HABITATION
EH-PU-2 CAMPSITE, ABOVE GRAVEL PIT SMALL HABITATION SITE
EH-PU-3 CAMPSITE, SMALL HABITATION SITE, TOILET, ETC.
EH-PU-4 BULLDOZER CUT, STONE RING.
EH-PU-5 LOESS CUT, HABITATION SITE, LATE PREHISTORIC
EH-PU-6 TO 10 ONE MAJOR SITE WEST END OF LAKE JOHNSON
EH-PV-14 BEDROCK TERRACE SMALL HABITATION SITE.

NOTE: EDGES OF ALL TERRACES ARE CONSIDERED POTENTIAL SITES.

8 ARCHEOLOGICAL SITES

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project number — no. du projet
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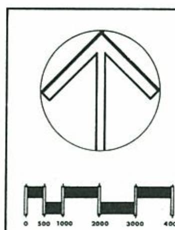


PART 3 ANALYSIS

PROGRAM

The identification of corridor alternatives involved the analysis and mapping of three prime factors, namely: (1) Environmental Impact, (2) Engineering Considerations, and (3) Visual Resources and Land Features. For each of the prime factors a number of factors were designated. The nature and number of factors within each category varied depending on the prime factor being considered. For example, land, water, vegetation and wildlife were factors for Environmental Impact. Topography, soils and stability, water, and operational considerations were the factors for Engineering Considerations. The two factors for the third prime factor are self-explanatory.

Each factor was then analyzed on the basis of a number of sub-factors. These sub-factors varied depending on the nature of the factor being considered. For example, the sub-factors for the land portion of Environmental Impact were regional significance, landform complexity, and geologic features. The sub-factors for the operational portion of Engineering Considerations were sun shadow and relative relief.

The sub-factors provided the basis for the application of three-scale rating which was plotted on clear overlay maps. An overlay of the appropriate sub-factor maps provided the basis for development of factor composites. The composite of the three prime factor composites illustrates areas on the basis of corridor suitability and was used to identify and analyze a variety of corridor alternatives. This last step provided the basis for the recommendations pertaining to the most desirable route for the two new lanes of the Trans-Canada Highway.

ENVIRONMENTAL IMPACT

The assessment of the potential impact to the environment was derived from the consideration of four factors, namely: (1) land, (2) water, (3) vegetation, and (4) wildlife.

1. Land

The sub-factors used to establish the land composite were the following: (a) regional significance, (b) landform complexity, and (c) geologic features.

The rating in terms of regional significance was derived by measuring the surface area of each landform category and establishing its position relative to the area occupied by other landforms. In other words, the landforms we have least of are the most important. Therefore, landforms such as meltwater channel, escarpments and active floodplains were rated high whereas alluvial fans and outwash were placed in the moderate category.

The degree of complexity was based on the structure and form of the landforms found in the study area. So, for example, the terraces consisting of till and rolling topography were rated low whereas the steeply sloped escarpments made up of outwash gravels, till and colluvium were rated high. Important geologic features such as interesting exposed bedrock features, archaeologic sites, and petrified wood were also placed in the high category.

2. Water

The sub-factors used to establish the water composite were the following: (a) Ground Water, and (b) Surface Water.

The rating in terms of ground water was derived by mapping the aquifer zones and assessing them on the basis of pollution implications. Critical areas were identified along the major aquifers of the upland terrace where disturbances could affect the system at lower elevations. Spring outlets adjacent to Chinaman's Creek and Duthill Fish Hatchery were also assessed as being critical areas. The large aquifer located within the deep valley floor gravels was considered moderately sensitive and all the remaining areas were assessed a low rating.

Surface water in the form of continuous flowing systems, lakes, wetlands and marshes were considered to be highly sensitive to development. The actual designated area included a buffer zone of approximately 150 feet which was considered to be the minimum distance required to insure the protection of the surface water resource. The same buffer was applied to the channels of intermittant streams although the rating of these features was designated as moderate.

3. Vegetation

The sub-factors used to establish the vegetation composite were the following: (a) Regional Significance, and (b) Composition Complexity.

The rating in terms of regional significance was derived by measuring the surface area of each vegetation unit and establishing its position relative to the area occupied by the other vegetation classes. For example those areas such as south-west facing slopes, parklands, and Douglas Fir terraces which represent less than ten percent of the study area, were rated highly sensitive. The relatively uninteresting lodgepole pine-spruce unit which covers over 45 percent of the area was placed in the low category.

The degree of complexity was based on the number and distribution of species within a unit, and the associated soils. For example, the parklands and riverlands were rated high, the remaining complexes on alluvial soils moderate, and the pine complexes low.

4. Wildlife

The sub-factors used to establish the Wildlife Composite were the following: (a) Habitat Rating, (b) Habitat Significance, and (c) Habitat Features.

The habitat for significant species of fish and wildlife were mapped and rated on the basis of quality. A compilation of this data formed the basis for a final habitat rating map. For example, prime winter range for elk, and trout spawning areas were designated as highly sensitive areas. Therefore, the Bow Valley Flood Plain and Chinaman's Creek were mapped as critical zones.

The surface coverage of the various habitats relative to the total study area became the basis for establishing the habitat significance rating. For example, there is a dearth of prime winter range compared to the total habitat of the study area and therefore it was considered to be of high significance. Analysis of these sub-factors indicated that because of the local geomorphology and vegetation both the quality and quantity of wildlife considerations were coincident. Therefore, all three sub-factors were mapped as one to form the Wildlife Composite Map. Isolated wildlife features such as the osprey nest and coyote dens were rated as highly sensitive areas.

ENGINEERING CONSIDERATIONS

The analysis of the Engineering Considerations was derived from a study of four factors, namely: (1) Topography, (2) Soils and Stability, (3) Water, and (4) Operational Considerations.

1. Topography

The critical sub-factor used to assess topographic suitability for highway development was slope. Despite the fact that slopes can be modified through the construction process, there is an obvious reflection in development costs. In addition, the length and slopes of the grades of the finished product affect operational and pollution rates because of the associated demands on the motor vehicle. Consequently slopes of less than 6 percent were considered to be the most ideal conditions for a highway location. Slopes between 6 and 10 percent were designated as having moderate suitability. Anything over 10 percent was considered to have serious consequences and was rated in the low suitability category.

2. Soils and Stability

An analysis of the surficial geology information provided the basis for assessing potential construction restraints. Where possible, other indicators associated with prevailing soil and vegetation conditions were used to support the conclusions.

Areas which have the greatest constraints include alluvium associated with active drainage channels and the steep-sided active fans south of the Bow River. In addition, colluvium, lacustrine and glacio-lacustrine silts, and organic material were also considered to pose significant construction problems. The subsidence area associated with abandoned coal mines located west of Johnson Lake was also designated as a critical area.

The large areas composed of till were considered on the average to represent moderate construction restraints. Those areas exhibiting few if any problems include alluvium and outwash associated with the abandoned portions of fans, terraces and flood plains.

3. Water

The assessment of construction restraints associated with water is a reflection of prevailing drainage and groundwater conditions.

Those areas posing the most serious problems were identified as the active portion of alluvial fans and drainage channels, water bodies, wetland sites, colluvium and lacustrine deposits, spring locations and intermittent drainage systems. The outside boundaries for these areas also included a buffer zone of approximately 150 feet.

Till was considered to present on the average only moderate restraints. The well drained coarse textured materials associated with stable alluvial fans, terraces and floodplains were considered to pose the least construction restraints.

4. Operational Considerations

The sub-factors used to establish the operational considerations composite were the following: (a) maintenance and (b) relative elevations.

The critical maintenance consideration was assumed to be the winter season when the length of sun exposure could affect highway considerations. Sun angle exposure simulation was applied to the study area and as a result three zones were designated. These zones reflect the relative probability of ice conditions assuming the existence of a highway. The final map indicates that the worst conditions probably occur south of the railway right-of-way. The relative elevation map indicates on a large scale the problem of moving traffic vertically. From this map, it becomes immediately apparent that significant vertical changes are encountered between the valley floor and upper portion of the till terrace.

PLANNING AND VISUAL IMPLICATIONS

At the time of the study, much of the planning with regard to circulation within the park was yet to be completed. However, indications were that the Trans-Canada Highway would become a limited access artery -- at least for the first 7.8 miles west of the east park gate. Therefore, potential recreation development sites were not viewed as possible influences in the location of a highway corridor. Regardless, potential sites and existing features were inventoried for the following reasons: (a) The assumption could change; (b) The sites and features could be important as part of an interior parkway; (c) The sites and features exhibit implications after a corridor is identified; and (d) There is a need for a visitor orientation centre in the study area.

Items considered to be prime features within the study area were archaeological sites, hoodoos, rivers, springs, creeks, lakes, wetlands, and escarpments. Areas immediately adjacent to these features were considered to have high visual value. Most of the parkland and floodplain areas which exhibit open spaces associated with a variety of vegetation were considered to be of moderate value. The remaining areas which constitute the dense monotonous stands of pine and spruce were rated as having low value.

Areas which were considered to represent the most disturbed zones included the highway, power development, and power lines. A moderate category was applied to those areas immediately adjacent to these disturbed zones. Most of the areas was relatively unaffected by man and was rated low or in a natural state.

PRIME FACTOR CONSIDERATIONS

1. Environmental Impact (Volume II, Map 9)

Zones of potentially high impact include all the important drainage systems and water bodies, plus a buffer zone of approximately 150 feet. Other highly sensitive areas include wetlands and escarpments.

Areas considered to be moderately sensitive to development include most of the Bow Valley floor or floodplain, alluvial fans and meltwater channels.

The least sensitive areas dominate much of the main valley terrace and are coincident with dense monotonous stands of pine and pine-spruce on rolling topography.

2. Engineering Considerations (Volume II, Map 10)

The deep, well-drained gravels of the Bow Valley floor and Carrot Creek fan provide few if any construction problems. Critical zones within these areas are limited to the active river and creek channels, spring outlets and wetlands.

The remaining areas which present significant engineering problems are the escarpments which border the Bow Valley floodplain and numerous meltwater channels. Materials making up the floor of these meltwater channels are also considered to present major problems.

Most of the main valley terrace, lower terraces, and lower valley slopes were considered to present only moderate engineering problems.

3. Planning and Visual Implications (Volume II, Map 11)

Areas with recreational development potential and/or prime visual features together with appropriate buffer zones were not considered as suitable locations for a highway corridor. These resources include shorelands, riverland, archaeological sites and hoodoos. Most of the remaining portions of the valley floor and alluvial fans, and all the wetland areas were considered to be of moderate value. By far the largest area which in general is coincident with the main valley terrace, is considered to have few visual and planning implications.

PART 4 CORRIDOR IDENTIFICATION AND SELECTION

CORRIDOR ALTERNATIVES

1. Environmental Impact (Volume II, Maps 12-17)

a. Route Corridor "A"

Between the east gate and Carrot Creek fan the corridor parallels the existing right-of-way. This area is considered to be a low impact zone and the proposed alignment does not generate further comment.

Carrot Creek fan is considered to be a high impact zone for a variety of reasons. The area exhibits a large degree of vegetation diversity, and is highly valuable as wildlife winter range. The fan which contains the Carrot Creek and is a source of groundwater, is also considered a relatively significant and unique geologic feature. Because of the complex nature of this fan, the impact varies with location. The main implication of Corridor "A" appears to be possible complications related to animal movement. In this location the fan is relatively narrow and is contained within steep-sided walls. The corridor would in effect divide the habitat into smaller units thereby possibly increasing the frequency and concentration of animal crossings.

Between Carrot Creek fan and the traffic circle, the corridor courses on top of the main terrace or bench of the Bow Valley. The vegetation is simple consisting of dense stands of lodgepole pine or lodgepole pine-spruce and is considered poor wildlife habitat. Animal residence is expected to be light and spread out. Consequently much of this area is rated as a low impact zone.

There are a number of exceptions, however, which are related to the existence of water, land, and habitat features. At stations 170 and 260 the corridor crosses meltwater channels which contain intermittent flowing creeks. These sites also represent a greater variety of cover than the adjacent areas. The possible requirement of wildlife underpasses at these locations and careful treatment of the stream are important considerations.

At stations 220 - 230 the corridor courses along the edge of a large meltwater channel. The edge provides semi-open south facing slopes which includes remnant Douglas fir and is the northern portion of an area which is considered important wildlife habitat. The possibility of wildlife conflict is the main consideration in this location.

Johnson's Lake represents an important scenic and relatively tranquil feature within the study area. The corridor courses along the south shore and cuts across the west end. It is expected that a highway in this area would adversely affect the existing use of the lake especially in terms of noise pollution.

Between Johnson's Lake and the traffic circle the corridor courses in close proximity to the edge of the terrace. This area consists of semi-open south facing slopes and is considered important winter elk range. This area is also characterized by considerable bear activity and is the general location for coyote denning. Development of a corridor along this route would require careful consideration of these factors.

Access to the traffic circle area will require modification to the Cascade River floor. This area has already been considerably affected by past gravel excavation operations. Development of the corridor through this area would cut an artifically constructed lake in half and possibly adversely affect the existing recreational use of this feature and adjacent shoreland.

b. Route Corridor "B"

This corridor is located to closely parallel the railway right-of-way throughout the entire study area. This proposal includes relocating a three-mile portion of the line 200 feet from its existing position. Assuming the implementation of certain forest and wildlife management programs, and the construction of at least two wildlife crossings, it appears that this corridor will pose the least adverse affects to the environment.

Between the east gate and the Duthill wetland, the corridor courses along the toe of Carrot Creek fan and the edge of a large floodplain complex. Therefore this significant ecological unit will be largely left intact and the impact should be minimal. Also there is an opportunity to have a recovery area of trees between the highway and railway which will hopefully aid the wildlife in their attempts to cross these two transportation corridors.

Relocation of the railway right-of-way and location of the new east-bound highway lanes on the present railway right-of-way avoids contact with major impact areas adjacent to the north side of the existing Trans-Canada Highway. It also opens the opportunity to build in a number of animal crossings in an area which is reportedly subject to high rates of animal kills.

High impact areas which would be avoided include: (a) Duthill Wetland 220-250; (b) Side Cut Gravel Site 250-260; (c) Chinaman's Creek 260-320; and (d) Power Station Site and Area 320-380.

Careful handling of the reconstruction of the four lanes and Cascade channel east of the Cascade River crossing will reduce the impact in this area. Wildlife control and a possible underpass may also be considered necessary in this area.

c. Route Corridor "B-1"

This corridor involves twinning the existing two lanes throughout the entire study area. Regardless of the environmental characteristics present in any particular location, there is a general objection to this type of highway design. Biologically, the problem is related to a more than proportionate increase in highway accidents involving collisions with animals, as a result of doubling the number of lanes in a single corridor. In addition to the unacceptable manner of the kills and the often related animal suffering there is also the danger to human life either directly or indirectly as a result of initial contact with wildlife. A four lane highway which is divided by a buffer area of trees provides a recovery zone for animals in addition to having planning and visual advantages.

Between the east gate and Carrot fan the environmental impact should be small (as discussed under Corridor "A"). The only objection is the fact that the two new lanes will be located adjacent to the existing highway.

The traverse across the Carrot fan creates another artificial obstacle which will separate the upper portion of the fan from the

Plate No. 1

This picture clearly illustrates the influence of the railway building era. The parkland type of vegetation which is characteristic of the Carrot Creek fan provides excellent wildlife winter range and is visually pleasing. Note the predominance of spruce in the regenerating areas which, in the years to come, could decrease the present quality of the habitat.

Plate No. 2

The center of this picture represents the boundary between two important ecological units. The one on the left is sub-climax lodgepole pine on till. The other side includes a variety of hardwoods and softwoods growing on fine alluvium which forms the sub-surface base of local meltwater channels. The intermittent creek identified by the arrow is a characteristic feature of many of the linear depressions located in this area.

Plate No. 3

The wetland on the right, which is located west of Carrot Creek and is part of the Bow River flood plain, is considered one of the most important ecological units in the study area. Aside from being the habitat for a variety of wildlife, this area affords many opportunities for ecological and geological interpretation. Sites of this nature are characteristic of high environmental impact designations.

Plate No. 4

The forest cover on the left side of the highway contains a relatively large number of young Douglas fir. This area which is part of a band of parkland vegetation located on south-facing lower terrace slopes, has high visual quality and provides suitable wildlife habitat.

lower portion and the Bow River flood plain. The latter features are part of a large ecological unit which aside from being important winter range provides numerous interpretive opportunities. Implementation of this alternative will undoubtedly require provision of a wildlife underpass at the Carrot Creek bridge and wildlife movement control in the area.

West of Carrot Creek the route swings to the north side of the existing lanes. This area offers semi-open south facing slopes which are considered important habitat for wildlife. In addition this narrow strip which is part of a lower or intermediate terrace contains a large concentration of young Douglas fir. This same situation was not encountered in any other location in the study area.

Between station 190 and 220 there is a major cut and fill requirement which will obliterate a portion of the Duthill wetland and creek. Consequently this area is considered to have significant environmental impact implications.

From Duthill Creek to the traffic circle corridor "B-1" is the same as Corridor "B". The major potential environmental impact areas avoided by relocating the railway are discussed in the previous section.

d. Borrow Pits

In general since Corridor "A" is largely a cut and fill operation, the requirements for borrow material should be minimal. The same situation applies to Corridor "B-1" at least up to Duthill wetland. Corridor "B" which coincides with the last half of Corridor "B-1" will undoubtedly involve borrow-pit excavation.

As a general rule, areas which are coincident with high quality wildlife and/or significant geologic features should be avoided as possible sources of borrow. In reality achievement of this objective is in most cases impractical in terms of the increased hauling distances and capital construction costs. However creation of a borrow pit does not necessarily have to result in an adverse environmental impact.

In the case of Corridor "B" it may be assumed that appropriate and sufficient borrow material is present in close proximity to the entire route. The locations could involve both the active and non-active portions of the Bow and Cascade River flood plains. Depending on current park policies and programs, it is possible through controlled construction treatment and technique to actually improve existing habitat or even create new habitat. This sensitive and scientific approach may also be used in the initial development phase to minimize environmental impact during construction.

These considerations are part of the highway design portion of the program where the objective is to minimize the environmental impact of the highway within a designated corridor. In this next phase of the project, biologists and geologists, which are part of the study team, will play an important role in working with the design engineering team to achieve this objective.

e. Resource Management

There are resource management problems within the study area, many of which will be compounded by the twinning program.

The main problem is related to the fact that the lower portion of the Bow Valley provides the winter range for big game animals. It is also a fact that this habitat is in short supply compared to the availability of summer range. Fire prevention and transportation corridor development have further aggrivated the situation by altering normal vegetation succession which favours the production of high quality habitat. Therefore the quality of habitat is gradually being reduced.

The net result of corridor development in this situation is paradoxical in that instead of destroying habitat they provide strips of highly favourable habitat. As the habitat in the region deteriorates, these zones become more attractive and the frequency of highway kills increases.

Amelioration of this unsatisfactory situation requires a long-range program of research and experimentation. The overall objective is to decrease the quality and quantity of habitat along highway rights-of-way while achieving the opposite result in other areas. Control and limitation of animal crossings through fencing, reflectors and game underpasses is another important objective.

2. Engineering Considerations *
Volume II - Maps 14 - 17

a. 1968 D.P.W. Design

During the preliminary surveys for this facility it was established through consultation with officials of the National Parks Branch that there was little or no requirement for out-bound traffic to report to the entrance gateway and as a consequence the east bound lanes were terminated at a point outside the Park boundary a distance of some 2,600 feet and aligned with the proposed Alberta Department of Highways location which has subsequently been constructed. This separation of out-bound from in-bound traffic would allow the entrance facilities to be increased from three lanes to at least five and help reduce the bottlenecks occurring with new registrants entering the Park system.

* This portion of the text was supplied by D.P.W.

From this start location the alignment traversed the bench on good granular materials to station 20 where it dropped into a low, swampy area for a distance of some 600 feet.

From the Park boundary at station 26 the alignment crossed relatively open meadow-like areas on increasingly good foundation materials spilled out from Carrot Creek fan and on an alignment converging on the Canadian Pacific Railway. This divergence in traffic flow from the railroad would serve to minimize the effect of headlight glare from the locomotives in those areas where it is not possible to leave a screen of trees between the alignment and the railway.

At station 83 the alignment commences to curve around the toe of the Carrot Creek fan generally parallel to the railroad and crosses the active part of the fan approximately four hundred feet north of the railroad on a divergent path. It was contemplated that a new channel could be excavated for Carrot Creek to control the flow which presently meanders across the active fan and discharges into the flow channel from the beaver pond. This revised channel would serve as a source of much-needed borrow material.

From station 123 to 135 the alignment traverses a low swampy area cut by numerous drainage channels falling away to the south. The alignment has been located to cut across the head ends of these channels which broaden out to become major water courses towards the railroad. Materials investigations in this area indicate that firm foundation is available at a depth of four to five feet so that stripping to firm footing is entirely feasible through the area.

From station 135 the alignment curves to converge on the railway again on good foundation materials. The highway and the railway are not intervisible through this area because of the extensive tree screen between.

Plate No. 5

Duthill Creek represents a small but scenic water system which courses in a meandering fashion along the edge of the Duthill wetland. The complex history of this area related to beaver activity provides excellent interpretive opportunities. It also provides valuable fish habitat. The picture shows the area which would be destroyed if the new two lanes were placed immediately adjacent to the existing alignment.

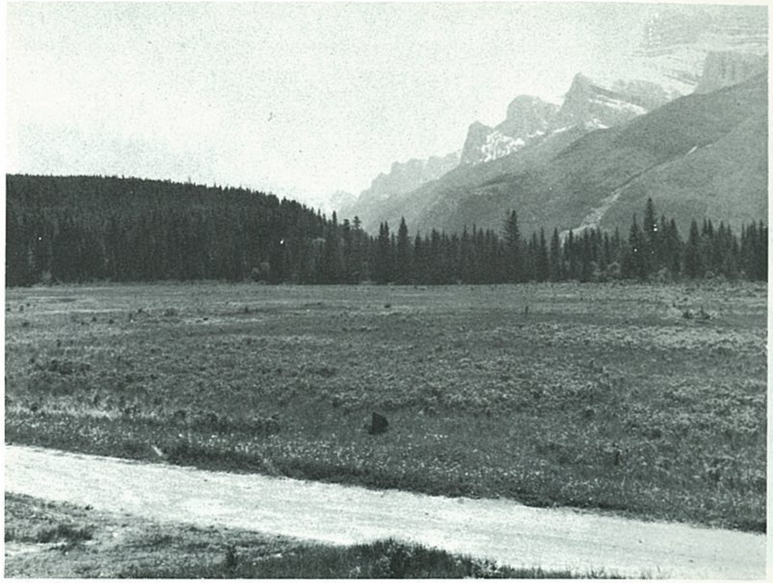


Plate No. 6

The Duthill wetland has developed as the result of hundreds of years of spring and beaver activity. The infrequent occurrence of sites of this nature within the study area together with their value as wildlife habitat established the basis for coincident high environmental impact ratings.

Plate No. 7

The shores and waters of Johnson's Lake provide a variety of extensive recreational activities such as fishing, canoeing and picnicking. A relatively peaceful atmosphere is maintained despite the close proximity of the existing Trans-Canada Highway. The proposed upper corridor route which courses across the south-west corner of the route could result in significant noise and visual forms of pollution.

Plate No. 8

This picture clearly illustrates the problem posed by not implementing the proposal to relocate the railway right-of-way. Both the blind protecting Chinaman's Creek and portions of the creek and associated ponds will be destroyed. Chinaman's Creek, which flows into the Bow River via the Cascade River, is considered to be an important spawning area.

At station 181 the alignment commences to curve to generally parallel the railway to the point where it merges with the present Trans-Canada Highway at station 250. Foundation conditions through this area are good to excellent.

From station 250 westward the east-bound alignment follows the existing Trans-Canada for a considerable distance since there is insufficient room to locate the additional lanes between the highway and the railway and provide any median between the lanes without encroachment on C.P.R. right-of-way.

At station 250 (new alignment) or station 220 (T.C.H. chainage) the new traffic lanes would be constructed for west-bound traffic. Divergence would be made at the curve at the foot of the hill to a location approximately 100 feet north of the existing Trans-Canada Highway. The divergence commences on a relatively high fill and the first thousand feet crosses unstable swampy foundation caused by ancient and more recent beaver activity.

At station 255 the proposed alignment commences to curve around what is locally known as the Indian Grave Cut which will require a large extension to the existing cut at this location. Although a new cut slope will be opened up the overall height of the cut will be reduced owing to a drop in the terrain elevation behind the existing top of cut.

From station 267 to station 305 the alignment for the west-bound lanes utilizes the existing abandoned roadway to utilize the present clearing and cover the scar formed by this road. Foundation conditions are somewhat swampy and unstable owing to the presence of Chinaman's Creek and numerous underground springs and water flows. Despite the questionable nature of the foundation stability can be achieved by stripping of overburden as witness the existing Trans-Canada Highway through the same area.

At station 306 the proposed alignment would skirt the Greenhouse Property and while the highway proper would not encroach on the property, which has since been acquired by the National and Historic Parks Branch, the right-of-way clearing and the necessary relocation of Chinaman's Creek would remove the existing tree screen opening up the unsightly complex to full fiew.

From station 307 to station 351 it was proposed to relocate both lanes of the highway and abandon and remove the existing Trans-Canada Highway. The reasons for this were twofold; firstly, to avoid re-cutting the existing very high cut slope immediately east of the Power House, and secondly, to provide a better configuration of the two lanes at the crossing of the tailrace in front of the Power House itself. The existing structures under the highway can be utilized for the west-bound lane crossing but new structures would be required for the east-bound lanes. Since downstream hydraulics in the tailrace are critical the new crossing would require a bridge structure instead of twin culverts as exist under the existing highway and the railway. Through this area there is a requirement to relocate the existing unloading ramp on the railway by swinging the spur generally parallel to the main line track. No encroachment by the pavement surface on to railway right-of-way is required at this location however some encroachment, of fill slopes and an overlap of rights-of-way would have to be covered by an easement.

From station 351 to station 376 the additional lanes would be built as the west-bound lanes to the north of the existing Trans-Canada Highway in view of the inadequate room between the highway and in view of the inadequate room between the highway and the railway. Separation of the two lanes here has been reduced to 62 feet giving a median width of 24 feet edge to edge of pavement owing to the cramped area available.

From station 376 to station 390 the additional lanes would be built as the east-bound lanes on the south side of the existing Trans-Canada Highway requiring a slight encroachment on the existing Cascade River Channel. Since the flow in this channel is controlled by the Calgary Power Minnewanka Dam and restricted to the capacity of the spillway a volume believed to be in the neighbourhood of 1,200 c.f.s., the encroachment should be of little import. Since the installation of the second generator at the Power House in 1955-56 capable of passing 750 c.f.s. raising the possible total flow through the generating station to 1,500 c.f.s. it is thought that the necessity of using the Minnewanka spillway is remote, however the channel of the Cascade River should be capable of passing the volume of the spillway capacity in case of generator station failures at the time of maximum lake level.

From station 390 to the Cascade River Bridge at station 405 the additional lanes would be constructed as the west-bound lanes to the north of the existing highway. This construction would require a very large cut from station 397 to station 404 with cut slopes approaching 175 feet in height.

The study concluded at the crossing of the Cascade River which would require widening of the existing bridge to take the additional lanes or the construction of a separate structure to carry the west-bound traffic.

With the exception of large roadway cuts at the Indian Grave Cut at mile 5 and the final cut at the approach to the Cascade River at mile 7.8 the proposed alignment would be constructed in slight fill and most of the material would be required from borrow pits. Several possible pit locations were indicated in the 1968 study. Borrow could possibly be reduced somewhat by judicious revisions to the proposed grade line especially in the Carrot Creek fan area, however this would increase the backslope area considerably creating a greater visual impact.

This proposal requires the convergence with and divergence from the existing Trans-Canada Highway at four locations and the complete re-location of both lanes over a distance of some one-half mile. As a consequence the interference to traffic during construction will be considerable.

The maximum gradient on this alignment is 1.6% at mile 4.75 on the west-bound lanes.

b. Route Corridor "A"

Since there exists no possibility of climbing on to the so-called upper bench inside the Park prior to the Carrot Creek fan area, route corridor "A" requires the twinning of the existing lanes from the Park entrance to station 40. In order to provide vertical alignment flexibility through this area the separation between opposing lanes of traffic was selected at 110 feet which will allow a variance in grade elevation at any one location of approximately 10 feet. Through this area it was decided to construct the additional lanes as east-bound to the south of the existing highway in order to avoid a recutting of the extensive cut slope climbing out of the park entrance area which has stabilized itself since construction and has a significant grass growth at this time. At station 60 these lanes are tied back into the existing Trans-Canada Highway and from here westward the existing Highway will become the east-bound lanes.

At station 40 the proposed alignment swings away from the existing Trans-Canada Highway up the Carrot Creek fan on a 3.2% climbing grade to cross the creek at approximately station 87. Since this alignment is across the alluvial fan the foundation conditions are excellent.

At station 87 the alignment enters one of the numerous ancient meltwater channels existing throughout the general area. This is the only feasible entrance to the upper terrace area since massive cuts would preclude moving very far either up or down stream.

From station 87 to station 120 the alignment follows the meltwater channel crossing from the northern slope to the southern slope in the process. Foundation materials are relatively good with the channel floor apparently sound gravel under slight overburden and the valley sides being composed of glacial till material apparently quite dry and stable.

At station 120 the alignment skirts a small lake remnant and is located on the south slope of the valley. Some consideration was given to maintaining a southern exposure by by-passing the lake on the north slope, however a substantial ridge requiring large cuts exists at the east end of the lake which dictates the northern exposure. Cut slopes in this area are in the plus or minus eleven feet range and the heavy timber and northern exposure will influence the snow melt rate in the early spring to a certain extent. Grades in this section are in the +3% category and foundation conditions are relatively good being through apparently dry glacial till material with a high granular composition.

From station 125 to station 150 the alignment traverses fairly heavily wooded park-like areas on a relatively level gradient over apparently good foundation conditions.

At station 150 the alignment drops slightly into a transverse meltwater channel with a running stream. Foundation conditions appear to be good to excellent through this area and tree cover is quite dense.

From station 150 to station 175 the alignment traverses the previously mentioned meltwater channel and a tributary approaching from the right skirting an open meadow on the right-hand side. Tree cover is fairly dense, park-like, and foundation conditions are apparently good with some question concerning stability in the area of the open meadow depending upon the final location alignment in this area.

From station 175 to station 195 the alignment climbs out of the meltwater channel on a 3% grade to a saddle between the meltwater channel just crossed and the one further to the west. The terrain through the area slopes gently to the south and cut heights are in the plus or minus seventeen foot range.

From station 190 to station 220 the alignment falls slightly to the rim of the massive meltwater channel through relatively densely forested park-like country with good foundation conditions. Materials appear to be relatively dry glacial till mixed with granular.

From station 220 to station 240 the alignment climbs slightly on a 1.5% grade skirting the rim of the meltwater channel. The terrain slopes significantly up from the rim and cut heights in this area could be in the neighborhood of plus or minus 33 feet. Materials appear to be dry glacial till and the forest cover is medium dense park-like.

From station 240 to station 264 the alignment drops into the meltwater channel on a minus 5% grade. Fairly heavy through cuts will be required where the alignment crosses the rim of the meltwater channel with cut slopes in the neighborhood of plus or minus 37 feet and fills of plus or minus 32 feet will occur at the near edge of the channel. Foundation materials appear to be dry glacial till with alluvial bouldery granular material in the bottom of the channel with a minimum of overburden except in the vicinity of the running creek at approximately station 261.

From station 264 to station 291 the alignment climbs back out of the meltwater channel on a 4% grade with once again relatively large cuts where the grade breaks through the rim of the channel. Forest cover on the western rim of the channel is considerably denser and foundation materials deteriorate considerably towards the western end of this section. Water seepage from the rise south of Johnson's Lake towards the lake is prevalent and some difficulty with stability of backslopes is to be anticipated.

From station 291 to station 320 the alignment drops slightly to the crossing of the Two Jack Lake Road skirting the south side of Johnson's Lake but located considerably above lake level. Cut slopes in this area will be in the neighbourhood of plus or minus 26 feet and foundation conditions are relatively poor with considerable underground seepage evident making backslope stability questionable. The forest cover is quite dense throughout this section.

At station 320 the alignment crosses the tip of Johnson's Lake and subsequently the Two Jack Lake Road. Depending upon the traffic flow studies in the area it is conceivable that an interchange structure or at least an overpass for this intersection will be required.

From station 320 to station 351 the alignment rises on a 1.9% grade along a sandstone ridge skirting a depression on the left which contains many slump areas over the old mine workings. The possibility of mine workings under the sandstone ridge exists but without the maps of the underground workings the location of possible weak areas is unknown. This section of the alignment might require a relocation of the Calgary Power transmission line depending upon the final alignment.

At station 351 the alignment crosses the Calgary Power penstocks requiring an overpass structure and an artificial hump in the vertical grade to provide the required clearance. An alternative, which could be more costly, would be to re-grade the penstocks to lower them and eliminate the humped grade. Some overpass structure would still be required however, unless the penstocks were replaced with buried steel lines: an extremely costly solution.

From station 351 to station 360 the alignment crosses the tail end of another meltwater channel and foundation is somewhat adverse with wet swampy conditions prevalent. Underlying and surrounding materials are sandy and granular however and foundation should be achieved after stripping.

From station 360 to station 394 the alignment traverses a higher area of more open park-like nature dotted with abandoned sand and gravel pits on a 2.4% grade. This area is considerably drier and foundation conditions should be much more favourable.

At station 395 the alignment crosses the head end of the meltwater channel and foundation conditions for a short stretch are dubious as the channel is crossed. The forest cover changes dramatically here with a great increase in density to jack pine and spruce.

From station 395 to station 405 the alignment follows another meltwater channel with a rock ridge on the right. Forest cover is very dense and foundation conditions might be a problem in the bottom of the channel.

At station 405 a proposal to cut down the hillside to meet the present Trans-Canada alignment at the Cascade River crossing was looked at and discarded as impractical owing to the extreme sidehill scar which would result. An archaeological site on the bench below station 405 presents a further obstacle to this alignment proposal.

From station 405 to station 420 the alignment generally follows the meltwater channel to search out the lowest point on the rim of the Cascade River Valley for the plunge to the valley floor. At station 405 the vertical alignment enters a through cut through the valley rim with cuts in the neighbourhood of plus or minus 50 feet. Materials are sandy silts and stability of cut slopes will be questionable. Several sloughing and slump areas are visible in the existing valley walls occurring in the material overlying the rock existing at lower elevations. The grade dropping into the valley is 5%, considered to be a desirable maximum for winter operation.

Where the alignment enters the valley fills in the neighbourhood of plus or minus 88 feet are encountered and a 3° curve is required to align the highway for continuation to the west. A substantial drainage structure will be required for the Cascade River flow of 1,200 c.f.s. previously discussed.

At station 444 the grade meets the ground and can be continued westward in any configuration dictated by studies to be carried out for this area.

This proposal can be constructed primarily as a balanced grade line requiring little or no borrow with the exception of aggregate materials, however without a full-scale materials investigation along the route problems of foundation and backslope stability in some areas must be suspect to a certain degree. The much greater incidence of cuts and fills will present a higher visual impact than any line constructed at the lower elevations. This is especially true at the Cascade River Valley where the necessary large through cut and high fill will present a massive scar which will be difficult to beautify.

c. Route Corridor "B"

This alignment corridor was described as generally parallel to the Canadian Pacific Railway. However, from station 0 to station 110 it was assumed that it would, for all intents and purposes, duplicate the D.P.W. 1968 design, the description of which has been presented heretofore.

Like the D.P.W. design this proposal entails tieing the alignment in to the Alberta Provincial highway outside the Park boundary; however, there is some indication now that out-bound traffic may be required to pass through a check at the Park boundary and an alignment has been indicated to achieve this result. It is entirely possible to swing back to the existing gate complex as indicated through park-like terrain with good foundation conditions with the exception of a short swampy area just west of the exit buildings.

From station 110 to station 150 the alignment parallel to the railway would cut across the extensive drainage from the beaver pond at the base of the escarpment. This would require extensive and complex drainage structures to handle this water flow and it is earnestly recommended that, if this route corridor is selected, diversion is made here to the 1968 D.P.W. design to intercept these drainage channels at their head ends where control is much easier. The location near the railway requires considerably longer passage over the swampy terrain

check this

where foundation conditions are questionable.

From station 150 to station 220 foundation conditions are again favourable and little difficulty would be encountered, the terrain being essentially the same as that encountered on the D.P.W. design.

From station 220 westward the impact on the sensitive areas at Duthill and the Chinaman's Creek area and the cramped situation at the Calgary Power generating station can be minimized by relocating the railroad over a distance of some three miles and locating the additional east-bound lanes of the highway in the existing railway right-of-way.

This proposal would entail relocating the railroad parallel to itself a distance of 200 feet southward from the vicinity of station 220 to the vicinity of station 420 at the curve immediately west of the crossing of the Cascade River. Some encroachment on the Cascade River channel is required at station 250, however adequate space is available in the active channel to divert the stream with rip-rap protection for the railroad embankment. The only other control for the railroad relocation occurs at the crossing of the Hoodoo road at station 335 where the relocated railroad centre line comes close to the end of the existing Cascade River bridge. If this road is to remain in service under the traffic pattern presently under study the railroad grade and the bridge grade will have to be coincident. Immediately west of the Hoodoo road there is another apparent encroachment on the Cascade River bed, however the tailrace channel has been artificially controlled by Calgary Power in this vicinity and the encroachment only affects dry channels. The relocated railroad will require a new crossing of the generating station tailrace. This crossing will be situated far enough downstream, however, that the tailrace hydraulics should be such that a twin culvert installation, similar to that existing for the present railroad location, should be adequate for the crossing. This should be considerably cheaper than a bridge structure. Near the end of the re-alignment the overflow channel of the Cascade River must be crossed. Here again a twin culvert installation should suffice replacing the existing twin span bridge. The re-alignment becomes coincident with the present alignment at the curve immediately west of the Cascade River crossing. Moving the railroad 200 feet will enable a substantial screen of trees to remain between the railroad and the proposed additional lanes of the highway thus eliminating headlight interference and screening the construction from view.

From approximately station 230 the additional lanes of traffic will be constructed for the east-bound direction on the existing railroad right-of-way. This will require a minimum of right-of-way clearing and will, for the most part, leave a screen of trees between opposing lanes of traffic. Through the sensitive areas at Duthill and Chinaman's Creek there will be no further encroachment to the north and the status quo will remain unchanged through this area. This proposal will obviate the necessity of reopening the large cut at station 275 and immeasurably decrease the congestion at the generating station site. By building headwalls for the culverts a tailrace crossing the existing culverts can be used for the highway lanes, in fact by lowering the grade through this area it may well be possible to utilize the culverts with no additional construction.

At station 410 the additional lanes will leave the existing railroad location and pass to the north side of the Cascade River. This

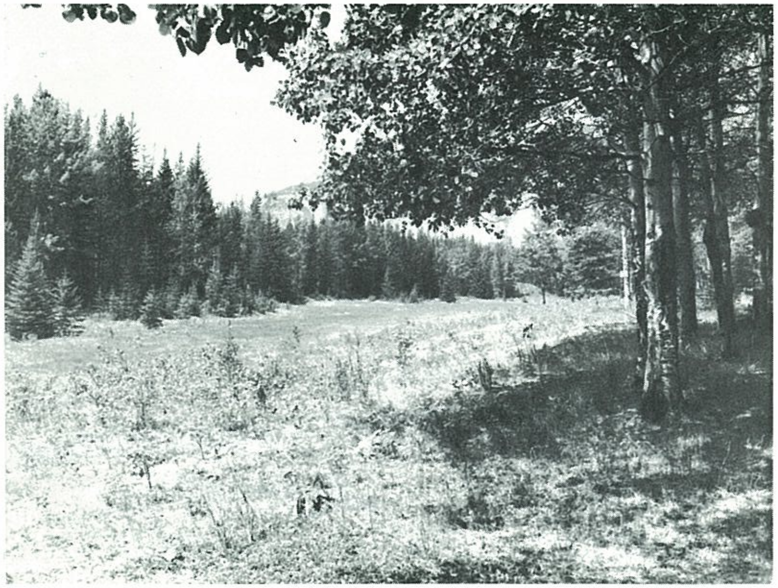


Plate No. 9

This area is underlain by numerous abandoned coal mine shafts. Deterioration of these shafts has no doubt caused the subsidence conditions which prevail in this area. Conditions of this nature were considered to present severe engineering restraints and therefore this area was rated highly unsuitable for highway development.

Plate No. 10

This picture represents a classic example of an ice-contact outwash profile. The lower left portion represents the outwash while the centre portion of the picture exhibits the till. Despite the varying texture of this type of outwash it can if present in large enough quantities provide valuable sources of borrow material.

Plate No. 11

Poorly drained areas which include ponds such as illustrated in this picture can provide serious engineering problems. The value of this area as fish and wildlife habitat, and the scenic qualities of the background hoodoos adds further support to the idea of locating a highway elsewhere.

Plate No. 12

This picture illustrates to some degree the vast supplies of coarse-textured materials available along most of the Bow Valley flood plain. The steeply sloping form and tremendous size of an adjacent alluvial fan is also visible. Both landforms can, depending on the location, provide valuable sources of construction material.

crossover will not require passage of the stream under the lanes since it can be channelled to pass between the relocated railway and the highway.

From station 410 to the Cascade River bridge at the west end of the study area it is proposed to parallel the existing highway lanes 62 feet to the south. This will require encroachment on the river channel and a constriction in the flow area but owing to the controlled nature of the stream as previously discussed sufficient flow area should be available. This proposal obviates the necessity of reopening the rock cut slope at station 415 and leaves the petrified wood location and the archaeological site untouched. It also does not require the opening of the large cut slope immediately east of the Cascade River bridge. It does, however, require an extension to the existing bridge or the construction of a new structure to carry the additional lanes.

The final three thousand feet of this proposed location will cause a constricted transportation corridor the full impact of which cannot readily be assessed without a detailed study of the area but it is felt to be entirely feasible. A further refinement to the railroad relocation through this area would entail the construction of a curved tunnel for the railroad through the shoulder of the hill emerging beyond the traffic circle. This could effect a reduction in curvature and crest vertical curve height for the railroad favourably affecting their operational costs and remove the railroad completely from this constricted area. The additional lanes of traffic could then utilize the existing railroad grade with minor modifications leaving the channelized Cascade River between the opposing lanes of traffic.

Like the D.P.W. 1968 proposal this route corridor would be built almost entirely from borrow, in fact the two roadway cut areas encountered on the D.P.W. proposal have now been eliminated. It will however be possible to fit the roadway into the landscape with a minimum of visual impact. In addition, since the additional lanes are completely independent of the existing highway there will be an absolute minimum of interference to traffic during construction.

d. Route Corridor "B-1"

As a variation to route corridor "B" the alignment "B-1" was proposed to twin the existing lanes of the Trans-Canada with a normal separation between lanes to provide a depressed median. This would entail newly designed additional lanes from mile 0 to mile 4 and the utilization of route corridor "B" design from mile 4 to mile 7.8.

For reasons of flexibility in vertical alignment the separation between opposing lanes was chosen at 100 feet as previously discussed in the description of route corridor "A" and the south side of the highway chosen for the additional lanes from station 0 to station 80 at the Carrot Creek crossing. In this alternative the new construction was carried to the curve immediately west of the Carrot Creek crossing to avoid the artificiality introduced by switching lanes in the middle of a tangent. The construction through this section is on good materials and would present little difficulty with fairly extensive cut and fill climbing up out of the east gate area. This alignment does however eliminate the necessity of re-cutting the large cut slope at station 25. At station 80 the new alignment will require the construction of a new bridge over Carrot Creek and the new lanes will merge with the existing Trans-Canada Highway at station 87.

Because of constrictions on the south side of the existing highway to the west at stations 120 and 130 where it crosses major meltwater channels and at station 175 where the alignment closely approaches the edge of the escarpment the new lanes west of Carrot Creek would be constructed as west-bound lanes to the north of the highway. The new alignment will diverge from the existing highway at station 75 and will require a second new crossing of Carrot Creek. It will be necessary to re-cut the slope immediately west of Carrot Creek however because the terrain falls away slightly behind the present top of cut the overall height of cut will be reduced to plus or minus 88 feet although its length will be increased.

From station 90 to station 140 the alignment traverses easy terrain with good foundation materials crossing the meltwater channel at station 130 on a lower fill section than on the existing highway.

At station 140 considerable difficulty with an unstable silt deposit was experienced during the construction of the existing highway requiring sub-excavation to a depth of some 12 feet and blanketing the silt off with a thick layer of sand. To avoid this condition in any new construction the vertical alignment would be raised and the alignment fitted in to the slope above the present grade. This material appears to be fairly dry glacial till which should be reasonably stable. Cut slopes in this area would be in the neighbourhood of plus or minus 48 feet.

From station 150 to station 190 the alignment parallel to the existing highway traverses relatively easy terrain at the same elevation as or slightly higher than the existing highway with cut slopes in the area of station 180 approaching the plus or minus 25 foot range.

At station 190 the alignment drops to the valley floor on a grade of 4% where it merges with the present alignment at station 220. This alignment will encroach slightly on the Duthill sensitive area at this location interfering with the stream flow and with the evidence of ancient beaver activity.

Similar to the alignment chosen for route corridor "B" it is recommended that the railroad be removed southward to the new location and the additional lanes located on the existing railway alignment. As a consequence the new alignment will leave the existing Trans-Canada Highway at station 210 and divert to the railway alignment on a 2° curve. From here westward the alignment duplicates that suggested for route corridor "B".

This alignment requires two crossovers from the existing highway with some traffic interference necessary and also the opening up of substantial roadway cuts in the area from station 0 to station 210 most notably at the Carrot Creek area and from station 175 to station 205. It is felt that a balanced grade line can be achieved in the first four miles but from mile 4 westward the grade would be constructed in whole from borrow material.

This alignment proposal will possibly require the relocation of the existing underground Alberta Government Telephone cable from station 80 to station 210 since it is presently installed north of the existing highway.

e. Railway Modifications Generally

In recognition of the fact that the environmental impact in the Duthill, Chinaman's Creek, Cascade Power House areas could be minimized extensively by relocating the railroad as described under the route corridor "B" description an on-site meeting with representatives of the Canadian Pacific Railway was convened. During the meeting the terrain was examined and the general concept was discussed. It was generally agreed that the necessary grade work could be done under the highway contract but that all sub-ballasting, ballasting, tie and track laying, telegraph line relocations, etc., would be handled by the C.P.R. and the cost passed on to the Government. In addition, the removal of all track and appurtenances on the existing track would be handled by the C.P.R. and the cost minus the value of the salvaged material would likewise be passed on to the Government.

A general agreement was reached with the Divisional Engineer of the railway company that the relocation was feasible and that the C.P.R. would have no objection to it per se, provided that suitable agreement could be reached regarding transfer of right-of-way and that the operating cost of the railway was not affected adversely.

Subsequently, information regarding the cost of the C.P.R.'s portion of the relocation was received from the Divisional Engineer of the C.P.R. to the effect that the net cost to the Government would be $87,000.00 per mile. This figure together with an estimated grading cost for the relocation has been used in arriving at the cost of route corridors "B" and "B-1" presented elsewhere in this report.

It must be emphasized that the preliminary negotiations carried out to date have dealt only with the engineering aspects of the relocation and there has been no input with regard to rights-of-way transfer or negotiations. Any costs involved in this aspect of the relocation have to be considered over and above the estimates contained herein.

3. Planning and Visual Implications (Volume II, Maps 12 - 17)

The selected corridors were evaluated as to the visual impact including both the projected view from the road and the final alignment's appearance as a man-made feature within the Park. The implications as to future planning and Park uses were also reviewed for each corridor.

a. Route Corridor "A"

The new alignment, moving in a westerly direction, closely parallels the existing highway from the Park gate to Carrot Creek. The result will be a similar visual experience to the present route. The introduction of a landscape median will improve the visual quality over the urban section just outside the Park.

The west-bound line then diverges from the existing route and moves up the Carrot Creek fan toward the upper terrace area. This section, with its diversity of vegetation and open space, Carrot Creek, and curvilinear alighment, could be an interesting visual zone with the exception of the transmission line right-of-way that must be crossed near Carrot Creek.

Stations 110 to 300 will be a rather monotonous section due to the uniformity of forest cover and enclosed view. The potential for extensive views over the Bow Valley is difficult to capitalize on due to the heavy forest cover and the alignment's relative position to the edge of the valley rim. The somewhat choppy characteristic of the topography will require numerous cuts and fill sections making it difficult to visually integrate the road with the land.

At Johnson's Lake views would be opened up for the road users but again these qualities could be offset by the transmission line easement and the required filling in to the lake.

Between stations 400 and 408, excellent views will be possible over the valley and Banff townsite. As the road moves down to the valley floor, dramatic views of Cascade Mountain would present themselves; however, local conditions require an abrupt transition with extensive cuts and fills.

Visually, Corridor "A" would be hidden for the most part from observation from other points in the Park. However, a number of negative visual scars will result. These include an eighteen-foot cut required immediately west of Carrot Creek, filling into Johnson's Lake, general cut and fill sections of six feet throughout the upper area, and a massive scar resulting from the corridor transition to the valley floor between stations 405 and 440 requiring fifty-foot cuts and seventy-foot fills.

From a planning aspect the route opens up access to the upper area. However, it is not likely that a significant amount of development would occur in this zone. The corridor adjacent to Johnson's Lake may make it too accessible and lead to its over-use.

b. Route Corridor "B"

As this new alignment proposal moves in an easterly direction, we begin our review at the traffic circle area. The first half of this corridor requires that the highway and the railway be combined. The proposal recommends moving the railroad to allow for a visually acceptable alignment, with buffers of trees between train and auto routes, as well as a green median on the roadway. Major views would be similar to the present alignment for this section. The alignment leaves the existing Trans-Canada Highway route at station 230 and generally parallels the railroad to the east gate. The proposed route passes through a diversity of plant materials and a variety of open spaces that provide interesting park-like views. In most cases an adequate buffer of existing trees will separate the highway from the visual distraction and headlights of passing trains.

The visual impact of Corridor "B" is concentrated along existing highway and railway routes and therefore does not introduce a man-made feature in a new area. The uniform topography allows for a close-fitting vertical alignment, minimizing the clearing requirement.

This alignment offers access to the Bow Valley floor, providing the opportunity to develop a minor interpretive or picnic site if future park planning so dictates. The position of the railroad eliminates any direct visual connection to the Bow River. The 1968 D.P.W. proposal offers a similar visual experience to Corridor "B" with the exception of the western section. That alignment does not necessitate moving the railroad and confines itself to the existing right-of-way and immediately adjacent lands. The resulting visual impact will be greater and the view from the highway less desirable.

c. Route Corridor "B-1"

In twinning the present Trans-Canada Highway throughout the length of the study area, as proposed by Corridor "B-1", the driver's visual experience will remain virtually unchanged from the current situation. The visual impact of the twinning, however, will be much greater within the total context of the Park due to numerous cuts necessitated in the right-of-way widening process.

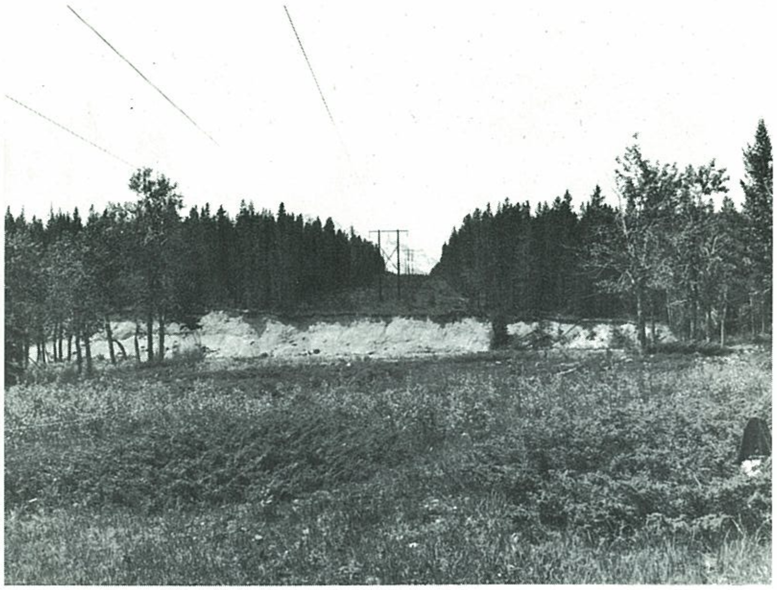


Plate No. 13

This scene represents a classic example of a negative visual feature. The impact of these power corridors is considerably reduced when they are not readily visible from railway lines, highways, hiking trails or recreational site development.

Plate No. 14

The dilapidated buildings in the lower centre portion of the photograph are part of a greenhouse business which formerly operated within the park. While this area is presently not visible from the existing highway it could become a negative visual feature provided the railway is not relocated.

Plate No. 15

Slopes which are steep and subject to erosion are difficult to stabilize. In many cases regrowth of vegetation is slow or impossible. Consequently roadside scars of this nature can persist for decades after the highway construction is completed.

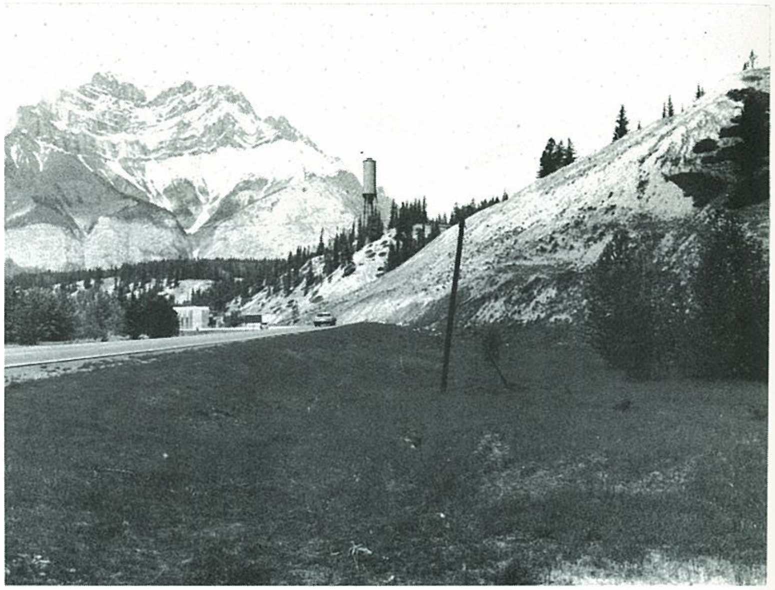


Plate No. 16

This photograph illustrates another classic example of a negative visual feature. Aside from the feature being totally out of context with the desired atmosphere of a National Park, the structures are unsuitable in form and colour. In addition, depending on the viewer's position, the tower and power station mar the majestic picture of Cascade Mountain.

APPENDIX A

GEOLOGIC HISTORY

1 EXPLORATION

Up to the middle of the nineteenth century the Bow River Valley had been travelled only by Indians. Since then, however, a great variety of white adventurers have visited the area. Notable among these have been geologists. James Hector was the first, arriving in 1858 with Captain John Palliser's expedition. In fact, Hector's discovery of Banff's "warm mineral springs" appears to be the prime motivation of the first coach road into the area. Then, George M. Dawson and R. G. McConnell of the Geological Survey of Canada began detailed work in the late 1800's. McConnell's pioneer studies on the Paleozoic rocks turned out to be particularly fundamental for all subsequent work in this part of the Rocky Mountains. At the turn of the century, D. B. Dowling of the Survey became engaged in a study of the coal resources of the Bow River Valley and eventually contributed a monumental inventory of this valuable material that occupied much of his life.

Since the early 1900's much geologic exploration of Paleozoic and Mesozoic rocks has been undertaken by the petroleum industry for extrapolation into the subsurface of the adjacent oil-rich foothills. This work began primarily at the period of discovery of Turner Valley which culminated in 1936. Subsequent more detailed work within the last 36 years has been carried out by the Geological Survey of Canada and industry which has resulted in a large amount of information that provides a modern concept of the early geologic history and origin of the mountains.

The complex glacial history of Bow River Valley was unravelled by N. W. Rutter in 1965, and reports on existing glaciers in Banff Park include over 100 documented investigations, some of which date back to 1907.

2 DEVELOPMENT

A layer of sedimentary rock nearly three miles thick occurs below the surface in the study area. These rocks record the fascinating kaliedoscope of changes of life and landscape that have occurred in this part of Alberta throughout the last 600 million years of geologic time. Below this thick layer of sediments are the granitic rocks of Precambrian age which are in reality the subsurface extension of the ancient rocks that form the great expanse of the Canadian Shield 600 miles to the northeast.

As a result of exploration for hydrocarbons in Alberta, a vast amount of knowledge has been gained about this thick sequence of sedimentary rocks. These deposits were formed during the three major divisions of geologic time known as the Paleozoic, Mesozoic, and Cenozoic Eras.

a. During the Paleozoic Era

The lowest group of sedimentary rocks fall within the Paleozoic Era spanning a time interval from 600 to 225 million years ago. Throughout the Paleozoic Era an extension of the Pacific Ocean occupied a large part of Western Canada. However, broad upheavals took place during this time and resulted in numerous alternating phases of dry land and sea. Life evolved from simple forms to an astonishing array of marine creatures in the sea and exotic vegetation on dry land.

One of the most important economic aspects of the Paleozoic Era was the deposition of porous limestone and dolomite, and the growth of extensive coral and algae reefs in the tropical Paleozoic seas for which Banff is famous in the world geologic arena. Upon burial and ideal "trap" conditions these porous beds far below the surface later acted as reservoirs for the entrapment of oil and gas. As early as 1914 gas was known from the area of Turner Valley, 50 miles to the east, and in 1936 Alberta's first great oilfield was discovered at Turner Valley in Paleozoic dolomite at a depth of over 6000 feet.

b. During the Mesozoic Era

The next geologic period is known as the Mesozoic Era which lasted from 225 to 70 million years ago. Forms of life were more highly developed than those in the Paleozoic Era, but Alberta still experienced fluctuating conditions of alternating invasions of the sea and emergence of dry land. The greatest part of the sediment deposited in the Mesozoic seas was sand and mud, later to form sandstone and shale in response to compaction under additional layers. The dominant sandy nature of these sediments reflects a gradual change to an environment quite different from that of the reef-bearing tropical seas of the Paleozoic Era. The main reason for this change was that the Mesozoic Era was a time of more persistent and stronger upheaval to the west of Alberta providing highlands upon which agencies of erosion set to work. Rivers developed in the elevated regions and flowed eastward carrying detritus to the embayments of the sea. Finally, near the end of the Mesozoic Era, the sea was pushed entirely out of Alberta. The area of the present Foothills, parts of the Front Ranges and adjacent plains turned into a vast swamp and deltaic coastland where thick vegetation grew which was later to be compacted and transformed into coal. A great variety of long-extinct reptiles achieved a truly spectacular array of form and habitation during the Mesozoic Era in Alberta, but an equally distinctive marine invertebrate fauna far to the east also marks this period of time. A splendid plant growth clad the deltaic banks of the rivers and would have presented a luxuriant landscape to a traveller at that time; in addition, the lush vegetation provided a staple diet to the Mesozoic dinosaurs.

c. During the Cenozoic Era

The Mesozoic Era was succeeded by the Cenozoic Era of geologic time, popularly known as the Age of Mammals. At the beginning of the Cenozoic Era about 70 million years ago much of the foothills area received tremendous quantities of streamborn sand dumped by large rivers off the rising western highlands. The Rockies themselves received little of this deposition since they were beginning to rise also. The uplift pressures in the west began to strengthen and migrate eastward affecting the interlayered limestone, dolomite, shale and sandstone beds in this part of Alberta. This pressure from the west, or compression, together with an overall uplifting force caused the folding, sliding and elevation of the layered rocks forming the majestic and castellated prominences of the Rocky Mountains of today.

The Mountain-building forces subsided gradually providing the pause necessary for the development of another series of vast rivers carrying pebbles and boulders down from the newly created highland. The gravel on top of the Cypress Hills and possibly Porcupine Hills testifies to the existence of these mysterious rivers. During the next 25 million years the elevated area to the west again began to rise, but much more slowly this time. This allowed these preglacial rivers to dissect or begin to cut down into the land surface. The result was the initial formation of the loci of our major valleys which were up to 2000 feet deep in the mountains and up to 1500 feet deep in the plains. In this way the fundamental architecture of the Rockies we know today was determined. However, the form of the mountains was destined to undergo still another change - that change related to the world-wide cooling trend. The shift towards a cooler climate was not drastic, perhaps amounting to an annual average of two to three degrees colder, but the effect was strongly reflected throughout the world.

Because of the newly created uplifted mountains to the west, great snowfields accumulated at high elevations. Gradually the snowfields gave rise to glaciers, great rivers of ice which flowed down the valleys rendering profound effects on the existing landforms as they ground and gouged their way to the plains. Although it is known that the glacial period endured for perhaps 2 million years, only the deposits of glaciers that advanced in the last 45,000 years have been recognized in the park. There have been at least three main advances down the Bow Valley and all but the last flowed beyond the mountains. The earliest glacier is referred to as the Pre-Bow Valley advance which was at least 1500 feet thick. Very little is known about this glacier since the till that was deposited when it melted is in the subsurface, but gravels that were deposited during recession occur in the bluffs east of Banff townsite.

The most extensive advance in the area is represented by deposits which form most of the landforms today. This advance is called the Bow Valley advance and probably reached its maximum extent over 15,000 years ago. Even during this advance the ice never reached an elevation higher than 8,000 feet so there were many nunataks poking through the ice such as the top of Cascade Mountain. The Bow Valley glacier was at least 2,500 feet at Banff townsite and extended well into the foothills probably joining with the continental ice sheet in some way. Apart from a minor re-advance, the Bow Valley glacier recession was marked by the formation of a complicated series of outwash terraces which characterize the valley today.

The next valley glacier development is known as the Eisenhower Junction advance which occurred over 9,000 years ago. This glacier did not reach the study area. Likely, however, the cirques in the mountains adjacent to the area contained cirque glaciers during this period. Some of the canyons, such as Carrot Creek, were probably subject to erosion during the melting of these cirque glaciers at this time.

Since the Eisenhower Junction advance, less extensive advances have taken place in the Banff area. These were confined to cirques and higher reaches of the tributary valleys of the Bow River and only erosion of their meltwater would have had any modifying effect on the terrain in the study area.

A warming period between 4,000 and 6,500 years ago occurred in the Banff area and is referred to as the Altithermal.

This period is represented by wind blown sand deposits mainly and a volcanic ash layer which has been found in other similarly affected areas. However, the most profound change since glacial time is clearly recorded by the development of the Bow River Valley and its tributaries. The valley floor has been systematically lowered about 200 feet since the disappearance of ice, and has formed a remarkably complex series of abandoned terraces and channels. There were times during this period when there was much more river erosion and deposition than we see today. This is well shown by the existance of very large abandoned alluvial fans such as the one at Carrot Creek. In fact the material was deposited so fast in these fans that the Bow River was unable to maintain its normal development and had to change course. This partially accounts for the meandering and braided channel the Bow follows through the area today.

The scenic attraction of the Rockies today is in a very large measure due to erosion by glaciers and to the landforms developed during the recession of the glaciers. Glacial deposits are the parent materials of most soils in the area which support the vegetation. The vegetation is turn provides sustenance for wildlife and the habitat which originated long ago completes the physical and biological necessities for continued sustenance of this environment.

APPENDIX B

GEOLOGIC FEATURES & IMPLICATIONS

Geologic features of recreational, scientific or engineering significance in the area are related to aspects of the bedrock geology, surficial deposits, geomorphic units and groundwater.

1 Features of the Bedrock

a. Fossils - Petrified Wood

Between mile 6.5 and 7.8 the present highway has been cut into a thin bedded series of sandstone and shale of the Kootenay Formation (Cretaceous age). The beds are steeply inclined to the west illustrating the degree of tilting during uplift of the mountains. Several examples of coal seams occur within these rocks, and excellent specimens of petrified "tree" stumps and other plant fossils abound in outcrops along the slope.

b. Subsidence Pits and Coal Mines

Several near-surface coal mines operated in the early 1900's close to Anthracite. The one right at Anthracite received the most mining according to old records, and in recent years the old stopes have started to collapse. The surface is presently pock-marked by a series of subsidence pits presumably located over the old stopes. Surface and groundwater is seeping into the pits and may be increasing the rate of erosion.

2 Geomorphic Features and Surficial Deposits

a. Scarps and Slopes

All slopes and scarps of the area are acted upon by gravity or mass movement processes. Although generally the slopes appear to be quite stable and composed of cohesive dense materials, some localities such as those underlain by glacio-lacustrine sediments are highly sensitive to disturbance of any kind.

Areas of a terrace adjacent to scarp warrant special consideration since archaeologic sites are often concentrated close to scarp edges.

b. Active Alluvial Fans

Carrot Creek active alluvial fan, although considerably restricted by the railroad, will nevertheless respond dramatically to any measurable disturbance. For example, if material is removed from the base of the fan, the stream will begin to restore equilibrium by accelerated erosion upstream and corresponding deposition downstream. Precise consequences of disturbances require more study to define.

c. Alluvial Terraces and Abandoned Alluvial Fans

The principal scientific value of abandoned fans and alluvial terraces is that these are naturally formed features of the terrain and record certain events of the geological development of the park. Some of the landforms of these features are defined only by subtle breaks in slope or other minor features of the topography.

Terraces and fans are also groundwater aquifers and may act as significant recharge areas for an area. All deleterious activity in recharge areas will therefore eventually be reflected in the chemistry and behaviour of a groundwater reservoir.

d. Outwash Terraces and Ground Moraine

Most of the surface above the general level of the Bow River and tributary valleys is composed of either stratified drift in outwash terraces or till which appears as ground moraine. These materials are the most common and least sensitive to development, except for where influenced by other factors such as groundwater or slope instability.

e. Features Related to Groundwater

The basic planning implications presented by a groundwater evaluation is to insure that areas of recharge are protected from undesirable injection of deleterious materials or activity, and to recognize areas of discharge and their relation to other factors of the natural and social environment. Therefore, a careful cause and effect analysis of a groundwater region must be carried out prior to development.

3 Summary of Environmental Geology Implications

a. All potential fossil localities should be protected.

b. If deep cuts are to be made it would be most resourceful to blend the cut into a natural declivity of the terrain. New cuts are not altogether undesirable and in fact add to the growing knowledge of geologic features of the park.

c. Landforms such as abandoned alluvial terraces and fans should be protected from destruction since these features record specific phases of the geologic history and are not easily discernible under the best conditions. Also, good examples of such features are rare.

d. Disturbance of active alluvial fans must be thoroughly analyzed for consequences of planned development.

e. Natural erosional landforms such as hoodoos and scarps are highly sensitive features in many ways and should not be disturbed.

f. The area of subsidence pits near Anthracite is to be completely avoided since the entire scarp and adjacent ground may be unstable. Detailed route selection is required here.

g. Till landforms are the least sensitive geologically for the purpose of development since there is an abundance of this kind of landform in the study area. Also, till is least permeable so that complications with respect to groundwater are minimal.

On the other hand, one exception to this general statement is that the most mature and nutrient-rich soil is developed on till, although these soils are usually very coarse textured. In contrast soils developed on alluvial deposits are least mature and contain less nutrients, therefore alluvial soils are least sensitive to development.

h. Outwash deposits, or stratified drift and meltwater channels represent important groundwater aquifers and present formidable development implications which demand thorough analysis.

i. The most suitable geologic feature on which to construct a road strictly from the standpoint of traditional engineering geology principles is on flat or gently sloping alluvial landforms that are composed of gravel.

j. Potential archaeological sites along the final route location should be thoroughly evaluated. It is further advised that an archaeologist be retained throughout the excavation phase of future construction.

APPENDIX C

VEGETATION & SOIL IMPLICATIONS

1 Lodgepole Pine

a. Regeneration Potential

Removal of the forest cover by fire will be followed by the same type of vegetation. This forest may be even more dense than the one it replaced. Removal of the forest cover by means other than fire will result in somewhat slower reforestation by a mixture of lodgepole pine and spruce. Some trembling aspen or balsam poplar may also become established. This type of disturbance will result in improved wildlife habitat at least until the tree canopy closes in. Erosion following removal of the tree layer is not severe because the herb cover becomes more dense. This type has a moderate to good tolerance to use by man.

b. Stability

This type is largely the result of one severe burn. Previous forest types on these sites could have been spruce, spruce-pine, or pure pine. On most sites succession will lead to a dense spruce or a spruce-pine forest. This process will remove much of the grass cover resulting in poor wildlife habitat, particularly for large mammals.

Shrubs + Forbs too

c. Complexity

This type is very simple, both in terms of species composition and spatial variation. Succession to spruce will result in a forest which also lacks complexity. — diversity?

d. Value

This type is used for grazing and browsing to some extent during the summer and fall. It receives only light use during the winter by deer and elk. Winter use is restricted because of snow cover and lack of a significant browse layer. Snow melts very slowly in this type because of dense tree canopy.

This type is very monotonous and fairly extensive in the area. It has little aesthetic value other than providing a continuous forest cover.

2 Lodgepole Pine - Spruce

a. Regeneration Potential

Removal by severe fire will result in dense lodgepole pine stands. Trembling aspen and balsam poplar will increase if there is a residual of these species in the pre-fire stand. Removal of forest cover without fire will produce a slightly more open forest with an increase in the spruce component. This will improve the wildlife habitat value until the forest canopy returns to its original density. Erosion following removal of vegetation is minimal due to the general lack of steep slopes and a tendency for the herb layer to form a good ground cover. In general, tolerance to use by man is good except in very dense stands with a sparse herb layer.

b. Stability

This type forms as a result of a severe burn followed by several partial burns or ground fires. This type of burning has resulted in stands which are slightly more open than the even-aged lodgepole pine stands. These stands were more open in the past and contained a higher proportion of Douglas fir because of frequent ground fires. The lack of such fires in the last fifty years has resulted in a trend towards denser forests, an increase in spruce and a deterioration of the herb and shrub layers. This type will change very slowly in the future. It will become slightly more dense and the proportion of spruce will increase. Stands near the valley bottom will probably remain fairly open. Both this type and the lodgepole pine type are very susceptible to fire. It is likely that there will be some fires in these types in the future even with the present strict fire control policy.

c. Complexity

This type is quite simple in both species composition and spatial variation. Present fire control policies will result in an even greater simplicity.

d. Value

There is moderate use by deer and elk for grazing and browsing during the summer and fall. Winter use is limited by the snow cover which makes accessibility to the herb layer difficult. Very sparse shrub layer is a limiting factor as well.

This type may be considered important only because it is very extensive. Otherwise its importance rating is low because of lack of variability, low wildlife habitat value, and limited recreation potential.

3 Aspen - Poplar, Poplar - Spruce

a. Regeneration Potential

Removal of this type by fire or other means will result in a dense growth of aspen and poplar suckers from the old root systems. Spruce is almost completely eliminated by fire. Erosion is not a problem in this type because of the dense herb layer and good soil fertility. Disturbance or removal of the trees almost always results in excellent wildlife habitat.

b. Stability

This type is well adapted to both crown and ground fires and can maintain itself indefinitely under these conditions. With fire protection there has probably been a slight increase in the spruce component, however the aspen and poplar seem to be holding their own in most stands. The dense herb layer makes invasion by spruce very difficult. It appears that, in general, aspen and poplar will continue to dominate this type, although spruce may be able to take over some sites. Shifting of the stream across the fan and flooding will also help to maintain the aspen and poplar. The open nature of these stands and the dense herb layer make them very tolerant to use by man.

c. Complexity

The herb layer is quite rich in species. This type varies considerably from site to site in both tree density and species composition.

d. Value

Excellent wildlife habitat for large mammals as well as a number of species of small mammals and birds. The type is used during all seasons but is particularly important as winter habitat. Animals browse on aspen and poplar suckers as well as other shrubs. Snow is removed more rapidly here because of deciduous tree cover. This allows animals to use the herb layer. Overuse is a problem in many stands where aspen and poplar suckers have been reduced to a very low level.

The open nature of these stands plus their diversity and interesting wildlife and vegetation make this type considerably more desirable for recreation than most others.

4 Spruce

a. Regeneration Potential

A return to the spruce forest occurs quite rapidly in subtype 1. In subtype 2, spruce will return more slowly because of dryer conditions. During this period the ground will be covered by a moderately dense herb layer. Erosion is not likely to be a problem except during floods. At this time erosion may take place on disturbed sites. Natural erosion also takes place by shifting of the river channels. Tolerance to use by man is only fair. Heavy use, particularly in subtype 1, quickly destroys the ground cover.

b. Stability

Neither subtype is very susceptible to fire because the stands are usually surrounded by open areas which will not carry fire. Adequate moisture conditions are also beneficial in this regard. Although it cannot be said with any certainty, it appears that this type is quite stable. In some stands there is a tendency towards a more dense spruce canopy. However, this increase in spruce density in some stands is balanced by removal of other stands by shifting of the river channel, thus creating younger sites which will eventually carry stands of the spruce type. Artificial control of the river channels will result in a greater area of this type.

c. Complexity

There is considerable variation in both environment and vegetation structure and composition as indicated by the necessity of breaking this type into two subtypes. However, any individual stand is fairly simple in vegetation composition.

d. Value

Dense spruce stands provide cover for wildlife in areas where such stands of other types is usually lacking. This type will provide some grazing and browsing, particularly in the more open subtype 2.

It is not an important winter feeding area because of snow cover and the general absence of good browse species.

Subtype 1 has some interpretive value because, along with the Douglas fir they contain the oldest and largest trees at lower elevations in the park. The fact that it is the only mature coniferous type close to the river makes it a very conspicuous type for anyone using the river or riverbank.

5 Parkland

Alluvial Fans

a. Regeneration Potential

Removal of vegetation by fire or other means will result in healthy stands of aspen and greatly improve wildlife habitat. Erosion is not likely to be a problem.

b. Stability

This type appears to be slowly developing towards dominance by spruce. Suckering by the overmature aspen is very limited. Suckers have been mostly removed by wildlife. Present stands are very tolerant to use by man.

c. Complexity

Vegetation is quite simple except for the herb layer. Spatial variation is moderately complex.

d. Value

This type was very good wildlife habitat in the past when frequent fires swept through the stands, burning the ground vegetation and sometimes even the trees. It has deteriorated to some extent in recent years due to heavy wildlife use and the overmature nature of the aspen. It is still used fairly heavily. A return to young aspen would result in excellent wildlife habitat.

Terraces and Upland Areas

a. Regeneration Potential

Disturbance will probably result in an increase in aspen and Douglas fir. This type is not very susceptible to fires because of the open nature of the stands. Reforestation should be quite rapid. Erosion is not a problem except on slopes.

b. Stability

This is difficult to generalize for this type. Most stands are the result of differential burning. Denser stands of spruce and Douglas fir can be expected with continued fire control.

c. Complexity

Tree cover is variable because of differential burning. Herb and shrub layers are quite simple and uniform. Spatial variation is considerable.

d. Value

This type is of some importance to wildlife but not prime habitat by any means. Some sites are exposed on southerly slopes and, therefore, provide some grazing in winter and spring.

Flood Plain

a. Regeneration Potential

Disturbance will result in rapid regeneration of dense spruce. Removal of the fine sediments will result in colonization by balsam poplar. Erosion is not a problem in this type.

b. Stability

Succession to closed stands of spruce is rapidly proceeding in this type. This is quite likely due to blockage of the alternate channels of the Bow River by the C.P.R. tracks. This has resulted in a reduced intensity of flooding and the deposition of fine sediments. These conditions are ideal for the invasion of spruce. If it were not for the C.P.R. tracks, much of this area would belong to the active flood plain type. Under present conditions, succession can be expected to proceed to the dense subtype of the spruce type over much of this area.

c. Complexity

The successional trend here is from complexity (active flood plain) to simplicity (spruce forest).

d. Value

At present this is not high quality wildlife habitat due to the lack of a significant shrub layer. It is used some for grazing. Succession to spruce will result in the loss of what habitat value it presently has.

Meltwater Channel

a. Regeneration Potential

This type seems to be relatively stable. Aspen is reproducing and the number of spruce saplings is small.

b. Complexity

Stands are moderately complex, however spatial variation is limited because of the small area occupied by this type.

c. Value

Very good wildlife habitat for both winter and summer use. The shrub layer provides excellent browse.

Important because it covers only a small fraction of the total area. May be important for scientific purposes because it can be used to study conditions under which good wildlife habitat is maintained.

6. Wet Meadow

Upland Forest

a. Regeneration Potential

Disturbance will be followed by a rapid recovery of the same type of vegetation unless the water level is changed. Lowering of the water table will probably result in spruce and willow invasion.

b. Stability

This type is very stable unless disturbed. May be a long-term trend towards filling in by sediments and invasion by willow and spruce.

c. Complexity

Vegetation is simple although variation from slough to slough is considerable because of environmental differences.

d. Value

This type is of little importance to big game except for a limited amount of use by Moose. It is important habitat for small mammals and birds, some of which are highly dependent on this type. It is also important because it is a distinct type of limited occurrence in the area. Could be used for interpretation.

Flood Plain and Alluvial Fan

a. Regeneration Potential

Disturbance will result in a fairly rapid return to the same vegetation unless there is a change in the water table.

b. Stability

This type is stable except for a small amount of spruce invasion around the margins. If drainage is improved, succession to spruce will take place. This will result in a deterioration of the shrub layer and a marked decrease in value as wildlife habitat.

c. Complexity

This type consists of moderately complex communities which vary considerably from site to site.

d. Value

Excellent habitat for moose, both in winter and summer. It is also important winter habitat for deer and elk because of the dense cover of highly palitable browse species. Beaver and a number of other small mammals are highly dependent on this type. It is also important because of the limited area which it covers. Has very high potential for interpretive purposes.

7. Dry Southwest Facing Slopes

a. Regeneration Potential

Disturbance will be followed by a return of a forest which is very similar to the present type.

This will be a slow process on steep slopes. Erosion can be severe on steep slopes. This has happened around the townsite of Anthracite. This type can only withstand light use by man because of the thin soils, sparse ground cover and susceptibility to erosion.

b. Stability

These stands have changed little since the coming of the white man. They should change very little under present conditions, except for a slight tendency towards an increase in density of the tree cover.

c. Complexity

This type is quite variable due to environmental differences and historical factors.

d. Value

This type is important for both large and small mammals and birds. Elk and deer use this type heavily in winter and spring. Southerly-facing aspect of this type means that it is largely free of snow in winter so that animals can graze with little difficulty. It is heavily used in spring because new grass shoots are present here sooner than in any of the other types.

This is a very distinct type of forest which is of limited extent in the area. Old stands have high aesthetic value. This type is the only example of a savanna-type forest in the park. It has potential for interpretive purposes.

8 Active Flood Plain

a. Regeneration Potential

Removal of vegetation will be followed by a similar type of vegetation. This process will be slow because of the poor soil and droughty conditions. The vegetation does not provide a dense cover so that protection against erosion is not good. However, erodability of gravels is not great except during flooding and if this occurs, it is unlikely that the vegetation can stop erosion. This type has a good tolerance to use by man because of the coarse gravels and sparse vegetation cover.

b. Stability

This type is very dynamic in the sense that various changes are going on in different parts of the flood plain at the same time. These are related to erosion and deposition produced by the river and the resultant adjustments by the vegetation. These changes tend to balance out over the whole area so that the net change as a whole is close to zero. Artificial control of the river channel can result in deposition of finer material and plant succession leading to the spruce type. The building of the C.P.R. track has produced this change in some areas. It is unlikely that fire protection will produce any changes in the vegetation.

c. Complexity

The considerable complexity of this type has already been referred to. Although vegetation is simple, its spatial variation is considerable. Its dynamic nature also adds to the complexity.

d. Value

This type is important winter habitat for large mammals. Elk, deer and moose use the area for browsing. Heavily used species are balsam poplar and willows. There is also significant amounts of use here during other seasons.

This type has moderately high recreational value because of its open nature and close proximity to the river. It is also a good place to observe wildlife. It has potential for various types of park interpretation such as those related to the river, plant succession, and wildlife.

9. Mountain Slopes

a. Regeneration Potential

Recovery after disturbance is often slow because of the shallow soils. Erosion can be a problem in sites which have some soil development.

b. Stability

Although much of this type has been burned in the past, many old trees can be found here. Fires tend to burn very unevenly so that many trees survive. Although the average age of these stands will increase with time, it is unlikely that the overall characteristics will change much in the future. Stands will remain open and species composition should not change to any great extent.

c. Complexity

While species composition is relatively simple, both the pattern and density varies greatly due to natural factors such as slope, bedrock, exposure and fire.

d. Value

Those parts of this type at lower elevations are important winter habitats for bighorn sheep. The southerly aspect, steep slopes and lack of a deep snow cover provide the necessary conditions for this animal. Summer use by elk and deer is fairly heavy throughout this type.

APPENDIX D

HIGHWAY DEVELOPMENT & WILDLIFE MANAGEMENT

The entire Bow River Valley is utilized as a winter range by a large percentage of ungulates occurring in the study area. The construction of another road through such habitat would destroy a significant portion of an already critical resource.

Furthermore, those sections of the proposed new highway which parallel the existing highway with a median separating the two would probably result in a much higher mortality rate for ungulates than now exists.

Studies conducted in the United States indicate that mortality of big game more than doubles for two lane highways when compared to the original single lane. (Dr. Val Geist, pers. comm.)

There are several possible methods to offset this increased mortality.

1. Use of Reflector Mirrors

An inexpensive method which has resulted in a sensational reduction of white-tailed deer auto accidents in Missouri might be equally effective for elk.

In one study conducted in Missouri, 29 deer were killed at night along a quarter-mile stretch of highway in the twelve months prior to the use of reflectors. During the next twelve months after installing the reflectors, there were no nighttime deer-car collisions on the same stretch. In another area, collisions dropped from 19 to 2 through the use of reflectors.

The reflectors, which cost about forty cents each, were set 150 feet apart and staggered so there was one every 75 feet along the road.

An examination of the available kill statistics in the study area revealed two "hot spots" which elk, and to a lesser extent other animals, favored as crossing points. These are shown on the accompanying maps and are located just inside the park boundary at the east gate, and in the area of the Tunnel Mountain Road.

The fact that traditional crossover points exist, facilitates the implementation of control techniques such as reflectors and methods of regulating animal movement via underpasses or fencing discussed in the following paragraphs.

2. Redirecting Big Game

Other studies have indicated animal fatalities on highways are reduced or eliminated by providing underpasses at traditional crossing points.

Judicious use of metal fencing hidden in the trees bordering the road would direct big game to the traditional crossover sites where the use of reflectors or underpasses might control animal mortality.

Seeding the right of way attracts not only ungulates but also bears. Replacement of seeded areas by cobbled sections constructed of stones

would prefer to see some type of unpalatable vegetation rather than stones.

could be utilized to prevent ungulates from crossing the highway at that point as well as being less attractive to bears.

Assuming any of the above methods were used to prevent or diminish the number of big game-auto collisions, the problem of reducing the already limited winter range remains.

This problem could be circumvented by constructing the road on the terrace where the forest cover is sub-climax and predominantly lodgepole pine. As may be seen on the wildlife map, this area provides poor winter range for ungulates, Class 3. There are a few scattered stands of Douglas Fir which, because of their scarcity and uniqueness in the park, should be considered in any site location of a highway on the terrace.

Existing winter range must either be maintained or replaced if one undertakes a developmental activity that destroys this already limited area. If the decision is reached, on the basis of other resource inventories, to construct the highway in its proposed location the effect on ungulate populations would not be detrimental if clear-cutting of lodgepole pine were to be carried out on the mountain slopes under certain strict conditions.

Under existing parks policy, fires are kept under strict control. It is for this reason that winter range is at a premium, and the beaver are almost extinct, since natural plant succession which would provide meadows and aspen growth after a forest fire are replaced by an unnatural permanent sub-climax forest cover.

Studies in Montana (Basile, et al, 1971) have shown that the clearcutting of lodgepole pine stimulates production of understory vegetation that may provide a grazing resource for livestock and big game for an estimated 20 years or more. Peak production of 800 to 1,000 lbs./acre occurred about 11 years after clearcutting.

On this basis, therefore, clearcutting of lodgepole pine is recommended if the highway is constructed in the Bow Valley, if:

a. the sites for clearcutting are chosen on the basis of sound ecological principles to maximize understory production. Such principles include a knowledge of factors of topography and soil.

b. the clearing is done in winter by manpower (chain saws) and the fallen trees removed by horse (to minimize environmental damage by heavy machinery).

c. the clearing is done in such a way that it does not look unnatural, i.e., a straight line similar to hydro rights-of-way.

d. the trees are cut as low to the ground as possible.

Bears, as mentioned previously, are drawn to the roadsides that have been seeded to prevent soil erosion, and for aesthetic reasons.

Although the opportunity to see wildlife is equated with the basic function of a National Park, such artificial techniques as seeding roadsides creates an unnatural situation which is a hazard not only to the bear but also to the park visitor. Alternate methods, such as cobbling, should be evaluated in any new highway construction planned in the park.

The proposed highway route cuts very close to a hill near the traffic circle that provides a denning area for coyotes. Although they are wary of man and the close proximity of a big highway would undoubtedly cause them to move elsewhere, there would appear to be other areas in the park suitable as den sites.

The beaver, like the elk, is a victim of unnatural ecological events that are diminishing its habitat in National Parks. For this reason it is desirable not to encroach further on the beaver's domain. The proposed route is at a sufficient distance from the one remaining family of beaver in the area, and is so located as to minimize habitat destruction that there would probably be no significantly adverse effect on the beaver population. As a matter of fact, the proposed highway includes a scenic lookout where park visitors might view the colony.

There is one Osprey nest (see Map 6) that has been utilized for the past seven or eight years. The proposed road passes very close to this nest. However, the Osprey is reasonably flexible to any disturbance in its environment as witness the nest location with respect to the railway.

Certain precautions should be undertaken to preserve this nest, principally during the constructional phases of the highway. The birds would probably become accustomed to normal traffic noises. However, to deaden the noise, the existing sparse tree cover should be augmented to provide a buffer, or even the construction of a berm should be considered.

The critical noise levels would be encountered during construction and of particular concern would be any blasting in the vicinity during egg-laying. The recorded arrival dates for the Osprey in Banff were April 29th and April 23rd in each of two years. No construction should be allowed from mid-April to the end of May. ?
late April to mid June

In addition to the serious potential encroachment on critical winter range for ungulates, the one other critical environmental impact that would occur if the proposed highway were built is on the fish resource, particularly Chinaman's Creek.

The proposed route would almost completely eradicate this excellent spawning area. Furthermore, constructional activities would cause siltations of the balance of the creek which would negate its spawning capabilities.

The suggestion has been made that a "replacement" creek could be constructed using one of the old creek beds. In theory this is possible but in practice it is costly, with no assurance of producing a suitable spawning area, which if accomplished might take several years before fish utilization occurred.

The road would also render a potential fish hatchery site (Duthill) unusable for that purpose. The water flowing down from Johnson's Lake (through Chinaman's Creek) combined with the underground springs in the area provide a wide range for temperature control throughout the year which is a prerequisite for good hatchery management.

It is strongly recommended, therefore, that the road not be located so as to adversely effect either the creek or the hatchery site.

APPENDIX E

COST ESTIMATES AND ECONOMIC ANALYSIS*

1. INTRODUCTION

The cost of a section of highway is not limited to the initial cost of construction but continues on in the form of user and maintenance costs for whatever period the highway acts as a transportation artery. Although the existance and relevance of road-user and maintenance costs are generally accepted, their magnitude and relative importance are not so frequently recognized and all too often major decisions aremade on the basis of only the initial construction cost under the generally false impression that this is the largest portion of the costs related to the highway facility. The taxpayer who, through his tax dollar, provides the initial investment for construction of the highway, similarly finances the annual cost of its maintenance as well as directly or indirectly paying the cost of operating vehicles on this facility. As servants or agents acting on behalf of this taxpayer owner-operator, we are obligated to consider his total cost resulting from the highway in the interests of providing him with the most economical and efficient facility possible regardless of whether or not the costs involved are part of highway department expenditures or budgets. We are likewise obligated to ensure that the search for highway economy does not undermine the non-highway interests of the taxpayer and we therefore must strive for a proper balance or trade-off between highway economy and non-highway interests. This of course is the objective of the study which has resulted in this report.

In the calculation and analysis of costs, an effort has been made to determine and consider all relevant construction, user and maintenance costs which can reasonably be established or estimated at this point in the project activities. This hopefully will display the true magnitude of these costs and the impact which they have on the overall economy of the highway taking into account the time value of money. It is further hoped that the economic analysis of the various physically feasible alternatives will provide some form of dollar guide or framework to which the decision maker can relate when making his decision on the proper balance between highway economy and non-highway consequences. Even though the non-highway interests can seldom be expressed in financial terms directly, the trade-off of calculated highway economy in favour of non-highway interests will indirectly establish the minimum value placed on these non-highway interests by the decision maker.

The methodology and formulae used in the economic analysis were based on or taken from the book "Economic Analysis for Highways" by Robley Winfrey. The user cost information was also taken from tables in the same source.

*This section was submitted by D.P.W.

2. SUMMARY AND ANALYSIS OF RESULTS

The basic objective of an economic analysis is to consider all costs of a number of alternatives and to seek out and identify the alternative which will provide the required level of service for the required period of time at the lowest overall cost. It is frequently, or probably even generally found in project analysis that the increasing order of magnitude of capital costs for a number of alternatives will be different than that for the corresponding user and/or maintenance costs. It is consequently necessary to look at the combined overall costs for each alternative in terms of the required level of service over the required or available service life of the facility taking into account the time value of money and establishing the alternative that is truely the most economical, which would not necessarily be the one the least expensive to construct. In the case in question however, the situation exists where the order of the alternatives in terms of increasing construction costs is the same as that for the user and maintenance costs. The selection of the most economical alternative and the ranking of the economical desirability of the remaining alternatives becomes an obvious matter without any analysis of cost data and such analysis then only serves to indicate the relative levels of economy between the different alternatives and the values of highway economy that would be sacrificed if other than the most economical alternative is to be selected.

The comparative analysis results of the four basic alternatives are tabulated in tables, 1, 2, 3 and 4 and are graphically illustrated in figures 1 and 2. The various costs for each alternative used in the analysis are tabulated in table 5.

The three expressions of comparative analysis are defined as follows:

Equivalent Uniform Annual Cost - The conversion of all project costs to the equivalent of a single uniform annual cost for each year of the project service life.

Present Worth of Costs - an expression of all costs occurring during the project service life in terms of their present worth or value at the beginning of the project service life. This concept can be equated to a fund yielding monetary return that would have to be set up at the beginning of the project in order to finance the initial construction as well as all subsequent user and maintenance costs.

Future Worth of Costs - an expression of all costs occurring during the project service life in terms of their future compounded value at the end of the service life of the project. This can be equated to the future value of a fund which would result if deposits equivalent in amounts and timing of project costs were made at a monetary rate of return equivalent to the vestcharge rate.

It should be noted that while the values tabulated for the above noted expressions are numerically significantly different, they are arithmetically equal for each vestcharge rate (i); i.e. the values for all the alternatives under one expression can be changed to one of the other expressions by the use of a single multiplying factor. There is therefore no difference between expressions in the relative economic desirability of the different alternatives and it is left to the personal preference of the decision maker to use whichever expression best portrays to him the significance of the different highway costs. By assuming a vestcharge or interest rate of 0%, the present and future worth of costs figures represent the simple arithmetic summation of all the project costs over the service life of the project, and the equivalent uniform annual cost represents the simple arithmetic total divided by the project service life. The readers attention is directed to table 4 which indicates the variance in comparisons which can result by considering only construction costs of projects as opposed to considering total costs.

On the basis of only highway economy considerations, the DPW 1968 Proposal is the most desirable alternative. This alternative however has a considerable ecological impact in its western half which makes it undesirable from the point of view of non-highway interests. The alternative next most desirable economically is Proposal "B" which supposedly has a tolerable level of ecological and environmental impact. The user and maintenance costs for both alternatives are considered to be equal with the only significant difference between the two being the cost of relocating a section of railway under Proposal "B" which allows the placement of the highway in less sensitive terrain and which is estimated to represent an additional construction cost of approximately $482,000. If the decision maker accepts that the reduction in the ecological and environmental impact as described elsewhere in this report, justifies the additional construction cost in light of the affect it has on the project cost, then Proposal "B" should be considered to be the route corridor which achieves the desired balance between highway economy and non-highway interests. The decision maker is cautioned to not only restrict his evaluation of this balance to the relationship of construction cost increase to total construction costs but to also recognize the impact of the cost increase in relation to the total cost or economy of the highway facility such as is indicated by the equivalent uniform annual cost, the present worth of costs or the future worth of costs. The variance that can result in the impact relationship is indicated by the percentage comparisons shown in table 4.

3. ANALYSIS CRITERIA

(a) Basic Assumptions

In calculating and analysing costs the following assumptions were made;

(i) That the existing highway incorporated into the new facility will be structurally adequate for the projected service life.

(ii) That the projected volume increase in traffic would not be affected by whichever alternative was chosen.

(iii) That the operating speed, or attempted operating speed, would be 65 mph for cars and 55 mph for trucks.

(iv) The same level of service can be provided within each alternative route corridor.

(v) There would be no terminal value in the facility at the end of the service life.

(vi) The volume and classification of eastbound traffic is the same as westbound traffic.

(b) Analysis Period

The expected service life for the project, and hence the analysis period for economic analysis, was based on the present growth rate of traffic volumes using the existing highway. Traffic volumes over the last eleven (11) years (one way westbound) are tabulated and graphically shown on figure 3 from which it was concluded for the purpose of the analysis that the growth rate is a uniform annual amount of 51,000 vehicles.

Due to the influence of summer traffic on the TCH in the National Parks, the 75 day mid-summer average daily traffic volume is considered to be the logical criterion in determining required highway capacity and projected service life of the proposed new facility.

Based on 1971-72 traffic volumes the present ADT_{75} is calculated to be 9,830 VPD both ways, which is 1.88 times the annual ADT. The practical capacity of the existing two lane facility to provide Level C service has been determined to be approximately 4,800 VPD both ways.

The practical Level C capacity of the proposed 4 lane facility is estimated at approximately 21,000 VPD both ways. This will of course depend on the final location and geometrics of the new facility. When the

ADT_{75} reaches this level the annual ADT would be $\frac{21,000}{1.88} = 11,170$ VPD both ways or a total annual one way traffic of 2,040,000 vehicles. Assuming that the present annual increase in one way traffic of 51,000 vehicles will continue at a uniform rate, it can then be calculated that it would take approximately 21 years to reach the practical Level C capacity of the proposed new facility. This also assumes that the ratio of ADT_{75} to annual ADT would remain approximately at 1.88 which might be unlikely if Parks policies will have a tendency to limit volumes of visitors that can be accommodated in the National Parks.

From the above it appears that a practical service life of 25 years can be assumed for the purpose of an economic analysis of various alternatives.

(c) Vestcharge Rate

The term "vestcharge rate" has been coined by Robley Winfrey which he uses to express the time value of monies invested as a percentage rate per annum. It represents the sacrifice on the part of those who supply the monies for the facility insofar as they are denied any possible receipt of monetary interest or of monetary return on the investments or expenditures in question. In an economic analysis the vestcharge rate is used as a time discounting factor which makes it possible to add together construction cost (a one-time large sum) and maintenance and user expenses (an annual disbursement) to get a meaningful total.

The rate of vestcharge appropriate to a particular economic analysis may be dependent on many factors, some of which might be;

- The price that citizens are currently paying on money they borrow for personal or business purposes.
- The probable earning rate of return in private investments or the concurrent alternative uses of the money.
- The probable rate of interest to be paid on current borrowings by the government concerned.
- The risks and uncertainties involved in the particular proposed improvement being studied.

There is of course always controversy as to an appropriate vestcharge rate for any venture particularly in the case of public projects. Mr. Winfrey suggests vestcharge rates for economic analysis of public works in the range of 7 to 15% per year. For this particular analysis four separate comparisons of alternatives have been carried out using vestcharge rates of 0%, 4%, 7% and 15% for the purpose of:

- showing the effect on total cost calculations by the different vestcharge rate assumptions that might be made, and,

- to indicate that there is no difference in the ranking of the economic desirability of alternatives on this project regardless of the vestcharge rate selected.

Although Mr. Winfrey points out that the use of a 0% vestcharge rate is a pitfall in economic analysis, it has been used in this analysis because it is a convenient method of showing the simple arithmetic summation of all costs and expenditures involved.

4. DETERMINATION OF COSTS AND EXPENDITURES

(a) Construction Cost

The determination of the anticipated initial construction cost of the different alternatives was accomplished by using as a base, the detailed estimate prepared for the DPW 1968 Proposal which is itemized as follows:

ITEM	ESTIMATED QUANTITY	TOTAL AMOUNT
Clearing.	110 AC.	.33,000.
Grubbing.	110 AC.	.16,500.
Excavation Common . .	770,000 CY. . .	308,000.
Excavation Rock . . .	32,200 CY. . .	80,500.
Compaction Pneumatic Tired Roller, Complete Unit	.600 Hr..	3,000.
Compaction Grid Roller	.1,600 Hr.. . . .	.24,000.
Compaction Vibratory Roller Steel	900 Hr..	9,000.
Compaction Self Powered Hand Operated Vibratory.	100 Hr..	500.
Water for Compaction (in 1,000 gal. units)	.4,500	18,000.
Overhaul (1,000 ft. free haul).	.214,000 CYM. .	.42,800.
Channel Excavation Common.	2,450 CY	1,250.
Granular sub base (Class 2)	.124,900 T. . .	112,410.
Hauling Class 1 & 2 .	.639,000 TM . .	63,900.
Granular Base course (Class 1)	38,400 T. . .	.44,160.
Bituminous Material MC 250.	2,450 T. . .	102,900.
Cold Laid asphaltic plant mix	46,400 T. . .	278,400.
Heavy rip rap	2,320 CY . .	9,280.

ITEM	ESTIMATED QUANTITY	TOTAL AMOUNT
Supply Corrugated Metal Pipe		
18" dia. 16 ga.	1,092 LF.	3,822.
24" dia. 16 ga.	488 ".	2,074.
36" dia. 12 ga.	126 ".	1,260.
48" dia. 12 ga.	210 ".	3,360.
30" dia. 14 ga.	214 ".	1,337.50
60" dia. 10 ga.	114 ".	2,622.
Supply Corrugated pipe arch		
36" x 22" x 14 ga.	336 LF.	3,360.
58" x 36" x 12 ga.	90 ".	1,620.
72" x 44" x 10 ga.	280 ".	7,000.
Supply Structural plate pipe arch 14'-10 x 9'-8 (5 ga.)	50 LF.	4,250.
Install corrugated metal pipe		
18" diameter	1,092 LF.	1,365.
24" diameter	488 ".	732.
30" diameter	214 ".	374.50
36" diameter	126 ".	252.
48" diameter	210 ".	525.
60" diameter	114 ".	456.
Install corrugated pipe arch		
36" x 22"	336 LF.	672.
58" x 36"	90 LF.	315.
72" x 44"	280 ".	1,400.
Install Structural Plate pipe arch 14'-10 x 9'-8	50 LF.	1,500.
Vehicles for engineers use, 1 only ½ ton pick-up	12 Mo.	2,400.
Seeding and Fertilizing	105 Ac.	11,500.
Mulching	10 Ac.	2,500.
Guiderail materials, supply & delivery		
(a) guiderail sections (including splice bolts & post bolts)	690 Ea.	11,700.
(b) 8"x8"x7'-0, end posts (including 8"x8"x14" offset blocks)	78 Ea.	1,170.
(c) 6"x8"x6'-0 line posts (including 6"x8"x14" offset blocks)	625 Ea.	5,625.
(d) Terminal sections (including splice bolts & post bolts)	26 Ea.	91.
Guiderail, Install	8,600 LF.	12,900.
Guiderail, remove & stockpile	995 LF.	995.

ITEM	ESTIMATED QUANTITY	TOTAL AMOUNT
Calgary Power Tailrace Structure & Carrot Creek Headwalls & Wing-walls (rough estimate)		100,000.
Extension to Structure at Cascade River		76,000.
Contingencies (10%)		141,322.
TOTAL		$1,554,550.

The construction estimates for the other alternatives were established by a preliminary measurement and calculation of the major work items involved such as earthwork, and by applying to this judgement factors for unit prices and other related items of work based on terrain and construction factors that can be anticipated in these other alternatives to arrive at what are felt to be realistic relative estimates of construction cost. A tabulation of these estimates is contained in table 5 in the Summary and Analysis of Results.

The anticipated value of construction cost of the railway relocation which forms a part of Proposals B and B1 can be broken down as follows:

- Cost of clearing, sub-grade construction and drainage for the relocated railway which tentatively would be carried out as a part of the highway construction operation - $208,000.
- Cost of sub-ballast, ballast, placing of new track, removal of existing track and relocation of signal and switching equipment which would be carried out by the railway - $280,000.

Total - $488,000.

This anticipated construction cost of railway relocation essentially is the difference in estimated construction costs between Proposal B and the DPW 1968 Proposal. As previously mentioned, discussions with the railway people to date have involved only physical feasibility of the railway relocation and the related construction costs that could be anticipated. No discussion has taken place with regard to possible negotiations for right-of-way exchange and there is therefore no indication of what costs, if any, might result from this. The attitude of the railway at present is that they would be prepared to consider the relocation provided they are placed in no less favourable position from the standpoint of operation and maintenance than they are at the present time.

Even though the railway could be relocated as previously described there would still be a very narrow and restricted transportation corridor situation for a relatively short section at the western extremity of the project where it would not be feasible to relocate the railway southward to a new surface installation. The possibility of a tunnel situation for the railroad in this area has been looked at in a very cursory fashion which, according to the railway, would probably cost in excess of $5,000,000. to construct. This possibility was discarded as a consideration at an early stage since the result would have no significant reduction on user and/or maintenance cost of highway facility and it is felt that the increase in cost could not be justified solely on ecological and environmental grounds.

In looking at the construction cost estimates for the various alternatives, it must be recognized that these are based on a sample or typical alignment within each corridor alternative to facilitate the examination and evaluation of the relative merits of the various corridors. During the detailed location of an alignment within the selected corridor and the subsequent detailed design of the highway facility, localized changes and refinements will undoubtedly be found necessary and/or desirable which in turn will have a greater or lesser impact on the construction cost. This will also apply to some extent to the user and maintenance costs that have been indicated.

It must also be recognized that there is no cost provision included for possible wildlife control facilities as it is felt that while sensitive areas have been identified at this time, the possible configurations and costs of desirable control facilities could only be realistically established during the later detailed design phase of the project.

(b) Road User Cost

The road user costs were estimated taking into account the costs of fuel, tires, engine oil, vehicle maintenance and vehicle depreciation. The impact of these costs was calculated under the varying conditions of vertical gradient, horizontal curvature and vehicle speed changes resulting from conditions of gradient or curvature. The user cost factors were extracted from tables in

Robley Winfrey's book and a correction to the cost calculation was applied to reflect the cost of fuel tax. The cost tables as presented by Mr. Winfrey disregard fuel tax as a user cost as it is common in the U.S.A. that fuel tax is a direct revenue back into the highway fund. By considering fuel tax as a user cost under those circumstances, a variation in the fuel tax to finance highway facilities that were justified by economic analysis would require a re-evaluation of the analysis to determine the impact on justification of the economical solution by the change in fuel tax. He therefore chooses to disregard the fuel tax in the analysis for the economical solution but further points out fuel tax can be considered as a cost where the tax does not revert directly back to the highway fund and provides fuel consumption tables through which the appropriate adjustment can be made. Since fuel tax in our system is not a direct revenue to highway financing a sample calculation was done under one alternative to establish a user cost correction factor of 35% which was then applied to all the user cost calculations.

To develop a road user cost base the calculations were carried out using the traffic volume and vehicle classifications experienced in the 1971-72 fiscal year as recorded by National Parks at the Banff East Gate. This volume, the classifications, and the conversion to vehicle categories for purposes of using the cost factor tables are tabulated in table 6. The resulting annual road user costs established for each alternative reflecting the direction of travel are tabulated in table 7. It has previously been concluded for the purpose of this analysis that the present growth of traffic volume is a uniform annual amount and in terms of user cost increase it is further assumed that the traffic classification and consequently the user costs will increase in the same proportions. On this basis the anticipated uniform annual user cost increase has been calculated and is also tabulated in table 7.

To ensure that the relative user cost calculations for each alternative reflect equal levels of service, the westbound user costs for all alternatives were taken from the present east gate to the Minnewanka Traffic Circle or a point directly opposite the traffic circle and the eastbound user costs for all alternatives were taken from the present highway crossing of the Cascade River to a point about 2,000 feet east of the Park Gate where the eastbound lanes for Proposal B and DPW 1968 Proposal would join onto the Provincial Highway.

(c) Highway Maintenance Costs

The anticipated costs of highway maintenance for each alternative is a somewhat more difficult area of costs to establish and it was found necessary to rely almost entirely on relative value judgements based on anticipated highway conditions under each alternative. To provide a starting point for such value judgements the 1971-72 maintenance cost for the approximate same length of the existing highway was obtained from National Parks which was then expanded to reflect that the new facility would in effect be two similar highways of equivalent length. Further expansion was included to reflect administration costs and depreciation of maintenance equipment which were not included in the National Parks figure. The value judgements were then applied to this developed base considering factors such as;

- the effects on winter maintenance requirements because of gradient and curvature.

- the effect on operating costs of maintenance equipment by gradient and curvature which could be related to user costs for commercial vehicles.

- the impact of accessibility, i.e. the wide separation between opposing lanes such as would occur in Proposals A and B.

- the nature of roadside areas anticipated within each alternative.

The resulting established maintenance costs are tabulated in table 8. Similar to road user costs, it is felt that maintenance costs will increase with traffic volumes but recognizing the fact that this would not be in the same proportion. To establish a value for this increase it was assumed that the increase would be at half the proportional rate for that of traffic volume or approximately 2.7% per year based on maintenance costs established for the equivalent 1971-72 service level. These increase costs are also tabulated in table 8.

5. ANALYSIS METHODS

(a) Formulae and Terms

The basic formulae used in the analysis are;

- EQUIVALENT UNIFORM ANNUAL COST (EUAC)

EUAC= I(CR-i-n) +U+Gu (GUS-i-n)+K+GK(GUS-i-r

EUAC is the expression of construction cost, user cost and maintenance cost in terms of a single equivalent uniform annual expenditure for each year during the service life of the facility taking into account the time discounting of expenditures.

- PRESENT WORTH OF COSTS AND EXPENSES (PWOC)

PWOC = I+U(SPW-i-n)+Gu(GPW-i-n) +K(SPW-i-n)+Gk(GPW-i-n)

These formulae have been taken from Robley Winfrey's book with the explanation of terms as follows;

I - Construction Cost

U - Annual road user cost at the beginning of the project service life (based on 1971-72 service levels)

Gu - Uniform annual gradient increase in road user costs.

K - Annual maintenance costs at the beginning of the project service life.

Gk - Uniform annual gradient increase in maintenance costs.

n - Anticipated project service life.

i - Vestcharge or time-discounting rate.

(CR-i-n) - Capital recovery or return factor used to convert a one time payment to an equivalent uniform annual cost.

(GUS-i-n) - Gradient uniform series factor used to convert a uniformly increasing series of annual amounts to an equivalent uniform annual amount.

(SPW-i-n) - Series present worth factor used to convert a series of equal annual amounts to an equivalent present worth at the beginning of the project service life.

(GPW-i-n) - Gradient present worth factor used to convert a uniformly increasing series of annual amounts to an equivalent present worth at the beginning of the project service life.

In addition to the expressions outlined above it was felt there might be some interest in showing the future worth of costs and expenditures, i.e. what the future value of all costs and expenditures would be at the end of the project service life if they were used in some other endeavour that yielded a monetary return. To do this the following formula was used;

- FUTURE WORTH OF COSTS AND EXPENSES

(FWOC)

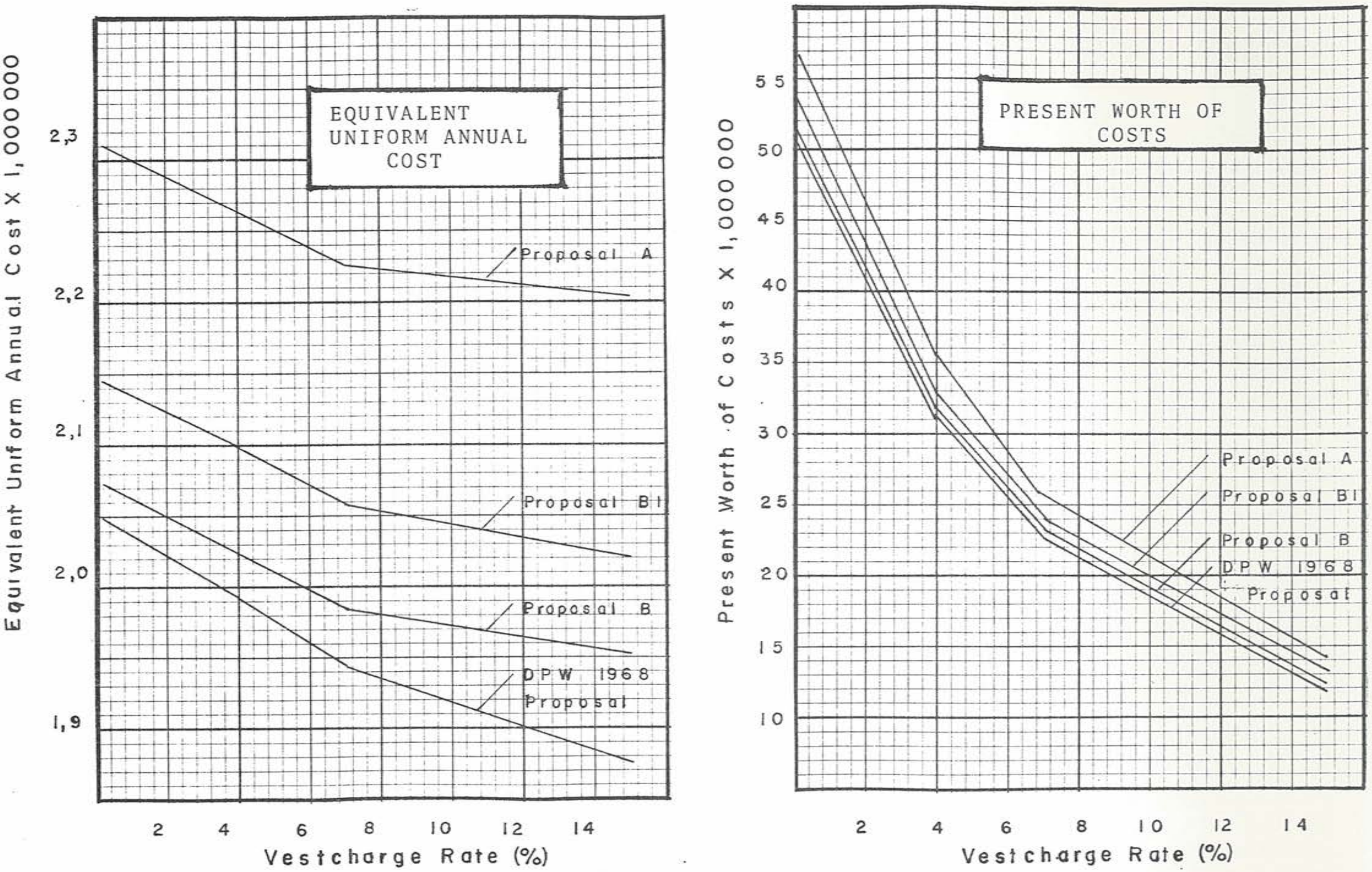
FWOC = EUAC(SCA-i-n)

Where (SCA-i-n) is the series compound amount factor used to convert a series of equal annual amounts to an equivalent future compounded amount.

(b) Calculation of Results

A summary outline of the results obtained by the application of the above described formulae has been presented in tables 1, 2, 3, and 4 and figures 1 and 2. A further breakdown of the equivalent uniform annual cost and present worth of cost calculations is contained in tables 9, 10, 11 and 12.

FIGURE 1


EQUIVALENT UNIFORM ANNUAL COST
Equivalent Uniform Annual Cost X 1,000 000
2,3
2,2
2,1
2,0
1,9
Proposal A
Proposal B1
Proposal B
DPW 1968 Proposal
2
4
6
8
10
12
14
Vestcharge Rate (%)
PRESENT WORTH OF COSTS
Present Worth of Costs X 1,000 000
55
50
45
40
35
30
25
20
15
10
Proposal A
Proposal B1
Proposal B
DPW 1968 Proposal
2
4
6
8
10
12
14
Vestcharge Rate (%)

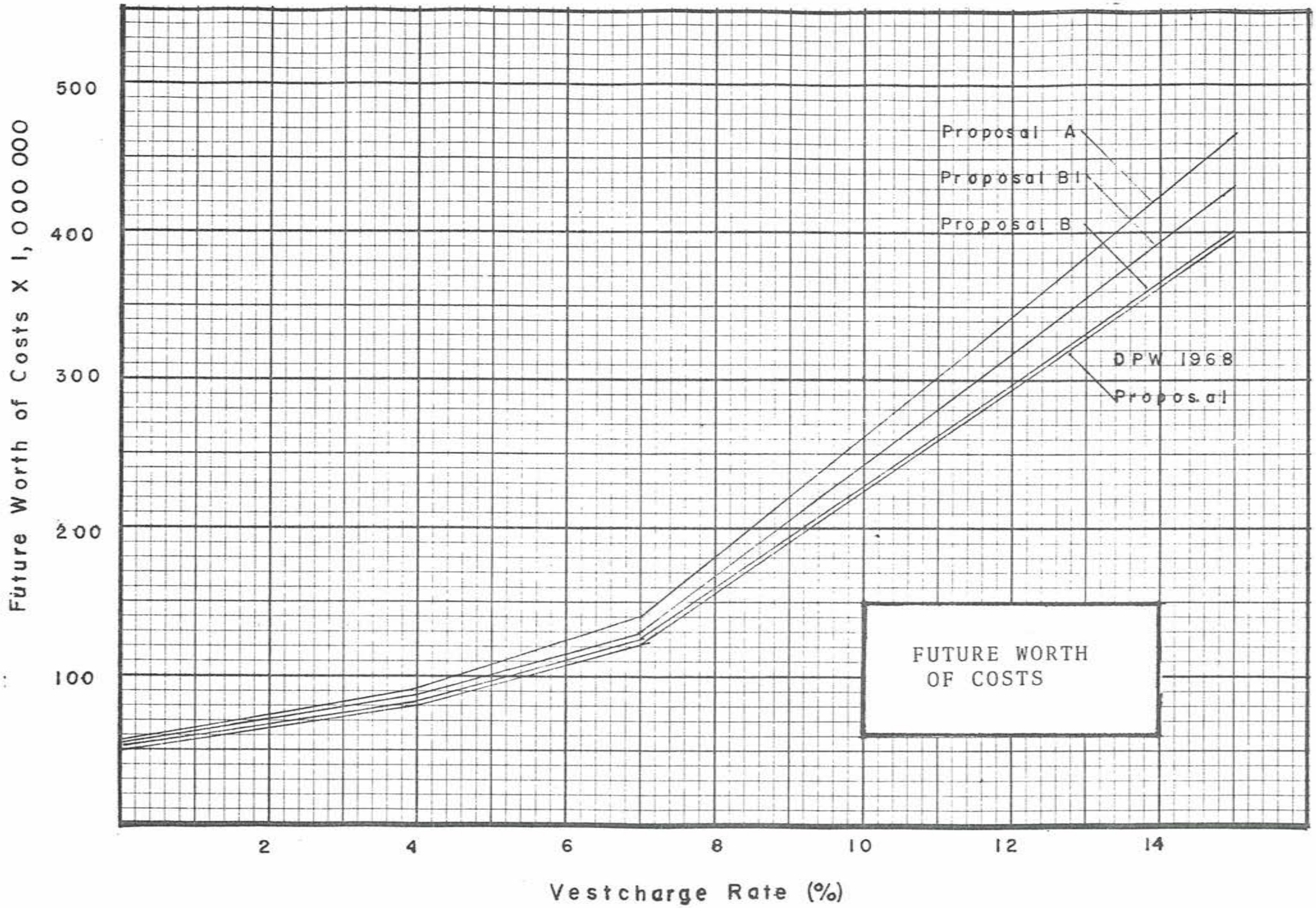

Future Worth of Costs X 1,000 000
500
400
300
200
100
Proposal A
Proposal B1
Proposal B
DPW 1968
Proposal
FUTURE WORTH OF COSTS
2
4
6
8
10
12
14
Vestcharge Rate (%)

FIGURE 3

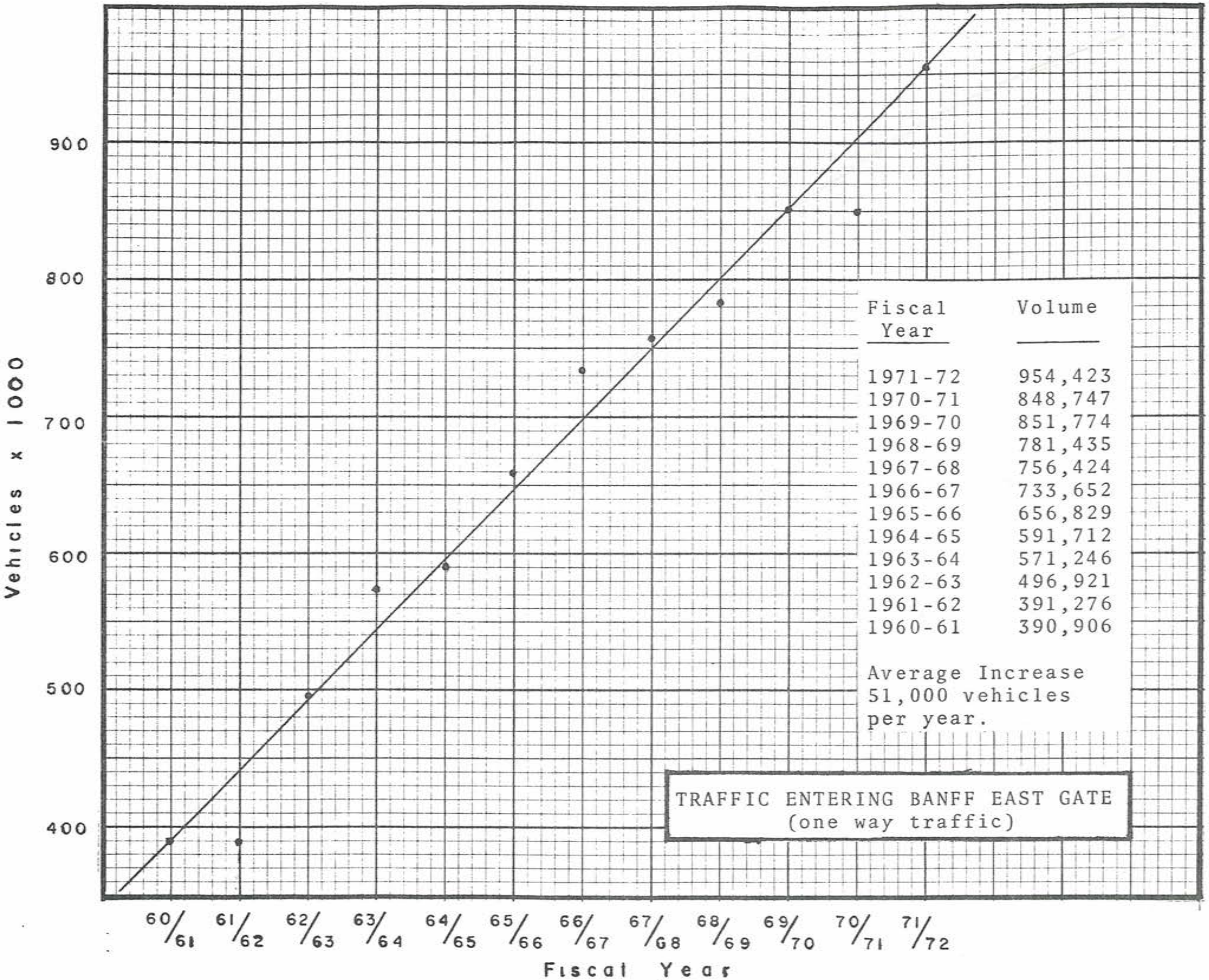

Vehicles x 1000
900
800
700
600
500
400
60/61
61/62
62/63
63/64
64/65
65/66
66/67
67/68
68/69
69/70
70/71
71/72
Fiscal Year
Fiscal Year Volume
1971-72 954,423
1970-71 848,747
1969-70 851,774
1968-69 781,435
1967-68 756,424
1966-67 733,652
1965-66 656,829
1964-65 591,712
1963-64 571,246
1962-63 496,921
1961-62 391,276
1960-61 390,906
Average Increase 51,000 vehicles per year.
TRAFFIC ENTERING BANFF EAST GATE
(one way traffic)

TABLE 1

LISTING OF EQUIVALENT UNIFORM ANNUAL

COST FROM LOW TO HIGH

n= 25 years

ALTERNATIVE	i=0%		i=4%		i=7%		i=15%	
	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF
DPW 1968 Proposal	$2,054,040		$ 1,996,725		$ 1,945,675		$ 1,879,820	
		$19,275		$30,835		$41,340		$74,535
Proposal 'B'	2,073,315		2,027,560		1,987,015		1,954,355	
		75,060		72,710		70,600		67,400
Proposal 'B1'	2,148,375		2,100,270		2,057,615		2,021,755	
		164,690		167,475		170,080		185,125
Proposal 'A'	2,313,065		2,267,745		2,227,695		2,206,880	
Total Difference High to Low		259,025		271,020		282,020		327,060

LISTING OF PRESENT WORTH OF COSTS

FROM LOW TO HIGH

n= 25 years

ALTERNATIVE	i=0%		i=4%		i=7%		i=15%	
	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF
DPW 1968 Proposal	$51,351,000		$31,193,420		$22,674,280		$12,151,695	
		$481,800		$481,800		$481,800		$481,800
Proposal 'B'	51,832,800		31,675,220		23,156,080		12,633,495	
		1,876,575		1,135,805		822,745		435,555
Proposal 'B1'	53,709,375		32,811,025		23,978,825		13,069,050	
		4,117,250		2,616,405		1,982,080		1,195,925
Proposal 'A'	57,826,625		35,427,430		25,960,905		14,264,975	
Total Difference High to Low		6,475,625		4,234,010		3,286,625		2,113,280

LISTING OF FUTURE WORTH OF COSTS

FROM LOW TO HIGH

n= 25 years

ALTERNATIVE	i=0%		i=4%		i=7%		i=15%	
	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF	AMOUNT	DIFF
DPW 1968 Proposal	$51,351,000		$83,155,410		$123,062,000		$400,012,535	
		$481,800		1,284,150		$2,614,710		15,860,530
Proposal 'B'	51,832,800		84,439,560		125,676,710		415,873,065	
		1,876,575		3,028,074		4,466,200		14,342,245
Proposal 'B1'	53,709,375		87,467,634		130,142,910		430,215,310	
		4,117,250		6,974,646		10,756,570		39,393,305
Proposal 'A'	57,826,625		94,442,280		140,899,480		469,608,615	
Total Difference High to Low		6,475,625		11,286,870		17,837,480		69,596,080

ECONOMIC COMPARISONS BY TOTAL COST AND

BY CONSTRUCTION COST ONLY

ALTERNATIVE	CONSTRUCTION COST ONLY		TOTAL COSTS EXPRESSED AS EQUIVALENT UNIFORM ANNUAL COSTS							
			i=0%		i=4%		i=7%		i=15%	
	AMOUNT	% INC.	AMOUNT	% INC.	AMOUNT	% INC.	AMOUNT	% INC.	AMOUNT	% INC.
DPW 1968 Proposal	$1,554,550		2,054,040		$1,996,725		$1,945,675		1,879,820	
Proposal 'B'	2,036,350	30.9	2,073,315	0.9	2,027,560	1.6	1,987,015	2.1	1,954,355	3.9
Proposal 'B1'	2,080,750	33.8	2,148,375	4.6	2,100,270	5.2	2,057,615	5.8	2,021,755	7.6
Proposal 'A'	2,478,250	59.4	2,313,065	12.6	2,267,745	13.6	2,227,695	14.5	2,206,880	17.4

NOTE: PERCENTAGE INCREASES EXPRESSED AS INCREASES OVER DPW 1968 PROPOSAL.

SUMMARY OF COSTS USED IN ECONOMIC ANALYSIS

ALTERNATIVE	CONSTRUCTION COST (I)	INITIAL ANNUAL ROAD USER COST (U)	UNIFORM ANNUAL ROAD USER COST INCREASE (Gu)	INITIAL ANNUAL MAINTENANCE COST (K)	UNIFORM ANNUAL MAINTENANCE COST INCREASE (Gk)
Proposal 'A'	$2,478,250.	$1,254,495.	$ 67,115.	$ 90,500.	$ 2,400.
Proposal 'B'	2,036,350.	1,139,493.	60,965.	67,800.	1,800.
Proposal 'B1'	2,080,750.	1,179,605.	63,110.	72,600.	1,925.
DPW 1968 Proposal	1,554,440.	1,139,493.	60,965.	67,800.	1,800.

EXPECTED PROJECT SERVICE LIFE(n) FOR

EACH ALTERNATIVE IS 25 YEARS.

TRAFFIC VOLUME AND VEHICLE CLASSIFICATION

PARK EAST GATE COUNT 1971-72		CATEGORY FOR OPERATING COSTS					
TYPE	NO.	4k	5k	12k	40k	50k	
Trucks	55,000		2,000	23,000	15,000	15,000	
Buses	7,052			3,052	4,000		
Cars with Trailers	65,000		65,000				
Cars	827,371	775,000	52,371				
TOTALS	954,423	775,000	119,371	26,052	19,000	15,000	
Rounded Totals	954,500	775,000	119,400	26,100	19,000	15,000	
Percentages	100	81.2	12.5	2.7	2.0	1.6	

ANNUAL USER COST SUMMARY

(BASED ON 1971-72 TRAFFIC VOLUME)

PROPOSAL	COST BY VEHICLE CLASSIFICATION 4kip	5kip	12kip	40kip	50kip	TOTAL DIRECTIONAL COSTS	TOTAL ROUND TRIP COST
'A' Westbound	420,595	90,300	33,370	78,165	70,275	692,705	
'A' Eastbound	386,065	75,050	26,145	40,005	34,525	561,790	
'A' Round Trip	806,660	165,350	59,515	118,170	104,800		1,254,495
'B' Westbound	406,990	82,885	28,785	50,185	39,365	608,210	
'B' Eastbound	382,925	73,825	23,818	28,035	22,680	531,283	
'B' Round Trip	789,915	156,710	52,603	78,220	62,045		1,139,493
'B1' Westbound	406,990	83,045	29,600	53,655	43,205	616,495	
'B1' Eastbound	386,065	75,530	26,285	40,340	34,890	563,110	
'B1' Round Trip	793,055	158,575	55,885	93,995	78,095		1,179,605

NOTE:

1. User cost for DPW 1968 proposal can be assumed to be the same as Proposal 'B'.

2. Estimated uniform annual user cost increase:

   Proposal 'A' - $ 67,115
   Proposal 'B' - $ 60,965
   Proposal 'B1'- $ 63,110
   DPW 1968
   Proposal - $ 60,965

ESTIMATED ANNUAL MAINTENANCE COST

MAINTENANCE CATEGORY	BASE FROM EXISTING COSTS	PROJECTED COSTS		
		PROPOSAL A	PROPOSAL B	PROPOSAL B1
1. Supervision, Inspection, Stand-by, Administration, etc.	$13,000	$13,000	$13,000	$13,000
2. Summer surface maintenance including delineators, signs, warning devices, guardrail, etc.	19,400	22,500	16,500	19,400
3. Winter maintenance	35,200	45,000	32,000	35,200
4. Slopes, ditches, roadside areas	6,300	10,000	6,300	5,000
TOTALS	$73,900	$90,500	$67,800	$72,600

1. Maintenance cost for DPW 1968 proposal can be assumed the same as proposal 'B'.

2. Estimated uniform annual maintenance cost increases:

   Proposal 'A' - $2,400.
   Proposal 'B' - 1,800.
   Proposal 'B1' - 1,925.

TABLE 9

ECONOMIC COMPARISONS

i=0%   n-25 years

DATA OR FACTOR	PROPOSAL 'A'	PROPOSAL 'B'	PROPOSAL 'B1'	DPW 1968 PROPOSAL
I	2,478,250	2,036,350	2,080,750	1,554,550
U	1,254,495	1,139,495	1,179,605	1,139,495
Gu	67,115	60,965	63,110	60,965
K	90,500	67,800	72,600	67,800
Gk	2,400	1,800	1,925	1,800
(CR-i-n)	0.04	0.04	0.04	0.04
(GUS-i-n)	12.50	12.50	12.50	12.50
(SPW-i-n)	25.0	25.0	25.0	25.0
(GPW-i-n)	312.5	312.5	312.5	312.5
I(CR-i-n)	99,130	81,455	83,230	62,180
U(SPW-i-n)	31,362,375	28,487,375	29,490,125	28,487,375
Gu(GUS-i-n)	838,940	762,065	788,875	762,065
Gu(GPW-i-n)	20,973,440	19,051,565	19,721,875	19,051,565
K(SPW-i-n)	2,262,500	1,695,000	1,815,000	1,695,000
Gk(GUS-i-n)	30,000	22,500	24,065	22,500
Gk(GPW-i-n)	750,000	562,500	601,565	562,500
EUAC	2,313,065	2,073,315	2,148,375	2,054,040
PWOC	57,826,625	51,832,800	53,709,375	51,351,000

TABLE 9

TABLE 10

ECONOMIC COMPARISONS

i=4%   n=25 years

DATA OR FACTOR	PROPOSAL 'A'	PROPOSAL 'B'	PROPOSAL 'B1'	DPW 1968 PROPOSAL
I	2,478,250	2,036,350	2,080,750	1,554,550
U	1,254,495	1,139,495	1,179,605	1,139,495
Gu	67,115	60,965	63,110	60,965
K	90,500	67,800	72,600	67,800
Gk	2,400	1,800	1,925	1,800
(CR-i-n)	0.0640	0.0640	0.0640	0.0640
(GUS-i-n)	10.9925	10.9925	10.9925	10.9925
(SPW-i-n)	15.6221	15.6221	15.6221	15.6221
(GPW-i-n)	171.7261	171.7261	171.7261	171.7261
I(CR-i-n)	158,610	130,325	133,170	99,490
U(SPW-i-n)	19,597,845	17,801,305	18,427,905	17,801,305
Gu(GUS-i-n)	737,760	670,155	693,735	670,155
Gu(GPW-i-n)	11,525,395	10,469,280	10,837,635	10,469,280
K(SPW-i-n)	1,413,800	1,059,180	1,134,165	1,059,180
Gk(GUS-i-n)	26,380	19,785	21,160	19,785
Gk(GPW-i-n)	412,140	309,105	330,570	309,105
EUAC	2,267,745	2,027,560	2,100,270	1,996,725
PWOC	35,427,430	31,675,220	32,811,025	31,193,420

TABLE 10

ECONOMIC COMPARISONS

i=7%   n=25 years

DATA OR FACTOR	PROPOSAL 'A'	PROPOSAL 'B'	PROPOSAL 'B1'	DPW 1968 PROPOSAL
I	2,478,250	2,036,350	2,080,750	1,554,550
U	1,254,495	1,139,495	1,179,605	1,139,495
Gu	67,115	60,965	63,110	60,965
K	90,500	67,800	72,600	67,800
Gk	2,400	1,800	1,925	1,800
(CR-i-n)	0.0858	0.0858	0.0858	0.0858
(GUS-i-n)	9.6391	9.6391	9.6391	9.6391
(SPW-i-n)	11.6536	11.6536	11.6536	11.6536
(GPW-i-n)	112.3301	112.3301	112.3301	112.3301
I(CR-i-n)	212,635	174,720	178,530	133,380
U(SPW-i-n)	14,619,385	13,279,220	13,746,645	13,279,220
Gu(GUS-i-n)	646,930	587,650	608,325	587,650
Gu(GPW-i-n)	7,539,030	6,848,200	7,089,145	6,848,200
K(SPW-i-n)	1,054,650	790,115	846,050	790,115
Gk(GUS-i-n)	23,135	17,350	18,555	17,350
Gk(GPW-i-n)	269,590	202,195	216,235	202,195
EUAC	2,227,695	1,987,015	2,057,615	1,945,675
PWOC	25,960,905	23,156,080	23,978,825	22,674,280

TABLE 11

ECONOMIC COMPARISONS

i=15% n=25 years

DATA OR FACTOR	PROPOSAL 'A'	PROPOSAL 'B'	PROPOSAL 'B1'	DPW 1968 PROPOSAL
I	2,478,250	2,036,350	2,080,750	1,554,550
U	1,254,495	1,139,495	1,179,605	1,139,495
Gu	67,115	60,965	63,110	60,965
K	90,500	67,800	72,600	67,800
Gk	2,400	1,800	1,925	1,800
(CR-i-n)	0.1547	0.1547	0.1547	0.1547
(GUS-i-n)	6.8834	6.8834	6.8834	6.8834
(SPW-i-n)	6.4642	6.4642	6.4642	6.4642
(GPW-i-n)	44.4955	44.4955	44.4955	44.4955
I(CR-i-n)	383,385	315,025	321,890	240,490
U(SPW-i-n)	8,109,275	7,365,890	7,625,235	7,365,890
Gu(GUS-i-n)	461,980	419,645	434,410	419,645
Gu(GPW-i-n)	2,985,650	2,712,890	2,808,110	2,712,890
K(SPW-i-n)	585,010	438,270	469,300	438,270
Gk(GUS-i-n)	16,520	12,390	13,250	12,390
Gk(GPW-i-n)	106,790	80,095	85,655	80,095
EUAC	2,206,880	1,954,355	2,021,755	1,879,820
PWOC	14,264,975	12,633,495	13,069,050	12,151,695

TABLE 12

ERRATA

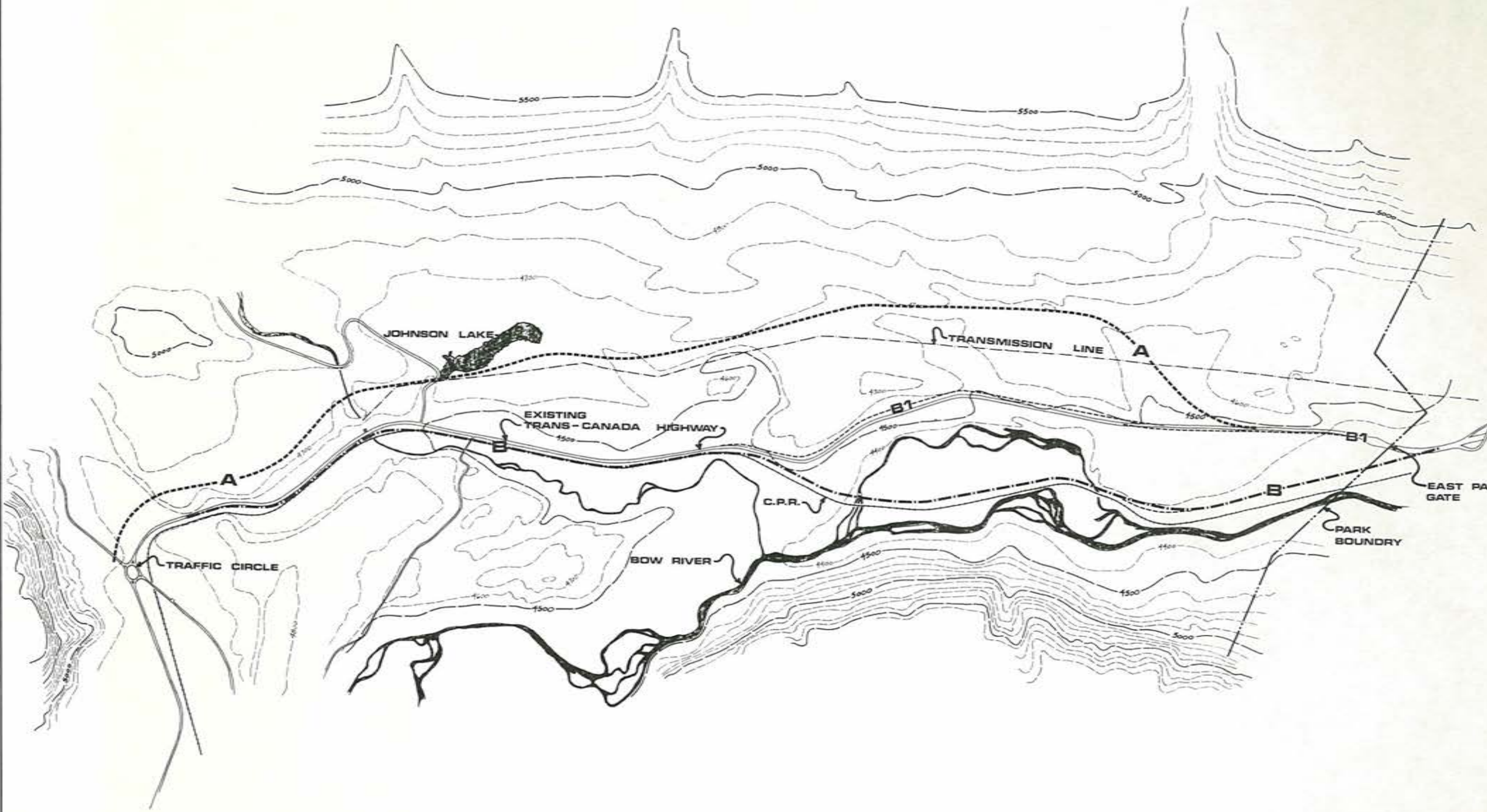
letter:	last line, decision-making process
page i:	paragraph 1, column 1, last line - becoming
page iv:	column 1, line 32, visibility
page v:	column 1, No. 2, line 1, compatible
	following page vi insert Map "Corridor Alternatives"
page 30:	No. 2, paragraph 3, line 8, intermittent
page 31:	column 1, No. 1, paragraph 1, line 7, change affect to effect
	column 2, move over first line to left-hand margin
	column 2, No. 3, paragraph 3, line 4 floodplain should be two words.
page 32:	column 1, line 1, change affect to effect
	column 2, paragraph 2, line 6, change unaffected to uneffected
page 40:	column 1, line 3, aggravated

Appendix A

page A-1:	column 2, paragraph 1, line 3, kaleidoscope

Appendix E

page E-1:	paragraph 1, line 12, change aremade to are made
page E-2:	paragraph 1, line 22, change truely to truly



Department of Public Works
Ministère des Travaux public

CALGARY DISTRICT

Lombard North Planning L
RESOURCE DEVELOPMENT
CONSULTANTS

SCALE: 1" = 1320'

T.C.H. BANFF PARK
FOUR LANING
MILE 0-7.8

CORRIDOR ALTERNATIVES

85854